Enhancement of aquatic productivity through application of organic manure (vermicompost)

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MASTER OF FISHERY SCIENCE
In
Aquatic Environment Management

By

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CERTIFICATE

This is to certify that the work embodied in the thesis entitled "***Enhancement of aquatic productivity through application of organic manure (vermicompost)***" submitted by **Priyanka Raysamant** in partial fulfilment of requirements for the **degree of Master of Fishery Science (Aquatic Environment Management)** in the Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, is the faithful and bonafied research work carried out under my supervision and guidance. The results of the investigation reported in this thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

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(AQUATIC ENVIRONMENT MANAGEMENT)

We, the undersigned, have been satisfied with the performance of **Priyanka Raysamant** in the viva voce examination, conducted today, the....May 02......, 2012, recommend that the thesis be accepted for the award of the degree.

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Acronyms

Symbols	Abbreviations
V.C:	**Vermicompost**
C.D:	**Cow dung**
DO:	**Dissolved oxygen**
GPP:	**Gross Primary Productivity**
NPP:	**Net Primary Productivity**
PO_4-P:	**Phosphate-phosphorous**
NO_3-N:	**Nitrate- nitrogen**

CHPATER-1

INTRODUCTION

Organic farming is a modem, sustainable farming system, which maintains the long term fertility of the soil and uses less of Earth's finite resources to produce high quality nutritious food. During recent times, organic aqua farming developed from organic farming concept has been put into practice in farmer's field in the rural areas (Bhaumik et. al, 2009).

Organic farming is based on a holistic view where nature is considered as a whole with an intrinsic value of its own, leading to take moral responsibility regarding the ecological, economical and social aspects of aquaculture production. Through this practice chemical fertilizer and pesticides are avoided and the fish health as maintened along with recycling of nutrients (Laird, 1999).

1.1 Organic aquaculture and the environment

Organic farming restricts the use of artificial chemical, fertilizer and pesticides, chemotherapeutic medicines including antibiotics and encourages utilization of natural nutrients, probiotics and bio-remedial measures. It has the potential to reserve the depleting productivity, biodiversity, mangrove and other habitats. Global climatic change is considered one of the most urgent environmental problems. The main negative impact on climate change is emission of greenhouse gases and the agriculture sector contributes to over 20% of global anthropogenic greenhouse gas emission. Moreover the mixed farming and diversity of organic crop rotations are protecting the fragile soil surface and may even counteract climate change by restoring the organic matter content.

1.2 Need for Organic Farming in India

The need for organic farming in India arises from the un-sustainability of agriculture production and the damage caused to ecology through the conventional farming practices. The present system of agriculture which can be called as 'conventional' and practiced the world over evolved in the western nations as a product of their socio-economic environment which promoted an overriding quest for accumulation of wealth. This method of farming adopted by other countries is inherently self destructive and unsustainable.

The national productivity of many of the cereal crops, millets, oilseeds, pulses and horticultural crops continues to be one of the lowest in the world in spite of the green revolution. The fertilizer and pesticide consumption has increased manifold; but this trend has not been reflected in the crop productivity to that extent. The country's farming sector has started showing indications of reversing the rising productivity as against the increasing trend of input use

The un-sustainability of Indian agriculture is caused by the modern farming methods which have badly affected/damaged production resources and the environment. For all these reasons the present study was conducted using different doses and compositions of vermicompost for use in aquaculture with the following aim and objectives.

1.3 Economics of organic farming

The replacement of external inputs by farm-derived resources as in case of organic form normally leads to reduction in variable input coast under organic management. Studies have shown that the common organic agricultural combination of lower input coasts and favourable price premiums can offset reduced yields and make organic farms equally or often more profitable than conventional farms. Studies indicated that there is a reduction in cost of production and increased gross and net return in organic farms in compared to traditional farms. As the organic inputs are used optimally the feed requirements reduced and also the use of yeast based organic preparations elicits the immune status of shrimp and has role in enhancing the growth rate.

1.4 Status and development of organic aquaculture

Aquaculture, much like organic agriculture, is one of the world's fastest growing food sectors. Globally aquaculture production has been growing at an average rate of 9% per year since 1970, compared with 2.9% for terrestrial farmed meat production and 1.3% for capture fisheries. However, to date, aquaculture has lagged behind the agriculture sector in terms of the quantities and diversity of organic produce. This delay is largely due to the absence of universally accepted standards and accreditation criteria for the production of organic aquaculture production. It is also due to certifying bodies being almost totally restricted to a handful of organization within developed countries, even though these countries produced less than 10% of total global aquaculture production in 1999. Although no official statistical data are available concerning the global production of certified organic aquaculture products, it is estimated that total production in the year 2000 was only about 5,000 metric tonnes, primarily from European countries. This included 4,000 tonnes of salmon, 100-200 tones of carp and accompanying fresh water species and 100 tonnes of blue mussels.

Some conscious is growing in the country towards the demand for organic food production where one of the components is fish. The term "organic" implies that certain standards for production and processing are adhered to and that impartial organizations take part in the inspection and certification process. Besides this vermicompost neem manure is also important manure. It is also now gaining popularity because it is environmentally friendly and also the compound found in it helps to increase the N and P content of soil. It is rich in Sulphur, Potassium, Calcium and Nitrogen. The benefits are:

1. Bio Degradable and Eco friendly.
2. Nourishes the soil and plants by providing all the macro and micro nutrients.
3. Helps to eliminate bacteria responsible for denitrifying the soil.
4. Ideal for cash crops and food crops.
5. Increases the yield of crops.
6. Helps to reduce the usage of fertilizer, thus reducing the cost of growing plants.

The aim of the experiment is to "**Ensure the use organic waste materials as organic manure so that the aquaculture practices become more profitable and ultimately the environment will be protected not only from harmful effects of chemical fertilizers but also from the organic waste pollutants**".

The **objectives** are:

1. To find out suitable substrate (vermicompost) for application as organic manure in aquaculture practices.
2. To find out the suitable dose and composition of organic manure to be applied for better pond productivity.
3. To study the impact of organic manure on water quality parameter.

CHAPTER - 2

REVIEW OF LITERATURE

In the recent years much emphasis has been placed on the study of our environment not solely for academic reasons, but rather for elucidation of man's effect on environment, and an important part of this has been the study of aquatic ecosystem.The reviewed literature is presented under the following heads:

2.1. Water productivity
2.2. Organic fertilizers
2.3. Vermicompost
2.4.Concept of Vermicomposting biotechnology
2.5. Use of Vermicomposting biotechnology to recycle organic wastes
2.6. Application of vermicompost in aquaculture

2.1 Water productivity

Water productivity is an important aspect in fish culture ponds.Each and every culture system requires a pond with good water quality for getting better production. Now-a-days the use of chemical fertilization for increasing the water productivity became a habit for farmers; the harmful effect of these chemicalscannot be avoided. These chemicals not only affects the water quality by increasing the eutrophic condition but also creates the health hazards for the aquatic animals leading to decrease in aesthetic value of pond environment. A common approach for increasing fish production in ponds is the direct application of fertilizer, which enhances production of plankton, a natural food item for fish (Chakrabarti and Jana, 1998). Pond fertilization practices using animal wastes are widely used in many countries to sustain productivity at low cost (Gupta and Noble, 2001; Majumder*et al.*, 2002).

Studies on physicochemical factors and phytoplankton standing crop of its habitat are essential for the proper management of water resources and for the prediction of the potential changes in the aquatic ecosystem. These factors have also been reported to be responsible for the heterogeneity in phytoplankton composition and biomass (El-Ayouty*et al.*, 1994, 1999; Ahmad *et al.*, 2001; Ibrahim *et al.*, 2003).

Many studies have shown positive correlation between pond fertilization and fish production (Boyd, 1984; Abdel- Tawwab*et al.* 2002 a, b). Increases in fish production infertilized ponds were attributed to the increments in primary productivity (Diana *et al.*, 1991; Ahmad *et al.* 2001; Abdel-Tawwab*et al.*, 2002a; 2002b).

