# PROGRESS IN POLLUTION RESEARCH

Proceedings of the National Young Scientists' Seminar
on Environmental Pollution, Bangalore

30th & 31st March 1989


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**K.V. DEVARAJ**
*Director of Research*

**R.V. KRISHNAMOORTHY**
*Department of Zoology*

**J. SRIKANTH**
*Department of Entomology*

**G.V. PRASAD REDDY**
*Department of Entomology*

**T.V. RAMACHANDRA PRASAD**
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# PREFACE

Environmental pollution and greenhouse effect, the direct consequences of human activities, are endangering our future. The changes occurring in the environment due to the rapidly expanding human populations, dwindling forest resources and wildlife, and pollution are inexorable. Climatic changes, global warming and greenhouse effect have recently become the focus of significant media attention. The harrowing effects of soil erosion and pollution have become a hindrance to sustainable agriculture. If we begin to assess the devastation we have caused to the environment and look at the way ahead, we will realize that the situation has reached alarming levels and we are slowly heading towards a point of no return. The impact of these events in our country, although not comparable to the magnitude of the situation in other parts of the globe, needs to be given a serious thought. The role of scientists lies in the analysis of the situation, prediction of future trends and formulation of amelioration programmes by constantly monitoring the ecological changes due to pollution. The efforts of young scientists, who play a major role in shaping the future of our country, should be channelised in this direction.

It is with this perspective a National Young Scientists' Seminar was organised in March 1989 and the present publication is the outcome of presentation of research information on environmental pollution in India. A critical look at the papers published in this proceedings will indicate that young scientists in India are aware of the ill effects of pollution and they have identified different areas of research to achieve the objective of understanding and preventing pollution. It is gratifying to note that various disciplines of pollution research are being investigated in the country. Although it is a beginning, an interdisciplinary approach to the problems is evident. It is hoped that the proceedings will be a source of inspiration and information for scientists desirous of studying environmental pollution.

We wish to thank all the people who helped in bringing out this volume precisely as we desired. Special thanks are due to the University of Agricultural Sciences, Bangalore; Institution of Agricultural Technologists, Bangalore; Karnataka Urban Water Supply and Drainage Board, and Department of Ecology and Environment, Government of Karnataka; Department of Ocean Development and Department of Science and Technology, Government of India, for financial assistance. Our thanks to M/s S.K. Offset Printers, Bangalore, for bringing out the volume with an elegant getup.

Bangalore
16 March 1990

Dr. K. KRISHNAMURTHY
Vice Chancellor
University of Agricultural Sciences
Bangalore 560065

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# Estimation of $NO_2$ and $SO_2$ Pollution Levels at Three Sites of Madurai City

**P. Muthusubramanian and C. Gopinathan**

School of Energy, Environment and Natural Resources, Madurai Kamraj University, Madurai 625021

## Abstract

Estimation of the atmospheric pollutants $SO_2$ and $NO_2$ at three sites in Madurai City has been done using Spectrophotometric method. For the analysis of gas samples, USEPA recommended method was adopted. Studies on the time variation of pollutant concentration in air with reference to atmospheric conditions, wind speed and directions are presented. The concentration levels of $NO_2$ were higher than those of $SO_2$ in all three sites studied.

## Introduction

Air pollution in India is reaching alarming proportions in major urban cities. The gaseous air pollutants like sulfur oxides $SO_2$ and $SO_3$ are mostly from the cômbustion of coal and oil in rubber plants, railways and chemical industries. The contaminants like $NO_2$ and other oxides of nitrogen are due to acid manufacturing plants and automobile exhausts (Stern, 1976).

Madurai (9° 54'N, 78° 06' E) is the second largest city of the state Tamil nadu and has a population of one million. The major industries situated in and around Madurai include textiles, rubber, cement and sugar. These are the major sources of gaseous pollutants. As part of systematic investigations on the air quality of Madurai, estimation of $SO_2$ pollution in an industrial area of Madurai city was carried out and it was found that the levels of $SO_2$ reach three times the permissible limit (Muthusubramanian and Umamaheshwari, 1988). In the present study, the pollution levels of $NO_2$ and $SO_2$ were estimated at three sites of Madurai city.

## Material and Methods

Madurai city was divided into concentric circles keeping Meenakshi temple as the centre with 1 km increase in the radius between two successive circles. Each concentric circle was called a zone. The samples were collected from three sites, i.e. IVth, Vth and VIth zone. All the three sampling sites were traffic points. The sampling durations were 8 h and 24 h for each site.

### *Apparatus*

Commercial high volume air sampler Envirotech Model No.APM 400 consisting of absorber trap, flow control and metering device, filter to remove particulate matter, sample collectors, temperature and pressure gauges, and a vacuum pump was employed. The flow rate was kept at 0.5 LPM so as to increase the collection efficiency.

### *Procedure*

US-EPA standard methods were followed to analyse both $SO_2$ and $NO_2$ concentration levels. The nominal range of the method was 0.005 and 0.4 ppm. Ambient nitrogen oxides were collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion ($NO_2^-$) produced during sampling was determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide and N-(1-napthyl)ethylene diamine dihydrochloride to form a highly coloured azo dye (Anon., 1977). The absorbance of the coloured solution was measured at 560 nm. The potential interference from $SO_2$ was eliminated by converting it to sulfate with hydrogen peroxide during analysis.

Ambient sulfur dioxide was also collected in the same way by bubbling air through a solution of 20 ml sodium tetrachloromercurate (TCM). For analysis of $SO_2$ concentration, the air sample was protected from sunlight and stored at 5°C. Twenty minutes were allowed between the sampling and analysis to ensure decomposition of any ozone that may be present. To the sample, 1 ml of formaldehyde and 5 ml of pararosaniline were added. After a lapse of 30 min, the absorbance of this mixed solution at 548 nm was read.

A series of standard air mixtures containing six known concentrations of $SO_2$ and $NO_2$ each were prepared. The absorbance of these standards and the sample solution was determined using a Spectronic 2000 UV visible spectrophotometer. A graph was drawn between the concentration of the pollutants in $\mu g/m^3$ and $A-A_0$ value where A was the absorbance of the standard solution and $A_0$ was the absorbance of the blank. A straight line of the best fit was drawn and the slopes were determined. The volume of air $V_R$ flown through the sample train was obtained by multiplying the rate of flow and the sampling time.

The sample concentration C present in the atmosphere was calculated using the formula

$$C = \frac{10^3(A-A_0)B_s}{V_R} D$$

where $B_s$ - calibration factor (slope)
$10^3$ - conversion of litres to cubic metres
D - dilution factor which is the ratio of the volume of the absorbing solution taken to the volume taken for analysis.

## Results and Discussion

The concentration levels of the pollutants $SO_2$ and $NO_2$ at three sites from IVth, Vth and VIth zones are presented along with all the meteorological parameters like wind velocity, temperature and humidity in Table 1. It was observed that the concentration levels of $NO_2$ were higher than those of $SO_2$ in all these three sites indicating that there was no $SO_2$ source in the immediate vicinity of these sites.

Higher wind velocity may be responsible for lower concentration levels of both $NO_2$ and $SO_2$. Higher concentration levels of $NO_2$ were due to the heavy traffic at these points. The concentration of both $NO_2$ and $SO_2$ was higher for 8 h sampling than for 24 h sampling. This does not imply that hourly mean concentrations were not high enough to cause ill effects. It can also be concluded that the pollution concentration and dispersion are controlled more by the atmospheric conditions rather than the period of sampling.

Table 1. $NO_2$ and $SO_2$ pollution levels at three sites of Madurai city.

| Sampling point | Date | Sampling duration (h) | $NO_2$ levels ($\mu g/m^3$) | $SO_2$ levels ($\mu g/m^3$) | Atmospheric condition | | |
|---|---|---|---|---|---|---|---|
| | | | | | Temp. (°C) | Wind velocity (km/h) | Weather condition |
| Site I | 31.12.88 | 8 | 4.935 | 1.1468 | 31.4 | 0.630 SW | Clear |
| (IVth zone) | 2.01.89 | 24 | 1.468 | 0.1618 | 29.5 | 0.660 W | Cloudy |
| Site II | 28.12.88 | 8 | 3.882 | 1.903 | 30.0 | 0.5165 NW | Clear |
| (Vth zone) | 29.12.88 | 24 | 1.612 | 1.1062 | 29.0 | 0.701 W | Cloudy |
| Site III | 3.01.89 | 8 | 5.854 | 1.323 | 28.0 | 0.570 W | Clear |
| (VIth zone) | 4.01.89 | 24 | 0.914 | 0.481 | 28.1 | 0.608 W | Clear |


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University of Agricultural Sciences, Bangalore, 1989. pp.6-9

# Estimation of Some Metal Concentrations in Suspended Particulate Matter Collected in Madurai City

**P. Muthusubramanian and S. Paul Mary Deborrah**

School of Energy, Environment and Natural Resources, Madurai Kamraj University, Madurai 625021

## Abstract

Concentration of selected metals, *viz.* Pb, Zn, Mn, Fe and Cu in particulate matter collected at four sites in Madurai City was estimated. The suspended particulate matter (SPM) was collected by filtration method using an EPM 2000 glass fibre filter paper. A high volume air sampler (model Envirctech APM 410) was operated at each site for a duration of 8 to 24 h. The metal concentrations were determined using a Perkin Elmer Model 500 Atomic Absorption Spectrometer. The concentration of these metals has been found in the following order Fe>Zn>Cu>Mn>Pb. The metals Fe, Zn and Cu which have significant presence in the particulate matter have comparatively low toxicity whereas the toxic metals Mn and Pb have comparatively very low concentrations in the particulate matter.

## Introduction

Dust particulate matter occupies the first place as a primary pollutant of atmospheric environment. Particulate is a term employed to describe dispersed air borne solids larger than single molecules (0.002 μ in dia) but smaller than 500 μ. Particles in this size range have a life time in suspension from a few seconds to several months and remain air borne for indefinite periods. Particles above 20 μ have large settling velocities and are removed from air by gravity and other processes (Kenneth, 1967). The generation of suspended particulate matter (SPM) is mainly due to industrial, agricultural and transportation activities. Wind storms, etc. also contribute towards SPM in general atmosphere. In the present study, concentration of selected metals, namely Pb, Zn, Mn, Fe and Cu in the SPM collected at four sites of Madurai City was estimated.

## Material and Methods

Madurai city has a high population density of 10 lakhs in its 46.99 square km area. The area around the bus stand is highly urbanized and has a high floating population. An average of 2500 pedestrians, cross the area in one hour. The city was divided into concentric circles called zones, keeping the Meenakshi temple as the centre, with radii of 1 and 2 km. These zones were labelled as industrial area, commercial area, residential area and sensitive area. From the first three zones, samples were collected from site III (commercial area), site I and II (traffic area) and IV (residential area). These sites (I, II, III) were located very near to central bus stand and railway junction. The bus stand and railway junction were located very near to each other.

### *Air sampling*

A high volume air sampler (model Envirotech APM 410) was operated at each site for durations of 8 to 24 h at a height of 5 to 10 m. The measurements were conducted at each site for two to four days. Whatman glass (EPM 2000) micro filter papers with retention efficiency of 99.99% for 0.6 μm particles were used with the air sampler. During the sampling period, the meteorological parameters, namely temperature, wind velocity and wind direction were recorded (Table 1). The amount of air collected for each sample was noted with the help of a flow meter. The volume of air collected at each site ranged from 240 to 720 $m^3$. The concentrations of SPM have been calculated in $\mu g/m^3$ at each sampling site. The weight of the air particulate matter was estimated by weighing the filter papers before and after sample collection.

Table 1. Meteorological data of the study area

| Sample site | Sampling duration (h) | Flow rate | Temperature (°C) | Wind velocity (m/sec) | Wind direction | Weather |
|---|---|---|---|---|---|---|
| I | 8 | 0.5 | 31.4 | 3 4 | E | Clear |
| | 24 | 0.5 | 33.1 | 2 1 | W | Rainy |
| II | 8 | 0.5 | 33.7 | 3.1 | NW | Clear |
| | 24 | 0.5 | 32 6 | 3.26 | ES | Clear |
| III | 8 | 0 5 | 32.3 | 4.2 | E | Clear |
| | 24 | 0.5 | 34.0 | 3.1 | E | Cloudy |
| IV | 8 | 0.5 | 30.4 | 6 4 | SW | Clear |
| | 24 | 0 5 | 31 6 | 4.2 | W | Clear |

*Experiment*

The SPM between 100 to 0 1 μ size were collected by drawing air at a rate of 0.5 $m^3$/min for 24 h through glass fibre filter with high volume air sampler. The glass filter used as filtering medium measured 8" x 9.8" in and had high retention efficiency combined with rapid flow rate, low pressure drop, high resistance to blockening and low affinity for moisture. Depending on the various meteorological and other factors, about 75 to 1600 $\mu g/m^3$ of particulates were collected in 24 h of sampling duration. In order to maintain uniform conditions and constant weight, the filter was dried in an air oven at 100 + 2°C for 2 h, cooled in a desiccator and weighed before use. The procedure was repeated after collecting the sample. By difference of weight and volume of air sampled, the particulate concentration in the atmosphere was calculated and presented in terms of weight in $\mu g/m^3$ of air.

*Sample preparation*

The collected sample of the particulate matter was dried in an oven at 100°C for 2 h. A strip of 3/4" x 8" was cut from the exposed filter using a template and a pizza cutter. Then 15 ml of 3M $HNO_3$ solution was added to cover the sample. It was boiled gently for 30 min and cooled to near room temperature. Extract and rinsings were replaced into 100 ml volumetric flasks. There after the solutions were made upto 100 ml volume (Zdrojewake *et al.*, 1972).

The analysis was carried out using an Atomic Absorption Spectrophotometer (Perkin Elmer Model 500). The recommended operating conditions (Kikuo, 1977) followed during the AAS estimation have been given in Table 2. The standard solutions of the

Table 2. Operating conditions of the atomic absorption spectrophotometer

| Metal | Wave length (nm) | Fuel | Support | Lamp current (mA) | Flame Stoichio-metry | Spectral band pass (nm) |
|---|---|---|---|---|---|---|
| Fe | 248.3 | $C_2H_2$ | Air | 30.0 | Oxidising | 0.2 |
| Zn | 213.9 | $C_2H_2$ | Air | 15.0 | Reducing | 0.7 |
| Pb | 283.3 | $C_2H_2$ | Air | 10.0 | Oxidising | 0.7 |
| Mn | 279.5 | $C_2H_2$ | Air | 20.0 | Oxidising | 0.2 |
| Cu | 324.8 | $C_2H_2$ | Air | 15.0 | Oxidising | 0.7 |

metals were suitably diluted to match the concentrations of the sample solutions within the measurement sensitivity for the calibration purposes. All the metals were determined using the air-acetylene flames. Three replicates were used for each sample.

## Results and Discussion

In the inner zone the SPM level was found to be very high in sites I and II (Table 3). At these sites, the SPM level was 3 times higher than the standard levels. From-the emission inventory, it is evident that the high traffic density around the bus stand and railway junction, and coal emission were responsible for the high level of SPM. Besides, many commercial centres like hotels, lodges, etc. are located in these zones. Many automobile workshops located in these zones also contribute to stationary source

Table 3. Concentration of selected metals recorded using atomic absorption spectrophotometer

| Sampling site | Sampling duration (h) | Volume of air | SPM collected (µg/m$^3$) | Conc. of various metals (µg/m$^3$) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Fe | Zn | Cu | Mn | Pb |
| I | 8 | 240 | 1530.95 | 30 69 | 5 417 | 2 51 | 0.457 | 0.103 |
| | 24 | 720 | 240 3 | 9 933 | 2.055 | 1.2 | 0.15 | 0.05 |
| II | 8 | 240 | 1428 33 | 62 25 | 6.325 | 2 9 | 1 05 | 0 115 |
| | 24 | 720 | 1226.39 | 42 5 | 3 4733 | 1 78 | 0.733 | 0.103 |
| III | 8 | 240 | 84 82 | 14.857 | 3 904 | 1 643 | 0 2143 | 0 068 |
| | 24 | 720 | 285.92 | 16 866 | 3.691 | 1 36 | 0.222 | 0.067 |
| IV | 8 | 240 | 124.32 | 18.673 | 2 794 | 1.12 | 0.1576 | 0.0285 |
| | 24 | 720 | 73.543 | 8 807 | 1 842 | 0 9 | 0.1256 | 0.0358 |

emissions. In the outer zone, the general level of SPM was found to be low. When compared to the level of SPM in the 8 h sampling, the 24 h level was low. Also the level of SPM in the inner zone was found to be higher than the outer zone levels in both 8 and 24 h sampling. This can be correlated to the variations in the traffic density between peak and non peak hours. It indicates that traffic density significantly contributes to SPM levels. Comparison of these values with standards is given in Table 4.

The concentrations of the selected metals in the SPM have been found to be in the following order: Fe>Zn>Cu>Mn>Pb (Table 3). If recommended tolerance limits in air are taken as an index of toxicity of these metals, then the order of toxicity of these metals is

Table 4. Comparison of SPM concentration with standards

| Sampling sites | Area | SPM concentration ($\mu g/m^3$) Standard maximum limit | Concentration in Madurai city |
|---|---|---|---|
| I | Industrial area | 500 | 1530.95 |
| II | Traffic area | 500 | 1428.33 |
| III | Sensitive area | 100 | 84.82 |
| IV | Residential area | 200 | 124.32 |

Pb>Mn>Zn>Cu>Fe. It is a favourable conclusion to find that the metals like Fe, Zn and Cu which have significant presence in the SPM have comparatively low toxicity and the more toxic metals like Mn and Pb have comparatively low concentrations in the particulate matter. Except Pb all the others are naturally occurring metals We are inclined to believe that the origin of Zn, Fe and Pb is industrial emissions and anthropogenic activities. It is possible that the presence of Fe, Mn and Cu is due to earth crustal dust and that of Zn and Pb is due to the possible long range transport of pollutants in the form of fine dust from the industries in the 4th and 5th zones. Fe and Mn in SPM may owe their origin to both railway emissions and earth crustal dust.

All the above metals, except lead, generally form the bulk of the particulate fall out materials from various sources. The hazardous effects of these metals have been reported. All dusts have been found to affect the lungs of workmen exposed to them (Filipo, 1950). Siderosis and iron pigmentation which are of low order of severity and usually require 6 to 10 year of exposure before diagonsable changes occur have been reported (Sander, 1944). Chronic Mn poisoning is a clearly characterised disease which results from the inhalation of manganese oxide dusts (Luckey *et al*., 1975). In view of such health hazards associated with metals, the metal concentrations present in Madurai City assume significance.

## Acknowledgements

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# Physico-chemical Characteristics of a Stream Polluted by Effluents from the Railway Locoshed Area, Bhusawal

**S.M. Jawale, S.M. Choubey, R.T. Mahajan and A.G. Karnik**
P.G. Department of Zoology, M.J. College, Jalgaon 425002

## Abstract

Investigations were carried out during 1987-88 on the physico-chemical characteristics of a stream in to which the effluents from Bhusawal locoshed are released. The physico-chemical parameters, such as colour, odour, pH, hardness, chloride, sulphates, temperature, oxygen content and $CO_2$ content were analysed for samples drawn from four sites at monthly intervals. Analysis of these samples indicated that during a flow of water concentrations of abnormal constituents decreased with respect to the down stream. Static bioassay carried out with the effluent did not show any mortality in the fish *Lebistes reticulatus* (Peters). It may be stated that there is no serious water pollution problem in the stream due to the effluents from the locoshed area.

## Introduction

Bhusawal, one of the divisional stations of Central Railway having heavy railway traffic, is directly connected with all important places of India. Maintenance and repair of loco engines are done in the locoshed of Bhusawal railway divisions. The effluent and sewage water from this locoshed are disposed of into a stream which reaches the river Tapti. River Tapti is a main source of potable water supply to Bhusawal city and Maharashtra Industrial Development Corporation, Jalgaon area. It was suggested by the local municipal authority and the people of Bhusawal city to analyse the stream water to understand the extent of pollution due to the locoshed effluent and sewage. Hence this study was undertaken.

## Material and Methods

Three sampling stations were selected in the stream between the locoshed and the river Tapti. Station I was selected at the site of disposal of effluent. Station II at about 1.75 km downstream from Station I and Station III a few meters away from the place where the stream joins the river. Samples from the river and from a nearby pond were also taken for comparison.

All samples were collected at monthly intervals in Corning stoppered glass bottles. These bottles were brought to the laboratory for analysis of their physico-chemical characteristics like preliminary test-colour, appearance, temperature, pH, dissolved oxygen, carbon dioxide, hardness and sulphates (Anon, 1976; Michael,1986; Saxena, 1987; Trivedi *et al.*, 1988). A static bioassay study of samples from all the stations was conducted on the fish *Lebistes reticulatus* (Peters) (Trivedi *et al.*, 1988).

## Results

The results of analysis of the samples from different stations are given in Table I. Water sample from Station I was dark yellow and turbid. The colour of water sample became brighter in downstream. Water from the river Tapti was clear. The temperature of the flowing sewage water varied from 27°C at Station III to 36°C at Station I. The pH of

Table 1. Monthly record of certain physico-chemical characteristics of a stream and Tapti River.

| Month | Sample | Physical feature | pH | Temperature (°C) | Total hardness (ppm) | Dissolved $O_2$ (mg/l) | Free $CO_2$ (mg/l) | Sulphate $SO_4$ (mg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| August | Sample I | TPY | 8.92 | 36.1 | 570.16 | 3.07 | 6.82 | 534.95 | 124.07 |
| | Sample II | TPY | 8.50 | 34.0 | 530.00 | 4.21 | 5.39 | 485.57 | 98.19 |
| | Sample III | TLY | 7.90 | 31.1 | 310.01 | 4.15 | 4.01 | 362.12 | 86.85 |
| | Tapti water | Muddy | 7.80 | 29.1 | 122.15 | 5.41 | 3.91 | 247.00 | 58.00 |
| Sept. | Sample I | TPY | 8.91 | 35.2 | 590.19 | 3.13 | 6.61 | 547.29 | 124.78 |
| | Sample II | TPY | 8.45 | 35.1 | 510.00 | 4.15 | 5.95 | 477.34 | 97.13 |
| | Sample III | TPY | 7.75 | 33.2 | 290.00 | 4.30 | 5.12 | 374.46 | 87.20 |
| | Tapti water | Turbid | 7.61 | 28.2 | 128.20 | 5.91 | 3.81 | 238.60 | 56.00 |
| Oct. | Sample I | Yellow | 8.79 | 36.1 | 570.28 | 3.25 | 6.41 | 555.52 | 100.86 |
| | Sample II | PY | 8.42 | 33.0 | 500.00 | 4.26 | 5.07 | 489.68 | 98.90 |
| | Sample III | HY | 7.91 | 31.1 | 280.00 | 4.26 | 4.12 | 358.00 | 86.85 |
| | Tapti water | Faint T | 7.21 | 29.3 | 180.25 | 5.31 | 3.90 | 230.44 | 56.72 |
| Nov. | Sample I | Dark Y | 8.80 | 30.3 | 580.09 | 3.18 | 6.51 | 539.00 | 123.72 |
| | Sample II | PY | 8.53 | 28.2 | 520.09 | 4.17 | 5.15 | 497.91 | 97.49 |
| | Sample III | HY | 7.95 | 27.2 | 300.18 | 4.37 | 4.07 | 362.12 | 85.43 |
| | Tapti water | Clear | 7.35 | 27.5 | 156.88 | 6.18 | 4.18 | 246.90 | 57.50 |
| Dec. | Sample I | Dark Y | 8.91 | 32.5 | 560.67 | 3.19 | 6.26 | 551.41 | 124.42 |
| | Sample II | PY | 8.45 | 31.6 | 510.10 | 4.28 | 5.12 | 493.80 | 97.13 |
| | Sample III | HY | 7.81 | 28.2 | 310.60 | 4.51 | 4.37 | 370.35 | 86.14 |
| | Tapti water | Faint T | 7.61 | 26.1 | 140.26 | 6.09 | 3.90 | 251.00 | 56.56 |
| Jan. | Sample I | TDY | 8.90 | 36.1 | 580.87 | 2.91 | 6.81 | 555.52 | 124.07 |
| | Sample II | TPY | 8.62 | 34.5 | 530.00 | 4.09 | 5.35 | 497.91 | 97.48 |
| | Sample III | THY | 7.91 | 30.1 | 290.00 | 4.43 | 4.12 | 378.58 | 85.78 |
| | Tapti water | Faint Y | 7.81 | 28.2 | 144.33 | 5.84 | 3.71 | 245.00 | 55.90 |

(cont'd)

Table 1. (cont'd)

| Month | Sample | Physical feature | pH | Temperature (°C) | Total hardness (ppm) | Dissolved $O_2$ (mg/l) | Free $CO_2$ (mg/l) | Sulphate $SO_4$ (mg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Feb. | Sample I | TDY | 8.80 | 35.3 | 590.51 | 3.05 | 6.81 | 563.23 | 125.12 |
| | Sample II | PY | 8.28 | 32.6 | 540.71 | 4.08 | 5.32 | 480.32 | 98.19 |
| | Sample III | HY | 8.09 | 31.1 | 300.00 | 4.57 | 4.01 | 355.00 | 86.00 |
| | Tapti water | Faint Y | 8.44 | 29.1 | 150.67 | 6.08 | 4.20 | 250.00 | 54.00 |
| March | Sample I | Dark Y | 8.75 | 36.0 | 595.67 | 3.19 | 6.87 | 547.20 | 125.65 |
| | Sample II | PY | 8.38 | 32.7 | 520.01 | 4.11 | 5.42 | 490.50 | 97.31 |
| | Sample III | HY | 8.09 | 31.2 | 310.02 | 4.37 | 4.15 | 347.00 | 85.50 |
| | Tapti water | Clear | 8.45 | 31.1 | 138.87 | 5.71 | 3.85 | 235.00 | 52.00 |
| April | Sample I | Dark Y | 8.82 | 36.1 | 610.00 | 3.02 | 6.87 | 556.31 | 128.06 |
| | Sample II | HY | 8.51 | 34.5 | 500.00 | 3.92 | 5.19 | 416.81 | 99.36 |
| | Sample III | HY | 8.15 | 33.2 | 315.00 | 4.12 | 4.57 | 363.00 | 86.92 |
| | Tapti water | Clear | 8.41 | 31.3 | 220.11 | 5.17 | 3.30 | 245.00 | 53.00 |
| May | Sample I | Dark Y | 8.90 | 36.2 | 620.09 | 2.91 | 6.95 | 539.00 | 127.33 |
| | Sample II | HY | 8.31 | 35.6 | 520.06 | 4.09 | 5.21 | 510.12 | 97.22 |
| | Sample III | HY | 8.01 | 33.3 | 325.20 | 4.12 | 4.31 | 350.12 | 86.55 |
| | Tapti water | Clear | 8.35 | 32.3 | 140.55 | 5.37 | 3.50 | 249.50 | 54.00 |
| June | Sample I | TY | 8.50 | 35.2 | 600.20 | 3.01 | 6.70 | 515.92 | 126.00 |
| | Sample II | TY | 8.28 | 35.7 | 490.10 | 4.21 | 5.01 | 493.71 | 98.00 |
| | Sample III | PY | 7.91 | 32.5 | 290.90 | 4.31 | 4.15 | 345.51 | 87.32 |
| | Tapti water | Muddy T | 7.50 | 30.3 | 120.20 | 5.82 | 4.17 | 243.05 | 56.00 |
| July | Sample I | TY | 8.37 | 34.3 | 590.30 | 3.20 | 6.01 | 507.29 | 123.62 |
| | Sample II | TPY | 8.15 | 32.2 | 470.00 | 4.09 | 5.21 | 476.33 | 96.57 |
| | Sample III | TPY | 7.81 | 30.2 | 280.20 | 4.25 | 4.09 | 343.24 | 86.70 |
| | Tapti water | Muddy | 7.60 | 29.7 | 125.20 | 5.60 | 3.91 | 240.07 | 43.50 |

TPY: Turbid Pale Yellow. PY: Pale Yellow. HY: Higher Yellow.

water from station I was alkaline (8.9), decreased from Station II (8.5) to Station III (7.9). In river Tapti it varied from 7.4 to 8.5. The dissolved oxygen range in the river Tapti was from 5.1 to 6.1 mg/l. Free carbondioxide in sample I was 6.9mg/l but it decreased as the water flowed and reached a minimum of 4.2 mg/l in the river. The chloride content of different water samples collected showed a decreasing concentration from Station I to Station III. The total hardness of sample which was 620 ppm from Station I decreased in Station II and III. In the river it fluctuated between 120 and 220 ppm. The sulphate content of different water samples showed a decreasing trend from Station I to Station III.

No mortality was observed in the fish *L. reticulatus* tested with all samples.

## Discussion

In the case of pollution by acidic and alkaline wastes, pH serves as an indicator to determine the level of pollution. The major constituents of the effluent from the railway locoshed Bhusawal are detergent, mineral oil, grease, etc. Therefore, it is alkaline in nature. The pH of the stream which carries the effluent from locoshed to the Tapti river declined from alkaline to neutral (pH 8.9 to 7.1). The decreasing temperature gradient and the increase in oxygen content from Station I to III may be responsible for the reduction in pH. Similar correlation of temperature and pH was established by Saxena *et al.* (1988). An increase in dissolved $O_2$ from sample I to III may be due to settling physical diffusion of air in water and also due to microflora present in the stream (Singh and Singh, 1988). The decrease in concentration of chloride and sulphate from Station I to III explains the increase in concentration of dissolved oxygen from sample I to sample III (Saxena, 1987).

Calcium is an important contributor to hardness of water. In the present study, the total hardness decreased with the flow of water and in the river water sample, it ranged between 120 and 220 ppm. Similar observations were made by Trivedi *et al.* (1989) in sewage water in different canals of Patna within a period of one year. In neutral freshwater, high concentration of chloride is considered to be an indicator of pollution due to organic waste of animal origin. Domestic sewage and industrial effluent may add to sulphate content of water (Saxena, 1987). Analysis of different water samples revealed that in Station I the constituents studied were higher in concentration but as they flowed downstream the concentration of these substances decreased.

Toxicity of any water pollutant may be evaluated on the basis of mortality in the fishes in the polluted water (Jhingran, 1983). In the present study no morality was observed in the fish *L. reticulatus* 96 h after exposure.

The analytical data of the river water indicated that there is no serious pollution in the river Tapti due to the effluent from railway locoshed area, Bhuswal

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# Studies on Some Chemical and Biological Properties of Krishna River Water and Polluted Water

**K.M. Harinikumar, V.P. Savalgi and Veena Savalgi**
Department of Microbiology, College of Agriculture, Raichur 584101

## Abstract

The chemical and biological properties of Krishna river water from various utility points were assessed. The pH of samples from different points varied from 1.9 to 8.7 and it was negatively correlated with electrical conductivity. The acidic pH of petrochemical effluent reduced saprophytic population. Turbidity of oil industrial effluent was higher than other water resources. The highest chlorine content was observed in petrochemical effluent. Microbial population was higher in sewage water than petrochemical effluent. The microbial population, in general, was influenced by the chemical properties of water. In sewage samples, microbial population decreased after aerial oxidation. Thus, properly treated effluent water can be used for irrigation purpose to grow different crop plants.

## Introduction

Many industries using large quantities of processed water are faced with the problem of waste water disposal. The use of such waste water on land for irrigation is considered to be an alternative to disposal by let-off into river systems. Sewage farming is practiced in Karnataka State by using mostly raw sewage and sometimes partially treated sewage. In selecting crops for sewage farms, the major consideration should be public health. As most of the sewage farms are using untreated raw or settled sewage, there is a danger to public health due to consumption of sewage grown uncooked plant products (Diwakar Rao, 1986). The present investigation was undertaken in Raichur, Karnataka, to know the changes in some chemical and biological properties of water samples collected from Krishna river base onwards at different drinking water processing and industrial disposal points, and their effect on germination of groundnut seeds.

## Material and Methods

*Collection of water samples*

One of the sources of water to Raichur city is Krishna river. The river water is lifted to a sedimentation tank, treated with alum followed by filtration and chlorination. The treated water is supplied for both domestic and industrial purposes. The water samples from different points (Table 1) were collected in standard sterilized bottles kept in an ice box. To compare the overall effect of pollution, another sample of borewell water was collected.

*Chemical analysis of water*

The hydrogen ion concentration, electrical conductivity, turbidity, total solids, alkalinity, chlorine content and salinity of collected water samples were analysed as per the procedures outlined by Saxena (1987), Jackson (1958) and Black (1965).

*Estimation of biological parameters*

As the biological parameters are one of the indicators of water pollution, the bacterial, fungal and *Escherichia coli* populations were estimated (Collins and Lyne, 1984).

*Seed germination test*

Groundnut (*Arachis hypogaea* cv. KRG 1) seeds were surface sterilised with 0.1% mercuric chloride and washed thrice with sterilized water. These seeds were placed in sterilized petri- plates containing filter paper. The water samples were added to each of these plates with three replications and incubated for 48 h. The per cent germination was calculated.

## Results

The water samples collected from different sampling points were analysed to know the changes occurring in the flow of water due to domestic and industrial use.

*Chemical changes*

Hydrogen ion concentration, electrical conductivity and turbidity of different water samples are presented in Table 1. The pH of samples varied from 1.9 to 8.7. The lowest pH (1.9) was observed in the petrochemical industries effluent before treatment followed by after (3.1) treatment. The variation in the remaining samples was minimum. The electrical conductivity was measured to know the load of electrolytes. The petrochemical effluent contained more electrolytes before treatment (18.50 m mhos/cm) followed by after treatment (9.43 m mhos/cm). The lowest was observed in samples collected from oil industries before treatment. The turbidity of water samples was expressed in terms of per cent transmittance. High transmittance or low turbidity was observed in borewell water followed by samples collected after filtration. The turbidity was high in oil industry effluent and sewage water.

The total solids, chlorine content, alkalinity and salinity of different water samples are given in Table 2. Total solids includes both dissolved and suspended particles in water samples. Higher total solids were observed in the samples collected from petrochemical industries before treatment (7.82 g/l) followed by after treatment (2.77 g/l). The lowest solids were observed in water samples collected after chlorination (0.10 g/l). In sewage total solids (2.40 g/l) were reduced after oxidation (1.57 g/l). The highest alkalinity was observed in sewage oxidation pond (24.01 mg/l) followed by sewage effluent at field (16.83 mg/l). The lowest was observed in petrochemical effluents (0.02 mg/l). The chlorine content was maximum in effluent collected from petrochemical industry before treatment (5106.18 mg/l) followed by treated effluent (3515.23 mg/l) The chlorine content increased significantly in sewage effluent (364.92 mg/l) compared to drinking water. The chlorine content of the remaining water samples did not show significant differences. The same trend was observed in salinity of water samples.

*Microbiological parameters*

The quality of drinking and irrigation water is dependent on the type and quantity of microbial load. Hence, the populations of bacteria, fungi and *E. coli* were estimated. The bacterial, fungal and *E. coli* populations in waters collected from different points are presented in Table 3. The bacterial population was maximum in sewage effluent (14.46 x $10^5$/ml) followed by sewage oxidation pond. There was no bacterial growth in petrochemical effluent. In general, medium bacterial population was observed in drinking water and reduced bacterial population was observed in oil industry effluent. The same trend was observed in the case of fungal population. The maximum population of *E. coli* was observed in raw sewage (2363.33 x $10^3$/ml). *E. coli* population was absent in petrochemical effluent. In remaining samples, *E. coli* population did not show significant differences.

Table 1. pH, electrical conductivity and turbidity of water collected from different points.

| Sampling point | pH | E.C. (m mhos/cm) | Turbidity (% transmittance) |
|---|---|---|---|
| River bed | 8.40b+ | 9.92de | 92.66 (74.32)c* |
| Sedimentation tank | 8.70 a | 1.00de | 95.00 (77.12)b |
| Alum treated plant | 8.40 b | 0.97de | 92.66 (74.30)c |
| Filtration tank | 8.50 b | 1.00de | 96.66 (79.50)a |
| After chlorination | 8.40 b | 1.00de | 93.00 (74.68)c |
| Petrochemical effluent before treatment | 1.90 i | 18.50a | 62.00 (51.94)g |
| Petrochemical effluent after treatment | 3.10h | 9.43b | 77.00 (61.35)d |
| Oil industry effluent before treatment | 7.43f | 0.80e | 15.00 (22.78)i |
| Oil industry effluent after treatment | 8.10c | 1.60c | 92.00 (73.50)c |
| Sewage | 7.10g | 1.50c | 54.00 (47.29)h |
| Sewage oxidation pond | 8.07c | 1.47c | 68.00 (55.55)i |
| Sewage field | 7.97d | 1.10d | 72.00 (58.05)e |
| Borewell water | 7.80e | 1.70c | 97.00 (80.12)a |

+ Means followed by the same letter in a column are not significantly different.
* Figures in parentheses are arcsin transformed values.

Table 2. Total solids, alkanity, chlorine content and salinity of water collected from different points.

| Sampling points | Total solids (g/l) | Alkalinity (mg/l) | Chlorine content (mg/l) | Salinity (g/l) |
|---|---|---|---|---|
| River bed | 1.20f+ | 11.37g | 245.57de | 458.56ef |
| Sedimentation tank | 0.52i | 12.41f | 316.27d | 574.34d |
| Alum treated plant | 0.54j | 15.66e | 242.20de | 435.08ef |
| Filtration tank | 0.35k | 11.25g | 235.07de | 422.70f |
| After chlorination | 0.10l | 10.60h | 79.33e | 140.43h |
| Petrochemical effluent before treatment | 7.82a | 0.02i | 5106.18a | 6300.00b |
| Petrochemical effluent after treatment | 2.77b | 0.02i | 3515.23b | 9500.00a |
| Oil industry effluent before treatment | 1.92d | 12.41f | 259.13de | 472.20e |
| Oil industry effluent after treatment | 1.02g | 12.40f | 137.67de | 266.49g |
| Sewage | 2.40c | 16.23d | 364.92c | 663.80c |
| Sewage oxidation pond | 1.57e | 24.01a | 317.70d | 575.01d |
| Sewage field | 0.82h | 16.83b | 303.64d | 555.14d |
| Borewell water | 0.60i | 16.61c | 245.40de | 447.43ef |

+ Means followed by the same letter in a column are not significantly different.

Table 3. Bacterial, fungal and *E. coli* populations in water collected from different points.

| Sampling point | Bacterial population (x $10^5$/ml) | Fungal population (x $10^3$/ml) | *E. coli* population (x $10^3$/ml) |
|---|---|---|---|
| River bed | 2.08g+ | 23.33f | 12.67c |
| Sedimentation tank | 3.74de | 45.00f | 33.33c |
| Alum treated plant | 3.36f | 23.33f | 70.00c |
| Filtration tank | 3.60ef | 35.00f | 43.33c |
| After chlorination | 3.95d | 125.33de | 3.00c |
| Petrochemical effluent before treatment | 0.00j | 2.00f | 0.00c |
| Petrochemical effluent after treatment | 1.72h | 22.28f | 1.67c |
| Oil industry effluent before treatment | 1.52h | 64.67ef | 10.00c |
| Oil industry effluent after treatment | 1.14i | 176.67d | 326.67c |
| Sewage | 14.46a | 1430.00a | 2363.33a |
| Sewage oxidation pond | 12.88b | 1293.33b | 1710.00b |
| Sewage field | 11.06c | 246.67c | 1433.33b |
| Borewell water | 3.95d | 56.67f | 50.33c |

+ Means followed by the same letter in a column are not significantly different

The effect of natural waters and effluent on germination of groundnut seeds showed that more seeds germinated in water collected from river followed by oil industry effluent. Inhibitory effect was observed in the case of petrochemical effluent whereas the remaining samples favoured germination.

## Discussion

The physico-chemical properties of water influence its quality and microbial activity. In our analysis, the lowest pH was observed in effluents of petrochemical industry, probably due to the presence of acids. The pH range of remaining samples varied from 7.1 to 8.7. The pH of natural water varied around 7, generally over 7, i.e. alkaline due to the presence of considerable quantity of carbonates (Dewis and Freitas, 1970). Pure water is a poor conductor of electricity. Acids, bases and salts in water make it a good conductor of electricity. Water with upto 20 m mhos/cm conductance is considered to be suitable for irrigation. Although the highest conductance observed in the petrochemical effluent was less than this limit, it is not possible to conclude that the effluent is good for irrigation considering conductance alone. Turbidity is due to the presence of suspended particles like clay, salt, organic matter, phytoplankton and other insoluble pollutants. The higher turbidity observed in the case of untreated oil refinery effluent may be due to the presence of suspended oilseed coat, seed particles, fungal growth and organic matter.

The highest quantity of total solids was observed in petrochemical effluent which may be due to higher chloride content. The effluent of oil industry and raw sewage contained high amounts of total solids which are more than the pollution control standards. The highest alkalinity was observed in samples collected from sewage oxidation pond followed by treated sewage. Since alkalinity is an indirect parameter to know the photosynthetic activity in water, the high alkalinity may be due to the presence of rich phytoplankton. The lowest or no phytoplankton activity observed in petrochemical effluent may be due to the high acidity of water.

Inland natural water, in general, has low chlorine concentration. Industrial effluents may increase the chlorine content in natural waters. The highest chlorine content observed in petrochemical effluents may be due to the presence of some chlorinated acids. It was more than the pollution control standard (600 mg/l) and such high chlorine content can affect both soil and plants. As the chlorine content in the remaining water samples was less than 600 mg/l, it is safe for irrigation purposes. The same trend was observed in salinity also.

The biological parameters also influence the quality of water. The highest bacterial population observed in sewage may be due to the presence of organic matter (Clark *et al.*, 1982). The absence of bacterial population in petrochemical effluent could be due to its acidity. The same trend was observed in the population of fungi except that there were some acid tolerant fungi growing in petrochemical effluent. The population of *E. coli*, an indicator organism for fecal contamination, was maximum in sewage effluents. The differences in *E. coli* population in the remaining samples were found to be not significant and their load was also less than the pollution control standard.

The studies on germination of groundnut seeds showed that river water, sewage water and treated oil refinery were good for crop growth. They enhanced seed germination but it was hindered by the effluent of petrochemical industries. It may be due to the high acidity and chlorine content of effluents.


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# Increased Level of Trace Metals in Pazhancauvery River Water due to Domestic Sewage Pollution

**S. Mani*, S. Swetharanyam* and S. Devi Swetharanyam****

*Department of Zoology, A.V.C. College, Mannampandal 609305, Mayiladuthurai

**Department of Zoology, D.G.G. Government Arts College for Women, Mayiladuthurai 609001

## Abstract

Water samples were collected from two different rivers, namely Pazhancauvery and Cauvery. The levels of copper, zinc, iron and manganese were determined at three different sits of each river. Concentration of all the four metals was comparatively higher in Pazhancauvery water samples than in Cauvery water samples. The Pazhancauvery channel runs through the main streets of Mayiladuthurai. Domestic sewage from different regions is allowed to enter and mix with the channel water. Besides this, oil, grease, waste pieces of wood and steel also find their way into Pazhancauvery from different areas of Mayiladuthurai. However, Cauvery river water was comparatively free from domestic sewage pollution as the river runs at some distance from the town area and domestic sewage does not enter the river.

## Introduction

River ecosystem, being shallow but with various enrichment processes, maintains unique environmental and hydrobiological features which results in the occurrence of typical fauna and flora in them. The trace elements and their interactions with one another form an important aspect of the eco-system of fresh water habitat. The importance of trace elements of freshwaters has received greater attention in recent years. Studies of trace metals were made by Goldman and Charles (1964) in Newzealand lakes. Metal concentration in sediments of freshwater environments of South and West Australia, East and South Africa, and West Asia was studied by Forstner (1977). The introduction of trace metals into water by anthropogenic activities was well discussed by Lipmann and Schlosinger (1979) and Lyons *et al.* (1983). In this paper, we present the results of comparative study of trace elements in the waters of Cauvery and Pazhancauvery rivers in Mayiladuthurai area.

## Material and Methods

The amounts of iron, copper, manganese and zinc in the water samples were estimated by using atomic absorption spectrophotometer (Model SP 191) available at the Soil Testing Laboratory, Aduthurai. Samples of 50 ml were taken and to each sample 50 ml 1N ammonium acetate was added, shaken well for an hour and filtered. The atomic absorption spectrophotometer was set in the AAS mode and was standardised by using two working standards, the first with the highest element concentration and the second with exactly half of the first concentration. Individual standardisation was carried out for each element. Then the element concentration of the sample was directly read by using appropriate hollow cathode lamp.

## Results and Discussion

The concentration of the trace metals iron, zinc, manganese and copper in both Pazhancauvery and Cauvery waters is given in Table 1.

Table 1. Trace metal contents of Pazhancauvery and Cauvery waters.

| Sample No. | Iron (ppm) | Zinc (ppm) | Manganese (ppm) | Copper (ppm) |
|---|---|---|---|---|
| | | Pazhancauvery water | | |
| 1 | 0.62 | 0.10 | 0.68 | 0.55 |
| 2 | 0.68 | 0.11 | 0.70 | 0.58 |
| 3 | 0.70 | 0.09 | 0.72 | 0.60 |
| | | Cauvery water | | |
| 1 | 0.40 | 0.06 | 0.50 | 0.51 |
| 2 | 0.44 | 0.06 | 0.52 | 0.52 |
| 3 | 0.48 | 0.07 | 0.48 | 0.54 |

Higher concentration of iron ranging from 0.62 to 0.70 ppm was observed in the water of Pazhancauvery than that of Cauvery. The concentrations of copper and manganese in the Pazhancauvery water ranged from 0.55 to 0.60 and 0.68 to 0.72 ppm, respectively. The concentration of zinc of Pazhancauvery water ranged from 0.09 to 0.11 ppm which was higher than that of Cauvery water. It is suggestive that drainage of sewage waters and soil leaching might have increased the levels of these elements in Pazhancauvery water. Jackson (1979) has also reported the leaching of trace metals into the lake-river system, Ontario, Canada, from scattered sources of the surroundings. Domestic sewage has been reported to enhance the concentration of trace metals, particularly zinc (Lyons *et al.*, 1983).

The concentrations of iron, zinc, manganese and copper in the water of Pazhancauvery were observed to be higher than that of Cauvery water. The levels of these trace metals in Pazhancauvery water were found to be influenced by the input of domestic sewages and flushing of water carrying these chemicals into the channel by anthropogenic activities.

## Acknowledgements

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# Distribution of Cu, Zn, Fe and Mn in the Sediments at Poompuhar (South East India)

**S. Mani[1], S. Swetharanyam[1], G.V. Gopinath[2], PR. Nagappan[2], G. Sivagurunathan[1], J. Tagore[3] and R. Kasinathan[3]**

[1]Department of Zoology, A.V.C. College, Mannampandal 609305
[2]Department of Zoology, Annamalai University, Annamalainagar 608002
[3]C.A.S. in Marine Biology, Porto Novo 608502

## Abstract

Levels of Cu, Zn, Fe and Mn were determined in the sediments at Poompuhar coast for a period of one year. Among the four metals studied, distribution of iron was found to be more and this was followed by zinc, copper and manganese. Concentrations of all the four metals were more pronounced during monsoon season.

## Introduction

Coastal contamination of heavy metals is being keenly observed in the recent years. The role of river in transporting material from continents to ocean is obvious. They carry metal in solution (Gibbs, 1973) which accumulate in the marine environment. These toxic metals get accumulated in the tissues of benthos which would consequently affect the benthic production. Studies on the distribution of trace elements have been carried out earlier by a number of workers (Murty *et al.*, 1978; Remani *et al.*, 1980; Venugopal *et al.*, 1982; Narayanan *et al.*, 1988 and Stella *et al.*, 1988) but such an effort in this area has not been made earlier and hence this study was carried out in the marine environs of Poompuhar.

## Material and Methods

Sediment samples were collected along the Poompuhar coast with a van veen grab for one year at monthly intervals. The samples were oven dried, homogenized and digested in a mixture of perchloric acid and nitric acid (Lithnor, 1975) followed by 0.5 ml of concentrated HCl. The solution was made upto 25 ml with ion free water. The metal concentrations were estimated using a Varan Atomic Absorption Spectrophotometer (Model 1100).

## Results and Discussion

Seasonal variations in the concentration of Cu, Zn, Fe and Mn (Table 1) showed that the concentration of copper varied from 43.0 to 140.0 µg, zinc varied from 40.0 to 502.0 µg, iron varied from 102.5 to 840.0 µg and manganese varied from 30.0 to 42.0 µg. Concentrations of all the four metals were found to be high during monsoon which was due to the inflow of river Cauvery which brings in lot of agricultural and terrigenus waste materials. Similar results were already reported by Narayanan *et al.* (1988) and Gopinath (1989). Lowest concentration of copper was found during premonsoon, zinc during summer and pre- monsoon, iron and manganese during pre-monsoon periods and this was due to reduced inflow of fresh water. Venugopal *et al.* (1982) have observed least concentrations of Cu, Zn and Fe during summer season and Gopinath (1989) has reported lowest levels of Mn and Zn during pre-monsoon and Cu during summer season.

Table 1. Seasonal variation in the concentrations of Cu, Zn, Fe and Mn at Poompuhar coast.

| Season | Month | Metal concentration (μg/g dry wt) | | | |
|---|---|---|---|---|---|
| | | Cu | Zn | Fe | Mn |
| Post-monsoon | Jan | 60.5 | 332.5 | 143.5 | 42.0 |
| | Feb | 60.0 | 69.0 | 129.0 | 30.0 |
| | Mar | 52.0 | 321.5 | 356.0 | 33.0 |
| Summer | Apr | 47.5 | 40.0 | 108.5 | 28.5 |
| | May | 46.5 | 136.5 | 141.5 | 31.0 |
| | Jun | 45.0 | 102.5 | 221.0 | 30.0 |
| Pre-monsoon | Jul | 45.0 | 84.0 | 127.5 | 31.0 |
| | Aug | 43.5 | 40.0 | 120.0 | 30.0 |
| | Sep | 43.0 | 56.0 | 102.5 | 30.0 |
| Monsoon | Oct | 78.0 | 175.0 | 532.0 | 35.0 |
| | Nov | 140.0 | 502.0 | 840.0 | 36.0 |
| | Dec | 90.5 | 260.5 | 443.5 | 38.0 |

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# Studies on the Metal Concentrations in Cauvery River and Poomphuhar Sea Coast, Tamil Nadu.

**M. Ayyavoo**

Department of Biology, 58, Bharathidasan Nagar, Muthaliar Pettai,
Pondicherry University, Pondicherry 605004.

## Abstract

The present paper deals with the concentration of metals, such as Fe, Zn, Cu and Mn from the water, soil and a crab of Poomphuhar sea coast and its sources from the Cauvery river system. The concentration of metals in the soil samples of sea coast was higher during monsoon. Fe and Zn were found in higher levels in river soil than in river mouth soil. The riverine water showed lower concentrations of all metals than sea water.

## Introduction

Metals are added to sea water through coastal supply by river and coastal erosion, deep sea supply from underwater valcanoes and release from bottom sediments by chemical processes, and transport through air. Metals exhibit a dynamic role in the living system. Data on concentration of Zn, Cu, Mn and Fe are scarce, especially from Indian coastal waters (Sarma *et al.*, 1968 ). Murthy and Veerayya (1981) investigated the trace elements in Vembanad Lake and adjoining river system of Kerala State. In normal life, heavy metals are a part of the dietary requirements of marine organisms. Trace metal composition in the edible crab *Scylla serrata* (Prasad and Neelakandan, 1987) and induction of metallothionein synthesis in the hepatopancreas of the same crab (Olafson *et al.*, 1979) indicated their involvement in the crustacean physiology. Marine and estuarine shell fish, particularly crustaceans consumed as food by human beings, are known to concentrate high levels of trace metals, both in natural and man impacted environments (Eisler, 1981). Protection and conservation of water resources imply the maintenance of natural flora and fauna in their dynamic balance. The present paper deals with concentrations of metals, such as Fe, Zn, Cu and Mn from the water, soil and a crab of Poomphuhar sea coast and its sources from the Cauvery river system.

## Material and Methods

The samples of surface sea water were digested with 1 ml of conc. $H_2SO_4$ and 5 ml of $HNO_3$. The digested sea water was directly used for estimation of trace metals (Vasanti *et al.*, 1981).

Soil samples of both river and sea were dried at 105 °C to constant weight. The dried solids were powdered fine using an agate mortar and mixed thoroughly. One g of the sample was weighed and transferred to a platinum disc. The samples were oxidised using nitric acid, perchloric acid and hydrofluoric acid (Jackson, 1965) and the residue dissolved in dilute hydrochloric acid and made upto 100 ml.

The fresh tissues of the crab, *Charybdis lucifera*, such as gonad, muscle and hepatopancreas were dissected out and digested with 5 ml of triacid mixture ($HNO_3$: $H_2SO_4$ : $HClO_4$ - 6:1:1) (Vasanti *et al.*, 1981).

Metal analysis of all the samples was done by using the atomic absorption spectrophotometer (Sp-190).

Table 1. Concentrations of trace elements (ppm) in the sea soil of Poompuhar coast

| Distance | Tide | Monsoon period (Sept. to Dec.) | | | | Pre-monsoon period (May to August) | | | | Post-monsoon period (Jan. to April) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu |
| – | Low | 8.60 | 2.48 | 3.04 | 1.80 | 8.46 | 2.22 | 2.96 | 1.70 | 7.96 | 2.01 | 2.21 | 1.50 |
| – | High | 8.76 | 1.22 | 1.96 | 1.60 | 7.46 | 1.12 | 1.64 | 1.27 | 6.26 | 1.02 | 1.54 | 1.23 |
| 100 feet away from the sea-water level | — | 4.10 | 1.18 | 2.50 | 1.50 | 5.02 | 1.78 | 2.75 | 1.60 | 5.24 | 1.92 | 2.92 | 1.80 |
| 50 feet away from the land surface | — | 3.94 | 1.16 | 0.68 | 1.56 | 4.01 | 1.48 | 0.82 | 1.62 | 4.14 | 1.56 | 0.95 | 1.72 |

Table 2. Concentration of trace elements (ppm) in the river soil of Cauvery.

| Area | Monsoon period (Sept. to Dec.) | | | | Pre-monsoon period (May to August) | | | | Post-monsoon period (Jan. to April) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu |
| Rivermouth soil | 6.72 | 1.56 | 3.02 | 1.72 | 5.26 | 1.47 | 2.92 | 1.65 | 4.56 | 1.34 | 2.13 | 1.60 |
| Rivr soil | 6.79 | 1.61 | 2.64 | 1.65 | 6.54 | 1.51 | 2.45 | 1.52 | 6.25 | 1.42 | 2.12 | 1.37 |

Table 3. Concentrations of trace elements (ppm) in the aquatic system of Cauvery and Poompuhar coast

| Area | Monsoon period (Sept. to Dec.) | | | | Pre-monsoon period (May to August) | | | | Post-monsoon period (Jan. to April) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu | Fe | Zn | Mn | Cu |
| Sea-water | 3.63 | 1.24 | 0.79 | 0.43 | 3.78 | 1.35 | 0.82 | 0.67 | 3.92 | 1.52 | 0.98 | 0.84 |
| Rivermouth water | 1.94 | 0.14 | 0.42 | 0.39 | 1.82 | 1.03 | 0.32 | 0.27 | 1.67 | 0.11 | 0.24 | 0.22 |
| River water | 0.63 | 0.22 | 0.21 | 0.32 | 0.58 | 0.11 | 0.19 | 0.29 | 0.54 | 0.10 | 0.17 | 0.27 |

Table 4. Metal composition (ppm) in different tissues of the crab *C. lucifera*

| Metal | Tissue | | |
|---|---|---|---|
| | Thoracic muscle | Hepatopancreas | Gonads |
| Copper | 1.50 | 1.26 | 0.87 |
| Zinc | 2.12 | 1.42 | 2.30 |
| Manganese | 0.34 | 0.41 | 0.53 |
| Iron | 2.42 | 1.78 | 2.60 |

## Results and Discussion

The concentrations of Zn, Mn and Cu in the soil samples of the Poomphuhar sea coast showed higher concentration during monsoon period under low tide conditions (Table 1) since during monsoon there is greater resuspension of sediments in sea water due to turbulance and run off from shore, in addition to the dilution of suspended material. A similar increasing trend in concentrations of trace metals during monsoon has been observed earlier (Vasanti *et al.*, 1981). During this period, the tidal currents slow down as a result of the land areas projecting into the sea area thus causing higher concentrations of trace elements (Pillai *et al.*, 1975). Soil samples of the area 50 ft away from the land surface showed a decreasing trend in concentrations of all the 4 metals (Table 1). This change in the concentration of metals may probably be due to the dilution of the sea periodically which in turn acts as a causating factor (Vasanthi *et al.*, 1981).

The concentrations of Fe and Zn in the river soil were of higher magnitude in all the 3 periods (Table 2). This could be due to the fact that the river all along its course receives various discharges from different industries in the form of effluents which contribute to the trace elements in the riverine ecosystem. But at the same time, the present study elucidated the fact that the riverine water had remarkably lower concentrations of all metals (Table 3). This could be due to the possible run off of water and bioutilization of metals (Armugam and Ravindranath, 1983) and the process of dilution all along the course of flow (Engel and Brouwer, 1974).

The present investigation made a clear distinction between the sea water and riverine water based on their metal concentrations (Table 3). For instance, the sea water had a higher range of concentrations of all the 4 metals. In the sea water, the possibility of absorption and retention of metal ions is always greater than that of the river water.

The metal composition (Table 4) in different tissues, such as thoracic muscle, hepatopancreas and gonads of *C. lucifera* did not show a clearcut trend. The extent of occurrence or accumulation of trace metals by the crab *C.lucifera* in different tissues is dependent upon the route of entry, i.e. either from surrounding medium or in the form of food and chemical material available in the media (Engel and Brouwer, 1894). The study can serve as a baseline information for further experimentation on bioaccumulation by the crab.

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# Toxicity of Waste Water of Paper and Pulp Mills to Rat Red Blood Cell Hemolysis

**Indu Shekhar Thakur and Shivakar Mishra**

Department of Environmental Sciences, College of Basic Science & Humanities, G.B.Pant University of Agriculture & Technology, Pantnagar 263145.

## Abstract

The toxicity of waste water effluent from paper and pulp mills has been assessed by *in vitro* estimation of the percentage hemolysis. The studies were performed in healthy mature rats receiving liquid effluents every day, injected intraperitoneally. The change in red blood cell hemolysis was assessed after 4, 9 and 15 days. The results of this study indicated that the percentage increase in hemolysis was in accordance with the concentration of effluent used. Further, maximum increase in hemolytic activity was observed at 12 min in all the blood samples from rats exposed to the effluent for 4, 9 and 15 days.

## Introduction

Paper and pulp mill industry is one of the oldest industries in India. These paper mills adopt different pulping processes (Saxena, 1978). The important chemicals used by most of the paper and pulp mills are sodium sulphate, sodium hydroxide, sodium sulphide, sodium carbonate, calcium hypochloride and magnesium bisulphate (Saxena *et al.* 1978). Among the different types of pulping process, the sulphite mill wastes are the strongest and soda process waste is the weakest (Reddy and Venkateshwarlu, 1985). The combined waste water from an integrated pulp and paper mill has high pH, BOD, suspended solid, COD, dissolved oxygen and lignin. These contribute significantly to the deterioration of water quality and are causes of toxicity (Reddy and Venkateswarlu, 1985; Gosh and Konar, 1980). Various treatment or monitoring devices have been used to reduce the pollution load of these industries (Leech and Thakore, 1970). But so far no satisfactory methods have been developed. There are reports of identification of chemical constituents of paper and pulp mill effluents that produce toxicity to worms, planktons and molluscs (Gosh and Konar, 1980; Leech and Thakore, 1970). The Century Paper and Pulp Mills Ltd., Ghanshyamdham, is situated at the foothill of Kumaun region of Himalayas. The air pollutants and liquid effluents of this industry have produced tremendous impact on the vast vegetation of this region. There are general observations in this region that the pollutants released by these industry produced vomiting tendency, itching in eyes, skin diseases and other symptoms in human beings and animals. But reports of toxicity produced by these effluents in animal system at cellular and genetic level are negligible.

Hemolysis of red blood cells provides a simple and rapid way of studying the effects of pollutants on biological membranes (Harington *et al.*, 1971). Numerous investigations have considered membrane model a measure of a pollutant's cytotoxicity (Allison *et al.*, 1966). The red blood cell membrane hemolysis has proved to be a simple and rapid way of attempting to find the possible correlation between cytotoxicity and hemolytic activity (Macnab and Harington, 1967). The interest of the present investigation was to analyse the physicochemical characteristics of liquid effluents of Century Paper and Pulp Mills Ltd., Ghanshyamdham, Lalkuan District, Nainital, and to evaluate its toxicity by red blood cell hemolysis in rat.

## Material and Methods

The composite effluent of paper and pulp mills was obtained after adopting pulping processing and suitable treatment prior to their discharge into the river. The colour, pH, dissolved oxygen, COD, and BOD were determined (Anon., 1975). The effluent was concentrated by evaporating the water and converted into solid form.

Male and female albino rats of Wistar strain weighing 190-200 g were maintained in groups of four in cages containing rice husk padding. The animals were fed with standard food and water was given *ad libitum*. One mg/ml effluent was injected intraperitoneally in three sets of animals and 1 ml veronal buffer (0.2 M, pH 7.2) was injected in the fourth set. After 4, 9 and 15 days blood was collected by cardiac puncture from anaesthesized rat in a syringe treatment with citrate saline.

The blood was washed three times in normal saline and a suspension of RBC was made in saline to a concentration of 1%. Aliquots of 1 ml of the RBC suspensions (1%) were mixed with 1ml veronal buffer (0.2 M, pH 7.2) and incubated with different concentrations of liquid effluent at 37°C for 40 min by occasional gentle agitation. The positive control consisted of 1 ml of 0.2% Triton x 100 to make 100 per cent hemolysis (Jaurand *et al.*, 1980). The reaction was terminated by 0.5 ml of 2.5 % gluteraldehyde solution made in cacodylate buffer (0.05 M, pH 7.2). These solutions were centrifuged at 1500 rpm for 10 min to allow broken membranes and unbroken cells to settle at the bottom. Absorbance of the supernatant containing released hemoglobulin was taken at 540 nm. The average O.D. of three replicates served to determine percent hemolysis.

Aliquots of 1 ml of RBC suspensions (1%) and 1 ml veronal buffer (0.2 M, pH 7.2) were incubated with 1 mg/ml liquid effluents for different time intervals at 37°C with occasional shaking. The reaction was terminated and absorbance was taken as described earlier.

## Results

*Physicochemical characterization*

The effluent of paper and pulp mills was obtained by pooling together the waste water from digestor house, pulp washing, pulp bleaching, chemical recovery, boiler blowdown, recaustizer and lime mud unit. The combined waste water effluent was dark brown in colour and its pH was 7.7. The dissolved oxygen, BOD and COD of the combined effluent were found to be 5 mg/l, 1140 mg/l and 3290 mg/l, respectively.

*Hemolytic activity of effluent*

*Dose dependent hemolytic activity :*

The dose dependent hemolytic activity of paper and pulp mill effluent is presented in Fig.1. The release of hemoglobin after the injection of liquid effluent into the rats indicated the percent hemolysis in accordance with the effluent concentration. Results showed that in the four sets of animals, hemolytic activity was maximum in 15 days followed by 9, 4 and 0 days. The rats that received effluent for 15 days showed 74% hemolysis after incubation with 2 mg/ml effluent whereas in 9 days and 4 days, the same concentration of effluent produced 67% and 64% hemolysis, respectively. Hemolysis of 50% for the *in vitro* estimations indicated a 50% toxicity level. Our data indicated that in 15 days, 0.78 mg/ml effluent produced 50% hemolysis whereas in 9 and 4 days, 0.88

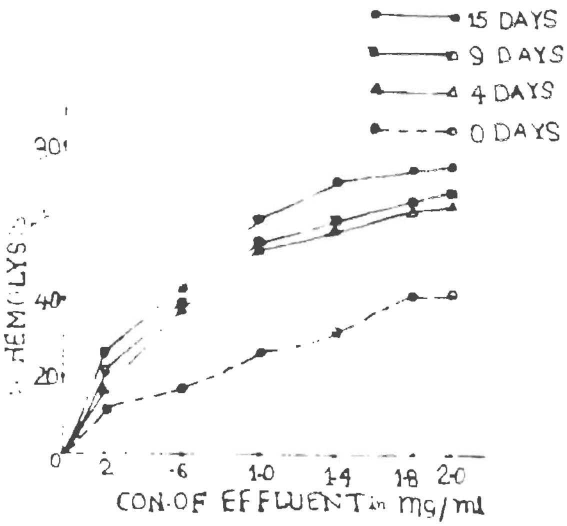


Fig.1. *In vitro* dose effect curve of percent hemolysis in rats treated with 1 mg/ml paper and pulp mill liquid effluent.

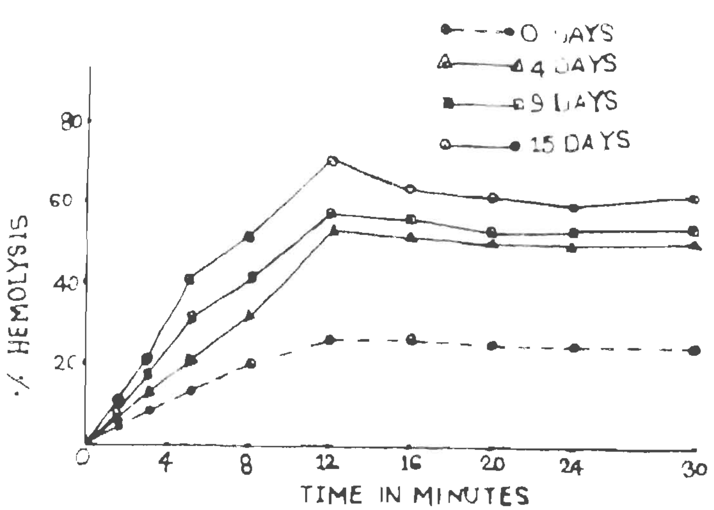


Fig.2. *In vitro* kinetic study of percent hemolysis in rats treated with 1 mg/ml paper and pulp mill liquid effluent.

mg/ml and 0.92 mg/ml effluent, respectively produced 50% hemolysis in rat blood cells. But in the control animal cell hemolytic activity was comparatively less.

*Time dependent hemolytic activity :*

The percentage hemolysis at various time intervals in the blood samples from rats exposed for 0, 4, 9 and 15 days are presented in Fig. 2. The maximum hemolysis occurred at 12 min in all these days. The 50% hemolysis assessed indicated that rats that received effluent regularly for 15 days produced 50% hemolysis after 7 min 48 sec whereas the rats exposed for 9 and 4 days showed 50% hemolysis after 10 min and 11 min 2 sec, respectively. But in control animals, hemolytic activity was less.

## Discussion

The combined waste water from an integrated pulp and paper mill that uses pulping process has high pollution load characterised by specific colour, pH, dissolved oxygen, BOD and COD values. Our observations are similar to the earlier studies of physico-chemical characterization of liquid effluent of paper and pulp mill (Saxena *et al.*, 1979; Gosh and Konar, 1980)

The significant finding of the present study is the cytotoxicity of liquid effluent by hemolytic activity in rats which received the effluent intraperitoneally. The dose dependent hemolysis of RBCs indicated extensive damage to the erythrocyte membrane which led to the release of hemoglobin into the suspensions. the effluents at high concentrations might have resulted in the formation of various metabolites which could have reached the blood stream. Such metabolites react with erythrocyte membrane and alter membrane permeability and membrane bound enzymes, (Macnab and Harington, 1967; Pele and Calvert, 1983). Most of these effects are probably due to the absorption and partial denaturation of proteins resulting in flexibility in ion channels of cell membrane by various concentrations of effluents (Light and Wei, 1977; Levander *et al.*, 1977; Levander *et al.*, 1980). The hemolysis of RBCs during various time intervals seen in animals injected with effluents also highlights the role of high concentrations in causing membrane damage. Further studies to establish the effects of effluent on membrane are in progress.

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# Impact of Automobile and Detergent Industry Wastes on the Hydrological Status of River Vaigai at Madurai City

**P. Kathirvel and P. Chandrasekaran**

Department of Zoology, Vivekananda College, Tiruvedagam West, Madurai 624217

## Abstract

A pilot survey was made to analyse the hydrological features of the river Vaigai water for a stretch of forty kilometers covering the city Madurai. The distance was categorised into three zones, namely down stream, city vicinity and upstream water. The estimated parameters, *viz.* dissolved oxygen, carbon dioxide, chlorides, hydrogen ion concentration, water colour and biological oxygen demand (BOD) exhibited characteristic variations. The influence of automobile service station, wastes like grease, oil and diesel, and discharges of detergent industry into the river greatly altered the parameters. Carbon dioxide, chlorides, BOD, hydrogen ion concentration showed an increasing trend whereas dissolved oxygen and transparency showed a decreasing trend. The down stream river water characteristics estimated at a regulator revealed the same features as those of city vicinity water and the parameters BOD and carbon dioxide exhibited rather higher values than those estimated at previous points.

## Introduction

The quality of river water is subject to wide variations because it depends on various uncertain factors, such as the character of catchment area, discharges of sewage and industrial wastes, climatic conditions, season of the year, etc. The character of water differs not only with individual river but also the nature of many points along the course of the river. It is usually found that the quality of river water at its head is good but it goes on deteriorating as the river proceeds along its course (Rangwala, 1984).

River Vaigai forms the central core of the pollution problems of Madurai City as it is used for the disposal of agricultural and domestic wastes. The earlier work on the impact of occupational chemical exposure on river Vaigai (Kathirvel and Chandrasekaran, 1988) has induced the authors to probe into the problem of disposal of diesel, oil, grease and lubricants from automobile service stations, soap industry waste and other byproducts. Hence, a detailed analysis of hydrochemical parameters of river Vaigai was carried out to study the impact of automobile and detergent industry wastes on the river.

## Material and Methods

River Vaigai starts from Vaigai dam situated at Periakulam, Madurai, and runs through Madurai, Ramanathapuram and Pasumpon Muthuramalingam districts crossing various places like Madurai, Paramakudi, and Rajasingamangalam and ends with a big lake.

The aquachemical characteristics, namely dissolved oxygen, carbondioxide, chlorides, hydrogen ion concentration, acidity and alkalinity, and biological oxygen demand (BOD) were analysed during July 1988 and March 1989. The river water was analysed in a stretch of 40 km *in toto* and a specific analysis was made in the vicinity of the city for a 12 km distance. The samples were collected at weekly intervals and fixed chemically for the estimation of various parameters. The dissolved oxygen (modified Winkler's method), carbondioxide (phenolphthalein indicator method), chlorides (argentrometric method) (Anon., 1965), acidity, alkalinity (phenolphthalein method), hydrogen ion concentration (paper method - BDH and electrometric method - digital method) and colour of the water were studied.

## Results and Discussion

The data on parameters like dissolved oxygen, carbondioxide, chlorides, acidity, alkalinity, pH and temperature were observed at various stations. These were classified as (1) pre-city river water at (a) Sholavandan area and (b) Kochadai; (2) city- vicinity water at (a) Kamarajar bridge, (b) railway bridge, (c) Muthiah Chettiar Padithurai, (d) Kalpalam and (e) Kuruvikaranchalai; (3) post-city river water at (a) Viraghanoor regulator.

In the city-vicinity river area, on the banks of river Vaigai, there are more than thirty lubrication cum automobile workshops which release their waste water with oily substances into the river. At and from Kurivikaranchalai, soap factory effluent is also released into the river. The dissolved oxygen in the stations in the city area ranged from $8.027 \pm 0.068$ to $0.612 \pm 0.083$ mg/l. The carbondioxide content varied from $0.465 \pm 0.067$ to $9.116 \pm 0.172$ mg/l. The chloride level varied from $29.423 \pm 1.179$ to $228 \pm 3.139$ mg/l. The pH ranged from 6.83 to 8.13. As far as the temperature is concerned, the atmospheric (AT) as well as surface water (SWT) temperatures were recorded for the entire period in all places. The AT ranged from 27 to 30°C and SWT ranged from 29 to 31.5°C. The acidity and alkalinity measured in terms of calcium carbonate ranged from 0.5 to $137.521 \pm 3.83$. The biological oxygen demand too increased due to the increased deterioration of water.

In the pre-city areas, due to free running of water without any discharges, the chosen parameters showed normal values. But in the city and post city areas, parameters like oxygen showed a decreasing trend whereas other parameters like carbondioxide and acidity showed an increasing trend. At places like Kalpalam, Kuruvikaranchalai and Viraghanoor regulator, immediately after Kachadai, the parameters showed a sharp alteration which was due to the discharge of wastes from automobile lubrication centres. They mainly contain diesel, grease, petrol, carbon and sulphides. The colour of the water too sharply changed from transparent, pale yellow or pale green to black or dark blue. The specific variations in the level of individual parameters analysed were a distinct feature of water pollution pertaining to BOD. At Kuruvikaranchalai a peak phase was observed on all the occasions except during rainy season. Subsequently, in the Viraghanoor regulator, a characteristic feature was observed wherein the regulatory role of the stagnant water as a self regulatory system was evident and already established (Anandavalli, 1986). This was observed in the present study by way of analysis of water both before and after Viraghanoor regulator.

At the stagnation point, i.e. before Viraghanoor regulator, the values of pollution parameters were strongly positive whereas at the releasing point, i.e. after the Viraghanoor regulator, the values slightly decreased which again indicated the self regulatory role of the regulator. The rocks and surface of substratum at the post regulatory point were found to have abundant sediments of salts which could be seen from a distance. Some amount of dilution was also seen at places between Muthiah Chettiar Padithurai and Kuruvikaranchalai. In this area, on the banks of river Vaigai, there are abundant huts and medium type living quarters the streets of which face the river and these street mouths are called 'Padithurai'. These streets are provided with corporation water supply taps which are not proper and leak incessantly. The leaking water along with waste water is led to the river without any storage system. In addition, people inhabiting the area defecate all around the street mouths and river beds. The increased flow of fresh, unused, leaking water into the river diluted the highly polluted water, resulting in the decrease of various pollution parameters. This trend showed further alterations before and after crossing the Viraghanoor regulator as discussed earlier.

The altered trend of different parameters at Kalpalam was highly significant. This was due to the large scale disposal of automobile wastes from both sides of river Vaigai. As the entire surface of water was covered by oil, there was no possibility for the atmospheric oxygen to dissolve which resulted in very low amount of oxygen in water.

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# Effects of Industrial Effluents on the Physico-chemical Properties of the River Bhavani and Ground Water at Bhavanisagar (Tamil Nadu)

**A.A. Sivakumar, M. Lekeshmanaswamy, R. Maragatham, N. Santhikumaresan and M. Aruchami**

P.G. and Research Department of Zoology, Kongunadu Arts and Science College, Coimbatore 641029

## Abstract

Analyses of physico-chemical properties of the river Bhavani and nearby ground water have been made for a period of one year. Studies showed significant changes in the physico-chemical properties due to the discharge of industrial effluents from a cardboard factory situated on the bank of the river. Temperature, total solid contents, COD and nutrients were found to have increased whereas decreased level of oxygen and anoxic condition were noticed at the place of release of the effluents.

## Introduction

Industrialization has its inevitable effect on pollution of air, water and soil based on the type of industry, nature of raw materials used and the manufacturing process involved (Hodges, 1973). Our aquatic waterbodies are getting progressively contaminated by effluents which often contain high amounts of pollutants. Many municipalities provide little or no treatment of their sewage before discharging it into the river waterway. Hence, the present investigation has been undertaken to understand the pollution in the river Bhavani and ground water system due to the leaching or percolation of effluents discharged by a cardboard factory at Bhavanisagar, Periyar District, Tamil Nadu State.

## Material and Methods

Water samples were collected for a period of 12 months, i.e. from October 1984 to September 1985 at 15 day intervals from five sites, namely Station I - before the discharge point of cardboard paper factory effluents; Station II - well water at a depth of 50 ft from the surface, 100 metres prior to the point of effluent discharge; Station III - at the discharge point of the cardboard paper factory effluents; Station IV - 100 metres away from the discharge point of the effluents; Station V - well water at a depth of about 50 feet from the surface nearly at the point of effluent discharge. The collected samples were analysed for physical and chemical factors by using standard methods (Anon., 1960).

## Results and Discussion

A total of 24 samples were analysed in each station during the study period. Mean values of the physico-chemical characters of the 24 samples were calculated and presented in Tables 1 to 3. At Stations I and II water samples were colourless. The greenish colour of the effluent sample observed at Station III may be due to the use of water paper and grass as raw materials in the factory. The brownish grey colour of the effluent samples may be due to the addition of lime during cooking process. There was no marked appearance of colour change in the samples between Stations III, IV and V. Highest water temperature was observed at Station III (34.0 to 31.6°C) compared to that of other stations

Table 1. Physical characters of the river Bhavani at five stations

| Physical characters | Station I | Station II | Station III | Station IV | Station V |
|---|---|---|---|---|---|
| Temperature (°C) | 28.20[a] (27.0-28.80)[b] | 29.90 (29.0-30.60) | 30.50 (30.0-31.60) | 28.40 (27.60-29.40) | 30.20 (30.0-30.70) |
| Suspended solids (ppm) | 309.50 (120-600) | 302.70 (100-560) | 620.40 (300-1000) | 443.60 (220-800) | 335.90 (120-720) |
| Dissolved solids (ppm) | 842.20 (400-1230) | 248.60 (100-440) | 1408.10 (450-3200) | 972.70 (410-1680) | 302.70 (120-600) |
| Total solids (ppm) | 1160.90 (540-1810) | 551.30 (250-860) | 2024.00 (1050-3880) | 1452.70 (1720-2460) | 620.50 (240-1070) |

[a] Mean of 24 observations
[b] Values in parentheses indicate range

Table 2. Chemical characters of the river Bhavani at five stations

| Chemical characters | Station I | Station II | Station III | Station IV | Station V |
|---|---|---|---|---|---|
| pH | 7.20[a] (7.10-7.50)[b] | 7.20 (7.00-7.50) | 6.70 (6.20-7.50) | 7.30 (7.10-7.60) | 7.50 (7.00-8.10 |
| Dissolved oxygen (ppm) | 4.80 (3.50-5.70) | 3.70 (2.90-4.40) | 0.40 (0.036) | 4.50 (3.20-5.50) | 3.40 (2.20-4.20) |
| Chlorides (ppm) | 22.50 (10.00-42.00) | 29.60 (10.00-45.00) | 66.00 (20.00-120.00) | 32.50 (14.30-83.00) | 36.30 (20.0-56.0) |
| Carbonates (ppm) | Nil | Nil | Nil | Nil | Nil |
| Bicarbonates (ppm) | 36.70 (10.00-48.00) | 38.70 (31.00-50.00) | 51.70 (30.00-68.00) | 41.50 (28.00-48.00) | 144.20 (102.00-185.00) |
| C.O.D (ppm) | 39.50 (12.00-60.00) | 63.30 (58.00-80.00) | 351.00 (300-400) | 73.70 (25.00-120.00) | 101.20 (75.00-160.00) |

[a] Mean of 24 observations
[b] Values in parentheses indicate range

(Table 1). This may be due the letting of hot effluents resulting from cooking of grass with lime under steam in the factory. Similar results were observed by Fry (1964) and Paramasivam and Sreenivasan (1981). Turbidity was measured by the estimation of suspended matter. The maximum amount of total solids, both dissolved and suspended, (3880 mg/l), was recorded at Station III. This may be due to the usage of waste paper, grass as well as due to the presence of lime and salts as dissolved and suspended solids. The possibility of percolation of effluents from the land fill area is not ruled out. Similar results were observed by Morissey (1983), Danielson and Sylla (1983).