The growth of fish is strongly correlated with increase in phytoplankton and zooplankton productivity as a result of fertilization (Abbas and Hafeez-Ur-Rehman, 2005). Fertilizers increase the level of primary productivity, dissolved oxygen, PH and total phosphorus (Qin et al., 1995).

The report of a study conducted by Ponce et al., (2010) to find out the effect of organic and chemical fertilization on phytoplankton and fish production in carp (Cyprinidae) in a poly culture system showed that the phytoplankton production was significantly high in ponds treated with organic manure. The pond condition with organic manure was found adequate to obtain high yield without commercial feed. So they recommended the use of organic manure due to their high availability and with low coast.Results obtained from an experiment on Effect of fertilization and low quality feed on water quality dynamics and growth performance of Nile Tilapia (Elnady et al., 2010) showed that higher photosynthesis activity and increased algae production in organic manure treatment. In water quality experiment also the growth of tilapia was more in organic manure as compared to chemical fertilizer.

The traditional manure cow dung also showed very good result in an experiment conducted with processed cow dung (Kumar, 2005). The cow dung was processed with various other organic wastes. This manure when applied in different fish culture system showed the better enhancement of phytoplankton production as well as the fish production.The results from an experiment conducted by Jha, Sarkar and Barat (2004) with organic manures like cow dung and poultry excreta showed that better result was found in both case but higher production in poultry with better water quality and abundance of planktons.

2.2 Organic fertilizers

Use of fertilizer is an age old practice all over the world. Both organic as well as chemical fertilizers are being used to produce live fish food organisms i.e. zooplankton (Sharma, 2003). Organic fertilizers are made from materials derived from living things. Animal manures, compost, bone meal and blood meal are organic fertilizers. The importance and, in some cases, the major problems associated with organic fertilizers, deserve special mention. Manure produced by cattle, pigs and poultry are used as organic fertilizer the world over. To this are added human excreta, especially in some Asian countries where animal and human excreta are traditionally used in fish culture as well as on soils. However, intensive livestock production has produced major problems of environmental degradation, a phenomenon which has been the subject of European and North American legislation and control. Unlike chemical fertilizers, organic material does more than provide organic nutrients. It also improves the soil structure, or tilth, and increases its ability to hold both water and nutrients. Pond fertilization practices using animal wastes are widely used in many countries to sustain pond productivity at low cost (Perker and Olah, 1999). Patra and Ray, (1988); Kestemont, (1995) and Zoccarato et al., (1995) and many others have recognized the efficiency of various organic manures in increasing productivity of fish ponds.

Juwarkar et al. (1992) showed that India has vast resources of various kinds of organic wastes, nutrient content of which may surpass in magnitude the total amount of nutrients being supplied through mineral fertilizers. Wide scale recycling of these waste materials will not only facilitate the resource utilization but will also promote environmental safety. In recent years vermicomposting biotechnology has emerged as a promising option for decomposing wide ranges of organic wastes with the help of earthworm gut microorganisms leading to more effective degradation of the waste and production of compost with higher nutrient status.

Table-1: Average nutrient content of different organic wastes

Type of wastes	Percentage content		
	N	P_2O_5	K_2O
Cattle dung	0.35	0.12	0.12
Poultry droppings	2.5-3.0	1.0-1.13	0.7-1.12
Pig dung	0.5-0.53	0.5-0.53	0.3-0.36
Goat and sheep dung	0.65	0.50	0.03
Veg. and food processing industry waste	1.8	1.5	1.2
Tobacco waste	4.5	15.0	5.5
Tea waste	3.5	0.5	1.5
Mustard oil cake	4.52	1.78	1.40
Soyabean oil cake	7.9	2.2	1.9
Sunflower oil cake	7.9	2.2	1.9
Neem cake	5.22	1.08	1.48
Mahua cake	3.11	0.89	1.48
Ground nut cake	7.29	1.68	1.33
Linseed oil cake	5.56	1.44	1.28
Castor cake	4.37	1.85	1.39
Human faces	1.35	0.75	0.50
Fish meal	7.0	6.0	2.0

Source: Tandon (1997); Gour et al. (2002)

The major objective of application of mineral fertilizers and organic manures to fish ponds is to increase the amount of primary fish food organism which forms the first echelon in the food chains and lead to the growth of fishes (Chattopadhyay, 2004). Among different pond fertilizing materials, the importance of different kinds of organic manure in Asian countries has been emphasized by Prowse (1996). However, with the increasing scarcity of traditional manures owing to competitive uses (Gupta *et al.*, 1998), more attention is now being paid on recycling of different organic wastes for such productive purposes.

Organically cultivated soils are relatively better attuned to withstand water stress and nutrient loss. Their potential to counter soil degradation is high and several experiments in arid areas reveal that organic farming may help to combat desertification (Alam and Wani, 2003). It is reported that about 70 hectares of desert in Egypt could be converted into fertile soil supporting livestock through organic and biodynamic practices. India, which has some areas of semi-arid and arid nature, can benefit from the experiment.

2.3 Vermicompost

Among the decomposed manures, vermicompost is rich in all types of major and minor nutrients, vitamins, enzymes, antibiotics, growth promoters etc. (Mitra, 1997; Bhusan and Yadav, 2003). The vermicomposting technology has two main advantages; firstly this technology can be used for speedy degradation or recycling of urban and rural waste for conversion of organic waste into highly useful manure, and thus solving the problem of waste disposal management and environment degradation in rural as well as in urban areas. Secondly, this has an additional benefit of production of production of earthworm meal to serve as a protein rich supplement for livestock industry. Thus the vermicompost might be cost effective manure in fish culture for replacing expensive chemical fertilizer.

The activities of earthworms for recycling of organic matter became the focus of attention by scientific community in mid-1990s and now vermicompost find an application in aquaculture to its advantage. Vermicompost is found to be more nutritious than cow dung/ farm yard manure in terms of more carbon and phosphorus, less potassium and comparable nitrogen (Shinde et al., 1992) and found to have better manurial property than RCD (raw cow dung) in terms of its effect on hydro biological properties (Sulochana et al., 2009). The growth maturation, cocoon production and reproduction potential of earthworms are not influenced by environmental condition alone but also strongly affected by the quality and availability of food (Reinecke et. al., 1990). The average nutrient contents reported for vermicompost are nitrogen 1.5 to 2.5 percent (average 2%), phosphorus 1 to 2.5 (average 1.75%), potash 1.00 to 2.00 (average 1.5%). In addition vermicast contain all micro nutrients and trace elements, which would also add up to at least 1% equivalent of nutrients. The vermicast has active biological life containing Azobacter, PSB, PGPR, etc.

As indicated by Ansari and Ismail (2001), the application of chemical fertilizers over a period has resulted in poor soil health, reduction in produce, and increase in incidences of pest and disease and environmental pollution. In order to cope with these trenchant problems, the vermin-technology has become the most suitable remedial device (Edwards and Bohlen, 1996; Kumar, 2005).

From earlier studies also it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants. Sreenivas et al. (2000) studied the integrated effect of application of fertilizer and vermicompost on soil available nitrozen (N) and uptake of ridge gourd (*Luffaacutangula*) at Rajendranagar, Andhra Pradesh, India. Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 t ha-1 vermicompost. Vermicomposting converts household waste into compost within 30 days, reduces the C: N ratio and retains more N than the traditional methods of preparing composts (Gandhi et al. 1997).

2.4 Concept of Vermicomposting biotechnology

Vermitechnology i.e. the production of vermicompost through the utilization of organic wastes by suitable species of earthworm is now being applied to aquaculture sectors in order to ensure higher fishery production and is expected to open up new vistas of sustainable environmental management and aquaculture development. Sustainable aquaculture depends upon eco-friendly and economically and socially viable culture system.Vermitechnology is the use of surface and subsurface local varieties of earthworm in composting and management of soil (Ismail, 2005). Vermicomposting is the biological degradation and stabilization of organic waste by earthworms and microorganisms to form vermicompost (Edwards and Neuhauser, 1988).