In the present investigation it was found that the Stations I, II, IV and V had near neutral water pH (Table 2). At Station III, the pH ranged from 6.20 to 7.50. The variations may be due to the usage of sulphuric acid in the manufacture of paper pulp which escapes

Table 3. Nutrient contents of the river Bhavani at five stations

| Nutrient | Station I | Station II | Station III | Station IV | Station V |
|---|---|---|---|---|---|
| Organic carbon | 0 05[a] | 0 098 | 0 205 | 0 073 | 0 16 |
| (ppm) | (0.015-0 410)[b] | (0 02-0 21) | (0 034 0 24) | (0 01-0 224) | (0 006-0 85) |
| Calcium | 35.80 | 52 30 | 138 75 | 47 30 | 65 10 |
| (ppm) | (20.00 55.00) | (40 00 68 00) | (70 00-230 0) | (20 00 70 00) | (30 00-140 0) |
| Magnesium | 3 17 | 6 20 | 21 80 | 6 30 | 8.06 |
| (ppm) | (1 00-6 50) | (2.70-10 00) | (7 50 37 50) | (3 50-8 30) | (6.00-12 00) |
| Phosphates | 60 90 | 54 90 | 66 50 | 72 30 | 96 04 |
| (ppm) | (38 00-82 00) | (42 00-72 00) | (53 00 85 00) | (480 00 102 00) | (42 00-162 00) |
| Nitrates | 1 40 | 1 30 | 2 25 | 1 50 | 1 50 |
| (ppm) | (0 42-3 25) | (0 25-3 14) | (0 075 5 90) | (0 13-3 48) | (0 03-3 62) |
| Silicates | 0 23 | 0 40 | 0 47 | 0 39 | 0 76 |
| (ppm) | (0 16-0 34) | (0 28 0 58) | (0 135 0 613) | (0.29 0 48) | (0 516-1 29) |
| Iron | 2.03 | 2 77 | 3 70 | 4 90 | 5 80 |
| (ppm) | (0.86-3 26) | (1.086-4 56) | (2 17-5 60) | (1 087 14 30) | (2.30 4 13) |

[a] Mean of 24 observations

[b] Values in parentheses indicate range

through the effluent into the water The maximum amount of dissolved oxygen was observed at Station I (5.70 mg/l). Dissolved oxygen in the water was found undetectable at Station III in most of the sampling periods. The anoxic condition may perhaps be due to the utilization of oxygen in the water by the effluents discharged from the factory. Similar observations were made by Motwani (1956) and David (1956). The chloride content was maximum at Station III which might be due to the usage of chlorides in the factory. Carbonate was found to be absent in all the water samples. The bicarbonate level was found to be high at Station V. The higher amount of bicarbonate might be due to the combination of excess carbondioxide with monocarbonates forming bicarbonates (Welch, 1952). The maximum amount of chemical oxygen demand was observed at Station III (400 mg/l). This is in line with the findings of Rajannan and Oblisami (1979). This maybe due to the use of chemicals like resin, alum and caustic soda in the cardboard manufacturing process.

The organic carbon was found to be maximum at Station III (0.24%) (Table 3). This maybe due to the use of resin and grass as raw material during the processing of cardboard paper. Resin is an aromatic hydrocarbon used at the rate of 6 to 7kg per day in the cardboard factory. Maximum level of calcium was recorded at Station III. This maybe due to the use of lime during the processing of cardboard paper. Decrease in the calcium content at Station IV may be due to dilution of the effluent in the river. An increase in the value at Station V may be due to the nature of the sediment in the well as also observed by Chaplelle (1983). High magnesium content was recorded at Station III. Similar results were reported by Thompson (1982) and Monteith(1983).

Higher amounts of phosphate were observed at Station V (162.0 mg/l) (Table 3). This could be due to the mixing of sewage and domestic wastes like detergents. Higher amount of nitrates (5.90 mg/l) was recorded at Station III which may be due to the high rate of decomposition of organic matter used in the factory. The amount of silicate in the river was found to be high at Station III due to mixing of the factory effluents. At Station IV, the value was low due to dilution of the effluents. The maximum amount of 1.29 mg/l of silicate was observed at Station V which may be due to the nature of the well. Maximum amount of iron was found at Station III (2.17 to 5.60 mg/l). At Station IV, the amount was found to be low which may be due to self purification of sedimentation (Groot, 1977; Kimmel and Goldman, 1977).

From the above results, it is obvious that the physico-chemical characters of river Bhavani and well water have changed due to the seepage and percolation of effluents from the paper factory. Thus the present study paves the way for further investigations on the effect of these polluted water bodies on biological systems including human beings.

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# Tannery Effluent and its Effects on Irrigation Water and Soil Health

**P. Muthuswamy, B. Habebullah and G.V. Kothandaraman**

Centre for Soil and Crop Management Studies, Tamil Nadu Agricultural University, Coimbatore 641003

## Abstract

In North Arcot District, Tamil Nadu, nearly 250 tanneries are engaged in the processing of skin and hides. The waste water discharged from these industries pollutes not only well water but also Palar river water and affects the soil productivity when irrigated with water from these sources. The results of analysis of tannery effluent, irrigation water from wells and river, and soil had indicated the presence of very high soluble salt, sodium and sodium adsorption ratio. The quality of well water located near the lagoons and along Palar river was also affected. The presence of high amounts of salt and sodium in the river and well water made the soil less productive.

## Introduction

Tanneries are a very important industry in Tamil Nadu earninig a sizeable foreign exchange by the export of leather and leather goods. Most of the tanneries are located in North Arcot, Salem, Chinglepet and Madurai districts These industries use large quantities of water for processing. Teekaraman *et al.* (1982) reported that in vegetable and chromic tanning mehtod of leather processing widely adopted in North Arcot, the quantity of effluent discharged varied from 30 to 35 l/kg of leather produced. The disposal of these effluents causes significant environmental pollution.

Pollution due to indiscriminate letting out of tannery effluents in to streams and rivers, and storage in pots and the consequent deleterious effects on soils, water and crop had been reported (Ahamed and Rangaswamy, 1977). A study was undertaken in North Arcot to assess the extent of pollution to irrigation water and soil health due to tannery effluents.

## Material and Methods

In North Arcot District nearly 250 tannery industries are involved in leather processing. Vegetable tannery process is being widely adopted followed by chromic tanning and in some of the factories both methods are being followed (Teekaraman et al., 1982). A survey on the disposal of effluent waste water indicated that it is mostly let into the lagoons and allowed to dry by solar evaporation system. Since the capacity of these lagoons is not commensurate with the quantity of effluents available for disposal, lagoons overflow into nearby fields and percolate into the wells. Some of the tanneries dispose of the effluents directly into the Palar river. Tannery effluent, river and well water samples, and soil samples were collected, analyzed and reported in this paper.

## Results and Discussion

*Tanery effluent*

The results of the analysis (Table 1) revealed that the effluents had very high soluble salt as indicated by high E.C.values (13 m mhos/cm). This was due to the addition of various chemicals such as sodium chloride, lime, ammonium chloride, sodium sulfide, sodium dichromate and sulfuric acid accounting for nearly 3.5 per cent in the water used for processing. The effluents contained large amounts of sodium, chloride, bicarbonates and other ions. Kamallam (1978) also recorded high E.C., sodium and chloride ions in the tannery effluent collected from Dindigul. The sodium adsorption ratio (SAR) was also very high. The sodium present above toxic limit in the effluent causes problems for proper growth of agricultural crops. Waste water from lagoons, where it was impounded for disposal by solar evaporation, also contained very high amount of salts because of salt concentration during evaporation

Table 1. Analysis of well and river water, tannery effluent and soil

| Particulars of samples | E.C. (m mhos/cm) | pH | Na | K | Ca | Mg | Cl | $HCO_3$ | SAR |
|---|---|---|---|---|---|---|---|---|---|
| | | | (m eq/l) | | | | | | |
| Normal well | 0.6 | 7.3 | 0.7 | — | 6.2 | 1.8 | — | 0.11 | 0.35 |
| Polluted well-1 | 3.3 | 7.3 | 52.2 | — | 21.2 | 3.2 | 1.0 | 0.15 | 15.00 |
| Polluted well-2 | 3.6 | 7.5 | 34.8 | 1.10 | 10.4 | 4.6 | 1.0 | 0.15 | 12.70 |
| Polluted well-3 | 5.2 | 7.2 | 54.3 | 0.59 | 27.0 | 3.4 | 1.78 | 0.20 | 13.90 |
| Palar river (unpolluted) | 0.57 | 0.72 | 5.4 | — | 3.8 | 0.6 | 2.00 | 0.10 | 3.86 |
| Palar river (polluted) | 3.6 | 7.5 | 41.3 | 0.95 | 6.0 | 2.0 | 1.10 | 0.11 | 20.60 |
| Effluent from industry | 13.0 | 7.8 | 195.6 | — | 7.0 | 1.4 | 4.96 | 0.34 | 72.4 |
| Effluent from lagoons | 19.0 | 7.2 | 331.5 | 1.36 | 13.0 | 1.6 | 8.24 | 0.34 | 122.7 |
| Normal soil | 0.41 | 7.9 | | | | | | | |
| Irrigated soil-I | 0.44 | 8.3 | | | | | | | |
| Irrigated soil-2 | 0.89 | 8.5 | | | | | | | |
| Irrigated soil-3 | 0.61 | 8.1 | | | | | | | |

*River water*

Due to the discharge of effluent water into the Palar river, the river water was also contaminated. The E.C. of unpolluted river water was 0.57 m mhos/cm which increased to 3.6 while sodium content increased from 5.4 to 41.3 meq/l. The SAR also increased from 3.86 to 20.6.

*Well water*

Percolating water from lagoons and the contaminated Palar river polluted the well water. The soluble salts in normal well water of this area were low as indicated by E.C.

values of 0.6 m mhos/cm which increased to 5.2 m mhos/cm because of seepage of river water and tannery effluent. Sodium content was nearly eighty times more than that in unpolluted well water and the SAR was also high. Similar effect of tannery effluent on surrounding environment was also reported by Varadarajan *et al.* (1970), Guruprasada Rao and Nandakumar (1981), Srinivas *et al.* (1984) and Anvarbatcha (1986).

A comparison of the salt content of well water or this area over previous years (Teekaraman *et al.*, 1982) revealed that there has been an increase in the concentration of salts in well water with time.

*Soil productivity*

The results of analysis of normal soil and that irrigated with polluted river and well water has indicated accumulation of salts resulting in a marginal increase in pH which can lead to loss of productivity. Similar ill effect due to tannery effluent pollution on productivity of soil was also reported by Thabaraj *et al.* (1964). The yield of paddy, ragi, cholam, sugarcane and coconut of this tract has declined. The present study indicated the need for the use of coir pith the liberal addition of organic manures alongwith gypsum as soil amendments to increase the productivity of the soil.

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# Physico-chemical Aspects of Flyash Management

**Bikal Kumar Gupta , D. Pathak and A.K. Bhattacharya**
School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067.

## Abstract

A column study was conducted with Delhi soil amended with 2.5% and 5% flyash (w/w) in the upper layer. The whole profile was leached with distilled water for two months and the leachates were analysed for available N, P and K along with pH, electrical conductivity and organic matter at different time intervals.

## Introduction

Coal is the most important and economic fuel available for power generation and is widely used as a source of energy all over the world. Flyash is the term used to describe the very fine ash resulting from the combustion of finely grounded coal that comes out from chimneys of thermal power plants along with other gases and spreads over a large area. According to the Central Fuel Research Institute Bulletin 1986-87, in India, 29 million tonnes of flyash is being produced annually and this figure may reach nearly 83 million tonnes by 2000 A.D. after consumption of more coal for power generation.

Chemically all naturally existing elements can be found in flyash (Klein *et al.*, 1975 ; Kaakinen *et al.*,1975). Flyash has been used to stop erosion (Adams *et al.*, 1972) and to reclaim land for the growth of forage and pasture crops (Barber. 1974). Flyash can also be an effective amendment in neutralising soil acidity or correcting some deficiencies of B, MO, P, K and Zn (Martens, 1971; Doran and Marten, 1972; Schnappinger *et al.*, 1975) and as a soil amendment for the growth of plants (Adriano *et al.*, 1978; Furr *et al.*, 1976).

Flyash disposed on land is subject to leaching by atmospheric moisture, rain and water used to pond the ash or to irrigate flyash amended soil. The landfill disposal of flyash has an impact on hydrological systems. The potential for ground water contamination receives substantially less attention and the result is an ever growing number of ground water contamination problems. (Doglas, 1980). There are several ways to study the long term leaching behaviour of flyash in the laboratory. When columns of flyash were leached continuously with distilled water, Na, K and pH decreased steadily (Dina *et al.*, 1988). The present study was designed to find out the possible leaching of the essential nutrients N, P and K from 2.5% and 5% flyash amended soil.

## Material and Methods

Soil was collected from the Jawaharlal Nehru University (J.N.U) campus drawing from the surface upto a depth of 80 cm in three layers. Soil of each layer was air-dried and mechanically ground to pass through a 2 mm sieve. The flyash was collected from Badarpur Thermal Power Station situated at a distance of 20 km from the J.N.U campus, New Delhi.

Five columns of purplex glass measuring 87 x 14.5 x 19.5 $cm^3$ were fabricated. One steel plate having many bores was placed in the bottom of each lysimeter (column). All the columns were washed initially with 0.01N HCL, then ten times with tap water and finally five times with double distilled water. Five cm deep gravel and then 5 cm deep washed sand were packed in the bottom. All the lysimeters were packed with third and second layers of soil. The upper 15 cm of lysimeters were packed with 2.5% and 5% flyash amended soil (w/w of total) in duplicate. The upper layer of one lysimeter was packed with soil without flyash for control. Two liters of double distilled water per day was added upto three days for stabilization of the soil profile. The rate of watering of column was kept at about 80-90 drops per minute for three to four hours daily upto two months. Leachate samples from the saturated soil of different lysimeters were collected after 5, 10, 20, 40 and 60 days.

*(i) Soil and flyash analysis*

Initially experimental soil and flyash were analysed for pH and E.C. by usual methods (Table 1). Organic carbon and available nitrogen, phosphorus and potassium were determined by the method of Walkley and Black (1934) as modified by Chopra and Kanwar (1976), Subbaiah and Asija (1956) and alkaline $NH_4$-acetate extraction method (Allen *et al.*, 1974).

Table 1. Physico-chemical properties of experimental soil and flyash

| Parameters | Soil | Flyash |
|---|---|---|
| pH | 8.01 | 7.70 |
| Water holding capacity (%) | 28.24 | 66.95 |
| Electrical conductivity (m mho/cm) | 0.115 | 0.12 |
| Organic carbon (%) | 0.352 | 0.410 |
| Available nitrogen (ppm) | 58.26 | 50.00 |
| Available phosphorus (ppm) | 9.9 | 270.00 |
| Available potassium (ppm) | 191.55 | 125.00 |

*(ii) Leachate analysis*

Leachates were analysed for pH and E.C. directly. Organic matter and available nitrogen, phosphorus and potassium were determined by the same methods used for soil and flyash.

## Results and Discussion

The pH of all the column leachates decreased with time (Table 2). On the 20th day, a slight increase in pH of all the columns was noticed. But the decrease in pH was found to be more in 5% than in 2.5% flyash amendment and least in the control leachate. Mobile-immobile phase phenomenon in soil and flyash might have contributed to the changes of pH in the above pattern (Mansell *et al.*, 1986).

The progressive decrease of E.C. in all the leachates with time indicated a decrease in soluble salt concentration. The ion complexation and chelation of soluble ion with organic matter might account for the slightly lower values of electrical conductivity (Russell, 1975). Organic matter is almost insoluble in double distilled water. In all the cases, it decreased drastically on the 10th day. The decreasing trend continued upto 60th day of the experiment except for an increase on the 40th day in both types of amendments.

Table 2. Periodic changes in pH, E.C. and organic matter in leachates of soil and flyash amended soil columns

| Time (days) | Control | | | 2.5% fly ash | | | 5% fly ash | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH | E.C. m mho/cm | Organic matter (*10' 3) | pH | E.C m mho/cm | Organic matter (*10' 3) | pH | E.C. m mho/cm | Organic matter (*10'-3) |
| 5 | 8.00 | .040 | 6.7 | 8.81 | .038 | 6.0 | 7.97 | .038 | 4.7 |
| 10 | 8.06 | .015 | 1.3 | 8.08 | .016 | 2.3 | 7.97 | .016 | 2.7 |
| 20 | 8.22 | .017 | 1.3 | 8.12 | .015 | .65 | 8.09 | .016 | 0.6 |
| 40 | 8.10 | .017 | 1.3 | 8.05 | .012 | 1.6 | 7.95 | .013 | 3.0 |
| 60 | 7.80 | .015 | 0.6 | 7.7 | .010 | .85 | 7.6 | .010 | 1.0 |

Table 3. Periodic changes in soluble N, P and K in leachate of soil and fly ash amended soil columns

| Treatment | Parameters | Time (days) | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 10 | 20 | 40 | 60 |
| Control | N | 1.12 | 0.87 | 1.12 | 0.87 | 0.85 |
| | P | 0.11 | 0.09 | 0.08 | 0.05 | 0.04 |
| | K | 2.2 | 1.6 | 1.1 | .95 | .8 |
| 2.5% fly ash | N | 1.10 | 0.82 | 0.85 | 0.78 | 0.65 |
| | P | 0.12 | 0.10 | 0.08 | 0.06 | 0.05 |
| | K | 1.8 | 1.6 | 1.3 | 1.00 | 0.95 |
| 5% fly ash | N | 0.95 | 0.65 | 0.78 | 0.52 | 0.31 |
| | P | 0.13 | 0.09 | 0.01 | 0.08 | 0.07 |
| | K | 2.00 | 1.8 | 1.4 | 1.1 | 1.00 |

Nitrogen concentration in control leachate was found to be higher than in 2.5% and 5% flyash amendment on the 5th day and all the values decreased with time (Table 3). On the 60th day, the available nitrogen concentration of leachate of 2.5% flyash amendment column was found to be less than that of control while in 5% amendment it was found to be half of that in 2.5% flyash amendment column. Less availability of nitrogen can also be supported by the decrease in organic matter with time.

Phosphorus concentration of leachate from all the columns was found to decrease successively with time. The decrease in control was maximum while in 2.5% and 5% flyash amendment it was less. This might be due to larger available phosphorus present in flyash than in the soil. Mineralization and decrease in pH may be accounted for the high rate of phosphorus concentration in leachates of 2.5% and 5% flyash amendment (Goss and Stelart, 1979). The decrease in potassium concentration in the leachate of control column was higher than in 2.5% and 5% flyash amendment. This could be due to higher fixation in flyash amendment and microbial immobilization.

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# Understanding Mined Spoils - Donimalai Iron Ore Mine, a Case Study.

**T.S. Channesh and C.A. Srinivasamurthy**

Department of Soil Science and Agricultural Chemistry,
University of Agricultural Sciences, G.K.V.K., Bangalore 560065

## Abstract

Iron ore mine spoils at Donimalai, Bellary district, Karnataka, were studied for their properties. Six sites, grouped according to the age of spoils, were selected and compared with three adjacent soils. The physical properties of spoils, such as bulk density and particle density were similar to those of adjacent soils. Texturally they belonged to sandy loam class. The spoil was acidic with the pH ranging from 5.0 to 6.6. Electrical conductivity recorded ranged from 0.22 to 0.71 m mhos/cm at 25°C and cation exchange capacity varied from 8.9 to 19.4 m eq/100 g. Exchangeable bases and DTPA extractable micronutrients were comparable with adjacent soils expect with respect to iron and manganese.

## Introduction

The overburden or spoils from mines which form the landscape influence the normal soil formation. A proper understanding and scientific explanation to define their disturbance as well as properties are essential which provide clues to their genesis and geomorphological pattern (Pederson *et al.*, 1980). Such units on mined land surface were defined by considering pre-mined soil and overburden characteristics (Indorante and Jansen, 1984). Rutherford *et al.* (1982) showed that in understanding mined land, the initial system may serve as a base for further pedogenesis. Pederson *et al.* (1980) have shown that the mine soils were typically low in organic matter with high coarse fragments. Most of the previous studies on mined land have been done to assess the degree of disturbance and contamination (Hazlett *et al.*, 1983). In India, vegetation has been established in different mined areas using some agricultural practices. However, at most of the sites top soiling or regular amendments are used to maintain the vegetation. Still a proper understanding of the material as a medium of plant growth and processes that govern the pedogenesis is little.

As the spoils are subjected to continuous disturbance and dumped in valleys, there will be natural disturibution of particles. The object of this research was to understand the typical properties of spoils in comparison with adjacent soils which would help for further revegetation for stabilization.

## Material and Methods

### *The area*

Donimalai Iron Ore Mine, Bellary district, Karnataka, operated by National Mineral Development Corportion Ltd. produces about 6 to 8 million tonnes of spoils per year. The overburden or mine spoil is either left behind in the mined area or dumped in the valleys nearby. These dumps have drastically affected the local landscape. This area is devoid of vegetation and this has resulted in wide scale soil erosion leading to contamination of nearby cultivated lands. The mining site is situated between 15° 16' North latitude and 70° 35' East longitude at an altitude of 3400 ft above mean sea level and is about 8 km south east of Sandur town in Bellary district. The present study area consisted of 300 acres at different elevations and the adjacent native soils. Spoil samples were collected from freshly opened pits as well as old mined sites. The selected sites were categorized into six groups according to their age, *viz.* fresh to 2 years, 2 to 4 years, 4 to 6 years, 6 to 8 years and 10 to 12 years. For studying the pre-mining history, adjacent pre-mined soils were sampled at the mine and at 2 km and 5 km away from the mine. From each location, for both spoils and soils, five samples were collected randomly at two depths, namely 0 to 10 and 10 to 20 cm. Since the sites were at different elevations, care was taken to make the samples to better represent the area. The morphology of the sites was discribed as suggested by the Soil Survey Staff (1951)

*Laboratory methods*

Samples collected were dried in shade, powered and sieved with 2 mm sieve for further analysis. Coarse fragments measuring more than 2 mm size from spoil materials were estimated. The pH and EC were determined using 1:2.5 soil to water ratio. The physical properties, such as bulk density, particle density, water holding capacity, porosity and particle size distribution were determined (Piper, 1966). Odour was evaluated using munsel soil colour chart. Later, the chemical properties, such as exchangeable K, Ca, Mg and Na, and available sulphur were determined (Jakson, 1973). The minor elements, *viz.* Fe, Mn, Zn and Cu were extracted with DTPA and evaluated by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

## Results and Discussion

*General trends*

The geomorphological data of the study site are given in Table 1. Conventional soil horizon nomenclature could not be employed as the site was continuously disturbed and was at different elevations. The surface horizons varied highly with respect to colour description. There was no evidence of organic staining in the case of spoils. No sites showed apparent stratification by colour differentiation

The textural variation as evidenced in the field could not be confirmed by particle size analysis of bulk samples. Only a little variation in particle size distribution occurred between and within the sites. The coarse fragments in spoils were as high as 31.5 %. All sites belonged to sandy loam in textural class Generally, spoils were dominated by sand and silt with only small amount of clay (10.74 to 18.16 %). Spoils were not comparable with adjacent soils which had well distributed particle fractions with considerable amount of clay (28.14 to 42.75 %).

*Physical properties*

The physical properties are listed in Table 2. While few studies indicated the poor physical qualities of spoils (Pederson *et al.*, 1982), a similar trend was observed in these spoils also. There was no structural evidence in spoils. Densitywise, spoils were comparable with soils with a few exceptions which had higher P.D. (2.88 g/cc) and lower B.D. (1.22 g/cc). Spoils had high pore space and were not comparable with soils. The maximum water holding capacity of spoils was lower than that of soils. The general trend

Table 1. Geomorphology of iron ore mine spoils and adjacent soils

| Site | Depth (cm) | Colour description | Particle size distribution (%) | | | Coarse fragments of 2 mm size (%) | Textural class |
|---|---|---|---|---|---|---|---|
| | | | Sand | Silt | Clay | | |
| Less than 2 year old spoils | 0-10 | 2.5 YR 4/6 Red | 58.76 | 28.44 | 12.80 | 28.3 | Sandy loam |
| | 10-20 | 2.5 YR 3/6 Dark Red | 66.80 | 19.84 | 13.36 | 23.1 | Sandy loam |
| 2 to 4 year old spoils | 0-10 | 2.5 YR 5/4 Red Brown | 72.10 | 13.62 | 12.28 | 31.3 | Sandy loam |
| | 10-20 | 2.5 YR 3/4 Dark Red | 75.10 | 10.38 | 14.52 | 30.5 | Sandy loam |
| 4 to 6 year old spoils | 0-10 | 7.5 YR 5/6 Strong Brown | 79.30 | 9.96 | 10.74 | 23.5 | Sandy loam |
| | 10-20 | 7.5 YR 5/6 Strong Brown | 76.70 | 11.90 | 11.40 | 22.5 | Sandy loam |
| 6 to 8 year old spoils | 0-10 | 2.5 YR 3/4 Dark Reddish | 70.60 | 12.82 | 16.58 | 27.5 | Sandy loam |
| | 10-20 | 2.5 YR 4/4 Reddish Brown | 72.26 | 12.38 | 15.36 | 23.6 | Sandy loam |
| 8 to 10 year old spoils | 0-10 | 2.5 YR 3/2 Dusky Red | 71.74 | 11.82 | 16.44 | 28.3 | Sandy loam |
| | 10-20 | 2.5 YR 3/2 Dusky Red | 71.14 | 10.66 | 18.16 | 31.5 | Sandy loam |
| 10 to 12 year old spoils | 0-10 | 7.5 YR 4/4 Dark Red | 73.08 | 10.38 | 16.54 | 28.1 | Sandy loam |
| | 10-20 | 7.5 YR 3/6 Dark Red | 74.58 | 9.66 | 15.76 | 25.1 | Sandy loam |
| Adjacent soil near mining site | 0-10 | 5 YR 4/3 Red Brown | 44.00 | 21.68 | 34.32 | 00.5 | Loam |
| | 10-20 | 5 YR 4/3 Red Brown | 39.10 | 22.54 | 38.36 | 00.0 | Loam |
| Adjacent soil 2 km from mining site | 0-10 | 2.5 YR 3/6 Dark Red | 44.62 | 26.60 | 28.78 | 00.0 | Clay Loam |
| | 10-20 | 2.5 YR 3/6 Dark Red | 43.38 | 26.32 | 28.14 | 00.0 | Clay Loam |
| Adjacent soil 5 km from mining site | 0-10 | 5 YR 3/6 Dark Red | 32.20 | 20.45 | 42.35 | 00.0 | Loam |
| | 10-20 | 5 YR 3/6 Dark Red | 36.75 | 20.5 | 42.75 | 00.0 | Loam |

Table 2. Physical properties of iron ore mine spoils and adjacent soils

| Site | Bulk density (g/cc) | | Particle density (g/cc) | | Porosity (%) | | Maximum water holding capacity (%) | |
|---|---|---|---|---|---|---|---|---|
| | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth |
| Less than 2 year old spoils | 1.22 | 1.24 | 2.77 | 2.80 | 56.06 | 55.56 | 38.39 | 38.17 |
| 2 to 4 year old spoils | 1.27 | 1.31 | 2.73 | 2.76 | 53.22 | 52.59 | 39.82 | 40.12 |
| 4 to 6 year old spois | 1.27 | 1.30 | 2.80 | 2.81 | 54.52 | 53.92 | 39.78 | 38.99 |
| 6 to 8 year old spoils | 1.31 | 1.32 | 2.88 | 2.83 | 55.07 | 53.30 | 39.85 | 39.11 |
| 8 to 10 year old spoils | 1.26 | 1.31 | 2.77 | 2.70 | 54.56 | 51.84 | 39.90 | 39.16 |
| 10-12 year old spoils | 1.29 | 1.31 | 2.68 | 2 71 | 51.94 | 51.70 | 40.78 | 40.72 |
| Adjacent soil near mining site | 1.31 | 1.32 | 2.60 | 2.61 | 49.46 | 49.57 | 42.17 | 41.01 |
| Adjacent soil 2 km away from mining site | 1.32 | 1.32 | 2.59 | 2.61 | 49.03 | 49.27 | 43.47 | 42.30 |
| Adjacent soil 5 km away from mining site | 1.32 | 1.32 | 2.60 | 2.60 | 49.37 | 49.31 | 42.79 | 42.27 |
| 'F' test | * | * | * | * | * | * | * | * |
| C.D. at 5% | 0.04 | 0.04 | 0.01 | 0.09 | 2 63 | 1.96 | 1.79 | 1.56 |

* Significant at $P < 0.05$

Table 3. Physico-chemical properties of iron ore mine spoils and adjacent soils

| Site | pH | | E.C. at 25°C (m mhos/cm) | | Cation exchange capcity (m eq/100 g) | |
|---|---|---|---|---|---|---|
| | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth |
| Less than 2 year old spils | 5.0 | 5.4 | 0.22 | 0.22 | 17.52 | 16.5 |
| 2 to 4 year old spoils | 5.6 | 5.6 | 0.23 | 0.24 | 10.84 | 12.4 |
| 4 to 6 year old spoils | 5.9 | 5.8 | 0.37 | 0.38 | 11.98 | 8.9 |
| 6 to 8 year old spoils | 6.2 | 6.2 | 0.67 | 0.67 | 15.54 | 14.1 |
| 8 to 10 year old spoils | 6.5 | 6.4 | 0.62 | 0.68 | 19.40 | 14.5 |
| 10 to 12 year old spoils | 6.6 | 6.6 | 0.62 | 0.71 | 16.97 | 17.2 |
| Adjacent soil near mining site | 6.8 | 6.7 | 0.22 | 0.24 | 14.98 | 13.1 |
| Adjacent soil 2 km away from mining site | 6.9 | 6.8 | 0.28 | 0.28 | 16.16 | 21.3 |
| Adjacent soil 5 km away from mining site | 6.9 | 6.9 | 0.32 | 0.33 | 17.27 | 19.5 |
| 'F' test | * | * | * | * | * | * |
| C.D. at 5% | 0.19 | 0.15 | 0.09 | 0.07 | 5.43 | 4.94 |

* *Signficant at P < 0.05*

Table 4. Content of exchangeable bases in iron ore mine spoils and adjacent soils

| Site | K (m eq/100 g) | | Ca (m eq/100 g) | | Mg (m eq/100 g) | | Na (m eq/100 g) | |
|---|---|---|---|---|---|---|---|---|
| | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth |
| Less than 2 year old spoils | 4.3 | 4.2 | 0.92 | 0.92 | 0.45 | 0.24 | 3.5 | 3.1 |
| 2 to 4 year old spoils | 4.8 | 4.6 | 0.91 | 0.92 | 0.75 | 0.87 | 6.3 | 4.1 |
| 4 to 6 year old spoils | 6.1 | 6.5 | 0.89 | 0.97 | 0.58 | 0.65 | 6.4 | 6.5 |
| 6 to 8 year old spoils | 6.5 | 6.5 | 1.13 | 0.78 | 0.72 | 0.91 | 6.2 | 6.1 |
| 8 to 10 year old spoils | 6.2 | 6.2 | 1.38 | 0.41 | 0.84 | 0.95 | 6.8 | 6.2 |
| 10 to 12 year old spoils | 4.5 | 6.7 | 1.26 | 1.15 | 1.09 | 0.78 | 7.1 | 6.3 |
| Adjacent soil near mining site | 4.5 | 4.5 | 2.61 | 2.91 | 2.48 | 2.18 | 4.1 | 4.1 |
| Adjacent soil 2 km away from mining site | 6.5 | 6.8 | 2.39 | 2.17 | 2.28 | 1.90 | 2.8 | 3.1 |
| Adjacent soil 5 km away from mining site | 6.2 | 6.2 | 2.50 | 2.89 | 2.97 | 1.97 | 2.3 | 3.2 |
| 'F' test | * | * | * | * | * | * | * | * |
| C.D. at 5% | 2.19 | 2.21 | 1.05 | 0.87 | 1.44 | 0.89 | 1.98 | 2.01 |

* Significant at $P < 0.05$

Table 5. DPTA extractable micronutrient content in iron ore spoils and adjacent soils

| Site | Fe (ppm) | | Mn (ppm) | | Cu (ppm) | | Zn (ppm) | |
|---|---|---|---|---|---|---|---|---|
| | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth | 0-10 cm depth | 10-20 cm depth |
| Less than 2 year old spoils | 193.64 | 148.34 | 32.18 | 34.89 | 0.98 | 0.88 | 0.86 | 0.65 |
| 2 to 4 year old spoils | 188.24 | 161.92 | 28.52 | 27.86 | 0.99 | 0.84 | 0.15 | 0.85 |
| 4 to 6 year old spoils | 167.89 | 114.63 | 37.50 | 39.96 | 1.15 | 1.12 | 0.95 | 0.65 |
| 6 to 8 year old spoils | 165.54 | 101.04 | 45.82 | 32.90 | 0.84 | 0.64 | 0.70 | 0.50 |
| 8 to 10 year old spoils | 154.42 | 78.57 | 27.96 | 22.10 | 0.99 | 0.68 | 0.68 | 0.39 |
| 10 to 12 year old spoils | 104.17 | 71.37 | 19.90 | 16.16 | 0.76 | 0.69 | 0.79 | 0.36 |
| Adjacent soil near mining site | 25.09 | 23.04 | 14.74 | 9.99 | 0.52 | 0.33 | 0.56 | 0.38 |
| Adjacent soil 2 km away from mining site | 15.74 | 11.95 | 10.74 | 8.43 | 0.33 | 0.25 | 0.51 | 0.33 |
| Adjacent soil 5 km away from mining site | 13.86 | 9.00 | 6.15 | 6.21 | 0.48 | 0.21 | 0.49 | 0.46 |
| 'F' test | * | * | * | * | * | * | * | * |
| C.D. at 5% | 39.65 | 30.36 | 16.97 | 9.77 | 0.26 | 0.31 | 0.41 | 0.36 |

* Significant at $P < 0.05$

Table 6. Phyntic value of spoils

| Site | Iron | | | | Sulphur | | | |
|---|---|---|---|---|---|---|---|---|
| | 0-10 cm depth | | 10-20 cm depth | | 0-10 cm depth | | 10-20 cm depth | |
| | Total (%) | Available (ppm) | Total (%) | Available (ppm) | Total (%) | Available (ppm) | Total (%) | Available (ppm) |
| Less than 2 year old spoils | 18.83 | 193.6 | 16.7 | 148.3 | 1.10 | 15.5 | 1.2 | 17.9 |
| 2 to 4 year old spoils | 16.98 | 188.2 | 16.6 | 161.9 | 0.56 | 32.9 | 0.61 | 27.1 |
| 4 to 6 year old spoils | 17.6 | 167.9 | 16.7 | 114.6 | 0.82 | 25.5 | 0.90 | 31.3 |
| 6 to 8 year old spoils | 17.8 | 165.5 | 17.4 | 101.04 | 1.20 | 23.9 | 1.30 | 21.5 |
| 8 to 10 year old spoils | 12.4 | 154.42 | 17.7 | 78.57 | 0.45 | 19.1 | 0.60 | 15.2 |
| 10 to 12 year old spoils | 10.5 | 104.17 | 13.3 | 71.37 | 0.35 | 23.5 | 0.40 | 23.7 |

in spoils showed that as they became older, there would be a slight improvement in their properties.

*Physico-chemical properties*

The physico-chemical properties are given in Table 3. The spoils are typically acidic in nature. The pH showed an increasing trend with age of the spoils. The older spoils were on par with adjacent soils. The electrical conductivity also showed variation with age. Accumulation of salt occurred with prolonged exposure to atmosphere. Cation exchange capacity of spoils was of considerable acidic soil range. The increase in CEC may be due to the slightly higher content of clay sized particles present in older spoils compared to fresh spoils.

*Chemical properties*

Results of chemical analysis are presented in Table 4 and 5 for exchangeable bases and minor elements, respectively. The amount of K, Ca, Mg and Na in all the spoils studied were found to be within the ranges of adjacent soils with little exceptions in fresh spoils (Table 4). This is not surprising as the major element content of parent materials of spoils and soils are essentially similar, supporting the idea that spoils can be potential media for plant growth.

The minor elements extracted with DTPA in spoils were in variable concentrations and differed very much from those of soils (Table 5).

Spoils were analysed for their pyritic value and found to be poor (Table 6) with less total sulphur and high iron. This indicated that in oxide mine spoils, 'S' content is likely to be low.

In conclusion, analysis of iron ore spoils in camparison with adjacent (pre-mined) soils showed that the spoils were acidic. The pH and EC of spoils increased with age. The exchangeable bases and minor elements were found similar to soils with exceptions.


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# Accumulation and Movement of Ca and Mg in Flyash Amended Soil

**Dependra Pathak , B.K. Gupta and A.K. Bhattacharya**

School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067.

### Abstract

A laboratory experiment under controlled conditions was set up to study the effect of flyash amendment on the accumulation and movement of Ca and Mg in soil columns at certain intervals for a period of two months. It was found that different patterns were obtained for different layers due to their positional as well as physico-chemical differences. The periodic changes observed in pH, E.C., organic carbon, Ca and Mg were interpreted independently as well as in relation to one another in order to unfold the complexities of this biospherical compartment.

### Introduction

Today, coal is the most important fossil fuel for power generation throughout the world. India with its substantial coal reserve finds it judicious and economical for thermal power generation. But it poses the problem of flyash disposal. Even today huge amount of flyash is coming out as waste material from the existing thermal power plants. Flyash is the main residue of coal combustion. The average ash content of thermal grade coal is 28% which goes up to as high as 42% in inferior grades. The flyash produced has to be either disposed of or utilized. A certain quantity of flyash is used in concrete and ceramics, as base material in road beds, reclamation of spoil areas (Adam *et al*., 1972), acidity corrections, etc. But a great amount of it still remains undisposed. The usual methods of ash disposal are (a) dumping in a disposal area, (b) placement and compaction in a controlled fill, (c) slurrying with water followed by pumping into a lagoon or impoundment, etc. Besides the above, flyash has been suggested as an amendment and microelement enriching material in agriculture (Martens *et al*., 1970). They have also been used to improve soil physical properties (Chang *et al*., 1977; Giedrojc *et al*., 1980).

The two thermal power stations, namely Badarpur and Indraprastha around Delhi which are the major suppliers of electricity to Delhi, produce huge amount of flyash. Most of the ash is continuously dumped in nearby areas. But since last few years it is also being used in agriculture for amending soil. Today we know almost all the constituents of flyash. Presence of as many as 46 elements has been reported in coals used in electric power generation (Block and Dams, 1975). The present piece of work was undertaken to study the flyash amendment effect on soil using columns and its possible utilization in agriculture.

### Material and Methods

Delhi soil was collected layerwise from uncultivated land and was filled in perplexoglass columns up to 70 cm maintaining the field profile. After mixing the flyash collected from Badarpur Thermal Power Plant in the upper 15 cm layer of the columns in two sets of 2.5% and 5% w/w, it was leached with double distilled water at the rate of 2 l/day in each column for 60 days. Samples were collected from three different depths of the 70 cm profile, *viz*. 10, 30 and 50 cm from all columns at intervals of 0,5,10,20,40 and

60 days and analysed for the parameters pH, E.C., organic carbon(O.C.), Ca and Mg. In addition to these samples, raw flyash and field soil were also analysed (Table 1).

Table 1. Physico-chemical properties of experimental soil and flyash

| Parameters | Soil | | | Fly ash |
|---|---|---|---|---|
| | 0-15 cm | 15-40 cm | 40-70 cm | |
| pH | 7.92 | 7.93 | 8.18 | 7.70 |
| Water holding capacity (%) | 26.23 | 28.07 | 30.4 | 66.95 |
| Electrical conductivity (m mhos/cm) | 0.11 | 0.12 | 0.12 | 0.11 |
| Organic carbon (%) | 0.171 | 0.169 | 0.114 | 0.41 |
| Available calcium (ppm) | 1440 | 1448 | 1456 | 1390 |
| Available magnesium (ppm) | 250 | 234 | 222 | 132.5 |

The pH was determined by a digital pH meter using 3 gm samples in 30 ml water and E.C. using a direct reading E.C. meter. Organic carbon was determined by the addition of an oxidising agent to the soil in excess and subsequent titration and determination of the excess oxidising agent. The oxidising agent used was acidified potassium dichromate and the excess of dichromate was back titrated with ferrous ammonium sulphate using diphenylamine as an indicator.

Available Ca and Mg were determined by the Atomic Absorption Spectroscopic (A.A.S) method. The samples were prepared by adding 100 cc of ammonium acetate (pH 9.0) to 4g of the experimental sample. Extraction was done by shaking this solution in a mechanical shaker for one h and filtering through No.42 filter paper. Both Ca and Mg standards were prepared and for control interference in flame, strontium chloride solution was prepared. The standards and samples were run through the A.A.S. at 422.7 nm for Ca and 285.2nm for Mg. Instrument readings were multiplied with the degree of dilution.

## Results and Discussion

The pH and E.C. values have decreased periodically in our experiment whereas O.C. has shown very less change during the experimental period.

The available Ca level change with time followed different patterns in the three different layers as evident from Table 2. Flyash contains substantial amount of available Ca. In layers "a" there was a gradual decrease in the available Ca concentration throughout the period. During the first 5 days, there was a sharp decrease in all the three types of columns. Ca content in columns amended with 5% flyash decreased more rapidly than that in the column amended with 2.5% flyash which in turn decreased more rapidly than the control in first 5 days. The rate of decrease lessened on 20th day of the experiment.

Layer "b" showed constancy of available Ca content up to the 10th day which, however, decreased sharply on the 20th day and later on the change became gradual. Layer "c" showed a slight increase in the Ca content in the first 10 days. Subsequently it decreased till the 40th day which later on showed constancy.

Table 2. Periodic changes in available Ca (ppm) in oil columns treated with flyash*

| Treatment | Depth | Time (days) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 5 | 10 | 20 | 40 | 60 |
| Unamended column for control | 10 cm (layer "a") | 1440 | 1420 | 1403 | 1390 | 1340 | 1330 |
| | 30 cm (layer "b") | 1448 | 1442 | 1440 | 1401 | 1381 | 1383 |
| | 50 cm (layer "c") | 1456 | 1460 | 1459 | 1454 | 1390 | 1389 |
| Column amended with 2.5% flyash | 10 cm (layer "a") | 1435 | 1400 | 1385 | 1370 | 1345 | 1325 |
| | 30 cm (layer "b") | 1445 | 1445 | 1437 | 1397 | 1342 | 1333 |
| | 50 cm (layer "c") | 1452 | 1462 | 1465 | 1449 | 1372 | 1365 |
| Column amended with 5% flyash | 10 cm (layer "a") | 1425 | 1390 | 1380 | 1375 | 1320 | 1317 |
| | 30 cm (layer "b") | 1446 | 1441 | 1427 | 1385 | 1344 | 1345 |
| | 50 cm (layer "c") | 1454 | 1468 | 1471 | 1444 | 1362 | 1372 |

* Available Ca (ppm) in flyash = 1390

The available Ca content in flyash was 1390 ppm which was close to the available Ca content in soil. This was evident from the layer "a" value of different columns. The gradual decrease up to the 10th day of the experiment was mostly due to leaching. The decreased rate of decrease on the 20th day suggested the possibility of some Ca release in available form during that period. This increase may be due to weathering and time-lag effect. Here the increase was not pronounced. This was probably due to the precipitation of Ca as phosphates, as the pH was high and phosphate content was considerable in soil and flyash. A rapid decreasing rate in the upper layer in the treatment column may be due to the glassy matrix structure of flyash particles. Constancy of Ca level in layer "b" was probably due to the accumulation of Ca from the upper layer After 20 days, leaching predominates in layer "b" but not supported by layer "c" pattern. This brings in the possibility of precipitation of Ca as phosphate and microbial immobilisation which make them unavailable. Available Ca content increased up to 10th day of experiment in layer "c" due to the dominance of accumulation over leaching effects. Later on it decreased probably due to the same cause as in layer "b"

Table 3 indicates that Mg level change with time did not follow the same pattern in all the three layers of flyash amended soil columns and control. In layer "a" initially there was more Mg available in control than the column containing 2.5% flyash which in turn contained more Mg than that in column with 5% flyash. It decreased gradually up to the 10th day of the experiment which, however, increased sharply on the 20th day. Subsequently it came down on the 40th day which again showed an increase on the 60th day. Layer "b" showed a sharp increase in Mg concentration on the 5th day with a sudden decrease on the 10th day of the experiment. On the 20th day, the level again increased and later on up to the 60th day a gradual decrease pattern was observed. In layer "c" Mg level increased till the 10th day of the experiment which later on decreased gradually till the last day of the experiment.

Table 3. Periodic changes in available Mg (ppm) in soil columns treated with flyash*.

| Treatment | Depth | Time (days) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 5 | 10 | 20 | 40 | 60 |
| Unamended column for control | 10 cm (layer "a") | 250 | 225 | 212.5 | 250 | 180 | 200 |
| | 30 cm (layer "b") | 197.5 | 265 | 185 | 225 | 217.5 | 177.5 |
| | 50 cm (layer "c") | 230 | 265 | 290 | 275 | 247.5 | 185 |
| Column amended with 2.5% flyash | 10 cm (layer "a") | 234 | 224 | 221 | 237.5 | 1177.5 | 212.5 |
| | 30 cm (layer "b") | 201 | 253 | 203 | 210 | 217 | 193 |
| | 50 cm (layer "c") | 232 | 270 | 313 | 282 | 231 | 180 |
| Column amended with 5% | 10 cm (layer "a") | 222 | 205 | 201 | 231 | 182 | 203 |
| | 30 cm (layer "b") | 198 | 237 | 198.5 | 226 | 210 | 182 |
| | 50 cm (layer "c") | 221 | 275 | 316 | 273 | 242 | 182 |

* Available Mg (ppm) in flyash = 132.5

Flyash contains 132.5 ppm Mg which is less than that in the different layers of soil (Table 1). The decrease of Mg up to the 10th day in layer "a" was largely due to leaching effects. Subsequent sharp increase was probably due to 'time-lag effect of mobile-immobile phase phenomenon, weathering, microbial activity, etc. In the later stages leaching predominates. Due to the positional difference of layer "b" and "c" which receive the leachates coming through layer "a" and "b", respectively, and competition between various physico chemical factors, different patterns have been observed. Layer "c" showed increase of concentration till the 10th day due to high accumulation of Mg.

The gradual decrease observed later was probably due to the overriding effect of leaching over other factors. After comparing the raw flyash and soil, and the periodic changes of the parameters pH, E.C., O.C. and available Ca and Mg in various layers, it seems that flyash amendment of the above type can be practiced as far as these parameters are concerned but other parameters also need intensive study.

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# Dielectrophoresis of Chloroplasts — A New Technique in Biomonitoring of Low Levels of $SO_2$

**Adeel Ahmed**, M.S.R. Murthy*, S.H. Raza*, G.G. Krishna****

*Department of Botany, Osmania University, Hyderabad 500007
**Department of Physics, Nizam College, Hyderabad 500001

## Abstract

Neutral matter subjected to 'Nonuniform Electric Fields' undergoes translational motion due to the action of dielectrophoretic force and the phenomenon is called dielectrophoresis. Dielectrophoresis acting on dielectric constant rather than on net charge has proven useful in investigations on the physiology and biochemistry of living matter. The chloroplasts of *Croton bonplandianum* collected from different environmental conditions were subjected to dynamic dielectrophoresis in spherical field geometry. Dielectrophoretic collection of chloroplasts was measured as a function of applied frequency and conductivity of the suspension. There was a characteristic difference in the dielectrophoretic behaviour of chloroplasts between control, polluted area plants and $SO_2$ fumigated plants. A characteristic relationship was observed between the dielectrophoretic response of chloroplasts and degree of damage caused to plants. The dielectrophoretic studies on chloroplasts of plants growing in polluted environments would be helpful in biomonitoring and assessing the impact of air pollution at subcellular level.

## Introduction

Dielectrophoresis is the translational motion of neutral matter caused by polarization effects in nonuniform electric fields (NUEF). Dielectrophoresis differs from electrophoresis in which a charged particle migrates towards the opposite polarity to that of charge carried by the particle whatever may be the electric field, uniform or nonuniform. It is found to have enormous biological applications, *viz.* in differentiating the cells that differ in kind or nutrient state, in distinguishing diseased from normal cells, in separating living cells from dead, in unravelling the nature of living systems, etc. (Crane and Pohl, 1978; Gopala Krishnan *et al.*, 1983; Pohl, 1973; Pohl and Hank, 1966).

The dielectrophoretic response of living cells suspended in aqueous media varies characteristically and considerably with the frequency of the applied field, conductivity of the liquid medium and physiological state of cell or organisms (Crane and Pohl, 1978). Under prolonged exposure to low levels of $SO_2$, plants experience chronic injury leading to physiological and biochemical decline especially affecting the chloroplasts machinery (Ayazloo *et al.*, 1982; Wellburn *et al.*,1972). Such a decline in physiology and biochemistry also alters the polarization characters of chloroplasts leading to changes in dielectrophoretic behaviour. The dielectrophoretic studies on this organelle would reveal direct and rapid information on phytotoxicity of $SO_2$. In view of this, the present investigation has been taken up with the following objectives: (1) to evaluate the influence of certain physical variables such as frequency of the applied electric field and conductivity of the suspension on dielectrophoretic behaviour of chloroplasts (2) to characterize the frequency of peaks and shifts of dielectrophoretic response of chloroplasts with the degree of damage caused by $SO_2$ pollution (3) to compare the dielectrophoretic response of control plants with the plants collected from industrial areas and those treated with $SO_2$ experimentally (4) to assess the possibility of using dielectrophoretic response of chloroplasts for biomonitoring and controlling air pollution.

## Material and Methods

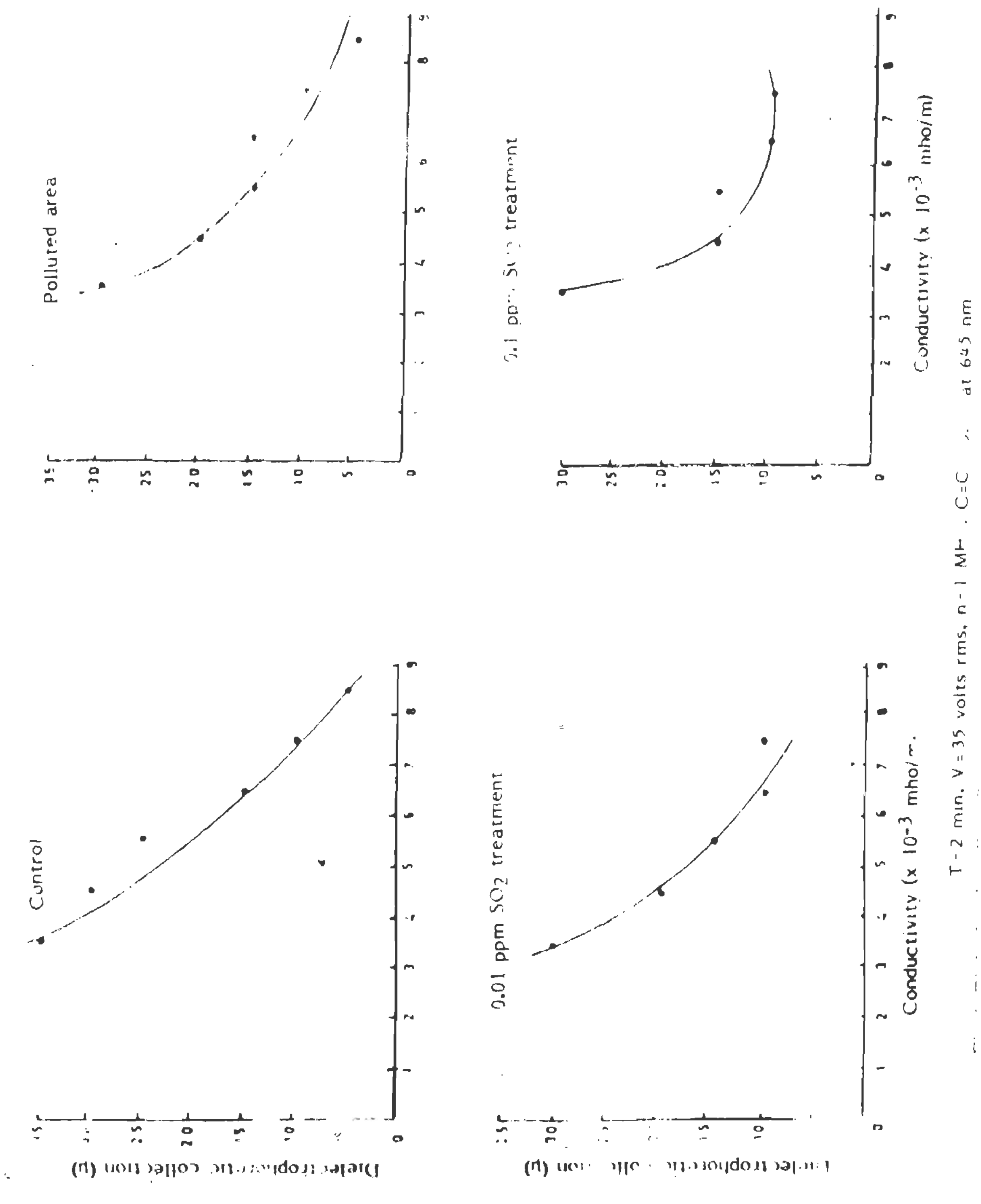
Dielectrophoresis was done in a pin-pin type electrode chamber. A pair of platinum wires of 300 μ diameter was placed 1 mm above the surface of a glass slide in such a way that their axes lie along the same straight line with their rounded tips facing each other and were separated by 350 microns. The wires were passed through a nonconducting ring of 0.3 ml capacity and 1.0 cm internal diameter. When this ring was cemented on a glass slide it formed the pin-pin electrode chamber to produce spherical field geometry. The electrode chamber was mounted on a conventional microscopic stage and observations were made with an eye piece micrometer marked into 100 division/cm each corresponding to 10 microns at 10X of the objective. The A.C. signals were drawn from an oscillator (Radart Signal Generator Type 922-8), the frequency and voltage of which were measured by a double beam oscilloscope (Phillips GM 6012). The signals were amplified using a two stage amplifier, constructed in our laboratory (Anwar Ali,1983). Conductivity meter (Systronics-305) and Spectro colorimeter (Systronics-13) were used to determine conductivity and concentration (OD at 670 nm) of chloroplast suspension, respectively.

The dielectrophoretic behaviour was evaluated for the chloroplast isolated from *Croton bonplandianum*, a highly abundant plant in industrial areas of Hyderabad. The annual mean of $SO_2$ levels in the area were 40 $\mu g/m^3$ and 4 h peak concentrations were 125 $\mu g/m^3$ (Murthy, 1987). The selection of plants was also made on the basis of their suitability for easy isolation of chloroplasts. A set of plants was also exposed to 0.01 ppm and 0.1 ppm of $SO_2$ daily for 5 h for a period of 15 days using the standard methods (Katz, 1968). Leaf samples were collected from control, $SO_2$ treated plants and also from industrial areas in early morning. While collecting plant samples from the field, care was taken to see that sampling was done at isoecological conditions of temperature, light and soil.

Chloroplasts were prepared from 10 g of fresh leaves in 100 ml of 0.05 M Tris buffer (pH 7.4) containing 1M EDTA, 5 mM mercapto ethanol and 0.01% bovine serum albumin (Ting *et al.*, 1971). The chloroplasts were suspended in isotonic glycine and glucose mixture (1.5% glycine and 4% glucose in the volume ratio 9:1). The chloroplast suspensions were kept on ice prior to dielectrophoresis and the experiment was carried out at room temperature. The dielectrophoretic response of chloroplasts as a function of conductivity was found out at a fixed frequency, voltage, elapsed time and concentration of the suspension and as a function of frequency was carried out at a fixed conductivity, voltage, elapsed time and concentration. The chloroplast suspension of fixed volume (0.2 ml) was dropped into the chamber and the signals were applied between the platinum electrodes. The chloroplasts were collected at the rounded tips of the electrodes in the form of pearl chains. The average chain length was measured for 2 minutes under microscope which gives the 'Dielectrophoretic Collection'.

## Results

The data on conductivity and yield of chloroplasts of *C. bonplandianum* are presented in Fig.1. The yield spectrum is a nonlinear function of conductivity. The



Control
Polluted area
0.01 ppm SO2 treatment
Conductivity (x 10-3 mho/m)
T - 2 min, V = 35 volts rms

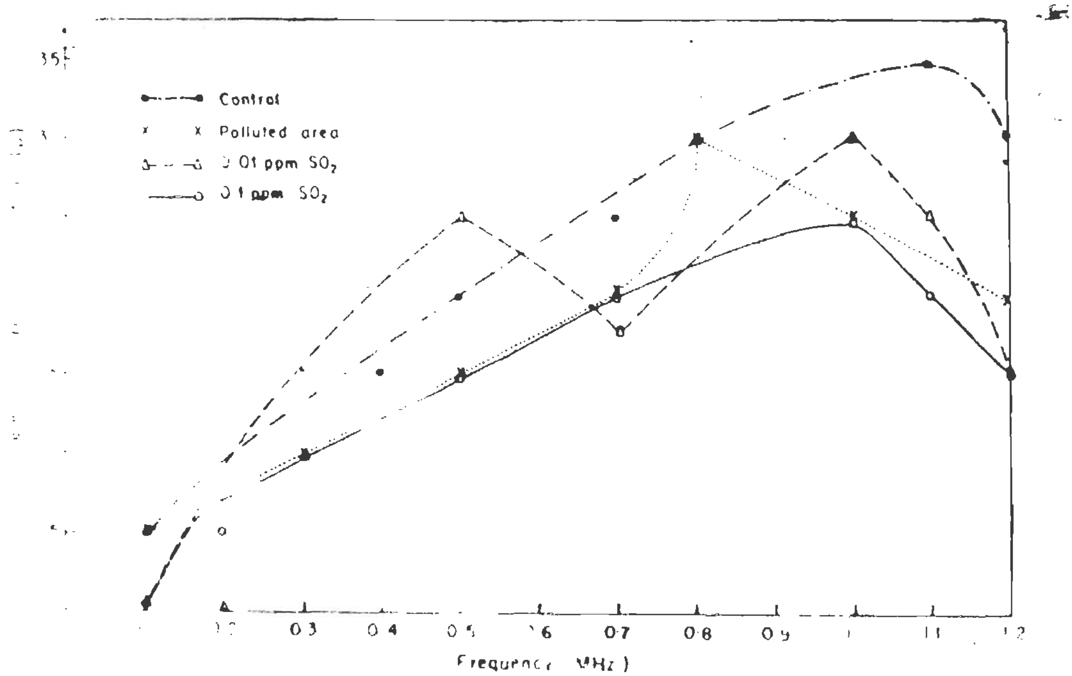



Fig.2 Dielectrophoretic collection of *Croton bonplandianum* chloroplasts as a function of frequency.

phenomenon was well exhibited in control plants when the maximum collection of 35 microns was found at $3.5 \times 10^{-3}$ mho/m and 5 microns at the maximum conductivity $8.5 \times 10^{-3}$ mho/m. The dielectrophoretic collection decreased steeply in the plants of polluted area and $SO_2$ treatment. In all the cases the maximum collection was 30 microns at $3.5 \times 10^{-3}$ mho/m. However, practically there was no collection at $8.5 \times 10^{-3}$ mho/m conductivity in $SO_2$ treated plants.

The dielectrophoretic collection of chloroplasts in *Croton* as a function of frequency is presented in Fig.2. In control plants the collection was found to be nonlinear with a frequency peak of 35 μ at 1.1 MHz. In polluted plant samples, the peak gets shifted to 0.8 MHz and collection was also comparatively less. In low concentration treated plants two frequency peaks were noticed at 0.5 MHz and 1 MHz. However, beyond 1 MHz the collection declined drastically. In plants treated with high concentration (0.1 ppm) of $SO_2$ there was a maximum collection at 1 MHz. However, maximum length of pearl chain was 25 microns as compared to high collections in control plants.

## Discussion

Strictly speaking ideal or perfect dielectrics do not exist in practice and they are only theoretical models having zero conductivity. An ideal dielectric will have a finite nonzero inphase dielectric constant and a zero valued out of phase dielectric constant. However, real dielectrics do conduct and a biological suspension exhibits both conductivity and polarizability. Hence the dielectrophoretic response of living cells and of various other particles suspended in liquid or gaseous media strongly depends on the frequency of the applied field and the conductivity of the medium. When dielectrophoresis is applied to cells and organelles it reflects the polarization mechanisms sensitive to their physiological state. The physiological state of chloroplast under sulfurdioxide pollution is much altered as the chloroplasts are the primary targets of $SO_2$ toxicity for the damage (Asado and Kiso, 1973; Tanaka and Sughara, 1980; Wellburn *et al.*, 1972).

Similarly, in the present investigation also, considerable reduction in chlorophyll content was observed in plants growing in polluted areas. This was further confirmed by controlled field exposure studies. An increase in foliar sulfate content was found in the plants of industrial areas and in $SO_2$ treated plants than in control. The relative per cent water content was found reduced in $SO_2$ treated plants and in plants growing in industrial sites. Therefore, the results conclude that the plants under experimentation were considerably affected by $SO_2$ pollution and would have a greater bearing on the polarization characters of chloroplasts leading to differences in dielectrophoretic behaviour.

The dielectrophoretic collection as a function of conductivity was found to be nonlinear. In plants treated with high concentrations of $SO_2$ the dielectrophoretic collection was found to be poor. It might be due to the change in membrane permeability, loss of water and accumulation of ions like $SO_3^{2-}$, $SO_4^{2-}$, $OH^-$ , etc. (Kellar and Jager, 1980). In our investigation also decrease in relative water content and accumulation of sulfate in leaves was observed. Such an altered internal ionic environment shows ready variance as a result of change in the conductivity of the suspending medium. At the fixed frequency of 1 MHz, dielectrophoretic collection declined with increased conductivity which might be due to changes in Maxwell Wagner interfacial bulk polarization caused at membrane level. The dielectrophoretic collection was found to be zero at higher conductivities of the suspension in $SO_2$ treated plants. This is because of the fact that polarization shows a steady decline when the conductivities of particle and the medium approach each other (Ayazloo *et al.*, 1982).

The polarization changes due to physiological decline were characterised by the frequency peaks and shifts of dielectrophoretic collection of chloroplasts. In plants growing under polluted conditions dielectrophoretic collection of chloroplasts was relatively less with a peak at 0.8 MHz. This was due to the altered polarizability caused by the loss of polar substances like water and accumulation of $SO_4$ in the plants growing in industrial area. The peak at this level was associated with Maxwell-Wagner interfacial bulk polarization probably modified by surface associated conductivity which can operate on the material enclosed within the individual thylakoids (Pohl, 1973). Further, the dielectrophoretic response at this altered frequency peak in relation to control could be identified as the manifestation of existing degree of pollution.

Similarly, in $SO_2$ treated plants also there was a backward shift in the frequency maxima as compared to control, followed by decreased collection of chloroplasts. This trend gains support from the studies of Wiley (1970) on canine erythrocytes where it was reported that there was a decline in erythrocytes collection followed by shift in the frequency from 1 MHz to 100 MHz due to sodium cyanide, a respiratory inhibitor. The frequency shifts and decreased collection must have resulted mainly from loss of water, sulfate accumulation and chlorophyll reduction. These factors bring ionic imbalances in the chloroplasts (Keller and Jager, 1980) and could affect or alter the conductivity of stromal matrix thereby changing the yield spectra at surface conductance modified Maxwell Wagner polarization frequency ranges. It has also been reported in other experiments on chloroplasts (Pohl, 1973), on canine erythrocytes that the relative stabilisation of dielectrophoretic collection was due to ionic losses or to the maintenance of stable ionic environment in the interior of the cells. Therefore, dielectrophoretic response at these frequency ranges in $SO_2$ treated plants revealed that the toxicity of $SO_2$ might also change the properties of membrane. Further, at higher dosages the yield spectra became poor which showed that chloroplasts are more damaged at high concentration.

The study revealed that changes caused in physiological and biochemical characters of chloroplasts by $SO_2$ pollution would alter the yield spectra of chloroplasts. On the other hand, it would also provide a good means to characterise the frequency peaks and shifts with the specific damage caused. Hence, the dielectrophoretic studies on chloroplasts of plants growing in polluted environments would be helpful in assessing the degree of air pollution. Once the real significance of the frequency peaks and shifts of chloroplasts was unfolded and characterised with the help of different biochemical and physiological analysis, the technique can be conceivably used to study the mechanism of action of different pollutants on structure and function of chloroplasts. The technique will be more useful when studied at wide range of frequencies (100 Hz to 100 MHz) in evaluating the resistance and susceptibilities of plants to air pollution. The dielectrophoretic technique, at such wide range of frequencies, has the potential to translate the pollutant effects at all structural levels including interior of the organelles within a minimum time period of testing. This time period may minimise the probability of interference of reversible changes caused in the primary site of action of different gaseous pollutants.

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# Effect of Cement Factory Kiln Exhaust on Nature of Stomata and Physiology of Some Plants

**K. Swaminathan, S. Pongaliappan and T. Gunamani**
Department of Botany, Kongunadu Arts and Science College, Coimbatore 641029.

## Abstract

The cement factory kiln exhaust caused retardation in plant growth, necrosis, cracks, injuries and border effect on trunks, branches and leaves of some plants. The stomatal morphology, index, size and number, and epidermal cell number were not significantly affected by kiln exhaust but the nature of the stomata was greatly affected. The effects included plugging of stomatal aperture, closure of stomata, deformation of guard cells and malformation of subsidiary cells. These effects in turn reduced the rate of photosynthesis, carbohydrate content and rate of respiration which led to retardation in growth of the plants.

## Introduction

The earth's atmosphere is one of the most important requirements for all living beings for performing essential life functions. The living beings take air from atmosphere for respiration, photosynthesis, nitrogen fixation , etc. and discharge unwanted gas and wastes into the atmosphere to some extent. But due to rapid expansion of industries and population explosion, the pollution in atmosphere has increased enormously. Air pollution is caused by various types of pollutants like smoke, dust, fumes, mists, gases, radioactive substances, organic and inorganic materials. Cement dust, a common air pollutant in the vicinity of cement factories and construction places, has significant and devastating effects on plants under both cultivated and natural conditions. In the present investigation, the effect of kiln exhaust of Madukkarai Cement Factory, Caimbatore, on some plants was studied.

## Material and Methods

The plant samples were collected from sites located in the north east side of the factory which corresponded to the wind direction during the study period. These sites were nearly 1km away from the factory. The control plant samples were collected nearly 15 km away from the factory. The following plants were selected for study : *Azadirachta indica* L., *Cocos nucifera* L., *Mangifera indica* L., *Prosopis cineraria* (L) Druce and *Tamarindus indica* L. The leaf samples were collected from different trees at random from a height of 2 to 3 m above the ground level, keeping the age of leaves and their location from the tip of the trunk or branch constant.

Epidermal peelings were prepared by the method of Hickey (1973) and the numbers of stomata and epidermal cells were measured in different randomely selected epidermal peelings. In the case of polluted leaves, the affected stomatal percentage was calculated. The stomatal length and width were measured by using micrometres. Stomatal types of normal and polluted area were recorded. The stomatal index (SI) was calculated by the following formula :

$$SI = \frac{\text{Number of stomata}}{\text{Number of stomata + Number of epidermal cells}} \times 100$$

The chlorophyll content of the leaf samples was estimated by the method of Arnon (1949). Starch content was estimated by the method of Yoshida *et al.* (1976) and reducing sugars by Nelson (1944) and Somogyi (1952) method. The rate of photosynthesis and respiration in leaf samples were estimated by using Infra Red Gas Analyser (Umbriet *et al.*, 1972).

## Results and Discussion

The chemical composition of the kiln exhaust is presented in Table 1. The observations made on the plants selected revealed that the morphological features of the plants growing in the vicinity of the cement factory were very much affected by the cement factory kiln exhaust. The plants were fully covered by dust particles and exhibited cracks on the trunks and branches. the size of the leaves was greatly reduced and they showed necrosis and chlorosis. In *T.indica and P. cineraria,* the number of pinnae/panicles was also reduced.

Table 1. Chemical composition of cement factory kiln exhaust

| | Chemical components | Percentage |
|---|---|---|
| A. | Solid components : | |
| | Calcium oxide | 50.00 |
| | Silicon oxide | 9.50 |
| | Aluminium oxide | 5.50 |
| | Ferric oxide | 2.50 |
| | Sulphur trioxide | 1.25 |
| B. | Gaseous components : | |
| | Carbondioxide | 25.00 |
| | Sulphurdioxide | 2.00 |
| | Nitrous oxide | 1.00 |
| | Carbon monoxide | Trace |

Sharma and Dunn (1969) stated that the pattern of stomatal development, stomatal type, types of trichomes and stomatal index could be used as criteria for pollution. In the present study, the effect of kiln exhaust on leaf stomatal morphology and number, and length, width and number of epidermal cells were used as pollution indicators. The results (Table 2, 3 and 4) showed that the type of stomata was not affected by the kiln exhaust. The number of stomata was only slightly altered in all the plants studied, but different plants responsed in different patterns. Similarly, the epidermal cells of different plants responded differently to kiln exhaust. These results indicated that none of the epidermal traits were consistently modified by the kiln exhaust. The modifications were neither specific nor characteristic of each plant (Posthumus, 1976). Walker and Dunn (1967) and Krishnamurthy (1978) stated that the stomatal type was extremely variable in the same plant even under non-polluted environment. So it is very difficult to use the epidermal characters as pollution indicators.

Even though the stomatal morphology, number and index, and epidermal cell number were not significantly affected, the nature of the stomata was much affected by kiln exhaust. The affected stomatal percentage varied from a minimum of 9.97% in *M.indica* to a maximum of 44.44% in *T. indica* leaves. The damage to stomata included

Table 2. Effect of cement factory kiln exhaust on stomatal type and stomatal index in leaves.

| Name of the plant | Stomatal type | | | | Stomatal index | | | | Affected stomatal percentage | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adaxial | | Abaxial | | Adaxial | | Abaxial | | Adaxial | | Abaxial | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Azadirachta indica* | — | — | Anomo-cytic | Anomo-cytic | — | — | 10.5169 ± 0.9636 | 9.4475 ± 0.6044 | — | — | — | 15.81 ± 2.91 |
| *Cocos nucifera* | — | — | Grami-nuous | Grami-nuous | — | — | 6.3297 ± 1.7112 | 11.5474 ± 3.4727 | — | — | — | 22.98 ± 1.56 |
| *Mangifera indica* | — | — | Para-cytic | Para-cytic | — | — | 8.4032 ± 0.2312 | 4.0844 ± 3.3249 | — | — | — | 9.97 ± 1.90 |
| *Prosopis cineraria* | Parcytic- & anomo-cytic | Paracytic & anomo-cytic | Paracytic & anomo-cytic | Paracytic & anomo-cytic | 13.0168 ± 1.1148 | 19.0906 ± 1.1164 | 7.0622 ± 1.0372 | 9.4887 ± 1.0902 | — — | 27.41 ± 2.84 | — — | 36.28 ± 3.86 |
| *Tamarindus indica* | Para-cytic | Para-cytic | Para-cytic | Para-cytic | 2.5471 ± 0.6379 | 6.0352 ± 0.9285 | 14.5385 ± 0.8376 | 20.2444 ± 0.5402 | — | 44.44 ± 3.85 | — | 39.33 ± 2.73 |

Table 3. Effect of cement factory kiln exhaust on the number, length and width of stomata in leaves.

| | Stomatal number | | | | Stomata length (µm) | | | | Stomatal width (µm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adaxial | | Abaxial | | Adaxial | | Abaxial | | Adaxial | | Abaxial | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Azadirachta indica* | — | — | 33.666 ± 0.6999 | 31.666 ± 4.496 | — | — | 21.687 ± 0.5044 | 22.577 ± 1.2562 | — | — | 18.133 ± 0.8695 | 10.517 ± 0.9635 |
| *Cocos nucifera* | — | — | 7.666 ± 1.247 | 12.0 ± 0.8164 | — | — | 34.843 ± 0.5044 | 41.587 ± 3.0311 | — | — | 22.4 | 19.910 ± 1.8140 |
| *Mangifera indica* | — | — | 47.333 ± 3.858 | 50.666 ± 5.557 | — | — | 18.843 ± 1.0088 | 17.420 ± 0.5020 | — | — | 23.107 ± 1.3300 | 19.553 ± 1.3300 |
| *Prosopis cineraria* | 16.0 ± 1.4142 | 23.333 ± 1.247 | 7.333 ± 1.247 | 11.667 ± 1.6996 | 25.6 ± 2.303 | 21.33 | 25.2466 ± 1.3300 | 24.887 ± 1.3345 | 18.84 ± 2.799 | 19.2 ± 1.7391 | 18.843 ± 1.0088 | 19.553 ± 1.0064 |
| *Tamarindus indica* | 3.0 ± 0.8164 | 7.667 ± 4.714 | 23.333 ± 1.247 | 29.0 ± 5.099 | 17.776 ± 1.33 | 20.257 ± 0.8573 | 17.066 ± 0.8695 | 19.2 ± 0.8736 | 15.643 ± 0.5044 | 15.643 ± 1.3345 | 13.153 ± 1.0064 | 17.420 ± 1.0040 |

plugging of stomatal aperture by particulate particles, closure of stomata, deformation of guard cells or malformation of subsidiary cells.

Table 4. Effect of cement factory kiln exhaust on epidermal cell number in leaves

| Name of the plant | Epidermal cell numbers | | | |
|---|---|---|---|---|
| | Adaxial | | Abaxial | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Azadirachta indica* | 223.666 (± 14.7044) | 237.666 (± 15.965) | 228.333 (± 24.2807) | 305.0 (± 47.770) |
| *Cocos nucifera* | 101.0 (± 10.9848) | 108.666 (± 9.2855) | 117.333 (± 19.618) | 95.333 (± 20.805) |
| *Mangifera indica* | 212.333 (± 11.3235) | 252.333 (± 10.873) | 415.666 (± 36.740) | 456.0 (± 42.926) |
| *Prosopis cineraria* | 108.0 (± 14.966) | 99.333 (± 8.9566) | 102.333 (± 14.007) | 111.0 (± 5.887) |
| *Tamarindus indica* | 116.0 (± 18.882) | (120.666 (± 13.199) | 142.0 (± 16.329) | 114.666 (± 21.7460) |

Gaseous and many particulate pollutants are known to cause chlorosis in leaves and other green parts of plants (Capron and Mansfield, 1976; Rao and Pal, 1978; Madhoolika Agrawal *et al.*, 1982 and 1985; Patel and Sakuntaladevi 1986). In the present investigation also a significant reduction in the toal chlorophyll content was observed in the leaves polluted by cement dust particles (Table 5). The maximum reduction occured in the leaves of *M.indica* (61.78%) and minimum in *A. indica* (13.72%). Along with the reduction in total chlorophyll content, reduction in chlorophyll 'a' and 'b' contents was also observed in polluted leaves. This reduction in chlorophyll content could be due to the degradation of chlorophyll into phaeophytin by the loss of $Mg^{2+}$ ions (Rao and Le Blanc, 1966; Singh and Rao, 1980), induction of the chlorophyllase enzyme activity which could degrade chlorophyll or inhibition of chlorophyll formation by the pollutants (Chang, 1975).

The rate of photosynthesis was drastically reduced in the plants growing in the vicinity of cement factory (Table 6). The maximum reduction was observed in *P.cineraria* (68.40%) while the minimum was in *A.indica* (0.71%). This reduction in photosynthetic rate resulted in a corresponding decrease in carbohydrates of the leaves such as starch, total sugars and reducing sugars. This reduction in photosynthetic rate and carbohydrate level could be due to the following reasons : (1) the dust particulates that completely covered the leaves might have interfered with the incidence of sunlight by acting as light screens (2) reduced canopy, retarded growth, reduced chlorophyll content, leaf necrosis, injuries border effects and reduced number and size of leaves of polluted plants resulted in a total reduction in photosynthetic activity (3) the plugging of stomatal aperture by particulate particles, closure of stomata, deformation of guard cells and malformation of subsidiary cells (Table 2) might have inhibited the gaseous exchange resulting in reduced rate of photosynthesis. This was further supported by the reduction in rate of respiration (Table 7) which also involved exchange of gases (4) There might have been a reduction in Hill's reaction due to kiln exhaust as reported by Chang (1975) in fluoride polluted plants.

Table 5. Effect of cement factory kiln exhaust on chlorophyll content in leaves.

| Name of the plant | Total Chlorophyll (mg/g of leaf) | | | Chlorophyll 'a' (mg/g of leaf) | | | Chlorophyll 'b' (mg/g of leaf) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal leaf | Polluted leaf | % Inhibition | Normal leaf | Polluted leaf | % Inhibition | Normal leaf | Polluted leaf | % Inhibition |
| *Azadirachta indica* | 0.9149 ± 0.0121 | 0.7894 ± 0.0027 | 13.72 | 0.5611 ± 0.0317 | 0.4456 ± 0.0261 | 20.58 | 0.3442 ± 0.0927 | 0.3361 ± 0.0147 | 2.35 |
| *Cocos nucifera* | 0.9691 ± 0.0232 | 0.3961 ± 0.0027 | 59.13 | 0.7301 ± 0.0012 | 0.2667 ± 0.0059 | 63.47 | 0.2268 ± 0.0690 | 0.1249 ± 0.0259 | 44.93 |
| *Mangifera indica* | 0.8868 ± 0.0419 | 0.3379 ± 0.0094 | 61.78 | 0.3035 ± 0.0039 | 0.2854 ± 0.0275 | 5.96 | 0.5507 ± 0.0429 | 0.0478 ± 0.0032 | 91.32 |
| *Prosopis cineraria* | 0.9515 ± 0.0325 | 0.7841 ± 0.0231 | 21.38 | 0.3139 ± 0.0937 | 0.2969 ± 0.0197 | 5.42 | 0.6316 ± 0.0195 | 0.4457 ± 0.0113 | 29.43 |
| *Tamarindus indica* | 0.5929 ± 0.0093 | 0.2610 ± 0.0063 | 55.98 | 0.3286 ± 0.0067 | 0.1360 ± 0.0069 | 58.61 | 0.2586 ± 0.0074 | 0.1227 ± 0.0056 | 52.55 |

Table 6. Effect of cement factory kiln exhaust on rate of photosynthesis and carbohydrate content in leaves.

| Name of the plant | Rate of photosynthesis (mg $CO_2$ uptake/$m^2$/sec) | | | Starch (mg/g of leaf) | | | Total sugars (mg/g of leaf) | | | Reducing sugars (mg/g of leaf) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal leaf | Polluted leaf | % Inhibition | Normal leaf | Polluted leaf | % Inhibition | Normal leaf | Polluted leaf | % Inhibition | Normal leaf | Polluted leaf | % Inhibition |
| *Azadirachta indica* | 0.4624 ± 0.0231 | 0.4591 ± 0.0827 | 0.71 | 26.5 ± 1.5 | 19.5 ± 1.8 | 26.42 | 24.32 ± 2.297 | 22.08 ± 1.627 | 9.21 | 6.880 ± 1.121 | 3.280 ± 0.762 | 52.33 |
| *Cocos nucifera* | 0.2881 ± 0.0019 | 0.2628 ± 0.0820 | 8.78 | 31 ± 1.7 | 22.5 ± 3.6 | 27.42 | 24.0 ± 1.926 | 22.72 ± 3.710 | 5.33 | 7.040 ± 1.265 | 5.760 ± 1.971 | 18.18 |
| *Mangifera indica* | 0.3812 ± 0.0968 | 0.2446 ± 0.0739 | 31.05 | 55 ± 3.2 | 33 ± 4.6 | 40.00 | 22.08 ± 1.133 | 16.20 ± 3.215 | 26.63 | 8.640 ± 0.825 | 4.320 ± 0.927 | 50.00 |
| *Prosopis cineraria* | 0.4899 ± 0.1087 | 0.1548 ± 0.0083 | 68.40 | 38 ± 3.3 | 19 ± 2.2 | 50.00 | 18.24 ± 2.625 | 12.32 ± 1.127 | 32.45 | 6.080 ± 1.635 | 2.520 ± 0.0078 | 58.55 |
| *Tamindus indica* | 0.2839 ± 0.0742 | 0.1683 ± 0.0084 | 40.72 | 20.5 ± 2.1 | 10.5 ± 1.9 | 48.78 | 18.24 ± 1.716 | 12.48 ± 0.997 | 31.58 | 6.720 ± 0.416 | 2.560 ± 0.0078 | 61.90 |

Table 7. Effect of cement factory kiln exhaust on rate of respiration

| Name of the plant | Rate of respiration (mg $CO_2$ released/$m^2$/sec) | | |
|---|---|---|---|
| | Normal leaf | Polluted leaf | % Inhibition |
| *Azadirachata indica* | 0.5360 (± 0.0392) | 0.3231 (± 0.0257) | 39.72 |
| *Cocos nucifera* | 0.4802 (± 0.0132) | 0.4097 (± 0.0963) | 14.68 |
| *Mangifera indica* | 0.5664 (± 0.046) | 0.4280 (± 0.0257) | 24.44 |
| *Prosopis cineraria* | 0.5511 (± 0.1105) | 0.1596 (± 0.0062) | 71.04 |
| *Tamarindus indica* | 0.4271 (± 0.0216) | 0.2271 (± 0.0139) | 46.83 |

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# Effect of Cement Dust on the Leaf Anatomy and Dermal Appendages of Some Plants

**T. Gunamani, R. Gurusamy and K. Swaminathan**
Department of Botany, Kongunadu Arts and Sciences College, Coimbatore 641029.