Vermicomposting, which is composting using worms, can be a faster alternative for organic waste treatment, with the added advantage of better quality fertilizer with nutrients in the slow-release form. Vermicomposting also adds valuable soil microbes into compost and digestive fluids of worms can also be beneficial. Vermicomposting is the breakdown of organic material that, in contrast to microbial composting, involves the joint action of different species of earthworms (not all earthworms are composting worms) and microorganisms and does not involve a thermophilic (i.e., high heat) stage. Because the matrix contains many different organisms, this can be considered as an anthropogenic ecosystem. As the agents of turning, fragmentation and aeration, the worms consume organic wastes such as food waste, animal wastes and sewage sludge to produce a soil conditioner. Vermicomposting may only process organic waste of a suitable structure for worms and the optimum waste streams include some food wastes, sewage sludge, garden waste (leaves and grass) and manure. Studies have shown that vermiculture is an effective method of treating pathogen-rich waste materials and domestic solid and liquid wastes. Charles Darwin was the first to write that worms could be used in converting organic waste into a fertilizer.

Importance of earthworms in maintaining fertility of soils was emphasized years back. Beneficial effects of these earthworms in improving structure, aeration, nutrient status and some other properties of the soils and, thereby, the growth of crops have been known since long. However, the knowledge about the efficiency of some groups of the earthworms in decomposing various organic materials was gathered later on and the concept of utilizing this behavior for composting wide ranges of organic wastes was conceived during mid twentieth century (Senapati, 1993). Earthworms which live on upper surface of soils feed mainly on plant litter and other organic debris available there. Since these earthworms, known as epigeics can consume a variety of organic matters, they are most suitable for converting organic wastes into useful organic manures. However, uses of other groups of earthworms in such composting process have also been reported by Lavelle and Martin (1992).

These epigeic earthworms being voracious feeders can consume large quantities of different organic materials. In comparison to their high rate of consumption, these earthworms utilize only a very small portion for their body synthesis and excrete about 90-95% of the ingested materials as vermicast. The food materials ingested by the earthworms are thus subjected to more intense microbial activity in the alimentary canal not only due to these higher concentrations of different micro-organisms but also owing to increased surface area of the food particles meshed to very fine sizes while passing through the gizzard. In addition to the activities of the microbes, occurrence of various enzymes in earthworm guts also helps such processes. All these components mix thoroughly with the food materials consumed by the earthworms and are released with their excreta to be known as vermicast. These vermicasts undergo rapid aerobic decomposition in presence of different microbes, which activity is accelerated by various enzymes and encouraged by occurrence of numbers of growth promoting substances. Aerobic micro-organisms being more active decomposers than the anaerobic, degradation of the vermicasts takes place more rapidly than the traditional "pit composting" method and a nutrient rich well humified organic manure is obtained in shorter period of time which is termed as "vermicompost".

2.5 Use of Vermicomposting biotechnology to recycle organic wastes

Vermicomposting biotechnology helps in recycling different organic wastes with the help of large numbers of aerobic microorganisms and these results, in general, in better nutrient status of the produced materials, as compared to those prepared by traditional composting systems. Shinde*et al.*, (1992) reported vermicompost prepared from farm yard wastes to exhibit higher nutrient status. Similar observations have been made by Rasal*et al.*, (1993) also who stated introduction of earthworms in sugarcane trash to result in decreased C: N ratio and increased availability of N. That vermicomposting of animal and agricultural residues results in significantly higher nutrient content and microbial population within a period of six weeks (Table-2) has been shown by Jambhekar (1992). While working on nature and magnitudes of transformation of Phosphorous during the course of vermicomposting of different wastes, Ghosh*et al.*, (2000) further observed that vermicomposting process tended to reduce the quantum of fixation of P as insoluble Fe, Al and Ca phosphate and also helped to mineralize P from organic to inorganic forms. Among the effects of different microorganisms and enzymes contributing to such increased availability of P, major emphasis may be given to presence of very high concentration of phosphate solubilizing bacteria (PSB) in the vermicasts. Bhattacharya and Chattopadhyay (2001, 2002) reported vermicasts prepared from mixtures of cattle wastes and fly ash to exhibit rich occurrence of nitrogen fixing and phosphate solubilizing organisms in vermicompost.

Concentrations of available N, P and K in the two organic manures have been shown in table-2. As observed in the table, vermicompost resulted in considerable higher occurrence of different nutrients both in total and available forms. Similar benefits of vermicomposting over traditional composting have been reported by Kale (1993), Ghosh*et al* (1999) and others.

Based on this opinion, Mandal and Chattopadhyay (1992) calculated that for achieving 1000 kg of fish yield in a fish pond ha^{-1} yr^{-1} under natural condition, 13.7 g organic carbon should be assimilated m^{-3} day^{-1} through photosynthesis of primary fish food organisms. The fish production is likely to increase with this primary productivity, till the response curve tends to decline (Chattopadhyay, 2004). Since this is unlikely that a pond system will be able to supply necessary amount of different nutrient elements for such biotic production, these nutrients are added to the fish ponds in the forms of mineral fertilizers and /or organic manures.

A study on comparative efficiency of organic manures as fish food using the manures like cow dung, poultry, goat, pig, horse and a mixture of cow dung with poultry. According to the results from this experiment, *Chlorophyceae* was the dominant group among the phytoplankton in general followed by *Myxophyceae* and *Diatomaceae*.

Results from the study of hydrological characteristics and primary productivity in fish ponds (Singh and Sharma, 1999) manured with 3 different manures like cow dung, poultry, and pig showed the best result in poultry excreta. It also showed higher value of DO, pH, carbonate and bicarbonate

Table- 2: Nutrient Profile of Vermicompost and cow dung

Nutrient Profile of Vermicompost and cow dung	Vermicompost	Cow dung
N (%)	1.6- 2.5	0.5-2
PO (%)	0.7-1.7	0.2-0.8
KO (%)	1.5-2.4	0.5-1.5
Ca (%)	0.5-1.2	1.2
Mg (%)	0.15	0.19
S (%)	0.4-0.8	0-1.2

Mn (ppm)	**96.51**	**69.00**
Fe (ppm)	**175.20**	**146.50**
Zn (ppm)	**24.43**	**14.50**
Cu (ppm)	**4.89**	**2.80**
C:N ratio	**15.50**	**31.28**
Organic Carbon	**65.4**	**20.58**
Time for preparation of compost	**3 months**	**12 months**
Resistance to disease and insects	**Can be developed**	**Cannot be developed**

Source: Technical Buletin-8, NRCWA, ICAR

2.6 Application of vermicompost in aquaculture

The most common method of solid waste disposal is land spreading which causes pollution of soil as well as surface and ground water resulting in mortality of aquatic organisms. Vermicomposting of wastes controls the pollution of soil and water, thus ensures the survivility and growth of fish, prawn and other aquatic organisms. The application of vermicastings which is a high grade organic fertilizer, to the aquaculture ponds reduces the input cost making the aquaculture production process more profitable and it also helps in controlling the harmful effects of chemical fertilizer application. Deolalikar and Mitra (1996) have used vermicompost prepared from paper mill solid waste for fertilizing aquaculture tanks and found an increase in net primary productivity from 32.08 to 220.83 mg C/m /h. Vermicompost application also showed better growth of rohu fish (*Labeorohita*) when compared with other commercially available organic manures (Deolalikar and Mitra, 1997).The direct application of vermicompost as fertilizer and manure in fish culture system showed significance result in diversity and abundance of plankton (Chakrabarty and Das, 2010). They used three treatments in their experiment out of which highest phytoplankton and zooplankton production was found in vermicompost. The fish production was also highest in vermicompost treatment.

The growth performance of *Oreochromismosambicus* as well as phytoplankton and zooplankton were studied with different treatment like vermicompost, mixed fertilizer, and SSP (Chakrabarty, Bag and Das, 2010). It was found that the best growth of fish as well as phytoplankton and zooplankton showed by vermicompost than others. According to them the gradation of fertilizer in an ascending order is like vermicompost, mixed fertilizer, and SSP.

An experiment conducted by Kaur and Ansal for assessment of vermicompost as fish pond manure and also to find out the effect of vermicompost on water quality as well as on growth of *Cyprinuscarpio*. In the experiment three different doses of vermicompost and cow dung was used. During their experiment the water quality parameters were found to be within the optimum limits for carp culture in all types of treatments. This experiment showed that the fish growth in terms of weight gain, % weight gain and specific growth rate was more in VC_{15} followed by VC_{20}, VC_{10}, and cow dung.

Results of the experiment conducted by Singh and Sharma (1999) with organic manures like cow dung, pig dung and poultry excreta to determine the efficiency of these manures found that, the production was more in poultry excreta followed by pig dung and cow dung.The experiment conducted by Chattopadhyay*et al.*, (2009) with vermicompost and cow dung to compare the efficiency of these two showed the best result for vermicompost rather than the traditional cow dung.

Table-3: Status of major nutrients and microbial population in organic wastes treated with and without earthworms

Substrate	Parameters				
	C : N ratio	N (%)	Available P_2O_5 (%)	Available K_2O (%)	Microbial count
Cowdung					
Original	49.1	0.53	0.003	0.104	-
Vermicomposted	16.8	1.20	0.004	0.396	24×10^6
Untreated	24.0	1.00	0.003	0.192	18×10^5
Pigmanure					
Original	55.3	0.68	0.050	0.050	-
Vermicomposted	15.5	1.80	0.151	1.150	30×10^6
Untreated	40.0	0.80	0.080	0.110	28×10^5
Sugarcane trash					
Original	38.17	0.66	0.080	0.020	-
Vermicomposted	16.07	1.40	0.100	0.010	24×10^6
Untreated	30.72	0.80	0.090	0.060	20×10^5

Source: Jambhekar (1992)

CHAPTER - 3

MATERIALS AND METHODS

This chapter deals with the description of the study area and environment, Experimental set up, and techniques employed for analyzing the data. The methodology is presented under the following major heads.

3.1 Description of the study area and environment
3.2 Materials used
3.3 Experimental set up
3.4 Analytical techniques employed

3.1 Description of Study area and environment

The present study has been carried out in department of Aquatic Environment Management of Faculty of Fishery Sciences, West Bengal, for a period of 90 days. This experiment was conducted to find out the efficiency of vermicompost with comparison to the traditional manure like cow dung. The experiment was mesocosm in nature, as it was carried out in laboratory condition. The experiment has three phases, out of which two phases were conducted in laboratory or mesocosm condition with glass aquaria and the third phase was carried out with cement cisterns in a field condition. The cisterns were placed adjacent to the culture pond of the faculty to simulate the natural environmental condition.

3.2.Materials used

MANURES

1. Vermicompost: Vermicompost selected for the study were three different substrates i.e.

Type of vermicompost and substrates used for preparation

Type of vermicompost	Substrates
Vermicompost - 1	Neem leaves
Vermicompost – 2	Mangrove leaves (*A. affinis*)
Vermicompost - 3	Vegetable waste (Cabbage leaves)

2. Cow dung: In this experiment the cow dung was used in dried and powdered form in spite of raw cow dung. The raw cow dung was sun dried before using and the moisture content was estimated about 50% of the raw dung.

SOURCE OF SOLIL AND WATER

For experiment phase 1 & 2 the tap water was collected and stored in a FRP tank before 1 month of the beginning of experiment. During this time it was provided with soil and some aquatic weeds for simulating the natural condition with minute growth of planktons. In 3rd phase the water was from pond itself before one day of experiment.

The soil was collected from the culture pond only from where the water was collected. After collection the soil was sundried for three days before use.

3.3Experimental set up

The experiment was conducted in three phases which are described as follows:

Experiment phase I:

A single dose of all three types of vermicompost and cow dung was applied@ 5 ton/ha in water. Accordingly 5 gm of each of V.C and 4.5 gm dry weight of cow dung was applied. The experiment was set for 30 days and after application of manures the water parameters were studied in 3 days intervals.

Experiment phase II:

Multiple doses of the manures were applied in second phase. Hence the same dose as first phase was splited into three phases as follows:

1. 50% of initial dose i.e. 4.5 gm for vermicompost and 2.1 for dry cow dung
2. 25 % of initial dose i.e. 2.1 for vermicompost and 1.05 for drycow dung
3. 25 % of initial dose i.e. 2.1 for vermicompost and 1.05 for drycow dung

The splited doses are applied in three phases in an interval of 72 hrs and all the parameters were studied in same interval as first phase.

Experiment phase III:

This phase of experiment was conducted with cement cisterns of capacity 200 L. The tanks were placed near the pond itself and it was exposed directly to the sun light. It was totally under natural condition. A single dose of both vermicompost and cow dung was applied as the better result was found in single dose application from the above two phases of experiment.

All the physico-chemical parameters were studied during morning hours at regular interval of 72 hours for the total time period i.e. 90 days for each phase of experiment. The time gap was 72 hrs because the plankton growth was found to be increasing making the water colour greenish from this time onwards. So to avoid the all the parameters were taken in this time to get the exact result.

During each sampling the water and air temperature was also recorded. For biological parameters at the end of each phase the plankton was collected through plankton net and both quantitative and qualitative analysis was carried out.

3.4Analytical techniques employed

Methods for examination of the water and soil parameters were followed from APHA (Standard methods for the examination of water and waste water), 2002.

3.4.1 Physico-chemical parameters of water and soil

3.4.1.1 Temperature

The profile of air and water temperature was recorded with the help of a sensitive thermometer with an accuracy of +/- 0.1° c.

3.4.1.2 Hydrogen ion concentration (pH)

The pH of water was measured with pH paper as well as pH meter.

3.4.1.3 Total alkalinity

The aid base titration of phenolphthalein alkalinity was determined by following the standard methods from APHA. Phenolphthalein alkalinity value represented the carbonate content. The total value of bicarbonate was expressed in ppm.

3.4.1.4 Hardness

Hardness was estimated by complexometric titration, the major cations imparting hardness to water are calcium and magnesium. These ions react with EDTA to form soluble complexes and the completion of reaction is indicated by colour change with eriochrome black T (EBT) as indicator for hardness. The values of hardness were expressed in ppm.

3.4.1.5 Dissolved oxygen

Dissolved oxygen was estimated by following the Winkler's method and the values were expressed in mg/lit.

3.4.1.6 Available Phosphorus

The available phosphorus in water was estimated by stannous chloride method. The result was obtained in form of absorbance of light that passes through the sample which was detected by spectrophotometer at 690 nm of wave length. The more the light absorbed the more is value of phosphorus. The value of phosphorus was obtained by plotting the value of absorbance on a standard graph.

3.4.1.7 Nitrate-nitrogen

The available Nitrogen in the form of Nitrate was estimated by Ultraviolet Spectrophotometric screening method. The result was obtained in form of absorbance of light that passes through the sample which was detected by spectrophotometer at 220 and 275 nm of wave length. Two wave lengths are used to avoid the interference due to dissolved organic matter. The value of nitrate was obtained by plotting the value of absorbance on a standard graph.

3.4.2 Primary productivity

The important parameter in this experiment was primary productivity as it indicates the presence of primary producers or planktons. Primary productivity includes both Gross primary productivity (GPP) and Net primary productivity (NPP). During this study the primary productivity was estimated by light and dark bottle method. The calculation of GPP and NPP was done by the following formula and values were expressed in "mg C/m3/hr".

Calculation

$$\text{GPP:} \quad \frac{LB - DB}{T} \times \frac{0.375}{1.2} \times 1000$$

$$\text{NPP:} \quad \frac{LB - IB}{T} \times \frac{0.375}{1.2} \times 1000$$

Where LB: Light bottle

DB: Dark bottle

IB: Initial bottle

T: Time of exposure to sun

0.375: Ratio of weight of C and O

1.2: Photosynthetic co-efficient

3.4.3.1 Soil organic carbon

The organic carbon content of soil was estimated by rapid titrimetric method of Walkley and Black. Under this method organic matter in soil is oxidized with excess potassium dichromate using the heat of concentrated sulfuric acid. The unutilized potassium dichromate is then traced with ferrous ammonium sulphate and amount of organic carbon is determined from the amount of potassium dichromate used for oxidation. The calculation to find out the carbon value was done by the following formula and value was expressed in percentage.