## Abstract

Enormous amount of cement kiln dust is deposited on the flora present in the vicinity of the cement factory at Madukkarai, Coimbatore. The cement kiln exhaust affected the morphology and anatomy of five plants selected. The aerial parts of all the plants were coated fully with the dust. The deleterious effects of the dust on the morphology of the leaves included reduction in leaf size, necrosis, change of colour, curling of leaves, etc. Anatomically, the leaf thickness was altered, the epidermal cell wall was modified, the epidermal cell number increased and the size decreased. The number and size of the trichomes decreased. Due to heavy deposition of the cement kiln dust, a significant percentage of stomata were clogged. The various other abnormalities observed were giant stomata, stomata with single cell, shrinkage of guard cells, etc.

## Introduction

Atmospheric pollutants adversely affect plants in various ways. The histological changes most commonly noted in pollution injured leaves include plasmolysis, granulation or disorganization of cell contents and cell collapse or disintegration (Darely and Middleton, 1966). Parthasarathy *et al.* (1975) studied the effect of cement dust on maize crop and found that most of the characters like leaf size, number and size of cobs, and plant height have been suppressed when compared to plants in non-polluted fields. Dry cement kiln dust appears to have little deleterious effect. But in the presence of moisture, the dust solidifies into a hard adherent crust which can damage plant tissue and inhibit growth. The present study was undertaken to assess the effects of cement kiln dust pollution on the leaf anatomy and dermal appendages of some plants near a cement factory in Madukkarai area which is 15 km away from Coimbatore City. The sedimentation rate of the cement kiln dust was estimated as 2.430 $g/m^2/day$.

## Material and Methods

The materials were collected from herbs growing near the Madukkarai Cement Factory. The plants selected for the present study were *Achyranthes aspera* L. var. *aspera, Calotropis gigantea* (L) R. Br. *Catharanthus pusillus* (Murr) G. Don., *Croton bonplandianum* Bail. and *Peristrophe paniculata* (Forssk) Br.

Polluted leaves were collected periodically from different herbs at random, keeping the age of the leaves and their position on branch constant. Unpolluted leaves were collected from in and around Kongunadu Arts and Science College campus which is 15 km away from the factory site. Care was taken to see that the collection of control materials was done from plants of the same age, variety and height, growing under identical edaphic and climatic conditions. Fixation of both polluted and control materials was done in the field in FAA. Then they were processed for microtomy using T.B.A. series and paraffin embedding medium (Johanson, 1940).

To obtain trichome measurements, small segments of leaves were removed from near the midregion avoiding major veins and their free hand sections were obtained and mounted in water after staining with safranin. Alternatively, trichomes were scraped off of the leaf surface into a drop of water. For each type of trichome, length, width and number of cells per trichome were determined on both upper and lower epidermal surfaces.

To study the stomata, epidermal peelings were prepared by subjecting the leaf bits to Jeffrey's maceration fluid. Good peels were obtained in all cases except *C. gigantea*. For this plant, peelings were obtained using copper sulphate nitric acid solution. The solution was prepared by dissolving 10 g of copper sulphate crystals in 100 ml of boiled water. After cooling, 20 ml of concentrated nitric acid was added. Leaves were left in this solution for 24 h after which upper and lower epidermis peeled off without any damage. After thorough washing in water, the peelings were stained with Heidenheins haematoxylin or tannic acid and ferric chloride (Foster, 1934).

After removing the deposited dust from the polluted leaf, cross sections of the leaves were taken at a thickness of 10.15 $\mu$ using microtome. The thickness of the lamina was calculated and compared with that of unpolluted leaves. The number of stomata, epidermal cells and trichomes were measured in 10 different randomly selected areas. To avoid border effect, epidermal peelings were made only from middle portion of the leaf half way between the margin and midrib. Samples were chosen in the same way for calculating stomatal index which was worked out using the formula.

$$SI = \frac{\text{Number of stomata}}{\text{Number of stomata + Number of epidermal cells}} \times 100$$

For vein clearance, the leaves were boiled in 5% sodium hydroxide solution for 5 min, washed in distilled water and stained with safranin.

## Results and Discussion

*Effect on leaves*

In *A.aspera* and *P.paniculata* the size of the leaf was reduced and the tip portion was damaged. In *G.gigantea*, though there was no reduction in the leaf size the colour of the leaf changed to grey in polluted plants. Due to heavy deposition of the cement dust in *C. pusillus* the colour of the plant changed to yellow. In *C. bonplandianum* the leaves of polluted plants were curved when compared to plants in unpolluted area.

*Structure of leaf*

In *A. aspera, C. gigantea, C. pusillus* and *C. bonplandianum*, the length of the palisade parenchyma increased in polluted leaves when compared to the normal leaf (Table 1). In leaves where the palisade parenchyma increases in length, the shape of the spongy parenchyma becomes irregular and the inter cellular air space area increases. Because of the increase in palisade parenchyma, the thickness of the leaf also increased. In *P. paniculata* the leaf thickness was reduced in polluted leaves when compared to the normal leaves.

Table 1. Effect of cement dust on lamina thickness and palisade length

| Name of the plant | Lamina thickness (μ) | | Palisade parenchyma length (μ) | |
|---|---|---|---|---|
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 153 ± 17.493 | 261 ± 52.478 | 81 ±7.348 | 193 ± 54.837 |
| *Calotropics gigantea* | 357 ± 32.031 | 525 ± 53.665 | 114 ±15.297 | 183 ± 17.493 |
| *Catharanthus pusillus* | 195 ± 13.416 | 227 ± 30.265 | 105 ± 9.486 | 120 ± 9.486 |
| *Croton bonplandianum* | 126 ± 14.283 | 174 ± 15.290 | 75 ± 0 | 81 ± 7.348 |
| *Peristrotphe paniculata* | 135 ± 11.225 | 92 ± 6.782 | 63 ± 6 | 45 ± 9.486 |

Table 2. Effect of cement dust on the number of epidermal cells per 0.109 sq mm in leaves

| Name of the plant | Adaxial epidermis | | Abaxial epidermis | |
|---|---|---|---|---|
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 35.666 ± 2.494 | 78.33 ± 2.494 | 46.0 ± 2.944 | 70.04 ± 7.789 |
| *Calotropics gigantea* | 241.33 ± 15.628 | 344.33 ± 14.009 | 278.0 ± 13.140 | 289.0 ± 9.933 |
| *Catharanthus pusillus* | 60.0 ± 4.082 | 105.0 ± 14.719 | 89.33 ± 3.299 | 101.0 ± 13.491 |
| *Croton bonplandianum* | 177.33 ± 13.199 | 251.0 ± 23.437 | 129.33 ± 13.072 | 259 ± 23.289 |
| *Peristrotphe paniculata* | 60.0 ± 7.4833 | 79.0 ± 7.788 | 66.0 ± 12.328 | 69.66 ± 8.219 |

Table 3. Effect of cement dust on trichome number per 0.10896 sq.mm. in leaves

| Name of the plant | Type of trochomes | Adaxial surface | | Abaxial surface | |
|---|---|---|---|---|---|
| | | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | Unicellular | 6 | 4 | 7 | 5 |
| *Calotropics gigantea* | — | — | — | — | — |
| *Catharanthus pusillus* | — | — | — | — | — |
| *Croton bonplandianum* | — | — | — | — | — |
| *Peristrotphe paniculata* | Unicellular | 3 | 2 | 4 | 4 |

Table 4 Effect of cement dust on the length and width of trichomes in leaves.

| Name of the plant | Length of trichomes (μ) | | | | Width of trichomes (μ) | | | |
|---|---|---|---|---|---|---|---|---|
| | Adaxial surface | | Abaxial surface | | Adaxial surface | | Abaxial surface | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 242 ± 33.794 | 160 ± 20.833 | 175 ± 20.832 | 130 ± 158.675 | 25 ± 5.099 | 16 ± 1.414 | 17 ± 2..828 | 9 ± 1.414 |
| *Calotropics gigantea* | — | — | — | — | — | — | — | — |
| *Catharanthus pusillus* | — | — | — | — | — | — | — | — |
| *Croton bonplandianum* | — | — | — | — | — | — | — | — |
| *Peristrotphe paniculata* | 249.28 ± 14.736 | 196.2 ± 38.628 | 253 ± 13.066 | 204 ± 26.870 | 20.53 ± 3.04 | 45.4 ± 5.528 | 40.20 ± 3.04 | 22.8 ± 2.403 |

*Epidermal cells*

The number of abaxial and adaxial epidermal cells per microscopic field area (0.109 sq.mm) is presented in (Table 2). It is clear from the data that in *A.aspera, C.gigantea, C.pusillus* and *C.bonplandianum* the number of epidermal cells increased due to pollution. In *C.bonplandianum* the straight anticlinal walls of the epidermal cells had become wavy. But Nareshkumar (1986) reported that the wavy anticlinal walls of the unpolluted leaves became straight due to air pollution. Others (Jafri *et al.*, 1979) have reported an increase in the number of epidermal cells. The increase in the number of epidermal cells observed in the present work needs further confirmation under different polluted environments in order to ascertain the indicator value of this character.

Longer trichomes are considered an adaptation to pollution because they are believed to act as effective insulators by trapping dust particles which may otherwise clog the stomata and adversely affect gaseous exchange (Sharma and Butler, 1975). They are also believed to probably provide shade to the leaf surface, thus lowering the leaf temperature and possibly slowing down the rate of chemical reactions harmful to plants (Treshow, 1970). But in the present study the trichome number decreased in the polluted plants (Table 3). The length and width of the trichomes also decreased in *A.aspera* and *P.paniculata* (Table 4). The reduction in the number, and length and width of the trichomes may be due to a heavy deposition of the cement kiln dust on the young developing leaves resulting in the suppression of the development and growth of the trichomes.

Cement dust pollution brings about injury in a significant percentage of stomata either during ontogeny or after full differentiation depending upon the plant. The most important factor implicated in bringing about deleterious effect on leaves is the formation of a thick coating on the surface of the leaves. In the present investiagation, the stomatal number per 0.10896 sq. mm decreased in *C.pusillus* due to pollution (Table 5). This reduction in stomatal number may be an adaptation to decrease the amount of toxic pollutants, especially gases entering the leaf (Sharma and Butler, 1975). All the other plants showed an increase in the stomatal number in polluted area. Any change in stomatal density occurs only at the formative stages of the plant part concerned when the stomata get differentiated. The stomatal index increased in all the polluted plants on the abaxical side only (Table 6). The stomatal length and width increased in all the polluted plants studied (Table 7).

The other abnormalities of stomata recorded in this study were giant stomata, shrinkage of guard cells, stomata with single guard cell, etc. In the presence of free moisture the dust particles form an alkaline environment at the stomatal opening affecting the osmotic relations of guard and subsidiary cells. Plasmolysis takes place in guard cells and some subsidiary cells and so the cell as a whole shrinks. Suppression of the development of one or both guard cells (Krishnamurthy and Rajachidambaram, 1980) is a type of ontogenetic injury while at maturity progressive shrinkage of one or occasionaly both guard cells is brought about by the dust clogging the stomata. Clogging of stomatal opening is an important factor in the reduction of gaseous exchange.

There is practically no evidence for the dust particles to be transported through the stomata into the leaf mesophyll. Different pollutants have different effects on the leaf mesophyll tissue (Krishnamurthy and Rajachidambaram, 1980). Ozone mainly affects palisade mesophyll. Sulphur oxide and flourides affect both spongy and palisade

Table 5. Effect of cement dust on stomatal number in leaves

| Name of the plant | Stomatal number in 0.10896 sq. mm | | | | Affected stomatal percentage | | | |
|---|---|---|---|---|---|---|---|---|
| | Adaxial surface | | Abaxial surface | | Adaxial surface | | Abaxial surface | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 5.66 ± 0.943 | 6 ± 0.816 | 16.666 ± 0.816 | 37.333 ± 1.659 | — | 16.6 | — | 6.25 |
| *Calotropics gigantea* | 24.66 ± 3.682 | 28.66 ± 2.055 | 24.0 ± 1 633 | 37.6 ± 1.247 | — | 25.58 | — | 17.6 |
| *Catharanthus pusillus* | 44.66 ± 2.064 | 10.333 ± 2.054 | 8 ± 1.633 | 6.66 ± 8.498 | — | 38.17 | — | 9.5 |
| *Croton bonplandianum* | 15.66 ± 0.943 | 35 666 ± 4.922 | 17.666 ± 1.247 | 49 ± 3.265 | — | 14.95 | — | 12.87 |
| *Peristrotphe paniculata* | 5.333 ± 0.471 | 20.66 ± 3.091 | 42.33 ± 4.642 | 24 ± 2.944 | — | 19.04 | — | 16.6 |

Table 6. Effect of cement dust on stomatal index

| Name of the plant | Stomatal index | | | |
|---|---|---|---|---|
| | Adaxial | | Abaxial | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 13.727 ± 2.205 | 7.12 ± 0.917 | 28.86 ± 1.945 | 35.6 ± 0.881 |
| *Calotropis gigantea* | 9.22 ± 0.738 | 7.675 ± 223 | 7.939 ± 0.738 | 11.531 ± 0.139 |
| *Catharanthus pasillus* | 11.811 ± 2.639 | 8.891 ± 0.532 | 33.325 ± 0.205 | 39.77 ± 1.005 |
| *Croton bonplandianum* | 8.132 ± 0.359 | 12.44 ± 1.015 | 12.13 ± 1.599 | 14.539 ± 0.204 |
| *Peristrophe paniculata* | 7.800 ± 0.946 | 25.77 ± 4.176 | 20.656 ± 0.967 | 35.385 ± 2.274 |

Table 7. Effect of cement dust on the length and width of stomata in leaves

| Name of the plant | Length of the stomata (μ) | | | | Width of the stomata (μ) | | | |
|---|---|---|---|---|---|---|---|---|
| | Adaxial surface | | Abaxial surface | | Adaxial surface | | Abaxial surface | |
| | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf | Normal leaf | Polluted leaf |
| *Achyranthes aspera* | 22.293 ± 0.358 | 34.706 ± 7.480 | 19.76 ± 1.241 | 22.293 ± 0.358 | 19.0 ± 1.241 | 26.093 ± 1.561 | 14.947 ± 2.798 | 16.46 ± 0.716 |
| *Calotropics gigantea* | 26.093 ± 1791 | 27.36 ± 0.625 | 28.06 ± 1.291 | 35.58 ± 0.358 | 21 533 ± 1.994 | 23.56 ± 1.078 | 19 ± 1.0748 | 22.04 ± 1.861 |
| *Catharanthus pusillus* | 28.373 ± 1.291 | 26.85 ± 0.947 | 23.56 ± 0.620 | 29.89 ± 2.507 | 20.26 ± 0.947 | 22.29 ± 2.179 | 19 ± 1.241 | 23.05 ± 4.657 |
| *Croton bonplandianum* | 24.066 ± 0.358 | 24.827 ± 2.179 | 30.906 ± 1.433 | 32.17 ± 2.349 | 19.76 ± 1.074 | 21.02 ± 1.561 | 27.106 ± 3.061 | 27.881 ± 4.657 |
| *Peristrotphe paniculata* | 21.533 ± 0.358 | 22.607 ± 3.858 | 29.89 ± 0.716 | 31.28 ± 2.237 | 19.76 ± 1.074 | 16.21 ± 1.561 | 24.82 ± 1.433 | 23.66 ± 2.357 |

parenchyma (Solberg and Adams, 1956).The present study indicated that cement dust pollution brings about increase in the length of the palisade parenchyma and shrinkage in the spongy parenchyma. The shrinkage in the spongy parenchyma is probably brought about by the entry of alkaline solution. Along with the increase in the size of palisade parenchyma, the thickness of the leaf also increased resulting in an increase in the chloroplast content. This may be an adaptation to increase the photosynthetic activity of the polluted plants. Chaudhari *et al.* (1984) reported an increase in thickness of the veins in *Lycopersicon lycospersicum* var. *angurlata* when exposed to air pollution. In the present study, *P.paniculta* showed an increase in thickness of the veins.

No general conclusions can be drawn from the effects of cement kiln dust until each source is classified and studied separately because the cement kiln dust is actually a heterogenous substance whose constituents and amounts vary with time and location.

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# Influence of Industrial Effluent on Seed Germination and Seedling Growth of Some Crop Plants

**B.B. Biradar, M. Mahadevappa and C.A. Shrinivasamurthy**
Department of Seed Technology, University of Agricultural Sciences
Bangalore 560065

## Abstract

The physico-chemical analysis of industrial effluent and the effluent mixed pond water has revealed that the dissolved (900 mg/l and 875 mg/l, respectively) and suspended (2600 mg/l and 2475 mg/l , respectively) solids ranged above the level of maximum permissible concentrations. The effluent has shown greater stimulatory effect on the relative germination percentage in *Oryza sativa* (118.0), *Zea mays* (108.5), *Vigna sinensis* (106.2) and *Helianthus annuus* (105.3) than pond water and control. The retarding effect of the effluent on seedling growth was evident in all the crops which ranged from 12.7 to 46.0% in shoot length and 5.9 to 63.2% in root length.

## Introduction

As a consequence of rapid industrialisation, most of the urban and rural water ponds/lakes are being continuously polluted by wastes. Various pollutants discharged by industries are deteriorating the quality of air, water and soil at an alarming rate. Consequently, these industrial effluents adversely affect the growth of fauna and flora in nature. Since a large proportion of lake water is being used for irrigation without any treatment, the growth and yield of crops are significantly affected (Makki *et al.*, 1987; Ajmal and Khan, 1984 and 1985; El-Leboudi *et al.*, 1982; Jerath and Sahai, 1982). The main cause for water pollution is the presence of high proportion of trace elements and total solids. The effect of different factory effluents on germination, growth and yield of crop plants has drawn the attention of several workers (Sahai *et al.*, 1979; Subiah and Sree Ramulu, 1979; Sisodia and Bedi, 1985; Chaudhary *et al.*, 1987).

In this context, to ascertain the influence of industrial effluent and effluent mixed pond water on seed germination and seedling growth, the present studies were carried out on seven important crop plants.

## Material and Methods

The effluent was collected from the drains of Bharat Electronics, Bangalore, that open at Hebbal lake, north Bangalore, and the lake water was collected randomly at different points. These samples were subjected to physico-chemical analysis. The total solids (both suspended and dissolved), pH and EC of the samples were determined using the methods proposed by Anon. (1976) and trace elements were quantitively estimated by using Atomic Absorption Spectrophotometer.

Pure seeds of seven crops, *viz. Oryza sativa* (Cv.Jaya), *Zea mays* (Cv.Deccan 101), *Eleusine coracana* (Cv.Indar 9), *Vigna sinensis* (Cv.C152), *Glycine max* (Cv.KHSb2), *Helianthus annuus* (Cv.Morden) and *Arachis hypogeae* (Cv.JL 24) were included in the studies. The germination papers dipped in the industrial effluent and effluent mixed pond water served as treatments while deionised water served as control. Hundred seeds of each crop were placed for germination in four replications using between paper towel (BP) method as prescribed by Anon (1976 b). The germination counts were taken on the 5th and 8th day after incubation for all crops except *Oryza sativa* for which observations were taken on the 14th day. The shoot and root growth were recorded on the 5th, 8th and 14th day after sowing (Agrawal, 1986).

The data on seed germination were expressed in relative percentage over control and those of root and shoot growth in percent increase or decrease over control. The data were subjected to analysis of variance.

## Results and Discussion

The results of the physico-chemical analyses of both effluent and pond water are presented in Table 1. The industrial effluent was found to contain maximum total suspended solids (2600 mg/l), total dissolved solids (900 mg/l) and trace elements. This was closely followed by effluent mixed pond water. This clearly showed that the effluent contained harmful pollutants in much higher concentration than the permissible limits. The lower amount of contaminants in lake water may be due to dilution effect by pure water coming into lake from other sources and also the presence of abundant water hyacinth (*Eichhornia crassipes*) which is known to act as a scavenger of heavy metals in polluted waters (Vora and Rao, 1988; Trivedy, 1983).

Table 1. Physical and chemical properties of the effluent and effluent mixed pond water

| Properties | Effluent | Pond water | Maximum* recommended concentration |
|---|---|---|---|
| Colour | Brownish | Lightish green | Absent |
| Odour | Pungent | Pleasant | Absent |
| pH | 7.7 | 8.4 | — |
| EC (m mhos/cm) | 1.8 | 1.4 | — |
| Total solids (mg/l): | | | |
| a. Suspended solids | 2600 | 2475 | 2100 |
| b. Dissolved solids | 900 | 875 | 600 |
| Heavy metals (mg/l): | | | |
| Zn | Traces | Traces | — |
| Cu | Traces | Traces | — |
| B | 0.56 | 0.32 | — |
| Mn | Traces | Traces | — |
| Ca | 162 | 162 | — |
| Fe | Traces | Traces | — |
| Mg | 44.1 | 13.2 | — |
| $P_2O_5$ | 21.0 | 4.0 | — |

* Indian Standard Institution (1974 and 1977)

It is evident from Table 2 that the relative germination percent was higher in effluent treated seeds in *O. sativa* (118.6), *Z. mays* (108.5), *V. sinensis* (106.2) and *H. annuus* (105.3) while it was affected to a varied extent in *E. coracana* (82.7), *A. hypogaea* (79.3) and *G. max* (99.2) over the control. Effluent mixed pond water also showed a similar trend in stimulating the germination of certain crops.

Table 2. Relative germination percentage of crop plants as affected by industrial effluent and effluent mixed pond water

| Crop | Control (%) | Relative germination percentage | |
|---|---|---|---|
| | | Pond water | Effluent |
| *Oryza sativa* | 75.0 | 104.1 | 118.6 |
| *Zea mays* | 87.6 | 106.5 | 108.5 |
| *Eleusine coracana* | 91.0 | 97.5 | 82.7 |
| *Vigna sinensis* | 90.0 | 103.7 | 106.2 |
| *Glycine max* | 91.3 | 99.3 | 99.2 |
| *Helianthus annuus* | 94.6 | 100.1 | 105.3 |
| *Arachis hypogaea* | 78.6 | 108.1 | 79.3 |
| SEm± | 3.45 | 3.01 | 2.16 |
| C.V. (%) | 6.86 | 4.30 | 5.84 |
| F-test | * | ** | * |

* Significant at 5%; ** Significant at 1%.

A peculiar phenomenon wherein there was a great variation in germination in most species in the same lot due to different sources of water was noticed. Deionised (control) water is a standardised medium in which all the viable and non-dormant seeds are expected to germinate. But the increase in germination over control in effluents pointed out the stimulation of a few physiologically inactive seeds of the lot. The contaminants, electrical conductivity, pH and organic chemicals of the effluent at a specific quantity, period and conditions influence the bio-chemical make up of the seeds such that the seeds which would otherwise develop into abnormal seedlings or remain hard would also become normal seedlings. This phenomenon is referred as 'repair mechanism'. The prevalence of 'repair mechanism' could possibly be the reason for higher germination in effluent treatments. While making studies on lettuce, Villiers and Edgecumbe (1975) had encountered such phenomenon. They observed that imbibed storage of dormant seeds checks the formation of chromosomal aberration and even reversed the effects of mechanical damage in seeds. These observations suggest that maintenance of viability in imbibed seeds is due to the operation of an efficient bio-chemical repair mechanism. Damage to macromolecule may accumulate and may only be repaired when the seeds are imbibed for germination. Some of the damages are reversible if the seed is hydrated, probably through the operation of subcellular repair and turnover mechanism (Robert, 1981). Similarly, Saxena and Bhatnagar (1986) pointed out that brick kiln deposit showed stimulatory effect on grams. Among perennials, conifers were less affected by the toxicity of heavy metals than broad leaved trees (Patterson and Olson, 1983). However, Jones (1961) suggested a mechanism of metal tolerance that would be temperature dependent. Waughman *et al.* (1983) also reported that mere increase in temperature is sufficient to eliminate the problem of heavy metal toxicity. However, retarding germination under effluent condition in millet (*Hordeum vulgare*) (Brijesh Bahadur and Sharma, 1988)

*Phaseolus aureus* (Sharma, 1982), *Pisum sativum* (Sharma, 1983), *Cicer arietinum* (Singh, 1984) and *Oryza sativa* (Singh and Mishra, 1987) was reported earlier.

Though germination was better in majority of crops studied under effluent condition, the seedling growth in terms of shoot and root length of all crops was significantly reduced as compared to control (Table 3). The percent decrease in shoot length ranged from 12.7 to 46.0 and root length from 5.9 to 63.2 in the case of effluent followed by pond water with a reduction of 9.9 to 57.4% and 3.7 to 75.3%, respectively. Among the seven crops, *Oryza sativa* has shown higher sensitivity to effluent toxicity in both the treatments. The reduction in seedling growth may be attributed to the interaction of subtoxic levels of different elements (Subiah and Sree Ramulu, 1979). Many other crops were also sensitive to effluent toxicity at seedling stage. *Cicer arietinum* growth was inhibited by the heavy metal Ni (Singh, 1984). Excess supply of heavy metals retarded seedling growth of barley (Agarawal *et al.*, 1961), rice and corn (Singh and Mishra, 1987). But cardboard factory effluent did not affect greatly the seedling growth of *Oryza sativa* (Dixit *et al.*, 1986).

Table 3. Percent increase or decrease of shoot and root length of crop plants over control as affected by the industrial effluent and effluent mixed pond water

| Crop | Shoot length (% increase or decrease) | | | Root length (% increase or decrease) | | |
|---|---|---|---|---|---|---|
| | Control (cm) | Pond water | Effluent | Control (cm) | Pond water | Effluent |
| *Oryza sativa* | 4.7 | –57.4 | –31.9 | 9.5 | –75.3 | –63.2 |
| *Zea mays* | 19.4 | –19.1 | –41.0 | 15.4 | – 9.3 | –21.9 |
| *Eleusine coracana* | 7.1 | – 9.9 | –12.7 | 5.6 | –67.9 | –42.9 |
| *Vigna sinensis* | 18.9 | –35.5 | –37.6 | 10.9 | – 3.7 | –22.9 |
| *Glycine max* | 16.6 | –44.0 | –39.8 | 18.2 | –75.2 | –30.8 |
| *Helianthus annuus* | 15.1 | –39.7 | –39.7 | 13.6 | + 6.8 | – 5.9 |
| *Arachis hypogaea* | 5.0 | –62.0 | –32.0 | 13.1 | –52.7 | –23.7 |
| SEm± | 0.53 | 0.59 | 0.54 | 0.65 | 0.50 | 0.79 |
| CV (%) | 7.42 | 12.46 | 12.03 | 9.25 | 10.01 | 15.41 |
| F-test | ** | ** | * | ** | ** | ** |

** Significant at 1%.

The study indicated that in most of the crop plants studied, germination of seeds was stimulated by the trace elements present in the effluent but the same effluent had shown drastic reduction in growth of juvenile stages.

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# Studies on $NH_3$ Pollution with Special Reference to *Cajanus cajan* and *Zea mays*

**Nirmala Babu Rao and S.H. Raza**

Department of Botany, Osmania University, Hyderabad 500007.

## Abstract

The effects of $NH_3$ exposure on *Cajanus cajan* (var. ICP-1-6) and *Zea mays* (var. 70 EH-starch) were discussed. Fifteen day old plants were exposed individually to 6.25 and 1.6 ppm concentrations for 60 and 5 min each. The effects were analysed in terms of nitrogen, sulphur, chlorophyll and protein content, and yield. Though the treatment was given at juvenile stage, the effects were found pronounced at later stages of growth. The chlorophyll and sulphur content, and seed yield showed a decreasing trend. However, protein content increased at low concentrations whereas nitrogen accumulation was seen at all concentrations.

## Introduction

Ammonia is an important raw material in the manufacture of nitric products, including domestic incineration, refrigeration and cooling, and in the operation of automobiles (Swain, 1949; Magill and Boneliel, 1952; Cholak, 1952; Zutschi, 1971). Symptoms of dark or complete blackening and bleaching of leaves of the plants growing in and around such establishments were observed in tomato and buckwheat (Zimmerman *et al.*,1931;Thronton and Setterstron, 1940). The real manifestation of gaseous effects depends mostly on the concentration and duration of exposure of gases, and age and genetic constitution of the plant. However, the studies on phytotoxic effects of $NH_3$ are very limited. Hence, the present investigation has been carried out to uncover the effects of $NH_3$ at different dosages on maize and redgram.

## Material and Methods

Fifteen day old plants of *Zea mays* (var. 70 EH-Starch) and *Cajanus cajan* (var. ICP-1-6) were used for the present study. For the evolution of 1ppm ammonia gas, 11.5 ml of 1m freshly prepared liquid ammonia is necessary (Leveggi *et al*., 1973). Individual seedlings were subjected to 6.25 and 1.6 ppm ammonia treatments by enclosing in chambers for 60 and 5 min each. Untreated plants constituted the control. Plants were analysed for chlorophyll (Arnon, 1949) at 15 and 90 days after exposure, 1000 seeds weight (Puri, 1950), protein (Anon., 1975), nitrogen (Piper, 1966) and sulphur (Patterson, 1958).

## Results and Discussion

The data on the damage caused to the total chlorophyll content of plants treated with ammonia are presented in Table 1. Leaves of the affected plants developed chlorotic spots as they had lost chlorophyll. Loss of chlorophyll was more in *C.cajan* than in *Z.mays* at 15 days after exposure. A good recovery in chlorophyll content was found in *C.cajan* than in *Z.mays*. Similar observations were made by Boralkar (1979) in *Trigonella* and Raza and Zulekha Bano (1981) in black gram revealing the harmful effects of $NH_3$ pollution.

Table 1. Percentage reduction and recovery in chlorophyll content in ammonia treated *Zea mays* and *Cajanus cajan*

| Days after exposure | 6.25 ppm | | 1.6 ppm | |
|---|---|---|---|---|
| | 60 min | 5 min | 60 min | 5 min |
| | | *Zea mays* | | |
| 15 | 30.00 | 16.66 | 16.68 | 10.00 |
| 90 | 17.43 | 8.25 | 8.28 | 0.91 |
| % recovery by 90th day | 41.90 | 50.48 | 50.66 | 90.90 |
| | | *Cajanus cajan* | | |
| 15 | 68.96 | 48.27 | 48.97 | 18.64 |
| 90 | 21.33 | 14.16 | 11.66 | 4.16 |
| % recovery by 90th day | 69.06 | 70.66 | 76.18 | 77.68 |

| | | *Z. mays* | *C. cajan* |
|---|---|---|---|
| Control plant chlorophyll | 15 days | 8.7 | 3.433 |
| (mg/g dry wt) | 90 days | 15.37 | 7.975 |

Table 2. Percentage reduction in 1000 seed weight and protein content in ammonia treated *Zea mays* and *Cajanus cajan*

| Parameter | 6.25 ppm | | 1.6 ppm | |
|---|---|---|---|---|
| | 60 min | 5 min | 60 min | 5 min |
| | | *Zea mays* | | |
| Seed weight | 74.87 | 31.39 | 25.53 | 3.19 |
| Protein content | 29.15 | 10.40 | 14.30 | 2.07* |
| | | *Cajanus cajan* | | |
| Seed weight | 77.34 | 59.38 | 50.63 | 45.67 |
| Protein content | 30.49 | 7.62 | 7.62 | 8.57* |

*Percent increase

| | *Z. mays* | *C. cajan* |
|---|---|---|
| Control plant seed wt (g) | 282 | 222.0 |
| Control plant protein content (%) | 20.27 | 22.17 |

Table 2 presents the percentage reduction of 100 seed weight and protein content in *Z.mays* and *C.cajan* treated with $NH_3$. When exposed to 1.6 ppm for 5 min there was a net gain in the protein content upto 2.07% in *Z.mays* and 8.57% in *C.cajan* due to increase in the nitrogen content. Similar observations were noted by Chaudary and Rao (1977), Bedi *et al.* (1980), Bell and Bedi (1983). The beneficial effects of $NH_3$ followed one of O'Gara's (1922) principle indicating the metabolization of ammonia to non toxic products resulting in increase in yield and and protein content of the seeds.

Treatment of $NH_3$ on plants has brought in remarkable increase in nitrogen content of plants and reduction in sulphur content of plants compared to control (Table 3). The amount of increase in nitrogen content in ammonia treated plants, calculated in terms of percentage over control, was higher in *Z.mays.* The maximum value of 27.82% was found on the 45th day in plants exposed to 1.6 ppm for 60 min. The rate of nitrogen increase in the plant was found varying with age. Similar observations on differential absorption and assimilation of ammonia uptake in soya bean, sunflower, corn and cotton were made by Hutchinson *et al.* (1972). In *C. cajan* a different trend was observed in the variation of nitrogen content as a function of age. The excess nitrogen which accumulated due to ammonia treatment was found gradually increasing with age. The lowest accumulation (8.29%) was noticed on the 90th day in plants exposed to 1.6 ppm for 5 min. The plants treated with ammonia showed low levels of sulphur.

Table 3. Percentage reduction of sulphur and accumulation of nitrogen in ammonia treated *Zea mays* and *Cajanus cajan.*

| Parameter | 6.25 ppm | | | | 1.6 ppm | | | |
|---|---|---|---|---|---|---|---|---|
| | 60 min | | 5 min | | 60 min | | 5 min | |
| | 45th day | 90th day | 45th day | 90th day | 45th day | 90th day | 45th day | 90th day |
| | | | *Zea mays* | | | | | |
| Sulphur | 13.77 | 15.32 | 10.57 | 8.07 | 3.60 | 5.68 | 1.68 | 2.85* |
| Nitrogen | 27.82 | 19.55 | 19.60 | 12.43 | 19.40 | 14.52 | 14.60 | 9.40 |
| | | | *Cajanus cajan* | | | | | |
| Sulphur | 14.11 | 16.08 | 9.93 | 10.34 | 2.76 | 3.68 | 1.42 | 3.46 |
| Nitrogen | 22.48 | 15.47 | 15.18 | 18.32 | 10.06 | 17.62 | 8.29 | 10.42 |

| * Percent increase | | *Z. mays* | *C. cajan* |
|---|---|---|---|
| Control plant nitrogen (%) | 45th day | 9.2 | 6.55 |
| | 90th day | 11.5 | 8.30 |
| Control plant sulphur (%) | 45th day | 0.212 | 0.157 |
| | 90th day | 0.235 | 0.204 |

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# Studies on Ascorbic Acid Levels Under Chronic Dosages of $SO_2$

**O. Bhagya Lakshmi, M.S.R. Murthy and S.H. Raza**
Department of Botany, Osmania University, Hyderabad 500007

## Abstract

Ascorbic acid, being a strong reducing agent has drawn much attention pertaining to the assessment of $SO_2$ tolerance in trees. In the present investigation, the levels of ascorbic acid in certain plants under ambient $SO_2$ exposure were determined. The trees were observed to become sensitized in terms of their ascorbic acid content. *Albizzia, Eugenia, Acacia* and *Datura* were found showing an increase in endogenous ascorbic acid levels. *Polyalthia* and *Pongamia* were found showing a decrease in ascorbic acid contents.

## Introduction

The phytotoxic effects of low levels of $SO_2$ on plants under long term exposure with intermittent short time high peak levels have been a point of great importance. Ascorbic acid is a powerful reducer and has long been known as one of the factors responsible for air pollution resistance in plants (Freebrain, 1960; Nandi *et al.*, 1981). Decreased ascorbic acid concentrations have been observed in $SO_2$ fumigated plants (Choudary and Rao, 1977). Tolerant tissues can elevate the endogenous levels of ascorbic acid under air pollution stress to offer its protective effect against scavenging toxic radicals (Pierre and Queirz, 1981). Hence, the role of ascorbic acid under stress conditions of air pollution is expected to be quite complex and could vary with the dosage levels. However, studies uncovering the status of different tropical trees, shrubs and herbs in relation to ascorbic acid levels are quite meager. The present investigation was carried out to assess the ascorbic acid levels in plants growing in industrial areas of Hyderabad.

## Material and Methods

The study has been made on a comparative basis in two sites, *viz.* Nacharam Industrial Complex and Nizam College botanical gardens which represented high and low pollution areas, respectively. Nacharam Industrial Complex is located in south east Hyderabad and hosts a wide variety of factories, such as pharmaceuticals, distilleries, breweries, fertilisers, food products, dyes and ferro alloy products. Nizam' College botanical garden which is nearly 12 km away from Nacharam is found relatively free from aerial emissions and was hence selected as less polluted area representing the control. The peak levels and annual means of $SO_2$ in the polluted area were 110 $\mu g/m^3$ and 14 $\mu g/m^3$, respectively while in control area they were 56 $\mu g/m^3$ and 8 $\mu g/m^3$, respectively.

Sampling of trees, shrubs and herbs was done quarterly for two years, i.e. from March 1985 to Feb. 1987. Since most of the vegetation comprises deciduous type, sampling period has been arranged in such a way that it coincided with the biological age of newly originated leaves and old leaves before their fall. Sampling was done in morning hours under isoecological conditions of light, temperature and soil conditions. Leaves collected were immediately brought to the laboratory and were analysed for sulfate content (Patterson, 1958) and ascorbic acid (Singh, 1977).

## Results

The foliar sulfate content of trees, shrubs and herbs growing in industrial and non-industrial areas is presented in Table 1. Plants growing in Nizam College botanical garden, i.e. low pollution area showed comparatively less sulfate content than those growing in polluted environments. In polluted area, it has been found that sulfate accumulated in almost all trees as a function of ambient $SO_2$ levels. During summer season, sulfur accumulated enormously in *Pithecolobium dulce, Nerium odorum,* and *Sida cordifolia.* In rainy season, the sulfate accumulation was found diluted. Coefficient of correlation was worked out between ambient $SO_2$ levels and accumulated sulfate in plants (Table 1).

The per cent decline in ascorbic acid content of trees, shrubs and herbs growing in polluted environment was calculated in relation to the less polluted area. The values represent the average of 8 seasons comprising two years data (Table 2). The maximum reduction of 39.75% was found in *Eugenia jambolana.* Amongst shrubs and herbs, *Nerium odorum* and *Tephrosia purpura* were found affected to the maximum extent of 26.7 and 29.45%, respectively. There was also a good relationship between seasonal sulfate accumulation, $SO_2$ levels and ascorbic acid damage. In most of the plants statistical analysis has revealed significant relationship between the degree of $SO_2$ levels, foliar sulfate and ascorbic acid damage (Table 2).

## Discussion

The ascorbic acid levels in a plant of a given age under sublethal levels of $SO_2$ depend on 2 factors: (1) rate of production of free toxic radicals, such as $SO^-_3$, $HSO^-_3$, $OH^-$, $O^-_2$, etc during photo-oxidation of $SO^-_3$ to $SO^-_4$ where sulfites are generated from $SO_2$ absorbed. The free radical production under $SO_2$ exposure would increase/decrease the free radical scavengers, such as ascorbic acid, superoxide dismutase, peroxidase etc. (Pierre and Queirz, 1981; Shuwen *et al.*, 1981) based on dosage and physiological status of a plant; (2) degree of sulfate accumulation. The sulfate accumulation would bring in wide variety of secondary effects, reducing the ascorbic acid production (Keller and Jager, 1980). Hence, in the present investigation an attempt has been made to assess the ascorbic acid variations in plants growing in industrial establishments and to correlate with ambient $SO_2$ levels and sulfate accumulation.

It was found that in industrial area, the peak concentration of $SO_2$ was 110 $\mu g/m^3$ with an annual mean of 14 μg/m3. This sort of different peak and mean concentrations raises the question of possible sensitization of vegetation to a given $SO_2$ pollution dose leading to accumulation of sulfur to toxic levels. It is also possible that peak levels of the gas may be responsible for plant response but are concealed within the overall mean. It being the cause, plants growing in industrial areas must have shown sulfate in excess quantities than in non-industrial areas (Table 1). Similarly, Cowling and Lockyer (1978) reported accumulation of sulfate in rye grass exposed to 50 $\mu g/m^3$ of $SO_2$ for 55 days. Malcolom and Garforth (1977) and Huttunen *et al.* (1985) showed in their findings that under prolonged low levels of $SO_2$ exposure, excess sulfur accumulates largely as sulfate. There was a significant relationship between ascorbic acid content and ambient $SO_2$ levels and sulfate accumulation.

Amongst the trees observed, *Eugenia jambolana, Polyalthia longifolia* and *Caesalpinia pulcherima*, and amongst herbs, *Tephrosia purpurea* were found severely

Table 1. Foliar sulfate (%) in plants in low and high pollution areas

| Name of the plant | Summer | | Monsoon | | Winter | | Autumn | | r |
|---|---|---|---|---|---|---|---|---|---|
| | LP | HP | LP | HP | LP | HP | LP | HP | |
| Trees : | | | | | | | | | |
| *Albizzia lebbeck* Benth. | 0.008 | 0.093 | 0.007 | 0.025 | 0.045 | 0.12 | 0.0005 | 0.065 | 0.48$^{NS}$ |
| *Annona squamosa* Linn. | 0.0085 | 0.0295 | 0.005 | 0.0155 | 0.0065 | 0.0695 | 0.0065 | 0.075 | 0.08$^{NS}$ |
| *Azadirachta indica* A. Juss. | 0.0045 | 0.057 | 0.01 | 0.015 | 0.0145 | 0.0365 | 0.0045 | 0.035 | 0.68* |
| *Caesalpinia pulcherima* Roxb. | 0.056 | 0.054 | 0.025 | 0.015 | 0.0095 | 0.023 | 0.0065 | 0.027 | 0.67* |
| *Cassia fistula* Linn. | 0.005 | 0.086 | 0.0065 | 0.04 | 0.0065 | 0.0535 | 0.006 | 0.085 | 0.39$^{NS}$ |
| *Dalbergia sissoo* Linn. | 0.007 | 0.097 | 0.0065 | 0.040 | 0.0045 | 0.1 | 0.027 | 0.0905 | 0.56* |
| *Eugenia jambolana* Linn. | 0.005 | 0.058 | 0.008 | 0.016 | 0.0075 | 0.04 | 0.0115 | 0.0345 | 0.93** |
| *Phoenix sylvestris* Roxb. | 0.006 | 0.046 | 0.008 | 0.04 | 0.008 | 0.08 | 0.004 | 0.05 | 0.30$^{NS}$ |
| *Pithecolobium dulce* Benth. | 0.0075 | 0.120 | 0.008 | 0.057 | 0.0055 | 0.063 | 0.005 | 0.08 | 0.86** |
| *Polyalthia longifolia* H.K. F&t | 0.03 | 0.115 | 0.0135 | 0.08 | 0.023 | 0.08 | 0.007 | 0.09 | 0.80* |
| *Pongamia glabra* Vant. | 0.0075 | 0.11 | 0.0235 | 0.09 | 0.0695 | 0.1 | 0.008 | 0.08 | 0.78* |
| Shrubs : | | | | | | | | | |
| *Acacia* sps. Willd. | 0.005 | 0.090 | 0.007 | 0.040 | 0.019 | 0.085 | 0.006 | 0.072 | 0.86** |
| *Bougainvillea spectabilis* Linn. | 0.008 | 0.095 | 0.046 | 0.068 | 0.005 | 0.089 | 0.008 | 0.107 | 0.85** |
| *Calotropis procera* R. Br. (F.B.I. IV) | 0.008 | 0.065 | 0.005 | 0.065 | 0.003 | 0.1 | 0.008 | 0.065 | –0.17$^{NS}$ |
| *Ipomea aquatica* Linn. | 0.006 | 0.105 | 0.013 | 0.081 | 0.002 | 0.115 | 0.009 | 0.069 | 0.70* |
| *Nerium odorum* Soland | 0.005 | 0.105 | 0.015 | 0.112 | 0.010 | 0.100 | 0.007 | 0.091 | 0.29$^{NS}$ |
| Herbs : | | | | | | | | | |
| *Datura stramonium* Linn. | 0.013 | 0.087 | 0.010 | 0.035 | 0.029 | 0.038 | 0.007 | 0.069 | 0.76* |
| *Euphorbia hirta* Linn. | 0.005 | 0.155 | 0.012 | 0.050 | 0.005 | 0.081 | 0.005 | 0.091 | 0.52* |
| *Lantana camara* Linn. | 0.019 | 0.106 | 0.013 | 0.082 | 0.006 | 0.081 | 0.006 | 0.088 | 0.79* |
| *Parthenium hysterophorus* Linn. | 0.024 | 0.104 | 0.004 | 0.081 | 0.006 | 0.105 | 0.003 | 0.082 | 0.62* |
| *Sida cordifolia* Linn. | 0.006 | 0.200 | 0.022 | 0.042 | 0.003 | 0.084 | 0.024 | 0.116 | 0.70* |
| *Tephrosia purpurea* Pers. | 0.025 | 0.081 | 0.010 | 0.090 | 0.006 | 0.105 | 0.002 | 0.083 | -0.36$^{NS}$ |
| *Tribulus terrestris* Linn. | 0.015 | 0.093 | 0.003 | 0.083 | 0.005 | 0.115 | 0.004 | 0.078 | -0.19$^{NS}$ |
| *Tridax procumbens* Linn. | 0.015 | 0.0965 | 0.007 | 0.091 | 0.004 | 0.156 | 0.005 | 0.110 | 0.47$^{NS}$ |

LP = Low pollution area (control); HP = High pollution area;
r = Correlation coefficient between ambient $SO_2$ levels and foliar $SO_4$ levels
* = Significant at 5% level (n = 8); ** = Significant at 1% level (n = 8)
NS = Non-significant

Table 2. Percentage reduction in ascorbic acid in plants around polluted environment

| Name of the plant | Summer | Monsoon | Winter | Autumn | $r_1$ | $r_2$ |
|---|---|---|---|---|---|---|
| Trees : | | | | | | |
| *Albizzia lebbeck* | 1.97$^+$(1.0)$^{++}$ | 6.65(7.45) | 1.6(7.45) | 0.00(8.9) | –0.58* | 0.33 |
| *Annona squamosa* | 7.95(13.8) | 9.95(15.85) | 5.6(5.0) | 7.65(14.25) | –0.23 | 0.07$^{NS}$ |
| *Azadirachta indica* | 18.7(15.75) | 7.3(16.35) | 12.05(13.4) | 1.7$^+$(14.4) | 0.67* | 0.61* |
| *Caesalpinia pulcherima* | 15.1(9.1) | 4.45(0.2) | 23.55(8.2) | 2.67(9.0) | –0.27$^{NS}$ | 0.37 |
| *Cassia fistula* | 15.75(12.4) | 12.85(14.75) | 17.45(13.15) | 6.55(-1.0) | –0.14$^{NS}$ | –0.21$^{NS}$ |
| *Dalbergia sissoo* | 5.15(15.25) | 8.59(14.7) | 5.3(14.6) | 1.6(14.8) | –0.18$^{NS}$ | 0.15$^{NS}$ |
| *Eugenia jambolana* | 8.8$^+$(4.3) | 39.75(5.85) | 15.85(6.1) | 5.60(1.0) | –0.01$^{NS}$ | –0.52* |
| *Phoenix sylvestris* | 14.35(11.75) | 0.85(6.0) | 4.05(6.4) | 5.4(15.4) | 0.10$^{NS}$ | 0.36$^{NS}$ |
| *Pithecolobium dulce* | 8.25(12.2) | 5.57(15.1) | 3.55(14.1) | 2.88(13.1) | –0.2$^{NS}$ | 0.15$^{NS}$ |
| *Polyalthia longifolia* | 32.05(8.4) | 12.77(6.7) | 1.57(7.7) | 3.35(7.05 | 0.94** | –0.67* |
| *Pongamia glabra* | —(2.8) | 26.26(8.9) | 3.32(7.7) | 8.15(9.75) | –0.57* | –0.27$^{NS}$ |
| Shrubs : | | | | | | |
| *Acacia* sps | 9.4(6.15) | 1.85$^+$(10.0) | 15.8(8.15) | 6.1(7.3) | 0.93* | 0.8* |
| *Bougainvillea spectabilis* | 15.45(6.15) | 16.55(10.0) | 13.4(13.1) | 5.4(10.4 | –0.27 | –0.1$^{NS}$ |
| *Calotropis procera* | 7.95(12.0) | 5.7(12.75) | 6.4(12.75) | 8.3(11.0 | 0.52* | –0.02$^{NS}$ |
| *Ipomea aquatica* | 14.65(6.5) | 3.35(6.35) | 13.7(10.6) | 9.45(8.4) | 0.65* | 0.25$^{NS}$ |
| *Nerium odorum* | 26.7(10.9) | 13.5(5.81) | 9.1(4.9) | 14.7(12.5) | 0.95** | 0.05$^{NS}$ |
| Herbs : | | | | | | |
| *Datura stramonium* | 11.65(5.65) | 6.95$^+$(6.65) | 5.05(6.45) | 6.20(6.65) | 0.17$^{NS}$ | –0.26$^{NS}$ |
| *Euphorbia hirta* | 24.85(7.9) | 9.20(6.65) | 13.2(13.9) | 16.6(8.8) | 0.95** | 0.56* |
| *Lanata camara* | 20.90(13.35) | 10.70(15.2) | 7.85(12.2) | 14.3(10.8) | 0.46$^{NS}$ | 0.56* |
| *Parthenium hysterophorus* | 20.8(14.0) | 17.0(13.59) | 1.695(11.69) | 13.25(16.9) | 0.2$^{NS}$ | 0.58* |
| *Sida cardifolia* | 15.80(7.65) | 12.45(10.85) | 19.8(12.4) | 5.35(7.2) | 0.28$^{NS}$ | 0.54* |
| *Tephorisa purpurea* | 26.30(7.24) | 13.15(10.9) | 16.8(12.2) | 29.45(13.4) | –0.24$^{NS}$ | –0.27$^{NS}$ |
| *Tribulus terrestris* | 7.5(14.5) | 4.98(14.55) | 4.45(10.94) | 17.30(15.75) | 0.22$^{NS}$ | –0.62* |
| *Tridax procumbens* | 15.7(10.6) | 8.85(5.31) | 22.9(13.01) | 15.75(11.2) | 0.65* | 0.5* |

\+ Percent increase; ++ Figures in parentheses indicate control values

$r_1$ Correlation coefficient between ascorbic acid reduction and ambient $SO_2$ levels

$r_2$ Correlation coefficient between ascorbic acid reduction and foliar $SO_4$ levels

* Signficant at 5% level (n=8); ** Significant at 1% level (n=8) NS Non-significant.

affected in their ascorbic acid content. There was an exponential rise in the decline of ascorbic acid as a function of increase in excess sulfate content. This trend of decline in ascorbic acid under stress levels of $SO_2$ has been reported (Prasad and Rao, 1982). A great deal of variation has been noticed in the levels of ascorbic acid in plants in different seasons. This could be not only due to the age but also the varied influence of environmental conditions. The decrease in ascorbic acid after a certain age could be due to either the destruction of ascorbic acid or the decreased availability of precursors, i.e. sugars and consequently a decrease in the rate of synthesis of ascorbic acid (Sweeny *et al.*, 1960).

There was an increase in the production of ascorbic acid in certain plants, *viz. Albizza, Eugenia, Acacia, Datura,* etc. in some seasons due to $SO_2$ stress which revealed the defence mechanism of the plant. Tolerant tissues can elevate the endogenous levels of ascorbic acid under air pollution stress to offer its protective effect against scavenging toxic radicals (Pierre and Queirz, 1981). Further, ascorbic acid can protect against accumulation of superoxide radicals, hydroxy radicals and hydrogen peroxide, and develop resistance against oxidants and other pollutants (Asada, 1980; Miller and Xenikos, 1979).

In certain plants, *viz. Eugenia jambolana* and *Tribulus terrestris,* there was a negative relationship between accumulated sulfate and reduction in ascorbic acid content. This kind of higher reduction at relatively low levels of sulfate accumulation might have resulted from the decline in the resistance of plants in scavenging toxic radicals, under prolonged exposures of $SO_2$. The rate of production of free radicals, active oxygen and sulfite levels must have increased at a faster rate than the equivalent processes involved in the production of free radical scavengers (Murray, 1985). This could affect the production of precursors of ascorbic acid, i.e. sugars leading to the decline of ascorbic acid under low sulfate levels.

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# Effects of Mercury and Manganese on Some Pysiological Aspects of Radish (*Raphanus sativus* L.)

**D. Srinivas and V.P. Singh**
School of Studies in Botany, Vikram University, Ujjain 456010

## Abstract

Studies on the effects of mercury and manganese on the physiological aspects of radish in nutrient solution indicated that both the metals inhibited the metabolic activities of the plant. Chlorophyll synthesis in the leaves, root length and fresh weight were affected. Hill reaction activity from isolated chloroplasts was depressed and protein content of the leaves was also inhibited by mercury and manganese.

## Introduction

Metallic elements are an intrinsic component of the environment. Their presence is considered unique in the sense that it is difficult to eliminate them completely from the environment with which they are contaminated. With the increasing use of a wide variety of metals in industry and daily life, problems arising from toxic metal pollution of the environment have assumed various dimensions. Higgins and Burns (1975) reported that mercury is a highly toxic element with no beneficial biological function. Manganese is an essential micronutrient but when it is found in abnormally high concentrations it proves toxic. Current emphasis on soil, water and air pollution, food quality and food and energy storage in certain parts of the world makes it desirable to observe the role of excess metals in plant growth.

Metal toxicity in plants was reviewed by various workers like Lisk (1972), Foy *et al.* (1978). The objective of this paper was to evaluate the toxicity of the two important metals, *viz.* mercury and manganese in radish, *Raphanus sativus* L., with particular emphasis on amount of chlorophyll, fresh weight, Hill reaction activity and protein content.

## Material and Methods

Seeds of radish were surface sterilized with 0.01% solution of mercuric chloride for 5 min and washed thoroughly several times with sterilized distilled water. Standard solutions of the two heavy metals mercury ($Hg^{2+}$), and manganese ($Mn^{2+}$) were prepared separately using their chloride salts and dilutions containing 5, 10, 100 and 200 ppm were made. Nutrient solution of 1/10 strength was used in the culture experiment. No precipitate appeared in any of these stock solutions. All water used for these solutions was distilled twice.

Seeds of radish were soaked separately in these solutions and were taken for germination in petridishes lined with Whatman No. 1 filter paper rinsed with different concentrations of mercury and manganese at 25± 2°C. Petridishes were received light of 7000 lux for 10 h daily. Control sets were also maintained throughout the experiment. Chlorophyll, Hill reaction activity, fresh weight, root length and protein content of the leaves of 10 day old seedlings were estimated.

## Results and Discussion

The two metals Hg and Mn showed inhibitory effects although their toxic ranges differed. The root growth was inhibited by various concentrations of these metals (Fig. 1). At higher concentrations (100 and 200 ppm) manganese inhibited the root length to a greater extent than mercury. Lepp (1977) has reported decreased growth of lettuce shoot and root when heavy metal solutions were applied individually. At lower concentrations also mercury and manganese had an inhibitory effect on root length.

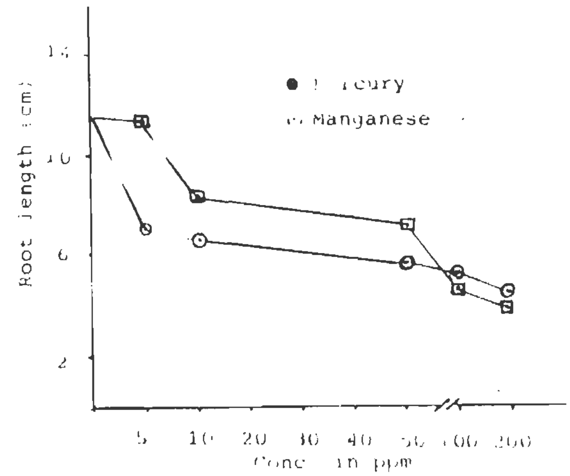


Fig. 1. Effect of mercury and manganese on root growth of radish.

Average fresh weight of the seedlings was also inhibited by the metals. In the control set the average fresh weight was 0.312 g but when the concentrations were increased from 5 to 200 ppm, the fresh weight decreased from 0.125g to 0.073 g for Hg and 0.163 g to 0.079 g for Mn (Fig.2). Terry *et al.* (1975) and Morghan *et al.* (1976) have studied Mn toxicity biochemically and concluded that the toxicity was associated with the destruction of auxin (indole acetic acid) in cotton, amino acid imbalance in potato with reduced leaf cell number and volume, and reduced leaf and root dry weight in sugarbeet. Singh *et al.* (1962) found that both height and weight of soybean plants were influenced by the concentration of iron and manganese.

From Fig. 3, it is clear that mercury and manganese had decreased the chlorophyll content in the leaves of radish. In the control set, the quantity of chlorophyll was 120 μg/0.1 ml solution but when the concentrations increased from 5 to 200 ppm the quantities decreased from 76 μg/0.1 ml to 33 μg/0.1 ml solution in mercury and 90 μg/0.1 ml to 45 μg /0.1 ml solution in manganese. It is understood that the presence of high nutrient levels of metal ions in the growing medium of plants affected the growth and showed qualitative and quantitative changes in enzymatic activities. Scarponi and Perucci (1984) reported that heavy metals and related metal organic compounds suppressed the activity of $\alpha$ amino levulunic acid dehydratase which regulates the chlorophyll biogenesis. Plant disorders can be caused by high concentrations of manganese in tobacco, barely, potato and palms (Bortner, 1935; Berger and Gerluff; 1948;

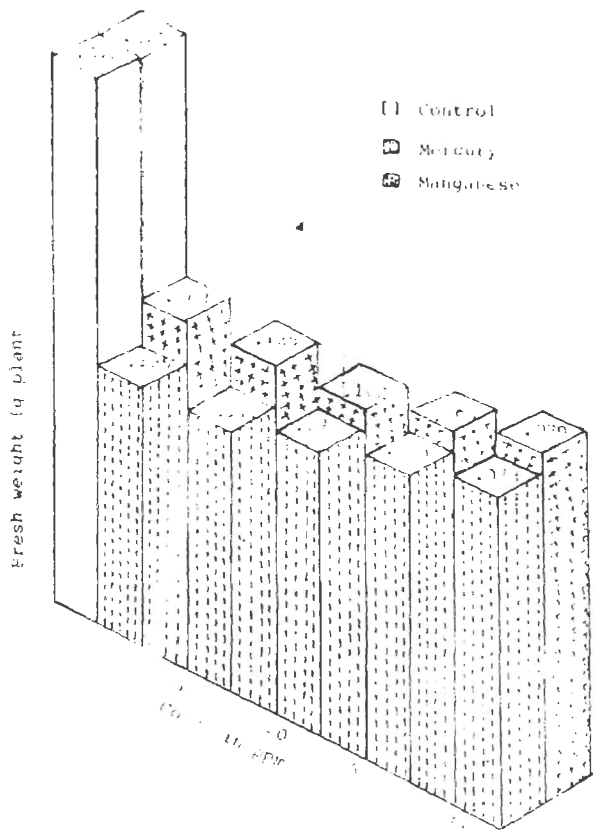


Fig. 2. Effect of mercury and manganese on fresh weight of radish seedlings.

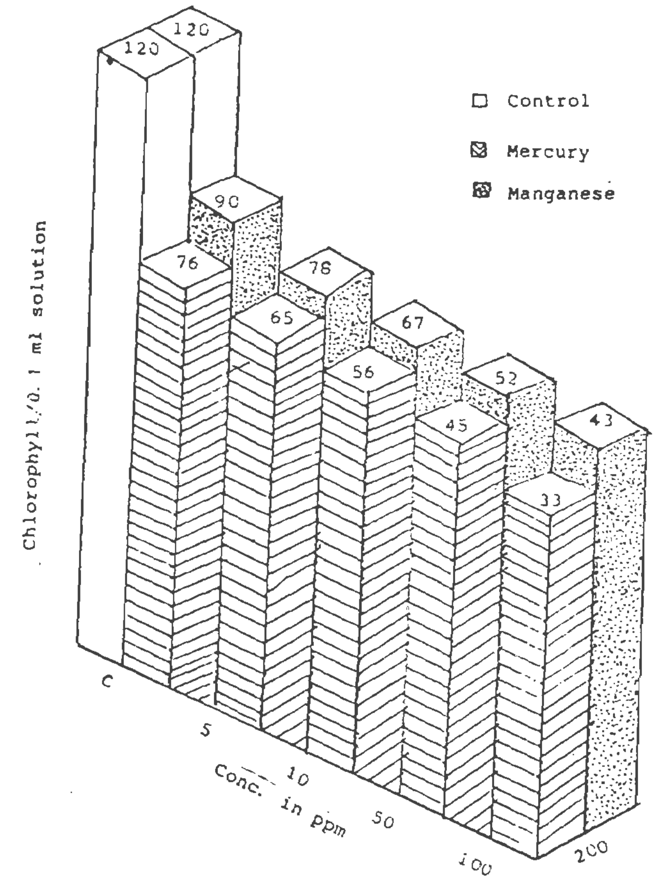


Fig. 3. Effect of mercury and manganese on chlorophyll content of radish seedlings.

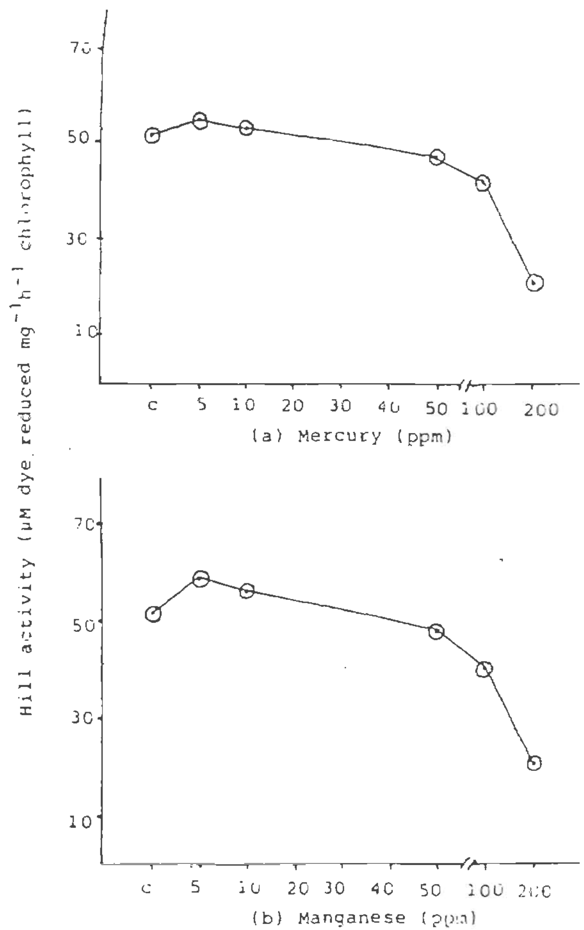


Fig. 4. Effect of various concentrations of mercury and manganese on Hill activity of chloroplasts.

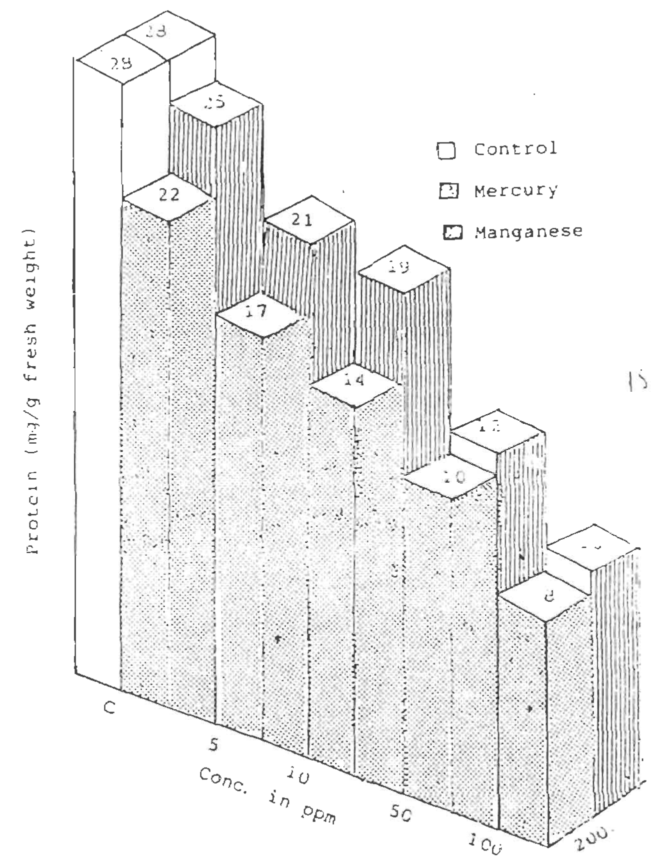


Fig.5. Effect of mercury and manganese on protein content of radish seedlings.

Subbarao and Lal, 1955). Miles *et al.* (1972) reported that photosystem II activity of an isolated chloroplast was inhibited by heavy metals, the primary site of inhibition being the oxidizing site of PS II.

Hill reaction activity of chloroplasts isolated from the leaves was also inhibited by mercury and manganese. The values were obtained after plotting a regression line (Yp = a + bx). Though Hill activity is a light dependent oxygen evolution process in the presence of a variety of artificial electron acceptors, e.g. indophenol dye used in the present study, at higher concentrations of mercury and manganese the activity was depresssed (Fig. 4). In control, the activity was measured as 52 $\mu$M dye reduced $mg^{-1}$ $h^{-1}$ of chlorophyll whereas at the concentrations of 100 and 200 ppm it was 42 and 21 $\mu$M dye reduced $mg^{-1}$ $h^{-1}$ of chlorophyll, respectively for mercury and 41 and 21 $\mu$M dye reduced $mg^{-1}$ $h^{-1}$, respectively for manganese.

Protein content of leaves was also inhibited by mercury and manganese. In control set the protein content of the leaves was measured as 28 mg $g^{-1}$ fresh weight whereas at 100 and 200 ppm concentrations it has reached 10 and 8 mg $g^{-1}$ fresh weight, respectively for mercury and 12 and 10 mg $g^{-1}$ fresh weight , respectively for manganese (Fig. 5). High inhibition was observed at higher concentration of mercury followed by manganese. Vaulina *et al.* (1979) reported that heavy metals bring a considerable decrease in the rate of all the metabolic processes of the cell including protein content. It is possible that at the high metal concentrations the selectivity of the cell membranes was reduced, thus allowing more rapid entry of metals. The present findings showed that in nutrient solutions of mercury and manganese, the former exhibited toxicity both at lower and higher concentrations (5 to 200 ppm) whereas the latter exhibited toxicity at higher concentration though it is an essential micronutrient for plant growth.

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# Heavy Metal Stress on Growth, Nitrogen Constituents and Nitrate Reduction in *Psophocarpus tetragonolobus* (L.) DC.

**N. Lakshmanan* and K. Santhaguru**

Centre for Research and P.G.Department of Botany, Thiagarajar College, Madurai 625009

* Department of Botany, Vivekananda College, Tiruvedakam West 624217.

## Abstract

Influence of cadmium chloride on percent germination, root and shoot length, number of lateral roots, dry weight, total nitrogen, total free-amino acids, proline, nitrate and nitrate reductase of winged bean *Psophocarpus tetragonolobus* (L) DC. was studied. Cadmium chloride caused a decrease in percent germination, root length, fresh weight, dry weight, total free amino acids and nitrate, but increased the accumulation of proline. However, at very low concentration, $Cd^{2+}$ caused an increase in the number of lateral roots and nitrate accumulation.

## Introduction

Heavy metals are known to inhibit germination, root-shoot length, fresh weight and dry weight (Pathak *et al.*, 1987). Heavy metal induced inhibitory effects on mobilization of N and P during germination and seedling growth (Sharma, 1985) and nitrate reductase activity (Ramadoss, 1979; Buczek *et al.*, 1980, Muthuchelian *et al.*, 1988) have been reported in a number of plants.

Cadmium is one of the most toxic elements in the biosphere and is readily absorbed (Marschner, 1983). In this communication, we report the effect of cadmium chloride on growth, nitrogen constituents and *in vivo* nitrate reductase activity of winged bean, a perennial legume and a protein rich crop receiving increased attention in recent times.

## Material and Methods

Seeds of winged bean, *Psophocarpus tetragonolobus* (L) DC., obtained from Tamil Nadu Agricultural University, Coimbatore, were surface sterilized with 0.1 $HgCl_2$ for 5 min and washed several times with sterile distilled water. They were treated with $CdCl_2$ at 0, 1, 10, 50 and 100 mg/l for 24h and washed several times with sterile distilled water. Then they were germinated in petriplates lined with moist filter paper and watered with sterile tap water. Seven day old seedlings were transferred to earthen pots (10" x 16") containing tap water washed sand. Tap water was used to water the sand cultures.

Seven day old seedlings were separated into roots and shoots and their length and the number of lateral roots were determined. The roots and shoots were cut into small bits and dried in an oven at 80°C to a constant weight.

*In vivo* nitrate reductase was assayed by incubating the plant material with nitrate reductase assay mixture in dark for 1 h. The assay mixture in 5 ml final volume contained 100 μ mole $KNO_3$, 475 μ mole potassium phosphate buffer (pH 7.5) and 5% n-propanol. The activity of nitrate reductase was expressed as μ mole $NO_2$ formed /h/g fresh weight. Total nitrogen (Umbreit *et al.*, 1972), total free-amino acids (Lee and Takahashi, 1966), proline (Bates *et al.*, 1973), nitrate (Andrews, 1967) and nitrite (Showe and De Moss, 1968) were determined.

## Results and Discussion

The extent of $Cd^{2+}$ induced inhibition of seed germination was dosage dependent (Fig.1) and was much pronounced at higher concentration (100 mg/l). This is in conformity with earlier reports of heavy metal induced reduction in percent germination of seeds (Singh, 1983; Lata, 1984; Pathak *et al.*, 1987).

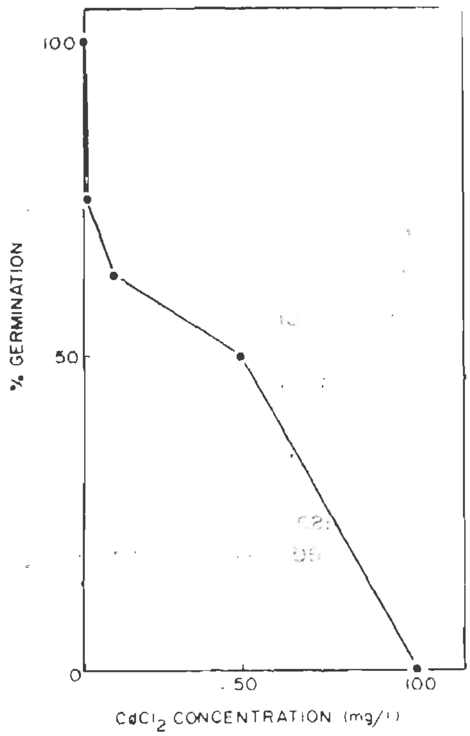


Fig. 1. Effect of cadmium chloride on percent germination of winged bean.

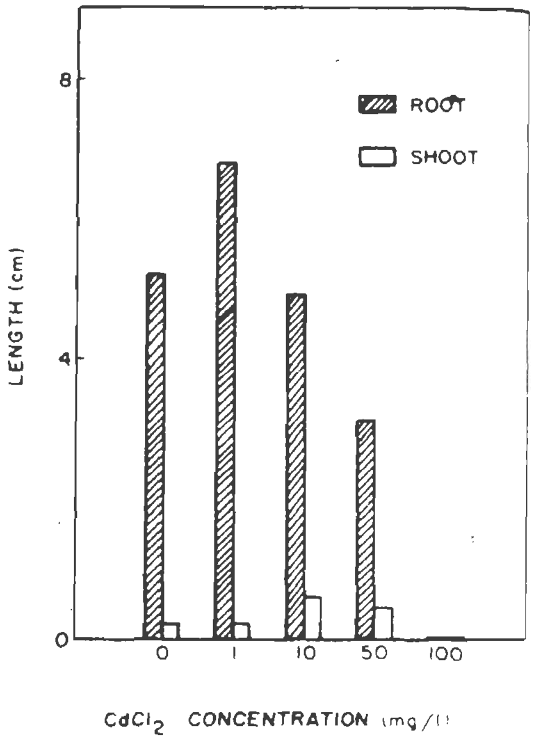


Fig.2. Effect of cadmium chloride on root and shoot length of winged bean.

While low dosage of $Cd^{2+}$ enhanced the root length and number of lateral roots (Fig.2 and Table 1), high dosage had a negative effect on root length. Interestingly, the shoot length (Fig.2) was promoted at high dosages of $Cd^{2+}$. In accordance with other studies (Turner, 1973), the reduction in winged bean growth may be partially due to root damage because at higher $Cd^{2+}$ concentrations root system was more severely affected than their shoot system.

Table 1. Effect of cadmium chloride on lateral roots in winged bean

| $CdCl_2$ (mg/l) | Number of lateral roots/plant |
|---|---|
| 0 | 4.4 |
| 1 | 11.7 |
| 10 | 7.0 |
| 50 | 3.0 |
| 100 | 0.0 |

As heavy metals bind with proteins (Jeromē and Ferguson, 1972), the dual effects of promotion and inhibition of plant growth by low and high concentrations of $Cd^{2+}$ could be through injury of enzymes crucial for germination and initial seedling growth. Cadmium chloride caused a decline in fresh and dry matter yield of both roots and shoots (Fig.3 and 4) and the effect was a function of $Cd^{2+}$ concentration. Similar reduction in fresh and dry matter was found in barley seedlings (Pathak *et al.*, 1987). Since $Cd^{2+}$ is known to affect photosystem-II activity (Bazzaz and Govindjee, 1974), the reduction in dry matter yield could be due to the disorganization of photosynthetic apparatus.

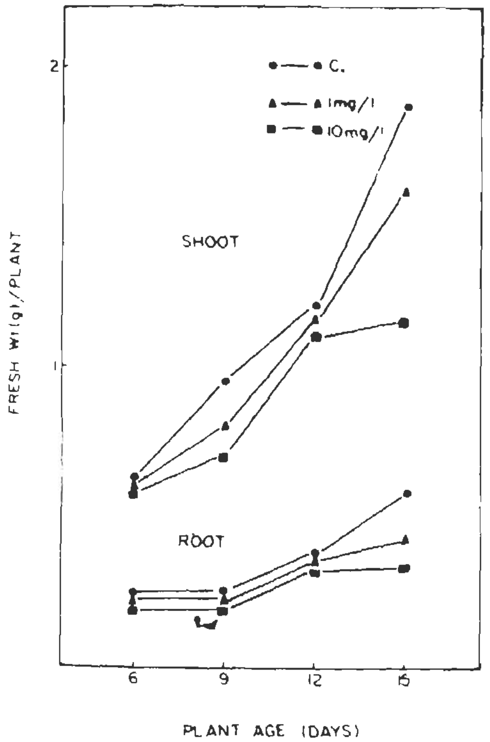


Fig. 3. Effect of cadmium chloride on root and shoot fresh weight of winged bean

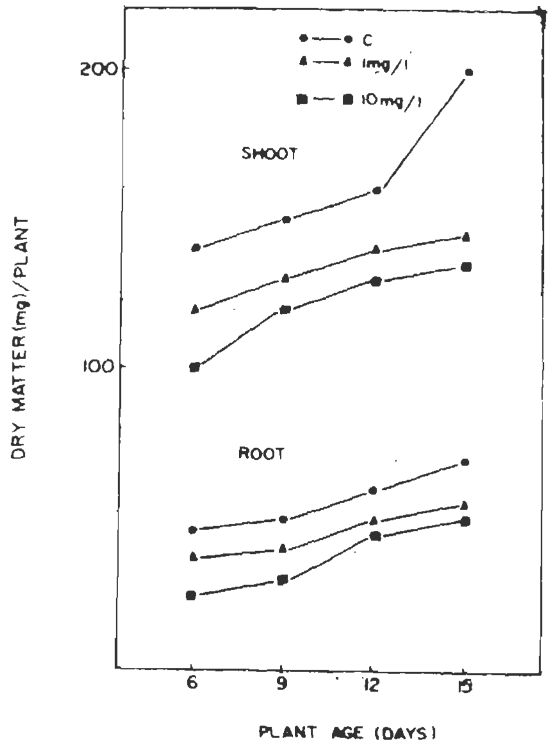


Fig. 4. Effect of cadmium chloride on root and shoot dry matter yield of winged bean

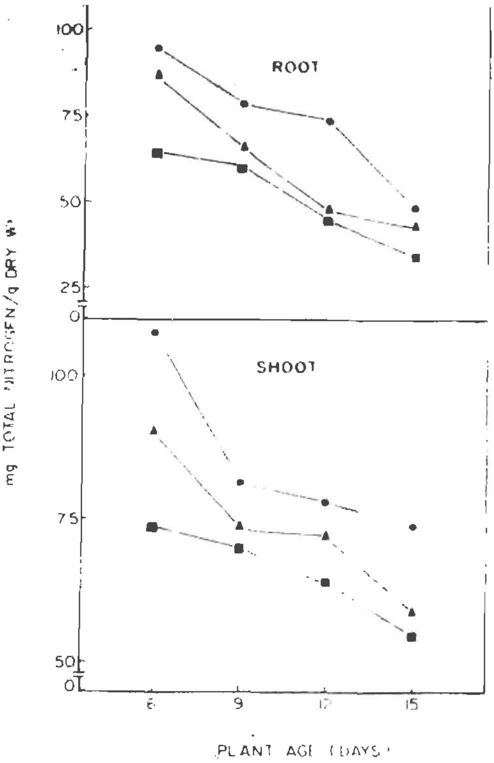


Fig. 5. Nitrogen content in roots and shoots of winged bean under $Cd^{2+}$ stress.

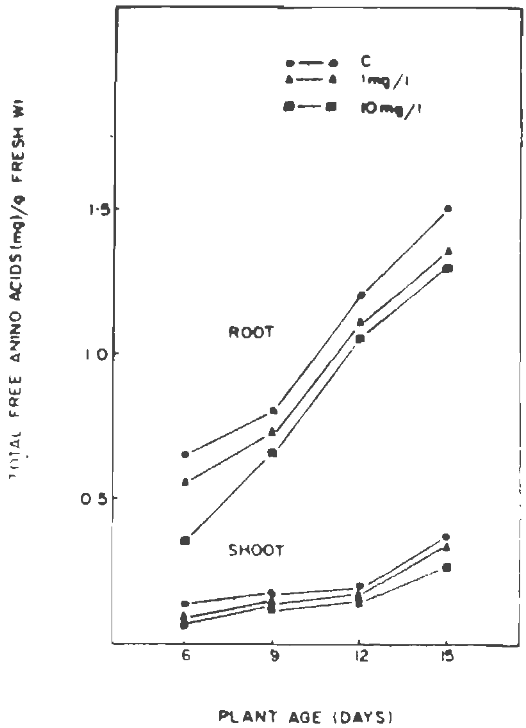


Fig. 6.. Effect of cadmium chloride on total free-amino acids in roots and shoots of winged bean.

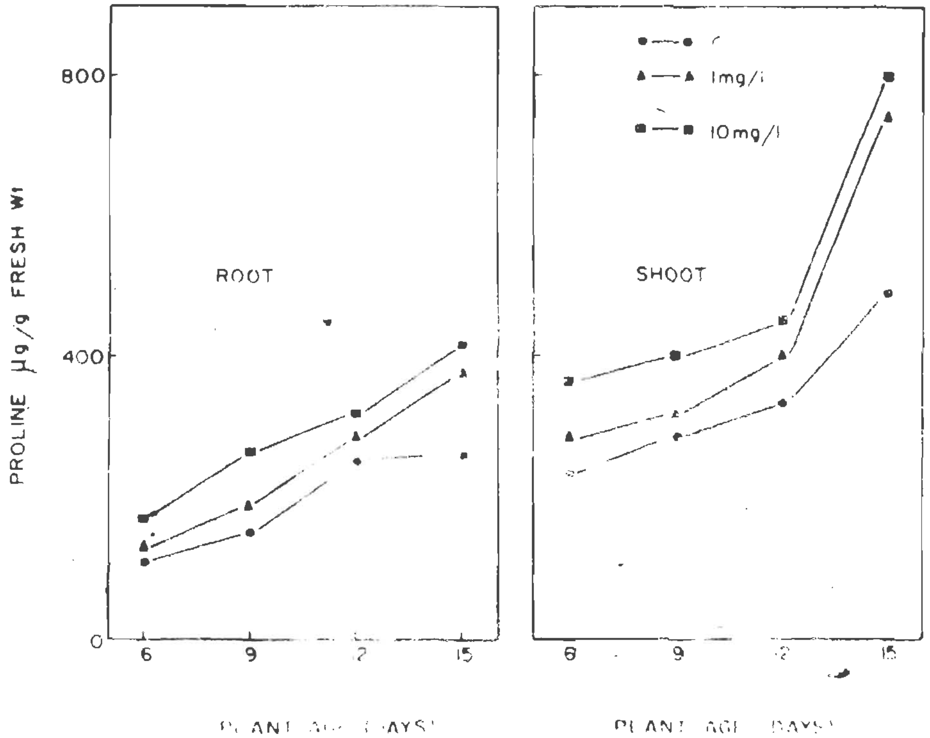


Fig. 7. Effect of cadmium chloride on proline accumulation in roots and shoots of winged bea

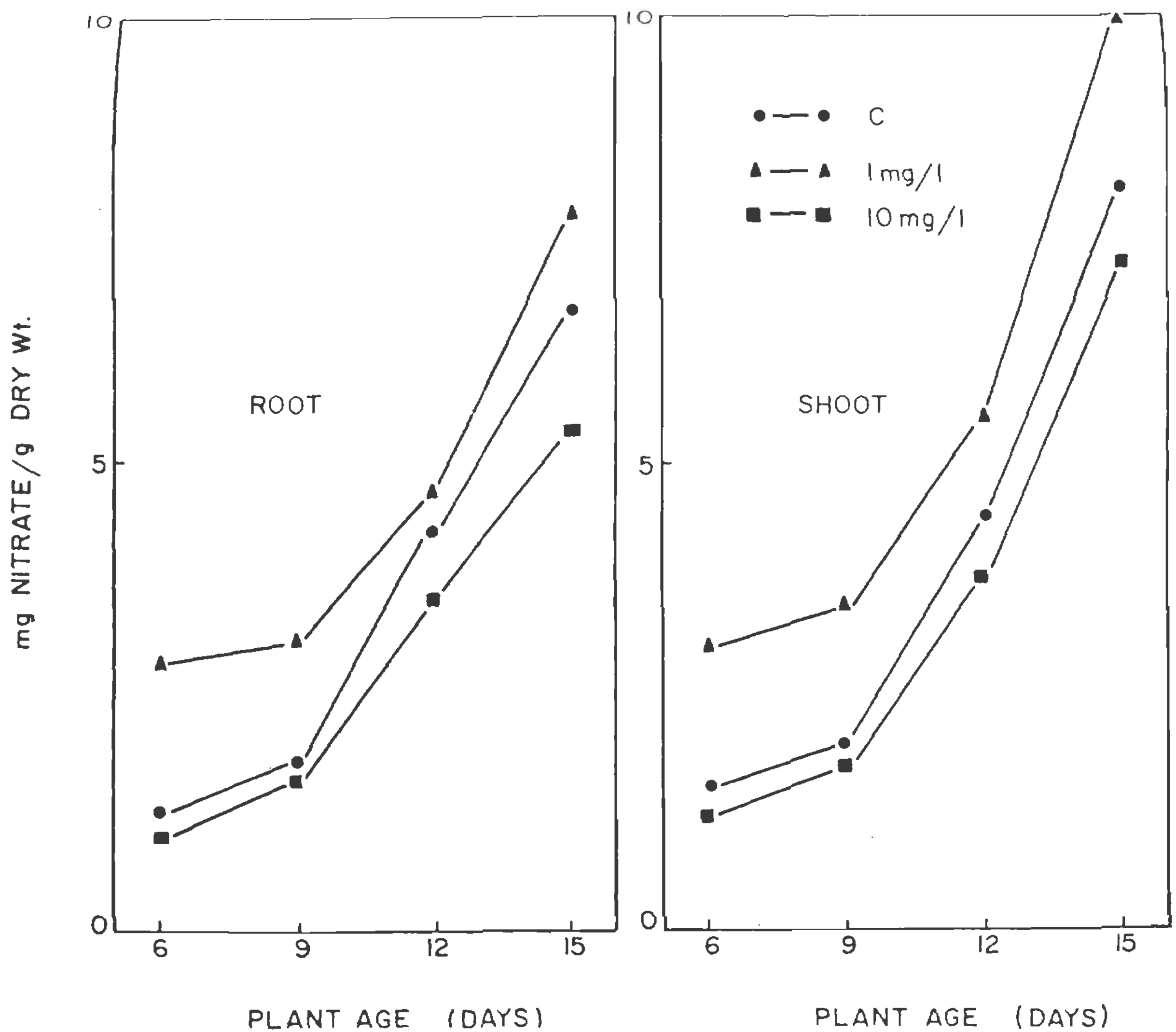


Fig. 8. Changes in nitrate content in roots and shoots of $Cd^{2+}$ treated winged bean.

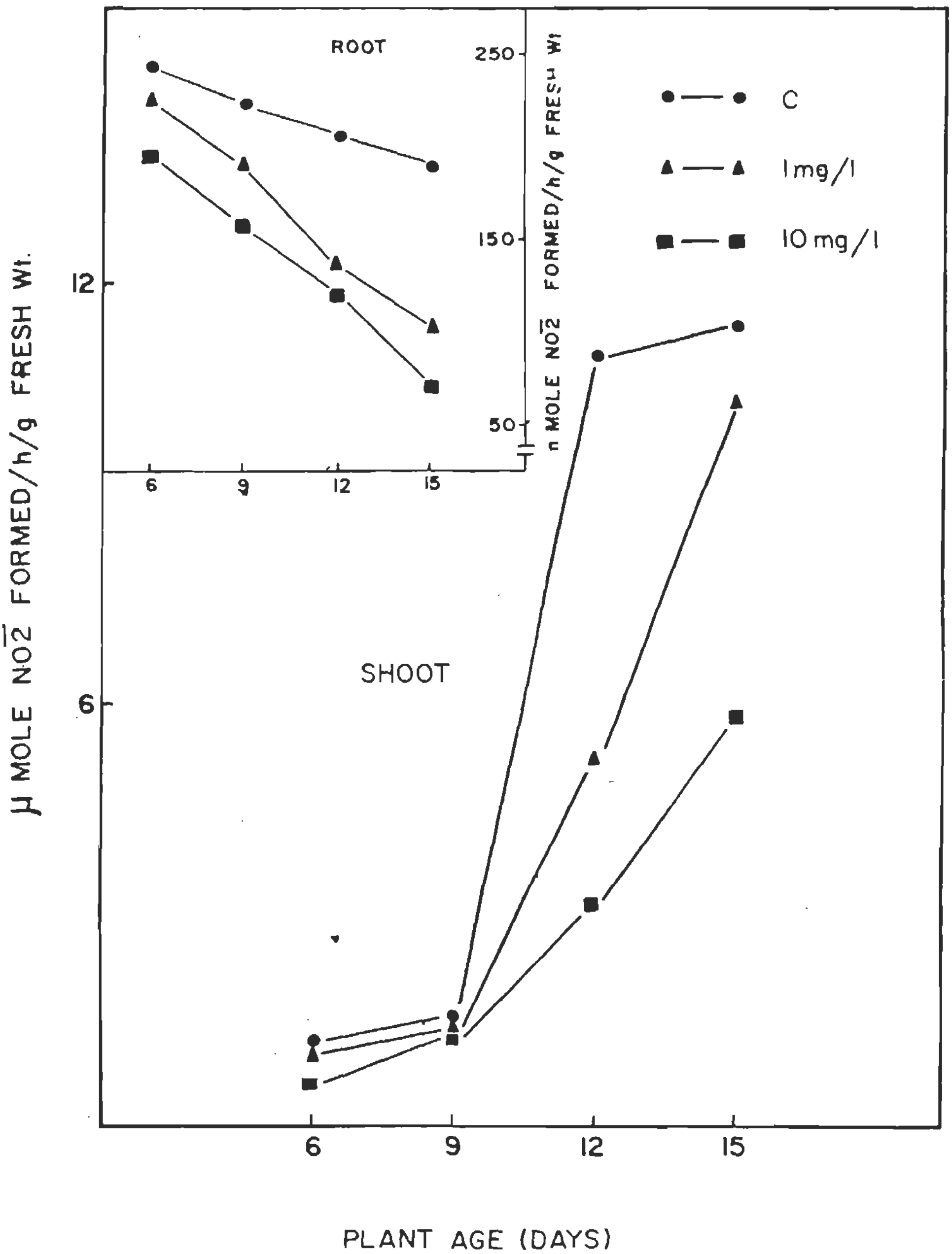


Fig. 9. *In vivo* nitrate reductase activity in roots and shoots of winged bean under $Cd^{2+}$ stress.

A steady decrease in total nitrogen (specific) in both roots and shoots (Fig.5) was the result of cotyledonary nitrogen dependent growth conditions. $Cd^{2+}$ treated plants showed a concentration- dependent reduction in total nitrogen (specific) and this reduction could probably be due to a loss of protein fraction that binds with $Cd^{2+}$, because heavy metal treated plants contain high protein nitrogen and low non-protein nitrogen (Kumar and Bisht, 1986).

Treatment of seeds with $Cd^{2+}$ affected the free-amino acid content in both root and shoots (Fig.6) at all concentrations tested. In contrast, proline accumulation was found to increase with increasing concentration of $Cd^{2+}$ (Fig.7). It has been suggested that proline accumulation during water stress may be due to *de novo* synthesis (Barnett and Naylor, 1966) or decrease in proline utilization by decreasing protein synthesis (Stewart, 1973). As total free-amino acids are inhibited in $Cd^{2+}$ treated winged beans, the accumulation of proline could be due to a decrease in utilization for protein synthesis.

Roots had less nitrate nitrogen than shoots (Fig. 8). While lower concentration of $Cd^{2+}$ promoted nitrate accumulation in both roots and shoots, higher concentration inhibited this process. $Cd^{2+}$ treated plants showed a decrease in *in vivo* nitrate reductase activity (Fig. 9). Again the decrease in nitrate reductase activity was a function of $Cd^{2+}$ concentration. Heavy metal induced reduction in nitrate reductase activity has been reported earlier (Ramadoss, 1979; Buczek *et al.*, 1980). It has been shown that radioactive vanadium binds with nitrate reductase (Lee *et al*., 1974) and vanadium forms an analogue of the molybdenum enzyme. However, a partial reactivation of vanadate inhibited nitrate reductase occurred when vanadate concentration was decreased by dilution. Though the present study does not include nitrate uptake, the positive relationship between nitrate reductase and nitrate content in roots and shoots indicated the substrate induced nature of the enzyme (Foy and Fleming, 1982).

In conclusion, it may be stated that $Cd^{2+}$ is beneficial to seedling growth of winged bean at very low concentration. Secondly, proline accumulation can be taken as an indication of heavy metal stress as in other stresses.

**Acknowledgements**

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University of Agricultural Sciences, Bangalore, 1989. pp.113-116

# Effect of Pulp and Paper Mill Effluent on the Primary Productivity

**M. Rajendra Kumar, S.J. Jose Rose, O.N. Seth and K.D. Mishra**
P.G. Department of Zoology, Aquaculture and Environment, S.S.L. Jain College, Vidisha 464001

## Abstract

In the present investigation, effects of pulp and paper mill effluents on the productivity of pond water were studied. The primary production was estimated by the light and dark bottle method in nursery ponds. Amongst the five effluent concentrations tried, i.e. 1, 5, 10, 20 and 30%, the gross primary productivity was enhanced in 1 and 5% concentrations but in 10, 20 and 30% concentrations it decreased when compared to normal pond water. At higher concentrations the value of community respiration became equal to the gross primary production. At lower concentrations the productivity was observed to increase whereas at higher concentrations the rate of primary productivity decreased.

## Introduction

The short exposure of pulp and paper mill effluent is reported to affect the productivity of freshwater phytoplankton or periphyton (Saniassy *et al.*, 1977; Eloranta and Eloranta,1980; Eloranta and Laitinen, 1981 and 1982; Van Coillie *et al.*, 1984). Rainville *et al.* (1975) have reported decreased productivity for the estuarine blue-green algae *Coccachloris elebans* due to exposure to primary treated BKME concentrations. Nikunen (1983) and Walsh *et al.* (1982) have reported that lower dilutions of effluent caused stimulation of algal growth. Thosar and Das (1984) have pointed out that organisms which survive in toxicant water need more oxygen for survival.

From the available literature it is clear that the effect of pulp and paper mill effluent on the primary productivity of pond water has not been worked out so far. The present study deals with the primary production trends in pond water treated with the effluent of the Shivshakti Paper Mill situated on the bank of river Betwa in Vidisha, Madhya Pradesh.

## Material and Methods

The mill selected for the present study manufactures brown paper with a capacity of 10 tons/day by using wheat straw and waste paper as raw material. The mill has no paper effluent treatment plant and its effluent is discharged into the river Betwa after partial settling. The effluent was collected from the discharge channel of the mill and stored in a refrigerator. The dilutions 1, 5, 10, 20 and 30% were prepared using pond water. The physico-chemical characteristics of the effluent and pond water are given in Table 1. The primary production of the pond water was estimated by the light and dark bottle method of Gardener and Gran (1927), as recommended by Vollenweider (1969). Dissolved oxygen concentration in the above experiments was measured with the modified Winkler's method (Anon., 1985). All oxygen values obtained in the present study were converted to carbon values by a factor 0.375 (Odum,1956).

One dark and one light bottle were filled with effluent dilution of each concentration and were incubated in the pond for 6 hours along with a light and dark bottle containing pond water without effluent concentration as control.

Table 1. Physico-chemical characteristics of effluent and pond water.

| Parameter | Effluent | Pond water |
|---|---|---|
| Colour | Dark brown | Green |
| Turbidity (NTU) | 320 | 28 |
| Conductivity (mMho) | 191 | 0.56 |
| pH | 5.5 | 8 |
| $CO_2$ (mg/l) | 145.2 | 8.8 |
| DO (mg/l) | Nil | 8.9 |
| BOD (mg/l) | 4800 | 1.2 |
| Chloride (mg/l) | 740 | 190.2 |
| Alkalinity (mg/l) | 300 | 160 |
| Hardness (mg/l) | 280 | 180 |
| Total solids (mg/l) | 3240 | 400 |
| TDS (mg/l) | 2840 | 200 |
| TSS (mg/l) | 400 | 200 |

## Results and Discussion

The gross productivity of unpolluted water was found to be 1351.30 mgC/$m^3$/h. In effluent treated water, the gross productivity increased at lower concentrations whereas a sharp decline was observed in the higher concentrations (Fig.1). In 1% dilution the gross production was estimated to be 1764.19 mgC/$m^3$/h showing an increase of 30.55% over control. Similarly, in 5% dilution the value of gross production was found to be 1801.728 mgC/$m^3$/h showing an increase of 33.33% over control. The value of net primary productivity was found to be 900.86 mgC/$m^3$/h in control. In 1% effluent concentration, NP was 975.93 mgC/$m^3$/h showing an increase of 8.44% over control. In 5% dilution it was 1351.29 mgC/$m^3$/h showing an increase of 50% over control. This clearly indicated that both gross and net primary productivity increased in the lower dilutions of effluent. In the higher concentrations, i.e. 10, 20 and 30% the value of gross primary productivity decreased by 11, 55, 77%, respectively over the normal values whereas the net primary productivity reached zero in all the three concentrations. This was due to the fact that the community respiration became equal to the value of gross primary productivity.

The value of community respiration showed an uneven pattern with increasing concentration of effluent. In 1% concentration it increased by 83% whereas it remained unchanged in 5% concentration. In 10% concentration a very high value of community respiration was observed with an increase of 166% over the normal value. In 20% dilution the community respiration showed an increase of only 33% whereas it decreased in 30% dilution by 33%. This clearly indicated that the respiratory activity of plankton was highest in 10% dilution and dropped down at 20 and 30% dilutions.

The increase in primary productivity recorded in lower concentrations of pulp and paper mill effluents is in agreement with the work of Nikunen (1983) who has mentioned that lower dilutions of effluent caused stimulation of algal growth. Walsh *et al.* (1982) also reported enhanced growth of marine algae upto 1% concentration. In the present study considerable decrease was observed in the primary productivity at higher concentrations.

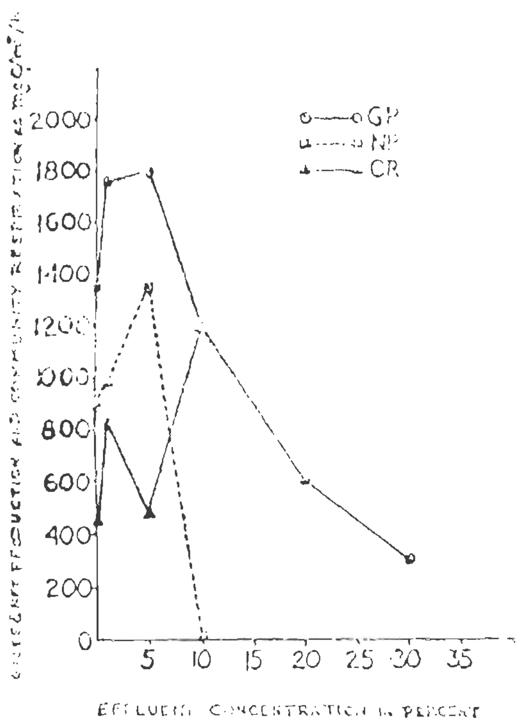


Fig.1. Effect of effluent on productivity and community respiration

Similar observations were reported by other workers due to pulp and paper mill effluents (Nikunen, 1983; Bothwell and Stockner,1980; Rainville *et al.*, 1975). These workers have opined that the inhibition of photosynthetic activity by the dark colour of effluents was the major reason for the decrease in the primary productivity.

In the present study, the level of community respiration has been found to increase with the concentration of the effluent. Thosar and Das (1984) have pointed out that the organisms that survive in toxicants need more oxygen to survive.

Finally it can be concluded that the pulp and paper mill effluents caused a dramatic change in the primary productivity of the receiving waters. At lower concentrations the productivity increased due to increase in nutrient level whereas it decreased at higher effluent concentrations due to the colour of effluents. On the basis of these observations it is suggested that a very low concentration of effluent in receiving water may not cause any damage to the producer community but higher concentrations may affect the survival, growth and photosynthetic activity of producers and may lead to eutrophic condition at a lower stage.

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# Effects of Soft Drinks Industrial Effluent on Certain Haematological Parameters of the Fish *Sarotherodon mossambicus* (Peters)

**R. Balaji, R. Sugumaran and P. Rajendran***

P.G. Department of Zoology, Vivekananda College, Tiruvedakam West, Madurai 624217

## Abstract

The freshwater fish *Sarotherodon mossambicus* (Peters) was exposed to different concentrations of soft drinks industrial effluent to find the manifestation and maximum survival time. Significant decrease in total erythrocytes and increase in total leukocytes were noticed in the fish exposed to 25% industrial effluent for 10 days. Other haematological parameters like coagulation time, haemoglobin content and morphometry did not show any significant change. Irregular shape and poiklocytosis were noticed in erythrocyte cells of the exposed fish.

## Introduction

In toxicity experiments,blood often manifests pathological changes before external signs of poisoning are noticed (Panigrahi and Misra,1979). Haemotological observations are perhaps the easiest tools to diagnose in physiological studies of higher mammals (Schalm,1967). The effect of toxic substances on the haematology of fish was studied by Haniffa *et al.* (1985) and Joshi (1987). There are a number of reports on the physiological, biochemical and histochemical changes in the blood and tissues of fish exposed to a variety of other pollutants (Kaltz *et al.*, 1969). In the present investigation, an attempt has been made to study the effect of soft drinks effluent on certain haematological parameters of the freshwater fish *Sarotherodon mossambicus*. The soft drinks effluent which contains suspended solids has been a major concern in water pollution programmes because fish communities are affected by suspended solids (Verma and Dalela, 1975).

## Material and Methods

The test fish *S. mossambicus* were collected from a local pond and acclimated to laboratory conditions and fed on oil cakes. Different concentrations of soft drink effluent were prepared using tap water. Five healthy fishes of equal size were recruited from the stock and left in the treated water to find the manifestation and maximum survival time according to Waren (1900) and Wuhurmen (1952), respectively. The physico-chemical properties of the effluent were analysed. Twenty five per cent effluent concentration was selected for the haematological studies. To minimize variations in properties, the same effluent was used throughout the experiment. At the end of ten days exposure,blood was collected from the gill arches. Total erythrocytes (T.E.C.) and total leukocytes (T.L.C.) and haemoglobin (Hb) content of the blood were studied by Neubauer counting-chamber and Sahli's haemoglobinometer. Morphometric and morphological studies were also done using micrometer and blood smears stained with Lesihman's Stain.

* For further communication

## Results and Discussion

Table 1 and Fig.1 present the physico chemical properties of the effluent and the manifestation and maximum survival time of *S. mossambicus* exposed to soft drinks effluents, respectively. It was observed that the fish survived for more than ten days in the 25% concentration of the effluent. At this concentration after 10 days of exposure, significant decrease in erythrocyte count was noticed (Table 2). This is in contrast to the earlier report of Haniffa and Isai Arasu (1985) in which fishes exposed to paper mill and textile mill effluents showed an increase in total erythrocytes count. According to Sharma and Joshi (1985), the increase in total erythrocyte and Hb content was due to asphyxiation. But the considerable decrease in erythrocyte count in the present study is similar to the findings on fishes exposed to mercury by Panigrahi and Misra (1982) who attributed this phenomenon to haemolytic anemia. An interesting observation in our experiment is that there was no significant decrease in the Hb content. This may be due to the toxic effect of the effluent which has interfered with the haemopoeisis thereby decreasing T.E.C.

Table 1. Physico chemical properties of tap water and effluent used for the experiment.

| Parameters | Tap water | Effluent |
|---|---|---|
| Colour | — | Gray |
| Odour | — | Pungent smell |
| pH | 7.1 | 7.9 |
| Oxygen (ml/l) | 5.723 | Nil |
| Carbondioxide (mg/l) | 7.491 | 99.88 |
| Chlorinity (g/l) | 1.571 | 10.363 |

Table 2. Effect of soft drinks effluent on certain haematological parameters of *Sarotherodon mossambicus*

| Haematological parameter | Control | Effluent concentration (25%) | Student 't' test |
|---|---|---|---|
| Coagulation time (sec) | 22.25 ± 0.5* | 23.5 ± 0.577 | P> 0.10 |
| Haemoglobin content (g/100 ml) | 15.5± 0.577 | 15.75 ± 0.5 | P> 0.50 |
| Morphometry of erythrocytes (mm) : | | | |
| Length | 0.01642 ± 0.00177 | 0.01303 ± 0.00249 | P> 0.10 |
| Width | 0.00910 ± 0.00179 | 0.01017 ± 0.00172 | P> 0.50 |
| RBC count ($10^6$/mm$^3$) | 0.562500± 0.017078 | 0.490000 ± 0.018257 | P< 0.02 |
| WBC count ($10^6$/mm$^3$) | 0.353868 ± 0.02232 | 0.380537 ± 0.0770 | P< 0.001 |

* Mean ± S.D. from five individual observations.

The blood smear preparations showed a number of morphological changes in the erythrocytes (Fig.2). The control fishes showed elliptical R.B.C.'s with central nucleus whereas treated fishes showed swellings resulting in poiklocytosis with rough surface. The

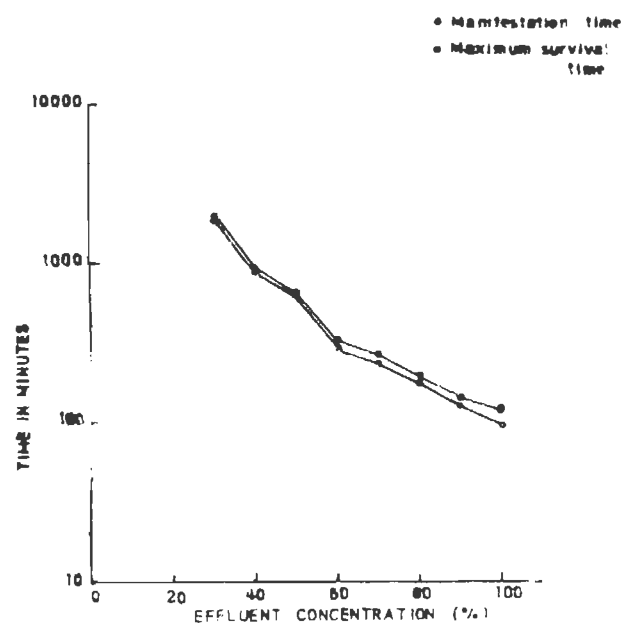


Fig.1. Manifestation and maximum survival time of *S. mossambicus* exposed to different concentrations of the effluent.


Fig.2. Erythrocytes of control (Plate I) and experimental (Plate II) *S. mossambicus*.

swellings and poiklocytosis observed maybe due to the abnormality in erythropoiesis resulting in damage to the circulating tissue.

The significant increase in the total leukocyte count corroborates the earlier work on fishes by Agarwal *et al.* (1983) and Goel and Sharma (1987). The increase in T.L.C. may be due to the leukocytosis caused by stress of the effluent. The increase in T.L.C. is an adaptive value to meet the stressful condition of the animals(Goel and Sharma, 1987).

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# Survival, Food Utilization and Growth of *Labeo rohita* (Hamilton) in Domestic Waste Waters

**M.R.Rajan**

School of Energy, Environment and Natural Resources, Madurai Kamaraj University, Madurai 625021.

## Abstract

Studies on the survival of the fish *Labeo rohita* (Hamilton) in different concentrations of domestic sewage showed that 71% concentration was sublethal while 74% was the $LC_{50}$ at 10 days after exposure. The sublethal effect of sewage on food utilization, growth and conversion efficiency of the fish was estimated. The food consumption of the fish decreased with increasing concentration of sewage. The absorption efficiency of fish reared in sewage free water and different concentrations of sewage did not vary significantly. The growth rate of fish reared in 20% sewage increased two fold compared to those reared in sewage free water. The growth of the fish was inhibited at higher concentrations of sewage (30 and 40%) considerably. The gross and net conversion efficiencies of the fish reared in sewage-free water and 10% sewage did not vary significantly whereas 20% sewage increased the gross and net conversion efficiencies. The other groups of fishes reared in higher concentrations exhibited reduced conversion.

## Introduction

Environmental pollution, especially water pollution, is a major issue of modern life. Industrial discharge, sewage and surface run off water from land treated with plant protection chemicals degenerate the quality of water. This will not only affect the inhabitants of water bodies, particularly fishes, but also the health of human beings. Pesticides used in agricultural operations affect the survival and growth of few fresh water fishes (Web and Brett, 1973 ; Nagendran and Shakunthala, 1979 ; Arunachalam *et al.*, 1980; Arunachalam and Palanichamy, 1982 ; Manoharan and Subbiah, 1982 ). Likewise fertilizers used in excess to promote crop production also affect the survival and growth of fish (Palanichamy *et al.*, 1985). Raw sewage as well as domestic sewage are detrimental to fish life due to their low dissolved oxygen content and noxious chemical content. There is a paucity of information on the survival, growth and food utilization of fishes in waste waters. Hence, in the present studies, the effect of waste water on the fish *Labeo rohita* (Hamilton) at sublethal concentrations was investigated.

## Material and Methods

Juveniles of *L. rohita* (2.4 ± 0.4 g) were procured from Anaipatti, Madurai, and acclimated in the laboratory in glass aquaria (2m x 0.5m x 1m) at 28 ± 2°C for 15 days. During laboratory acclimation, the fish were fed on fish feeds prepared in the form of dry pellets containing groundnut oil cake, rice bran, wheat flour and fish meal. The sewage was collected from the ladies hostel and staff quarters of Madurai Kamaraj University. The physico-chemical characters of the sewage are presented in Table 1.

Considering the original sewage as 100%, the effluent was diluted to 10 to 90% with tap water. Different concentrations of sewage were taken in polyethylene troughs

Table 1. Physico-chemical parameters of sewage

| Parameter | | Mean ± S.D. | Range |
|---|---|---|---|
| pH | (°C) | 8.95± 0.43 | 8.3 - 9.42 |
| Temperature | (µ mhos) | 32.2± 1.88 | 28 - 34 |
| Conductivity | ($mgl^{-1}$) | 1014.5± 110.6 | 840 - 1270 |
| Total solids | ($mgl^{-1}$) | 1.87 ± 0.51 | 1.2 - 3.0 |
| Total dissolved solids | ($mgl^{-1}$) | 1.81 ± 0.41 | 1.3 - 2.4 |
| Total suspended solids | ($mgl^{-1}$) | 0.31 ± 0.09 | 0.1 - 0.5 |
| Dissolved oxygen | ($mgl^{-1}$) | 0.46 ± 0.26 | Nil - 0.84 |
| Dissolved carbondioxide | ($mgl^{-1}$) | 57.31 ± 17.39 | 35.2 - 91.4 |
| $H_2S$ | ($mgl^{-1}$) | 0.382 ± 0.07 | 0.26 - 0.47 |
| Chloride | ($mgl^{-1}$) | 49.41 ± 4.36 | 42.60 - 53.96 |
| EDTA hardness | ($mgl^{-1}$) | 221.9 ± 16.34 | 205 - 250 |
| Ammonia | ($mgl^{-1}$) | 1.76 ± 1.13 | 0.44 - 3.0 |
| Inorganic phosphorous | ($mgl^{-1}$) | 1.467 ± 0.744 | 0.37 - 2.44 |
| Calcium | ($mgl^{-1}$) | 28 ± 1.05 | 27 - 30 |
| Sodium | (meg) | 169 ± 2.82 | 166 - 170 |
| Potassium | (meg) | 356.1 ± 14.36 | 354 - 370 |

(30cm x 35cm x 15cm). The volume of the medium in polyethylene troughs was maintained at 10 liters. In each concentration of sewage 10 fishes were introduced. The mortality of fish observed at 24h intervals was expressed in terms of percentage. From these observations the sublethal, median lethal and lethal concentrations were found.

For rearing experiments, different concentrations of sewage, such as 10, 20, 30, and 40 % were prepared since the sublethal concentration was found to be 70%. These media were taken in polyethylene troughs (30cm x 35cm x 15cm). The volume in each trough was maintained at 10 liters. The fingerlings were distributed among the tanks at a stocking density of 10 fish per tank with treatments in triplicate. The control fish were reared in sewage free fresh water. Individuals with similar body weight were dried and the percentage of dry matter was calculated. Using this percentage, the dry weight of the test individuals was calculated. During rearing, the fish were fed ad libitum on a diet of the prepared food once in a day for 2h from 10 A.M. to 12 noon. Immediately after the feeding time, the food remains in the trough were collected using a pipette without disturbing the fish and the actual consumption was calculated. The medium was changed daily to give constant effect of sewage on fish. At the time of changing the culture medium, the entire trough water was filtered for the collection of faeces. The faeces were dried at 95°C and weighed. The rearing experiments were continued for 45 days. On the final day, the test individuals were weighed in live condition, killed, dried to constant weight and the dry weight was recorded. The food utilization scheme was expressed following the modified form of IBP formula (Arunachalam and Palanichamy, 1982 ; Pandian *et al.*, 1972 ; Arunachalam and Ravichandra Reddy, 1979).The formula adopted was $C = P + M + F$ where C is food consumed ; P production or growth; M energy loss due to respiration and nitrogenous excretory products; and F faeces.

Food consumption was determined by subtracting the dry weight of the unfed materials from the dry weight of the food given. The feeding rate was calculated as mg dry food consumed per g live fish per day.

$$\text{Feeding rate} = \frac{\text{Total dry food consumed}}{\text{Number of days x Initial live weight of fish}}$$

Food absorption was determined by subtracting the faeces from the total food consumed by the fish and the absorption rate was expressed as mg dry food absorbed per g live fish per day.

$$\text{Absorption rate} = \frac{\text{Total food absorbed}}{\text{Number of days x Initial live weight}}$$

The absorption efficiency was calculated as the percentage of food absorbed in relation to food consumed.

$$\text{Absorption efficiency} = \frac{\text{Food absorbed}}{\text{Food consumed}} \times 100$$

The gain in dry weight of the test fish was found following sacrifice method and treated as production of growth.

$$\text{Growth rate} = \frac{\text{Total gain in weight}}{\text{Number of days x Initial live weight}}$$

Metabolic rate of fish was calculated by subtracting the growth rate from absorption rate. Gross conversion efficiency was calculated as the percentage of food converted into body tissues in relation to feeding rate.

$$\text{Gross conversion efficiency} = \frac{\text{Growth rate}}{\text{Feeding rate}} \times 100$$

Net conversion efficiency was calculated as the percentage of food converted into body tissues in relation to absorption rate.

$$\text{Net conversion efficiency} = \frac{\text{Growth rate}}{\text{Absorption rate}} \times 100$$

## Results and Discussion

The survival of *L. rohita* in different concentrations of sewage is presented in Table 2. The results indicated that 70% sewage was sublethal as it did not cause any mortality even at the end of 10 days. In general, as concentration increased mortality of fish increased. The 100% lethal concentration at 24 h exposure was 80% At 240 h exposure, 74% concentration caused 50% mortality.

Food consumption of *L. rohita* decreased with increasing concentration of sewage (Table 3). The food consumption of the fish when reared in fresh water was 20.77 mg dry food consumed per g live fish per day. The food consumption of fish reared in 20% sewage (18.86 mg dry food consumed per g live fish per day) increased slightly when compared to those reared in 10% sewage. At the other concentrations, the food consumption decreased significantly. The food consumption of fish reared in sewage water, in general, was less than that of fish reared in sewage free water.

The absorption rate and absorption efficiency of the fish reared in sewage free water and in different sublethal concentration of sewage did not differ significantly.

Table 2. Effect of different concentrations of domestic sewage on the survival of *Labeo rohita*.

| Concentration of Sewage (%) | Percentage mortality at different exposure intervals (h) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 24 | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 |
| 70 | | | | | | | | | | |
| 71 | | | | | | | | | 0 | 10 |
| 72 | | | | | | | | | 10 | 20 |
| 73 | | | | | | | 10 | 20 | 20 | 30 |
| 74 | | | | | | 10 | 20 | 20 | 30 | 50 |
| 75 | | | | | 10 | 20 | 30 | 50 | 60 | 70 |
| 76 | | | | 10 | 20 | 30 | 50 | 60 | 70 | 100 |
| 77 | | | 10 | 20 | 30 | 50 | 70 | 100 | | |
| 78 | | 10 | 30 | 50 | 70 | 100 | | | | |
| 79 | 50 | 70 | 100 | | | | | | | |
| 80 | 100 | | | | | | | | | |

The growth rate of fish reared in sewage free water was 0.762 mg dry weight per g live fish per day. But at 10% of sewage, growth rate decreased to 0.635 mg dry weight per g live fish per day. The growth rate of fish reared in 20% sewage was 1.46 mg dry weight per g live fish per day showing a two fold increase over that of sewage free water. In higher concentrations of the test medium, *viz.*, 30 and 40 % the growth rate decreased to 0.375 and 0.325 mg dry weight per g live fish per day, respectively.

The metabolic rate of fish reared in sewage free water was 16.46 mg per g per day. At 10 and 20% sewage concentrations, the metabolic rate was 12.35 and 14.04 mg per g per day, respectively. The metabolic rate significantly decreased to 11.86 and 11.78 mg per g per day at 30 and 40 % sewage, respectively.

The gross and net conversion efficiencies of the fish reared in sewage free water and 10% sewage did not differ significantly. The gross and net conversion efficiencies of fish reared in 20% were higher than those in the control. The other groups of fishes have shown decreasing efficiencies.

The survival studies revealed that 70% sewage concentration was the tolerance limit for the fish *L.rohita*. Beyond this limit, mortality occurred and the mortality rate increased with increasing concentration of sewage. The mortality may be due to the absence of dissolved oxygen in the sewage. There are several reports on the toxic effects of heavy metals, pesticides, chemical fertilizers, distillery effluents and textile industry effluents on fishes (Arunachalam *et al.*, 1980; Arunachalam and Palanichamy, 1982; Palanichamy, *et al.*, 1985; Haniffa and Porchelvi, 1985 ; Rajan and Balasubramanian, 1988; Howrath and Sprague, 1978 ; Davies, 1976; Brungs, 1969; Sam Manchar and Srinivasa Reddy, 1982; Moni, 1984).

The results of the rearing experiments indicated that 10% sewage had significant effect on feeding rate but did not reduce the growth rate and conversion efficiencies

Table 3. Effect of different concentrations of sewage on food utilization and conversion efficiency of *Labeo rohita*

| Food utilization parameters | Sewage free medium | Concentration of sewage (%) | | | |
|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 |
| Feeding rate (mg/g live fish per day) | $20.77 \pm 0.12^{a}$ | $17.59 \pm 3.06^{b}$ | $18.86 \pm 0.35^{c}$ | $16.66 \pm 3.20^{d}$ | $16.03 \pm 2.59^{e}$ |
| Absorption rate (mg/g live fish per day) | $16.94 \pm 0.29$ | $14.08 \pm 1.34$ | $16.75 \pm 1.05$ | $15.49 \pm 2.32$ | $14.93 \pm 2.57$ |
| Growth rate (mg/g live fish per day) | $0.762 \pm 0.15^{a}$ | $0.635 \pm 0.34^{b}$ | $1.46 \pm 0.64^{c}$ | $0.375 \pm 0.15^{d}$ | $0.325 \pm 0.11^{e}$ |
| Metabolic rate (mg/g live fish per day) | $16.46 \pm 0.43^{a}$ | $12.35 \pm 0.38^{b}$ | $14.04 \pm 1.33^{c}$ | $11.86 \pm 3.08$ | $11.78 \pm 0.33$ |
| Absorption efficiency (%) | $84.86 \pm 0.17$ | $82.57 \pm 0.14$ | $83.66 \pm 1.65$ | $86.59 \pm 0.90$ | $86.67 \pm 0.49$ |
| Gross conversion efficiency (%) | $3.61 \pm 0.31$a | $3.80 \pm 1.04^{b}$ | $7.88 \pm 3.68^{c}$ | $2.66 \pm 0.43$ | $2.29 \pm 0.26$ |
| Net conversion efficiency | $4.19 \pm 0.40$a | $4.61 \pm 1.26^{b}$ | $9.57 \pm 4.60^{c}$ | $2.89 \pm 0.26$ | $2.59 \pm 0.27$ |

| | | | | | |
|---|---|---|---|---|---|
| Feeding rate | a vs b | t = 3.00 S | Metabolic rate | a vs b | t = 15.27 S |
| | a vs c | t = 12.24 S | | a vs c | t = 4.12 S |
| | a vs d | t = 3.73 S | | | |
| | a vs e | t = 5.24 S | Gross conversion efficiency | a vs b | t = 0.423 NS |
| Growth rate | a vs b | t = 0.779 NS | | a vs c | t = 7.48 S |
| | a vs c | t = 1.090 NS | | | |
| | a vs d | t = 3.87 S | Net conversion efficiency | a vs b | t = 0.759 NS |
| | a vs e | t = 5.08 S | | a vs c | t = 8.61 S |

S = significant; NS = Non-significant.

significantly. At higher concentrations of sewage the feeding rate decreased. As a consequence of decreased food consumption, the food energy diverted for the growth of the fish was restricted resulting in reduced growth. The low body weight exhibited by the fish could be due to the effect of low dissolved oxygen, nutrients and the effect of toxic substances in the sewage. The lower metabolic rates in the fish reared in sewage medium than that in the fish reared in sewage free water could be due to the low amount of dissolved oxygen.

Studies on the effects of chemical substances on food consumption, growth and conversion efficiency have been carried out with other tropical fishes also. Several workers have reported poor growth when reared in a medium containing higher concentrations of pesticides, textile industrial effluent and other chemical substances as metabolic stressors (Arunachalam *et al.*, 1980 ; Arunachalam and Palanichamy, 1982 ; Manoharan and Subbiah, 1982 ; Rajan and Balasubramanian, 1988). Palanichamy *et al.*, (1985) have also reported such poor feeding and growth in fishes when reared in a medium containing higher concentrations of chemical fertilizers. However, the results of the present experiment indicated that at a definite concentration of sewage (20%), the growth of the fish *L.rohita* was slightly enhanced though the sewage, in general, inhibited its growth.

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# Sublethal Effects of Textile Mill Effluent on Protein, Carbohydrate and Lipid Content of Different Tissues of *Cyprinus carpio* (Linnaeus)

**M.R. Rajan**

School of Energy, Environment and Natural Resources, Madurai Kamaraj University, Madurai 625021

## Abstract

The fish *Cyprinus carpio* (Linnaeus) was reared in 2, 4, 8 and 12 % concentrations of a textile mill effluent under laboratory conditions. The protein, carbohydrate and lipid contents of muscle, liver and intestine significantly decreased in the fish reared in effluents compared to control.

## Introduction

It is known that tissue protein, carbohydrate and lipids play a major role as energy precursors for fishes exposed to stress conditions (Fontaine and Hatley, 1953; Idler and Clemens, 1959; Umminger, 1970; Ramalingam, 1980). Though considerable information is available dealing with the determination of acute toxic levels of several pollutants, studies on the impact of toxicants on energy sources are relatively few. Hence, an attempt has been made to study the effect of sublethal concentrations of textile mill effluent on protein, carbohydrate and lipids of muscle, liver and intestine of *Cyprinus carpio* (Linnaeus).

## Material and Methods

Juveniles of *C.carpio* (2.5 ± 0.3 gm) were procured from a fish farm near Palani, S. India, and acclimated to laboratory conditions and feeding schedule keeping them in a large glass aquarium. Considering the original effluent 100%, 2, 4, 8 and 12 % concentrations were prepared with tap water as the sublethal concentration was found to be 13% in a preliminary study. For biochemical studies, a group of 10 individuals were exposed to the four concentrations of effluent for 21 days in cylindrical glass aquaria (30 × 24 cm) while control fish were exposed to effluent free water. During rearing, the fish were fed on ad libitum diet of silkworm pupae once in a day at 8 A.M. for two hours. The medium was renewed daily to give constant effect of effluent on fish. The fish thus acclimated to effluent medium were taken for bio-chemical assay of protein, carbohydrate and lipid in muscle, liver and intestine. Protein, carbohydrate and lipid contents were estimated by the method of Lowry *et al.* (1951), Roe (1955) and Floch *et al.* (1957), respectively.

## Results and Discussion

When *C.carpio* was reared in different sublethal concentrations of textile mill effluent, there was a significant decrease in protein content of muscle, liver and intestine with increasing concentrations (Table 1). The carbohydrate content in the three different tissues of *C. carpio* decreased significantly with increasing concentrations of textile mill effluent (Table 2). The lipid content of muscle, liver and intestine also decreased with increasing concentrations of textile mill effluent (Table 3).

Table 1. Effect of textile mill effluent on the levels of total protein (mg/mg) in different tissues of *Cyprinus carpio*.

| Tissue | Control | Effluent concentration (%) | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 12 |
| Muscle | $0.17^{a} \pm 0.02$ | $0.15^{b} \pm 0.01$ | $0.12^{c} \pm 0.02$ | $0.12^{d} \pm 0.02$ | $0.100^{e} \pm 0.030$ |
| Liver | $0.15^{a} \pm 0.01$ | $0.14^{b} \pm 0.02$ | $0.11^{c} \pm 0.02$ | $0.07^{d} \pm 0.93$ | $0.075^{e} \pm 0.020$ |
| Intestine | $0.13^{a} \pm 0.01$ | $0.12^{b} \pm 0.02$ | $0.10^{c} \pm 0.005$ | $0.10^{d} \pm 0.01$ | $0.010^{e} \pm 0.020$ |

| | | | | | |
|---|---|---|---|---|---|
| Muscle | a vs b | t = 2.22 NS | Liver | a vs b | t = 1.11 NS |
| | a vs c | t = 4.16 S | | a vs c | t = 4.44 S |
| | a vs d | t = 4.16 S | | a vs d | t = 6.15 S |
| | a vs e | t = 4.37 S | | a vs e | t = 8.33 S |
| Intestine | a vs b | t = 1.11 NS | | | |
| | a vs c | t = 6.52 S | | | |
| | a vs d | t = 5.00 S | | | |
| | a vs e | t = 5.55 S | | | |

S = Significant
NS = Not significant

Table 2. Effect of textile mill effluent on the levels of total carbohydrate (mg/mg wet tissue) in different tissues of *Cyprinus carpio*.

| Tissue | Control | Effluent concentration (%) | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 12 |
| Muscle | $0.045^{a} \pm 0.01$ | $0.035^{b} \pm 0.01$ | $0.035 \pm 0.005$ | $0.03 \pm 0.000$ | $0.03 \pm 0.000$ |
| Liver | $0.04^{a} \pm 0.01$ | $0.035^{b} \pm 0.005$ | $0.035 \pm 0.000$ | $0.03d \pm 0.005$ | $0.03 \pm 0.000$ |
| Intestine | $0.045^{a} \pm 0.01$ | $0.046^{b} \pm 0.01$ | $0.035^{c} \pm 0.005$ | $0.035^{d} \pm 0.005$ | $0.03 \pm 0.005$ |

| | | |
|---|---|---|
| Muscle | a vs b | t = 1/66 NS |
| Liver | a vs b | t = 1.56 NS |
| Intestine | a vs b | t = 0.833 NS |
| | a vs c | t = 2.17 NS |

NS = Not significant

The fishes constitute one of the major sources of cheap nutrition for human beings (Bhagowati and Rath, 1982). The nutritional value of different fishes depends on their bio-chemical composition like protein, carbohydrate, lipids, amino acids, vitamins, mineral contents, etc. Yet biochemical changes induced in different tissues of fishes by pollutants do not seem to have been studied in significant detail (Natarajan, 1981; Murthy and Devi, 1982). In the present investigation, different concentrations of textile effluent significantly

Table 3. Effect of textile mill effluent on the levels of total lipid (mg/mg wet tissue) in different tissues of *Cyprinus carpio*

| Tissue | Control | Effluent concentration (%) | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 12 |
| Muscle | $0.017^{a} \pm 0.0005$ | $0.015^{b} \pm 0.001$ | $0.015^{c} \pm 0.0005$ | $0.014^{d} \pm 0.0005$ | $0.004^{e} \pm 0.0005$ |
| Liver | $0.016^{a} \pm 0.0007$ | $0.015^{b} \pm 0.0005$ | $0.004^{c} \pm 0.005$ | $0.004 \pm 0.000$ | $0.004 \pm 0.000$ |
| Intestine | $0.014 \pm 0.0002$ | $0.014 \pm 0.0005$ | $0.014 \pm 0.001$ | $0.004 \pm 0.000$ | $0.003 \pm 0.0005$ |

Muscle a vs b $t = 4.34$ S
a vs c $t = 6.25$ S
a vs d $t = 9.37$ S
a vs e $t = 4.06$ S

Liver a vs b $t = 2.56$ S
a vs c $t = 6.25$ S

S = Significant

reduced the total protein in muscle, liver and intestine of *C carpio*. Similar observations were noted when fish were exposed to pesticides (Lone and Javaid, 1976; Shakoori *et al.*, 1976; Rath and Misra, 1980). The decline in the protein suggested an intensive proteolysis in respective tissues which in turn could contribute to the increase of free amino acids to be fed into the tricarboxylic acid cycle as keto acids (Sahib, 1979). Such a possibility is further strengthened by the investigations of Mehrule *et al.* (1971) and Shakoori *et al.* (1976) which revealed both qualitative and quantitative variations in the tissue amino acids of fishes exposed to toxicants.

The effluent reduced the total carbohydrate in muscle, liver and intestine. This is in accordance with the findings of Murthy and Devi (1982). In this context, Umminger (1970) is of the opinion that carbohydrate represents the principal and immediate energy precursor for fishes exposed to stress conditions while proteins are the energy source to be utilized during chronic periods of stress.

When the fish were reared in effluent medium in the present study, all the tissues showed a significant decline in lipid content. Generally, more energy is needed to mitigate any stress condition. This energy may be obtained from carbohydrates or proteins or lipids. Decline in the lipid content might be due to the utilization of lipids for the energy demand under stress conditions (Rao and Rao, 1981; Harpert *et al.*, 1977).

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# Effect of Bleaching Factory Effluent on Growth and Food Utilization of *Oreochromis mossambicus*

**N. Balambigai, N. Santhikumaresan, A.A. Sivakumar and M. Aruchami**
Department of Zoology, Kongunadu Arts and Science College, Coimbatore 641029

## Abstract

Various kinds of wastes, such as paper pulp, municipal and industrial effluents and sewage can be recycled to advantageous use or waste water can be reclaimed through aquaculture. In the present study, the impact of different concentrations (1, 1.2, 1.4, 1.6 and 1.8%) of a bleaching factory effluent on the growth and food utilization of the fish *Oreochromis mossambicus* was studied. An increase in consumption, absorption and growth rate was observed at higher concentrations of the effluent which was higher than in the control fish.

## Introduction

Fish have adapted themselves to live in various types of natural waters ranging from pure snow-fed brooks to the complex sea water. Introduction of effluent results in loss of living organisms in that media. Various kinds of wastes, such as industrial, municipal and sewage can be recycled through aquaculture. Very little work has been done on this aspect (Tam *et al.*, 1986; Victor and George, 1987). The present study was, therefore, undertaken to have a basic understanding of the effect of bleaching factory effluent on the growth and food utilization of the fish *Oreochromis mossambicus*.

## Material and Methods

A bleaching factory located on the bank of river Bhavani, Coimbatore District, discharges its untreated effluents in to the river. The physico-chemical characteristics of the effluents and the control water samples were analysed following standard methods (Anon., 1967).

Static bioassays for determining acute toxicity were conducted as recommended by the U.S. EPA (Anon., 1973). River water before the point of release of the effluent was used as control. Based on an exploratory test, 5 concentrations of the effluent, *viz.* 1, 1.2, 1.4, 1.6 and 1.8% were prepared.

Fingerlings of *O. mossambicus* weighing 5 ± 0.05 g were collected from a local pond and acclimated to the laboratory temperature in a glass aquarium for a period of one month. The fish were fed ad libitum on chopped pieces of goat liver. At the end of the acclimation period, the fish were starved for a day to evacuate the gut contents and weighed individually.

The test fish were reared individually in cylindrical aquaria (15 cm diam) containing 2 litres of water and were fed ad libitum. After 6 h of feeding, the unfed remains were collected and dried. Faeces egested by the fish were collected once in three days by filtering the entire aquarium water. The aquarium water was changed once in three days. Samples of fish, food provided, unfed food and faeces were dried at 80°C to obtain a constant weight. Following the IBP formula of Petrusewicz and MacFadyan (1970), the rates of growth, consumption and absorption were calculated.

## Results and Discussion

Table 1 presents the chemical characteristics of the control and the effluent water samples. Table 2 shows the rates of food consumption, absorption and growth of the fish *O. mossambicus* subjected to different concentrations of bleaching factory effluents. The present study revealed that the effluent samples were near neutral in pH and rich in nutrients whereas those of control had minimum levels of nutrients. The effluent treated fishes showed increase in their body weight, rates of food consumption, absorption and growth.

Table 1. Chemical characteristics of Bhavani river water and effluent samples

| Parameter | Control | Effluent |
|---|---|---|
| pH | 6.7 | 6.0 |
| D.O. (ppm) | 8.0 | 4.0 |
| Calcium (ppm) | 30.0 | 175.0 |
| Magnesium (ppm) | 0.04 | 0.01 |
| Phosphate (ppm) | 3.16 | 4.47 |
| Nitrite (ppm) | 3.28 | 5.47 |
| Silicate (ppm) | 0.28 | 0.67 |
| Iron (ppm) | 1.12 | 1.72 |
| Chloride (ppm) | 30.50 | 210.00 |

Table 2. Rates of consumption, absorption and growth of the fish *O. mossambicus* exposed to different concentrations of bleaching factory effluent for 21 days

| Effluent concentration (%) | Consumption rate (mg/g body/day) | Absorption rate (mg/g body/day) | Growth rate (mg/g body/day) |
|---|---|---|---|
| Control | 0.73 ± 0.06* | 0.267 ± 0.06 | 1.4 ± 0.1 |
| 1.0 | 0.70 ± 0.26 | 0.573 ± 0.44 | 1.4 ± 0.6 |
| 1.2 | 1.03 ± 0.12 | 0.57 ± 0 .15 | 1.567 ± 0.32 |
| 1.4 | 1.37 ± 0.40 | 0.90 ± 0.4 | 1.7 ± 0.1 |
| 1.6 | 1.50 ± 1.90 | 1.1 ± 0.17 | 1.77 ± 0 21 |
| 1.8 | 2.77 ± 0.80 | 2.3 ± 0 .81 | 2.967 ± 0 .80 |

* Mean of three indivduals ± S.D.

The bleaching factory effluent was found to be a gustatory stimulant because the consumption rate increased with increased effluent concentration. The addition of effluent to the water body affected the growth rate of the fish. Tam *et al.* (1986) observed that the growth of the fish *Salvelinees fontinalis* was inhibited initially when exposed to sublethally low levels but a recovery was seen in the latter phase of the experiment.

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# Heavy Metal (Fe, Zn & Mn) Concentrations in the Tissues of the Fish *Therapon jarbua* (Forskal) in Vellar Estuary

**S. Senthilnathan, A. Magendran, T. Balasubramanian and V.K. Venugopalan**

Centre of Advanced Study in Marine Biology, Annamalai University,
Parangipettai 608502

## Abstract

The concentrations of the heavy metals, *viz.* Fe, Zn and Mn were analysed from different tissues of the fish *Therapon jarbua* (Forskal) occurring in Vellar estuary for a period of one year from December 1983 to November 1984. The organwise distribution of heavy metals was found in the order of liver > gill > body tissue. Seasonally, the concentration of heavy metals was found to be low during summer months and high during postmonsoon and monsoon months. The extent of bioconcentration of heavy metals in the fish in relation to the salinity of the ambient medium is discussed.

## Introduction

Information on the levels of heavy metals in edible organisms is important in view of the environmental health hazards resulting from discharge of industrial wastes containing toxic metals. These metals are biomagnified in the food chain and reach human beings to cause deleterious effects. The ability of fishes to concentrate heavy metals in their tissues has been widely reported (Keckes and Miettinen, 1970; Wood, 1974) and this may exceed critical toxic levels (Kavira, 1983). The present investigation was made to collect preliminary data on the distribution and seasonal variation of Fe, Zn and Mn in the gill, liver and body tissue of *Therapon jarbua* (Forskal), one of the commonly occurring estuarine fishes.

## Material and Methods

*T. jarbua* was fished from the vicinity of jetty area in Vellar estuary by using a cast net. Samples of individual tissues, *viz.* gill, liver and body tissues were removed, wiped dry and weighed before and after drying at 100°C in an oven. The dried samples of individual tissues were pooled, weighed to 500 mg and subjected to wet oxidation with $HNO_3$ and $HClO_4$ (Topping, 1973) until a clear solution was obtained. The digested samples were then made upto 25 ml with metal free water for analysis by an atomic absorption spectrophotometer. The precision of the method was found to be ± 0.1.

## Results and Discussion

The seasonal variation and trend of distribution of Fe, Zn and Mn in the tissues, namely gill, liver and body tissue of the fish *T. jarbua* are shown in Table1. Among the organs investigated, liver showed higher concentrations of Fe and Zn followed by gill whereas lower values were observed in the body tissues. However, the gill showed higher concentration of Mn followed by liver and body tissue. Honda *et al.* (1979) also observed a remarkably high concentration of Zn in liver and relatively low concentration in gill filament in albacore *Thunnus alalonga* and bonito *Katsuwonus pelamis* of Jawa island. DeSouya and Naqvi (1979) observed that the concentrations of Fe and Zn were found to be lower in muscle and higher in gill and liver of mullet *Mugil cephalus* from

Visakhapatnam. The high concentration observed in the gill compared to body tissue could be due to the mucus layer of the gill which has high adsorption capacity (Pentreath,1973). According to Goldberg (1965), the mucus exposed to the seawater acts as a surface adsorption sheet, either for selective removal of metal or for general accumulation from the ambient medium. Greig and Wenzloff (1977) observed higher level of Mn concentration in the liver followed by the muscle in *Limanda ferruginea, Pseudopleuronectes americanus* and *Urophycis chuss* from the New York Bight and Lay Island Sound. Greig *et al.* (1977) found higher level of Mn concentration in liver tissues compared to the flesh of *Scopthalmus aguosus* from ocean disposal sites of the middle eastern United States. Vorob 'Yev and Zaystev (1975) found the iron accumulation in *Scridinus erythrophthalmus* in the order of gill followed by liver and muscle. The greater bioconcentration of trace metals in liver and gill may be mainly due to the dark nature of these tissues. In marine fishes, the darkened muscles are highly vascularized and significant with iron bearing respiratory pigments than lighter tissues (Held,1971) and thereby serve as a potential storehouse for trace elements.

Table 1. The distribution of Fe, Zn and Mn in different tissues of the fish *Therapon jarbua* from Vellar estuary (μg/g)

| Metal | Tissue | Postmonsoon Min | Postmonsoon Max | Summer Min | Summer Max | Premonsoon Min | Premonsoon Max | Monsoon Min | Monsoon Max |
|---|---|---|---|---|---|---|---|---|---|
| Fe | Gill | 714 | 2750 | 500 | 2100 | 200 | 2757 | 1500 | 2638 |
| | | (2010)* | | (1134) | | (1489) | | (2101) | |
| | Liver | 2300 | 6739 | 1279 | 2714 | 1320 | 3500 | 1295 | 4780 |
| | | (4620) | | (1880) | | (2217) | | (2382) | |
| | Body tissue | 350 | 1650 | 250 | 500 | 150 | 850 | 100 | 700 |
| | | (1175) | | (350) | | (616) | | (229) | |
| Zn | Gill | 140.1 | 275.1 | 182.1 | 310.1 | 114.6 | 281 | 125 | 506 |
| | | (206.5) | | (247) | | (195) | | (370) | |
| | Liver | 120 | 375 | 185 | 534 | 110 | 218.4 | 114.4 | 482 |
| | | (230) | | (309.8) | | (153.5) | | (343) | |
| | Body tissue | 38 | 190 | 66.6 | 151 | 351. | 149.6 | 49.6 | 112 |
| | | (87) | | (121) | | (82.4) | | (93.3) | |
| Mn | Gill | 23 | 49 | 3 | 15 | 16 | 38.25 | 31.9 | 48 |
| | | (38.4) | | (8.8) | | (25.0) | | (37.7) | |
| | Liver | 20.8 | 28 | 1.5 | 25 | 8.13 | 35 | 17.5 | 38 |
| | | (24.8) | | (9.58) | | (18.44) | | (25.2) | |
| | Body tissue | 9.5 | 20 | 1.5 | 7.6 | 6 | 13 | 6 | 25 |
| | | (12.2) | | (4.8) | | (10.5) | | (15.33) | |

* Values in parenthesis are means

The bioconcentration of Fe, Zn and Mn in the tissues of gill, liver and body tissue showed higher values during the monsoon and postmonsoon period whereas lower values were found during summer for Fe and Mn and premonsoon for Zn. The higher were found during summer for Fe and Mn and premonsoon for Zn. The higher concentration during monsoon and postmonsoon could be mainly due to the land runoff along with agricultural drainage and municipal waste resulting in high accumulation of metals in the tissues of *T. jarbua*. Lower concentrations during summer and premonsoon might be due to the meagre runoff during that period and lower concentration of these metals in the ambient medium. In general, *T. jarbua* are active swimmers and are capable of tolerating extreme salinity variations. The correlation between the concentration of Fe and Mn in the gill, liver and body tissues and salinity showed highly significant inverse relationship (Table 2). The salinity may, hence, be considered one of the governing factors in the bio-accumulation of Fe and Mn in *T. jarbua*. The correlation between tissue Zn concentration and salinity was non significant.

Table 2. *Simple correlation coefficient (r) values between the metal concentration in different tissues and salinity.*

| Tissue | Fe | | Zn | | Mn | |
|---|---|---|---|---|---|---|
| | *r* | p | r | p | r | p |
| Gill | −0.438 | P< .05 | −0.1094 | NS | −0.6371 | P> .01 |
| Liver | −0.538 | P> .01 | −0.3562 | NS | −0.4638 | P< .05 |
| Body tissue | −0.232 | NS | 0.1232 | NS | −0.5221 | P> .01 |

NS = Non-significant

Estuarine organisms are known to concentrate metals preferentially in certain organs. Different factors have been reported to influence the metal uptake in teleosts including respiratory rate (Edwards, 1967; Zaba and Harris,1978), temperature (Saltman and Boroughs, 1960; Shulman *et al.*, 1961; Eisler and LaRoche, 1972; Negilski, 1976), salinity of the medium (Shulman *et al.*, 1961; Eisler and LaRoche, 1972), distance from the point source (Cutshall *et al.*, 1977) and metabolic transformation of metal into various chemical substances with different retention time (Baptist *et al.*, 1970). The results of the present study carried out for a period of one year clearly indicated the nature of accumulation of Fe, Zn and Mn in the different tissues of *T. jarbua* and a significant relationship with the master parameter of the estuaries, the salinity, although such effect may control partially, if not fully, the biological characteristics of organisms under investigation.

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# Biochemical Changes due to Short Term Cadmium Toxicity in the Prawn *Macrobrachium idella* (Hilgendorf)

**P. Villalan, K.R. Narayanan and S. Ajmalkhan**
Centre of Advanced Study in Marine Biology, Annamalai University,
Parangipettai 608502

## Abstract

The prawn *Macrobrachium idella* (Hilgendorf) was exposed to cadmium at 650 ppb, its' median lethal concentration ($LC_{50}$), for 24 and 96 h. The changes in the glycogen, protein and lipid in muscle and hepatopancreas were analysed in exposed animals. The glycogen, protein and lipid values were found to be lower than in control and the fall in the values was proportionate to the exposure time. The haemolymph sugar was also estimated and its level increased in the exposed animals compared to that in control and this increase was also proportionate to the exposure duration.

## Introduction

Many short term lethality studies have been conducted on the effects of metals on marine and freshwater invertebrates and fishes (Sprague, 1969). Such studies include both lethal and sublethal effects of metals on marine animals (Eisler,1971; Thurberg *et al.*, 1973; Ahsanullah 1976; Vernberg *et al.*, 1977). Such studies have been necessitated by the widespread and indiscriminate use of heavy metals in industries which has been causing great concern as the environment is being dangerously contaminated. Through food chain these heavy metals ultimately reach the human beings. Intake of food contaminated with cadmium manifested in the outbreak of painful and crippling disease called "itai-itai" in Japan (Eisler, 1971). Hence monitoring of this heavy metal in seafood and the ill effects on biochemical constituents should be investigated in detail. *Macrobrachium idella* (Hilgendorf) is an ecologically important and widely distributed brackish water prawn which has good potential for economic exploitation. It is of interest, therefore, to examine the biochemical changes in this organism due to short term cadmium toxicity.

## Material and Methods

Prawns of medium size (6-7 cm in length) and average weight of 12 g were collected from the freshwater zone of Vellar estuary, Porto Novo. In the laboratory, they were maintained for a week in a large fibre glass tank containing well aerated tap water (salinity 0.2 ppt). During the acclimation the prawns were fed with chopped clam meat twice a day but were starved for 24 h prior to the experiment. The level of cadmium employed in these experiments was selected on the basis of short term (acute) static renewal bioassay. The prawns were exposed for 24 and 96 h to 650 ppb cadmium, its 96 h $LC_{50}$ to the prawn, and the biochemical constituents like glycogen (Wedemeyer and Yasutake, 1977), proteins (Raymont *et al.*, 1964) and lipids (Folch *et al.*, 1957) were analysed in hepatopancreas and muscle. The haemolymph sugar level was also analysed (Dubois *et al.*,1956).

## Results

Changes in glycogen, protein, lipid and haemolymph sugar level of *M. idella* after exposure to cadmium for 24 and 96 h are presented in table 1.

Table 1. Biochemical constituents in control and cadmium exposed individuals of the prawn *Macrobrachium idella*

| Treatment | Body part | Glycogen (mg/g) | Protein (mg/g) | Lipid (mg/g) | Haemolymph sugar (mg/100 ml) |
|---|---|---|---|---|---|
| Control | Mus: | 20.74 | 94.6 | 40.33 | 26.22 |
| | Hep: | 41.69 | 199.8 | 180.61 | |
| After 24 h of cadmium exposure | Mus: | 16.78 (19.09)* | 53.21 (43.75) | 38.23 (5.21) | 41.93 (59.91) |
| | Hep: | 30.81 (26.09) | 144.3 (27.77) | 165.0 (8.64) | |
| After 96 h of cadmium exposure | Mus: | 14.37 (30.71) | 36.16 (61.77) | 20.49 (49.19) | 71.76 (173.68) |
| | Hep: | 16.4 3 (59.87) | 140.09 (29.88) | 123.10 (31.84) | |

* Values in parentheses are percentage change over the control.
Mus: Muscle; Hep: Hepatopancreas.

In control prawns, the glycogen content in the muscle and hepatopancreas was 20.74 and 41.69 mg/g, respectively. In organisms exposed for 24 and 96 h the glycogen content decreased by 19.09 and 30.71% respectively in muscles and 26.09 and 59.87%, respectively in hepatopancreas. The protein content in control prawns in the muscle and hepatopancreas was 94.6 and 199.8 mg/g, respectively. The protein values of muscle and hepatopancreas decreased by 43.75 and 27.77% and 61.77 and 29.88%, respectively at 24 and 96 h after exposure. In prawns maintained in control the lipid values of muscle and hepatopancreas were 40.33 and 180.61 mg/g, respectively. After exposure for 24 and 96 h, the values recorded in muscle and hepatopancreas decreased by 5.21 and 8.64%, and 49.19 and 31.84%, respectively. In control the haemolymph sugar level was 26.22 mg/100 ml whereas in exposed organisms the levels increased by 59.91 and 173.68%, respectively after 24 and 96 h of exposure.

## Discussion

In the present study, the glycogen content after exposure for 24 and 96 h decreased over that of control. Ghafghazi and Mennear (1975) and Singhal *et al.* (1976) also observed the same trend and attributed it to cadmium-induced hyperglycemia. Glycogen is the main reserve source of energy for animals during normal metabolism. Adverse environmental conditions would affect normal metabolism and health of an animal altering the glycogen reserve. Pragatheeswaran (1987) also noted a reduction in glycogen level in *Ambasis commersoni* treated with copper, zinc and mercury.

In the case of protein, reduced levels were noticed compared to control. Villalan *et al.* (1988b) observed the same in the crab *Thalamita crenata* exposed to zinc. Protein, the energy source to be spared during chronic periods of stress, gets depleted and the lowering in protein levels could be attributed to the extensive proteolysis which contributes to the increase of free amino acids to be fed into tricarboxylic acid cycle(TCA) as ketoacids.

The lipid content also declined due to cadmium exposure. This could be due to the utilization of the same during stress situation when there would be demand for more energy to tide over the stress. Similar results were observed in *Thalamita crenata* due to exposure to copper and zinc (Villalan *et al.*, 1988 a and b).

In the case of haemolymph sugar, a significant increase due to cadmium exposure was noticed indicating the stress caused by the heavy metal. Selvakumar (1981) also noticed blood glucose elevation in copper treated fish *Terapon jarbua.*

The present study demonstrated that in aquatic animals, build up of heavy metal pollutants like cadmium can alter the biochemical constituents. This calls for strict regulatory measures in effluent treatment from industries and other sources.

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# Seasonal Variations of the Heavy Metals Copper and Zinc in Different Body Parts of a Venerid Clam *Sunetta scripta* (Linnaeus)

**J. Tagore, R. Kasinathan, G.A. Thivakaran, A. Shanmugam, V.S. Chandrasekaran and S. Mani***

Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai 608502

*Department of Zoology, A.V.C. College, Mannampandal 609305

## Abstract

Bioaccumulation of Cu and Zn were observed in the soft body parts, such as gill, mantle, foot, adductor muscle and stomach of the clam *Sunetta scripta* (Linnaeus) from the Porto Novo coast for a period of one year (January to December 1986). The concentration of Zn was found to be higher than that of Cu in all the body parts. High metal load (479.0 ppm of Zn and 422.5 ppm of Cu) was found during monsoon and postmonsoon periods while low metal content (17.5 ppm of Zn and 87.0 ppm of Cu) was recorded during summer. Bioaccumulation was more in gill and mantle than in the other body parts.

## Introduction

The ability of bivalves to accumulate heavy metals in excess than that found in their environment has been well documented earlier (Brooks and Rumsby, 1965; Watling and Watling, 1976; Rajendran *et al.*, 1988). In Indian coastal waters, bioaccumulation and cycling of various heavy metals have been studied by Sankaranarayanan *et al.* (1978), Kumaraguru (1980), Magendran (1985), Senthilnathan (1985) and Rajendran *et al.* (1988) in the edible oyster *Crassostrea madrasensis*. So far, no information is available on the heavy metal bioaccumulation in the venerid clam *Sunetta scripta* except the study on its Fe and Mn accumulation by Tagore *et al.* (1987). Therefore, the present study has been carried out on the levels of Zn and Cu and their seasonal variations in different body parts like gill, mantle, foot, adductor muscle and stomach of *Sunetta scripta*.

## Material and Methods

Specimens of *S. scripta* ranging from 30 to 35 mm in shell height were collected at monthly intervals for a period of one year (January to December 1985) from the sandy beaches of the Porto Novo coast (Lat. 11°29' N; Long. 79°46' E). The animals were kept in filtered sea water for one day to clear the stomach contents. The gill, mantle, foot, adductor muscle and stomach were dissected out and oven dried at 60°C. The metals were estimated in the dried material after wet digestion (Eisler *et al.*, 1978) with conc. $H_2SO_4$ and conc. $HClO_4$ in the ratio of 3:1. The fine tissue powder was digested and made upto a constant volume with 0.05 N $HNO_3$. The digested samples were made upto 25 ml with 5% nitric acid and analysed for Cu and Zn using a Perkin Elmer atomic absorption spectrophotometer.

## Results and Discussion

The concentration of Zn was relatively more than that of Cu in all the body parts analysed (Tables 1 and 2). Seasonal variations in the heavy metal concentrations were also discernible from the data. High values of Zn and Cu were observed during monsoon

Table 1. Seasonal variation of Zn (ppm) in *Sunetta scripta*

| Season | Month | Gill | Mantle | Foot | Adductor muscle | Stomach |
|---|---|---|---|---|---|---|
| Post-monsoon | January | 112.0 | 347.5 | 117.0 | 131.5 | 163.5 |
| | February | 382.5 | 119.5 | 17.5 | 292.0 | 129.0 |
| | March | 306.0 | 367.0 | 268.5 | 138.5 | 171.5 |
| Summer | April | 115.5 | 123.0 | 172.5 | 122.5 | 102.5 |
| | May | 230.0 | 121.0 | 150.5 | 328.0 | 100.5 |
| | June | 74.0 | 79.0 | 192.5 | 44.0 | 315.5 |
| Premonsoon | July | 387.4 | 141.5 | 115.0 | 169.0 | 172.5 |
| | August | 217.0 | 100.0 | 87.0 | 153.0 | 100.0 |
| | September | 123.0 | 121.0 | 111.5 | 102.0 | 91.0 |
| Monsoon | October | 308.5 | 122.0 | 120.5 | 268.0 | 91.5 |
| | November | 479.0 | 407.0 | 137.5 | 193.5 | 213.5 |
| | December | 367.4 | 327.0 | 197.5 | 249.0 | 235.5 |
| | $\overline{X}$ | 258.53 | 231.29 | 140.63 | 190.92 | 168.88 |

Table 2. Seasonal variation of Cu (ppm) in *Sunetta scripta*

| Season | Month | Gill | Mantle | Foot | Adductor muscle | Stomach |
|---|---|---|---|---|---|---|
| Post-monsoon | January | 101.0 | 88.0 | 118.0 | 119.5 | 95.0 |
| | February | 199.0 | 99.0 | 99.0 | 105.0 | 99.0 |
| | March | 102.0 | 101.0 | 100.0 | 100.0 | 105.0 |
| Summer | April | 104.0 | 100.5 | 101.0 | 101.0 | 105.5 |
| | May | 168.0 | 102.0 | 103.5 | 100.5 | 103.0 |
| | June | 102.5 | 102.5 | 102.5 | 87.0 | 111.0 |
| Premonsoon | July | 246.5 | 223.5 | 106.5 | 100.0 | 106.5 |
| | August | 196.5 | 103.0 | 88.0 | 104.0 | 100.0 |
| | September | 101.5 | 97.0 | 100.0 | 116.0 | 121.0 |
| Monsoon | October | 261.0 | 101.5 | 103.5 | 217.0 | 102.0 |
| | November | 422.5 | 125.5 | 102.5 | 250.0 | 108.0 |
| | December | 284.0 | 276.5 | 102.5 | 116.0 | 174.0 |
| | $\overline{X}$ | 190.71 | 126.67 | 102.25 | 126.33 | 110.83 |

(October) and early postmonsoon (January). High Zn and Cu levels in *C. madrasensis* have been observed earlier in Porto Novo waters (Magendran, 1985; Rajendran *et al.*, 1988). Subramanian (1981) has reported high metal concentrations during monsoon and low levels during summer in *C. madrasensis* collected from Pitchavaram mangroves. Similar observation on the seasonality in heavy metal levels has also been reported by Tagore *et al.* (1987). Influx of high amount of freshwater due to monsoon rains may be a causative factor for the increase in heavy metal concentration and subsequent bioaccumulation in the clams during monsoon and postmonsoon seasons.

Concentrations of both Cu and Zn were found to be in the descending order from gill, mantle, adductor muscle, stomach and foot. High concentrations of metals in gill and mantle have been reported earlier in *C. madrasensis* (Subramanian, 1981; Rajendran *et al.*, 1988). As gills are responsible for the water flow in bivalves, they are continuously exposed to metal accumulation than the other body parts. The mucus secretion covering the gills and mantles also causes high metal concentration as reported earlier in *C. madrasensis* (Wolfe and Coburn, 1970) and *Ostrea edulis* (George *et al.*, 1978). The filter feeding nature of bivalves is also a reason for the high accumulation of metals in their gills (Brooks and Rumsby, 1965). Higher accumulation of Cu and Zn than other metals has been found out in *C. madrasensis* (Magendran, 1985), *C. virginica* (Wolfe and Coburn, 1970) and *Pecter maximus* and *Chlamys opercularis* (Bryan, 1973).

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# A Study on the Population Density of *Onuphis cremata* in Relation to Sediment Texture and Pollution

**G. Sivagurunathan*, M. Varadharajan*, S. Mani*, G.V. Gopinath** and G. Amuthavalli****

*Department of Zoology, A.V.C. College, Mannampandal 609305
**Department of Zoology, Annamalai University, Annamalainagar 608002

## Abstract

The population density of the macrobenthic animal *Onuphis cremata* was studied to assess the effect of sediment texture, and sewage and industrial pollution on its distribution. Sediment samples were collected from three different marine environs at Cuddalore coast for a period of six months and their composition was analysed. Tidal influence and low clay content resulted in a low population density of this animal. High clay content and enriched organic nutrients held a high population density.

## Introduction

Distribution of macrobenthos varies with a wide range of environmental parameters. Population density is an excellent index which can be used for community analysis and for monitoring the changes in the environment. The ecology (Ayyappan Nair *et al.*, 1980; Chandran *et al.*, 1982; Chandran, 1987), factors influencing the recruitment and establishment (Thorsan, 1966), and the distribution and seasonal abundance (Gopalakrishna Pillai, 1977) of benthic communities have been very well studied.

The distribution of infauna is considerably dependent on the sediment texture Jones (1956) attempted to classify the benthic animals in relation to soil texture. Recently, Sivagurunathan *et al.* (1988) have reported the influence of sediment texture and soil pollution on the population density of earthworms. Pollution due to various anthropogenic activities often causes eutrophication which affects the very trophic structure of benthic communities in such a way that the suspension feeders are replaced by deposit feeders (Ott and Fedra, 1977; Officer *et al.*, 1984; Stachowitsch and Avcin, 1988). Monitoring pollution using benthos is in operation for the past five decades since most of the benthos are sedentary or less motile and accumulate pollutants and thereby serve as potential pollution indicators.

## Material and Methods

The present study deals with the effect of sediment texture and industrial pollution on the population density of the microbenthic animal *Onuphis cremata*. The present study was carried out at Cuddalore coast (south east coast of India; Lat. 11°42', Long. 79° 46' E) for a period of six months. The sediment samples were collected from three different marine environs of Cuddalore coast, namely Station I - back water area receiving domestic sewage; Station II - estuarine biotope receiving industrial wastes; Station III - intertidal region of the open ocean using Van Veen grab at fortnightly intervals from January to June 1988. These collected sediments were sieved through a hand sieve (0.5 mm mesh) along with the habitat water and the animals retained on the sieve were collected for estimation of population density. The sediment texture was determined by the gravimetric method as described by Rama Rao *et al.* (1985).

## Results and Discussion

Population density of *O. cremata* fluctuated between 200 to 344/m$^2$ at Station I that was highly polluted with the sewage of Cuddalore city; 25 to 288/m$^2$ at Station II which received the industrial effluents through the river Uppanar; 0 to 120/m$^2$ at Station III which was free from pollution (Table 1).

Table 1. Population fluctuations of *Onuphis cremata* at three sites of Cuddalore coast

| Month | Fortnight | Population density/m$^2$ | | |
|---|---|---|---|---|
| | | Station I | Station II | Station III |
| Jan | I | 344 | 262 | 120 |
| | II | 328 | 288 | 86 |
| Feb | I | 211 | 264 | 75 |
| | II | 289 | 238 | 47 |
| Mar | I | 260 | 166 | 56 |
| | II | 237 | 105 | 32 |
| Apr | I | 200 | 198 | 56 |
| | II | 216 | 89 | 0 |
| May | I | 229 | 25 | 86 |
| | II | 238 | 67 | 91 |
| Jun | I | 261 | 98 | 98 |
| | II | 258 | 102 | 90 |

The sediment composition of the above three stations showed that Station I possessed 14% clay, 47% silt, and 39% sand; Station II had 6% clay, 90.5% silt and 3.5% sand; Station III harboured 4% clay, 54.3% silt and 41.7% sand. The highest population density recorded at Station I was due to its enrichment by organic matter brought in by the discharge of sewage. The higher level of clay fraction (14%) was also one of the reasons for the high population density. Station II possessed the intermediate value of population density and it was due to its estuarine habitat which holds considerable amount of nutrients and moderate amount of clay. The lowest population density recorded at Station III was due to tidal influence, meagre amount of clay content and organic matter. The predominance of sand and silt compared to clay may also be responsible for the lowest population density. Sivagurunathan *et al.* (1988) and Gopinath (1989) have reported high population density of earthworms and polychaetes in subterranean environment which holds low sand fractions and high humus.

The present study has shown that the population density of *O. cremata* was more predominant at the place receiving domestic sewage than that receiving industrial wastes or the intertidal open sea. The higher amount of clay fraction in the sediment held larger population of *O. cremata*.

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# SESSION II

# PESTICIDES AND BIOPARTICLES

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# Residues of Certain Soil Applied Insecticide-cum-Nematicides in Potato

**K. Rajukkannu, G. Rajendran, A. Regupathy and S. Jayaraj**
Centre for Plant Protection Studies, Tamil Nadu Agricultural University
Coimbatore 641003.

## Abstract

During 1984-86, field experiments were carried out in Nilgiris, Tamil Nadu, to assess the residues of certain soil applied granular insecticides in potato tubers following their application against cyst nematodes. The high organic matter content (1 to 10%) in soils of Nilgiris has necessitated the application of aldicarb, phorate, carbofuran, phenamiphos and quinalphos in extremely higher doses (3 to 5 kg a.i./ha) to get the required bio-efficacy against the pest. In all the treatments both the single (at planting) and double split doses (one at planting and another 45 days after) had left residues below the tolerance levels in tubers. However, the tubers harvested from summer experiments had always contained more residues than those from autumn season crop. Although potatoes cultivated in plains were reported to possess higher residues even for the dose of 1.5 or 2.0 kg a.i./ha, the multifold increased doses to potato crop in Nilgiris did not leave appreciable residues.