Calculation:

% of organic carbon is

(B - A) × 0.3

Where

B: Titration value in blank

A: Titration value in sample

3.4.3.2 Soil available phosphorus

The available phosphorus in soil was estimated by Olsen method as the pH of soil was more than 6. The result was obtained in form of absorbance of light that passes through the sample which was detected by spectrophotometer at 660 nm of wave length. The value of phosphorus was obtained by plotting the value of absorbance on a standard graph.

3.4.3.3 Soil available nitrogen

The available nitrogen in soil was estimated with the help of Kjeldal distillation unit. In this process the $KMnO_4$ in an alkaline medium acts as a weak oxidizing agent. Hence when $KMnO_4$andNaOH are added to a soil, $KMnO_4$oxidizes the organic form of nitrogen to amines. In presence of alkali NH_3 volatilizes. During distillation NH_3comes out from the distillation flask and is absorbed in H_2SO_4. The nitrogen content of soil is found out by the formula:

$$\text{Kg N ha-1} = \frac{(V_a \times S_a - V_b \times S_b)}{W} \times 28000$$

Where,

V_a= Volume of acid taken

S_a= Strength of acid

V_b =Volume of alkali consumed in titration

S_b = Strength of alkali taken

W = Weight of soil taken

3.4.4Biological parameter

3.4.4.1Plankton collection

To study the biological parameters qualitative and quantitative analysis of planktons were carried out following the methods as described in APHA. The plankton was collected through plankton net separately from each aquaria and cement cistern. After collection the planktons were preserved in 5% formalin for further analysis in laboratory.

3.4.4.2 Qualitative method of estimation

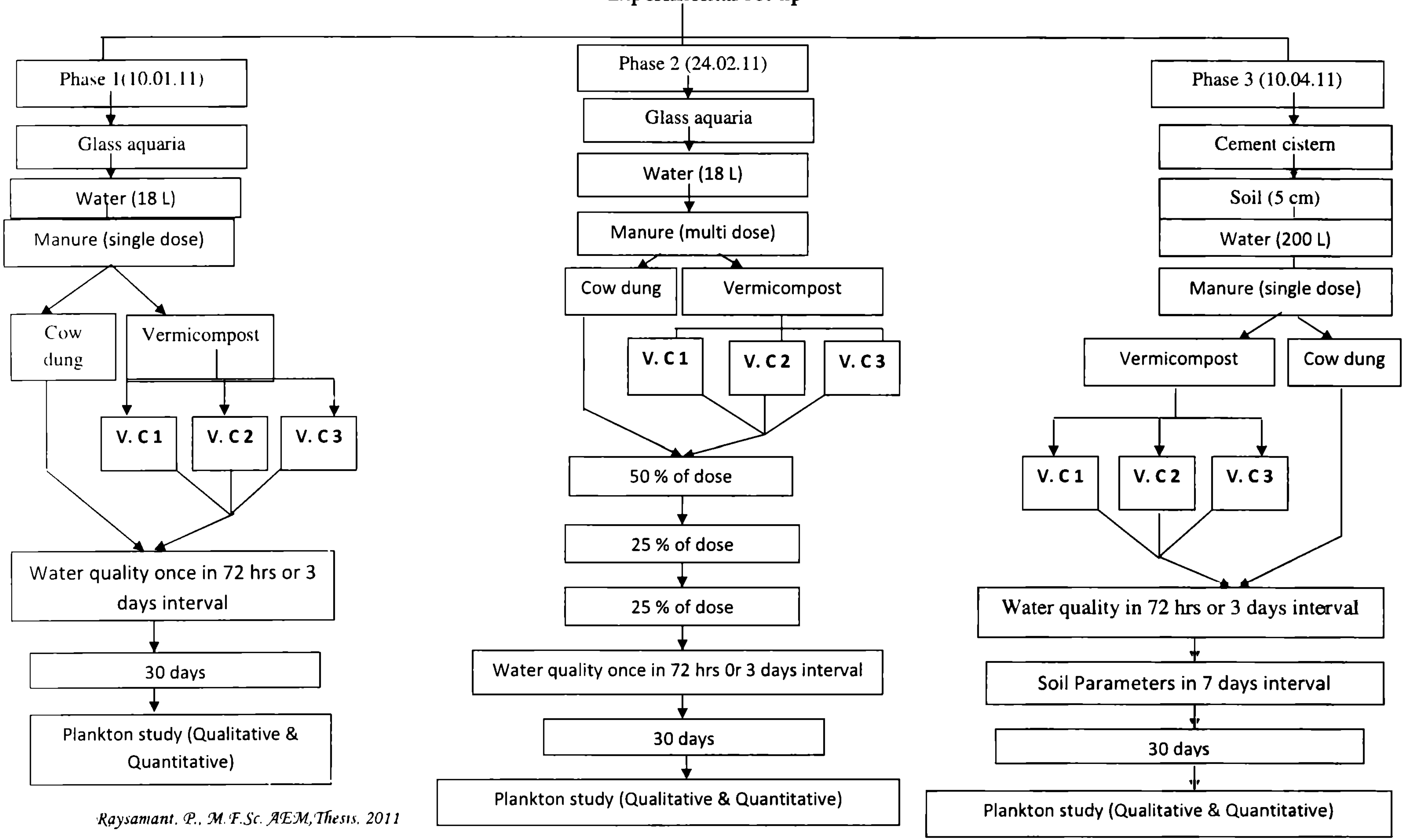
The qualitative analysis was carried out to know the type of planktons produced in treatment tanks. It was conducted using a trinocular microscope following the drop count method. In this method first one drop of sample was taken on a glass slide using a standard dropper. Then the slide was put under microscope for observation. The species were counted by moving the slide under microscope.

3.4.4.3 Quantitative method of estimation

The quantitative analysis was carried out by following the gravimetric method i.e. wet weight and dry weight method. The collect samples were filtered with the help of a filter and the weight was taken denoted as wet weight. Then the mass of plankton with filter paper was taken for drying and after drying the weight was denoted as dry weight. This shows the quantity of plankton present in 1 lit of water.

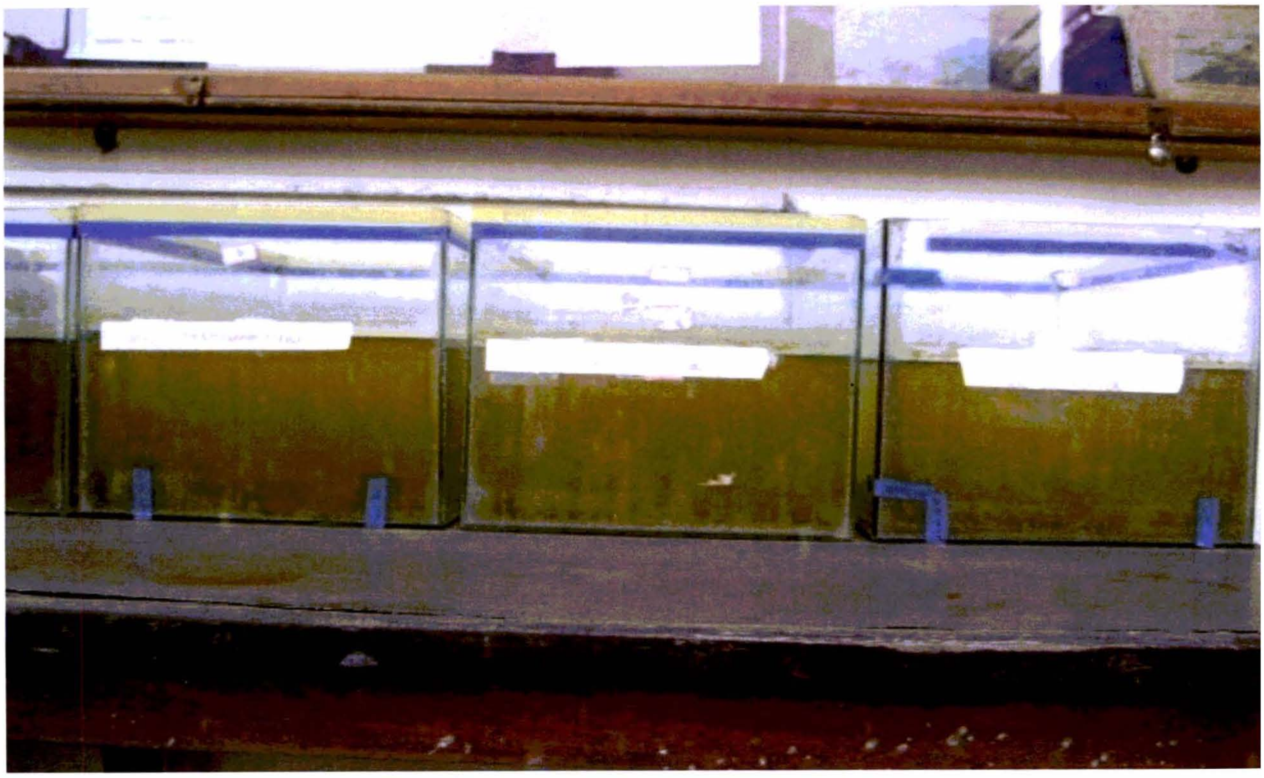
The flow chart of the experimental set up has given below.