## Introduction

The potato cyst nematodes or golden nematodes *Globodera rostochinensis* and *Globodera Pallida* affect potato crop and reduce the tuber yield considerably (Krishnaprasad and Krishnappa, 1981; Overman and Jones, 1975). The potato cultivation in the Nilgiris district has been virtually paralysed by these pests and the seed yield ratio which was 1:10 a decade back has come down to 1:3 in recent years. Potent insecticides like carbofuran, aldicarb, phorate, phenamiphos and quninalphos have been used to control these pests. However, the damage caused by the nematodes has become increasingly severe in recent years and extremely heavy doses of these systemic poisons are being applied by farmers to save the crop and increase profit margins without cognizance of the danger of toxic residues involved in such heavy applications. Therefore, with a view to assess the residues of these chemicals in the stem tuber, experiments were conducted in Nilgiris during 1984-86. The results obtained are presented in this communication.

## Material and Methods

The field experiments were conducted in Thummanatti, a village situated 2200 m above MSL in Nilgiris district, Tamil Nadu, India. Being a hill area, this region enjoys a humid temperate climate with an annual rainfall of 1000 to 1300 mm. The soil comes under the order ultisol and formed from granitic parent material (charnokites) situated at an elevation of 1500 to 2300 mm above MSL with a pH range of 4 to 5.5. They are rich in organic matter (3 to 10%), nitrogen, phosphorus but poor in bases. Kaolinite was found to be the chief clay mineral with interstratified vermiculite-illite coming next in abundance.

Three field experiments were conducted with the variety Kufri Jyothi. The first experiment was laid during summer (March to May, 1984 using carbofuran @2.5 and 3 kg a.i./ha; aldicarb @ 1, 2 and 3 kg a.i./ha; quinalphos @ 5 kg a.i./ha applied both as single and two split doses. The entire single and one of the two split doses were applied at the time of planting and the second split dose was applied 45 days after planting. The treatments were replicated twice in a completely randomised block design and the harvest of tubers was done 122 and 77days after the application of the single and the second split application treatments, respectively.

The second and third experiments were conducted during summer '85 and autumn (August to November) '86, respectively. In the second experiment, carbofuran was applied at 2.5 and 4 kg a.i./ha, phorate at 4 kg a.i./ha and quinalphos at 5 kg a.i./ha. Both single and split applications were made and the harvest was done 120 and 75 days after the treatments, respectively. In the third experiment, carbofuran at 2.5, 3, 3.5 and 4 kg a.i./ha; phorate at 3, 4 and 5 kg a.i./ha; phenamiphos at 3, 4 and 5 kg a.i./ha and quinalphos at 4 and 5 kg a.i./ha were applied. All the four chemicals were applied as two split doses, the first at planting and the second 45 days after planting. The duration of the autumn crop was 140 days and the harvest of the tubers was made 95 days after the second split application.

The tuber samples were brought to the laboratory immediately after harvest and analysed for the insecticide residues.

*Carbofuran* : The residues of carbofuran in potato tubers were extracted with acetonitrile and cleaned up by petroleum ether partition and $NH_4Cl$ - phosphoric acid coagulation. Carbofuran and its metabolites were recovered from the coagulation filtrate in dichloromethane, from which phenols were removed by mild (0.1 N NaOH) alkali extraction. The residues were then converted to trifluro acetyl derivative (TFAA) by treatment with trifluro acetyl anhydride in ethyl acetate at 45°C for 16 hours and the derivatised residues were assessed through GLC-NPD system.The sensitivity of the method was 0.006 ppm in 50 g sample with a recovery of 89%.

*Aldicarb* : Aldicarb residues in potato tubers were extracted with acetone and partitioned with methylene chloride. The extract was cleaned up through coagulation ($NH_4Cl$ - phosphoric acid) technique (Miskus *et al.*, 1959). The residues were estimated as aldicarb sulfoxide by the method of Johnson and Stanbury (1966). The sensitivity of the method was 0.06 ppm with a sample size of 50 g and the recovery was 89%.

*Quinalphos* : The residues of quinalphos were extracted with acetone and after evaporating acetone, the aqeuous remainder was extracted with dichloromethane. The extract was cleaned up by passing through a column containing silica gel. The eluate was evaporated and the residue re-dissolved in 5 ml of toluene and an aliquot of 1 µl was injected into the GLC-NPD system. The sensitivity of the method was 0.005 ppm with 50 g sample size and the recovery was 90%.

*Phorate* : The residues of phorate were extracted with dichloromethane-methanol (9:1). The filtrate was concentrated to near dryness and redissolved in cyclohexane + acetone (78:2), cleaned up and fractionated through a column containing deactivated silica gel. The fractions containing phorate, phorate sulfoxide and phorate sulfone were analysed through GLC-NPD system. The sensitivity of the method was 0.003 ppm for the sample size of 50 g and recovery for the three compounds had ranged between 86 and 92%.

*Phenamiphos* : The residues of phenamiphos were extracted with acetone and partitioned with chloroform. The chloroform extract was cleaned up through a chromatographic column containing acid washed charcoal and celite (1:4). The extract was concentrated and re-dissolved in n-hexane, and an aliquot of 1 µl was injected into GLC-NPD system. The sensitivity was 0.06 ppm with a sample size of 50 g and the recovery was 92%.

### Results and Discussion

In the summer '84 trial, both single and split doses of carbofuran applied @ 2.5 kg a.i./ha did not leave any residues in tubers (Table 1). However, when the dose was increased to 3 kg, the tubers contained residues, the level being higher for split dose than the single dose treatment. The higher residue observed in split dose than the single dose might be due to the short interval (77 days) between the last application and the harvest as against 122 days gap for single dose treatment. In the second experiment also (Summer '85) a similar trend was observed. Only the higher dose of 4 kg a.i./ha treatment had left residues. In the third experiment conducted during antumn '86, only split applications were made and all the treatments had left residues in the tubers. The residue levels were found to be much lower than the values obtained from the previous two summer experiments.

Table 1. Carbofuran residues in/on potato tubers

| Dose (kg a.i./ha) | Method of application | Interval between last application and harvest (days) | Residues (ppm) | | Tolerance level (ppm) |
|---|---|---|---|---|---|
| | | | Washed raw tubers | Washed, boiled and skin peeled tubers | |
| | | Expt. No. 1(Summer '84) | | | |
| 1. 2.5 | S | 122 | ND | — | 1.00 |
| 2. 1.25 + 1.25 | SP | 77 | ND | — | |
| 3. 3.00 | S | 122 | 0.153 | 0.038 | |
| 4. 1.5 + 1.5 | SP | 77 | 0.263 | 0.085 | |
| | | Expt. No.2 (Summer '85) | | | |
| 1. 2.5 | S | 120 | ND | — | 1.00 |
| 2. 1.25 + 1.25 | SP | 75 | ND | — | |
| 3. 4.0 | S | 120 | 0.126 | 0.042 | |
| 4. 2.0 + 2.0 | SP | 75 | 0.240 | 0.063 | |
| | | Expt. No.3 (Autumn '86) | | | |
| 1. 1.25 + 1.25 | SP | 95 | 0.035 | — | 1.00 |
| 2. 1.5 + 1.5 | SP | 95 | 0.044 | — | |
| 3. 1.75 + 1.75 | SP | 95 | 0.066 | — | |
| 4. 2.0 + 2.0 | SP | 95 | 0.090 | | |

S = Single; SP = Split; ND = Non-detectable.

Table 2. Aldicarb and phorate residues in/on potato tubers

| Dose (kg a.i./ha) | Method of application | Interval between last application and harvest (days) | Residues (ppm) Washed raw tubers | Residues (ppm) Washed, boiled and skin peeled tubers | Tolerance level (ppm) |
|---|---|---|---|---|---|
| | | Expt. No.1 (Summer '84) | | | |
| Aldicarb | | | | | |
| 1. 1.00 | S | 122 | ND | — | 1.00 |
| 2. 0.5 + 0.5 | SP | 77 | 0.065 | ND | |
| 3. 2.0 | S | 122 | 0.088 | ND | |
| 4. 1.0 + 1.0 | SP | 77 | 0.123 | 0.045 | |
| 5. 3.0 | S | 122 | 0.106 | 0.040 | |
| 6. 1.5 + 1.5 | SP | 77 | 0.192 | 0.055 | |
| | | Expt. No. 2 (Summer '85) | | | |
| Phorate | | | | | |
| 1. 3.0 | S | 120 | 0.106 | ND | 0.5 |
| 2. 1.5 + 1.5 | SP | 75 | 0.135 | ND | |
| 3. 4.0 | S | 120 | 0.112 | ND | |
| 4. 2.0+ 2.0 | SP | 75 | 0.176 | 0.045 | |
| | | Expt. No. 3 (Autumn '86) | | | |
| Phorate | | | | | |
| 1. 1.5 + 1.5 | SP | 95 | 0.024 | — | 0.5 |
| 2. 2.0 + 2.0 | SP | 95 | 0.039 | — | |
| 3. 2.5 + 2.5 | SP | 95 | 0.079 | — | |

S = Single; SP = Split; ND = Non-detectable.

Mythyantha *et al.* (1977) observed that when single dose application of carbofuran @ 1.125, 1.875, 2.625 and 334 kg a.i./ha was made to potato in Nilgiris, the residues left in the tubers at the time of harvest were 0.080, 0.170, 0.190 and 0.295 ppm, respectively. The residues in all seasons were well below the tolerance level of 1.00 ppm and cooking (boiling and skin peeling) had further reduced the residues.

When aldicarb was applied @ 1 kg a.i./ha as a single dose, there was no residue in tubers (Table 2). But when the same dose was applied in two splits, 0.065 ppm was found in tubers. The increased dose of 2 and 3 kg a.i./ha both as single and split applications had left residues; but all were below the tolerance level of 1.00 ppm. Phorate was tried both in summer '85 and autumn '86 experiments. The residues present in the tubers harvested in summer '85 were higher than those harvested in autumn '86 (Table 2). The boiled and skin peeled tubers contained almost non-detectable residues.

When quinalphos was applied to potato crop @ 5 kg a.i./ha as a single dose during summer '84 and '85, residues in tubers were non-detectable (Table 3). However, when the chemical was applied in split dose, 0.077 and 0.081 ppm residues, respectively were found. During autumn '86, when 4 and 5 kg a.i./ha doses were applied in two split doses, both had left residues to the level of 0.034 and 0.059 ppm, respectively. Phenamiphos treatments were tried only in the third experiment conducted during autumn '86. In all the three doses, *viz.* 3, 4 and 5 kg a.i./ha (split application) phenamiphos residues were not detected in tubers.

Table 3. Residues of quinolphos and phenamiphos in/on potato tubers

| Dose (kg a.i./ha) | Method of application | Interval between last application and harvest (days) | Residues (ppm) Washed raw tubers | Residues (ppm) Washed,boiled and skin peeled tubers | Tolerance level (ppm) |
|---|---|---|---|---|---|
| | | Expt. No. 1(Summer '84) | | | |
| Quinolphos | | | | | |
| 1. 5.0 | S | 122 | ND | — | NA |
| 2. 2.5 + 2.5 | SP | 77 | 0.077 | ND | |
| | | Expt. No.2 (Summer '85) | | | |
| 1. 5.0 | S | 122 | ND | — | |
| 2. 2.5 + 2.5 | SP | 77 | 0.081 | ND | |
| | | Expt.No. 3 (Autumn '86). | | | |
| 1. 2.0 + 2.0 | SP | 95 | 0.034 | — | |
| 2. 2.5 + 2.5 | SP | 95 | 0.059 | — | |
| Phenamiphos | | Expt.No. 3 (Autumn '86) | | | |
| 1. 1.5 + 1.5 | SP | 95 | ND | — | 0.5 |
| 2. 2.0 + 2.0 | SP | 95 | ND | — | (for carrots |
| 3. 2.5 + 2.5 | SP | 95 | ND | | garlic, tomato, etc.) |

S = Single; SP =Split; ND = Non-detectable.

In general, the results of the investigation revealed that carbofuran, phorate and quinalphos had left higher residues in tubers in summer than in the autumn crop. Under cool autumn conditions, when the mean minimum and maximum temperatures were low, a slow degradation, longer persistence in soil and higher residues in tubers are expected. But contrary to this, the residue levels were higher during summer than autumn. It has been reported earlier that in plains even at the maximum dose of 2 kg a.i./ha., phorate (Awasthi *et al.*, 1977) and phorate and aldicarb (Mishra and Nagaiah, 1986) in Jullunder (Punjab), and carbofuran in Bangalore (Anon., 1977) had left higher residues, sometimes above the tolerance levels, as compared to the residues found in the present investigation. In addition, application of phorate, carbofuran, aldicarb and quinalphos to many other crops in plains at doses never exceeding 2.0 kg a.i./ha resulted in considerable residues in crop produce though below the tolerance levels (Dixit *et al.*, 1976; Anon., 1977; Rajukkannu and Sree Ramulu, 1983; Rajukkannu *et al.*, 1977). Although the doses used in the present investigation were 3 to 4 fold higher, the residues observed in tubers were comparatively low.

The organic matter content of the soils of plains ranges between 0.1 to 1.0% while the soils of Nilgiris regions contain 1 to 10% organic matter. Organic matter is the potential adsorber of non-polar organic pesticide (Adams and Li, 1971; Rajukkannu and Sree Ramulu, 1978) and some quantity of the parent pesticide gets adsorbed first on the surface and becomes inactivated. The differences in the quantity of organic matter present in the soils of these two regions would explain the magnitude of the adsorption of non-polar organic pesticides in them. Being systemic in nature, all these compounds are converted into more polar metabolites in soils. Phorate, aldicarb and phenamiphos molecules contain aliphatic thioether moiety which on oxidation give rise to the corresponding sulfoxides (fast) and sulfons (slow). Carbofuran is metabolised to 3-hydroxy, 3-keto and their respective phenolic and conjugated compounds (Caro *et al.*, 1973). All these metabolites because of their polar nature would not get adsorbed on organic or mineral colloids and these compounds would be in soil solution and readily available for pest control in soil or for root absorption. Under these conditions,if there is enough water allowed to percolate through the soil, all these compounds which are highly water soluble might be leached away from the soil. Rajukkannu and Sree Ramulu (1983) observed that the leaching of carbofuran was very rapid in red, black and alluvial soils and the effluents contained 55, 36.5 and 41.5%, respectively of the added carbofuran. Nilgiris, being a hilly region situated above 1500 to 2300 m above MSL, possesses a humid climate and experiences a heavy annual rainfall of 1000 to 1300 mm. The average rainfall during autumn season (562 mm) is higher than during summer (180 mm). The rain water percolates through the organic soil very rapidly and is drained along the slope removing most of the water soluble metabolites of these pesticides constantly and the uptake by potato crop becomes low. This situation is in contrast with the crops grown in plains where there is not enough organic matter or high rainfall to adsorb the non polar compounds or to leach away the water soluble compounds from the soil. This results in higher residues in crops grown in plains even for the low dosage of 1.5 or 2.0 kg a.i./ha.

The present investigation has revealed that the high organic matter content in Nilgiris soils necessitates the application of aldicarb, phorate, carbofuran, phenamiphos and quinalphos in three to four fold higher doses (upto 5 kg a.i./ha) to get the required bio-efficacy. This multifold increase in doses did not leave appreciable residues in the tubers due to the higher solubility of the metabolites of these chemicals and the higher annual rainfall received during the cropping season which helped the chemical to leach away from the soils.

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# Effect of Organophosphorus Insecticides on Primary Productivity of Stabilisation Pond

**Y.M. Jayaraj and K. Janakiram**

Department of Microbiology, Gulbarga University, Gulbarga 585106

## Abstract

The present study has attempted to record the effect of four commonly used organophosphorus insecticides, namely dichlorvos, dimethoate, monocrotophos and phosphamidon on the algal activity. The measurement of primary productivity adopting light and dark bottle method with four hours incubation was employed to assess the pesticide toxicity. The results showed that dimethoate was the most toxic amongst the four insecticides to microbial primary productivity.

## Introduction

The stabilisation pond constitutes a complex ecosystem consisting of bacteria, algae, fungi, protozoa, rotifers and some higher organisms. The symbiotic activity of algae and bacteria of the stabilisation pond is said to be responsible for the stabilisation of organic wastes (Gloyna, 1971). Algae is the principal contributor of oxygen for the aerobic biodegradation of organic wastes. In turn they utilise the resultant inorganic nutrients and $CO_2$ in the presence of solar energy during photosynthesis,liberating abundant quantity of oxygen. Thus, any detrimental effect on algae is likely to derange the entire process of bio-degradation and productivity.

Of late, due to decentralisation of industrialisation and the emergence of small scale and medium scale industries in towns and cities and usage of pesticides, the municipal wastes no longer consist of only the wastes of domestic origin but also toxic materials like heavy metals, detergents and pesticides. Thus, the presence of such potentially toxic and hazardous material in wastewater can stultify the efficiency of stabilisation pond. Few reports are available on the effect of pesticides on the growth, productivity and biomass of unialgal cultures. Parathion was shown to reduce the photosynthetic oxygen production by *Scendesmus quadricauda* by about 60% (Lohmann and Hagedorn, 1986). Derby and Ruber (1970) have shown that the photosynthetic activity of marine algae was inhibited by 100 ppb of fenthion and temephos. Similarly, Ware and Roan (1970) have shown that malathion and diazinon inhibited the photosynthesis of estuarine phytoplanktons at 1 ppm concentration. Lacunae exist with regard to the effect of pesticides on the primary productivity of aquatic ecosystem and stabilisation pond. Hence, an attempt has been made to study the effect of organophosphorus insecticides on the primary productivity of stabilisation pond.

## Material and Methods

Pond water samples of a laboratory model pond and a field stabilisation pond constituted the material. The detention period of both the ponds was 10 days. The method adopted to evaluate the primary productivity was light and dark bottle method of Wollenweider (1976). The insecticides used were dichlorvos, dimethoate, monocrotophos and phosphamidon. They were of technical grade and the test concentrations employed ranged from 5-500 mg/l.

Pond water samples collected from field or laboratory model pond were homogenised and were distributed in equal quantities to 5 sets of flasks, each set consisting of 6 flasks. The solution of insecticide to be tested was added to the first five flasks of each series of a given set so as to give the required concentration (mg/l). The last flask acted as control. The last set of flasks was added with the mixture of all the four insecticides in equal proportions.

The contents of each flask (sample + known insecticide concentration) were mixed properly and distributed to two BOD bottles labelled as light bottle (LB) and dark bottle (DB).All the bottles labelled as DB were covered with black wrappers to prevent the entry of light. The bottles were stoppered firmly avoiding air bubbles and were immersed in the water medium of stabilisation pond and were incubated for 4 h at mid-day light and temperature conditions. The dissolved oxygen (DO) concentration of pond water sample before addition of insecticides and that of samples of light and dark bottles after 4 h incubation was measured by modified Winkler's (1888) method. The 3 components of primary productivity, namely gross productivity (GP), net productivity (NP) and respiration (R) were calculated as per the following formulae :

a) $\text{GP (mg of } O_2 \text{ lib/l/hr)} = \dfrac{\text{DO of LB–DO of DB}}{\text{Hours of incubation}}$

b) $\text{NP (mg of } O_2 \text{ lb/l/hr)} = \dfrac{\text{DO of LB–DO of IB}}{\text{Hours of incubation}}$

c) $\text{R (mg of } O_2 \text{ conc./l/hr)} = \dfrac{\text{DO of IB–DO of DB}}{\text{Hours of incubation}}$

The effective concentration ($EC_{50}$) values of a given insecticide/mixture of insecticides on primary productivity was calculated by applying probit analysis (Finney, 1971).

## Results and Discussion

The calculated $EC_{50}$ values of insecticides, both individually and as a mixture, on the microbial primary productivity of laboratory model pond/field pond are given in Table 1. The $EC_{50}$ values thus calculated were tested for confirmation thrice during a span of 15 days. From the results, it is evident that dimethoate was more toxic to microbial primary productivity when compared to other insectides in both laboratory model and field pond.

Table 1. $EC_{50}$ values of insecticides on primary productivity of (1) laboratory model stabilisation pond and (2) field stabilisation pond.

| Insecticide | Gross productivity | | Net productivity | |
|---|---|---|---|---|
| | 1 | 2 | 1 | 2 |
| Dichlorvos | 505.7 | 891.3 | 500.0 | 749.9 |
| Dimethoate | 042.2 | 154.0 | 025.0 | 129.6 |
| Monocrotophos | 398.1 | 1122.0 | 224.0 | 794.3 |
| Phosphamidon | 562.3 | 944.1 | 266.1 | 891.3 |
| Mixture | 091.7 | 354.8 | 072.9 | 316.2 |

The order of toxicity of the insecticides to the primary productivity of laboratory model pond was dimethoate mixture > monocrotophos > dichlorvos > phosphamidon for GP and dimethoate > mixture > monocrotophos > phosphamidon > dichlorvos for NP.

The $EC_{50}$ values of insecticides on the primary productivity of field pond were 1.25 to 5 times higher than those observed in the case of laboratory model pond. The order of toxicity of the insecticides on primary productivity of field pond was dimethoate > mixture > dichlorvos > phosphamidon > monocrotophos for GP and dimethoate > mixture > dichlorvos > monocrotophos > phosphamidon for NP.

The differences in the $EC_{50}$ values of insecticides to primary productivity of laboratory model and field pond could be attributed to possible microbial diversity, adaptation and effective microbial degradation and detoxification of the insecticides. The mixture of all the 4 insecticides brought about considerable inhibition of the primary productivity of both field as well as laboratory model pond. The $EC_{50}$ values obtained in the case of mixture of the 4 insecticides were usually more than the $EC_{50}$ value obtained for dimethoate but considerably lower than the $EC_{50}$ values of other insecticides (Table1).

There appears to be no inhibitory effect of insecticides on the respiratory activity of microorganisms. The percent response for respiration of microorganisms in the presence of the insecticides except dimethoate was more than that of control and it increased with increase in dosage. However, in the case of dimethoate, the utilisation of oxygen from the medium could not be attributed to the aerobic biodegradation of wastes. Increased oxygen utilisation was observed in the presence of DDT (Pritchard and Dines, 1972; Patil *et al.*, 1985). Such an increased rate of oxygen consumption was attributed to the metabolism of reserve food material within cells. However, Nasar (1977) observed the inhibition of both photosynthesis and respiration in the presence of endrin. When applied in mg/l range, organochlorine insecticides have been proved to affect photosynthesis, respiration and growth rate in fresh water and marine algal populations (Menzel *et al.*, 1970; Mosser *et al.*, 1972). On the contrary, 2,4-dichlorophenoxy acetic acid (2,4-D) at $4 \times 10^{-4}$ M concentration did not affect photosynthetic activity while affecting respiration (Chai and Chung, 1975). Respiration was less sensitive to triazines and at times respiration was stimulated by the herbicides at and above 0.0001 mg/l concentration (Spirescu, 1978).

In the absence of literature on the effect of dichlorvos, dimethoate, monocrotophos and phosphamidon on microorganisms, the present study assumes significance. It is interesting to note that the insecticides are less toxic when compared to some other organophosphorus insecticides like malathion, diazinon, fenitrothion and temephos, and some of the organochlorine insecticides. Hence, from the ecosystem point of view, these organophosphorus insecticides except dimethoate appear to be less toxic as these are required in quantities more than 100 mg/l to induce 50% inhibition.

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# Biochemical Changes due to Acute Endosulfan Toxicity in the Prawn *Macrobrachium idella* (Hilgendorf)

**K.R. Narayanan, P. Villalan and S. Ajmalkhan**

Centre of Advanced Study in Marine Biology, Annamalai University,
Parangipettai 608502

## Abstract

The changes in the protein, lipid and glycogen in muscle and hepatopancreas of the prawn *Macrobrachium idella* exposed for 24 and 96 h to 6.5 ppb endosulfan, its 96 h median lethal concentration ($LC_{50}$) to the prawn, were analysed. In the exposed animals, protein, glycogen and lipid values were found to be lower than in control and the fall in values was proportionate to the exposure time. The hemolymph sugar was also estimated and its level increased in the exposed animals compared to that in control and this increase was also proportionate to the exposure duration.

## Introduction

Diversified application of pesticides, both for agriculture and public health purposes, has resulted in the escape of large quantities of these chemicals into the environment. The waste discharged from pesticide manufacturing industries constitutes the second greatest source of pesticides to the aquatic environment (Nimmo, 1985). Eversince the beginning of the use of pesticides, severe ecological imbalances seemed to have occurred chiefly in the coastal environment of many countries (Carson, 1964). The tragic occurrences of 'Yusho' and 'Hondigodu' syndrome in Japan and India in 1968 and 1977, respectively, have been attributed to long term consumption of rice oil contaminated with PCB's in the case of the former and the consumption of crabs and fish contaminated with pesticides in the case of the latter (NIN, 1977; Clark, 1986). Considering the above facts it is necessary to investigate the toxic effects of pesticides on organisms so that defensive methods could be developed. The present study traces the changes in protein, glycogen, lipid and haemolymph sugar levels in the edible brackish water prawn *Macrobrachium idella* (Hilgendorf) due to endosulfan toxicity.

## Material and Methods

Specimens of *M.idella* meant for the present study were collected from the freshwater zone of the Vellar estuary, Porto Novo. The size of the prawns ranged from 6 to 7 cm in length and 11 to 13 g in weight. These prawns were acclimatized in the laboratory for a week in well aerated tap water. The prawns were fed daily twice with chopped clam meat, but were starved for 24 h prior to the experiment. The prawns were exposed to 5.6 ppb endosulfan, its 96 h $LC_{50}$ value to the prawn as estimated earlier. After 24 and 96 h of exposure the biochemical constituents like protein, glycogen and lipid in hepatopancreas and muscle and also the sugar level in haemolymph were estimated following the methods of Raymont *et al.* (1964); Wedemeyer and Yasutake (1977), Folch *et al.* (1957) and Dubois *et al.* (1956), respectively.

## Results

Changes in protein, glycogen, lipid and haemolymph sugar level of the prawn after 24 and 96 h of exposure to endosulfan are presented in Table 1.

Table 1. Biochemical constituents in control and endosulfan exposed individuals of the prawn *Macrobrachium idella*

| Treatment | Body part | Protein (mg/g) | Glycogen (mg/g) | Lipid (mg/g) | Haemolymph sugar (mg/100 ml) |
|---|---|---|---|---|---|
| Control | Mus: | 94.6 | 20.74 | 40.33 | 26.22 |
| | Hep: | 199.8 | 41.69 | 180 | |
| After 24 h of exposure to endosulfan | Mus: | 86.5 (8.56)* | 19.01 (8.34) | 35.6 (11.73) | 46.86 (78.72) |
| | Hep: | 176.0 (11.92) | 36.41 (12.67) | 16.20 (10.3) | |
| After 96h of exposure to endosulfan | Mus: | 75.0 (20.71) | 16.72 (17.74) | 30.2 (25.12) | 100.74 (2 84.2) |
| | Hep: | 101.0 (49.15) | 22.89 (45.09) | 149.0 (17.50) | |

*Values in parentheses are the percentage change over the control.
Mus: Muscle; Hep: Hepatopancreas.

*Protein content*

The protein content decreased both in muscle and hepatopancreas compared to control. The decrease of protein content in muscle after 24 and 96 h of exposure over control was 8.56 and 20.71%, respectively while it was 11.92 and 49.15%, respectively in the hepatopancreas.

*Glycogen content*

Like protein, glycogen level also decreased following exposure. The decrease in glycogen content in muscle after exposing them to endosulfan for 24 and 96 h was 8.34 and 17.74%, respectively, while it was 12.67 and 45.09%, respectively in the hepatopancreas.

*Lipid content*

The lipid level also decreased after exposure to endosulfan. The decrease was to the extent of 11.73 and 25.2% in the muscle and 10.3 and 17.5% in the hepatopancreas after 24 and 64 h of exposure, respectively.

*Sugar level*

The haemolymph sugar level increased by 78.72 and 284.2%, respectively after 24 and 96 h of exposure to endosulfan.

## Discussion

Exposure to endosulfan reduced the protein content in muscle and hepatopancreas of the prawn *M. idella*. Similar results were reported due to phosphamidon in *Metapenaeus monoceros* (Vijayalakshmi and Ramana Rao, 1985). The decrease in protein content may be due to enhanced proteolysis to meet the high energy demands caused by the pesticides. Glycogen content also decreased both in the muscle and hepatopancreas due to exposure to endosulfan. Similar results were reported in the prawn, *Penaeus indicus* due to phosphamidon (Reddy and Ramana Rao, 1987). They suggested that among the carbohydrates,the glycogen content decreased rapidly indicative of its immediate mobilization towards energy synthesis by the prawn tissue. Reddy (1986) reported that the synthesis and utilization of glycogen are altered during stress caused by the pesticide. The decrease in lipid content may be due to the utilisation of the same to overcome the stress caused by the pesticide. Endosulfan elicited a rapid elevation in haemolymph sugar level also in the present study. Similar results were found in the freshwater crab *Barytelphusa canicularis* exposed to DDT (Jawale, 1985). The increased sugar level in haemolymph indicated the stress caused by endosulfan.

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# Effect of the Pesticides Endosulfan and Dimethoate on Some Biological Constituents of the Paper Shells *Tellina ala* and *Tellina cuspis* (Mollusca: Bivalvia)

**T. Saratha and R. Kasinathan**

Centre of Advanced Study in Marine Biology, Annamalai University,
Parangipettai 608502

## Abstract

The 96 h $LC_{50}$ values of endosulfan and dimethoate to the paper shell *Tellina ala* and *Tellina cuspis* were estimated under laboratory conditions using static renewal technique. The changes in protein and amino acid in different soft tissues were analysed in insecticide exposed tellinids. The changes effected by the pesticide stress were discussed comparing the results with that of control.

## Introduction

Many synthetic organic pesticides were introduced over 40 years ago, but their effects on aquatic environments are still poorly understood. Among the pesticides, organochlorine compounds are highly persistent and accumulative in character (Nagarajan, 1987). Greeve and Wit (1971) reported that endosulfan was strongly adsorbed on to sediments in streams and ponds. Rajendran (1984) reported the occurrence of endosulfan in surface water of Vellar estuary which ranged from 0.02 to 1.37 ng/l. The translocation of endosulfan from agricultural fields to the aquatic environment poses a serious threat to fishes and shellfishes of commercial importance.

Among shellfishes, bivalves received much importance for their edibility. Tellinids are small benthic deposit feeding bivalves. At present they are being consumed by a small section of people. Nevertheless, the members of Tellinidae hold good potential in pisciculture practices as they form a good feed to other fishes (Ansell and Ann Trevallion, 1967). Being filter feeders, they are known to accumulate pollutant to several times the concentration in the ambient medium. Considerable work has been carried out on the effect of various pollutants on behavioural, physiological and pathological changes in many organisms. However, the available literature on the effect of pesticides on biochemical aspects in bivalves is limited. Hence, the present study was undertaken to elucidate the extent of pesticide effect on the biochemical composition like protein and total free amino acids in whole and different soft tissues of tellinids.

## Material and Methods

The paper shells *Tellina ala* and *Tellina cuspis* were collected from the mouth of Vellar estuary and brought to the laboratory, cleaned and acclimated to the laboratory conditions by keeping them in well aerated water with a temperature of 28 ± 1°C, pH of 7.5, and salinity of 20 ppt for 5 days. Adult shells of similar size group ranging from 30 to 32 mm in length were selected. They were fed with fresh phytoplankton. However, no food was given during the experimental period. Ten bivalves were exposed to each of the different concentrations of endosulfan and dimethoate. A control was also maintained which received the carrier solvent. The mortality and behavioural pattern were recorded at regular intervals. The $LC_{50}$ were determined by using Lichfield and Wilcoxon (1949) method.

The paper shells *T. ala* and *T. cuspis* were exposed to $LC_{50}$ concentration of endosulfan and dimethoate. The whole animal and different tissues like gonad, digestive diverticula,mantle, adductor and siphon from control and experimental animals were dissected out after 96 h of exposure and oven dried for 24 h at 60°C and analysed for protein. Wet tissues were taken for the estimation of total free amino acid. Protein was estimated by Biuret method as described by Raymont *et al.* (1964) and the total free amino acid was estimated following the method described by Moore and Stein (1954). The measurements were taken in a Model 220S Hitachi double beam spectrophotometer.

## Results

The protein content in whole animal, gonad, digestive diverticula, adductor, mantle and siphon of *T. ala* was found to decrease over control by 18.2, 15.1, 14, 6.5, 9.1 and 11.5%, respectively after 96 h of exposure to 10 ppb of endosulfan. In *T. cuspis* the observed decrease in protein content over the control after exposure to 6 ppb of endosulfan was 19, 17, 14, 5, 5 and 6.1% in whole animal, gonad, digestive diverticula, adductor, mantle and siphon, respectively.

After exposure to acute concentration of dimethoate the protein content in Tellinids decreased in all the tissues. The decrease in protein content over the control in whole animal, gonad, digestive diverticula, adductor, mantle and siphon in *T. ala* was 14.1, 12.3, 12,4.3, 8.5 and 9.1% while in *T.cuspis* it was 18.5, 14.9, 12.5, 3.5 and 5.5%, respectively over the control.

A similar trend was noticed in total free amino acid level in tellinids exposed to acute concentrations of endosulfan and dimethoate. The total free amino acid level in *T. ala* and *T.cuspis* exposed to 10 ppb and 6 ppb of endosulfan decreased over control by 24 and 13%, respectively while the decrease was to the tune of 25 and 22% in *T.ala* and *T. cuspis* exposed to 15 and 10 ppb of dimethoate, respectively. The decrease in amino acid level over the control in gonads, diverticula, siphon and mantle in *T. ala* exposed to 10 ppb endosulfan was 74.57, 44.11, 77.2 and 72.22%, respectively while the corresponding values were 72.7, 29.41,57.6 and 69.44%, respectively for *T. cuspis* exposed to 6 ppb endosulfan. The amino acid level in gonads, diverticula, siphon and mantle in *T.ala* exposed to 15 ppb dimethoate decreased by 18.9, 36.66, 18.6 and 30.66% over the control while in *T. cuspis* exposed to 10 ppb of the same insecticide it was to the extent of 9.9, 26, 16.94 and 18.66%, respectively.

In the present investigation, dose dependent decrease in protein and total free amino acid content was observed in gonad, digestive diverticula, siphon, mantle, adductor and whole animal of tellinids exposed to acute concentrations of pesticides after 96 h. The degree of reduction in biochemical constituents was higher in endosulfan exposed to tellinids than those exposed to dimethoate.Percentage reduction in total free amino acid and protein was more in *T. ala* than *T.cuspis*. The biochemical constituents in gonad and digestive diverticula were highly sensitive than in other body tissues.

## Discussion

A significant decrease in the protein content of whole animal and different tissues of the paper shells was observed after exposure to the pesticides endosulfan and dimethoate. Similar observations were made by Ramana Rao and Ramamurthi (1979) in Sumithion exposed *Pila globosa.* Emmanuel (1985) reported decreased protein content in *Anadara rhombea* exposed to WSF of diesel and suggested that it maybe due to enhanced utilization of protein by the animal during stressed condition. Stekoll *et al.* (1980) reported similar reduction in protein content in *Macoma balthica* exposed to Prudhoe Bay crude oil. In the present study, the reduction observed in the protein and total free amino acid contents in all the tissues of the tellinids exposed to the two pesticides might be due to the enhanced utilization of protein. Stirling (1970) reported that in *T. tenuis*, larger individuals were more susceptible to toxins than small individuals.

From the observations made in the present study it could be understood that pesticides affect aquatic organisms by chiefly affecting the metabolic parameters resulting in death.

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# Comparative Effect of Lindane ($\gamma$ - BHC) and Dimethoate on Oxygen Consumption in the Freshwater Fish *Sarotherodon mossambicus* (Peters)

**PR. Karpagaganapathy and C. Rajamanickam**

Department of Zoology, Annamalai University, Annamalainagar 608002

## Abstract

The rate of oxygen consumption was studied in *Sarotherodon mossambicus* (Peters) exposed to sublethal concentrations of lindane (0.1 mg/l) and dimethoate (0.035 ml/l) after 24 hours. The $O_2$ consumption increased in lindane exposed fish but decreased in dimethoate exposed fish when compared to controls. The pesticide lindane accelerated the respiratory metabolism while dimethoate retarded the respiratory metabolism.

## Introduction

The changes in the chemical nature of water, due to pesticide contamination, cause definite damage to aquatic life including fishes. Pollutants are known to induce physiological and biochemical changes in fishes before causing drastic cellular and systemic malfunctions. Respiration is the most commonly used tool for understanding the physiological action of pesticides. The respiratory rate of an organism is indicative of the physiological state and changes in respiratory rate may be indicative of environmental stress (Capuzzo, 1977; Capuzzo *et al.*, 1976). Since fishes are an important source of protéin, it will be more rewarding to have a thorough understanding of pesticide effects in fishes in order to improve fish conservation and fisheries development. The present study deals with the toxic effects of the organochlorine pesticide lindane and the organophosphorus pesticide dimethoate on oxygen consumption in the fresh water fish *Sarotherodon mossambicus*.

## Material and Methods

The fishes *S. mossambicus* were collected from the freshwater ponds around Annamalainagar, and acclimatized to the laborâtory conditions for 15 days. The fishes were fed with boiled egg or cooked rice on alternate days. Feeding was discontinued 48 h before the beginning of the experiment to reduce the quantum of excretory product in the test trough as suggested by Arora *et al.* (1972).

After exposing to sublethal concentrations of lindane (0.1 mg/l) and dimethoate (0.035 ml/l) for 24 h, oxygen consumption was estimated by Winkler's iodometric method as modified by Strickland and Parsons (1968). Values of oxygen consumption were expressed in ml/g/hr. Simultaneously, oxygen consumption of the control fishes was also estimated without the pesticide.

## Results and Discussion

The oxygen consumption of the control fish free from pesticide was found to be 0 238 ml/g/hr. When the fish *S. mossambicus* was exposed to sublethal concentration of lindane for 24 h, the oxygen consumption increased to 0.288 ml/g/h (+12.04%) from the mean control level. In the case of organophosphorus pesticide dimethoate, the fish exposed to sublethal concentration showed a decrease (−29.84%) in oxygen consumption (0.167 ml/g/h). The pesticide lindane increased the rate of oxygen consumption and the pesticide dimethoate decreased the rate of oxygen consumption (Table 1).

Table 1. Oxygen consumption (ml/g/h) of control and exposed *Sarotherodon mossambicus*

| Exposure | Oxygen consumption | Percent change over control |
|---|---|---|
| Control | 0.238 ± 0.004 | — |
| Sublethal concentration of lindane (0.1mg/l) | 0.288 ± 0.008 | + 12.04 |
| Sublethal concentration of dimethoate (0.035 ml/l) | 0.167 ± 0.006 | – 29.84 |

The increase in the rate of oxygen consumption in *S. mossambicus* exposed to lindane might be the reflection of an augmented physiological activity like osmosis at the cellular level in eliminating the pesticide and/or counteracting the pesticidal stress. The fish needs more oxygen in order to overcome the pesticide stress. Bakthavathsalam (1980) observed an increase in the rate of oxygen consumption due to stress induced by pesticide. Kulkarni and Bhaskar Rao (1988) in their studies on leech have reported an increase in the rate of oxygen consumption at initial periods of exposure to the pesticide medium.

The decrease in the rate of oxygen consumption to organophosphorus pesticide dimethoate exposed fish may be due to the interference in the respiration by decreasing blood pigment and $O_2$ binding efficiency. It has been suggested that in animals exposed to organophosphorus insecticides, death is due to asphyxia which is caused by respiratory failure (O'Brien, 1967). Bhagyalakshmi (1981) has reported that significant decrease in cellular oxidation may have contributed to the significant fall in oxygen consumption. The decrease of oxygen consumption due to methyl parathion in freshwater prawn was reported by Martin *et al. (1988)*.

It is concluded that in the present study the organochlorine pesticide lindane accelerated the respiration and the organophosphorus pesticide dimethoate slowed down the respiration after 24 h of exposure in *S. mossambicus*.

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# Acute Toxicity of Chlordane and Malathion to Different Life Stages of the Indian Major Carp *Cirrhina mrigala* (Hamilton)

**S. Solomon Ravi Kumar* and T.R. Chandrashekhara Gupta**

College of Fisheries, University of Agricultural Sciences, Mangalore 575002
(*Present address : BPL India Ltd, Bangalore)

## Abstract

Acute toxicity of the pesticides chlordane and malathion to the fertilised eggs, hatchlings and fingerlings of the Indian major carp *Cirrhina mrigala* (Hamilton) in soft and hard waters was studied using the static bioassay technique. In the case of chlordane, 15% egg mortality was recorded at the peak levels of 0.35 and 0.40 µg/l in soft water. The 72h $LC_{50}$ was 0.20 µg/l for hatchlings and 0.0098 µg/l for fingerlings. The hatching time under stress was reduced by 5h when compared to the control. A general decrease in the toxicity of chlordane was observed in all life stages of mrigala when the hardness of the medium was increased. Only 10% embryonic mortality was observed at the higher concentrations of 0.35 and 0.40 µg/l. A 72h $LC_{50}$ of 0.25 µg/l was recorded for the hatchlings while for the fingerlings it was 0.038 µg/l. Toxicity of malathion to the three life history stages of mrigala was found to be far less than that of chlordane. The time for hatching was reduced by 8h and 7h in soft and hard waters, respectively. The 72h $LC_{50}$ for hatchlings was found to be 8.0 and 11.0 µg/l, respectively in soft and hard water media. For fingerlings the 24h $LC_{50}$ values were 3.0 µg/l and 3.9 µg/l in soft and hard waters, respectively.

## Introduction

Organochlorine pesticide formulations are basically lipophilic and have low solubility and long persistance in the environment. Pryde(1976) categorised such pesticides as 'hard pesticides'. Chlordane is one of the organochlorine compounds formulated to replace the more toxic DDT. Green *et al.* (1967) found considerable levels of chlordane in the major rivers of United States of America. In the river and drinking water of Hawaii, Bevenue *et al.* (1971) estimated a mean concentration of 7.0 ng/l and a maximum of 13.0 ng/l.

Some information on the pesticide residues and their effect on fresh water fishes is available in published literature (Johnson, 1968; Holden, 1975). Based on bioassay studies, the toxicity of chlordane to bluegills and rainbow trout have been worked out (USDI, 1965 and 1971; Edwards, 1977). Chlordane was found to accelerate the embryonic development and reduce incubation time of crab embryos at concentrations below 1.0 mg/l (Malone and Blaylock, 1970). Chlordane is also known to affect the rate of oxygen uptake of the carp *Labeo rohita* (Bansal *et al.*, 1979). Malathion is a broad spectrum organophosphorus insecticide widely used in the control of a variety of insects including mosquitoes (Cook and Moore, 1976). The tolerance limits of malathion for several freshwater fishes have been worked out (USDI, 1963). Konar and Ghosh (1981) found that *T. mossambica* was more sensitive to malathion than to metasystox and ambithion. In the present study, the acute toxicity of chlordane and malathion to the Indian major carp *Cirrhina mrigala* (Hamilton) was investigated.

## Material and Methods

Fertilised and water hardened eggs of *C. mrigala* were collected from the breeding hapas and transported in enamel trays to the laboratory at Tungabhadra (T.B.) Fish Farm.

The yolked hatchlings, immediately after hatching, were transported to the laboratory. The experiments were terminated by the time of yolk absorption. The advanced fry of *C. mrigala*, bred and reared in T.B.Fish Farm, were brought and further reared to the fingerling sizes in the college fish farm. Fingerlings with 54.6 to 62.8 cm size range and 1.57 to 1.99 g weight range were used in the present studies. Ten fingerlings were used for each concentration.

Filtered and aerated pond water was used for bioassay tests involving fertilised eggs and hatchlings. Borewell water at the college fish farm was filtered, aerated and used for the tests on fingerlings. The pH of the water was 7.4 and hardness was 42 mg/l $CaCO_3$. The required hardness was obtained by the addition of $NaHCO_3$, $CaSO_4$, $MgSO_4$ and KCl at the rate of 192.0, 120.0, 120.0 and 8.0 mg/l, respectively (Thomas, 1971). The hardness of the water so prepared was 175 mg/l $CaCo_3$.

The toxicity of chlordane and malathion individually to all the 3 stages of *C. mrigala* was determined by static bioassay in the laboratory (Sprague, 1969). All the tests were carried out at room temperature 28±1°C.

## Results and Discussion

*Embryonic mortality and incubation*

A maximum of 15% mortality in soft water and 10% in hard water of the fertilised eggs was observed at the peak levels of 0.35 and 0.40 µg/l of chlordane exposure (Table 1). A slight difference was observed in the time required for hatching under chlordane stress in the two types of test medium. The incubation time markedly decreased from 32h in control to 27h at the highest concentration while the values were slightly higher in hard water medium. Further, in soft water, the stress caused a slight reduction in the size of the hatchlings. Egg mortality was 20% at 9.5 µg/l of malathion in soft water while it was slightly lower (15%) in hard water (Table 2). In both the media, the pesticide resulted in an accelerated hatching of the eggs.

Table 1. Embryonic mortality and hatching in *C. mrigala* under exposure to chlordane

| Conc. (µg/l) | Soft water: Mortality (%) | Soft water: Incubation period (h) | Hard water: Mortality (%) | Hard water: Incubation (period) (h) |
|---|---|---|---|---|
| Control | 0 | 32 | 0 | 32 |
| 0.10 | 0 | 30 | 0 | 32 |
| 0.15 | 0 | 30 | 0 | 32 |
| 0.20 | 0 | 30 | 0 | 32 |
| 0.25 | 10 | 28 | 0 | 32 |
| 0.30 | 10 | 27 | 0 | 30 |
| 0.35 | 15 | 27 | 10 | 28 |
| 0.40 | 15 | 27 | 10 | 28 |

It is clear from the above results that the fertilised eggs showed greater resistance to malathion than chlordane. Hansen *et al.* (1975) failed to observe embryonic mortality or changes in hatching time in sheepshead minnow *Cyprinodon variegatus* subjected to a 10 µg/l of Aroclor 1016 stress. Comparable situations have been reported in other fishes,

Table 2. Embryonic mortality and hatching in *C. mrigala* under exposure to malathion

| Conc. (µg/l) | Soft water | | Hard water | |
|---|---|---|---|---|
| | Mortality (%) | Incubation period (h) | Mortality (%) | Incubation (period) (h) |
| Control | 0 | 33 | 0 | 34 |
| 0.5 | 0 | 33 | 0 | 34 |
| 2.0 | 0 | 30 | 0 | 31 |
| 3.5 | 5 | 30 | 0 | 31 |
| 5.0 | 5 | 28 | 0 | 29 |
| 6.5 | 10 | 28 | 10 | 29 |
| 8.0 | 10 | 28 | 10 | 28 |
| 9.5 | 20 | 25 | 15 | 27 |

Table 3. Cumulative percentage mortality of yolked hatchlings of mrigal under chlordane stress

| Conc. (µg/l) | | Time (h) 12 | 24 | 36 | 48 | 60 | 72 |
|---|---|---|---|---|---|---|---|
| Control | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.10 | S | 0 | 0 | 0 | 10 | 15 | 25 |
| | H | 0 | 0 | 0 | 5 | 5 | 5 |
| 0.15 | S | 0 | 0 | 0 | 15 | 30 | 45 |
| | H | 0 | 0 | 0 | 5 | 15 | 15 |
| 0.20 | S | 0 | 0 | 0 | 20 | 45 | 60 |
| | H | 0 | 0 | 0 | 20 | 40 | 40 |
| 0.25 | S | 0 | 0 | 20 | 65 | 85 | 90 |
| | H | 0 | 0 | 0 | 25 | 45 | 45 |
| 0.30 | S | 0 | 0 | 20 | 75 | 90 | 90 |
| | H | 0 | 0 | 5 | 30 | 65 | 65 |
| 0.35 | S | 0 | 0 | 25 | 80 | 85 | 85 |
| | H | 0 | 0 | 10 | 40 | 80 | 90 |
| 0.40 | S | 0 | 0 | 25 | 85 | 85 | 85 |
| | H | 0 | 0 | 10 | 40 | 85 | 90 |

S = Soft water; H = Hard water.

such as channel catfish, fathead minnows and brook trout exposed to low levels of pesticides (Mayer *et al.*, 1977; Stauffer, 1979; Goodman *et al.*, 1976).

*Yolked hatchlings*

The present investigations have clearly brought out the differences in the toxic properties between chlordane and malathion to the hatchlings of mrigal (Tables 3 and 4). In soft water medium, chlordane caused 85% mortality at 0.4 µg/l concentration at 72h.

Table 4. Cumulative percentage mortality of yolked hatchlings of mrigal under malathion stress

| Conc. (µg/l) | | Time (h) 12 | 24 | 36 | 48 | 60 | 72 |
|---|---|---|---|---|---|---|---|
| Control | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.0 | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.5 | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 5.0 | S | 0 | 0 | 0 | 5 | 10 | 20 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.5 | S | 0 | 0 | 5 | 10 | 15 | 30 |
| | H | 0 | 0 | 0 | 5 | 10 | 20 |
| 8.0 | S | 0 | 0 | 10 | 25 | 40 | 50 |
| | H | 0 | 0 | 0 | 5 | 15 | 30 |
| 9.5 | S | 0 | 0 | 10 | 30 | 45 | 55 |
| | H | 0 | 0 | 0 | 10 | 25 | 40 |

S = Soft water; H = Hard water.

On the other hand, even at 9.5 µg/l, malathion caused only 55% mortality at 72h. The $LC_{50}$ at 72h was 0.2 and 0.8 µg/l, respectively for chlordane and malathion. The hatchlings at higher exposure levels of chlordane, i.e. 0.35 and 0.4 µg/l developed pronounced caudal bends. The hatchlings also showed a high degree of impaired swimming at these higher concentrations of the pesticide. In hard water, higher levels of both the pesticides were required to cause mortalities. Thus, the 72h $LC_{50}$ for chlordane was 0.25 µg/l while for malathion it was 11.0 µg/l.

*Fingerlings*

The 68 day old fingerlings of mrigal under chlordane stress in soft water suffered a mortality of 100% within 36h at 0.03 µg/l (Table 5). At and above 0.03 µg/l, the test fishes showed hyperactivity and impaired swimming behaviours. The 72h $LC_{50}$ value for chlordane was 0.0098 µg/l. Chlordane showed $LC_{50}$ values of 4.0 and 10.0 µg/l to bluegills and rainbow trout (USDI, 1965 and 1971). Macek *et al.* (1969), on the other hand, reported a very high value (77.0 µg/l) for chlordane to rainbow trout. The mortalities in fingerlings were lower when hard water was used as the medium. Only 20 to 50 % mortality was observed at the end of 96h at chlordane levels of 0.03 and 0.036 µg/l. The 72h $LC_{50}$ was found to be 0.038 µg/l as against 0.0098 µg/l in soft water. This suggested that the availability of the toxicant became considerably less with increase in the hardness of water.

The results obtained with malathion clearly showed that it was far less toxic than chlordane to the fingerlings of mrigal (Table 6). The 24 h $LC_{50}$ for malathion in soft water was 3.0 µg/l. Complete mortality was observed at 3.0 µg/l at 48h. On the other hand, the

Table 5. Cumulative percentage mortality of mrigal fingerlings under chlordane stress

| Conc. (µg/l) | | Time (h) 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| Control | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.0090 | S | 0 | 0 | 0 | 0 | 0 | 20 | 20 | 20 |
| 0.023 | H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.0092 | S | 0 | 0 | 0 | 0 | 10 | 20 | 20 | 20 |
| 0.03 | H | 0 | 0 | 0 | 10 | 20 | 20 | 20 | 20 |
| 0.0094 | S | 0 | 0 | 10 | 20 | 20 | 30 | 40 | 40 |
| 0.032 | H | 0 | 10 | 10 | 20 | 20 | 20 | 20 | 20 |
| 0.0096 | S | 0 | 0 | 0 | 20 | 30 | 30 | 40 | 40 |
| 0.034 | H | 0 | 30 | 30 | 40 | 40 | 40 | 50 | 50 |
| 0.01 | S | 0 | 30 | 30 | 40 | 50 | 50 | 50 | 60 |
| 0.036 | H | 0 | 20 | 20 | 50 | 50 | 50 | 50 | 50 |
| 0.02 | H | 0 | 80 | 100 | | | | | |
| 0.04 | H | 0 | 60 | 70 | 90 | 100 | | | |
| 0.03 | S | 0 | 100 | | | | | | |
| 0.05 | H | 0 | 90 | 100 | | | | | |

S = Soft water; H = Hard water.

Table 6. Cumulative percentage mortality of mrigal fingerlings under malathion stress

| Conc. (µg/l) | | Time (h) 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| Control | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.50 | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.50 | H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.00 | S | 0 | 0 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2.00 | H | 0 | 0 | 0 | 10 | 10 | 20 | 20 | 20 |
| 1.50 | S | 0 | 0 | 10 | 10 | 20 | 20 | 20 | 20 |
| 2.50 | H | 0 | 0 | 0 | 10 | 20 | 20 | 20 | 30 |
| 1.75 | S | 0 | 10 | 10 | 20 | 20 | 30 | 30 | 30 |
| 3.00 | H | 0 | 10 | 30 | 30 | 40 | 40 | 50 | 60 |
| 2.00 | S | 0 | 20 | 20 | 30 | 30 | 30 | 40 | 40 |
| 3.50 | H | 20 | 30 | 30 | 40 | 50 | 70 | 70 | 70 |
| 2.50 | S | 0 | 20 | 30 | 30 | 30 | 40 | 40 | 50 |
| 4.00 | H | 40 | 50 | 90 | 100 | | | | |
| 3.00 | S | 20 | 30 | 80 | 100 | | | | |
| 5.00 | H | 80 | 100 | | | | | | |

S = Soft water; H = Hard water.

same level of mortality in hard water was recorded at 5.0 µg/l at 24 h. The 24 h $LC_{50}$ was found to be 3.9 µg/l in this medium. Several earlier workers have failed to observe appreciable differences in the toxicity of organophosphorus pesticide formulations in soft and hard waters (Pickering and Henderson, 1966).


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# A Survey of Agrochemicals, their Usage and Economic Considerations in Sholavandan Firka, near Madurai City, Tamil Nadu

**S. Rajendran, A. Mani, and P. Rajendran**

P.G. Department of Zoology, Vivekananda College, Thiruvadakam West, Madurai 624217

## Abstract

A survey conducted on the usage of agrochemicals in Sholavandan Firka near Madurai City, Tamil Nadu, showed that it was more than the recommendations of the agricultural department. The excessive use of fertilizers and pesticides is likely to pollute the nearby Vaigai river through rain water. The economic analysis showed that the output due to the usage of agrochemicals was not substantial.

## Introduction

The modern advancement of science and technology has introduced various agrochemicals in the form of fertilizers and pesticides to improve the quantity and quality of agricultural produce. These agrochemicals are causing "biological boomerang" to the natural environment. The organochlorines affect biotic and abiotic system of the environment. In view of the health hazards occurring from pesticide usage, a detailed investigation is necessary to evaluate their compatibility and performance under field conditions. Hence, a preliminary attempt has been made to survey the usage of agro chemicals and economic considerations in Sholavandan which is located 15 km away from Madurai, Tamil Nadu.

## Material and Methods

A survey on the agrochemical usage has been carried out in six places of Sholavandan firka, namely Pettai, Sholavandan, Solaikuruchi, Thiruvedakam, Nedungulam and Thiruvalavaya Nellur during the year 1988. These areas are located on the banks of river Vaigai which is the main source of drinking water to Madurai City. The total cultivable area in this firka was obtained from the village administrative officers. The estimates of cultivated land area, non cultivated land area, nature of crop under cultivation, quality and quantity of fertilizer and pesticides used were calculated by conducting personal interviews with farmers. The total quantity of fertilizer was estimated by summing up the quantity used by each farmer while the total quantity of pesticide was calculated in kilograms by knowing the percentage of effective concentration in the case of liquid pesticides and these were expressed as kg/acre. The recommended dosages of pesticides and fertilizers for different crops were obtained from the Deputy Agricultural Officer.

## Results and Discussion

The total area of cultivation in the present study was found to be 6,500 ha. Paddy, banana, sugarcane and coconut are the most important crops cultivated in this area.

Table 1. Agrochemical usage pattern and economics at six places near Madurai City, Tamil Nadu

| Place of survey | Crop | Fertilizers (kg/acre) | | Insecticides (g/acre) | | Fungicides (g/acre) | | Income (Rs./acre) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Actual application | Recommended | Actual application | Recommended | Actual application | Recommended | Actual | Expected |
| Sholavandam | Paddy | 88.56 | 70.00 | 899.82 | 920 | 941.73 | 300 | 6,233.90 | 6,650 |
| | Banana | 267.76 | 475.00 | 2.14 | 15 | — | — | 27,142.00 | 25,000 |
| | Sugarcane | 184.50 | 180.00 | 30.29 | 120 | 382.98 | 300 | 15,880.15 | 21,200 |
| Pettai | Paddy | 111.57 | 70.00 | 852.84 | 920 | 203.39 | 300 | 6,228.20 | 6,650 |
| | Banana | 561.07 | 475.00 | 253.33 | 700 | — | — | 21,257.60 | 25,000 |
| | Sugarcane | 307.73 | 180.00 | 196.35 | 65 | 2,181.81 | 300 | 14,747.25 | 21,200 |
| Solaikuruchi | Paddy | 325.01 | 70.00 | 832.09 | 895 | 141.95 | 60 | 6,061.00 | 6,650 |
| | Banana | 325.05 | 475.00 | 352.94 | 700 | 105.88 | 60 | 28,187.50 | 25,000 |
| | Sugarcane | 253.70 | 180.00 | — | — | — | — | 19,270.80 | 21,200 |
| Thiruvedakam | Paddy | 147.03 | 70.00 | 1,803.44 | 920 | 145.00 | 40 | 6,672.80 | 6,650 |
| | Banana | 275.53 | 475.00 | 38.10 | 35 | 269.82 | 300 | 13,092.48 | 25,000 |
| | Sugarcane | — | — | — | — | — | — | — | — |
| Nedungulam | Paddy | 253.90 | 70.00 | 938.08 | 845 | 194.20 | 300 | 6,116.10 | 6,650 |
| | Banana | 253.84 | 475.00 | — | — | — | — | 20,000.00 | 25,000 |
| | Sugarcane | 189.65 | 180.00 | 48.33 | 110 | 300.00 | 90 | 15,568.75 | 21,200 |
| Thiruvalavaya Nellur | Paddy | 143.80 | 70.00 | 775.24 | 895 | 1,045.83 | 100 | 6,313.70 | 6,650 |
| | Banana | 120.86 | 475.00 | — | — | — | — | 20,000.00 | 25,000 |
| | Sugarcane | 329.98 | 180.00 | 475.92 | 835 | 1,717.85 | 300 | 14,747.25 | 21,200 |

*Fertilizers*

The chemical fertilizers used in this area mostly consisted of nitrogen, phosphorus and potash. Nitrogen usage for paddy was two and three fourth times greater than the recommended value. Regarding sugarcane and banana, it was almost equal and 0.4% less than the recommended values, respectively. The metabolites of nitrogen are highly toxic to fish (Buckley, 1978) and excess nitrogen in water can also be dangerous to bottle fed young babies causing oxygen starvation (Gopalakrishnan, 1987). Phosphorous usage was $2^1/2$ and 0.8 times higher for paddy and banana, respectively whereas for sugarcane it was equal to recommendations. It has been shown that the enrichment of phosphate in surface waters can stimulate algal and plant growth sufficiently to kill fish and other aquatic life (Sekar, 1982). Potassium usage for paddy and sugarcane was $2^1/2$ times more than the recommendation whereas for banana it was $2^1/2$ times less than the recommended dosage.

*Pesticides*

The amount of organochlorine pesticides used for paddy was one fourth times greater than the recommended level whereas for sugarcane and banana it was much lesser. Biological magnification of the insecticide endosulfan in tissues of fishes has been studied by many workers (Gupta, 1984; Subbiah, 1985). The organophosphate usage for paddy and sugarcane was $1^1/2$ times greater whereas for banana it was 0.25% less than the recommendations. Acute poisoning of man and mammals generally by OP insecticides is common in many countries due to the widespread application of these chemicals in agriculture, veterinary, medicine and public health (Slavoljub Lj Vitorovi, 1983). Carbamate usage for paddy and sugarcane was $2^1/2$ times and 2/3 times less than the recommended values whereas for banana it was not at all used.

Fungicide usage for paddy and sugarcane was $2^1/2$ times and $4^1/2$ times greater than the recommended values whereas for banana the usage was very much less than the recommendation. The studies of Murugan (1987) have shown that the primary productivity in *Hydrilla* and the protein content of the fish class Betrachus were greatly affected by fungicides.

*Economics of agrochemical usage*

The data show that there was no increase in net income in most of the places due to the usage of agrochemicals (Table 1). The studies of Duraisamy *et al.* (1987) showed that application of nitrogen and potassium influenced yield of sugarcane whereas phosphate did not have any effect. Likewise, sugarcane was also not affected by the application of fertilizer. The excess of chemicals used in these areas is likely to cause soil and water pollution.

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# Urban Tree Plantations : Some Implications of Air Pollution

**E.U.B. Reddi, K. Rangaiah and T. Byragi Reddy**
Department of Environmental Sciences, Andhra University, Waltair 530003

## Abstract

*Casuarina equisetifolia* is generally preferred to other tree species in urban tree plantations. But it poses a serious threat of pollen allergy. This can be eliminated by removing pollen bearing trees from the populations. Precautions in selecting suitable trees for urban tree plantation programmes are given. The measures can be extended with advantage to other dioecious members, such as *Phoenix, Borassus* and *Ailanthus.*

## Introduction

Vegetation influences human life to a considerable extent. Its importance is paramount in urban and industrial environs where pollution problems are evidently hazardous. To lessen the pollution problems, people have been advised to grow trees in these environs. For instance, large scale plantations of *Casuarina equisetifolia* have come up nowadays along the coast to serve as wind-breaks and shelter-belts. These plantations stabilize moving sand, prevent the scorching effect of desiccating winds and counter $SO_2$ and $NH_3$ pollution (Krishnamurthy, 1983). Moreover, *Casuarina* is an efficient dust collector because of its needle like branches and reduced scaley leaves. But, at the same time it acts as a source of biopollutants in the form of pollen grains. This paper deals with the pollution due to *Casuarina* plantation and its prevention.

## Material and Methods

*Casuarina* plants of the coastal, urban and sub-urbans of Visakhapatnam city, Andhra Pradesh, formed the study material. To determine the pollen productivity, mature and undehisced anthers were collected, squashed, spread on a clean glass slide with a droplet of lactophenol aniline blue and the entire area was scanned under microscope for pollen counting. The number of branches per tree, inflorescences per branch and anthers per inflorescence were counted. These figures were multiplied by the number of pollen grains of an anther to obtain the pollen productivity of the entire tree. The circadian pollen concentrations at the source were arrived at by operating a rotorod volumetric air sampler.

## Results and Discussion

### *Pollen productivity*

The present study showed that *Casuarina* produces on an average 620 pollen grains per anther and an average tree of six meters height, aged three years, will produce around 10,010,52,00,000 pollen grains in a season. According to Faegri and Iversen (1975) it is not the absolute quantity of pollen produced by a stamen or a flower or an inflorescence or even a whole plant but the number of pollen grains released into the air is a matter of primary concern. About 3% of the total pollen remains unliberated in the anthers of *Casuarina* while the remaining 97% will inflitrate into the atmosphere causing air pollution. Pollen grains are minute with sizes ranging from 23 to 40 μm. This feature makes the *Casuarina* pollen more buoyant. At population level, *Casuarina* was observed to flower most asynchronously. Hence, the pollen is available in the air throughout the year. Though the pollen concentrations are circadian, the nocturnal concentrations are negligible. During the day the pollen concentrations are abundant (4000 to 8000/$m^3$ of air sampled) between 7 A.M. and 10 A.M.

*Casuarina* is one of the principal plants producing allergenic pollen in Central and South America (Stanely and Linskens, 1974) and its allergenicity was reported by Levitz(1942), Morton(1981) and Agashe(1988).The ease and economy in raising the seedlings force majority of the agencies to prefer distributing *Casaurina* seedlings to the rest of the species thereby increasing the pollution hazards in the form of the pollen allergy.

*Control of pollen allergy*

Pollen pollution can be prevented with low cost. More than 90% of *Casuarina* population is seen in dioecious condition. So the threat of pollen allergy can easily be obliterated by preferring the female population to that of pollen producing male population. *Casuarina* pollen allergy can be controlled by (1) planting the seedlings doubled or tripled than what is actually necessary and (2) eliminating the pollen producing plants when the populations have their first bloom. The plants thus eliminated can meet the fuel needs of the urbanites. The same measures can be applied with advantage in other dioecious members of urban trees such as *Phoenix, Borassus* and *Ailanthus*.

Information available today on tree plantations is mostly from temperates. The principles that emanated from studies in the temperate regions many a time proved unsuitable to the tropical tree plantation programmes due to biogeographical considerations. A satisfactory knowledge in all the related intersectorial linkages to formulate comprehensive and sustainable solutions to environment-development problems is not yet available (Krishnamurthy, 1983). So there is an urgent need to study the role of trees in air pollution control programmes of urban and industrial environs of tropics in particular.

*Precautions to be followed in urban tree plantation programmes*

The following points should be considered while choosing plant species for urban tree plantation programmes. (1) The trees should be devoid of direct allergenicity through pollen and the like. (2) They should also be non allergenic indirectly by not housing pests and pathogens. For instance *Dalbergia sisso* is prone to severe attacks of fungal pathogens, such as *Phyllachora dalbergiae* and *Phyllactinia dalbergiae* (Bakshi, 1976). (3) They should be selected from the native flora because exotics may create some ecological problems. (4) They should be in mixed cultures. (5) They should be evergreen and of multipurpose. (6) They should be resistant to local pollutants. (7) They should act as efficient sinks of particulate contaminants of the atmosphere. (8) They should meet the socio- economic needs of the urbans.


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# Allelopathic Effects of *Cassia sericea* SW. on Some Crop Plants and *Parthenium hysterophorus* L.*

**S.N. Vasudevan and M. Mahadevappa**

Department of Seed Technology, University of Agricultural Sciences, Bangalore 560065

### Abstract

Allelopathic effects of *Cassia sericea* SW. on some crop plants and *Parthenium hysterophorus* L. was studied. Seed germination of the crop plants, in general, was unaffected by diluted aqueous extract of *C. sericea* plant parts except ragi, cowpea and horsegram. Germination of some crops like sorghum, bajra, cowpea, sunflower, safflower and niger was stimulated. Leaf extract of *C. sericea* inhibited the seed germination (upto 31% over control), and shoot and root growth (upto 7.1% and 13.8% over control, respectively) of parthenium.

### Introduction

*Parthenium hysterophorus* Linn. (family: Asteraceae) is an exotic and most feared noxious weed species in many states of India. Parthenium spreads rapidly in diverse habitats including cultivated fields (Dagar *et al.*, 1976 and Dagar and Singh, 1977). Its wide adaptability, allelopathic effects on other plant species and high rate of reproduction by seeds appear to be the major causes of its dominance.

Parthenium has attracted the attention of many scientists to some extent because of its harmful effects on crop plants but more because of its' effects on both human beings and cattle. Hence, the control of parthenium is of paramount importance. Mechanical and chemical methods, though effective, provide only temporary control. Biological approach through release of natural insect enemies is still under experimentation.

Mahadevappa and Joshi (1985), during the course of an ecological survey, noticed *Cassia sericea* SW., a weed of South American origin, exhibiting a smothering effect on the growth of parthenium weed in and around Dharwad, North Karnataka. Recent research findings and field applications indicate that *C. sericea* could be used as a biological agent to control the spread of parthenium. However, an in-depth study on the allelopathic effects of *C. sericea* on crop plants is needed before it is recommended for use in agro-ecosystems. Keeping this in view, the present investigation was taken up to evaluate the allelopathic impact of *C. sericea* on *P. hysterophorus* and some crop plants.

### Material and Methods

The present investigation involved pot culture experiments to evaluate the leachate extracts of *C. sericea* on the germination and seedling vigour of crop plants and

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parthenium. The experiment was conducted in the Department of Seed Technology, University of Agricultural Sciences, Bangalore, during 1985 and 1986. The crops included in the present study were ragi *(Eleusine coracana* (L.) Geartn.), sorghum *(Sorghum bicolor* (L.) Moench.), bajra *(Pennisetum typoides* Rich.), cowpea (*Vigna unguiculata* (L.) Walp), horsegram *(Dolichos biflorus* Linn.), sunflower *(Helianthus annuus* Linn.), safflower (*Carthamus tinctorius* Linn.) and niger (*Guizotia abyssinica* Cass.).

*Preparation of aqueous extract*

Aqueous extracts of leaf, stem, podwall and root of *C. sericea* were prepared from freshly harvested plant parts. Seventy five g fresh weight of the sample was macerated using pestle and mortar with 375 ml of distilled water. The resultant mash was filtered using Whatman No.1 filter paper. The volume was made up to 375 ml. The filtrate was diluted by using distilled water in 1:10, 1:50 and 1:100 proportions.

*Preparation of test solution*

A sample of 250 g of *C. sericea* leaves was soaked in 800 ml of distilled water for ten days. On the 10th day, the leaves were removed and the water was filtered using a Whatman No.1 filter paper. The test solution was diluted with distilled water in 1:10, 1:50 and 1:100 proportions.

A completely randomised design was employed involving five treatments replicated four times. Plastic pots containing 450g of soil were treated with 75 ml of aqueous extract a day prior to sowing and another 75 ml was used during the growth stage. Likewise, pots were sprayed with 75 ml each of test solution before and after the emergence of seedling. Water alone was used in the control pots. Observations on seed germination and seedling vigour were recorded. The data were subjected to analysis of variance.

## Results and Discussion

Undiluted aqueous leaf extract of *C. sericea* adversely affected the seed germination of ragi, sorghum, bajra, horsegram, cowpea and safflower, the per cent inhibition being 20.6, 5.9, 2.9, 8.6, 2.8 and 1.2, respectively as compared to control (Table 1). However, seed germination, and shoot and root growth of all crops, in general, were unaffected when aqueous leaf extract was diluted to 1:10, 1:50 and 1:100 proportions whereas a slight deviation was observed in horsegram and cowpea. Leaf extracts of a number of plant species as reported by Coutinho and Hashimoto (1971), Einhellig and Rasmursen (1973), Sarma (1974) and Bhatia *et al.* (1982), had both inhibitory and stimulatory effects on seed germination and growth of test plant species.

The shoot and root growth of all the crops except sorghum, safflower and horse gram was stimulated by the undiluted and diluted aqueous stem extract of *C. sericea* whereas undiluted aqueous extract inhibited germination of all the crops except sunflower (Table 2). Pandya (1975) and Tripathi and Srivastava (1970) observed similar trend in bajra and tomato due to *Celosia argentea* and *Eichornia crassipes,* respectively.

Table 1. Effect of leaf extract of *Cassia sericea* on seed germination, and shoot and root length of some crop plants

| Treatments | Germination (%) | Mean length (cm) Shoot | Root | Germination (%) | Mean length (cm) Shoot | Root |
|---|---|---|---|---|---|---|
| | Ragi | | | Horsegram | | |
| Control | 78.7 | 4.9 | 9.5 | 87.5 | 9.2 | 17.6 |
| Undiluted | 62.5(-20.6)+ | 4.8(-2.0) | 10.6(+11.6) | 80.0(-8.6) | 8.9(-3.2) | 19.8(+12.5) |
| 1:10 | 91.3(+16.0) | 5.5(+12.2) | 11.5(+21.7) | 86.3(-1.4) | 9.2(0.0) | 19.9(+13.2) |
| 1:50 | 77.5(-1.5) | 5.0(+2.0) | 12.6(+32.6) | 86.3(-1.4) | 9.4(+2.2) | 19.9(+13.2) |
| 1:100 | 81.3(+3.3) | 4.7(-4.1) | 10.9(+14.7) | 86.3(-1.4) | 9.9(+7.6) | 19.1(+8.5) |
| F-test | ** | NS | ** | NS | NS | NS |
| SEm ± | 3.67 | 0.29 | 0.41 | 0.36 | 0.37 | 0.66 |
| | Sorghum | | | Sunflower | | |
| Control | 85.0 | 12.7 | 9.9 | 40.0 | 7.8 | 7.9 |
| Undiluted | 80.0(-5.9) | 12.6(-0.8) | 10.7(+8.0) | 57.5(+43.7) | 9.3(+10.6) | 24.2(+17.6) |
| 1:10 | 86.3(+1.5) | 12.9(+1.6) | 10.9(+10.0) | 57.5(+43.7) | 8.8(+12.8) | 7.7(-2.5) |
| 1:50 | 93.7(+10.3) | 13.2(+3.9) | 10.8(+9.0) | 56.3(+40.6) | 10.0(+28.2) | 8.9(+12.6) |
| 1:100 | 86.3(+1.5) | 12.7(0.0) | 11.8(+19.2) | 46.3(+15.6) | 9.5(+21.8) | 8.6(+8.8) |
| F-test | NS | NS | ** | ** | * | * |
| SEm ± | 4.39 | 0.14 | 0.14 | 3.51 | 0.10 | 0.52 |
| | Bajra | | | Safflower | | |
| Control | 85.0 | 9.9 | 11.6 | 98.7 | 9.2 | 20.6 |
| Undiluted | 82.5(-2.9) | 9.7(-2.0) | 12.6(+8.6) | 97.5(-1.2) | 11.0(+19.6) | 24.2(+17.6) |
| 1:10 | 83.5(-1.7) | 10.9(+10.0) | 12.6(+8.6) | 95.0(-3.8) | 10.3(+11.9) | 25.7(+24.7) |
| 1:50 | 87.5(+2.9) | 9.8(-1.0) | 12.9(+11.2) | 98.7(0.0) | 9.9(+7.6) | 21.6(+4.8) |
| 1:100 | 88.1(+3.6) | 10.5(+6.1) | 12.9(+11.2) | 100.0(+1.3) | 10.1(+9.8) | 23.7(+15.1) |
| F-test | NS | * | NS | NS | ** | ** |
| SEm ± | 4.16 | 0.26 | 0.39 | 1.65 | 0.08 | 0.51 |
| | Cowpea | | | Niger | | |
| Control | 91.3 | 20.2 | 18.6 | 65.0 | 7.7 | 7.1 |
| Undiluted | 88.7(-2.8) | 20.9(+3.6) | 18.2(-2.2) | 67.5(+3.8) | 9.9(+28.6) | 8.8(+23.9) |
| 1:10 | 76.3(-16.4) | 21.7(+7.4) | 19.2(+3.3) | 71.3(+9.6) | 9.4(+22.1) | 8.9(+25.4) |
| 1:50 | 82.5(-9.6) | 21.1(+4.4) | 19.1(+2.7) | 67.5(+3.8) | 8.6(+11.7) | 9.3(+30.9) |
| 1:100 | 85.0(-6.8) | 20.5(+1.4) | 17.8(-4.3) | 71.3(+9.6) | 8.6(+11.7) | 8.8(+23.9) |
| F-test | NS | * | NS | NS | * | ** |
| SEm ± | 4.15 | 0.29 | 0.45 | 5.46 | 0.38 | 0.22 |

* Significant at 5% level
** Significant at 1% level
NS Non-significant

\+ Figures in parentheses indicate per cent over control

Podwall extract of *C. sericea*, in general, showed a positive influence on shoot and root growth except in ragi (Table 3). Seed germination, in general, was affected by the extract except in sunflower, safflower and niger. *Ludhigia abscendens* and *Ipomea*

Table 2 . Effect of stem extract of *Cassia sericea* on seed germination, and shoot and root length of some crop plants

| Treatments | Germination (%) | Mean length (cm) Shoot | Root | Germination (%) | Mean length (cm) Shoot | Root |
|---|---|---|---|---|---|---|
| | | Ragi | | | Horsegram | |
| Control | 78.7 | 4.9 | 9.5 | 87.5 | 9.2 | 17.6 |
| Undiluted | 63.7(-19.1)* | 5.1(+4.1)+ | 10.7(+12.6) | 75.0(-14.3) | 9.1(-1.1) | 18.5(+5.1) |
| 1:10 | 75.0(-4.7) | 5.0(+2.0) | 13.1(+37.9) | 71.3(-18.6) | 9.9(+7.6) | 20.6(17.1) |
| 1:50 | 72.5(-7.9) | 4.9(0.0) | 11.4(+20.0) | 76.3(-12.3) | 9.9(+7.6) | 20.4(+15.9) |
| 1:100 | 73.7(-6.4) | 5.1(+4.1) | 12.7(+33.7) | 77.5(-11.4) | 10.6(+15.2) | 20.1(+14.2) |
| F-test | NS | NS | ** | NS | ** | * |
| SEm ± | 5.60 | 0.20 | 0.38 | 4.26 | 0.24 | 0.69 |
| | | Sorghum | | | Sunflower | |
| Control | 85.0 | 12.7 | 9.9 | 40.0 | 7.8 | 7.9 |
| Undiluted | 78.7(-7.4) | 12.5(-1.6) | 11.7(+18.2) | 56.3(+40.6) | 9.7(+24.4) | 9.2(+16.5) |
| 1:10 | 92.5(+8.8) | 13.2(+3.9) | 12.7(+28.3) | 46.3(+15.6) | 9.7(+24.6) | 8.9(+12.6) |
| 1:50 | 87.5(+2.9) | 13.1(+3.1) | 12.9(+30.3) | 47.5(+18.7) | 8.7(+11.5) | 9.1(+15.2) |
| 1:100 | 90.0(+5.9) | 12.8(+0.8) | 12.3(+24.2) | 58.7(+46.8) | 9.4(+20.5) | 9.0(+13.9) |
| F-test | NS | ** | ** | NS | ** | NS |
| SEm ± | 4.39 | 0.09 | 0.21 | 5.05 | 0.21 | 0.49 |
| | | Bajra | | | Safflower | |
| Control | 85.0 | 9.9 | 11.6 | 98.7 | 9.2 | 20.6 |
| Undiluted | 83.7(-1.5) | 10.3(+4.0) | 13.0(+12.1) | 96.3(-2.5) | 9.2(0.0) | 22.4(+8.7) |
| 1:10 | 91.3(+7.4) | 10.8(+9.1) | 14.2(+22.4) | 98.7(0.0) | 9.6(+4.3) | 22.6(+9.7) |
| 1:50 | 87.5(+2.9) | 10.1(+2.0) | 13.2(+13.8) | 97.5(-1.2) | 9.9(+7.6) | 21.7(+5.3) |
| 1:100 | 91.3(+7.4) | 10.4(+5.1) | 13.9(+19.8) | 98.7( - ) | 9.7(+5.4) | 21.3(+3.4) |
| F-test | NS | NS | ** | NS | NS | NS |
| SEm ± | 4.6 | 0.39 | 0.27 | 1.82 | 0.29 | 0.51 |
| | | Cowpea | | | Niger | |
| Control | 91.3 | 20.2 | 18.6 | 65.0 | 7.7 | 7.1 |
| Undiluted | 85.0(-6.8) | 22.2(+9.9) | 18.7(+0.5) | 58.7(-9.6) | 8.8(+14.3) | 8.6(+21.1) |
| 1:10 | 90.0(-1.4) | 21.8(+7.9) | 19.7(+5.9) | 66.3(+2.0) | 8.6(+11.7) | 8.6(+21.1) |
| 1:50 | 93.7(+2.7) | 22.6(+11.9) | 18.2(-2.0) | 70.0(-7.6) | 8.8(+14.3) | 8.7(-22.5) |
| 1:100 | 96.3(+5.5) | 21.7(+7.5) | 18.4(-1.1) | 61.3(-5.7) | 8.3(+7.8) | 8.8(+23.9) |
| F-test | NS | * | NS | NS | NS | ** |
| SEm ± | 6.4 | 0.43 | 0.41 | 4.2 | 0.36 | 0.17 |

* Significant at 5% level ** Significant at 1% level NS Non-significant

+ *Figures in parentheses indicate per cent over control*

*aquetica* aqueous extract are reported to have promoted the growth of bajra seedlings (Singhvi and Sharma, 1984).