Experimental set up



Raysamant. P., M.F.Sc. AEM, Thesis, 2011

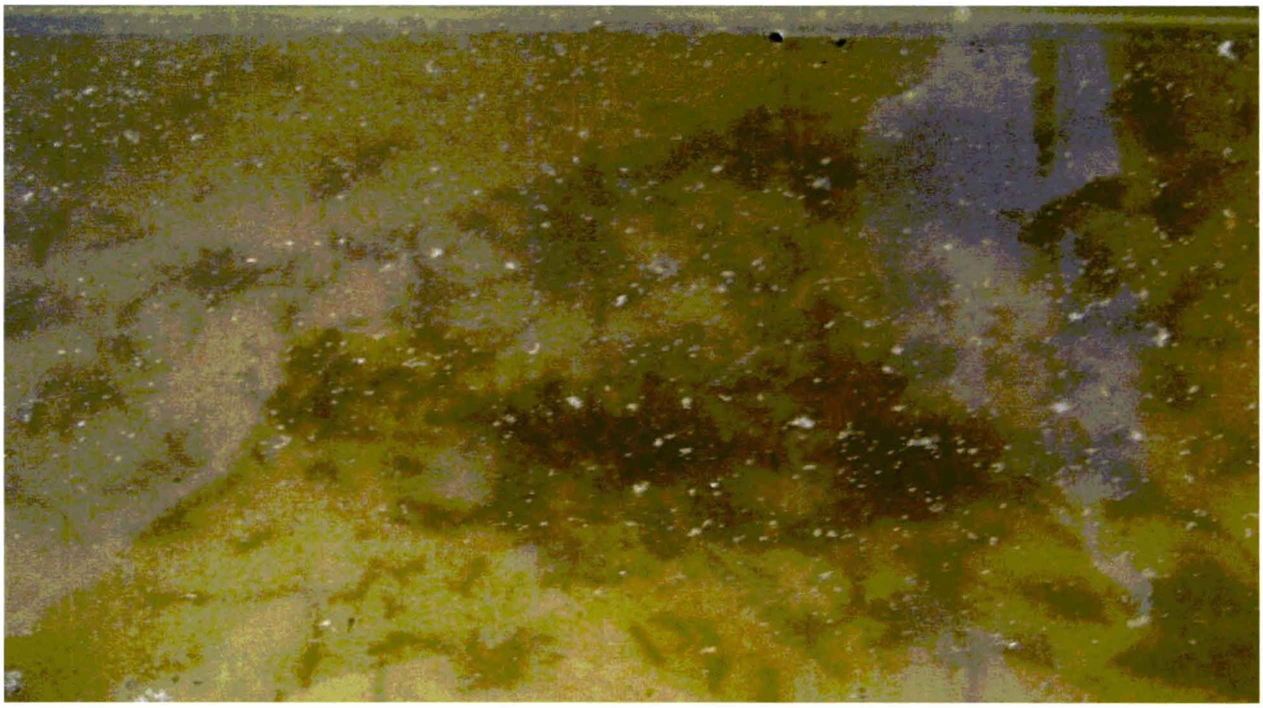
1. Set of aquariums during 1^{st}& 2^{nd} phase of experiment



2. Developed planktons with green colour of water

3. Water storage tank

4. Culture pond: source of water and soil



5. Bloom development during experiment

6. Set of cement cisterns during 3rd experiments

CHAPTER - 4

RESULTS

The physico-chemical parameters of experimental water, observed during January 2011 to May 2011 on different sampling days of three phases of experiment are illustrated and graphically presented in this chapter. The tabulated form of original data obtained from the investigations is presented in Annexure for easy reference.

Several studies have been conducted on the fish production efficiencies of different manures in various countries (Pekar and Olah, 1991; Vincke, 1991; Zoccarato*et al.*, 1995). However, very few investigations have been done to evaluate the impact of different organic manures on the hydrology and primary production in fish ponds (Zoccarato*et al.*, 1995). This present investigation was designed to obtain a comparative result of hydrology and primary production with application of organic manures like cow dung and vermicompost of different composition.

4.1 PHYSICO-CHEMICAL CHARACTERS OF WATER

The physico-chemical analysis has direct or indirect relation with the biotic community of aquatic ecosystem. Considering the fact the following physico-chemical parameter were analyzed and described below.

4.1.1 Assessment of the hydrological parameters of the experiment

The hydrological parameters of different treatments for experiment phase 1 has described below in details which are

4.1.2 Water temperature

The highest water temperature recorded during first phase of experiment was 25.14±0.4°C where as the lowest temperature was 19.03±0.10°C. From the graphical representation it can be clearly observed that there was continuously increase in the temperature throughout the experiment.

4.1.3 pH

The pH values of the water were reflected in the (Fig-1). The minimum and maximum water pH recorded during the experiment from control group was 8.01±0.007 and 8.23±0.007 and from treatment group was 8.01±0.01 and8.22±0.02 in V.C-1, 8.31±0.02 and 8.52±0.01 in V.C-2, 8.01±0.03 and 8.31±0.02 in V.C-3, 8.21±0.01 and 8.56±0.01 in cow dung. pH of control group was almost same with the treatment tanks. Throughout the experiment an alkaline pH was observed.

4.1.4 Dissolved Oxygen

The fluctuations in the dissolved oxygen of water were reflected in the (Fig-2) for experiment phase - 1. The minimum and maximum dissolved oxygen recorded from control was 7.72±0.04 mg/l and 9.62±0.13 mg/l and from treatment group was 8.25±0.08 mg/l and 12.83±0.04 mg/l in V.C-1, 7.16±0.02 mg/l and 12.31±0.13 mg/l in V.C-2, 8.11±0.07 mg/l and 12.79±0.02 mg/l in V.C-3, 6.8±0.04 mg/l and 9.44±0.10 mg/l in cow dung respectively. DO of control group and other treatment groups significantly vary from each other throughout the experiment. The highest DO value was found in V.C-1 treatment and it also showed the highest production of plankton and the lowest DO value was found in cow dung which was nearly equal to control tank or slightly higher than it.

4.1.5 Hardness

Hardness represents the calcium and magnesium content of water. The hardness of the experimental water during the phase-1 was found to be very high than it required. The highest value of hardness was recorded in tank treated with V.C-3. The minimum and maximum values encountered during the experiment are 1028.1±0.02 ppm and 1032.62±0.02 ppm in V.C-1, 1020.03±0.03 ppm and 1024.41±0.03 v in V.C-2, 1096.06±0.44 ppm and 1110.4±0.01 ppm in V.C-3, 1066.02±0.02 ppm and 1072.4±0.02 ppm in cow dung and 1070.05±0.02 ppm and 1072.41±0.01 ppm in control tank respectively. The hardness of the V.C-3 tank was found highest among the vermicompost treatment and the GPP was found lowest among them. There was not much fluctuation observed in other tank during the experiment.

4.1.6 Alkalinity

Alkalinity is the carbonate and bicarbonate content of water. The alkalinity was found in a suitable range during the experiment as required for production. The maximum and minimum ranges of alkalinity in different tanks during experiment are 60.32±0.3 ppm and 52.13±0.05 ppm in V.C-1, 64.12±0.08 ppm and 54.02±0.06 ppm in V.C-2, 48.14±0.01 ppm and 42.14±0.04 ppm in V.C-3, 38.14±0.01 ppm and 30.14±0.01 ppm in cow dung and 48.15±0.05 ppm and 34.02±0.06 ppm in control tank respectively. The alkalinity has not showed much variation during the experiment.

4.1.7 Phosphate

The highest and lowest ranges of phosphate recorded were 0.241±0.002 ppm and 0.101±0.003 ppm in V.C-1, 0.25±0.004 ppm and 0.104±0.002 ppm in V.C-2, 0.201±0.007 ppm and 0.089±0.004 ppm in V.C-3, 0.201±0.003 ppm and 0.029±0.002 ppm in cow dung, 0.107±0.002 ppm and 0.012±0.002 ppm in control tanks. The highest level was found in V.C-2 followed by V.C-1, V.C-3, cow dung, and control respectively.

4.1.8 Gross Primary Productivity (GPP)

The fluctuations in the GPP for experiment phase-1 of control and treatment water were reflected in the (Fig-3). From the graphical presentation and analysis it was found that the GPP in vermicompost was found much better than other treatments. In control the minimum and maximum value of GPP recorded were 22.56±0.21 mg $C/m^3/hr$ and 115.13 ±0.50 mg $C/m^3/hr$ respectively. The minimum and maximum value of GPP recorded in other treatments were 122.3±0.04 mg $C/m^3/hr$ and 326.05±0.43 mg $C/m^3/hr$ in V.C-1, 159.14±0.26 mg $C/m^3/hr$ and 319.36±0.10 mg $C/m^3/hr$ in V.C-2, 122.3±0.04 mg $C/m^3/hr$ and 305.12±0.11 mg $C/m^3/hr$ in V.C-3, 74.58±0.13 mg $C/m^3/hr$ and 215.1±0.44 mg $C/m^3/hr$ in cow dung respectively. From the graphical presentation it can be seen clearly that the peak of GPP was observed during the 3rd sampling of the experiment in almost all tanks and the highest value of GPP was found in V. C-1 and the lowest value was in control groups.

4.1.9 Net Primary Productivity (NPP)

From the graphical representations it has been found that the NPP has a sharp decrease from the 4th sampling up to the end. However the highest value of NPP was observed in V. C-3 treated tanks and the lowest in control tanks. The maximum and minimum value of NPP recorded in treatment groups were 195.15±0.39 mg $C/m^3/hr$ and 48.18±0.43 mg $C/m^3/hr$ in V.C-1, 249.36±0.13 mg $C/m^3/hr$ and 58.48±0.09 mg $C/m^3/hr$ in V.C-2, 251.12±0.13 mg $C/m^3/hr$ and 57.48±0.09 mg $C/m^3/hr$ mg $C/m^3/hr$ in V.C-3, 122.32±0.37 mg $C/m^3/hr$ and 20.48±0.18 mg $C/m^3/hr$ in cow dung respectively. The maximum and minimum values recorded from control group are 80.32±0.02 mg $C/m^3/hr$ and 20.63±0.15 mg $C/m^3/hr$ respectively.

4.1.10 Qualitative and quantitative analysis of plankton

The biological parameters in this phase of experiment were found in an optimum level showing the good primary productivity. The phytoplankton quantity was found to be less in cow dung as compare to the other compost treatment tanks. The commonly encountered phytoplankton groups are *Chlorophyceae, Bacillariophyceae* and *Cyanophyceae,* while the dominant Zooplankton belongs to the group of *Copepoda* and *Cladocera*. Out of these groups the most dominant group having more number of species is *Chlorophyceae*. In case of cow dung treatment the phytoplankton production was somewhat less than the zooplankton production. The high primary production indicates that the plankton production was quite good in all the treatments than the control tank. The details are given in the annexure in the tabular form. The different genera observed under different group in different treatments are illustrated in tables (Table No: 26-30) in annexure.

Fig-1: Fluctuations of average values of pH during different sampling days of the experimental period in different treatments

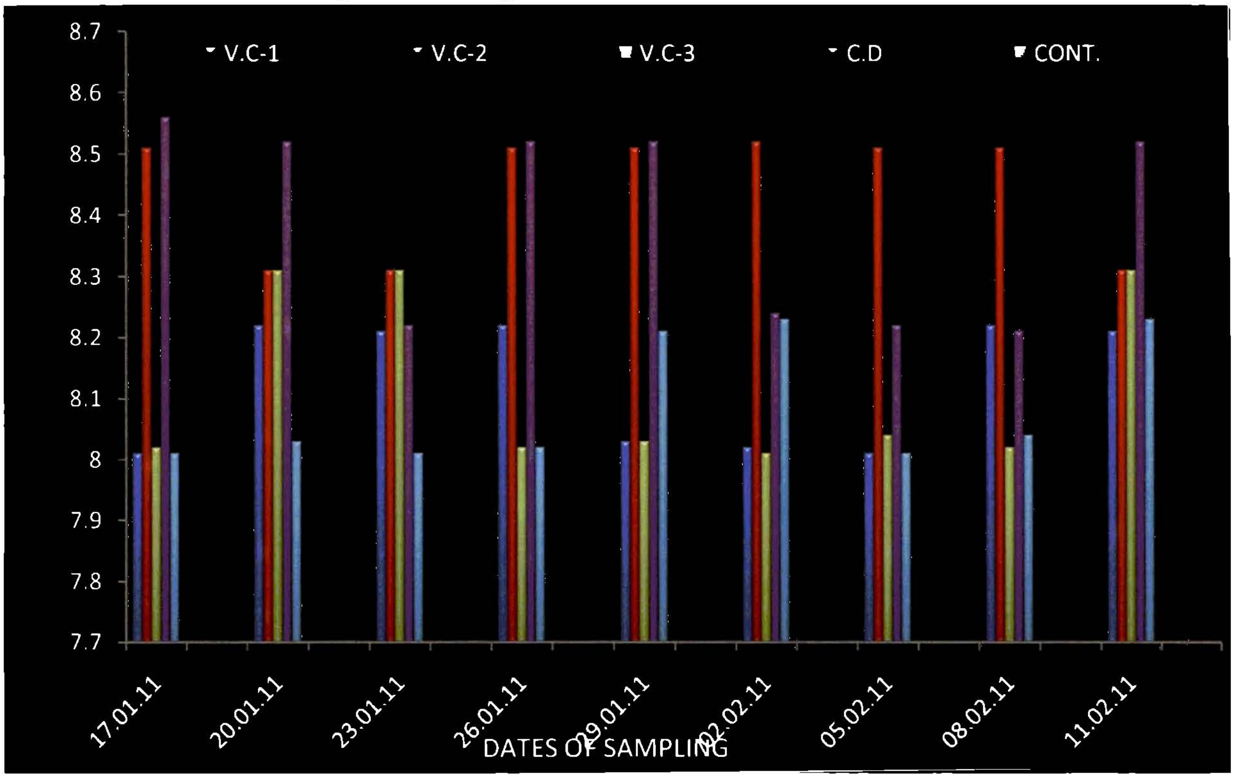


Fig-2: Fluctuations of average values of DO during different sampling days of the experimental period in different treatments