The undiluted aqueous root extract of *C. sericea* inhibited the germination of sorghum, cowpea and horse gram seeds whereas it stimulated the germination of

Table 3. Effect of podwall extract of *Cassia sericea* on seed germination, and shoot and root length of some crop plants

| Treatments | Germination (%) | Mean length (cm) Shoot | Root | Germination (%) | Mean length (cm) Shoot | Root |
|---|---|---|---|---|---|---|
| | | Ragi | | | Horsegram | |
| Control | 78.7 | 4.9 | 9.5 | 87.5 | 9.2 | 17.6 |
| undiluted | 51.3(-34 8)[+] | 4.8(-2.0) | 11.3(+18.8) | 77.5(-11.4) | 10.3(+11 9) | 21.1(+ 19.8) |
| 1.10 | 78.7(0.0) | 5.0(+2.0) | 12.1(+27 3) | 78.7(-10 0) | 10 1(+9.8) | 20.7(+17.6) |
| 1:50 | 75.0(-4.7) | 4 6(-6.1) | 12.8(+34.7) | 78.7(-10.0) | 9.8(+6.5) | 20.1(+14.2) |
| 1:100 | 85.0(+8.0) | 4.6(-6.1) | 12.9(+35 8) | 82.5(-5.7) | 10.1(+9.8) | 19.4(+10.2) |
| F-test | ** | NS | ** | NS | * | ** |
| SEm ± | 4.2 | 0.3 | 0.25 | 5.79 | 0.21 | 0.46 |
| | | Sorghum | | | Sunflower | |
| Control | 85.0 | 12.7 | 9.9 | 40 0 | 7.8 | 7.9 |
| Undiluted | 82.5(-2.9) | 12.8(+0.8) | 11.5(+16 2) | 52.5(+31.3) | 10.0(+28.2) | 8.9(+12.6) |
| 1 10 | 92 5(+8.8) | 13 7(+7.8) | 12 3(+24 2) | 56 3(+40 6) | 10 0(+28.2) | 9 4(+18 9) |
| 1:50 | 85.0(0 0) | 13.2(+3.9) | 12.3(+24 2) | 48 7(+21 8) | 8.8(+12.8) | 9.8(+24.1) |
| 1 100 | 81.3(-4.4) | 13.4(+5.5) | 11.3(+14 1) | 57 5(+43 7) | 10 3(+32.1) | 9.9(+25.3) |
| F-test | NS | ** | ** | ** | ** | NS |
| SEm ± | 5.27 | 0.18 | 0 10 | 2 99 | 0 32 | 0.49 |
| | | Bajra | | | Safflower | |
| Control | 85.0 | 9 9 | 11.6 | 98 7 | 9.2 | 20.6 |
| Undiluted | 85.0 | 10.6(+7 1) | 12.9(+11.2) | 100 0(+1 3) | 9 9(+7 6) | 22 9(+11 6) |
| 1.10 | 81.3(-4.4) | 10.3(+4.0) | 12.9(+11.2) | 100.0(+1 3) | 9 5(+3 3) | 21.8(+5.8) |
| 1.50 | 82.5( 2.9) | 11.2(+13.2) | 13.8(+18 9) | 100 0(+1 3) | 9 5(+6 5) | 21.6(+4.8) |
| 1:100 | 80 0(-5.9) | 10 2(+3.1) | 12.9(+11.2) | 100 0(+1.3) | 9 1( 1.1) | 22.5(+9.2) |
| F test | NS | NS | ** | NS | ** | NS |
| Sem ± | 4.8 | 0 30 | 0 21 | 0 56 | 0.17 | 0 52 |
| | | Cowpea | | | Niger | |
| Control | 91.3 | 20 2 | 18 6 | 65.0 | 7.7 | 7.1 |
| Undiluted | 78.7(-13.7) | 22 1(+9 3) | 18 7(+0 5) | 62.5(-3.8) | 9 4(+22.1) | 9.0(+26.7) |
| 1.10 | 92 5(+1.4) | 22 4(+10 8) | 19.1(+2.7) | 76 3(+17 3) | 9 74(+22.1) | 8.8(+23.9) |
| 1 50 | 91.3(0.0) | 22.5(+11 5) | 18.5( 0 5) | 75 0(+15 4) | 9 4(+22.1) | 9.1(+28.2) |
| 1:100 | 92.5(+1.4) | 22.8(+12 8) | 18 6(0 0) | 73 7(+13.4) | 8.7(+12 9) | 8.5(+19.7) |
| F-test | * | ** | NS | NS | ** | ** |
| SEm ± | 3.31 | 0 25 | 0.35 | 4.20 | 0 33 | 0.17 |

* Significant at 5% level  ** Significant at 1% level  NS Non-significant

+ Figures in the parentheses indicate per cent over control

sunflower and safflower (Table 4). A highly significant increase in root growth was also noticed in ragi, sorghum, bajra, horsegram, sunflower and niger over control.

Leaf extract of *C. sericea* had significant effect on germination, and shoot and root growth of *P. hysterophorus* (Table 5). This inhibitory property also reported by Jayakumar

Table 4. Effect of root extract of *Cassia sericea* on seed germination, and shoot and root length of some crop plants

| Treatments | Germination (%) | Mean length (cm) Shoot | Root | Germination (%) | Mean length (cm) Shoot | Root |
|---|---|---|---|---|---|---|
| | | Ragi | | | Horsegram | |
| Control | 78.7 | 4.9 | 9.5 | 87.5 | 9.2 | 17.6 |
| undiluted | 87.5 (+11.1)+ | 4.8 (-2.0) | 11.2 (+17.9) | 70.5 (-19.4) | 9.9 (+7.6) | 19.3 (+ 9.6) |
| 1:10 | 77.5 (−1.6) | 5.6 (+14.3) | 13.2 (+38.9) | 72.5 (−17.1) | 10.5 (+14.1) | 19.1 (+8.5) |
| 1:50 | 84.7 (+6.44) | 4.9 (0.0) | 12.8 (+34.7) | 87.5 (0.0) | 10.2 (+10.8) | 19.8 (+12.5) |
| 1:100 | 72.5 (+7.9) | 4.6 (−6.1) | 12.7 (+33.7) | 86.3 (−1.4) | 9.9 (+7.6) | 19.6 (+11.4) |
| F-test | NS | NS | ** | * | NS | NS |
| SEm ± | 5.26 | 0.25 | 0.36 | 4.99 | 0.38 | 0.70 |
| | | Sorghum | | | Sunflower | |
| Control | 85.0 | 12.7 | 9.9 | 40.0 | 7.8 | 7.9 |
| Undiluted | 81.3 (−4.4) | 13.3 (+4.7) | 12.4 (+25.3) | 52.5(+31.3) | 7.1 (−8.9) | 7.7 (−2.5) |
| 1:10 | 81.3 (−4.4) | 13.2 (+3.9) | 12.4 (+25.3) | 51.3(+28.3) | 7.4 (−5.2) | 9.2 (+16.5) |
| 1:50 | 82.3 (−3.2) | 13.1 (+3.1) | 12.4 (+25.3) | 47.5 (+18.7) | 7.2 (−7.7) | 8.9 (+12.6) |
| 1:100 | 90.0 (+5.9) | 13.2 (++3.9) | 13.1 (+32 3) | 43.7 (+9.4) | 7.9 (+1.4) | 9.3 (+17.7) |
| F-test | NS | NS | ** | NS | NS | NS |
| SEm ± | 3.56 | 0.23 | 0.22 | 3.62 | 0.47 | 0.73 |
| | | Bajra | | | Safflower | |
| Control | 85.0 | 9.9 | 11.6 | 98.7 | 9.2 | 20.6 |
| Undiluted | 86.3 (+1.5) | 10.1 (+2.0) | 13.3 (+14.6) | 100.0 (+1.3) | 9.5 (+3.3 | 21.5 (+4.4) |
| 1:10 | 88.7 (+4.4) | 10.5 (+6.1) | 14.2 (+22.4) | 100.0 (+1.3) | 9.4 (+2.2) | 21 8 (+5.8) |
| 1:50 | 87.5 (+2.9) | 9.6 (−3.0) | 13.3 (+14 6) | 100.0 (+1.3) | 9.2 (0.0) | 20 9 (+1.5) |
| 1:100 | 84.7 (−1.5) | 9.9 (0.0) | 13.8 (+18.9) | 100.0 (+1.3) | 9.1 (−1.1) | 20.9 (+1.5) |
| F-test | NS | NS | ** | NS | NS | NS |
| Sem ± | 3.2 | 0.26 | 0.33 | 0.56 | 0.22 | 0.53 |
| | | Cowpea | | | Niger | |
| Control | 91.3 | 20.2 | 18.6 | 65.0 | 7.7 | 7.1 |
| Undiluted | 77.5 (−15.1) | 21.8 (+7.8) | 18.5 (−0.5) | 72.5 (+11.5) | 8.9 (+15.6) | 8.6 (+21.1) |
| 1:10 | 97.5(+6.8) | 22.2 (+9.9) | 18.8 (+1.2) | 72.5 (−3.8) | 8.3 (+7.8) | 9.5 (+33.8) |
| 1:50 | 97.5 (+6.8) | 22.9 (+13.3) | 18.0 (−3.2) | 67.5 (+3.8) | 9.3 (+20.8) | 9.5 (+33.8) |
| 1:100 | 91.3 (0.0) | 22.4 (+10.9) | 18.0 (−3.2) | 57.5 (−11.5) | 8.8 (+14.3) | 8.9 (+25.4) |
| F-test | ** | ** | NS | NS | * | ** |
| SEm ± | 3.06 | 0.36 | 0.32 | 6.83 | 0.34 | 0.23 |

* Significant at 5% level  ** Significant at 1% level  NS Non-significant

+ *Figures in the parentheses indicate per cent over control*

(1985) can lead to smothering effect on parthenium germination and growth in nature (Mahadevappa and Joshi, 1985; Joshi and Mahadevappa, 1986).

The results indicated that seed germination, and root and shoot growth of crops were generally affected only by the undiluted aqueous extracts of various plant parts of *C. sericea.* It is unlikely that the leachates from different plant parts of *C. sericea* could

Table 5. Effect of *Cassia sericea* leaf extract spray on seed germination, and shoot and root length of *Parthenium hysterophorus*

| Treaments | Germination (%) | Mean length (cm) | |
|---|---|---|---|
| | | Shoot | Root |
| *Pre-emgergence* | | | |
| Control | 72.5 | 2.8 | 3.6 |
| Undiluted | 50.0 (−31.0)+ | 2.6 (−7.1) | 3.1 (−13.8) |
| 1:10 | 67.5 (−6.9) | 2.8 (0.0) | 3.5 (−2.7) |
| 1:50 | 70.0 (−3.4) | 2.8 (0.0) | 3.6 (0.0) |
| 1:100 | 71.25 (-1.7) | 2.8 (0.0) | 3.6 (0.0) |
| F-test | ** | NS | ** |
| SEm ± | 3.078 | 0.92 | 0.11 |
| *Post-emergence* | | | |
| Control | | 4.0 | 4.7 |
| Undiluted | | 3.9 (− 2.5) | 4.6 (−2.1) |
| 1:10 | | 3.9 (− 2.5) | 4.6 (−2.1) |
| 1:50 | | 4.1 (+ 2.5) | 4.6 (−2.1) |
| 1:100 | | 4.1 (+ 2.5) | 4.7 (0.0) |
| F-test | | NS | NS |
| SEm ± | | 0.138 | 0.107 |

**Significant at 1%level NS Non-significant

+ Figures in parentheses indicate per cent over control.

accumulate in any agricultural land at a concentration equivalent to undiluted extracts. Therefore, there should not be any fear of harmful effects on agricultural crops by the residues of *C. sericea* and it can be safely recommended for controlling parthenium weed in both agricultural and waste lands.

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# SESSION III

# POLLUTANTS AND PUBLIC HEALTH

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University of Agricultural Sciences, Bangalore, 1989. pp.191-192

# DDT-R Residues in Blood of Workers in Formulation Unit

**A. Regupathy, S. Kuttalam, S. Pasupathy and S.V. Krishnamoorthy**
Department of Agricultural Entomology, Centre for Plant Protection Studies,
Tamil Nadu Agricultural University, Coimbatore 641003

## Abstract

Contamination of DDT-R compounds in the blood of workers in a pesticide formulation unit was assessed. Blood samples were drawn from volunteers and analysed by GC-ECD. The DDT-R compounds detected in blood were O'P'-DDE (0.0028 to 0.3383 ppm), O'P'-DDD (0.0006 to 0.2863 ppm), O'P'-DDT (0.0022 to 0.3340 ppm), p'p' - DDE (0.0015 to 0.3561 ppm), p'p' - DDD (0.0015 to 0.1957 ppm) and p'p' - DDT (BDL to 0.2625 ppm) totalling 0.0393 to 1.0251 ppm.

## Introduction

The protection of industrial labour from pesticides is important to Indian pesticide industry. Pesticide exposure problem arises from industrial workers becoming ill as a result of their occupation.Simmons (1969) undertook a programme to measure the concentrations of organochlorine pesticides in sera of participants and to perform haematological and biochemical tests on specimens of their blood and urine. It is postulated that these measurements might serve as more sensitive indices of health status than symptoms and clinical signs. Though DDT usage was mainly restricted to public health programmes only, the highly persistent nature of the compound led to chronic health hazards. In the present study, the levels of DDT-R compounds in the blood of workers in a formulation unit were assessed.

## Material and Methods

The volunteer groups included different working classes, *viz.* supervisors, mixers, powdering men, packaging workers, jaw crushing women and laboratory chemists in a formulation unit belonging to 18 to 59 years of age. A modified Dale *et al.* (1970) procedure was followed for extraction of DDT-R residues from blood. Blood samples of 1ml from circulating blood were collected through vein puncture at 5.30 p.m., i.e. after their work was over in a 10 ml clean volumetric tube with Teflon lined screw cap containing one ml of formic acid and to this six ml of redistilled hexane solvent was added. The samples were transported to the laboratory in an ice-box and stored in deep freezer.

The extraction was done by shaking for 2 h in a slow speed rotating mixer. Centrifugal force was used to break the emulsions. The hexane layer was quantitatively transferred and extraction was repeated twice with 10 ml portions of hexane. The clean up of pooled hexane extract was done by sulphuric acid digestion method (Kapoor *et al.*, 1981). The lower phase was discarded and the upper n-hexane layer was made acid free by washing three times with 25 ml portions of distilled water. The sample was passed through 5 g anhydrous sodium sulphate to remove water molecules, concentrated to one ml and injected into GC-ECD (Chemito-3800) fitted with 1.5% OV 17 + 1.95% QF on gas chrom Q.

The operating parameters were : temperature, column 180°C, injector 200°C, detector source 240°C and detector base 220°C, gas flow, N2 - 30 ml/minute. The retention time of different DDT-R was; O'P'-DDE 780, p'p'-DDE 955, O'P' -DDD 1230, O'P'-DDT 1433, p'p'-DDD 1615 and p'p'-DDT 1980 sec. Blood samples fortified with DDT-R compounds over a range of 1-10 ppm had an average recovery of 88.8%.

## Results and Discussion

All the thirty subjects had DDT-R compounds in their blood ranging from 0.0393 to 1.0251 ppm with a mean of 0.3043 ppm (Table 1). Only 13.33% of the subjects had the p'p'-DDT compound below detectable level (BDL) and 0.2625 ppm was the maximum concentration in the blood. The concentration of other p'p'-isomers, namely p'p'-DDE and p'p'-DDD ranged from 0.0015 to 0.3561 and 0.0015 to 0.1957 ppm in the blood, respectively. The maximum limit of O'P'-isomers, *viz.* O'P -DDT, O'P' -DDD and O'P'-DDE were 0.3340, 0.2863 and 0.3383ppm, respectively in the blood. Morgan and Lin (1978) observed a concentration of 378-979 ppb of DDT and DDE in 2600 subjects in a nationwide epidemiologic study programme during 1967-1973.

Table 1. DDT-R levels (ppm) in blood of workers in a formulation unit

| | O'P'-DDE | p'p'-DDE | O'P'-DDD | O'P'-DDT | p'p'-DDD | p'p'-DDT | Total |
|---|---|---|---|---|---|---|---|
| Mean | 0.0515 | 0.0499 | 0.0416 | 0.0547 | 0.0464 | 0.0601 | 0.3043 |
| SD ± | 0.0850 | 0.0784 | 0.0615 | 0.0709 | 0.0520 | 0.0560 | 0.2505 |
| Range | 0.0028-<br>0.3383 | 0.0015-<br>0.3561 | 0.0006-<br>0.2863 | 0.0022-<br>0.3340 | 0.0015-<br>0.1957 | BDL-<br>0.2625 | 0.0393-<br>1.0251 |

BDL — Below detectable level.

Illiteracy, lack of information, insufficient steps to ensure safety, carelessness of the employees in the use of protective equipment and refusal to wear masks and gloves are the main causes of occupational exposure among the industrial workers of pesticide formulation unit. These small amounts of pesticides can also be responsible for diseases which manifest themselves many months or several years after continuous absorption in small daily doses. Because of their availability and probable diagnostic value with regard to the extent of both chronic and acute exposure to chlorinated hydrocarbon and other classes of pesticides, blood specimens present a convenient tissue for study.

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# A Study on the Hematological Changes in Coir Industry Workers

**T. Ravichandran, P. Rajendran and R. Sugumaran***

P.G. Department of Zoology, Vivekananda College, Tiruvedakam West
Madurai 624217

## Abstract

In the present study, the haemoglobin (Hb) content, total erythrocyte count (TEC), total leucocyte count (TLC), differential leucocyte count (DLC) and morphological changes in the red cells were analysed in 19 coir industry workers. Others in the same area formed the control group. There was a significant decrease in the g Hb content of the blood. The plasma membrane of the RBC showed a rough appearance due to shrinkage. However, there was no significant change in the TEC and TLC of the workers. The DLC showed that there was a significant increase in the eosinophils and a decrease in the monocytes. The possible effect of coir dust as an environmental pollutant is discussed.

## Introduction

It is well known that many of the environmental chemicals cause immunosuppression and reduce host resistance to invading germs (Gupta and Salinke, 1985). The immuno-suppressive effects of heavy metals like cadmium, lead, nickel, chromium and cobalt have been extensively studied (Jones *et al.*, 1971; Treagan, 1975). Similar studies have also been made on pesticides, industrial chemicals (Luster *et al.*, 1978; Sharma and Gehring, 1979) and other particulate pollutants like silica (Burns *et al.*, 1980), asbestos (Lange, 1980) and tobacco products (Finklea *et al.*, 1971; Anderson *et al.*, 1982). In the present work, the possible effect of coir dust as an environmental pollutant was studied by analysing the blood samples of coir industry workers.

## Material and Methods

Blood samples were collected from 19 coir industry workers and various blood parameters like haemoglobin estimation, total erythrocyte count (TEC), total leucocyte count (TLC) and differential leucocyte count (DLC) were made following the methods of Samuel (1986). Camera lucida diagrams of the red cells from stained blood smears were drawn (Tandon and Joshi, 1973).

## Results and Discussion

Results obtained from the survey studies and estimation of various blood parameters are presented in Table 1. Even though there was no significant difference in the total erythrocyte count, the haemoglobin estimation showed a highly significant decrease ($P<.001$) compared to the control group. The rough surface of the plasma membrane (Fig.1) was an interesting observation. Even the diameter of the RBC was reduced (mean 7.0 µ) compared to the control (mean 7.7 µ). This may be due to a decrease in the haemoglobin level of the cells. Similar decrease in haemoglobin levels was noticed in experimental fishes infected with trypanosome parasites (Joshi, 1985 and 1987). It is

* For further communication

well known that a relative state of immunodeficiency brings about a multitude of disorders in human and other experimental animals due to bacterial, viral and fungal infections. Hence it is obvious that the workers in the coir industry become highly anemic.

Table 1. Blood values of coir industry workers and control group.

| Parameter | Workers | Others | P Value |
|---|---|---|---|
| Hb (g/100 ml) | 11.1 ± 1.89* | 14.59 ± 1.1 | P < 0.001 |
| T.E.C. ($x10^6/\mu l$) | 1.788 ± 0.2 | 2.178 ± 0.36 | P > 0.10 |
| T.L.C. (/µl) | 8527.6 ± 2113.6 | 8186.842 ± 2021.1 | P > 0.5 |
| Neutrophils (%) | 50.8 ± 6.6 | 53 ± 5.3 | P > 0.2 |
| Eosinophils (%) | 10.3 ± 4.2 | 6.39 ± 2.6 | P < 0.05 |
| Lymphocytes (%) | 35.3 ± 7.3 | 36 ± 5.04 | P > 0.5 |
| Monocytes (%) | 2.8 ± 0.8 | 4.4 ± 1.6 | P < 0.002 |
| Basophils (%) | — | — | — |

* Mean ± S.D. of 19 observations.

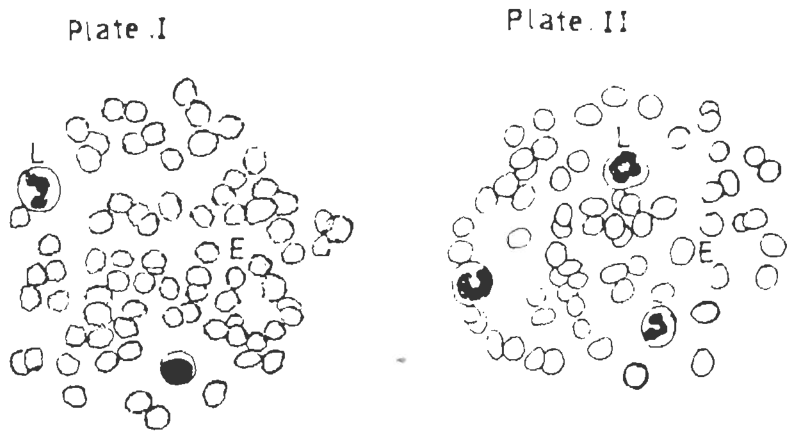


Fig.1. Erythrocytes (E) and leucocytes (L) of workers (Plate I) and others (Plate II) (400 X)

The total leucocyte count in the workers showed no significant change in number (P>.05) compared to the control (Table 1). However, there was a significant increase in the percentage of eosinophils (P<.05) and decrease in monocytes (P<.002). This suggested the infective state of the workers due to immuno- suppressive effects of coir dust. This corroborates the earlier reports of David (1980) in which a significant increase in the eosinophils was noticed in specific infections in the human beings. Reduced monocyte counts are seen during stress and infection and it may be a direct effect of myelotoxic and immuno-suppressive agents.

It has been shown that environmental toxic substances cause a reduction in the immunoglobulin levels (Anderson *et al.*, 1982). Hence, further studies on the immunoglobulin levels in the serum will help to elucidate the toxic effect of coir dust in the workers.


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# Bacterial Contaminants Associated with Fish

**M. Ramamani[1] and J.V. Ramana Rao[2]**

[1]College of Home Science, A.P.A.U, Hyderabad 500004

[2]Department of Zoology, Osmania University, Hyderabad 500007

## Abstract

The bacterial contaminants associated with fresh water fishes collected from markets around Hyderabad, Andhra Pradesh, were studied. Sterile swabs were used to collect the inoculum from various organs of fishes. These were streaked on nutrient agar and incubated at 37° C for 48 h. The bacterial flora of the fishes predominantly consisted of gram negative microorganisms. *Pediococcus, Achromobacter, Serratia, Moraxella,* Coccobacillary forms, fecal streptococci, *Micrococcus, Bacillus* and *Pseudomonas* were isolated.

## Introduction

Fish is an excellent source of protein of high biological value. It is a common non-vegetarian food in coastal regions where it is easily available. In regions like Hyderabad, Andhra Pradesh, it is mainly the fresh water fish which is available for consumption. Microorganisms from the environment contaminate the fish and may cause infection in man. The transmission of Salmonellosis from animals to man through contaminated animal food products has been very well known. Of the muscle foods consumed in the world today, fish and other seafood products are the most susceptible to postmortem deterioration. The microorganisms associated with fish first invade the tissues and after a brief lag period their multiplication commences. Diseases transmitted by fish are caused by the consumption of toxicants excreted by microorganisms such as bacteria and fungi. This paper describes the bacterial contaminants found on fish.

## Material and Methods

Fifty samples of different fish *viz. Puntius stigma, Mystus vittalus, Notoptorus* sp. and *Amblypharyngodon idella* were collected from the markets around Hyderabad. These samples were originally caught from the lakes of Hyderabad City. They were brought in sterile container to the laboratory.

Yeast extract agar and Meconkey agar media were prepared and autoclaved at 15 lbs pressure and 121°C for 20 min. The media was transferred to agar plates without any contamination by pour plate method. Swabs of absorbent cotton measuring 5 cm × 1.5 cm were prepared and autoclaved at 15 lbs pressure and 121°C temperature (Cruickshank, 1975).

The fish were cut longitudinally and the samples were collected by rotating the swabs in the intestinal tube firmly. In addition, samples for analyses were collected from organs like skin, scales and gills. The swabs were streaked on plates of media containing yeast extract agar and Meconkey agar. These were then incubated for 48 h at 37°C. Representative colonies were picked up and studied for their morphology by Gram's staining and for their motility by hanging drop technique. The organisms were identified according to Gradwohl (1964).

## Results and Discussion

The bacterial flora of fish isolated from various organs, such as skin, gills, scales and intestine in the present study are shown in Table 1. Bacterial flora of the freshwater fishes consisted of mostly gram negative microorganisms. The organisms isolated were: *Pediococcus, Achromobacter, Serratia, Moraxella;* Coccobacillary forms, fecal streptococci, *Micrococcus, Bacillus* and *Pseudomonas.* The predominant organisms were of Enterobacteriaceae group. The slime, scales, gills and intestines of fish carried considerable bacterial loads (Table 2).

Table 1. Bacterial flora isolated from various organs of fish

| Fish species | Slime | Gills | Scales | Intestine |
|---|---|---|---|---|
| *Puntius stigma* | *Micrococcus* | *Pseudomonas* | *Achromobacter* | Faecal streptococci |
| *Mystus vittatus* | Entero-bacteriaceae | *Moraxella* | *Pediococcus* | *Bacillus* |
| *Notoptorus* sp. | Coccobacillary forms | *Micrococcus* | *Serratia* | Faecal streptococci |
| *Amblypharyngodon idella* | *Micrococcus* | *Pseudomonas* | *Micrococcus* | *Pediococcus* |

Table 2. Bacterial load on different organs of fishes

| Organ | Total viable bacteria ($\times 10^6$/g) |
|---|---|
| Slime | 0.88 |
| Gill | 0.80 |
| Skin | 0.64 |
| Intestine | 0.26 |

The occurrence of feacal streptococci, *Pseudomonas* and other Enterobacteriaceae group of organisms indicated contamination from the environment. The pollution of water due to unsanitory conditions could be responsible for this contamination. Ingestion of the organisms associated with fish can result in gasteroenteritis which is a public health problem. Enterobacteriaceae and feacal streptococci indicate feacal contamination. However, it can be effectively controlled by maintaining proper sanitation.

By maintaining sanitary conditions and hygienic environment, pollution of water can be checked with which the chances of contamination could be minimised. The pollutants of water can affect the fish and consumption of contaminated fish can cause health hazard. The type of fish and the sources from which the fish are collected may influence the associated organisms. Fish ponds are often getting polluted which increases the chance of objectionable bacteria infecting the intestinal tract of fish. The method of catching and handling the fish could also account for these bacterial contaminations.

## Acknowledgements

The authors thank Prof M.A. Khan, Osmania University, for facilities and cooperation during the course of this work.

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# SESSION IV

# POLLUTION MANAGEMENT

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# Lignite Fly Ash: A Non-polluting Substance for Tackling Pest Problems

**P. Narayanasamy and A. Gnanakumar Daniel**

Department of Entomology, Faculty of Agriculture, Annamalai University
Annamalainagar 608002

## Abstract

In a series of experiments with Lignite Fly Ash (LFA), a by-product from the coal mines of Neyveli Lignite Corporation, Tamil Nadu, to find out its effect on a number of caterpillar pests, it was found that 100% mortality could be seen in all the species of insects irrespective of varied genera particularly *Melanitis leda ismene, Parnara mathias, Cnaphalocrocis medinalis, Pericallia ricini, Crocidolomia binotalis, Trichoplusia ni, Cosmophila erosa, Hymenia recurvalis* and *Helicoverpa armigera. In vitro* feeding tests with certain plant sap feeders indicated feeding deterrency of LFA towards *Nilaparvata lugens, Nephotettix virescens, Amritodes atkinsoni, Nisia nervosa* and *Toya* sp. which survived upto a period of 48 h. It is concluded that LFA can be utilized for containing pest problems effectively and might be considered an alternative for dust insecticides.

## Introduction

With insects, pathogens and weeds destroying more than one third of world crops (Cramer,1967) and lowering crop quality, pesticide use has become indispensable for modern crop protection technology. These chemicals have effectively controlled some pest species but their extensive use has led to serious social and environmental repercussions. To avert all these, new control agents which must be pest-specific, non-toxic to man and beneficial organisms, bio-degradable, less prone to pest resistance and relatively less expensive are being thought of.

Certain naturally occurring products have shown themselves to be potent agents for pest control recently (Saxena, 1983). Similarly Lignite Fly Ash (LFA), a product obtained by the combustion of lignite coal from Neyveli Lignite Corporation, Neyveli, containing among other elements 49.0% Silica ($SiO_2$) may be considered an agent for insect control. The use of LFA in the agricultural arena is only recent (Singh and Mahatim Singh, 1986; Raghupathy, 1989) besides its use for making bricks, cleaning powder, insulation bricks and in cement industry as carrier material. It appears that no study on the use of LFA against insect pests has been made so far. This investigation was therefore undertaken to find out the utility value of LFA in insect control.

## Material and Methods

*I. Plant surface dusting*

The LFA was dusted over the leaves at the rate of 2 g per plant using a laboratory fly ash duster devised at this laboratory. The duster had a broad central body with an opening (1.5 cm dia) at the top with a glass stopper and an arm in the anterior side (1 cm dia) and a posterior tube with a capillary canal (1 mm dia). Exact amount of LFA was taken inside the central body through the central opening and air was blown through the anterior arm which resulted in the discharge of LFA as a very fine dust. To enable the LFA to adhere firmly to the leaf surface, a water spray was given prior to treatment.

Details of the insects screened for their susceptibility to LFA treatment on leaves are furnished in Table 1. Ten caterpillars of each species were allowed to feed on the treated leaf placed over a moist filter paper kept in a petri dish replicated five times. Observations on the symptoms of poisoning and eventual mortality were recorded at every 12 h after treatment until the insects caged on untreated leaves grew to adult stage. Regarding borers,fruits/stem pieces were cut and the inner surface was dusted and larvae were allowed to feed.

i) Fate of mandibles in the larvae

In order to find out the fate of mandibles in larvae which showed symptoms of poisoning or those dead, the heads of such capterpillars were incised and treated with 10% KOH. The mandibles were dissected out and studied for their morphology, shape and number of teeth in comparison with those of untreated ones.

ii) Movement of LFA in the larval gut

The dead or affected larvae were used to track down the movement of LFA and the site of deposition. Larvae were dissected in distilled water. A linear cut along the length of alimentary canal was made and this was observed under a binocular compound microscope. The LFA particles were identified by their black colour.

*II. Topical application on insects*

In order to find out the effect of fly ash dusts on the larval body,LFA was dusted @ 1 g/caterpillar. The treated larva was provided with clean food material and was observed for the expression of symptoms of injury and/or mortality at every 12 h after treatment until untreated larvae grew to adult stage.

*III. Forced feeding experiment*

The sap feeders (Table 1) were subjected to forced feeding technique using a small glass vial covered with parafilm membrane. The vial was filled through a side arm projecting above with10% sucrose solution containing 0.1 g of LFA. A cylindrical mylar film cage was placed over the vial and 10 fresh adult females were confined in each vial. Observations on the number of insects that survived were recorded at 12 h intervals.

## Results and Discussion

Results on the susceptibility of different insect species to LFA treatment are presented in Table 1. Of the 35 insects screened for their reaction to LFA treatment, 19 caterpillars and 6 hoppers showed varying levels of mortality. Out of these *P. mathias, C. binotalis, T. ni, A. olivacea, C. indicus, H. viginctioctopunctata, M. viridanus, A. syngramma* and *P. pennatula* exhibited 100% mortality whereas a few, *viz. C. erosa, H. recurvalis* and *S. litura* developed into adult stage. Such adults were abnormal with shrunken bodies and poorly developed wings. In contrast to these, 6 other pests, namely *E. vitella, A. scalaris, A. gossypii, M.persicae* and *L. orbonalis* were found to thrive on LFA treated leaves and develop successfully into normal adults as LFA dusts could not reduce or stop their feeding process.

Table 1. Susceptibility of caterpillar and other pests to lignite fly ash (LFA) treatments

| Insect | Host | Instar used | Site of LFA deposition | Mortality (%) | Remarks |
|---|---|---|---|---|---|
| Horned caterpillar (*Melanitis leda ismene*) | Rice | Second | Crop | 46.20 (36 h) | |
| Skipper (*Parnara mathias*) | Rice | Second | Crop | 100 (120 h) | |
| Leaf folder (*Cnaphalocrocis medinalis*) | Rice | First | Crop | 90 (36 h) | |
| Black hairy caterpiller (*Pericallia ricini*) | Caster | Second | Crop | 90 (72 h) | |
| Leaf webber (*Crocidolomia binotalis*) | Cauliflower | First | Crop | 100 (72 h) | |
| Semi looper (*Trichoplusia ni*) | Cauliflower | Second | Foregut | 100 (72 h) | |
| Leaf feeder (*Helicoverpa armigera*) | Groundnut | Second | Foregut | 80 (72 h) | |
| Fruit borer (*Helicoverpa armigera*) | Tomato | Second | — | — | Larva developed into adult |
| Leaf folder (*Cosmophila erosa*) | Bhendi | Second | — | 60 (72 h) | Larva pupated and adult with defomed wings- |
| Leaf roller (*Hymenia recurvalis*) | Amaranthus | Second | — | 70 (72 h) | Abnormal adult formed |
| Hairy caterpillar (*Antoba olivacea*) | Brinjal | Second | Foregut | 100 (72 h) | |
| Tabacco caterpiller (*Spodoptera litura*) | Castor | Third | — | — | Abnormal adult formed |
| Early shoot borer (*Chilo indicus*) | Sugarcane | Third | Midgut | 100 (72h) | |
| Yellow hairy caterpillar (*Euproctis fraterna*) | Castor | Third | Midgut | 40 (48h) | |
| Hairy caterpillar (*Utethesia pulchella*) | Sesbania | Second | Midgut | 90 (72h) | |
| Leaf roller (*Gracillaria soyella*) | Soybean | Second | Midgut | 90 (72h) | |
| Spotted beetle (*Henosepilachna viginctioctopunctata*) | Brinjal | Second and adult | Midgut | 100 (24 h) | |
| Leaf weevil (*Myllocerus viridanus*) | Brinjal | Adult stage | Midgut | 100 (168h) | |

| | | | | | |
|---|---|---|---|---|---|
| Leaf webber (*Nephopteryx engraphylla*) | Sapota | Second | Midgut | 60 (48 h) | |
| Leaf miner (*Acrocercops syngramma*) | Sapota | Second | Midgut | 100 (48h) | |
| Hairy caterpillar (*Amata* sp.) | Pulses | Second | Midgut | 60 (72h) | |
| Leaf roller (*Sylepta derogata*) | Bhendi | Second | — | 60 (24h) | Few larvae pupated but no adult emerged |
| Yellow hairy caterpillar (*Psalis pennatula*) | Rice | Second | Foregut | 100 (48h) | |
| Boll worm (*Earias vitella*) | Cotton | Second | — | — | Normal adult emerged |
| Stem borer (*Azygophlebs scalaris*) | Cotton | Second | — | — | Normal adult emerged |
| Plant lice (*Aphis gossypii*) | Brinjal | Adults | — | — | Normal development |
| Tingid (*Stephanitis typicus*) | Brinjal | Adults and nymphs | — | — | Normal development |
| Plant lice (*Myzus persicae*) | Knol khol | Adults | — | — | Normal development |
| Fruit borer (*Leucinodes orbonalis*) | Brinjal | Second | — | — | Larva developed to adult |
| Brown plant hopper (*Nilaparvatha lugens*) | Rice | Adults | — | 100 (48h) | |
| Green leafhopper (*Nephotettix virescens*) | Rice | Adults | — | 100 (60h) | |
| White leafhopper (*Cicadella spectra*) | Rice | Adults | — | 100 (60h) | |
| White-striated planthopper (*Nisia nervosa*) | Cyperus | Adults | — | 100 (48h) | |
| Leaf hopper (*Amritodes atkinsoni*) | Mango | Adults | — | 100 (72h) | |
| Plant hopper (*Toya* spp.) | *Brachiaria* sp. | Adults | — | 100 (48h) | |

* Mortality figures recorded at specified hours after treatment

The affected caterpillars showed certain symptoms of poisoning due to LFA which were almost identical in all the species. Cessation of feeding, immobility, discolouration of body from yellow to brown starting on both ends of the body and shrivelling of the body were the series of symptoms expressed before the insects died.

To understand the mechanism of action of LFA, alimentary canals of affected insects were dissected out from the larvae and studied for the presence of these dusts. The dust invariably settled in either foregut or midgut which could be seen as a trail of black particles.

This might have hampered the digestion of food and blocked the food pathway thus paralysing the entire gut. It is, therefore, suggested that LFA may act as a stomach poison.

On examination of mandibles in the affected larvae it was found that irrespective of pest species, the sharp teeth in the mandibles were found worn out. The inner margin of each mandible became plain without serration thus becoming unfit for grinding and mastication.

Phytotoxicity due to LFA has not been observed during the course of investigation.

All the hoppers that fed on LFA treated sucrose solution were highly susceptible and showed 100% mortality in 48 to 72 h. Silica, the major constituent of LFA, might have acted on the alimentary canal by blocking the gut lumen besides disrupting feeding resulting in mortality.

When LFA was topically applied on the larval bodies, only *P. mathias* and *M. leda ismene* showed symptoms of injury and died due to deposition of the dust. All the others, however, had normal development.

Silica plays an important role in strengthening the stem in graminaceous plants as a way of affording protection against pest attack. The larvae of yellow rice borer were unable to attack the resistant varieties partly because of high silica content of their stems (Panda *et al.*, 1977). Mandibles of larvae of rice stem borer, *Chilo suppressalis,* had been found to wear out by feeding on silicated tissues (Djamin and Pathak, 1967) of resistant rice varieties. Similarly, application of silica through various forms was reported to reduce the incidence of thrips, leaf folder and stem borer in rice (Hanifa *et al.*, 1974; Tayabi and Azizi, 1984; Subramanian and Gopalaswamy,1988) and dipterous stem boring larvae in Italian Rye grass (Moore, 1984). Yoshihara and Sogawa (1979) observed that contents of soluble silicic acid and insoluble silica contents in rice varieties were positively related to BPH resistance. The present investigation brings to light for the first time the possible application of LFA in pest control programmes. This might serve as an alternative for insecticide dusts and will thus alleviate the problem of pesticide contamination. This would go a long way in rice pest control where unlimited quantities of pesticide dusts are dumped in.


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# Effect of Physico-chemical Treatments on the Microbial Amenability of Resin Industry Waste

**N.R. Shaikh[1], S.B. Sule[2], R. Natarajan[2] and V.B. Rale[1]**

[1]Department of Microbiology, University of Poona, Poona 411007
[2]Chemicals and Wastes Treatment Division, Thermax Private Ltd., Poona

## Abstract

Effluents from resin manufacturing industries are one of the bio-hazardous wastes. They are highly acidic and very toxic to biological systems. The effluent being very toxic to microbial systems, a primary treatment was designed to make it amenable to biodegradation. Primary treatment consisting the sequence 'aeration followed by sedimentation' was found to be more efficient than the sequence 'sedimentation followed by aeration' or aeration and sedimentation separately. After pretreatment, COD decreased and BOD increased. This proved that the effluent before treatment was toxic and became amenable after pretreatment. During aeration, froth was formed on the surface and this helped in COD reduction by removal of dissolved organic compounds. After pre-treatment, the effluent became suitable for conventional biological treatments.

## Introduction

A number of aromatic compounds such as divenylbenzene, polyvinyl derivatives of aromatic hydrocarbons, chlorinated derivatives of phenolic compounds and amines present in waste waters of a variety of industries are detrimental to microbiological systems. Hence, removal of these chemicals from industrial aqueous effluents is of great practical significance prior to their biological treatment. Existing methods for the removal of toxicants from waste water include adsorption on activated carbon, chemical oxidation, electro-chemical techniques and special techniques like dephenolation, use of specific enzymes like horse raddish peroxidase, etc. All these methods, although feasible, suffer from serious shortcomings, such as low efficiency and high cost. Hence, alternative methods are highly desirable.

Literature is now accumulating to substantiate the use of specific microbial agents for the abatement of initial severe toxicity of many wastes. The further down-stream treatment could be either biological or physico-chemical. Also, the reverse trend, i.e. usage of physico-chemical methods to reduce the harshness of wastes to microbial systems is in vogue.

Our experience in handling wastes from a synthetic resin manufacturing industry indicated that pre-treatment was essential before microbial communities could grow on the wastes. We now report on the use of physico-chemical methods to detoxify the resin industry wastes in the form of aeration and sedimentation after coagulation with lime.

## Material and Methods

The waste water effluent was collected from a well-known synthetic resin manufacturing industry near Pune. The physico- chemical features of the waste water were determined by analysing the pH, total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total

Kjeldahl nitrogen (TKN), dissolved oxygen (DO), sulphates and chlorides according to procedures outlined by Anon. (1985) and Trivedi and Geol (1984). The pH, COD and BOD were tested at the beginning and end of the pre-treatment to determine its efficiency.

*Microbiological studies*

The suitability of the effluent for the growth of microorganisms was tested by inoculating microorganisms from different sources on waste agar medium before and after the pre-treatment and observing the growth after incubating for 6 days at 27°C. Waste agar was prepared as per the composition of synthetic waste water given by Machinney (1962) with little modification that instead of distilled water, the effluent was used. No peptone was added. Agar was used at 2% concentration and sterility was checked every time before use.

Toxicity of the effluent before and after physico-chemical treatment was determined by agar diffusion method wherein nutrient agar was inoculated with mixed microbial population from different sources and the effluent was added to wells bored in nutrient agar. The plates were incubated at 27°C for 24 h and the extent of growth inhibition in terms of inhibition zones surrounding the wells was observed.

*Aeration studies*

Aeration was carried out in 2 l capacity glass cylinders with an inner diameter of 90.0 mm and working volume of 1 l. Glass cylinders were filled with 1 l of effluent and aerated with an air compressor at 0.5, 1, 2, and 4 l of air per min with the time duration of 4, 8, 12, and 16 h in each case. The froth formed on the surface was removed by a spatula.

*Sedimentation studies*

Sedimentation was carried out in same jars. Laboratory grade lime was used to adjust the pH of the effluent to various values as 6, 7, 8, 9 and 10 determined with the help of Eliko pH meter. After the addition of lime, the effluent was stirred for 20 min and then allowed to settle down.

## Results and Discussion

COD and BOD were studied to know the organic load in terms of oxygen demand by chemical and biological oxidants, respectively. Very low BOD:COD ratio indicates recalcitrant nature or toxicity of the waste. The effluent under study was treated by different methods and its amenability to microbial systems was monitored in terms of BOD values. We found that this waste was difficult to treat by biological treatment, prior to pre-treatment devised by us, due to high acidity and presence of toxic chemicals. However, the physico-chemical treatment reduced its toxicity and made it expedient to microorganisms.

The resin industry waste was highly acidic and pale in colour with a fishy smell. The characteristic features are presented in Table 1. The pH of the effluent was 1±0.1 and COD was in the range of 2015 to 3200 mg $l^{-1}$ while BOD was in the range of 20 to 80 mg $l^{-1}$ only. Chlorides and sulphates were also present in considerable amounts.

*Microbiological studies*

When micro-organisms from different sources were inoculated on waste agar medium and nutrient agar medium, there was no growth on the former even after incubating for 6 days at 27°C. But the nutrient agar organisms could grow luxuriously within

Table 1. Characteristics of the raw effluent collected from synthetic resin manufacturing industries

| Parameter | Sample Number | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| pH | 1.06 | 1.00 | 0.93 | 1.05 | 0.96 |
| Total suspended solids (mg $l^{-1}$) | 103 | 125 | 80 | 92 | 96 |
| Total dissolved solids (mg $l^{-1}$) | 10,172 | 9,780 | 11,085 | 10,900 | 7,960 |
| BOD (mg $l^{-1}$) | 20.0 | 50.0 | 20.0 | 76.0 | 80.0 |
| COD (mg $l^{-1}$) | 3,200 | 2,640 | 3,075 | 2,015 | 2,143 |
| Oil and grease (mg $l^{-1}$) | Nil | 5 | Nil | Nil | Nil |
| Chlorides (mg $l^{-1}$) | 6,000 | 3,256 | 3,590 | 4,400 | 2,682 |
| TKN (mg $l^{-1}$) | 3.6 | 4.3 | 4.0 | 2.32 | 3.1 |
| Sulphates (mg $l^{-1}$) | 1,306 | 2,241 | 1,100 | 2,938 | 1,621 |
| Phosphates (mg $l^{-1}$) | Nil | Nil | Nil | Nil | Nil |

24 h of incubation. When these microorganisms were inoculated on nutrient agar with bored wells containing effluent samples, inhibitory zones were observed around the wells of effluent but not around the control well. After subjecting the effluent to physico-chemical treatment devised by us, we could see the growth of organisms on waste agar as well as a reduction in zone of inhibition on nutrient agar. These results indicated reduced toxicity of the effluent during physico-chemical treatment.

*Aeration studies*

Fig.1 shows the effect of aeration time on COD and BOD of the effluent when aerated at the rate of 1 l/min for 4, 8, 12 and 16 h duration. After 8 h of aeration, COD was reduced by 26 to 44% which after 16 h of aeration was reduced by 25 to 46% in two samples. In the case of relative BOD, after 8 h of aeration, there was an increase to the tune of 380 to 1600% and after 16 h aeration the increase ranged from 420 to 1750% in two samples. Fig.2 shows the effect of aeration rate on COD and BOD of the effluent when aerated for 8 h. At the aeration rate of 1 l/min, the rate of reduction in COD and increase in BOD were considerable, the former ranging from 26 to 44% and the latter from 382 to 1500% in two samples. The rate of reduction in COD and increase in BOD was considerable upto 8 h of aeration time and 1 l/min of aeration rate which did not increase further even with an increase in aeration rate or aeration time. Therefore, for aeration treatment, the duration and rate should not be less than 8 h and 1 l/min/l of effluent respectively.

*Sedimentation studies*

Since the waste was highly acidic, the first requirement was to neutralise the waste to make it amenable. This was achieved by addition of lime. Fig.3 shows the effect of sedimentation at different pH on COD and BOD of the effluent. When lime was added to adjust the pH of the effluent from 6 to 10, the amount of sediment formed also increased.

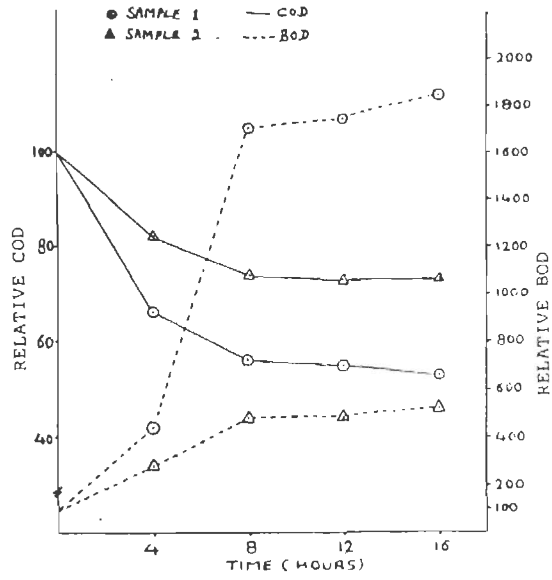


Fig. 1. Effect of aeration time on COD and BOD of effluent.

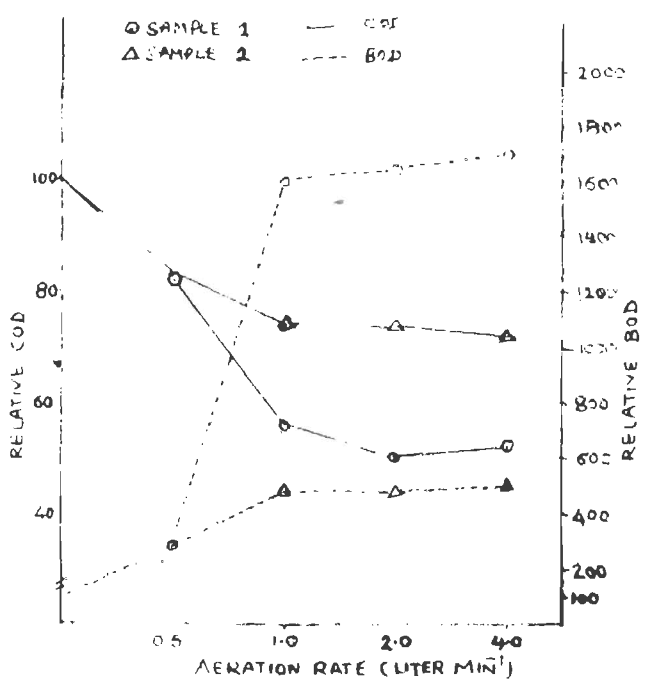


Fig. 2. Effect of aeration rate on COD and BOD of effluent.

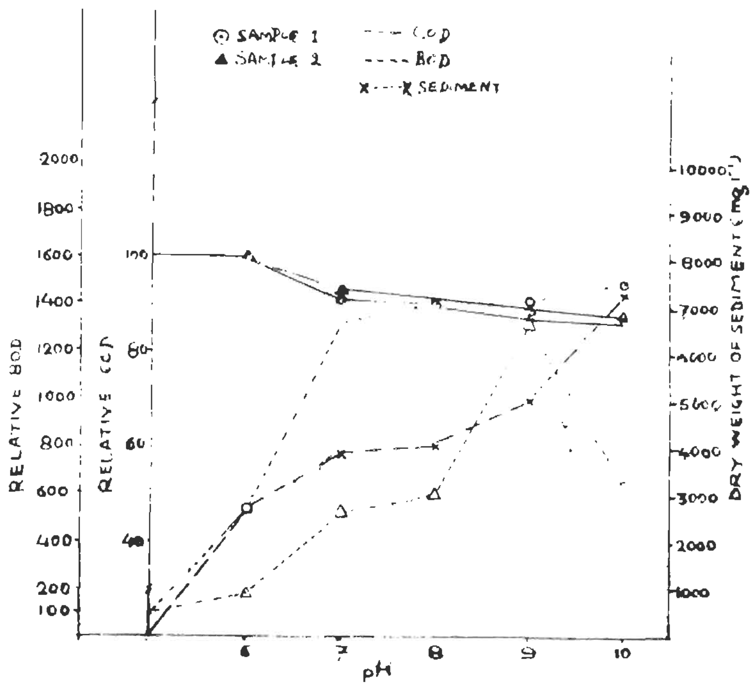


Fig.3. Effect of sedimentation on COD and BOD of effluent.

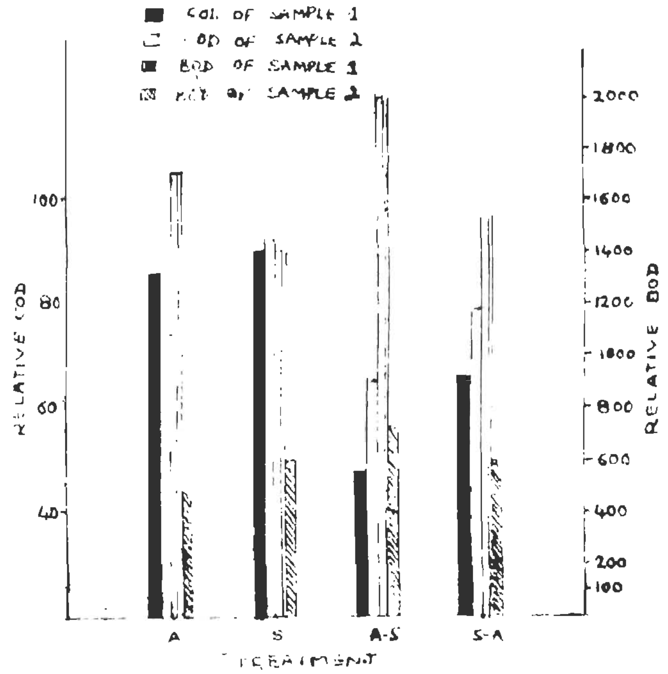


Fig.4. Effect of aeration (A) and sedimentation (S), separately and in sequence (A-S; S-A), on COD and BOD of effluent.

At pH 7, the rate of reduction in COD and increase in BOD was more than at 8, 9 and 10 pH. At pH 7, the reduction in COD ranged from 7 to 9% and increase in BOD ranged from 520 to 1325% in two samples. The rate of reduction and increase in COD and BOD, respectively, did not vary much beyond pH 7. Hence, lime should be added to adjust the pH just above 7.

*Aeration and sedimentation studies*

Fig. 4 shows the effect of aeration and sedimentation separately in comparison with the sequence of aeration followed by sedimentation and sedimentation followed by aeration on COD and BOD of the effluent. In the case of aeration followed by sedimentation, COD reduction ranged from 35 to 53% and BOD increase ranged from 636 to 2000% while in sedimentation followed by aeration, the corresponding values were 21 to 34% and 496 to 1450%, respectively, in two samples. These results showed that when the waste was treated in the sequence 'aeration followed by sedimentation', the reduction in COD and increase in BOD were more than those in separate aeration, sedimentation and the sequence of 'sedimentation followed by aeration'.

Aeration caused froth formation on the surface of the waste which removed the soluble resinous wastes in the form of insoluble froth, thus making the effluent free from resinous matter. However, the effluent remained highly acidic even after aeration. When we used lime, it neutralised the waste causing floc formation in the effluent. After sedimentation, the effluent did not show toxic effect as was observed previously. Our studies clearly indicated the usefulness of pre-treatment for detoxification of waste waters from synthetic resin manufacturing industries.


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# Urea and Ascorbic Acid as Ameliorators of Cement Dust Toxicity in *Oryza sativa*

**S.H. Raza, Nasreen Fatima and M.S.R. Murthy**
Department of Botany, Osmania University, Hyderabad 500007

## Abstract

An attempt has been made to find out the recovery from the inhibitory effect of cement dust in *Oryza sativa* (Var. B.P.T.5204). The observations have shown that rice was quite sensitive to cement dust when applied at 3g/m$^2$ daily from three leaf stage until harvest of the crop. The response was analysed in terms of number of leaves, total height, biomass and panicle characters. Urea and ascorbic acid were observed to be quite potent in reverting the inhibitory effect of cement dust. Urea could bring the maximum recovery in shoot and root biomass. These two substances were very useful in reverting the effect of cement dust with respect to height of the plant. Urea increased seed weight upto 35% while ascorbic acid upto 13.4%.

## Introduction

Cement dust is a common air pollutant around cement factories and construction sites. Chemically it is a mixture of oxides of calcium, potassium, aluminum, silicon and sodium . It has the property of setting into a hard mass forming a thick crust when it comes in contact with water. It leads to a decrease in water holding capacity of soil,increase in pH, conductivity, Ca and Al, and decrease in nitrogen availability thereby affecting the plant growth. Cement dust also affects plant growth directly by clogging the stomata, crust formation on leaves, alkalinity of stigma surfaces reducing the pollen germination (Anderson, 1914 ; Parthasarathy *et al*., 1975) and decrease in size and number of leaves, and height of plants. Further, cement dust toxicity is specific and is an intrinsic factor of soil and leaf characters of a given species. Hence, a comprehensive study encompassing the physiochemical factors of soil and leaf characters at different stages of growth are very much needed to draw a relation between the tolerance level and kind of injury imposed. The present attempt has been made to investigate the effect of cement dust on *Oryza sativa* (Var. B.P.T. 5204) considering the limited information available on this aspect. The main objectives were (i) to characterise the various plant parameters affected; (ii) to identify the susceptible stage of plant growth for cement dust toxicity and (iii) to revert the toxic effect of cement dust by urea and ascorbic acid.

## Material and Methods

Experimental plots of one square meter area were prepared and were entirely irrigated and fertilized. Seeds of rice were sown 10 cm apart. Plants were dusted with cement dust @ 3 g/m$^2$ from three leaf stage until harvest with the help of a hand rotary duster. Dusting was done during morning hours every day. Plants were enclosed in an open top polyethylene chamber at the time of dusting in order to prevent the loss of dust due to the action of wind. Along with the dust, 50 mg urea and 100 ppm ascorbic acid were added separately to the soil every day to find out their potential in reverting the inhibitory effects of cement dust. Untreated plants constituted the control and three replication were maintained. Plant samples were collected at 15 day intervals and observed for different characters, *viz.* number of leaves, total height, biomass, 1000 seed weight, number of panicles/plant and size of the panicle. Soil samples were collected from different treatment plots and at different stages of growth. Soil was analysed for pH, organic matter and electrical conductivity (Anon., 1975).

## Results

*Biomass*

The effect of cement dust on root and shoot biomass and its recovery is presented in Table 1. Shoot biomass was observed to be more than that of control from 15th to 45th day in dusted plants. The maximum was recorded on the 45th day, i.e. 75 % more than control. Then it was found to decrease which continued till the harvest of the crop. The maximum decrease (65%) was recorded on the 75th day. Shoot biomass was more than that of control until 45 days in urea and ascorbic acid treated plants. There was less decrease in shoot biomass with the increase in age in urea treated plants when compared to dusted plants. There was an increase in root biomass till 45th day in dusted plants which was 34.8% more than that of control. Thereafter, it showed a decreasing trend and the maximum decrease was found on the 75th day.

Table 1. Effect of cement dust, urea and ascorbic acid on percentage reduction and recovery of biomass of *Oryza sativa*

| Plant age (days) | Control* | | Cement dust | | Cement dust + urea | | Cement dust +ascorbic acid | |
|---|---|---|---|---|---|---|---|---|
| | Shoot | Root | Shoot | Root | Shoot | Root | Shoot | Root |
| 30 | 0.11 | 15.0 | 0.5* | 0.26* | 27.0* | 28.0* | 45.0* | 56.0* |
| 45 | 0.4 | 0.36 | 75.0* | 34.88* | 137.0* | 36.66* | 125.0* | 39 0* |
| 60 | 3.15 | 2.0 | 43.0 | 61.5 | 40.0 | 40.0 | 31.0 | 30.0 |
| 75 | 5.85 | 2.3 | 65.0 | 81.7 | 24.0 | 46.08 | 36.0 | 21.7 |
| 90 | 10.4 | 2.6 | 40.86 | 56.15 | 12.0 | 23.4 | 36.0 | 30.07 |
| 120 | 12.3 | 2.8 | 43.0 | 55.3 | 9.0 | 39.28 | 21.0 | 28.57 |
| 150 | 14.3 | 2.9 | 45.0 | 62.06 | 4.0 | 25.1 | 28.0 | 20.34 |

+ Control indicates the original biomass values ($g/m^2$); * Percent increase over control.

*Length*

The data on root and shoot length in relation to cement dust pollution are presented in Table 2. It is evident from the data that the vegetative characters are greatly affected. Till the 45th day there was a slight increase in the shoot length in dusted plants (26.5 cm) against that of control (24 cm). After the 45th day, until harvest, there was a gradual decrease in the shoot length. Urea and ascorbic acid were very effective in reverting the toxic effect of cement dust. Similar effects were noticed on root length which were more pronounced than in the case of shoots.

*Number of Leaves*

The number of leaves showed an increasing trend until 60 days in dusted plants and later decreased with the increase in age (Table 3). Urea and ascorbic acid treatments have not brought in any improvement in number of leaves.

Table 2. Effect of cement dust, urea and ascorbic acid on height (cm) of *Oryza sativa*.

| Plant age (days) | Control | | Cement dust | | Cement dust + urea | | Cement dust +ascorbic acid | |
|---|---|---|---|---|---|---|---|---|
| | Shoot | Root | Shoot | Root | Shoot | Root | Shoot | Root |
| 30 | 15.6 | 5.0 | 17 | 7.5 | 18 | 7.8 | 17.6 | 8.0 |
| 45 | 24.5 | 10.0 | 26.5 | 12.0 | 26.7 | 13.5 | 28.15 | 14.66 |
| 60 | 36.6 | 18.3 | 31.35 | 12.06 | 35.33 | 13.9 | 34.55 | 16.33 |
| 75 | 44 | 19.0 | 35 | 13.5 | 42.25 | 14.1 | 38.1 | 16.5 |
| 90 | 47 | 21.75 | 37.5 | 14.0 | 44.5 | 16.5 | 40.5 | 17.25 |
| 120 | 52.5 | 24.23 | 48.5 | 14.59 | 49.25 | 16.16 | 50.1 | 18.25 |
| 150 | 56.6 | 24.66 | 48 | 15.2 | 50 | 16.75 | 53.75 | 18.55 |

Table 3. Effect of cement dust, urea and ascorbic acid on the leaf number of *Oryza sativa*.

| Plant age (days) | Control | Cement dust | Cement dust + urea | Cement dust +ascorbic acid |
|---|---|---|---|---|
| 30 | 4.0 | 4.3 | 4.6 | 5.2 |
| 45 | 5.0 | 7.3 | 11.0 | 8.6 |
| 60 | 11.0 | 11.2 | 16.6 | 12.0 |
| 75 | 17.5 | 12.2 | 17.0 | 14.4 |
| 90 | 21.0 | 14.0 | 19.5 | 16.6 |
| 120 | 23.0 | 11.5 | 20.0 | 18.0 |
| 150 | 23.5 | 12.0 | 20.6 | 19.5 |

*Panicle characters*

The panicle number and size, and weight of 1000 grain obtained from the dusted plants were lower than those of control (Table 4). The average number of panicles/plant in dusted plots was 3.33 as against the control value of 4.5. The number of panicles increased in urea (11) and ascorbic acid (7.7) treatments. There was a decrease in the panicle size also because of the cement dust. Similarly, there was a reduction in the 1000 seed weight in dusted plants (24%) when compared to control. On the contrary, urea increased seed weight by 35% and ascorbic acid by 13.4% compared to control.

Table 4. Effect of cement dust, urea and ascorbic acid on panicle characters.

| Panicle character | Control | Cement dust | Cement dust + urea | Cement dust + ascorbic acid |
|---|---|---|---|---|
| Number of panicle/plant | 4.5 | 3.33 | 11.00 | 7.7 |
| Panicle size (cm) | 14.6 | 13.8 | 14.15 | 16.5 |
| 1000 grain wt (g) | 11.2 | 24.0* | 35.0+ | 13.4+ |

* Percent decrease over control; + percent increase over control.

*Soil characters*

The pH of soil from cement dusted plots increased from 7.5 to 9.75 at harvest whereas in the control plot it increased from 7.2 to 7.45 (Table 5). There was an increase in pH and electric conductivity in dusted plots compared to control.

## Discussion

Cement dust is known to show promotory and inhibitory effects based on the amount of dust load (Singh and Rao 1968). When the dust load was less till the 45th day, it had a stimulating effect and enhanced the biomass production of root and shoot. This result indicated that in initial stages, cement dust did not show toxic effect on the plant. The stimulating effect must have resulted from growth promoting substances such as calcium present in the dust. However, cement dust was observed to be toxic by decreasing biomass and length of root and shoot. The reduction could be attributed to the dust crust formed on the soil surface and changes in the physiochemical characters of soil (Table 5) which would possibly affect the mineral availability for plant metabolism. It is also likely that the reduction in the biomass may have resulted from a decreased photosynthetic function as the cement coating would interrupt absorption of light and diffusion of gases. Similar inhibitory effects on the biomass have also been reported in cotton (Oblisami *et al.*, 1978), maize (Parthasarathy *et al.*, 1975) and wheat (Singh and Rao, 1978). In our observations, partial reversion in the reduction in biomass could be attained by urea and ascorbic acid treatments.

In dusted plants the number of leaves was more than that in control upto 60 days but later it reduced. Similar observations were made by Parthasarathy *et al.*, (1975) in maize growing in cement dust polluted area.

The observations have shown that rice plant was quite sensitive to cement dust as the 3 g/$m^2$ dust could affect the number, size of panicles and the seed weight. Along with the reduction in number of panicles, seed weight was reduced upto 24%. This could be due to the dust load on stigma which might partially prevent the germination of pollen grains leading to failure of fertilization (Anderson, 1914).

It is evident from the data that application of urea and ascorbic acid not only helped in reverting the toxic effect of cement dust but also increased seed weight by 35% and 13.4%, respectively. Though there was a continuous decrease in growth parameters with age and continuous dusting, such an effect was found minimised in urea and ascorbic acid treated plants. The promotory effects of urea and ascorbic acid must have resulted from the increased nitrogen availability and reducing power of ascorbic acid, respectively.

Continuous dusting of plants was found unharmful to growth till the 45th day. However, dusting thereafter has made the plants more susceptible. Therefore, amelioration practices should be extensively started beforehand to protect the plants from such a damage. In the present investigation, urea and ascorbic acid were found to be good ameliorators in this regard.

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# Ionic Interaction of Sulphur and Molybdenum in Controlling Toxic Accumulation of Molybdenum in Tomato (*Lycopersicum esculentum* L.)

**K. Srinivasa Reddy and K. Sudhakara Reddy**

Department of Soil Science and Agricultural Chemistry, S.V.Agricultural College
Tirupati 517502.

## Abstract

Molybdenum, a heavy metallic plant nutrient, tends to accumulate as $MoO_{4-2}$ in toxic concentrations in plants when grown in soils that are moderate to strongly alkaline in reaction and poor in drainage. Among plant nutrients, sulphur and molybdenum have been known for their mutual antagonistic effects. Therefore, a short term double salt solution culture study involving potassium sulphate and a carrier free source of radioactive molybdenum ($^{99}Mo$) as $Na_2MoO_4.2H_2O$ was conducted to evaluate the magnitude of $SO_{4-2}$ and $MoO^{-2}_4$ anionic interaction in controlling the MO accumulation in two week old tomato seedlings. The results revealed the significant influence of $SO_{4-2}$ ions in reducing the concentration and uptake of $MoO_{4-2}$ in tomato seedlings. The mechanism of S–Mo interaction and the implications thereof have been discussed.

## Introduction

The absorption and translocation of a given plant nutrient are considerably influenced by the concentration of other nutrients in the medium which influences the growth and yield response of crops. The effect may be either synergistic or antagonistic. The antagonism may be due to blockage of either carrier site at the root surface or metal enzyme formation within the plant. Thus, the relative proportion of nutrients in the growth medium may be of as much significance as their absolute amounts present either in the external medium or in the plant tissue. Consequently, the critical concentration of a given nutrient in the soil and /or plant should be qualified in terms of other nutrients.

Interaction is the mutual or reciprocal action of one element upon another in relation to plant growth. Interactions may arise when a plant absorbs large amounts of an available nutrient and its concentration in the plant reaches excessive or toxic levels that interfere with the normal metabolic function of another nutrient.

## Material and Methods

A short term solution culture study was conducted to undertstand the mechanism of sulphur-molybdenum interaction in tomato seedlings using potassium sulphate and molybdenum trioxide labeled with a carrier free source of radioactive molybdenum as $Na_2MoO_4 .2H_2O$ in alkaline solution (Code : $Mo_3$). The specific activity maintained at the commencement of the nutrient absorption was 16.95 $\mu$ $cig^{-1}$Mo.

The stock solutions containing 1000 ppm S and 25 ppm Mo tagged with $^{99}$Mo were prepared separately and suitable aliquots of these solutions were mixed and made up to volume in 250 ml flasks to provide 0, 20, 40 and 60 ppm of S and 0.25, 0.50. 1.0 and 2.0 ppm of Mo.

Six 2-week old tomato seedlings of uniform growth were selected and their complete root system was immersed for a period of 24 h in the nutrient solutions taken in 250 ml conical flasks. Cotton was placed at the neck of the flasks for supporting the seedlings. At the end of absorption period, the seedlings were removed from the nutrient solutions. The roots were thoroughly washed with deionized water, solution of $CaCl_2.2H_2O$ (500 micromoles) and finally with non-radioactive solution of $MoO_3$ keeping the period of washing constant, i.e. 2 min for each sample. The last two solutions used for washing the roots were intended to remove the Mo absorbed by ion exchange and for removing the radioactive Mo absorbed on the root surface by isotopic exchange, respectively. The Mo concentrations used for the absorption study and of the $MoO_3$ solution used for washing the roots for a given treatment were kept identical. The root and shoot portions of the washed seedlings were separated and then oven dried at 65 ± 5 °C for 24 h. The dry weights of the samples were recorded and the samples were ground to a fine powder using stainless steel blender. The plant samples were digested in a 2:1 binary mixture of nitric acid and perchloric acid, filtered with Whatman 42 and made upto 100 ml volume. Suitable aliquots of these digested extracts of shoot and root samples were transferred to glass planchets (2ml capacity) and were evaporated using ultra violet lamp. The evaporated samples were cooled to the room temperature and were measured for hard beta particles (1.84 MeV) using G.M.Counter (Type 1031 ECIL, India) at the operational voltage of 1035 volts. All the counts recorded at a given time were corrected to a reference time using the decay equation. The concentration of radioactive $^{99}$Mo in µg Mo/g of plant material was calculated by dividing the counts of the experimental samples by the counts obtained from the standard stock solutions of $^{99}$Mo.

## Results and Discussion

The data on $^{99}$Mo content of shoots, roots and whole plants of tomato as affected by S and $^{99}$Mo application in a double salt solution culture study are presented in Table1. The results suggested that S application has not significantly influenced the Mo content of shoots. However, the decreasing trend in Mo content of shoots with increasing rates of sulphur was evident. Reduction in Mo content of plants due to S fertilization has been quite extensively reported (Stout and Meagher, 1948 ; Stout *et al.*, 1951; Reisenauer, 1963; Gupta and Munro, 1969; Pasricha and Randhawa , 1972; Jones and Ruckman, 1973; Gupta and Macleod, 1975; Mahendra Singh and Vinod Kumar, 1979). Lack of significant effect of various S levels in reducing Mo content might be due to lower rates of S used in the study. In fact, S levels used by Reiseneuer (1963), Gupta and Munro (1969), Gupta and Macleod (1975) and Mahendra Singh and Vinod Kumar (1979) in their experiments ranged from 50 to 360 ppm.

However, the Mo content of roots has been significantly reduced due to S application. It appears that the ratio between S and Mo governs the effect of sulphur on Mo accumulation in plants since it is evident from the data in Table 1 that the S levels adopted were effective in suppressing the Mo content of roots whose Mo accumulation ability is relatively lower than that for upper portions of the plant . Mo was reported to be preferentially accumulated in the interveinal areas of the leaves (Stout and Meagher, 1948). Evidently, the study, though lasted for only 24 h with respect to the nutrient absorption, indicated that higher rates of S beyond 60 ppm are required to reduce the Mo content of shoots.

Table 1. Effect of S and $^{99}$Mo application on the concentration of radioactive molybdenum (ppm) in tomato seedlings immersed in double salt solution culture medium for 24 h.

| Amount of $^{99}$Mo (ppm) | Amount of S (ppm) 0 | | | 20 | | | 40 | | | 60 | | | Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* |
| 0.25 | 5.64 | 8.54 | 7.09 | 4.65 | 3.07 | 3.86 | 4.05 | 3.46 | 3.76 | 4.45 | 2.90 | 3.67 | 4.70 | 4.49 | 4.59 |
| 0.50 | 8.89 | 11.35 | 10.12 | 10.54 | 8.43 | 9.48 | 10.40 | 4.57 | 7.48 | 9.18 | 4.50 | 6.84 | 9.75 | 7.21 | 8.48 |
| 1.00 | 21.19 | 11.90 | 16.94 | 20.36 | 7.12 | 13.74 | 19.18 | 7.30 | 13.24 | 18.28 | 6.23 | 12.25 | 19.75 | 8.14 | 13.94 |
| 2.00 | 34.07 | 10.99 | 22.53 | 28.88 | 10.04 | 19.46 | 25.08 | 10.46 | 17.77 | 39.13 | 15.39 | 27.26 | 31.79 | 11.72 | 21.75 |
| Mean | 17.45 | 10.69 | | 16.11 | 7.16 | | 14.68 | 6.45 | | 17.76 | 7.25 | | | | |

*WP = Whole Plant

| | | Shoot | Root | Whole plant |
|---|---|---|---|---|
| L.S.D. | S | N.S. | 2.71 | 1.39 |
| P=0.05 | Mo | 2.59 | 2.71 | 1.39 |
| | S x Mo | 5.18 | N.S. | 2.78 |

Table 2. Effect of S and $^{99}$Mo application on the uptake of radioactive molybdenum (µg/six plants) in tomato seedlings immersed in double salt solution culture medium for 24 h.

| Amount of $^{99}$Mo (ppm) | Amount of S (ppm) 0 | | | 20 | | | 40 | | | 60 | | | Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* | Shoot | Root | WP* |
| 0.25 | 2.45 | 0.47 | 2.92 | 1.95 | 0.17 | 2.12 | 1.74 | 0.18 | 1.92 | 1.52 | 0.15 | 1.67 | 1.91 | 0.24 | 2.15 |
| 0.50 | 2.86 | 0.43 | 3.29 | 2.93 | 0.36 | 3.29 | 3.35 | 0.16 | 3.51 | 2.05 | 0.14 | 2.19 | 2.80 | 0.27 | 3.07 |
| 1.00 | 8.42 | 0.58 | 9.00 | 7.37 | 0.36 | 7.73 | 6.83 | 0.34 | 7.17 | 5.48 | 0.25 | 5.73 | 7.02 | 0.38 | 7.40 |
| 2.00 | 12.63 | 0.45 | 13.08 | 10.89 | 0.44 | 11.33 | 10.16 | 0.56 | 10.72 | 9.58 | 0.42 | 10.00 | 10.81 | 0.47 | 11.28 |
| Mean | 6.59 | 0.48 | 7.07 | 5.78 | 0.33 | 6.11 | 5.52 | 0.31 | 5.83 | 4.66 | 0.24 | 4.90 | | | |

*WP = Whole Plant

| | | Shoot | Root | Whole plant |
|---|---|---|---|---|
| L.S.D. | S | N.S. | 0.13 | N.S. |
| P=0.05 | Mo | 2.72 | 0.13 | 1.96 |
| | S x Mo | N.S. | N.S. | N.S. |

Interestingly, the suppressing effect of S on tissue Mo content was quite evident when whole plants were considered for their Mo content which was significantly reduced due to S application though the Mo content did not differ in different levels of S.

The data on uptake of Mo by shoots, roots and whole plants of tomato as influenced by S and $^{99}$Mo application have been presented in Table 2. Sulphur application tended to decrease the Mo uptake by shoots while it significantly reduced the uptake of Mo by roots. Reisenauer (1963) reported that $SO^{2-}_4$ ions reduced $MoO^{2-}_4$ absorption by peas due to their mutual competition for primary plant root absorption sites since these ions are of similar charge and radius. Gupta and Munro (1969) also indicated that the major effect of sulphur on Mo content of the plant would be at the site of uptake on the root. The results obtained in the present study also suggested that the effect of $SO^{2-}_4$ ions in reducing the Mo content and uptake by tomato might be at the absorption site of the root. The data further indicated significant increase in Mo uptake both by shoot and root portions due to Mo application.

The data on $^{99}$Mo uptake by whole plants of tomato indicated non-significant reduction in Mo uptake due to S application which might be due to the lower rates of sulphur used in the study. The results also suggested the necessity for higher levels of sulphur application beyond 60 ppm to check excess Mo accumulation by crops.

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# Metal Pollution Control using Biosorbents

**C.R. Nagendra Rao[1] and C. Venkoba Char[2]**

[1] Department of Civil Engineering, Government Polytechnic, Anantapur 515001
[2] Department of Civil Engineering, Indian Institute of Technology, Kanpur 208016

## Abstract

Waste biomass like (i) *Ganoderma lucidum*, a wood-rotting, non edible mushroom, (ii) *Aspergillus niger*, the waste mycelia from citric acid fermentation industry and (iii) excess sludge from laboratory scale activated sludge unit were evaluated for their Cu(II) uptake potential under varied aqueous phase chemical composition. The kinetics, using a metal concentration of 0.5 mM and sorbent concentration of 4 g/L,showed a rapid uptake of the metal by all the sorbents. The optimum pH was observed to be 5.0 and the ionic strength from 0.03 to 0.17 did not have significant effect on metal removal potential of any sorbent. *G. lucidum* exhibited maximum Cu(II) uptake with percent removal as high as 98% followed by the waste activated sludge (42%) and *A.niger* (14%). The ranking of sorbents in terms of capacity was *G. lucidum*, waste activated sludge and *A.niger*. Thus , *G.lucidum* appears to be a potent biosorbent for heavy metal removal.

## Introduction

The increasing awareness of heavy metal toxicity and their biomagnification through food chains are responsible for the demand for detoxification of industrial effluents prior to their discharge into natural streams. Also the attractive commercial value of heavy metals warrants their separation and recovery. The existing treatment techniques for metal bearing effluents are conventional and non-conventional. The conventional methods include precipitation of the metal as metal hydroxide or sulfide and subsequent disposal of the resulting sludge. This method, though simple and cheap, has a few major disadvantages. Firstly, an enormous amount of sludge is produced, the disposal of which itself is a problem. Secondly, this method fails to meet the effluent quality standards when the metal concentrations are very low. Finally, the high metal values are lost as they are not recovered. In non-conventional methods, which include ion exchange, evaporation, electrolytic and adsorptive methods, the metal values are recovered and recycled. However, these methods are very expensive. Hence, it is appropriate to develop inexpensive alternate metal removal and recovery methods which are feasible for even low metal concentration.

A recent development in Environmental Biotechnology is the identification of biosorbents which have high affinity for inorganic pollutants. Many investigations revealed the ability of viable and non-viable microbes to absorb significant quantities of metal from aqueous phase. Algae, bacteria, fungi and yeasts have been reported as good metal scavengers (Norris and Kelly, 1979). Many studies have shown that the metals present in settled sewage can be removed in activated sludge plant (Brown *et al.*, 1973; Lester *et al.*, 1979; Oliver and Cosgrove, 1974; Stoveland *et al.*, 1979). However, it is realised that metal removal by living biomass is more complicated since nutrients and optimal conditions for its growth are to be provided. Also, unless the microbes are flocculating type, the separation becomes energy intensive. The use of dead biomass for metal scavenging is expected to obviate the problems associated with living organisms. Kumar and Dara (1980) investigated the use of treated agricultural products like bagasse, rice husk, onion skin, etc. for removal of heavy metals. Volesky (1987) and others have reported the decontamination of the effluent streams from mining, refining, nuclear fuel processing, electroplating and allied industries by dead microbes.

The biomass *Rhizopus arrhizus*, a by-product of industrial fermentation, has uranium and thorium uptake capacity as high as 180 $mg^{-1}$ of dry wt which exceeds the capacity of a common anionic exchange resin (IRA - 400) commonly used by uranium production agencies by 2 to 5 times (Tsezos and Volesky, 1981 ; Tsezos and Volesky, 1982). A commercial process "AMT-BIOCLAIM" was developed using a proprietary, granulated, non-living biosorbent, which has high capacity for accumulation of a wide range of metal cations (86 mg Ag/g, 21.4mg Cd/g, 152 mg Cu/g, 601 mg Pb/g and 137 mg Zn/g ) and the efficiency of metal removal from dilute solution exceeds 99% (Brierly *et al.*, 1986). The patent sorbent also accumulated gold upto 394 mg/g from gold cyanide solutions. Muzzarelli and Tanfani (1982) have investigated *Aspergillus niger*, a waste product of citric acid fermentation process, streptomyces from a pharamaceutical industry and *Mucor rouxii* grown on waste effluent for their ability to remove a wide spectrum of metals like Cr, Mn, Co, Ni, Cu and Zn and all the sorbents are reported to have shown good removals.

Recent investigations have revealed an excellent Cu(II) binding ability of *Ganoderma lucidum*, a wood rotting, non-edible mushroom (Muraleedharan *et al.*, 1987 and 1988). In the present study, *G.lucidum* and *Aspergillus niger*, the waste mycelia produced as a byproduct from laboratory scale activated sludge unit, were evaluated for their metal uptake potential under various aqueous phase chemical conditions with copper(II) as the model heavy metal.

## Material and Methods

*(a) Biosorbents*

*G. lucidum* (M), a wood-rotting, non-edible mushroom, *A. niger* (A), a waste mycelia supplied by "CITURGIA BIOCHEMICALS LIMITED" Surat, and the excess sludge from laboratory scale activated sludge unit operating on biological solids retention time (BSRT) of 6 days were dried and pulverised to a geometric mean (GM) size of 100 micron.

*(b) Reagents*

Stock Cu (II) solution of 0.2 mM to 1.8 mM, $KNO_3$ solution for adjusting the ionic strength and acetate and phthalate buffers were prepared using AR grade chemicals.

*(c) Kinetic experiments*

The reaction mixture of 50 ml containing 0.5 mM metal solution was contacted with 200 mg of biosorbent in a rotary shaker at 30 rpm and aliquots were drawn at different time intervals for estimation of the aqueous phase Cu(II) after separating the sorbent by filteration using Whatman 42 filter paper.

*(d) Sorption equilibria*

Batch sorption studies were conducted using 50ml reaction mixture containing metal solution of 0.2 mM to 1.8 mM, 200 mg of sorbents adjusted to the desired ionic strength by adding $KNO_3$ and pH by a suitable buffer. The entire mixture was agitated at

30rpm on a rotary shaker. The experimental protocol for sorption equilibria experiments is presented in Table 1.

Table 1: Experimental protocol for sorption equilibria
(Equilibrium time = 1 h)

| Sorbent | Initial metal concentration | pH-buffer | I.S. |
|---|---|---|---|
| *G. lucidum* (M) | 0.2-1.8 mM | 4-0.1 M acetate | 0.03, 0.17 |
| | | 5-0.1 M acetate | 0.03, 0.17 |
| | | 6-0.1 M phthalate | 0.03 , 0.17 |
| *A. niger* (A) | 0.2-1.8 mM | 4-0.1 M acetate | 0.03, 0.17 |
| | | 5-0.1 M acetate | 0.03, 0.17 |
| | | 6-0.1 M phthalate | 0.03, 0.17 |
| Sludge (S) | 0.4-1.8 mM | 5-0.1 M acetate | 0.03, 0.17 |

*(e) Estimation of copper (II)*

The residual aqueous phase Cu(II) was estimated by Cuprethol method (Anon., 1968).

## Results and Discussion

*Sorption kinetics*

The kinetics of Cu(II) uptake from 0.5 mM solution by dried and pulverised biosorbents is presented in Fig.1. In the case of *G.lucidum* and waste sludge, the Cu(II) removal was high and rapid with more than 90% of the total sorption occurring in 30

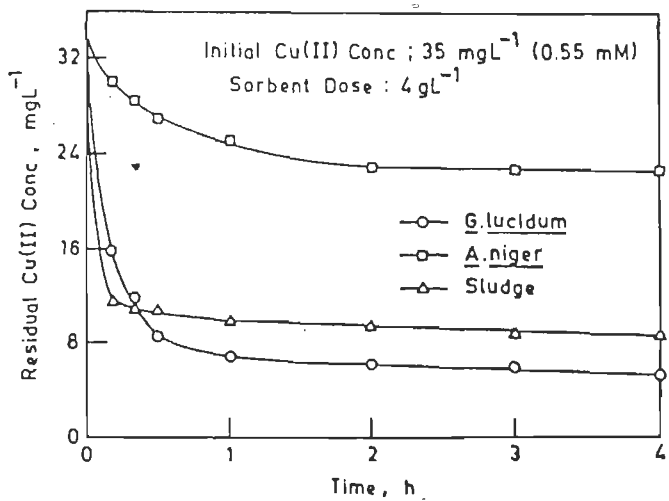


Fig.1. Kinetics of Cu(II) sorption by *G. lucidum, A. niger* and sludge from aqueous phase.

minutes and virtually all the removal occurring in less than an hour. However, *A. niger* showed relatively slower and lesser extent of metal uptake with 75% of total sorption occurring in one hour. This rapid uptake of sorbents would provide a short detention time and result in the use of much shallower beds of sorbent material.

*Effect of pH*

The pH of metal bearing wastewater is in the range of 4 to 6. The adsorption process for removal of pollutants from wastewater is highly dependent on aqueous phase pH which affects the surface charge of the absorbent, the degree of ionisation and speciation of sorbate. Hence, the effect of pH in the range of 4 to 6 was investigated and the results are presented in Fig.2. For any sorbent, the optimum pH was found to be 5.0. However, the slight increase in percent removal between pH 5 and 6 for sludge was negligible. Further, at any pH value, the maximum and minimum Cu(II) removals were given by *G. lucidum* and *A. niger*, respectively. Waste activated sludge showed only 40% removal of Cu(II).

*Sorption curves*

The Sorption curve is the characteristic of a sorption process. Sorption process proceeds till the sorbate concentration in the solution phase is in dynamic equilibrium with that in the solid phase. At this equilibrium, there will be a well defined distribution of sorbate between aqueous and solid phase. The sorption curves resulting from sorption equilibria experiments conducted to compare the performance of biosorbents to remove Cu(II) from aqueous phase at pH 5.0 and as influenced by the ionic strength are presented in Fig.3.

The steep curve for *G.lucidum* clearly demonstrated that it is the best sorbent among the three biosorbents investigated for Cu(ii) uptake with the highest affinity for the metal. This was followed by waste sludge and *A.niger*. Besides pH, the high ionic strength (I.S.) of aqueous phase, which can control the mobility of ions and thus can change the equilibrium constants, also influences the sorption process. The increase in I.S. from 0.03 to 0.17 did not have any significant effect on the performance of bisorbents. This independence of the process on I.S. facilitates easy control and operation of the sorption process.

The percent removal of Cu(II) from 0.5mM metal solution by the three sorbents (Table 2) also confirms the superiority of *G. lucidum* in metal removal.

Table 2. Percent removal of Cu(II) by biosorbents at pH 5.0 and I.S. 0.03

| Biosorbent | Percent Cu(II) removal |
|---|---|
| *G. lucidum* (M) | 98% |
| *A. niger* (A) | 14% |
| Waste sludge (S) | 40% |

*Sorption equilibria*

The equilibria data are most usually represented by the Freundlich and Langmuir isotherms. To facilitate easy extrapolation outside the experimental range and to interpolate within the range, the straight line plots are employed.

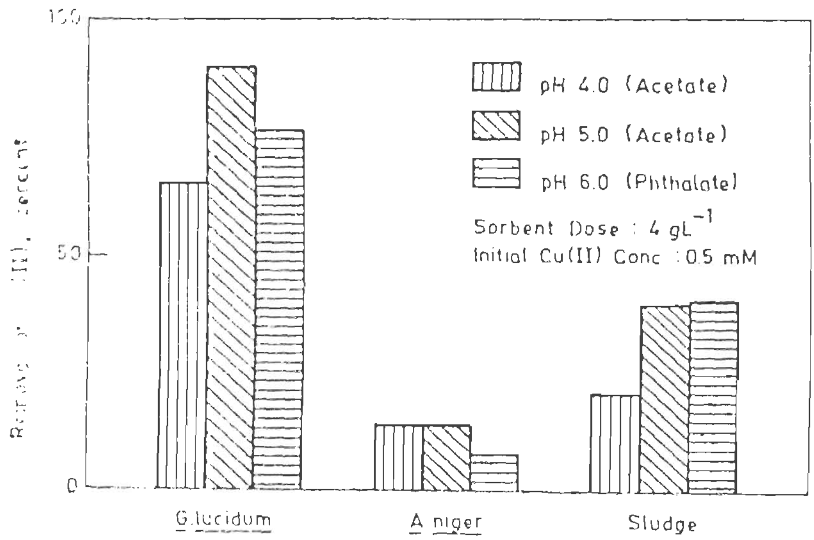


Fig.2. Effect of varying pH of aqueous phase on Cu(II) removal

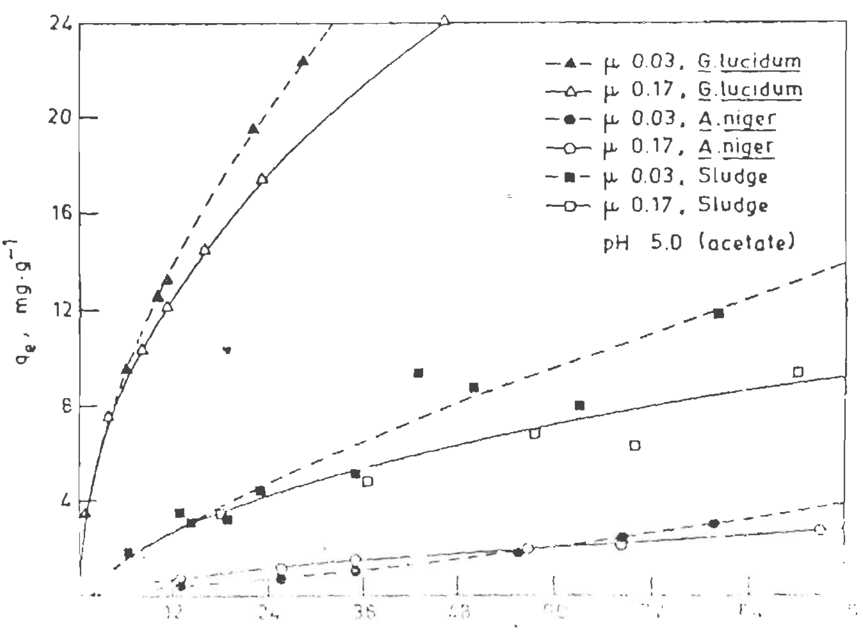


Fig.3. Comparison of Cu(II) uptake capacities of raw sorbents *G. lucidum*, *A. niger* and sludge

The linearised form of Freundlich equation is

$$\log q_e = \log K_f + 1/n \log C_e$$

where $q_e$ = amount of sorbate sorbed per unit wt of sorbent
$C_e$ = concentration of sorbate in solution at equilibrium
$K_f$ = constant related to sorption capacity
$1/n$ = constant related to sorption intensity

The linearised form of Langmuir equation is

$$1/q_e = 1/Q^o + 1/Q^o b \;.\; 1/C_e$$

where $q_e$ = amount of sorbate sorbed per unit wt of sorbent
$C_e$ = concentration of sorbate in solution at equilibrium
$Q^o b$ = constants

The least square method was used to estimate the isothermal parameters like $K_f$, $1/n$, $Q^o$ and b. These estimated isotherm parameters alongwith the relevant statistical information are shown in Table 3 and 4. The high values of coefficient of correlation and low values of standard error of estimate indicate that the experimental data of *G.lucidum* (pH 4, 5, and 6; I.S. 0.17) and waste sludge (pH 5; I.S. 0.17) gave better fit to the Freundlich equation whereas that of *A.niger* (pH 4, 5 and 6 ; I.S. 0.17) followed the Langmuir isotherm.

Table 3. Estimated isotherm parameters with relevant statistical information for *G. lucidum* and sludge

| Sorbent | pH | I.S. μ | Isotherm | $K_f$ | 1/n | 95% confidence interval Log $K_f$ | 95% confidence interval 1/n | Standard error of estimate | Coefficient of correlation (r) |
|---|---|---|---|---|---|---|---|---|---|
| G. lucidum | 4 | 0.17 | F* | 1.347 | 0.501 | (−0.09)–(0.35) | (0.33)–(0.67) | 0.07 | 0.93 |
| | | 0.03 | F | 2.727 | 0.35 | (0.34)–(0.52) | (0.28)–(0.42) | 0.03 | 0.98 |
| | 5 | 0.17 | F | 3.76 | 0.487 | (0.46)–(0.68) | (0.38)–(0.6) | 0.06 | 0.96 |
| | | 0.03 | F | 3.48 | 0.561 | (0.42)–(0.66) | (0.43)–(0.69) | 0.07 | 0.96 |
| | 6 | 0.17 | F | 0.144 | 0.706 | (−1.2)–(−0.5) | (0.47)–(0.95) | 0.08 | 0.94 |
| | | 0.03 | F | 0.157 | 0.698 | (−1.47)–(−0.15) | (0.26)–(1.14) | 0.15 | 0.82 |
| Sludge | 5 | 0.17 | F | 0.692 | 0.572 | (−0.66)–(0.34) | (0.19)–(9.48) | 0.88 | 0.87 |
| | | 0.03 | F | 0.38 | 0.79 | (−0.66)–(−0.18) | (0.60)–(0.98) | 0.07 | 0.98 |

*F — Freundlich isotherm.

The sorption curves along with the linearised plots for different pH values for three sorbents are presented in Fig. 4 to 6. The 95% confidence bands in the linearised plots

Table 4. Estimated isotherm parameters with relevant statistical information for *A.niger*

| Sorbent | pH | I.S. µ | Iso-therm | $(Q^0)$ | (b) | 95% confidence interval $(1/Q^0)$ | $(1/Q^0)$ | Standard error of estimate | Coefficient of correlation (r) |
|---|---|---|---|---|---|---|---|---|---|
| *A. niger* | 4 | 0.17 | L* | 3.63 | 0.007 | (–0.25)–(0.8) | (19.7)–(57.9) | 0.25 | 0.95 |
| | | 0.03 | L | 4.0 | 0.009 | (–0.14)–(0.7) | (12.3)–(68.6) | 0.40 | 0.83 |
| | 5 | 0.17 | L | 5.0 | 0.011 | (–0.14)–(0.54) | (6.25)–(29.2) | 0.22 | 0.88 |
| | | 0.03 | L | –5.9 | –0.004 | (–0.62)–(0.28) | (24.9)–(56.1) | 0.35 | 0.91 |
| | 6 | 0.17 | L | –25 | –0.0004 | (–0.84)–(0.76) | (73.2)–(135.4) | 0.39 | 0.99 |
| | | 0.03 | L | 1.1 | 0.007 | (–0.3)–(2.15) | (73.1)–(171) | 0.93 | 0.94 |

*L — Langmuir isotherm.

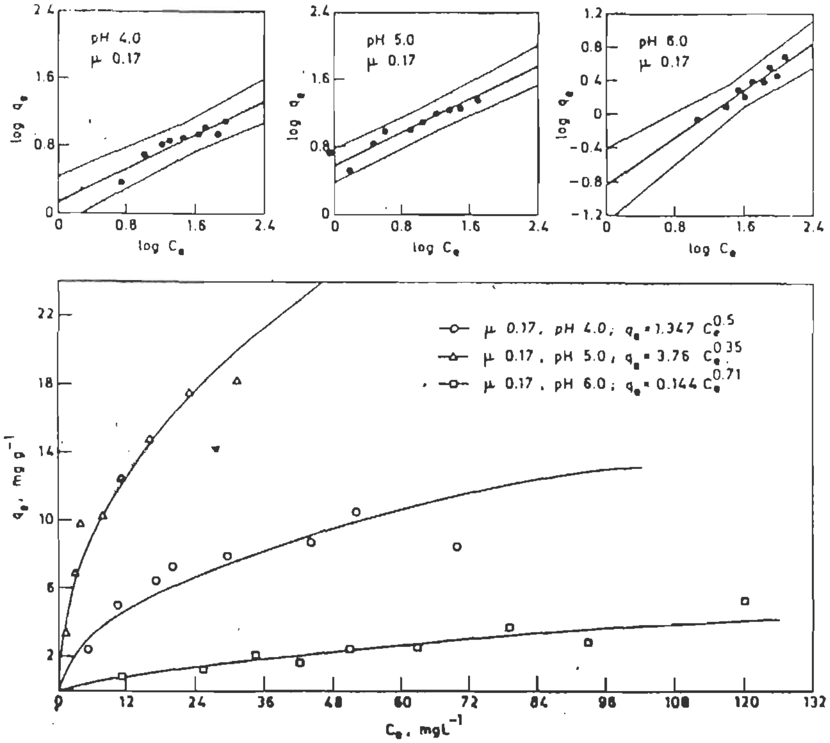


Fig.4. Equilibrium distributuion of Cu(II) between aqueous phase and *G. lucidum* at different pH

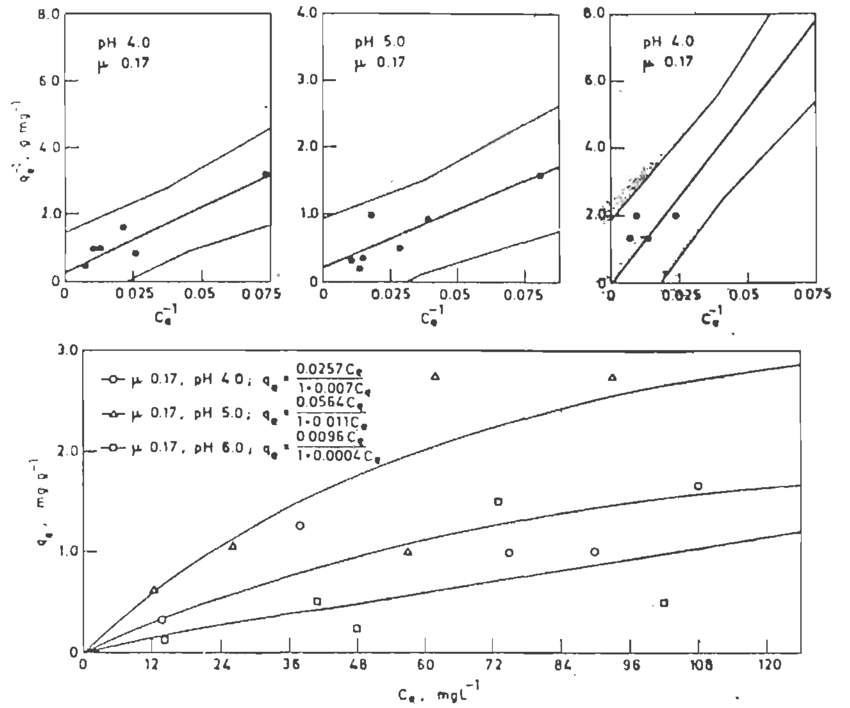


Fig.5. Equilibrium distribution of Cu(II) between aqueous phase and *A. niger* at different pH

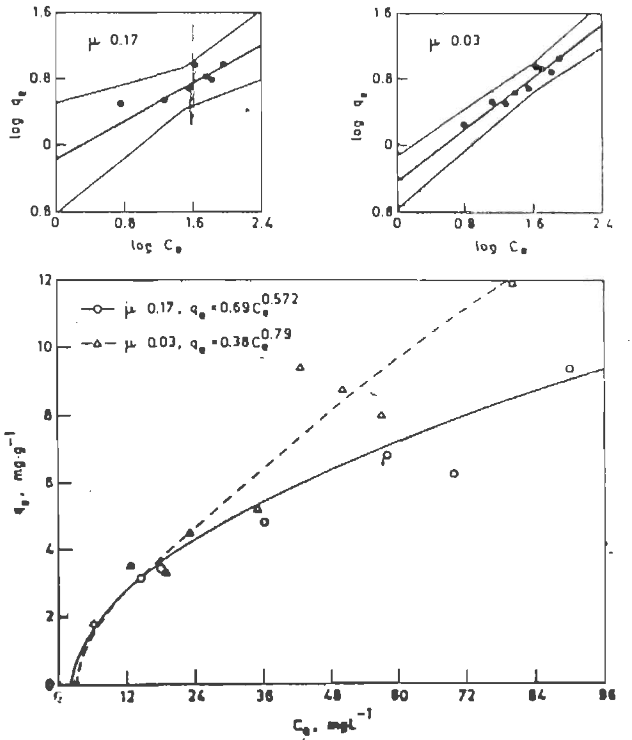


Fig.6. Equilibrium distribution of Cu(II) between aqueous phase and sludge at pH 5\0

indicate the certainty in the estimation of the value of $q_e$. If the confidence band is narrower, more is the certainty of value of $q_e$ being estimated. Wider band width indicates the variation of $q_e$ which may be due to experimental error or to sensitivity of the system to environmental parameters. From Fig.4 through 6, it can be observed that the band width was the narrowest for *G. lucidum* and widest for *A. niger* for all pH values. Fig.6 depicting the sorption isotherm for waste sludge at two ionic strengths and pH 5 also shows narrow band width. This shows that the prediction of $q_e$ is more certain for mushroom and sludge than *A.niger.*

The sorptive capacity gives important information like the maximum sorbate that can be sorbed per unit wt of sorbent for a given initial concentration (ultimate capacity) and the dose of sorbent required to have the desired final metal concentration. Table 5 gives the sorptive capacity of three biosorbents for a residual aqueous Cu(II) concentration of 3 mg/l which is the permissible effluent standard in India. From the table it can be seen that capacitywise also the sorbent *G.lucidum* was well ahead of the other two sorbents. This was followed by the sludge while *A.n iger,* trailing far behind, gave a dismal performance.

Table 5. Copper(II) sorptive capacity of biosorbents for a residual Cu(II) concentration of 3 mg $l^{-1}$

| Sorbent | Sorptive capacity (mg $g^{-1}$) | Remarks |
|---|---|---|
| *G. lucidum* (M) | 7.0 | pH 5.0 |
| Waste sludge (S) | 2.0 | I.S. 0.03 |
| *A. niger* (A) | 0.2 | Sorbent dose 4 g $l^{-1}$ |

## Conclusions

1. Of the three inactivated, dried and pulverised biomass, the biosorbents *G. lucidum* and waste activated sludge exhibited higher and rapid Cu(II) removal potential than *A.niger.*

2. In the pH range of investigation, the pH 5 appears to be optimum for all the sorbents. As the pH of metal plating waste waters was in the range of 5 to 6, there was no need for pH adjustment. Also at all the pH values, *G.lucidum* showed the maximum metal uptake potential.

3. Of the three sorbents, *G.lucidum* ranked top with Cu(II) uptake as high as 98% followed by waste activated sludge (42%) and *A.niger* (14%). The ionic strength in the range of 0.03 to 0.17 did not have significant effect on metal removal.

4. *G.lucidum* demonstrated its superiority, capacitywise also, yielding the highest Cu(II) sorptive capacity among the three sorbents. The dose of waste activated sludge, the next best sorbent, has to be increased atleast by 4 times and that of *A.niger* by 35 times to have the same efficiency as that of *G.lucidum.*

Thus *G.lucidum,* the wood-rotting, non-edible mushroom, with no cost of procurement and high metal binding affinity qualified itself as a best sorbent in the metal pollution control.

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# Copper Tailings Reclamation : A Microbial Approach

**S. Panigrahi and Pankaj Kumar**
School of Environmental Sciences, Jawaharlal Nehru University
New Delhi 110067

## Abstract

Surface mining and ore processing cause severe environmental degradation in land form. Vegetative stabilization of tailings is the most preferred one from ecological point of view. *Pisum sativum* plants were grown on copper tailings and with some amendments with soil collected from Jawaharlal Nehru University Campus. The *Rizobium* and mycorrhizal inoculations produced better results in terms of plant growth and nutrition when both the microbes were present than individual ones.

## Introduction

Surface mining and ore processing cause profound change in land form which bears little or no resemblance to the undisturbed soil (Wali and Kollman, 1977). Tailings generated are devoid of organic matter, the source of nitrogen, and may be deficient in available phosphorus, potassium and other micronutrients essential for plant growth and development (Boyum *et al.*, 1978).

Several studies of plants colonising industrial waste sites suggest that vascicular - arbuscular mycorrhizal fungi play an important role in reclaiming the disturbed area (Daft and Nicolson, 1974; Khan, 1978) with special reference to mining site. Pot experiments have proved that mycorrhizal fungi increase plant growth in harsh sites (Bethlenfalvay *et al.*, 1982; Daft and Hasckaylo, 1977; Hardie and Leyton, 1981; Lindsey *et al.*, 1977; Saif, 1981) and the survival of the plant (Aldon, 1975). In the copper mining area, plants with mycorrhizal association grew better and survived for a longer period of time(Day and Ludke, 1973; Peters, 1970; Shetron, 1983). In harsh site, the legumes are endomycorrhizal and the growth was manifold (Crush, 1974 and Daft and EL-Ghiami, 1975).

## Material and Methods

The area of sample collection was Hindustan Copper Limited, Khetri. The tailings dam covered an area of 0.975 square million meter with a capacity of 9 million cubic meter. Samples were taken from tailings pond and the field soil sample was collected from Jawaharlal Nehru University (J.N.U.) campus. Pea (*Pisum sativum*) seeds, *Glomus macrocarpus* and *Rhizobium leguminosarum* were collected from Indian Agricultural Research Institute, New Delhi. Pea plants were grown in different treatments of tailings in pots, the treatments being (i) 2 cm top soil on tailings and (ii) 4 cm top soil on tailings. The 2 sets were subdivided into 4 subsets, *viz.* (i) control (ii) *Rhizobium* inoculated plants, (iii) mycorrhizal inoculated plants and (iv) both *Rhizobium* and mycorrhizal inoculated plants. The tailings and J.N.U. soil were autoclaved (15 lbs for 45 min) prior to plantation. Seedlings were grown in a sterilized medium for 48 h. Thirty spores were given below the root in the case of mycorrhizal inoculation (Hall, 1976; Mosse and Hayman, 1980) and roots were dipped into the *Rhizobium* culture in the case of *Rhizobium* inoculation and then transferred to the pots and were grown for 80 days and harvested. Plants were taken out and dried in oven for 72 h at 60°C. Biomass, total nitrogen and total phosphate in plant tissues were analysed.

## Results and Discussion

It was noted that plants in pure tailings died within 4 to 7 days. The data given in Table 1 show that there was better biomass production in the case of combined inoculation of *Rhizobium* and mycorrhizal fungi than the mycorrhizal fungi or *Rhizobium* alone. It is quite evident from the studies that the endomycorrhizal fungi mobilise the micronutrients and sometimes macronutrients from the soil solutions, hence the biomass production was better than the non-mycorrhizal plants (Daft and EL-Ghiami, 1975; Hardie and Leyton, 1981 and Naffelen and Schenck, 1984). It can also be noted that the pod weight and number were quite high in the case of mycorrhizal infection. When the plant was inoculated both with *Rhizobium* and fungi, then pod weight was always more (Islam and Yanaba, 1981 and Smith, 1982).

Table 1. Effect of microbial treatment of copper tailings on the growth of *Pisum sativum*

| | Biomass (g/plant) | | Pod weight and number (in g) | |
|---|---|---|---|---|
| | 2 cm topsoil | 4 cm top soil | 2 cm top soil | 4 cm topsoil |
| Control | 0.16 ± 0.02 | 0.14 ± 0.015 | 0.06 2 pods | 0.3 5 pods |
| Rhizobium | 0.19 ± 0.016 | 0.18 ± 0.011 | 0.12 2 pods | 0 .24 2 pods |
| Mycorrhiza | 0.27 ± 0.09 | 0.28 ± 0.06 | 0.14 3 pods | 0.31 4 pods |
| Rhizobium+ Mycorrhiza | 0.28± 0.04 | 0.34 ± 0.08 | 0.75 10 pods | 0.82 9 pods |

The nitrogen as well as phosphate content were quite high when plants were treated with both *Rhizobium* and mycorrhiza (Table 2) than *Rhizobium* or mycorrhiza alone as earlier evidenced by Bowen and Smith (1981), Bledsoe and Zasoski (1983), Carling *et al.* (1978) and Stribley and Read (1976). So it can be concluded that legumes with *Rhizobium* and mycorrhizal fungi can be tried for the reclamation of copper tailings with some amendments in tailings.

Table 2. Effect of microbial treatment of copper tailings on the chemical composition of *Pisum sativum*

| | Nitrogen (mg/g) | | Phosphate (mg/g) | |
|---|---|---|---|---|
| | 2 cm topsoil | 4 cm top soil | 2 cm top soil | 4 cm topsoil |
| Control | 2.9 ± 0.48 | 7.38± 2.65 | 1.29± 0.08 | 0.79± 0.2 |
| Rhizobium | 10.97± 2.2 | 11.55± 1.83 | 0.98± 0.16 | 1.31± 0.19 |
| Mycorrhiza | 3.82± 0.51 | 8.39± 3.6 | 1.0 ± 0.14 | 1.33± 0. 59 |
| Rhizobium+ Mycorrhiza | 11.44 ± 1.32 | 12.69± 2.6 | 1.16± 0.14 | 1.71± 0.62 |

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# Effect of Treated Municipal Wastewater on Organic Matter and Nitrogen Content of Soil

**Mukesh Kumar, S. Roychoudhary and A.K. Bhattacharya**

School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067

## Abstract

Raw and treated sewage effluents were applied in soil columns for 60 days to study their effect on organic matter and nitrogen content of the soil. Four soil samples were collected from the columns at different depths at 15 day intervals and analyzed for pH, organic matter and available nitrogen. It has been observed that the primary treated and secondary treated sewage effluents were suitable for irrigation purpose. The column study revealed that there was an accumulation of organic matter and nitrogen in the uppermost layer and the subsequent layers also showed a definite distribution pattern. The available nitrogen was found to be highly correlated with organic matter ($r = 0.935$) while available nitrogen and organic matter had a significant negative correlation with pH of the soil.

## Introduction

Sewage irrigation is the best substitute for manures and fertilizers for soils poor in organic matter and plant nutrients. In addition to organic matter and nitrogen, sewage contains other important plant nutrients, such as phosphorus. sulphur, potassium, calcium and magnesium with smaller amounts of micronutrients particularly iron, manganese and boron (El-Nennah and El-Kobbia, 1983). Thus greater emphasis is required to be given to the application of municipal wastewaters and sewage sludges to agricultural soils. This will help reduce pollution prospects of surface water (Lance *et al.*, 1982), help economic and scientific disposal of the urban waste and effect nutrient recycling (Boswell, 1975; Day *et al.*, 1982).

The study in point was conducted to assess the physicochemical characteristics with special focus on the status of organic matter and available nitrogen content of the soil irrigated with raw, primary treated and secondary treated municipal wastewaters

## Material and Methods

Soil samples for the present studies were collected from the fallow land adjacent to the Jawaharlal Nehru University nursery, New Delhi. Samples were randomly taken from different points of the field upto a depth of 15 cm. The soil was air dried, passed through a 2 mm perforated sieve (Indian Standard, 1983) and filled in 60 cm PVC columns provided with side holes at regular intervals through which soil samples were taken out periodically for analysis.

After stabilizing the soil columns, different sewage effluents, *viz.* raw, primary treated and secondary treated collected from Okhla Sewage Treatment Plant, New Delhi, with tapwater as control, were poured into respective columns continuously for 60 days at a fixed rate of one litre a day. The soil samples were taken out from the uppermost layer, 15 cm, 30 cm and 45 cm layers at an interval of 15 days during the course of the experiment.

Standard procedures were followed for soil and wastewaters analysis (Jackson, 1973; Allen, 1974; Anon., 1980). The modified alkaline permanganate digestion method as suggested by Subbiah and Asija (1956) and evaluated by Hussain and Malik (1985) was employed to assess the available nitrogen content of soil as well as effluent samples. Organic matter was determined by the method of Walkley and Black as suggested by Allison (1956), Jackson (1973) and Chopra and Kanwar (1976).

## Results and Discussion

The physico-chemical characteristics of the original soil and sewage effluents have been shown in Table 1. The soil was sandy loam with low organic matter and available nitrogen content.

Table 1. Physico-chemical properties of experimental soil and municipal wastwaters

| Parameter | Soil | Municipal waste waters* | | |
|---|---|---|---|---|
| | | Raw | Primary treated | Secondary treated |
| Particle size: | | | | |
| % Sand | 57.4 | — | — | — |
| % Silt | 30.43 | — | — | — |
| % Clay | 12.17 | — | — | — |
| Water holding capacity (%) | 34.5 | — | — | — |
| pH | 8.45 | 7.46 | 7.48 | 7.76 |
| Electrical conductivity (m mhos/cm) | 0.095 | 1.05 | 1.08 | 1.14 |
| Organic matter (%) | 0.446 | 0.024 | 0.011 | 0.005 |
| Available nitrogen (ppm) | 56.0 | 26.85 | 21.65 | 16.05 |
| Available potassium (ppm) | 64.7 | 10.17 | 10.23 | 10.05 |
| Cation exchange capacity (meq/100 gm) | 8.2 | — | — | — |
| COD (mg/l) | — | 274.1 | 172.6 | 58.1 |
| BOD (mg/l) | — | 120.6 | 60.88 | 16.79 |

* Data represent average of duplicate samples collected on three different dates

The values of various parameters obtained for primary and secondary treated effluents in the present study showed that the range of pH, E.C., BOD and COD were well below the tolerance limits prescribed by Indain Standards Institution (Indian Standard, 1965 and 1982). Thus, the effluents from Okhla Sewage Treatment Plant might be utilized for irrigation purposes (Sekar and Bhattacharyya, 1982).

The application of sewage resulted in the decreases of soil pH (Table 2). While the decrease was considerable in th surface layers, it was less pronounced in subsequent layers. This is attributed to the formation of hydrogen ions during nitrification and formation of organic acids. In the surface layer of the soil profile treated with raw sewage, the pH value declined by one unit, i.e. from 8.4 to 7.45 within the first 15 days, However, this

Table 2. Periodic changes of pH in the soil columns under the application of sewage*

| Effluent type | Depth (cm) | 15 days | 30 days | 45 days | 60 days |
|---|---|---|---|---|---|
| Raw sewage | Surface layer | 7.45** | 7.60 | 7.55 | 7.50 |
| | 15 | 7.90 | 8.20 | 8.15 | 8.20 |
| | 30 | 8.00 | 8.15 | 8.30 | 8.35 |
| | 45 | 8.10 | 8.25 | 8.25 | 8.40 |
| Primary treated sewage | Surface layer | 7.65 | 7.75 | 7.60 | 7.65 |
| | 15 | 8.30 | 8.25 | 8.00 | 8.25 |
| | 30 | 8.20 | 8.30 | 8.25 | 8.45 |
| | 45 | 8.20 | 8.30 | 8.30 | 8.45 |
| Secondary treated sewage | Surface layer | 8.20 | 8.00 | 8.15 | 8.35 |
| | 15 | 8.10 | 8.20 | 8.30 | 8.45 |
| | 30 | 8.25 | 8.30 | 8.40 | 8.40 |
| | 45 | 8.00 | 8.35 | 8.35 | 8.50 |
| Tap water | Surface layer | 8.20 | 8.30 | 8.45 | 8.65 |
| | 15 | 8.35 | 8.30 | 8.45 | 8.50 |
| | 30 | 8.30 | 8.40 | 8.50 | 8.55 |
| | 45 | 8.40 | 8.50 | 8.60 | 8.55 |

* pH of original soil = 8.45
** Data represent average of duplicate samples

decrease in pH was comparatively less in other treatments including the control treatment with tap water. Again, while the surface layers experienced considerable change in pH values, the changes in the subsequent layers were less pronounced.

The organic matter content in the soil sample increased considerably after wastewater application as the wastewater was rich in organic matter (Table 3). Similar results were reported by Iskandar (1978). As the raw sewage contained more organic matter than that in other effluents its values were higher in all the layers of the soil columns treated with raw sewage. At the end of the incubation period, an increase of 10 % was observed in the layers of the columns where the primary treated sewage was applied while the increase in organic matter was about 7 % in the case of uppermost layer of the columns administered with secondary treated effluents. However, the increase was less pronounced in the subsequent layers of the columns and the values decreased with depth. This might be due to the fact that most of the organic matter in suspended form accumulated on the upper surface and only a small fraction of it moved downwards in the form of soluble organic matter.

In the case of control treatment the decrease in organic matter of the soil throughout the experiment could be due to the fact that it did not receive any organic matter during the period but loss of carbon might have occurred in the form of carbondioxide through normal microbial decomposition (Spyridakis and Welch, 1976).

Application of sewage effluent also resulted in the increase of available nitrogen of the soil, the increase being more pronounced in the surface layers (Table 4). Available

Table 3. Periodic changes of organic matter in the soil columns under the application of sewage*

| Effluent type | Depth (cm) | 15 days | 30 days | 45 days | 60 days |
|---|---|---|---|---|---|
| Raw sewage | Surface layer | 0.486** | 1.003 | 1.070 | 1.109 |
| | 15 | 0.465 | 0.457 | 0.423 | 0.488 |
| | 30 | 0.466 | 0.466 | 0.457 | 0.477 |
| | 45 | 0.432 | 0.432 | 0.446 | 0.444 |
| Primary treated sewage | Surface layer | 0.446 | 0.490 | 0.468 | 0.488 |
| | 15 | 0.405 | 0.401 | 0.401 | 0.432 |
| | 30 | 0.446 | 0.432 | 0.423 | 0.422 |
| | 45 | 0.405 | 0.432 | 0.432 | 0.466 |
| Secondary treated sewage | Surface layer | 0.446 | 0.445 | 0.446 | 0.477 |
| | 15 | 0.425 | 0.401 | 0.401 | 0.432 |
| | 30 | 0.405 | 0.432 | 0.446 | 0.432 |
| | 45 | 0.405 | 0.401 | 0.432 | 0.443 |
| Tap water | Surface layer | 0.406 | 0.423 | 0.399 | 0.399 |
| | 15 | 0.405 | 0.399 | 0.405 | 0.388 |
| | 30 | 0.425 | 0.405 | 0.399 | 0.339 |
| | 45 | 0.405 | 0.423 | 0.405 | 0.399 |

* Organic matter content of original soil = 0.445%

** Data represent average of duplicate samples

nitrogen in the surface layers of the soil treated with raw sewage increased appreciably within 30 days. The increase was obviously due to the fairly high amount of available nitrogen in the raw sewage effluent. Besides this, nitrogen released through mineralization of organic matter that accumulated on the surface layer of the soil could also account for the high value of available nitrogen in the surface layer. This corroborated the highly significant correlation between organic matter and available nitrogen (r = 0.935). The slight decrease in available nitrogen towards the end might be due to denitrification, volatilization of ammonical nitrogen, incorporation into microbial tissues and adsorption of ammonium ions by organic matter and clay fraction. It also indicated that the rate of loss of nitrogen exceeded the amount entering the soil profile through the sewage effluents

The increase in available nitrogen content was less in the lower layers of all the columns irrespective of the type of treatment. It showed that the soluble nitrogen moved downwards very slowly from the uppermost surface and less nitrogen was retained in the lower layers, which are in a reduced zone, due to denitrification process and immobilization of nitrogen in the bodies of microbial organisms.

Available nitrogen was found to be highly correlated with organic matter, while both the available nitrogen and organic matter had significant negative correlations with pH of the soil (Table 5).

Table 4. Periodic changes in available nitrogen (ppm) of soil under the application of sewage*

| Effluent type | Depth (cm) | 15 days | 30 days | 45 days | 60 days |
|---|---|---|---|---|---|
| Raw sewage | Surface layer | 117.6** | 184.8 | 176.4 | 173.6 |
| | 15 | 65.8 | 72.8 | 61.6 | 72.8 |
| | 30 | 67.2 | 64.4 | 68.6 | 70.0 |
| | 45 | 63.0 | 61.6 | 63.0 | 64.4 |
| Primary treated sewage | Surface layer | 75.6 | 84.0 | 77.0 | 78.4 |
| | 15 | 64.4 | 65.8 | 67.2 | 68.6 |
| | 30 | 67.2 | 68.6 | 64.4 | 64.4 |
| | 45 | 61.6 | 57.4 | 58.8 | 63.0 |
| Secondary treated sewage | Surface layer | 68.6 | 70.0 | 72.8 | 61.6 |
| | 15 | 67.2 | 61.6 | 61.6 | 54.6 |
| | 30 | 61.6 | 57.4 | 56.0 | 49.0 |
| | 45 | 61.6 | 54.6 | 50.4 | 50.4 |
| Tap water | Surface layer | 53.2 | 50.4 | 49.0 | 44.8 |
| | 15 | 50.4 | 51.8 | 50.4 | 46.2 |
| | 30 | 51.8 | 49.0 | 44.8 | 43.4 |
| | 45 | 50.4 | 47.6 | 42.0 | 43.4 |

* Available nitrogen in original soil = 56 ppm

** Data represent average of duplicate samples

Table 5. Correlation coefficient (r) between different parameters

| Parameter | r | t | df | P |
|---|---|---|---|---|
| Nitrogen and pH | −0.775 | 9.66 | 62 | $<10^{-6}$ |
| Organic matter and pH | −0.604 | 5.97 | 62 | $<10^{-6}$ |
| Nitrogen and organic matter | 0.935 | 20.8 | 62 | $< 10^{-6}$ |

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# Effect of Size and Stagnation of Sewage Water Bodies on the Population of Mosquitoes

**R. Selvaraj Pandian and P. Martin**

Post-Graduate and Research Department of Zoology
American College, Madurai 625002

## Abstract

Stagnant sewage water bodies form the breeding ground for medically important insect vectors. A systematic survey conducted at Madurai City showed that the density of vector population had a positive relation with the size of the stagnant sewage water bodies. Proper management of sewage water bodies in the city has been suggested to minimize the vector population.

## Introduction

The relationship between human health and his environment is a two-way process. We improve our living conditions and increase our comforts but the alterations to the environment may be harmful to our health. For example, irrigation projects and dam building, upon which improved food supply depends, can create favourable conditions for vectors of diseases (Kumar, 1987). Profuse use of water for domestic purposes and improper management of sewage water may lead to an increase in stagnant sewage water bodies both in the semi-urban and urban areas. These stagnant sewage water systems pollute the ground water system and also form a favourable habitat for the medically important vectors to breed in large number. An attempt has been made in the present study to find out the relation between the size of the sewage water bodies and the vector population in a few selected areas at Madurai.

## Material and Methods

Eight sites were selected to study the density of vector population at Madurai. The selection of these sites was based on the size of the nearby sewage water bodies which were grouped into four types, namely broad canal with stagnant sewage water body, narrow canal with stagnant sewage water body, narrow canal with running sewage water body and no stagnant sewage water bodies. The study has been carried out in February and March 1989.

The filarial vector *Culex quinquefasciatus* was selected for the present study to assess the impact of sewage water bodies on the population size of vectors. The biting mosquitoes were collected continuously for twenty four hours in the eight sites shown in Table 1. The method adopted by Pandian and Chandrashekaran (1980) was used to collect the mosquitoes. The portion below the knee of the collector was exposed to be bitten by mosquitoes. The alighted mosquitoes were collected in transparent plastic vials.

## Results and Discussion

Walker (1969) defined ground water pollution as an impairment of water quality by chemicals, heat or bacteria to a degree that does not necessarily create an actual public health hazard but does adversely affect such waters for domestic, farm, municipal or industrial use. However, the prolonged retention of sewage water in an area forms a permanent breeding ground for pathogenic viruses and bacteria and a storage ground for ova and cysts of pathogenic worms and protozoans (Kumar, 1987). The present study has shown that sewage water bodies constitute a potential breeding site for medically important vectors. Table 1 shows the number of mosquitoes collected in eight sites and the size of the sewage water bodies near the collection sites. There is a positive relation between the size of mosquito population and the size of the sewage water bodies. Proper management of sewage water system removes the breeding ground of the vectors totally resulting in maximum reduction of the population of vectors. Partial management of sewage water retains a reasonable breeding habitat for the vector and the population is maintained below the economic threshold level. However, improper management establishes favourable breeding habitats of the vectors and their population proliferates heavily. Hence, it has been suggested that proper management of sewage water, i.e. the narrowing down of the sewage water bodies and the prevention of stagnation will be of immense use in the minimization of vector population in cities.

Table 1. Relationship between the population of mosquitoes and size of the nearby sewage water bodies in Madurai City

| Site of collection | Size of the sewage water bodies | Total number of mosquitoes caught/day/man |
|---|---|---|
| Narimedu | +++ | 1170 |
| Goripalayam | +++ | 366 |
| Tirunagar | ++ | 90 |
| Thasildar Nagar | ++ | 51 |
| Chokkikulam | + | 43 |
| Krishnapuram Colony | + | 20 |
| Nagamalai | – | 2 |
| Pasumalai | – | 0 |

+++ Broad canal with stagnant sewage water body
++ Narrow canal with stagnant sewage water body
+ Narrow canal with running sewage water body
– No stagnant sewage water body

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# BOD Removal, Sulp .ide Turnover and Oxygen Production in Series Sewage Stabilization Ponds

**B.B. Hosetti*, G.M. Meti** and H.S. Patil****

*Chh Shahu Central Institute of Business, Education and Research, Shivaji University
Kolhapur 416004

**Department of Zoology, Karnatak University, Dharwad 580003

## Abstract

Observations were made on a series oxidation ponds unit located at Ranebennur in Dharwad District. These ponds were constructed by excavating the ground and are used to purify the city domestic waste waters. The raw waste passing through a settling tank was fed to series unit ponds. The effluent of one pond served as influent for the next in series. The performance of the treatment unit was studied in terms of BOD removal, bacterial kills, $H_2S$ turnover and oxygen production from the effluents. The pH and DO levels increased from pond to pond in series with the increase in aerobicity of the pond media. The study revealed that BOD reduction, bacterial removal and $H_2S$ production are the functions of aerobicity of the aquatic medium.

## Introduction

Perhaps the observation of self purification of rivers has led to the invention of series stabilization ponds. These are primarily used as tertiary treatment facilities to polish the effluents occurring from secondary treatment facilities. These are also widely used to treat raw sewage or settled sewage and effluents from isolated industrial units (Ellis, 1983). Ponds are conveniently classified into three categories, *viz.* aerobic,anaerobic and facultative. Aerobic ponds are shallow and heat up soon during summer in tropical climates and become inimical to pond community. Anaerobic ponds are suitable for strong nature wastes while facultative type ponds which include stabilization ponds may be applicable for all types of biological and trade wastes. However, these types will work more efficiently in series continuation. Hence, the present study on BOD removal, $H_2S$ turnover and $O_2$ production during treatment of domestic sewage in primary, secondary and tertiary ponds operated in series was conducted.

## Material and Methods

The primary ($S_1$), secondary ($S_2$) and tertiary(series unit) stabilization ponds constructed at Ranebennur in Dharwad District, Karnataka State, are operated to treat the community and city wastes. These were constructed by excavating the ground and putting soil on the dike. Inner slopes were provided with stone layers and outer face was turfed. The other details are given in Table 1.

The raw waste, after passing through a settling tank, was fed to the series ponds $S_1$, $S_2$ and $S_3$. The effluents from $S_3$ are used for irrigation purposes. The BOD, $H_2S$, DO and bacterial count were measured according to the procedures given by Anon. (1980). The pH was measured in a digital pH meter. Samples were collected and analysed once in a month from December 1986 to June 1987. The average values of seven readings are presented in Table 2.

Table 1. Characteristics of series stabilization ponds

| Characteristic | Primary pond ($S_1$) | Secondary pond ($S_2$) | Tertiary pond ($S_3$) |
|---|---|---|---|
| Length (m) | 21.3 | 51.8 | 24.4 |
| Breadth (m) | 34.1 | 34.1 | 34.1 |
| Depth (m) | 2.4 | 1.8 | 1.8 |
| Area ($m^2$) | 726.9 | 1,768.3 | 832.1 |
| Capacity($m^3$) | 1,739.8 | 2,558.5 | 1,523.4 |
| Detention time (days) | 2.6 | 5.0 | 4.3 |
| Waste | Domestic sewage | Domestic sewage | Domestic sewage |

Table 2. Quality of wastes in different treatment units in series

| Parameter | Raw waste | $S_1$ | $S_2$ | $S_3$ |
|---|---|---|---|---|
| $BOD_5$ (mg/l) | $298.7 \pm 51.9$ | $149.2 \pm 10.2$ | $87.00 \pm 19.1$ | $31.67 \pm 3.79$ |
| DO(mg/l) | $1.31 \pm 1.20$ | $2.60 \pm 0.60$ | $5.20 \pm 1.40$ | $9.00 \pm 2.70$ |
| pH | $6.7 \pm 0.6$ | $7.2 \pm 0.3$ | $7.6 \pm 0.2$ | $8.4 \pm 0.4$ |
| $H_2S$ (mg/l) | $2.61 \pm 0.5$ | $2.3 \pm 0.4$ | $1.4 \pm 0.6$ | $0.4 \pm 0.3$ |
| Bacteria ($x10^6$/ml) | $97.0 \pm 20.6$ | $54.7 \pm 11.9$ | $46.0 \pm 6.1$ | $23.0 \pm 0.1$ |

## Results and Discussion

The BOD of raw waste was 298.7 mg/l (Table 2). There was an abrupt decline in BOD values in $S_1$, $S_2$, and $S_3$, and the minimum value of 31.67 mg/l was recorded from $S_3$. It is clear that the degradable influents were decomposed and the water was upgraded by the action of microbes, thus a maximum combined effect in overall BOD reduction was reached. The removal of BOD was to the tune of 90%. Dissolved oxygen was meagre in the raw waste (1.31 mg/l) and it tended to increase as the waste passed further in succeeding ponds and maximum oxygen was recorded in the influents of tertiary pond (9.0 mg/l). The pH of the influent was slightly acidic (6.7) and that of primary, secondary and tertiary ponds showed an increasing trend. A maximum pH of 8.4 was noted in the tertiary treatment facility. The $H_2S$ ions were oxidised and later utilised in the metabolic process of various species of algae. The 2.61 mg/l of $H_2S$ recorded in the influent was reduced to a minimum of 0.4 mg/l. The bacterial count of influent waste was $97 \times 10^6$/ml and this was reduced to $54.7 \times 10^6$/ml, $46 \times 10^6$/ml and $23 \times 10^6$/ml in the primary, secondary and tertiary ponds, respectively. The reduction in bacteria in tertiary pond was found to be 95%.

The BOD removal is a function of temperature, detention time, depth and loading (Hosetti, *et al.*, 1985). It is reported that BOD removal is mainly due to proliferating algae in series oxidation ponds.The pH values showed an increasing trend in consecutive ponds. This could be attributed to the intense photosynthetic activity of algae. As a result, DO production increased from pond to pond in series. Thus, the study revealed that the degree of aerobiosis increased in successive ponds. The $H_2S$ production was higher in primary ponds indicating anaerobic conditions. The removal was found to be maximum at higher pH condition prevalent in tertiary pond. The sulphide reduction during daytime may be due to direct oxidation by photosynthetic oxygen produced by algae. Presence of heavy metals in sewage sludges will reduce the sulfide concentration by simultaneous combination with it to form insoluble sulfides (Gloyna,1971). Free sulfides will also be oxidised in the aerobic layers of the ponds to form thiosulfates and free sulfur (Drew,1976).

The sulfate reducing bacteria use sulfate ions as a terminal electron acceptor to produce hydrogen sulfide during anaerobic purification. It is indicated that this production is related to sulfide reducing bacterial number (Patil, 1979). The bacterial number is affected by predators like protozoans, crustaceans, high temperature, increased pH and algal competition (Hosetti,1987).

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# MINI REVIEWS

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# Photochemical Smog : An Insidious Hazard

**Swapan Chandra Deb**
School of Environmental Biology, A.P.S. University, Rewa 486003

## Abstract

Photochemical smog is increasing alarmingly all over the world. It is dispersed all over Europe and many other countries. The increased use of different stacks and particle removers has increased some metals and nitrogenous compounds which are transported atmospherically forming photochemical smog in combination with ultraviolet rays of the sun. For combating photochemical air pollution, many countries subscribing to the Cleaner Air Convention have now agreed to reduce nitrogen oxide ($NO_x$) emission levels by 25% by 1990-93. In India, improved stock taking, surveillance and research are most essential both at the administrative and academic levels to understand and minimise this invisible danger. The ecological effects of photochemical smog on atmosphere, vegetation, ecosystems and human health, and the various control measures for minimising photochemical smog are reviewed in this paper.

## Introduction

'Smog' is the unpleasant combination of 'smoke' and 'fog' coined by a British physician in 1905. Basically, photochemical smog is a reaction product from hydrocarbons, oxides of nitrogen or sulphur in the presence of ultraviolet rays of the sun. Photochemical smog is a burning problem all over the world. It is a modern, post-industrial form of ruination which is disturbing the forest, cropland and water ecosystems. It is also dangerous to human health and materials.

Some common oxidants required for photochemical smog formation are ozone ($O_3$), hydrogen peroxides, organic peroxides ($ROOH^-$), organic hydroxides (ROOH) and peroxyacyl nitrate (PAN). Among the various oxidants, ozone ($O_3$) is the indicator of photochemical smog formation. Hydrocarbons, olefins, oxides of nitrogen, oxides of sulphur and ultraviolet rays of the sun are the raw materials for photochemical smog (Pryide, 1973).

Two types of smog are recorded all over the world:

(i) Los Angeles smog consisting of sulphur oxides and particulates and

(ii) British smog consisting of nitrogen oxide and particulates.

## Probable Mechanism of Photochemical Smog Formation

The exact mechanism of photochemical smog formation is not known. The probable mechanisms contain two basic processes, i.e. (a) primary process and (b) secondary process.

(a) *Primary process*

Photodissociation of nitrogen dioxide takes place resulting in the formation of nitric oxide and atomic oxygen by absorption of UV rays of the sun in two steps.

$$N_2 + O_2 \xrightarrow{\text{(Complex reaction)}} NO + NO_2$$

Where $NO > NO_2$

$$NO_2 + h\nu \longrightarrow NO + O$$

(Bulter, 1979)

(b) *Secondary process*

Thermal reactions among the products of primary process take place in the presence of various dust particles or metallic substances.

$$O + O_2 + M \longrightarrow O_3 + M$$

Ozone ($O_3$) being a strong oxidizing agent oxidizes available nitrogen oxide to nitrogen dioxide.

$$O_3 + NO \longrightarrow NO_2 + O_2$$

This reaction is less effective and indicates the involvement of hydrocarbons in the formation of photochemical oxidant with the buildup of $O_3$ and other oxidation product such as PAN, etc.

Some of O and $O_3$ react with non-methane hydrocarbons like olefins, aromatics, etc. to form oxidized compounds and free radicals which react with NO to form more $NO_2$. Peroxyacyl nitrate (PAN) is formed in a side reaction with aldehyde as follows:

$$R\text{-}CHO \xrightarrow{HO} R\text{-}CO \xrightarrow{O_2} R\text{-}CO\text{-}O\text{-}O \xrightarrow{NO_2} R\text{-}CO\text{-}O\text{-}O\text{-}NO_2$$

| R-CHO | R-CO | R-CO-O-O | R-CO-O-O-NO2 |
|---|---|---|---|
| Aldehyde (where $R=CH_3$) | Acylradical | Peroxyacyl radical | Peroxyacy nitrate (PAN) |

## Historical Evidence

Photochemical smog formation was first recorded in London (U.K.) in 1905. Since then, each and every year it was recorded in some parts of the world. The major incident of smog formation was shown in Los Angeles (USA) in 1940 which consisted of oxides of sulphur and particulates in combination with metal and dust particles. In England it was seen during 1952 to 1955. It was also recorded in Scandinavia (1960-62), St. Louis (USA) (1969), China (1984) and India (1987). In addition to the above mentioned major incidents, minor occurrences are being recorded all over the world every year (Anon., 1987).

## Current and Future European Emission

Industrialization and automation are two important features of the European countries. Due to over industrialization, automation and urbanization, oxides of nitrogen ($NO_x$) and sulphur dioxide ($SO_2$) are released into the atmosphere at tremendous speed. Sudden increases in $SO_2$ emission were recorded in 1950s in Europe. In 1970s total emissions of $NO_x$ and $SO_2$ were at a constant level. Emission of oxides of nitrogen doubled between 1959 and 1973. It was declared by environmentalists that Sweden alone will release 80% sulphur (S) around 1995. In 1975 about 211000 tons of $SO_x$ were released. In 1983, 300000 tons of $SO_x$ were released. Around the year 2010, without any preventive measures, the emission of oxides of sulphur ($SO_x$) and nitrogen ($NO_x$) will increase by fourfolds.

## Photochemical Smog Situation In India

In India the problem of smog and acid precipitation was first recorded in Bombay in 1974. Later it was also recorded in Bombay, Delhi, Nagpur and Pune (Khemani, 1989).

Emission of $SO_2$ from the fossil fuel increased from 1.4 millions tons in 1966 to 4.5 million tons in 1986 and will increase remarkably around 2000 A.D. $SO_2$ concentration increased from 1.3 to 1.5 mg $m^{-3}$, i.e. 10 times higher than the 8 h standard for industrial areas (Anon., 1987). Inhabitants of coal belts of Jharia-Raniganj at Dhanbad are facing respiratory disorders (Anon., 1987). Pollutants in the air of that area far exceeded the standard air quality measures. Greater percent of $SO_2$, $NO_x$ and CO were found in and around the Jagannath open cast mining area (Anon., 1989).

## Consequences

Recent investigations revealed that photochemical smog affects the atmosphere, plants, animals and materials.

*Physical properties of the atmosphere*

Photochemical smog covers a wide area reducing visibility to as low as about half a kilometer. It also increases the air temperature by local 'green house effect' phenomenon. Formation of haze cloud is an important feature of photochemical smog (Bell, 1988). It can also decrease the sun's ultra-violet output in the course of the natural 11 years solar cycle (Tan, 1989).

*Vegetation*

Photochemical smog is injurious to vegetation. It causes lesions in the leaves, surface bleaching, bifacial necrosis and chlorosis of leaves and green parts of the plants. Ozone of the photochemical smog causes chlorotic stippling and necrotic spots in leaves, reduces photosynthesis rate and destroys pallisade cells. In addition, chronic injury in plants and induced resistance in plant pathogens were also noticed. Ozone also inhibited sporulation, germination or infection of rust disease (Bambawale, 1988). Peroxyacyl nitrate (PAN) of the smog reduces the rate of respiration tremendously and disturbs the metabolic activity of plants. $NO_2$ of the smog is the raw material of acid rain which causes leaf injury and reduced growth rate of the plants.

*Human health*

Ozone causes skin cancer and irritation of mucous membrane of throat and nose. At high concentrations $O_3$ causes choking and severe fatigue. It also oxidizes lung tissues and causes bronchial irritation, slight coughing and soreness in throat. It also reduces the visual acuity and causes headache. PAN acts as an eye irritator and carcinogen, and decreases the life expectancy. $NO_2$ of the smog enhances carboxy-haemoglobin formation instead of oxyhaemoglobin formation resulting in headache, eye irritation and other physical problems.

*Ecosystem*

The important consequences on ecosystems include elimination of sensitive species, decline in species diversity, removal of overstorey plants, decline in standing crops and decline in nutrient elements in the system (Huchabee, 1988). Ozone limits the biomass production, decreases the energy flow in ecosystems and interrupts essential recycling processes (Woodwell, 1970).

## Control Measures

A complete solution to the problem of photochemical smog is not possible. However, it can be minimised upto a satisfactory level. To minimize the photochemical smog problem, emission of raw materials, such as $H_2S$, $SO_2$, dust particles, CO, $CO_2$, etc. should be checked. The various processes that can be employed to check the raw materials of smog are as follows :

*Liming*

Limestone ($CaCO_3$), lime (CaO) or dolomite ($CaCO_3 . MgCO_3$) can be added to the gases in a combustion chamber to produce sulphates.

*Double alkali method*

A more active alkali (ammonia solution) is used to remove $SO_2$ and this is then recovered by using a second alkali (lime) to produce the sulphate.

*Water*

Water being a poor adsorbent for $SO_2$, can be used in combination with a catalyst of active carbon. Oxidation takes place on the moist catalyst surface and dilute $H_2SO_4$ is produced.

*Direct oxidation*

The direct oxidation of $SO_2$ to $SO_3$ is generally carried out at 450-600°C where the conversion is satisfactory and the rate is fast. $SO_2$ can be recovered for subsequent use in an acid plant.

*Scrubber*

This device is used to remove the oxides of nitrogen. The nitrogenous gases are scrubbed with the alkaline solution, namely Ca(OH), NaOH, $Na_2 CO_3$, etc.

*Control of particulate air pollutants*

In the most general terms, the control of particulate emission involves passing the gases through a chamber in which a force acts on the particulates and removes them from the gas stream. The force may be gravitational, electrostatic, thermal, centrifugal or internal. Devices that collect particles from air stream are settling chamber, cyclones, scrubbers, fitters, and electrostatic precipitators (Bookris, 1977).

In addition to the above mentioned processes, the following are also helpful in minimising pollutants in the transportation systems: (1) vehicular modification by crank case ventilation system, use of devices like catalytic exhausts and exhaust emission control system, (2) transport system management by the incorporation of green belt, better network design to total regional traffic and through various traffic restrain measures, such as parking taxes, vehicle metering and 'HC' emission taxes (Smith, 1986).

## Conclusions

Photochemical smog problems are a characteristic feature of valleys surrounded by mountains near or outside of sea coast. In India, all big cities have serious smog problems in winter from automobiles, industrial and domestic exhausts. Microbial devices for degrading hydrocarbons and particulates, alternate fuels, encouragement for small scale industries, biotechnological approaches for producing fog destroying strains of organisms, prevention of the production of chloroflurocarbon compounds and other $O_3$ depleting compounds and afforestation go a long way in protecting the environment from photochemical smog.

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# Effect of Certain Pollutants on Predatory Ground Beetles (Coleoptera: Carabidae)

**Prasad Kumar, S. Mallikarjunappa and D. Rajagopal**
Department of Entomology, University of Agricultural Sciences, GKVK
Bangalore 560065

### Abstract

Ground beetles (Coleoptera : Carabidae) are highly sensitive and intolerant to a variety of pollutants including petroleum oils, sulphur compounds, automobile exhausts and many currently used pesticides. The residues of chlorinated hydrocarbons, lead and radio active phosphorous have been traced and measured in these beetles. Pesticides, such as chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, fumigants and several herbicides cause significant mortality of naturally occurring predatory carabid beetles. The effect of certain pollutants on these beetles is briefly reviewed.

## Introduction

Ground beetles (Coleoptera : Carabidae) are an important component of soil fauna and the most abundant group distributed throughout the world. Both adults and larvae are predators on many agricultural crop pests, such as caterpillars, grubs, maggots, termites, aphids, snails, slugs, etc. Majority of the species are nocturnal and found in various protected places like under stones, logs, debris, leaf litter, dry leaves, etc. during day time.

The population and activity of carabid beetles are affected by a variety of polluting substances including petroleum oils, air borne sulphur compounds, automobile traffic pollutants and almost all currently used insecticides and herbicides. Several attempts made to use carabids in integrated control of crop pests have not been successful because these are killed by the application of toxic insecticides. The objective of this review is to show how carabids have been used to detect and measure the extent of pollution and to discuss the possible role of carabids as biological monitors of pollution.

## Effect of Oil Pollution on Carabid Beetles

Petroleum oils are potent insecticides and historically have been used for this purpose extensively. These are quite effective in suppressing the activity of predatory beetles in nature. Evans (1970) surveyed the upper littoral zone after oil spill off the coast of Santa Barbara, California, for damage caused to the crevice fauna. The carabid beetle *Thalassotrechus barbarae* (Horn) was selected as a representative indicator of this crevice community. Evans observed that *T.barbarae* was not found in the localities that were subjected to heavy or moderate deposits of oil. It is probable that populations of *T.barbarae*, which quite likely existed in these areas before, were killed along with other members of the high littoral crevice community by the oil.

## Effect of Atmospheric Pollutants on Carabid Beetles

*Sulphur compounds*

Atmospheric pollution by sulphur compounds from factories and sulphur mines has a considerable impact upon the surrounding predatory beetles. Carabid populations were investigated in five localities that were 900, 1200, 1650, 2100 and 2700 yards to the east of Kraft paper mill. Adrastic progressive reduction in the number of Carabids was recorded with increasing proximity to the mill. This reduction due to the fall out from the mill was related to either sulphate ion or sulphur compounds released into the air from the mill (Frietag and Hastings, 1973). Przybylski (1974) observed the absence of carabid population in wheat fields or grasslands near factories due to the toxic effect of sulphur dioxide released from them. Przybylski also remarks that observations over a long period should help to decide if it is possible to use these beetles as a kind of index bioindicator in the presence of sulphuric emanations in the atmosphere.

*Traffic pollution*

The activity of ground beetles is also reduced by the continuous movement of vehicles on roads. Maurer (1974) examined the fauna of carabids at the edge and in the interior of grassland adjacent to a very busy road and a little used road. The number of species and individual specimens of carabids were significantly lower at the edges of the busy road. The presence or absence of lead within the body was taken as an indicator of motor vehicle pollution. Individuals of the ground beetles *Carabus auratus* and *Pterostichus cupreus* captured near the edge of the busy road showed a significantly higher level of body lead than those captured in the middle of the field. Zhulidov and Emets (1979) estimated the lead content in the body of three species of *Carabus* in contaminated environments associated with automobile exhausts. They had lead contents of 104 to 131 mg/10 kg dry weight for the parking lot samples which decreased to 84 to 94 mg /10 kg dry weight by the roadway 600 m from parking lot and18 to 24 mg/10 kg in an oak grove.

## Effect of Herbicides on Carabid Beetles

Herbicides are quite toxic not only to plants but also to beneficial predators like carabids. Herbicides, such as 2,4-D, Chlorpropham, Simazin, Aphalon, Mesoranil, Semeron and Tripluralin cause mortality when applied at normal dosages. Tripluralin sprayed plots had the lowest number of eggs and fifth instar larvae of *Pieris rapae* and highest mortality of the carabid beetle *Harpalus rufipes*, a predator of *P.rapae* (Dempster, 1969).

## Effect of Insecticides on Carabid Beetles

Influence of insecticides and their residues on carabids has been studied by several workers. Almost all groups of insecticides, such as chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids and fumigants cause significant mortality of the naturally occurring beetles and as a result the natural control of pests by these predators may be reduced.

Incorporation of lindane into the surface layer of soil at 1 kg/ha in sugarbeet fields reduced the numbers of *Bembidion* spp. (Hossfeld, 1976). Dieldrin at concentrations below the required level to control cabbage root fly was toxic to several species of carabids which prey on immature stages of this fly (Mowat and Coaker, 1967). The carabid beetle *Harpalus* *rufipes* which climbs the plants and feeds on the young larvae of *Pieris rapae* was killed by the concentration of DDT that was used to control this pest (Dempster, 1968). Accumulated chlorinated hydrocarbon residues have been identified and measured in a number of carabid beetles common in crop fields (Thompson, 1973). This was demonstrated in *Harpalus pensylvanicus* and *Poecilus chalcites* by Sellers and Dham (1975) and Korschgen (1970).

Although organophosphorus insecticides are less persistent in soil than chlorinated hydrocarbons, they appear to have caused reduction in carabid popaulations for long periods. For example, Critchley (1972a) assessed the effects of soil applied thionazin on populations of carabids in potato field. Thionazin considerably reduced numbers of carabids upto eight weeks after application. Lower catches occurred again six months later when treated soils were rotated after harvesting the potato crop. The lower catches were attributed to the exposure of carabids to thionazin residues which had leached into deeper layers of the soil. Similarly, the toxicity of parathion (Van Dinther, 1963), methyl parathion and methomyl to both larvae and adults of *Calosoma sayi* in soybean fields (Price and Shepard, 1978) and phorate and terbufos granules, and carbofuran and carbaryl sprays to field collected adult beetles (Gholson *et al*., 1978) has been established. *Andersen and Sharman (1983) studied the effect of chlorofenvinphos and isofenphos on* carabids and their predation on eggs of turnip root fly *Delia floralis* in Swede fields. In the untreated plot 41.0% of the eggs were eaten in two or three days whereas in the isofenphos treated plot this proportion was only 24.4%. The catch of carabids was 49.9% lower in the isofenphos treated plot compared with the untreated one. Amongst carbamates, the residues of sevin were highly toxic to carabids for upto 12 months (Doane and Schaeffer, 1971).

Amongst synthetic pyrethroids, very few were found causing beetle mortality. Deltamethrin applied in winter fields to control cereal aphids reduced 30% of the beetles in the treated plots compared with control plots (Matcham and Hawker, 1985).

Immediate and long term effects of the soil fumigants ethylene dibromide, chloropicrin and dazomet were noticed on carabid beetles. All the compounds tested were initially toxic or repellent, as indicated by a fall in number, with dazomet appearing to have the greatest effect soon after application (Critchley, 1972 b).

## Conclusions

Carabids are natural predators of many phytophagous insects but are highly sensitive and intolerant to a variety of polluting substances. The findings of several research workers indicated that insecticides and their residues reduce populations of beneficial carabids and thereby increase pest populations in agricultural crops. Measurable quantities of residues of chlorinated hydrocarbons, lead and radioactive phosphorus have been found in carabid beetles, suggesting that these beetles can effectively serve as bioassay organisms for other persistent chemicals, heavy metals and radioactive substances.

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# Effect of Carbofuran on Beneficial Microorganisms – An Overview

**H.N. Vijayalakshml and Krishne Gowda**

Department of Agricultural Microbiology, University of Agricultural Sciences
Bangalore 560065Nnn

## Abstract

In recent years, carbofuran is being increasingly used in rice cultivation as probably the most effective insecticide for controlling brown planthopper (*Nilaparvatha lugens* Stall), a major pest of the crop. There is considerable literature on the fate of organochlorine and organophosphorous pesticides in soil. But the information on the fate of carbamate pesticides in soil environment and also their effect on non-target organisms is scanty. This review outlines the effect of carbofuran on agriculturally important microorganisms.

## Introduction

Pesticides play an important role in maintaining agricultural productivity but they also cause pollution of air, water, soil and food with possible adverse effects on human and animal health. In tropical developing countries organochlorine pesticides are still widely used for reasons of low cost, ready availability and indigenous capability to produce these pesticides. However, because of increasing concern over their effects on environment, efforts are being made to use organophosphorous and carbamate pesticides as a replacement for organochlorines. Carbamate and organophosphorous pesticides are increasingly recommended for control of specific pests not controlled by organochlorines. For instance, carbamates, such as carbaryl, carbofuran and 2–isopropylphenyl N–methyl carbamate (MIPC) are being used as most effective insecticides against the brown planthopper (*Nilaparvatha lugens* Stall), a major pest of rice in the tropics and sub-tropics.

Carbofuran (2,3-dihydro-2, 2-dimethyl-7 benzofuranyl N-methyl carbamate) is a broad spectrum, long residual insecticide and nematicide effective by contact, stomach and systemic action. It is particularly effective as a soil treatment for the control of soil insect pests (Apple *et al.*, 1969; Berry, 1971; Tappan, 1967). This review summarizes the effect of carbofuran on agriculturally important micro-organisms.

## Effect of Carbofuran on Microbial Population

Carbofuran at 1 and 5 ppm was inhibitory to the population of bacteria and fungi in sandy loam (pH 8.2) upto 4 weeks of incubation at 28°C but not at 5°C (Tu, 1972 and 1973). The microbial activity in rice rhizosphere was little affected by carbofuran (Kandaswamy *et al.*, 1975; Visalakshi *et al.*, 1980). But Venkateswarlu and Sethunathan (1978) found that its application led to almost four fold increase in bacterial population in the rhizosphere of rice plants over that of untreated controls. Similarly, its application led to 100 to 300 % increase in bacterial and actinomycete population (Mathur *et al.*, 1976 and 1980). Increases in microbial populations in rice rhizosphere were also reported by Jayachandran and Chandramohan (1977). Carbofuran application to a rice soil at 1.5 Kg a.i./ha was not deleterious to fungal and actinomycetes populations but bacterial population was inhibited (Purushothaman *et al.*, 1976). Carbofuran initially depressed the bacterial and fungal population in the rhizosphere of sorghum (Kandaswamy *et al.*, 1977) and of mung and wheat (Singh and Prasad, 1974 and 1979). At 1, 10 and 50 ppm a.i., it caused significant reduction in bacterial but not actinomycete and fungal population in a sandy loam soil (Tu, 1978; Miles *et al.*, 1981), an organic soil (Miles *et al.*, 1981) and in a soil under soybean crop (Varshney and Rana, 1981). At field recommended rates its effect on soil microflora was non significant (Varshney and Rana, 1987). However, it is known to stimulate bacterial and fungal populations in organic soil (Tu, 1979) and fungal populations in organic and clay soils (Tu, 1981).

Non-symbiotic nitrogen fixers were stimulated by carbofuran in the sandy loam soil and little affected in the organic and clay loam soils. The insecticide was inhibitory to the development of vesicular-arbusucular mycorrhiza in groundnut (Buckman and Clark, 1977) and innocuous in potato (Ocampo and Hayman, 1980).

### Effect of Carbofuran on Nitrogen Fixation

The nodulation and yield of groundnut (Kulkarni *et al.*, 1974) and nodulation and growth of soybean (Reddy and Rao, 1975) inoculated with *Rhizobium* spp. were not adversely affected by carbofuran. The insecticide was non toxic and had stimulatory effect on *Rhizobium* in groundnut (Joshi and Kulkarni, 1987). The ability of excised nodules of soybean plants to reduce acetylene was not inhibited by carbofuran (Rodell *et al.*, 1977) but in pure culture studies, it inhibited the growth of *Rhizobium* from redgram and the inhibition increased with insecticide concentration (Oblisami *et al.*, 1973). Likewise, it inhibited the growth of *R. leguminosorum and R. trifoli* and not of *R. meliloti* and *R.japonicum* (Lin *et al.*, 1972). The insecticide enhanced the incorporation of $^{14}C$-carbon in the whole cells of *Rhizobium* spp. but inhibited its growth *in vitro* and also reduced the nodule respiration, number and weight in cowpea plants (Palaniappan and Balasubramanian, 1983a and b).

Carbofuran was not toxic to *Azotobacter vinelandii* (Rodell*et al.*, 1977). In a sandy loam soil, at 5 and 10 ppm, it inhibited nitrogenase activity, measured by $C_2H_2$ reduction, between 2 and 6 days and increased the population of nonsymbiotic nitrogen fixers after 6 days of incubation (Tu, 1978). But in a clay loam and an organic soil, neither $C_2H_2$ reduction nor the population of non-symbiotic nitrogen fixers were affected by the insecticide applied at the same rates (Tu, 1979 and 1981). Nitrogen fixation by *Azospirillum* and anaerobic- $N_2$ fixers in 5 soils amended with cellulose was accelerated by 5 ppm of carbofuran (Nayak and Rao, 1980). This stimulation by carbofuran was noticed even when applied in combination with benomyl (Nayak and Rao, 1982). Carbofuran, irrespective of mode of application, stimulated the rhizosphere nitrogenase activity almost throughout the growing period of rice (Rao *et al.*, 1982 and 1983). The $C_2H_2$ reduction activity in the flood water of a submerged soil was stimulated by its application (Tirol *et al.*, 1981). Jena *et al.* (1987a) reported that carbofuran at 5 and 10 ppm significantly stimulated nitrogen fixation in the case of *Azospirillum* while IAA production by *Azospirillum* cultures was more pronounced at lower concentration in submerged soils. The insecticide showed no adverse effect on growth and acetylene reduction activity of a certain isolates of $N_2$ fixing endorhizosphere bacteria of wetland rice. In general, there was a stimulation of acetylene reduction activity (Vijayalakshmi, 1988).

Carbofuran enhanced survival, growth and nitrogen fixation of a blue green alga (*Nostoc muscorum*) at 25 ppm a.i. but showed algicidal properties at 1200 ppm a.i. (Kar and Singh, 1978a). It was a potential mutagen of *N. muscorum* (Kar and Singh, 1979a) and its toxicity to alga was dependent on pH, light intensity, population and nutrients (Kar and Singh, 1978b and 1979b). Both *N.muscorum* and *N.bharwajal* were capable of accumulating carbofuran from the nutrient medium within 10 to 15 days of inoculation (Kar and Singh, 1979a and 1979b).

### Effect of Carbofuran on Ammonification

There are several reports on the stimulation or inhibition of ammonification and nitrification processes in soil. A slight inhibition of these processes may be beneficial for efficient utilization of added fertilizers.

Tu (1972 and 1973) reported that carbofuran increased the production of ammonia from added peptone by 1 to 10 percent in a sandy loam soil. Likewise, it affected slight stimulation of nitrogen mineralization (Ross, 1974). But ammonification in an organic soil was not altered significantly (Mathur *et al.*, 1976 and 1980). There are also reports of significant inhibition of ammonification activity in the soil by the insecticide (Rajukkannu *et al.*, 1976; Sundaram *et al.*, 1977). Carbofuran applied at 10 ppm a.i. was not inhibitory to the mineralization of native soil nitrogen of a flooded soil (Tirol *et al.*, 1981). Sahrawat (1979) reported that at 10 and 50 ppm of soil in a sandy loam soil (pH 7.7) it did not show any effect on urea hydrolysis. Soil urease activity was little affected by the insecticide at 10,50 and 100 ppm (Sahrawat, 1981).

### Effect of Carbofuran on Nitrification

Among the biochemical processes in soils nitrification is probably the most sensitive to pesticides. Several reports have shown that carbofuran at 5 to 500 ppm was not inhibitory to nitrification in terms of nitrate formed (Lin *et al.*, 1972; Mathur *et al.*, 1976 and 1980; Palaniappan and Balasubramanian, 1986; Ramakrishna *et al.*. 1978; Ross, Sundaram *et al.*, 1977; Tirol *et al.*, 1981; Tu, 1972 and 1973; Turner, 1979). In contrary to this, carbofuran significantly stimulated nitrate formation (Mathur *et al.*, 1976 and 1980; Oblisami *et al.*, 1979; Ross, 1974; Tirol *et al.*, 1981) which was attributed to the formulation of the insecticide (Ramakrishna and Sethunathan, 1982).

Inhibitory effects of carbofuran on nitrification have also been reported (Rajukkannu *et al.*, 1976). Carbofuran was inhibitory to both ammonium and nitrite oxidation in a sandy loam soil (Sahrawat, 1979). It inhibited nitrification of added and native $NH_4^+N$ to nitrate in a vertisol during the first 10 days (Turner, 1979). It inhibited only *Nitrosomonas* in pure culture at concentrations of 7.5 and 10 μg/ml (Kukreja and Mishra, 1987). The effect of carbofuran and its degradation products on nitrification depends on the concentration of the chemical as well as the characteristic of the isolate studied. Therefore, it is not possible to generalize the effect of carbofuran and its degradation products on nitrification (Vijayalakshmi, 1988).

### Effect on Sulfur Oxidation and 'P' Solubilization

Sulfur oxidation in a sandy loam soil was little affected by carbofuran (Tu, 1972 and 1973). At 1 to 250 ppm, it inhibited sulfur oxidation in a soil upto 7 days but thereafter stimulated it (Wainwright, 1979). Carbofuran and its degradation products had no adverse effects on 'P' solubilizing activity of four 'P' solubilizing bacteria of wetland rice (Vijayalakshmi, 1988).

## Conclusions

The effect of carbofuran on soil microorganisms is highly variable and it appears to be dependent on organism and its isolates, soil characteristics, formulation and concentration of the chemical, etc. A clear understanding of the impact of the insecticide on soil microorganisms requires detailed studies under variable soil conditions.

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# Weeds as Environmental Pollutants

**M. Bharatha Lakshmi, Salomi Bina Simon and Mir Mustafa Husain**
Department of Agronomy, College of Agriculture
Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad 500030

**Abstract**

Weeds not only compete with crop plants for growth resources like light, moisture, nutrients, etc. but also cause harmful effects on plant and animal life by polluting the environment. Plant parts like roots, leaves, shoots and seeds produce toxicants which escape into the environment by weathering, exudation, leaching and volatalisation. Weeds like *Argemone mexicana*, *Sorghum halepense*, *Parthenium hysterophorus* and *Tribulus terrestris* produce toxic compounds like senguinarine, hydrocyanic acid, parthenin and sapogenins, respectively, that show adverse effects on growth and development of other crop plants. Besides polluting the soil environment, weeds like *Parthenium* and *Xanthium* cause health hazards to both livestock and human beings.

## Introduction

Environmental pollution has become a matter of much concern endangering plant and animal life on earth. Misuse of crop production techniques, such as indiscriminate use of insecticides, fungicides, and weedicides, and large scale use of chemical fertilizers has significantly added to the problem. Besides these pollutants, certain weeds produce toxic substances and thereby cause harmful effects in other companion plants as well as livestock and human beings.

Harmful effects of certain plants on others have prompted scientists to study plant-plant interactions. The phenomenon of allelopathy refers to any direct or indirect harmful effects of one plant on another through production of chemical compounds that escape into the environment. This kind of study is of recent origin and the present paper briefly reviews the pollution caused by weeds.

## Mode of Liberation of Toxic Substances

Toxic substances from the site of synthesis may be liberated into the environment by various processes. Table 1 presents these processes with examples.

Table 1. Mode of liberation of toxic substances

| Mode of liberation | Weed or crop | Plant part | Source |
|---|---|---|---|
| 1. Weathering | Alfalfa | Roots | Oleszek and Jurzysta (1987) |
| 2. Leaching | Velvet leaf | Leaf | Cotton and Einhelling (1980) |
| 3. Exudation | *Asparagus afficinalis* | Roots | Shafer and Garrison (1986) |
| 4. Volatalisation | *Parthenium hysterophorus* | Leaves | Sukhada, (1978) |

## Chemical Nature of Toxic Compounds

Most toxic compounds are secondary substances. Rice (1974) reported a scheme with 15 categories to which the toxic compounds belong. These are : (a) simple water soluble organic acids, straight-chain alchohols, aliphatic aldehydes and ketones (b) simple unsaturated lactones (c)long-chain fatty acids (d) naptho quinones and anthraquinones (e)terpenoids and steriods (f) simple phenols, benzoic acid and derivates (g) cinnamic acid (h) coumarins (i) flavonoids (j) tannins (k) amino acids and polypeptides (l) alkaloids and cyanohydrins (m) sulphides and mustard oil glycosides (n) purines and nucleosides (o) miscellaneous compounds. Seeds of several species of Rosaceae contain large amounts of cyanogenetic glucosides and release hydrocyanic acid which inhibits seed germination (Evenari, 1949). Toxic principles are found in several common weeds (Parihar and Kanodia, 1987).

## Mode of Action of Inhibitors

Toxic compounds produced in donor plants affect the recipients due to inhibitory action on various metabolic processes like cell division, cell elongation, photosynthesis, respiration, protein synthesis, membrane permeability, enzyme activity and nutrient uptake.

## Impact of Weeds on Plants and Plant Communities

Chemical substances liberted from different plants are ecologically important because these influence the dominance, productivity, species diversity and composition of plant communities, and vegetation dynamics (Whittaker, 1970). Allelopathic principles are known to affect the yield of other plants. For example, flax plants in the proximity of *Camelina alyssum* plants produced 40% less dry matter than the control which might be due to the leaching of toxic substances from leaves of *C.alyssum* (Grummer and Beyer. 1960).

Aqueous extracts of stem (Afeq and Sinha, 1970) and leaf extracts (Bhownik and Doll, 1979; Drost and Doll, 1980) are known to affect germination and seedling growth of several crop plants. Phytotoxic principles prevailing in fruit pulp of *Solanum surattense* hindered the germination of *Pennisetum typhoideum* and *Sesamum indicum* (Sharma and Sen, 1971).

Root extracts of several plants are known to possess allelopathic potential. For example, water extract of fried and ground rhizomes of quackgrass and aqueous solutions of the phytotoxin significantly inhibited seedling root growth of corn, oat, cucumber and alfalfa (Gabor and Veatch, 1981). Growth of leaves and roots of wheat was significantly reduced by root exudates of wild oat (Schumacher *et al.*, 1982).Water extracts of roots of canada thistle reduced germination of subterranean clover (Bendall, 1975). The tubers of yellow nutsedge (*Cyperus esculentus* inhibited the growth of oat coleoptile and germination of several crops (Tames *et al.*, 1973). Similar inhibitory effects of tubers of *Cyperus rotundus* on sorghum and soybeans (Lucena and Doll, 1976) and purple nutsedge on radish, onion and tomato seedlings (Meissner *et al.*, 1970) were reported. Extracts of some plants are also known to inhibit the growth of nitrogen fixing bacteria (Rice, 1964).

Phytotoxins leaching from dead gaint foxtail (*Setaria faberii*) tissue reduced corn growth by as much as 50% (Bell and Koeppe, 1972) while decaying underground organs of Johnson grass in soil and ethanolic extracts of soils containing decaying underground parts retarded both root and shoot growth of barley (Horowitz and Friedman, 1971).

*Parthenium*, an introduced weed of our country, is known to release phenolic growth inhibitors into the environment which negatively affect the growth of other plants growing in its vicinity (Parihar and Kanodia, 1987). Water soluble inhibitors of fruits and receptacles of *P.hysterophorus* adversely affected the seedling growth of wheat (Lakshmi Rajan, 1973). Aqueous extracts of leaves, stem and root inhibited germination in wheat and gram (Subba Rao *et al.*, 1977), germination as well as seedling growth of maize, greengram and sesame (Ravindranath, 1981) and chlorophyll production by cotyledons of radish, cabbage and cauliflower (Dubey *et al.*, 1979). Aqueous extracts of shoots arrested growth of peanut,. sunhemp and blackgram seedlings whereas germination was unaffected (Sarma *et al.*, 1976). Root exudates and decaying leaves inhibited nodulation in Burpees stingless bean and cowpea (Sukhada and Jayachandran, 1980).

*Parthenium*, besides polluting the soil with its water soluble toxins, also causes pollution of atmosphere by the dispersal of its pollen grain. Pollen deposited on leaves reduced chlorophyll content of leaves of certain plants (Sukhada and Jayachandran, 1980). Accumulation of pollen grains of parthenium on floral parts reduced grain filling in maize by 50%, and inhibited development of fruits in brinjal (Sukhada and Jayachandran, 1976), tomato, chillies and field bean (Char, 1977).

## Impact on Livestock

Besides affecting the growth and development of other plants by producing toxic substances, weeds were also found to be detrimental to livestock. Cows which passed through patches of *Parthenium* had inflamed udder and subsequently suffered from fever and rashes (Krishnamurthy *et al.*, 1977). Repeated contact of young rabbits with *Parthenium* caused their death (Sundara Rajulu and Gowri, 1976). Ingestion of *Parthenium* by buffaloes and bull calves caused both acute and chronic forms of toxicity (Narasimhan *et al.*, 1980; Parihar and Kanodia, 1987). Several other exotic weeds like *Xanthium strumarium, Tribulus terrestris, Lantana camara, Agrostema githago,* etc. possess toxic constituents that cause poisoning and pathological disorders in grazing animals (Parihar and Kanodia, 1987).

## Impact on Human Beings

Several plants belonging to sunflower family like *Chrysanthemum, Ambrosia, Xanthium* are known to be allergic to human beings. Arvind Lonkar (1976) reported itching in men engaged in outdoor work due to parthenium. *P. hysterophorus* pollen as an etiological factor in chronic eczematoid dermatitis was first detected by Shrinivas Ranade (1976). Parihar and Kanodia (1987) reported that weed species like *X.strumanium, Tribulus,* etc. were hazardous to human beings as they cause dermatitis, allergy, rhinitis and even asthma.

## Conclusions

Weeds are a potential source of environmental pollution. Weed plants contribute to pollution by releasing toxins from their parts or debris. Concerted efforts are needed to identify the toxins released by them. The production of toxins is mainly by leaching in wet climates and volatilization in dry climates. The amount of volatile organic materials produced by plants is enormous. There is little information on the amounts of various phytotoxins present in the environment, the methods and rates of their degradation, and the mechanisms of action.

Toxins of weeds are widespread in the environment not only in soil but also in the atmosphere. Allelopathy is not a peculiarity of a few species but a normal and mostly inconspicuous phenomenon of many geograpic areas and vegetation types (Datta and Chaterjee, 1971). As such it is inevitable that one plant adversely affects the other as seen in the impact of toxicants on plants and animals. Weeds like *Parthenium* cause serious environmental pollution affecting not only crop plants but also livestock and human beings. Hence there is a need for research efforts to find suitable biological methods to eradicate such weeds. Over the years, the accumulation of toxins, repellents and wastes of plants in our environment may not leave us with enough time to learn to avoid their occurrence in food. The present activities of man in loading the environment with toxins of weeds besides industrial wastes may lead to a greater pollution problem. Hence, it is necessary to study and evolve suitable methods of minimizing pollution by weeds.

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# Environmental Pollutants on Human and Animal Health

**K.C. Devaraj Urs and S.P. Biradar**
Department of Entomology, University of Agricultural Sciences, GKVK
Bangalore 560065

## Abstract

The environment is being polluted largely by industrial wastes, automobile exhausts, agricultural chemicals, stagnant water pools, open garbages, composts, open drains, slaughter houses, public latrines with poor sanitation, open air excretions, decaying organic matter, etc. Agricultural chemicals, especially pesticides, are the major agent of environmental pollution. From the site of their application, they may be carried by wind or volatalize in the atmosphere and contaminate other areas in precipitation. Exposure of pesticides occurs in a variety of ways during their manufacture, formulation, distribution, application, etc. The general public is exposed to pesticide residues through ingestion in a variety of food products, such as grains, flours, vegetables, fruits, fish and meat. Toxic chemicals like carbofuran, aldicarb, endosulfan, monocrotophos, phorate, etc. are suspected of carcinogenic, mutagenic and teratogenic effects in animals. According to a recent report of World Health Organization (WHO), the average mortality due to pesticide poisoning in the world is 1.8 percent or 28,000 deaths per annum. India accounts for one third of the pesticide poisoning cases in the third world.

## Introduction

Ever since the advent of industrial revolution, happiness has been linked with material prosperity. In the search for material prosperity, man has explored and exploited the natural resources rather ruthlessly. The rapid industrialization of the country created varied problems. Factories and industrial undertakings were set up in and around densely populated areas in a haphazard manner without regard to the safety of human beings living in such areas. The industrial as well as domestic wastes have been a source of pollution of water, soil and air. Automobile exhausts in no small measure are responsible for air pollution. Likewise, the land uses determine and control the quality of environment around us.

## A Healthy Environment

The environment is a major health determinant. An estimated 1.7 billion people lack access to clean water and about 1.2 billion live in unsanitary conditions. People have the right to be protected against environmental dangers that threaten the quality of life. However, this right still remains a distant prospect for people not only in developing countries but also in industrialized nations (Anon., 1989a).

### *Selenium toxicity*

Selenium is a trace element that is essential in minute amounts to human and animal health. At higher levels such as those found in some pesticides they are toxic. In the Kesterson National Wild-life Refuge, California, and farms throughout the western United States, selenium contamination appears to be a growing threat. Seleniumm contaminated water from nearby irrigated farmland killed more than 1000 ducks in the

Kesterson Refuge from 1983 to 1985. This contamination has also been linked to deformities in hatchings (Anon., 1988b).

*Talcum powder*

Talcum powder which is used all over the world is not refreshing as it is commonly believed to be but a source of skin and lung diseases. Excessive use of talcum powder could cause various lung and skin ailments due to the presence of magnesium silicate. Body tissue contaminated with talcum powder caused "granuloma", a form of skin tumor. Sprinkling of the powder on wounds and sores is also equally harmful (Anon., 1988a).

*Dust from chimneys*

A 1000 MW coal-fired electricity generating station burns about 20,000 tonnes of coal every 24 h and during the same period discharges about 10 tonnes of flyash into the atmosphere from tall chimneys. The discharged ash can escape the filtratin traps because of its light weight. Fire dust particles can penetrate the human body's own air filtration system and reach deep into the lungs and cause serious illness (Anon., 1988c). Similar considerations apply to other industries, such as flour-milling, cement and paint pigment manufacturing where work forces have to handle fine powders.

*High doses of vitamins may prove toxic*

Parents who stuff their children with vitamin tablets to make them healthy could be poisoning them instead as very high doses of vitamin B, C and D over a long period could prove toxic leading to kidney damage, gall stones and paralysis of nerves in the hands and feet (Tamkin, 1988).

*Food irradiation scandal abuses.*

The widespread abuse of food irradiation is a major global scandal because there is no method to detect irradiated foods. Consumers and countries can become wholesale victims of abuses of food irradiation (Anwar Fazal, 1989). Abuses include. food consignments rejected as being unfit for human consumption, subsequently being irradiated and marketed as fresh foods.

*Colours in sweets and oils are harmful*

The colourful sweetmeats, for instance, are not as sweet as they look. Many of those brightly coloured sweets are made from harmful compounds that are known to cause kidney damage, eye defects and some times even affect the reproductive systems (Anon., 1989b). Nor is mustard oil, widely used for cooking all that safe. An extensive survey in Uttar Pradesh revealed that in a fourth of the samples the oil had been adultrated with linseed and highly toxic argemone oil. Argemone poisoning causes swelling of limbs, nerve damage, heart attack and blindness.

*Pesticides*

Some of the pesticides used in agriculture are highly injurious to all forms of life and have also been found to be carcinogenic. Despite the proliferation of pesticides, DDT and BHC still account for 50,000 tonnes or two-thirds of the total consumption in the country (Kalra and Chawla, 1981) because these are cheap, easy to handle and attack a wide range of pests. However, once sprayed, they do not degrade easily and can persist in the environment for as long as 20 years. The soil then becomes a reservoir for these pesticides steadily transferring them to edible crops and polluting the groundwater and wildlife.

In 1984, a multi-centre study sponsored by the UN Food and Agriculture Organisation analysed as many as 1500 samples of cereals, pulses, milk, oil and meat from different parts of the country. Almost all the samples were contaminated with DDT and BHC (Anon., 1986). Breast milk taken from 50 lactating women had DDT and BHC residues atleast four times higher than in the other participating countries (Kalra and Chawla, 1982).

Tests with DDT on animals showed evidence of it being a carcinogen and causing chromosomal changes. In the US, it was feared that the bald eagle, the national emblem, was being extinct because of widespread spraying of DDT in its habitat. Animal studies with BHC showed clear evidence of its carcinogenic properties apart from the occurrence of spontaneous abortions and leading to severe liver and kidney damage (Visweswaraiah *et al.*, 1983). Pesticide residues in fish, birds and humans in isolated areas of the world can be attributed to distribution through food chain (Visweswaraiah *et al.*, 1975).

When humans swallow chemicals like DDT and BHC, they are absorbed by the small intestine. These then adhere to the fatty tissues (Dale *et al.*, 1965). The toxins usually pile up in the fatty tissues of vital organs such as the thyroid, heart, kidney, liver, mammary glands and testes. They can be transferred from the umbilical cord blood to the growing faetus and through breast feeding to babies. Over the years, the body can store about 50 to 100 mg of a wide variety of these toxins.

The impact of pesticide poisoning is insidious. In the districts of Shimoga and Chikmagalur, Karnataka, since 1975 over 300 people have been struck by a mysterious crippling attack of arthritis. In children, the disease, apart from crippling them, has inhibited their growth. Initial studies indicated that these people, mostly farm labourers, had switched to eating crabs from nearby fields which were being sprayed with pesticides frequently. The villagers who ate the crabs were believed to have been poisoned (Devaraj Urs, 1989). Farmers are known to spray methyl parathion on cauliflower to give it an extra white appearance (Davis *et al.*, 1974). Bhindi (okra) is dipped in copper sulphate to make it look greener. A thorough wash and a vinegar douse help to get rid of much of the toxin in vegetables. Some of the green vegetables when consumed without washing can cause neurosysticerosis, an infection of the central nervous system specially the brain (Kak, 1988). Grapes contain a high residue level of several pesticides. A good wash with a dash of detergent or baking soda can knock out these toxins (Visweswaraiah *et al.*, 1983).

Non-vegetarian food too is highly contaminated. Goats swallow pesticides when they graze near fields being sprayed with them. Hen do the same through the feed they eat which is usually the husk of grain. Fish too contain high amounts of DDT residues. In West Bengal, people spray endosulfan on water to stun fish and catch them (Joshi, 1986). Milk, which has a high content of fat, is an ideal storehouse for toxins. In bovine milk, contamination comes through the cattle fodder which has high levels of toxins. When milk is processed into butter, residue levels get magnified (Dikshith, 1988).

Pesticides continue to be used for various purposes and greatly benefit mankind. The ultimate solution to environmental problems lies in the use of minimum quantities of pesticides combined with other suitable and safer control measures.

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# Pesticide Residues in Food Products and their Control

**K.C. Devaraj Urs and G.V. Prasad Reddy**

Department of Entomology, University of Agricultural Sciences, Bangalore 560065

## Abstract

Pesticides are used in agriculture to sustain the growing demand for food and other raw materials for industries, and in public health to control vector-borne diseases. Increased and indiscriminate use of pesticides and introduction of newer chemicals in the absence of a regular monitoring programme are exposing our population to new dangers and risks arising from residues, etc. With the advent of modern agriculture and usage of numerous pesticides, establishment of "Crop Protective Clinics" at village, taluk and district levels is a great necessity. This paper deals with the pros and cons of pesticide usage in agriculture and public health.

## Introduction

Pesticides of different classes are used in all crops for the control of pests, diseases and weeds in the form of spray, dust, granule, fumigant and poison bait in the country. In pest control, excessive use of organochlorines like DDT and BHC in the fiftees led to the development of widespread resistance among many pest species. This necessitated the use of larger quantities of the more potent organophosphates and carbamates. However, these remained effective only for a short period. Larger quantities of both organochlorines and organophophates later began to be used in the form of mixtures on a large scale in the seventees. But these also led to the appearance of further resistant strains of pests. Then synthetic pyrethroids came in and the fields were sprayed or dusted more frequently in increasingly larger quantities leaving residue deposits with consequent residues in food grains.

## Consumption of Pesticides

The consumption of pesticides increased uniformly in the last three decades to boost up agricultural production and to minimise the losses due to pests. DDT and BHC together constitute over 50% of the total consumption of pesticides. These and certain other organochlorines, *viz*. aldrin, dieldrin, endrin, heptachlor, chlordane, etc are highly persistent and result in the contamination of water sources due to spray, drift, direct application, and surface run off resulting from irrigation and rainfall. These have been either banned or are in restricted use in developed countries but they are still being used in our country for various reasons.

## Pesticide Residues in Food Grains, Vegetables, Fruits, Soil and Water

"Silent Spring" was the first major publication (Carson, 1962) highlighting the potential hazards of persistent pesticides. This book brought awareness among people about the possible dangers of the use of pesticides. The production and the application of pesticides in agriculture, horticulture, warehouses (see Table 1) public health and industry results in contamination of the environment in innumerable ways and especially the food products.

Potter (1965) has listed three main problems with pesticides, *viz*. (a) the risk of poisoning human being particularly through dangerous residues in food-stuff, (b) the risk of general contamination of the environment by the use of persistent chemicals of high biological activity affecting domestic animals, beneficial insects and wild-life and (c) the production of strains of insect pests resistent to insecticides.

A survey conducted by Sowbhagya *et al.* (1983) to assess the magnitude of contamination of rice, jowar and wheat flour revealed that 20% of rice samples and 30% wheat flour samples contained BHC and DDT residues above the national tolerance limits. None of the jowar samples contained pesticide residue due to preservation of jowar in pit storages. Nandakumar *et al.* (1981) found high amounts of BHC and DDT residues in paddy straw warranting careful application of pesticides. Different varieties of raw coffee seeds collected in various seasons contained residues of the organochlorine pesticides BHC, DDT, dieldrin and aldrin (Suryanarayana Raju *et al.*, 1981).

The pattern, distribution and degradation of insecticide residues in different processed products showed that buttermilk contained 3 to 6 times less quantity of BHC as compared to butter. When butter was converted into butter oil, the loss of BHC was found to be in the range of 29 to 35%. Milk samples fortified with different concentrations of DDT exhibited 2 to 6 times higher insecticide residue in butter than in buttermilk (Srinivasa *et al.*, 1983).

Many of the synthetic pesticides are dispersed in soil, water and air. Pesticide residues in fish, birds and humans in isolated areas can be attributed to distribution through the food chain (Visweswariah *et al.*, 1975). Though the pesticide residues present in or on food are very minute, due to biomagnification in the food chain, they can affect brain, liver and nerve cells, and also cause cancer.

Pesticide residues from edible items can be removed by some decontaminating agents. For example, Visweswaraiah *et al.* (1983) found that 2% sodium bicarbonate and 2% acetic acid were more effective for the removal of lindane, malathion, dimethoate and carbaryl from grapes. Similarly, in studies conducted to remove lindane, BHC, and 'X' factor from fruits and vegetables using various solutions including cold water, hot water, 2% detergent solution, 2% acetic acid in water, 2% detergent solution, 2% sodium bicarbonate solution, a solution mixture containing 0.5% potassium permangante and 0.5% sodium bicarbonate, it was found that washing in cold or hot water was not able to remove much of lindane, BHC and 'X' factor. However, washing the fruits and vegetables in sodium bicarbonate solution significantly removed the residue (Suryanarayana Raju *et al.*, 1975 and 1983).

### Some Suggested Measures for Minimising Pesticide Residues

1. The provisions of the Central Insecticide Act passed in September 1968 and notified in October 1971 to regulate manufacture, import, sale, transport, distribution and use of insecticide with a view to prevent risks to human beings and animals should be properly and rigidly enforced throughout the country.
2. On account of the rapid increase in the consumption of pesticides, the problem of ensuring quality standards is important (see Table 2). Therefore, pesticide manufacturers and formulators should be made to produce data to back up claims for pesticide efficiency, toxicity to humans, animals and plants and environmental pollution.
3. Regular surveillance and monitoring of the workers/operators and subsequent analysis of such data could suggest intensity of exposure for pesticides.

Table 1. Consumption of different types of pesticides in the Karnataka State Warehousing Corporation during 1977-86.

| Chemical | Consumption (litres) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Malathion | 2078.90 | 772.12 | 257.95 | 321.97 | 653.53 | 907.43 | 907.20 | 947.36 | 1190.04 | 1062.25 |
| D.D.V.P | 365.82 | 174.72 | 50.09 | 91.78 | 134.40 | 95.88 | 107.15 | 127.05 | 274.05 | 325.10 |
| Zinc phosphide | 14.74 | 91.34 | 75.76 | 71.17 | 07.05 | 08.16 | 8.68 | 08.92 | 08.98 | 09.75 |
| Pyrethrum | 17.77 | 23.15 | 22.65 | 13.40 | 17.96 | – | 2.23 | – | – | – |
| Ratofin (S) | 19.47 | 56.85 | 36.07 | 13.33 | 04.71 | 13.76 | 54.90 | 02.08 | 01.07 | 05.18 |
| Ratofin (C) | 02.04 | 04.72 | 04.45 | 03.14 | 05.49 | 05.12 | 05.01 | 01.62 | 03.20 | 08.55 |
| Durofume | 28.35 | – | – | – | – | – | – | – | – | – |
| P. P. E | 06.00 | – | – | – | – | – | – | – | – | – |
| Pyrocone (X) | 05.00 | 02.50 | – | – | – | | – | – | – | – |
| Aldrin – | – | – | – | – | – | 09.40 | 06.00 | 63.60 | 620.25 | |
| Durobase | 30.00 | 05.00 | 05.00 | – | – | – | – | – | – | – |
| Cymag | – | – | 27.86 | 26.06 | 02.80 | 00.40 | 24.61 | – | – | – |
| Paradichloroenzene | – | – | – | – | – | – | – | – | 102.00 | – |
| Aluminimum phosphide (Tablets) | 673694 | 340608 | 102223 | 085861 | 186576 | 382427 | 639035 | 335557 | 634224 | 556820 |
| Ratobars (bars) | – | – | – | – | – | – | – | – | 350 | – |
| Chloridine | – | – | – | – | – | – | – | – | 102 | – |
| Methylbromide | – | – | – | – | – | – | – | – | – | 05.00 |
| E.D.B. (ampules) | – | – | – | – | – | – | – | – | – | 2374 |

Source : State Warehousing Corporation, Bangalore

Table 2. Analysis of pesticides during 1978 – 1987

| Year | No. of samples received | No. of sampl es analysed | No. of samples satisfactory | No. of samples misbranded | No. of samples rejected |
|---|---|---|---|---|---|
| 1978-1979 | 3780 | 3485 | 2701 | 782 | 297 |
| 1979 -1980 | 1134 | 0968 | 0862 | 106 | 166 |
| 1980-1981 | 1420 | 1218 | 1130 | 088 | 202 |
| 1981-1982 | 1486 | 1225 | 1085 | 139 | 261 |
| 1982-1983 | 1821 | 1645 | 1467 | 178 | 176 |
| 1983-1984 | 2136 | 2019 | 0793 | 226 | 117 |
| 1984-1985 | 1933 | 1671 | 1483 | 188 | 262 |
| 1985-1986 | 1000 | 0780 | 0716 | 064 | 220 |
| 1986-1987 | 1056 | 0764 | 0738 | 026 | 292 |
| Total 9 years | 15756 | 13775 | 10976 | 1797 | 1993 |

Source : Insecticides Control Laboratory, Director of Agriculture, Bangalore

Table 3. Analysis of insecticide abuse (suicides, homicides, food poisoning, etc.) during 1978-1987

| Year | Organo-chlorine | Organo-phosphorus | Carbamate | No. of cases analysed |
|---|---|---|---|---|
| 1978- 1979 | 072 | 0296 | – | 0368 |
| 1979-1980 | 085 | 0237 | – | 0322 |
| 1980-1981 | 203 | 0445 | 039 | 0715 |
| 1981-1982 | 229 | 0599 | 045 | 0875 |
| 1982-1983 | 509 | 1806 | 278 | 2593 |
| 1983-1984 | 216 | 0920 | 084 | 1220 |
| 1984-1985 | 169 | 1038 | 048 | 1255 |
| 1985-1986 | 243 | 1053 | 063 | 1359 |
| 1986-1987 | 345 | 1320 | 088 | 1753 |
| 1987-1988 | 332 | 1444 | 064 | 1840 |
| Total 10 years | 2403 | 9158 | 0711 | 12302 |

Source : Govt. Forensic Science Laboratory, Bangalore

4. A regionwise'Inventory' of pesticide use is of importance to ascertain the current manner of application as well as disposal of pesticide containers after use and the cause of contamination (see Table 3).
5. Tolerance limits for all kinds of pesticides used in different areas and commodities should be established in the near future.

6. Periodical 'refresher type' training programmes/courses need to be organised at taluk and village levels for the benefit of professional pest control operators. It is necessary to establish 'Crop Protection Clinics' at district and taluk levels on the lines of human and animal health clinics.
7. Protective clothing and devices like respirators, masks, goggles, boots, gloves, etc. should be provided to the occupational workers for use during handling, mixing and field applications.
8. Monitoring of pesticide residues in agriculture and food products should be taken up on priority basis. The minimum number of rounds of application, residue levels in grain and straw, and minimum waiting periods in the case of directly consumable produce like vegetables, fruits etc. need to be assessed.
9. There is an urgent need for the development of less hazardous and slow release formulations.
10. The use of broad spectrum and persistent pesticides should be discouraged in such agro-climatic conditions where there are chances of residual accumulations in low-lying areas like ponds, tanks, lakes, streams, etc.
11. Application of irradiation technique for food preservation considering its wide applications needs consideration.
12. Exploration of new approaches including synthetic pheromones, hormones, chemosterilents, antifeedants, host-plant resistant crop varieties, natural products, microbial pesticides, anti-metabolites and advanced cultural techniques as possible safer alternatives to conventional toxic pesticides as well as to use them as important components in the integrated pest management strategies need consideration on priority basis.

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# Integrated Pest Management — An Ideal Approach to Reduce Insecticides in Cotton Ecosystem

**S. Uthamasamy**

Department of Agricultural Entomology, Centre for Plant Protection Studies
Tamil Nadu Agricultural University, Coimbatore 641003

## Abstract

Cotton crop is attacked by a multitude of pests from sowing to harvest and insecticides are used intensively and extensively to manage them. Excessive and indiscriminate use of insecticides had led to problems of pest resurgence, elimination of natural enemies and pollution of the ecosystem. Implementation of integrated pest management (IPM) programmes on whole village basis has brought down the pesticide load in the ecosystem. Proper surveillance and monitoring are essential for adoption of IPM practices. The role of biocontrol agents, rational usage of pesticides and integration of various methods for successful management of cotton pests are discussed.

## Introduction

Cotton is a perennial arborescent tropical plant cultivated mostly as an annual all over the world. Nature seems to have designed cotton specifically to attract highly destructive insects. In India more than 150 pests are known to damage cotton crop (Sundaramurthy, 1986). Amongst these, the early season pests, *viz*. the green leafhopper *Amrasca devastans* (Dist.), thrips *Thrips tabaci* Linn. and *Scirtothrips dorsalis* Hood, and aphid *Aphis gossypii* Glover and the pests in the productive phase, namely the spotted and spiny bollworms, *Earias vittella* F. and *E. insulana* Boisd., the American bollworm *Heliothis armigera* (Hubner) and the pink bollworm *Pectinophora gossypiella* Saunders are serious pests in many states. The cotton stem weevil *Pempherulus affinis* Faust and the root feeding grubs of the ash weevils *Myllocerus* spp. exist in certain tracts and cause considerable damage. In recent years, the whitefly, *Bemisia tabaci* Gennadius, has caused much devastation in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Gujarat and other states. As per the estimates made in 1983, cotton pests are capable of inflicting upto 50% yield less amounting to Rs.3,400 million in India (Balasubramanian, 1986).

The intensification of cotton cultivation in the recent past has resulted in the occurrence of the crop all through the year in some areas especially the southern states which are highly favourable for continuous pest attack. The introduction of diverse genotypes of cotton with varied age groups under *Gossypium hirsutum*, *G. barbadense* and *G. arboreum* and the inter and intraspecies hybrids with higher fertilizer and irrigation regimes and indiscriminate and excessive usage of pesticides have changed the pest complex in many areas.

## Pre-Integrated Pest Management Era

The rapid changes in cotton production technologies in the past compelled the farmers to interact and adopt strategies to manage pests. Initially, they were convinced by the quick knock down effect of insecticides and so resorted to them as the first line of defence against cotton pests. The number of rounds of applications increased year after year and as many as 25 per cotton season were not uncommon. Increases in dosages, combinations and field mixes of chemicals were a regular phenomenon. These resulted not only in poor yields but also poor returns per unit area. In addition, the area under cotton decreased and many cotton farmers abandoned its cultivation. Greatest havocs of this type were observed in cotton ecosystem in some districts of Tamil Nadu and Andhra Pradesh.

## Integrated Pest Management Era

The Centre for Plant Protection Studies, Tamil Nadu Agricultural University and the Regional Station of Central Institute for Cotton Research, Coimbatore, initiated collaborative programmes for the development of Integrated Pest Management (IPM) through various methods. Sound programmes were developed integrating various components, *viz.* cultural and mechanical methods, use of biocontrol agents, augmentation and conservation of natural enemies and selective use of insecticides. The programme also envisaged regular monitoring of the population dynamics of pests *vis-a-vis* the natural enemies. Commencing from 1984, a pest surveillance programme has also been developed and this is being taken up as a collaborative venture between Tamilnadu Agricultural University and Tamil Nadu State Department of Agriculture (Jayaraj, 1985). This programme has helped in identifying the areas prone to certain pests, such as white fly, stem weevil, bollworms, etc. It was also possible to update the knowledge on the current status of key pests and to implement IPM. In addition, sudden and unusual occurrence of pests like the seedling weevil *Attactogaster finitimus* Fst. in some districts was observed through the monitoring programme in winter 1987 and it was possible to contain the same by timely management practices.

## Integrated Pest Management Approach

Realising the importance of IPM for effective management of cotton pests, the Tamil Nadu State Department of Agriculture has launched an area approach in Coimbatore district with the collaboration of Tamil Nadu Agricultural University and the Regional Station of Central Institute for Cotton Research (CICR) from 1982. An operational Research Project on IPM of cotton is also in operation by the CICR, Regional Centre. The three organizations through a collective and cooperative approach have educatd the cotton growers on the need for pest surveillance and IPM in cotton. As a result the farmers who were applying 20-25 rounds of insecticides have reduced the number of applications to only about 6-8 rounds. This has helped in preserving natural enemies, reducing the insecticide pollution in the cotton ecosystem and obtaining better economic returns. The biocontrol agents, such as *Menochilous* sp., *Aphelinus* sp., *Bracon* sp., *Apanteles* sp., *Chelonus* sp. and spiders were prevalent in higher numbers in fields of IPM villages than in non-IPM villages (Table 1) (Sundaramurthy, 1985).

Table 1. Effect of IPM system on the natural enemies and productivity of cotton.

| | Insecticides/ha | | Natural enemies (Number/sample) | Yield (Q/ha) |
|---|---|---|---|---|
| | Number of applications | a.i. (kg) | | |
| IPM-village | 6.37 | 3.82 | 26.8 | 21.4 |
| Non-IPM village | 10.71 | 9.23 | 10.9 | 22.2 |

Studies have also revealed the effect of different genotypes on insecticide usage, productivity of cotton and the natural enemy complex prevalent in the cotton ecosystems (Table 2).

Table 2. Effect of varieties on insecticide usage, natural enemies and productivity of cotton

| | Cultivars | | | |
|---|---|---|---|---|
| | MCU 5 | MCU 9 | Varalaxmi | Suvin |
| Insecticides (a.i. kg/ha) | 2.34 | 2.72 | 5.64 | 5.69 |
| Natural enemies (Number/sample) | 33.94 | 99.27 | 13.92 | 9.74 |
| Seed cotton yield (q/ha) | 18.10 | 23.28 | 21.17 | 17.32 |
| Stained cotton | 2.15 | 2.29 | 1.75 | 1.64 |

### The Current Scenario

Though the cropped area under cotton is only 5% in India, the pesticide load it takes is of the order of 52 to 55% (Balasubramanian, 1986). Among the pesticides, the synthetic pyrethroids have been put into cotton ecosystem with very aggressive promotional activities. Extensive and indiscriminate use of synthetic pyrethroids appeared to favour the outbreak of cotton whitefly (Jayaraj *et al.*, 1986), cotton aphid (Rangarajan *et al.*, 1986) and cotton mealy bug *Ferrisia virgata* (Cockrell) (Uthamasamy *et al.*, 1986). The resurgence of various pests as induced by insecticide applictions has been documented by Jayaraj (1986).

*(i) Cotton whitefly* Bemisia tabaci

A study conducted in Coimbatore district with 131 cotton farmers revealed that all the farmers had applied insecticides to cotton crop to control whitefly. The pattern of insecticidal applications and incidence of whitefly is presented in Table 3.

Table 3. Incidence of whitefly in relation to insecticide application

| Rounds of application | % farmers applied | Mean whitefly (population/leaf) |
|---|---|---|
| 1-3 | 8.4 | 2 to 5 |
| 4-6 | 58.0 | 5 to 10 |
| 7-9 | 26.7 | 9 to 19 |
| 10-12 | 6.1 | 24 to 28 |

The use pattern of organochlorine insecticides and carbamates was low, i.e. only one round of these pesticides had been applied by 43% of the farmers. The utilization of organophosphorus insecticides was more predominant. Synthetic pyrethroids were applied by 74.9% of farmers and it ranged from 1 to 3 rounds in addition to the conventional insecticides (Jayaraj *et al.*, 1986). During summer 1988, following an unusual incidence of *Heliothis armigera* on cotton in some areas of Madurai district, there was a large scale outbreak of the white fly in that area (Jayaraj *et al.*, 1988). Outbreak of whitefly was observed to be due to resurgence induced by insecticides particuarly synthetic pyrethroids. Thus, the whitefly has become a serious pest during the last few yeas primarily due to excessive and indiscriminate use of insecticies. It was reported to have caused a yield loss of 24 lakh quintals of cotton worth Rs.120 crores in Guntur district alone (Subba Rao *et al.*, 1987).

*(ii) The American bollworm* Heliothis armigera

In Punjab and Haryana, this insect inflicted heavy losses during 1983-84 due to its massive outbreak spreading from pigeonpea in the preceding season to cotton. During the past three years, this has assumed great significance on many crops and more so on cotton in south India. In Guntur area of Andhra Pradesh, the pest has devastated the cotton crop during 1987-88 season and the farmers could harvest only about 5 quintals of kapas/ha on an average as against the normal yield of about 15 quintals/ha. The loss has been estimated to be Rs. 416 crores in one season in Andhra Pradesh in about 5.20 lakh hectares. In Tamil Nadu, the pest was found widespread in summer cotton tract in 1987 and 1988. During rabi 1987-88, the pest was observed on many crops including cotton. The estimated loss to the crops in Tamil Nadu by *H. armigera* was about Rs. 93 crores in 1987-88 (Jayaraj, 1988).

An analysis of the causes for the outbreak of this pest revealed that farmers had applied 15-18 rounds of pesticides of various kinds on a calender basis without regard to the concepts of IPM. There were cases of 30 to 40 applications in a cotton season leading to heavy pesticide load in the ecosystem. Many farmers combined 3 or 4 insecticides together as tank mix, often at sublethal doses, which resulted in the failure to control the pest, wastage of costly inputs and pollution of the environment. Pesticide application was resorted to once in 5-7 days in many cases and the spraying was done on contract basis at Rs. 2.50 per tank. In order to cover larger areas in a shorter time, the spraymen used to modify the nozzle to empty the tank quickly. This has led to the delivery of particles of bigger size and large scale run off , polluting the soil and irrigation water.

### Suggested Measures for IPM in Cotton

(i)*Surveillance and monitoring* : Pest surveillance programme has to be practised in a more scientific manner by the extension functionaries in collaboration with Agricultural Universities and ICAR Institutes. The available techniques including the use of light and pheromone traps for monitoring bollworms have been reported by Jayaraj *et al.* (1988). Monitoring of cotton whitefly with yellow sticky traps as a simple and low cost technology has been demonstrated by Thangaraju *et al.* (1989). Such methods will go a long way in reducing the pesticide load in cotton ecosystem.

(ii)*Biocontrol agents* :There are effective biocontrol agents for the management of *H.armigera* and *Spodoptera litura* which are indigenously available in most cases. Large scale multiplication and use of nuclear polyhedrosis virus (NPV) will be very effective against these pests. The state departments of agriculture and Central Biological Control Laboratories should be able to mass produce the NPV in large quantities and supply to farmers to spray against the pest in the early stage in the evening hours in large areas to keep the pests under check (Jayaraj, 1988). Many parasites and predators are effective against the key pests of cotton, *viz.* leafhopper, whitefly and bollworms. Mass culture and field release of parasites like *Trichogramma* spp. and *Chelonus blackburnii* and predators like *Chrysopa* spp. and ladybird bettles in cotton ecosystems from early stage of the crop will result in minimal and need based application of insecticides.

(iii) *Chitin synthesis* : Chitin synthesis inhibitors like diflubenzuron are also effective against *H. armigera* and *S.litura*. This approach is compatible with other methods of management and if adopted will reduce the pesticide load in the ecosystem. The possibilities of integrating moult inhibitors in cotton pest management have been reported by Balasubramanian (1985).

(iv) *Resistant varieties* : Many useful entries with resistance to insects have been identified by the national programme and Agricultural Universities. Although complete resistance to pests is a distant possibility, the usefulness of moderate resistance cannot be ignored in integrated pest management programmes.

(v) *Insecticide management* : The importance of insecticides as components in IPM cannot be overlooked in the coming years although their use can be minimized. The pattern of use of chemicals should be altered by employing different groups of insecticides like organophosphorus, carbamate and organochlorine compounds in different rounds of application. Insecticides like phosalone and endosulfan which are relatively safe to natural enemies and pollinators should be preferred so that the existing biocontrol agents can be preserved.

## Outlook for the Future

Integrated pest management seems to be the answer for pest problems in the future. Development of insect resistant varieties is very vital and will be rewarding if research is strenglhened in this direction. Utilization of indigenously available parasites, predators and pathogens needs greater attention for reducing the pesticide load in ecosystem. In addition, continuous monitoring and surveillance are essential for decision making on the need to adopt control measures. Insecticides will continue to be a major component of pest management. Educating the cotton growers on the usefulness of IPM is important for successful implementation of IPM programmes. Above all, there is a need to judiciously integrate all these approaches so that IPM becomes possible as an economically viable, socially acceptable and ecologically sound method for increasing cotton production.

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# Integration of Weed Management Technology for Reducing Soil and Water Pollution

**Samunder Singh and R.K. Malik**

Department of Agronomy, Haryana Agricultural University, Hisar 125004

## Abstract

Studies conducted on the chemical control of weeds in different crops indicated that reduced doses of herbicides than the recommended doses can be used for weed control. In cereals, various agronomic practices can be integrated to reduce the herbicide dose. Cross row sowing, increased use of fertilizer, higher seed rate, sowing time, selection of varieties and time of herbicide application have a profound effect in controlling weeds in wheat with 25 % less herbicide dose. In sugarcane and cotton, inter-row cultivation can be successfully integrated for long season weed control. In pulses and oil seeds, hand hoeing at critical period and optimum sowing time have been found to be more useful than higher doses of herbicides. Oat and sorghum are sensitive to residues of atrazine, pendimethalin and fluchloralin while pulses and oilseeds to phenoxy herbicides. Suitable crop rotation can minimise these problems.

## Introduction

The losses caused by weeds are more than those caused by any other pest. Further, evolution of high yielding and dwarf varieties of crops with poor competiting ability has aggravated the situation. Herbicides have been found to be the most efficient and easy tool for the management of weeds. Increased use of fertilizer and irrigation facilities have also necessitated the use of herbicides. Non-availability of labour at critical periods and its high cost are also responsible for increased herbicide use.

The consumption of herbicides is much less in India than in other countries. Pesticide Association of India has forecasted that by the year 1988-89 the estimated consumption of herbicides is expected to increase to 4460 metric tonnes from 2450 metric tonnes of 1986-87, an increase of over 80%. In Haryana, there has been a 300% increase in the use of herbicides in wheat and paddy from 1981-82 to 1983-84. The adoption of chemical weed control will increase at a faster rate in wheat and paddy followed by vegetables, cotton, sugarcane, oilseeds and pulses.

This increased use of herbicides poses serious problems as it can adversely affect soil microorganisms that are beneficial to crops and their residual effect on succeeding crops. The carryover effects of volatile herbicides to adjacent sensitive crops may be devastating. Herbicides used for the control of aquatic weeds may harm water fauna, wildlife, livestock and even human beings when used for drinking purposes. This polluted water when used for irrigation may kill the germinating crop seedlings and may cause mortality in standing sensitive crops. Continuous use of a few herbicides may change the weed flora; it may also pollute air and water which may directly affect human beings and animals by entering into the food chain. All these problems can be avoided by reducing the herbicide quantity per unit area and increasing their efficiency by integrating them with the latest agro-techniques.

## Agronomic Practices and their Integration with Weed Management

*Soil preparation and sowing time*

Field preparation with two pre-sowing irrigations helps in destroying the flush of germinating weeds better than one irrigation. The crop-weed competition can be tilted in favour of the crop by manipulating sowing time. Suitablility of such techniques depends on individual problems. Studies conducted at Haryana Agricultural University revealed that in chickpea, maximum emergence of the most competitive weed *Chenopodium album* occurred in timely sown crop and decreased in late sown crop. Emergence of *Lathyrus aphaca* and *Vicia sativa* is more in late sown crop but the total dry matter of weeds is less than in timely sown crop. In wheat, *Avena ludoviciana* comes along with the timely sown crop whereas *Phalaris minor* is more in late sowings. This unsynchronised germinating behaviour of various weeds can be exploited for the benefit of crop by the manipulation of sowing time.

*Seed rate and sowing method*

Increased seed rate in wheat with cross row sowing not only decreased the losses even in weedy conditions but also increased the efficiency of herbicides.

*Increased fertilizer application*

In general, application of phosphatic fertilizers without nitrogen stimulates the growth of broad leaf weeds and contrary to it nitrogeneous fertilizers may stimulate grassy weeds. Appropriate combination of nutrients and control methods may change the weed-crop competition in favour of the crop. Application of 120 kg nitrogen alone reduced the losses caused by 160 plants/$m^2$ of *Trianthema* by 20% as compared to unfertilized plots. Also 15 plants/$m^2$ of *Trianthema* had no significant yield reduction in pearlmillet (Anon., 1985).

Similarly, in wheat, application of 120 kg N/ha in the presence of *L. aphaca* resulted in complete dominance by wheat. Bhagwati (1988) reported that the population of *C.album, Anagallis arvensis, Vicia sativa* and *Melitotus indica* decreased markedly with the increase in the nitrogen rates upto 120 kg/ha. Efficiency of isoproturon was more in fertilized plots than in the unfertilzed plots. Thus, fertilizer dose can effectively be integrated with herbicide by lowering the dose of the latter by 25% and mixing with 0.1% surfactant (Table1). In the case of the grassy weeds *Phalaris* and *Avena*, application of nitrogen can change the competition either in favour of wheat or weeds depending upon the situation. Increased application of nitrogen fertilizer even under increasing infestation of *Phalaris* and *Avena* (160 to 180 plant/$m^2$) was found to reduce the losses in yield.

*Selection of variety*

Selection of variety plays a pivotal role in managing the weed problem. Sandhu *et al.* (1981) reported that maximum dry matter accumulation by wild oat was in three gene dwarf varieties. This may be due to differential suppression. Early canopy cover and tall nature of variety had a smothering effect on weeds. Trials conducted at Haryana Agricultural University, Hisar, with wheat during 1988 and 1989 showed that under timely sown group of varieties, WH-147 and WH-283 were very good in this respect whereas HD-2009 was the poorest and HD-2329 and WH-423 were intermediate. Under late sown conditions, HD-2285 was the best competitor followed by WH-291 whereas S-308 and

Table 1. Grain yield of wheat (kg/ha) as influenced by graded doses of nitrogen and isoproturon alone or with 2, 4-D or surfactant

| Treatment | Rate (kg a.i./ha) | Nitrogen levels (kg/ha) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 40 | 80 | 120 | mean |
| Weedy check | | 2131 | 3809 | 4125 | 4251 | 3579 |
| Isoproturon + surfactant | 0.75 + 0.1% | 2630 | 4065 | 4522 | 4514 | 3937 |
| Isoproturon + 2, 4–D | 1.0 +0.5 | 2293 | 3945 | 4079 | 4099 | 3604 |
| Isoproturon | 1.0 | 2483 | 4007 | 4438 | 4522 | 3870 |
| Weed free | | 3208 | 4430 | 4970 | 5089 | 4424 |
| Mean | | 2557 | 4051 | 4427 | 4496 | |
| | | | N levels | | W.C.Treatment | |
| C.D. at 5% | | | 314 | | 168 | |

Table 2. Effect of time of application of isoproturon and 2,4-D on weed mortality and wheat yield

| Herbicide | Dose (kg a.i./ha) | Time of application (DAS) | Percent mortality of weeds | | | Wheat yield (kg/ha) |
|---|---|---|---|---|---|---|
| | | | *C. album* | *P. minor* | *A. ludoviciana* | |
| 2,4-D + Isoproturon | 0.75 + 0.5 | 20 | 100 | 85 | 30 | 5600 |
| " | " | 25 | 98 | 85 | 57 | 5559 |
| " | " | 30 | 99 | 79 | 70 | 5686 |
| " | " | 35 | 93 | 93 | 62 | 5437 |
| " | " | 40 | 93 | 73 | 49 | 4472 |
| " | " | 45 | 93 | 71 | 11 | 4445 |
| " | " | 50 | 93 | 44 | 3 | 3949 |
| Weedy check | | | 0 | 0 | 0 | 3706 |
| Weed free | | | 100 | 100 | 100 | 5832 |
| C.D. at 5% | | | 7 | 14 | 16 | 448 |

HD-2009 were the last. The efficiency of herbicides was also better in the varieties WH-147 and WH-283 than in HD-2009.

*Time and method of herbicide application*

Studies conducted at Haryana Agricultural University, Hisar, during 1985-1986 revealed that in wheat, maximum control of weeds was obtained when the herbicide was applied between 25 and 30 DAS. For increased weed kill, a combination of isoproturon and 2, 4-D was the best when applied before four weeks after sowing (Table 2). Application of isoproturon at 0.75 kg dose when applied just before first irrigation was better than at

1.0 kg after irrigation (Anon., 1988). Spraying was better than mixing with sand or urea. Mixing isoproturon with surfactant at 0.1% increased the weed kill at 25% less dose of herbicide. In late sown wheat, application of 0.5 kg isoproturon was found good when applied just before first irrigation.

*Integration of chemicals with mechanical method*

In long duration and wide spaced crops like cotton and sugarcane, long season weed management can only be obtained when application of herbicides at sowing time is supplemented with 1 or 2 hoeings. In pulses and oilseeds where desired success with herbicides has not been met, 1-2 hoeings or intercultural operations at critical periods are very helpful in attaining the targeted yield. In short duration crops, this critical period ranges from 3 to 6 weeks and upto 8 weeks in long duration crops.

*Crop rotation*

Raising of monoculture results in the dominance of particular weed flora which often becomes difficult to control. Continuous growing of cereals results in the increase of grassy weeds. In the case of rice-wheat rotation, *P. minor* is the main problem whereas in fallow-wheat rotation, perennial weeds become a serious problem. In 300-400% crop intensity sequence, annual weeds pose a problem which, however, are easy to control.

*Herbicide residues*

Studies conducted at Haryana Agricultural University, Hisar, indicated that 72% of atrazine was found to degrade in 120 days. The remaining 28% residue was found to cause injury to field oat when grown after bajra or maize. Fluchloralin incubated in the dark did not degrade upto 80 days (Anon., 1988). Residual effect of pendimethalin when applied in wheat was persistent for more than 8 months and was able to cause significant reduction in sorghum germination (Table 3). But isoproturon 50% was found to become inactive within 20 to 25 days of its application and thus does not create any problem for crops grown after wheat.

Table 3. Residual toxicity of pendimethalin applied in wheat on jowar and carpetweed

| Treatment | Jowar | | Population of carpetweed per g $m^2$ at 45 DAS |
|---|---|---|---|
| | Germination (%) at 20 DAS (%) | Dry wt/plant at 45 DAS (g) | |
| Control | 100.0 | 8.4 | 139.0 |
| Pendimethalin 1.0 kg a.i./ha | 66.5 | 6.2 | 72.2 |
| Pendimethalin 2.0 kg a.i./ha | 46.0 | 3.8 | 31.5 |
| C.D. at 5% | 7.6 | | |

Malik *et al.* (1982), Malik and Balyan (1982) and Singh *et al.* (1986) studied the residues of some aquatic herbicides in water used for irrigation. They found that atrazine, dalopan and diuron were deleterious in reducing crop growth and yield of some cereals and 2, 4-D to pulses and oilseeds. They were more harmful when the irrigation was applied at germination or young stage of the crop. Glyphosate and paraquat were found to be safe aquatic herbicides. The application of these herbicides at critical periods helps in better control and results in less residual problems.

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# Socio-economic Aspects of Environmental Pollution

**N.R. Gangadharappa, D. Nanjappa and B.L. Rame Gowda**
Department of Agricultural Extension, University of Agricultural Sciences
Bangalore 560024

## Abstract

The very fact that pollution is caused by man makes the understanding of the principles of human behaviour in this context essential. The various socio-economic aspects of pollution may be brought under two heads, namely (1) reasons for environmental pollution and (2) approaches to control pollution. The former includes (i) social aspects, such as beliefs and customs, values, illiteracy, lack of awareness and population explosion, (ii) economic aspects, such as under development and poverty, and (iii) political aspects, such as policies and measures. The approaches to control pollution include (i) education, (ii) people's participation, (iii) comprehensive policy measures, etc. There is an urgent need to evolve an integrated strategy for environmental protection and improvement.

## Introduction

Before the possible destruction of mankind due to the impact of pollution, one has to evolve strategies for its management. Environmental pollution started as an unwanted evil due to man's ignorance and has reached its height due to his addiction to sophistication and the increased resource utilization for higher production and consumption. The very fact that pollution is manmade makes the understanding of principles of human behaviour in this context every essential. This paper focuses the understanding of man and his environment, and the causes and strategies to overcome environmental pollution.

Environment has been defined as the aggregate of all the external conditions and influences affecting the life and development of organisms. The seven major constituents of environment are: (1) ecological relationship, (2) nutrition and health, (3) population, (4) pollution, (5) forest, (6) land use and (7) economic activity (Anon., 1989). It is often said that man far more than any other animal has developed the ability to modify the environment to live under a wide range of physical and biological conditions. Human ecosystem includes cities, crop fields, orchards, plantations, pastures, abandoned fields and areas devastated by industrial waste. Curiously, both social and biological scientists tend to neglect the study of human ecosystem which perhaps requires a blending of both social and biological knowledge. The causative factors of pollution are: (1) physical and biological factors, (2) social factors, (3) economic factors and (4) political factors. The emphasis of this paper is on the social, economic and political aspects of environmental pollution.

## Social Factors

### *Belief and customs*

Countries like India are still immersed in fatalistic beliefs and the associated customs in the name of worshipping God. For instance, people taking bath in groups in rivers near temples during Melas and Jatras leads to pollution of water and the surrounding environment resulting in the outbreak of epidemics.

*Values*

People place higher values for those who lead a sophisticated life in cities. This factor influences migration from rural to urban areas thus aggravating the situation of pollution in cities.

*Attitudes*

The traditional attitudes of people create a wide gap between traditional 'have nots' and modern 'haves'. People feel that earth is created for them and they exist to exploit its resources for their benefit. They have no idea that one day all the resources of this earth will be utilized and they will be left with no future (Anon., 1978).

*Illiteracy*

A 35% literacy percentage clubbed with 40% of the population living below poverty line (Mamoria, 1989) result in perpetuation of illiteracy. When people are illiterate, they will not realise the dangers of pollution but act as its promoters. For instance, the illiterate farmer uses pesticides and other chemicals irrationally and thus contributes to pollution. With their glorified values and customs of the past, illiterates foster the process of pollution.

*Lack of awareness*

Regardless of literacy, those who are directly linked with the process of pollution are more aware of its hazards. This is because the consequences are either stray or sporadic or the effect of pollution is not directly observable and not instantaneous many times. Lack of awareness, therefore, acts as a catalyst of environmental degradation.

*Population explosion*

If population increases exponentially, there will be a proportionate depletion of environmental resources leading to environmental crisis. With increasing birth rate and decreasing death rate, the third world countries are densely populated. Land being the limiting factor, population explosion has led to pollution in the name of meeting requirements of people.

## Economic Factors

*Underdevelopment and poverty*

Proliferation of slums, malnutrition, chronic diseases, etc. are directly associated with poverty. Economic growth without social justice is creating two classes of people, one with high purchasing power and another with low or no purchasing power. The former can involve in economic activities like industrialisation or modernization of agriculture without considering their impact on the society. On the contrary, the class with low purchasing power lives in unhygenic conditions and depend on natural resources of the earth for their survival which causes ecological imbalance in a long range. Poverty compels people to opt for sub-standard materials and food stuffs augmenting pollution both by the process of production and release of such products.

*Intensive agriculture*

Intensive agriculture involves the use of improved varieties, fertilizers, pesticides, irrigation, etc. The improved varieties are highly responsive to fertilizers but more susceptible to pests and diseases. This has led to indiscriminate use of fertilizers and pesticides which are causing environmental pollution. In addition, command areas are showing problems of salinity due to irrational use of water.

*Economic motives*

Psychological studies revealed that money is a strong motive for human actions (McClelland, 1955). Some activities that fetch high returns are the direct causes of environmental pollution. For example, farmers are making their own formulations by combining available pesticides, such as DDT as a spray to induce sprouting in grapes at Devanahalli taluk, Bangalore district.

*Product technology*

In the light of modernization, man is going for disposable articles like paper towels, facial tissues, beverage containers, etc. some of which are non-degradable. For example, a piece of plastic may survive longer than the civilization of Mohenjodaro and Harappa. The shift to non-degradables and disposables has given consumers a range of products and manufactures greater profits but it has given the society a monumental trash problem (Horton and Leslie, 1981).

## Political Factors

Politics mean not only to govern people in a said geographical area but also to have coordination among different nations to make human race survive forever on this continent without being endangered by conflicts, wars, natural hazards, ecological imbalance and environmental pollution. The major activities of politics lie in policy making. Policies are being enacted through different developmental departments like health, irrigation, agriculture, forestry, fishery, animal husbandry, etc. Further many boards like slum board, pollution board, water supply, sewage board, etc. are also authorised to enact these policies. When a particular policy related to environmental pollution is formulated, it is done in isolation by any one of these departments or boards. Thus a particular policy becomes meaningless making the pollution control difficult.

## Strategies to Overcome Environmental Pollution

*Education*

Envrionmental education is a prerequisite for generating awareness of environmental problems of all areas of human endeavour and planning. It should be viewed not only as a part of a fixed curriculum of formal or non-formal curriculum, but also as a part of inherent system culture.

*Formal education on environment*

The dominant trend in the incorporation of environmental dimension into the formal education process has been to infuse contents related to various environmental problems into natural sciences and social studies. A content analysis of 1st to 10th standard text books of Karnataka State (Table 1) revealed that there is a lack o' totality of vision though it provided evidences of some progress towards environment education. Further, it has stressed only the theoretical cognitive aspects with very little emphasis on effective and psychomotor components. The topics, such as (i) use and management of natural resources, (ii) environmental problems of cities, (iii) health and nutrition, (iv) desertification, etc. need adequate coverage.

Table 1. Contents analysis of science and social studies text-books of primary and lower secondary schools in Karnataka State

| Sciences | Social Studies |
|---|---|
| *Primary school* | |
| Water, air and weather | Our state, rivers and weather |
| Soil and soil erosion | Natural plant habit |
| Plant and animal life | Wild-life |
| Living beings and their adaptation to environment | Agricultural crops |
| Man's dependence on plants | Mineral resources |
| Plants and environment | Industries |
| Food resources | |
| Energy and our health | |
| *Lower Secondary School* | |
| Man and environment | Natural resources |
| Renewable and non-renewable resources | Influence of man's activities on nature |
| Pollution agents | Agriculture as a man occupation of human beings |
| Biological control | Indian population and food requirements |
| Population control | Energy resources |
| Food and nutrition | Industries |
| Communities | |

Source: Krishnamurthy (1983)

*Non-formal environmental education*

There is a need to incorporate the environmental dimension into the curriculum of non-formal education for people involved in industry and agriculture sector so as to provide the required environmental knowledge. Information related to health care practices, water management, use of chemicals, ecological balance, population control, soil conservation, etc. can be incorporated into the curriculum of adult education programme.

*Integrated efforts of different agencies in the formulation and implementation of environmental pollution policies*

To stop the environmental degradation, many organisations related directly or indirectly to environmental pollution have to be re-organised and brought under a single umbrella with specified rules and responsibilities. A strong coordinative linkage among different governmental and voluntary organisations has to be built up with greater accountability. A separate cell for the formulation of policies has to be formed. Policies should make provisions for positive inducements in the form of grants, subsidies, and low tax for those who do not pollute the environment and negative inducements in the form of special taxes and penalties for those who pollute the environment. Of the few possible approaches to industrial pollution abatement, *viz.* public education, judicial action, resource charge and abatement subsidy, the more effective means were resource charge and abatement subsidy (Hammer, 1976).

*People's participation*

The job of building a better environment must engage the enthusiasm and commitment of the entire society. Many governmental programmes like social forestry are not meeting good success, mainly due to lack of people's participation. On the contrary, it was found that whenever people are actively involved they are bound to share responsibilities in the execution and follow-up of the programmes. Hence, the developmental agencies should be adequately trained about mobilizing and motivating people for programmes related to environmental conservation.

*Role of mass media*

The mass media plays a significant role in furthering the cause of public environmental education. Mass media, such as newspapers, radio, magazines, and television help in spreading the information related to environment. The mass media are presently covering the topics related to population control, food and health problems, new energy resources, pollution, conservation and environment protection. However, the information on these related areas has to be emphasised with proper message treatment so as to influence people to act (Krishnamurthy, 1983).

*The role of voluntary agencies*

Non-governmental organisations have a vital role to play in preventing environmental degradation. Many voluntary organizations like Kerala Shastra Sahithya Parishath, Society for Clean Environment (SOCLEEN), Bombay Natural History Society, Karnataka Vigyan Parishath, Dosohli Gram Swarajya Mandal, Worldwide Fund for Nature (WWF), etc. are serving the cause of environmental protection by organizing fairs, exhibitions, nature camps, seminars, symposia, campaigns, etc. However, some of these agencies do not view environment in totality and their activities are mostly related to urban centres and forests. There is a need to orient these agencies on different dimensions of environment. They should have functional linkage with governmental programmes and also they can act as information gathering agencies or early warning system for the environment department.

*Role of village panchayats*

Channelising pollution control measures through these base level organizations needs special attention. The village panchayats are to be educated about the dangers of environmental pollution and their dynamic leadership is needed for creating better rural environment.

## Conclusions

The survival of mankind is doubtful if the process of environmental pollution continues unabated. Many agencies have started taking greater interest in this all important area. There is an urgent need to coordinate the activities of these agencies.

There is also a compelling need to document the environmental activities in different parts of the world using the successful ones in other suitable socio-economic settings.

Poverty is a major cause and effect of global environmental problems. It is, therefore, futile to attempt to deal with environmental problems without a broader perspective that encompasses the factors underlying world poverty and international inequality. The task of environmental awareness programmes should be to motivate the common man to act rather than wait for something to happen.

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# Socio-psychological Dimensions of Environmental Pollution Management

**K. Nagi Reddy*, S. Rathna Kumari** and V. Sridevi*****

* Department of Extension Education, S.V. Agricultural College, Tirupati 517502
** Department of Economics, S.V. University, Tirupati 517502
*** Department of Home Science, S.V. University, Tirupati 517502

## Abstract

The fund of knowledge on environmental pollution and socio-economic and psychological parameters that are interlaced with mankind are the obverse and reverse sides of the spectrum of environmental pollution management (EPM). The behavioural scientists may look with suspicion at the expertise of pollution control unless it is synthesized and processed to suit the socio-psychological dimensions of human life. Hence, EPM methodology must subsume these aspects to become more congruent with any culture.

## Introduction

The sociological variables that come in the way of alleviating the hazardous effects of pollutants are the value system, beliefs, customs, lack of awareness and illiteracy among the populace. Rigid attitudes, lack of self-motivation and innovativeness, and resistance to change constitute the psychological barriers to pollution control. While coining the packages to mitigate the ramifications of environmental pollution, economic viability is to be visualised to make them compatible with the financial resources at one's behest. The know-how on environmental pollution amelioration, and the socio-economic and psychological parameters that are intertwined with human society are the obverse and reverse sides of the spectrum of environmental pollution management (EPM). This paper highlights the behavioural and economic aspects that are related with EPM.

The planet earth is passing through a period of dramatic growth and radical change. Economic activity has multiplied to create a US $ 13 trillion economy and this could grow five or tenfold in the ensuing half century. Industrial production has grown more than fiftyfold over the past century, four-fifths of this growth since 1950. Such figures reflect and forecast profound impacts upon the biosphere as the world invests in farms, industries, houses, transport, etc. Much of the economic growth pulls raw material from forests, soils and waterways. The mainspring of economic activity is new technology. Such technology offers potential for slowing the dangerously rapid consumption of finite resources and also entails high risks that include new forms of pollution and the introduction to the planet of new variations of life forms that could change evolutionary pathways. In the mean time, the industries most heavily reliant on environmental resources and most heavily polluting are growing most rapidly in the developing world, where there is both more urgency for growth and less capacity to minimise damaging side effects.

These related changes have locked the global economy and global ecology together in new ways. We have in the past been concerned about the impacts of economic growth upon the environment. Now, we are forced to concern ourselves with the impacts of ecological stress-degradation of soils, water regimes, atmosphere, and forests upon our economic prosperity. We have in the more recent past been forced to face up to a sharp increase in economic interdependence among nations. We are now forced to accustom ourselves to an accelerating ecological interdependence among nations. Ecology and economy are becoming more interwoven locally, regionally, nationally and globally into a seamless net of causes and effects. A few examples of the effects of economic growth are :

- A leak from a pesticide factory in Bhopal killed well over 2000 and blinded and injured about two lakh people.
- The drought triggered, environment-development crisis in Africa peaked putting 35 million people at risk, killing perhaps a million.
- Liquid gas tanks exploded in Mexico city killing 1000 and leaving thousands more homeless.
- The Chernobyl nuclear reactor explosion sent nuclear fallout across Europe, increasing the risks of future human cancers.
- Agricultural chemicals, solvents and mercury flowed into Rhine river during a warehouse fire in Switzerland, killing millions of fish and threatening drinking water in the Federal Republic of Germany and the Netherlands.

The other shade of the spectrum of EPM is to encompass the socio-psychological and economic dimensions that are to be taken care of.

*Social*

The sociological variables that come in the way of alleviating the hazardous effects of pollutants are the value system, beliefs, customs, population explosion, lack of awareness and illiteracy among the populace. Here, human resource development is a crucial requirement not only to build up technical knowledge and capabilities but also to create new values to help individuals and nations cope with rapidly changing social, environmental and development realities. Governments should develop long term, multifaceted population policies and a campaign to pursue broad demographic goals to strengthen social and economic motivations for family planning. Tribal and indigenous people will need special attention as the forces of development disrupt their traditional life styles, life styles that can offer modern societies many lessons in the management of resources in complex forest, mountain and dryland ecosystems.

*Psychological*

The psychological dimensions that come in the way of pollution management are rigid attitudes, lack of self-motivation, lack of innovativeness and resistance to change. The psychic change in people to have positive attitude and the subsequent motivation could be brought about through formal and non-formal education systems, such as schools and collegiate education, non-formal and adult education, environmental education through extra curricular activities and nature camps.

*Economic*

International economic relations pose a particular problem for environmental management in many developing countries. Agriculture, forestry, energy production and mining generate at least half the GNP of many developing countries and account for even larger shares of livelihoods and employment. Exports of natural resources remain a large factor in their economies for the least developed. Most of these countries face enormous economic pressures, both international and domestic, to exploit their environmental resource base.

The recent crisis in Africa illustrates the ways in which economics and ecology can interact destructively and trip into disaster. Triggered by drought, its real causes lie deeper. They are to be found in part in national policies that gave too little attention, to the needs of smallholder agriculture and to the threats posed by rapidly rising populations. Their roots extend also to a global economic system that takes more of a poor continent than it puts in. Debts that they cannot pay force African nations relying on commodity sales to overuse their fragile soils, thus turning in the wealthy nations — and in many developing areas — make it hard for Africans to sell their goods for reasonable returns, putting yet more pressure on ecological systems. Aid from donor nations has not only been inadequate in scale but too often has reflected the priorities of the nations giving the aid rather than the needs of the recipients. The production base of the other developing world areas suffers similarly both from local failures and from the workings of international economic systems. As a consequence of the 'debt crisis' of Latin America, the region's natural resources are now being used not for development but to meet financial obligations in creditors abroad. The approach to the debt problem is short-sighted from several stand points — economic, political, environmental. It requires relatively poor families simultaneously to accept growing poverty while exporting growing amounts of scarce resources.

A majority of developing countries now have lower per capita incomes than when the decade began. Rising poverty and unemployment have increased pressure on environmental resources as more people have been forced to rely more directly upon them. Many governments have cut back efforts to protect the environment and to bring ecological considerations into development planning.

A thorough comprehension of these sensitive variables becomes the hallmark of EPM. Any EPM system may become feasible and effectual only when it encompasses both environmentalists and behaviourists. As an offshoot of such system, a well organised Extension Education Wing is to be created to translate the EPM know-how to the end users. The personnel manning and monitoring the extension activities must be capable of making rational and judicious use of audio-visual aids and extension methods to achieve the not so utopian goal of global pollution control.

A fiendish critique of what is proposed here may be nursing a genuine doubt about the adequacy of men, material, money and methods at the disposal of the third world countries. To mobilize these, concerted effort by governmental, non-governmental, voluntary, philanthropic and private agencies is necessary. They must work 'upstream' to change the products, processes, policies and pressures that give rise to pollution.

## References


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# PLENARY SESSION

## Report of the Plenary Session

Date: 31-3-1989
Time: 3.15 - 4.30 p.m.

Venue : Auditorium
UAS, Hebbal
Bangalore 560024

| | | |
|---|---|---|
| Chairman | : | Dr. K.R. Kulkarni<br>Director of Research<br>University of Agricultural Sciences<br>Bangalore |
| Co-chairman | : | Dr. B.C. Venkoba Char<br>Professor of Civil Engineering<br>Indian Institute of Technology<br>Kanpur |
| Rapporteurs | : | Mr. H.C. Sharath Chandra<br>Mr. T.V. Ramachandra Prasad |

### 1. Distribution of Prizes to Campus School Children of the University of Agricultural Sciences, Hebbal, for Painting Competition on Environmental Pollution

About 50 children of Campus School of University of Agricultural Sciences, Hebbal, participated in the painting competition on Environmental Pollution at Hebbal in the school premises. For this competition, five age groups, namely Group I-children of 1st and 2nd standards; II-children of 3rd and 4th standards; III- children of 4th and 5th standards; IV-children of 6th and 7th standards; V-children of 10th standard were made. The best paintings under each category were judged and awarded first and second prizes. In addition, complimentary prizes were also given to the next best competitors. The Co-Chairman Dr. C. Venkobachar presented the prizes to the children. The details of outcome of the competition are as follows :

| | | | |
|---|---|---|---|
| *Group-I* | First prize | : | D.R. Chandra, II Standard |
| | Second prize | : | R. Vidya, I Standard |
| | Complimentary prizes | : | Tanu, I Standard<br>Mamtha, II Standard<br>P.R. Varun, II Standard<br>G. Shwetha, II Standard |
| *Group-II* | First prize | : | B.S. Dinakar, III Standard |
| | Second prize | : | J. Balu, IV Standard |
| | Complimentary prizes | : | D.L. Ajay, III Standard<br>Parthasarathy, III Standard<br>Annie, III Standard<br>D.R. Roopa, IV Standard<br>S. Bhagyanathan, IV Standard<br>C.S. Nyer Firdoose, IV Standard<br>A.M. Savitha, IV Standard |

| | | | |
|---|---|---|---|
| Group-III | First prize | : | L.S. Goutam, V Standard |
| | Second prize | : | S. Lavanya, V Standard |
| | Complimentary prizes | : | Chetan Kashyap, V Standard |
| | | | H. Srinivasamurthy, V Standard |
| | | | J. Manjunatha Reddy, V Standard |
| | | | K.C. Rashmi, VI Standard |
| | | | N. Seshadri, VI Standard |
| | | | Raghu Vanshi, VI Standard |
| | | | K.J. Kiran, VI Standard |
| | | | S. Shivakumar, VI Standard |
| | | | Shubha Kar, VI Standard |
| *Group-IV* | First prize | : | B.P. Krishna Chaitanya, VII Standard |
| | Second prize | : | D. Kaverappa, VII Standard |
| | Complimentary prize | : | Jagadish N. VII Standard |
| *Group-V* | First prize | : | G.C. Shanthakumar, X Standard |

## 2. Presentation of Recommendations of the Sessions

Based on the discussions on the presentations of papers in each session, proceedings of the session are presented session-wise below:

***Session-I A : Industrial Wastes and Transport Exhausts***

Chairman : Dr. P. Narayanasamy, Reader in Entomology, Annamalai University, Tamilnadu

Rapporteurs : Dr. P.S. Jagadish and Mr. N.G. Kumar, University of Agricultural Sciences, Bangalore

Though 11 papers were scheduled for presentation in this session, only 7 papers were presented. Most of the papers mainly dealt with various aspects of pollution of air, water, soil, etc. due to industrial activities and automobile wastes. All the papers were thoroughly discussed.

The main discussion centered around the basic or fundamental aspects of every component of pollution with emphasis on the need to ascertain their composition and formulate possible ameliorative measures. It was felt that effort in future might be oriented towards the degradation or change of effluents that contaminate various water systems. Some light has been thrown on the knowledge of environmental pollution. Various ways and means are to be found out to alleviate these problems threatening the life of human beings and beneficial organisms.

Systematic studies with respect to flora and fauna of fresh water and marine forms are also lacking. This being the important component of the ecosystem and food chain, it is essential that studies in these lines should get due attention.

***Session-I B : Industrial Wastes and Transport Exhausts***

Chairman : Dr. Venkoba Char, Professor of Civil Engineering Indian Institute of Technology, Kanpur

Co-Chairman : Dr. T. Sathyanarayana, Hyderabad

Rapporteur : Dr. S. Subramanya, University of Agricultural Sciences Bangalore

Out of the 15 papers selected for presentation, 13 papers were presented. In this session (a) the effect of air pollutants like $SO_2$, $NH_3$, cement dust and fly ash on terrestrial flora and (b) effect of industrial and domestic effluents from soft drink, bleaching factory on aquatic life (fishes and macro-invertebrates) were discussed. The following observations and recommendations emerged during the discussions :

(1) Fly ash which is a pollutant has certain uses. It can be used for making bricks for non-load bearing walls in buildings, as an additive to soils in low concentrations to improve soil fertility, as soil conditioners and for prevention of water pollution in sandy soils. The study of cement dust on human health should be taken up besides its effect on growth and development of plants.

(2) Bio-monitoring technique for low levels of $SO_2$ by dielectrophoresis of chloroplasts has been developed. However, this method needs to be compared with the already established analytical methods. Further, the effect of formation of secondary pollutants from $SO_2$ should be monitored.

(3) The study of $NH_3$ pollution on plants revealed that $NH_3$ could be a growth promoting factor at very low concentrations.

(4) As there are sensitive and tolerant species of trees to varying degrees of air pollutants, selective planting of tree species can be undertaken to bio-monitor pollutants and to enhance tree canopy.

(5) The Donimali case study is very important in terms of environmental impact assessment of mining the area. In order to utilise the huge amount of overburden from mining industries, its enrichment with coir powder which helps in improving water retention with subsequent plant growth needs attention. However, the logistics involved need to be examined.

(6) The effect of effluents from soft drink and bleaching powder units on aquatic life, covered in two papers, require more thorough investigation. Standard methods should be followed for chemical analysis.

***Session-II : Pesticides and Bioparticles***

| | | |
|---|---|---|
| Chairman | : | Dr. S.N. Agashe, Professor of Botany<br>Bangalore University, Bangalore |
| Co-Chairman | : | Dr. T.K.S. Gowda, Associate Professor of Agricultural<br>Microbiology, University of Agricultural Sciences<br>Bangalore |
| Rapporteurs | : | Ms. N.A. Pushpalatha and Mr. S. Mallikarjunappa<br>University of Agricultural Sciences, Bangalore |

In this session nine papers were presented. Two of the listed papers were not presented. One additional paper was included for presentation. The papers presented mainly dealt with pollution of air, water, and food. There were seven papers on pesticide pollution and two papers on air pollutants dealing with pollen of different plant species, heavy metal transport and motor vehicle pollutants. The effects of all these pollutants on man, fish, insects and mites were covered. There were 2 papers on air pollution, 3 papers on water pollution and their effect on algae, bacteria and fish was covered.

*Salient features*

The pesticide dimethoate was highly toxic to primary productivity like algae, etc. in stabilization ponds. Malathion was highly toxic to fish both in hard water and soft water

The paper entitled 'Weeds as environmental pollutants' mainly touched upon the various kinds of pollutants including insects, fungi and higher plants which endanger the environment. The toxic effects of a variety of plants on the environment were highlighted in the paper. There were some lively discussions on the human health hazards due to some of these toxic plant species. During the discussion crop rotation was suggested as a practical means of checking the adverse effects of the chemicals produced by plants.

*Recommendations*

(1) Studies on fly ash for its chemical composition, solubility, $LD_{50}$ and phytotoxic effects need to be carried out for recommending its use in the field.

(2) It was suggested to take up systematic studies in an integrated approach, incorporating the presently available technologies in different cropping systems including cereals, pulses, cotton, sugarcane, oilseeds for viable recommendations in the field.

(3) Studies on the monitoring of toxic effects of plant species on human beings and crop rotation as a special measure for checking the adverse effects were suggested.

***Session IV B : Pollution Management and Constraints***

| | | |
|---|---|---|
| Chairman | : | Dr. A. Regupathy, Professor of Entomology<br>Tamil Nadu Agricultural University, Coimbatore |
| Co-Chairman | : | Dr. PR. Karpagaganapathy, Annamalai University<br>Annamalainagar |
| Rapporteur | : | Mr. K. Nagi Reddy, University of Agricultural Sciences<br>Bangalore |

Out of the scheduled 13 papers, only 7 were presented. One paper each was on pollution by resin industry waste, cement dust and municipal sewage water, one on molybdenum toxicity and one on the use of bioabsorbents to prevent metal pollution. Two papers brought an overview of the socio-economic aspects of environmental pollution, pesticides and their related environmental hazards.

*Salient features*

(1) (a) Synthetic resin industry effluent was detrimental to microbes. Dilution of the effluent (1:6) reduced the inhibitory effect on microbes.

(b) Treatment by aeration followed by sedimentation treatment with lime was found to be more efficient.

*Suggestion*: Isolation of efficient microorganism could improve the efficiency of effluent treatment.

(2) Application of urea and ascorbic acid was found to reverse the inhibitory effect of cement dust.

*Suggestion*: In assessing the effect of pollutants, simulation of experimental conditions prevailing in the problem area could be considered. In the present study 3 g dust was applied on paddy seedlings daily to study the deleterious effect of cement. Dust deposition/unit area may be assessed and this may be taken up for fixing the dose in such studies.

(3) Molybdenum accumulation in plants can be prevented through sulphur nutrition. The molybdenum toxicity should be given proper attention while growing fodder as it was found to cause molybdenosis in cattle.

(4) Pollution due to non-biodegradable and biomagnifiable heavy metal like Cu can be controlled using bioabsorbents. Waste biomass of *Ganoderma lucidum*, a non-edible mushroom, ranked top with 98% uptake of Cu than sludge (42%) and waste myclia of *Aspergillus niger*, a by-product from citric acid fermentation process (14%), in removing Cu at the ionic strength of 0.03 to 0.17 mg/g.

*Suggestion:* It was suggested that toxins of bioabsorbnts may also be looked into while using them in metal removal.

(5) Municipal waste water after treatment with activated sludge and aeration was found suitable for irrigation. It was stated that the digested activated sludge could be utilized as manure.

*Suggestion* : The heavy metal level in the digested sludge may be looked into before using it as manure as this will lead to accumulation of heavy metals in farm produce.

(6) While presenting an overview of socio-economic aspects leading to environmental pollution, the possibility of giving abatement subsidy and enforcing stringent punishment for violation have been suggested. Efforts should be made to establish functional linkages among different agencies concerned with the prevention of environmental pollution.

(7) While reviewing the various aspects of pesticide hazards, the need for regular monitoring of workers engaged in pesticide manufacture or use by their employers was suggested.

**3. Chairman's Remarks by Dr. K.R. Kulkarni, Director of Research, UAS, Bangalore**

The Chairman thanked the Chairmen of various Sessions for having read the proceedings. He emphasized the need for systematic efforts in documenting the sources causing pollution of water, air and food, and the means of ameliorating pollution to have a cleaner environment. Training could be imparted to young scientists on pollution. In addition, he stressed the need for having an "Association of Environmental Scientists" for holding periodical meetings/seminars to document the pollution hazards by various agencies and to bring out recommendations to mitigate the pollution problem.

**4. Vote of Thanks by Mr. K. Shankar, Treasurer**

At the outset, Mr. K. Shankar thanked the Chairman and Co-Chairman of the Plenary Session for conducting the deliberations and coming out with useful recommendations. He thanked the Chairman, Co-Chairman and Rapporteurs of various Sessions for conducting the Sessions and coming out with suggestions based on the discussions. Thanks were due to the campus school authorities and the children for arranging/participating in the painting competition.

The Treasurer thanked the UAS authorities for sparing the auditoriumn, seminar hall, audio-visual aids and providing transport facilities. Various organisations like Forest Department, Government of Karnataka; United Nations Environmental Protection Agency, Bangkok; International Union of Air Pollution Prevention Association, U.K.; Youth for Development and Co-operation, Netherlands; International Group of National Associations of Manufacturers of Agro-Chemical Products, Belgium, spared posters on environmental pollution for display during the seminar. Press, Doordarshan and All India Radio who carried the message were also thanked.

Mr. Shankar thanked the participants from different parts of the country and organising committee members for active co-operation in making this seminar a grand success. Thanks were also due to funding agencies like the University of Agricultural Sciences, Bangalore; Institution of Agricultural Technologists, Bangalore; Indian Council of Agricultural Research; Karnataka State Council for Science and Technology; Department of Science and Technology, Government of India; Department of Ecology and Environment, Government of Karnataka; Karnataka State Irrigation and Drainage Board, Bangalore; Department of Ocean Development, Government of India; Shri Chamundeswary Sugars Ltd.; Mangalore Chemicals & Fertilizers Ltd.; Karnataka State Seeds Corporation and other agencies, for their contribution in various ways in organising this seminar.

Lastly, he thanked one and all in making the Seminar a grand success.

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