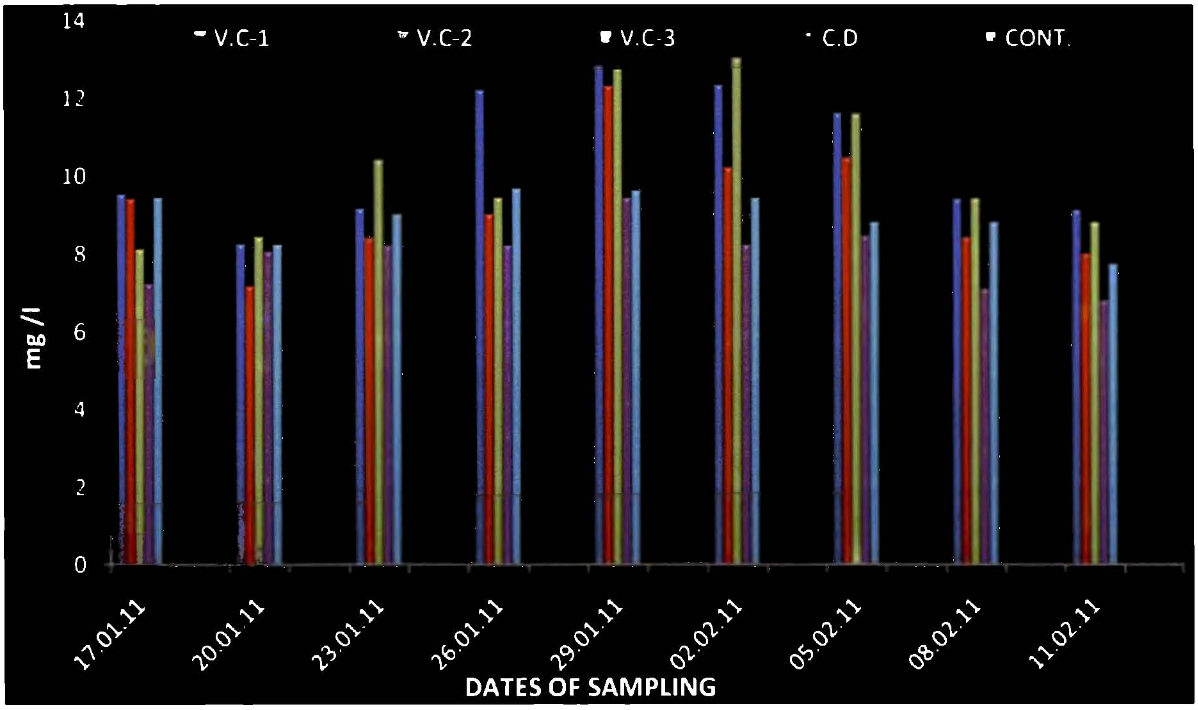


Fig-3: Fluctuations of average values of GPP during different sampling days of the experimental period

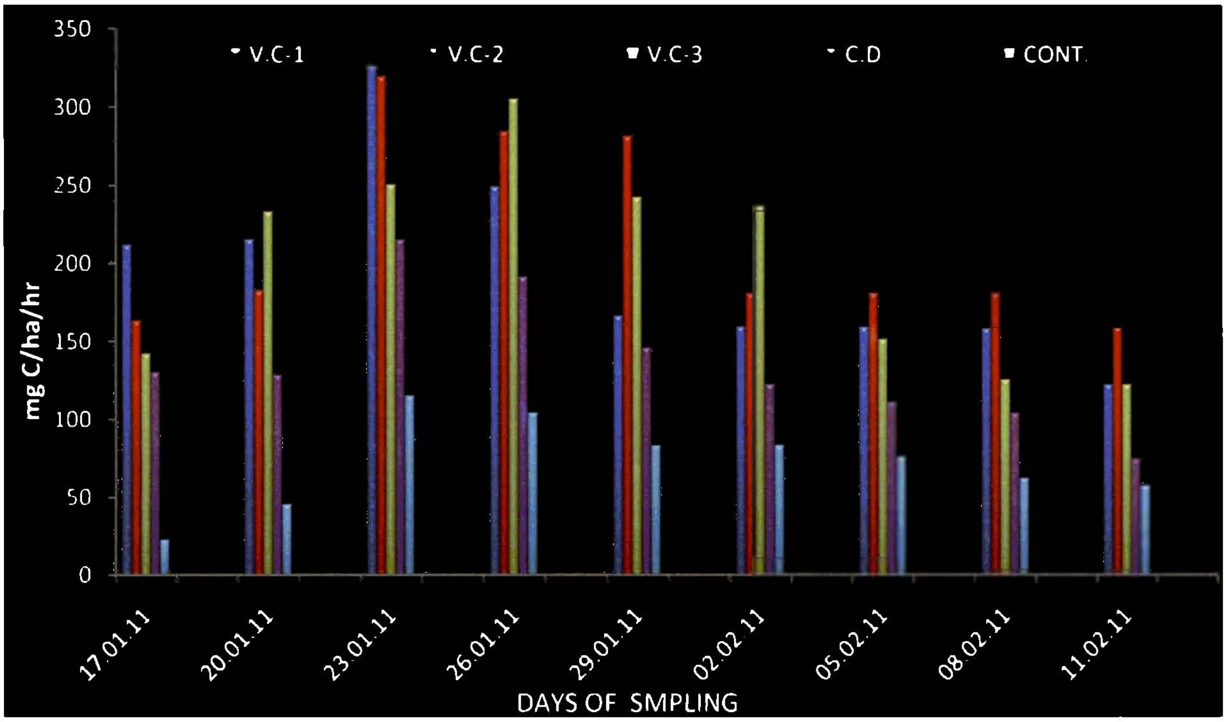


Fig-4: Fluctuations of average values of NPP during different sampling days of the experimental period

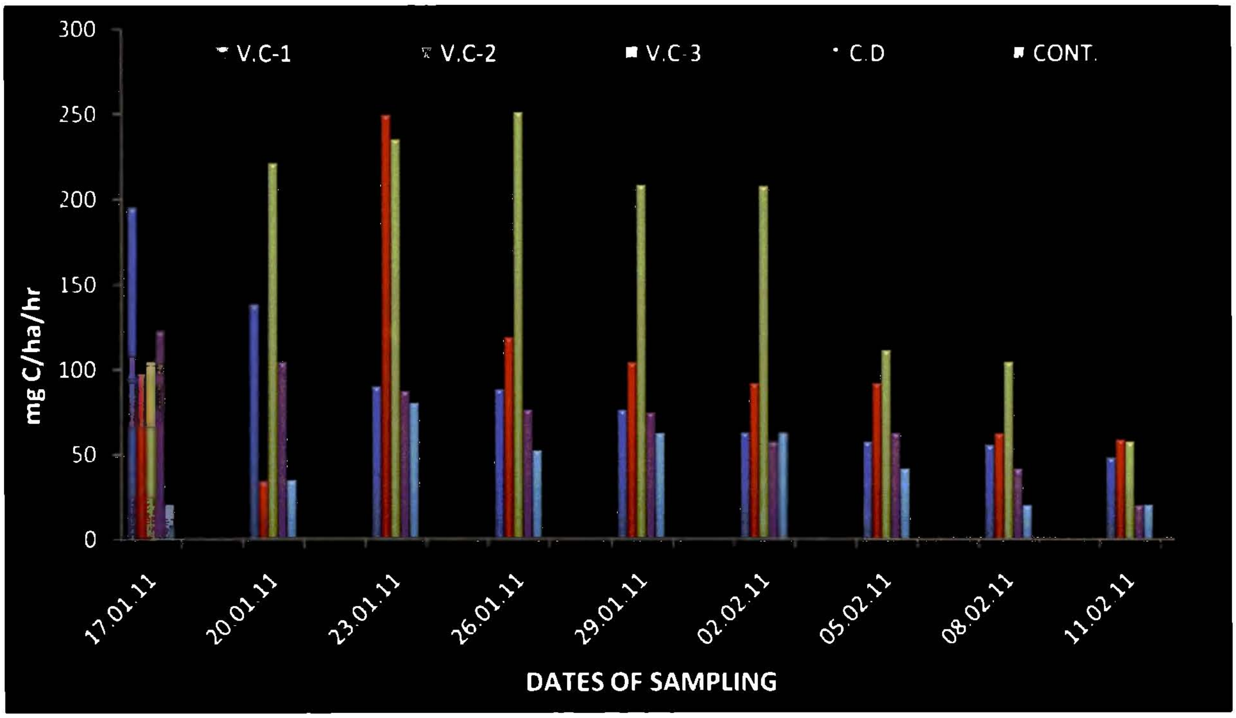


Fig-5: Fluctuations of average values of Hardness during different sampling days of the experimental period

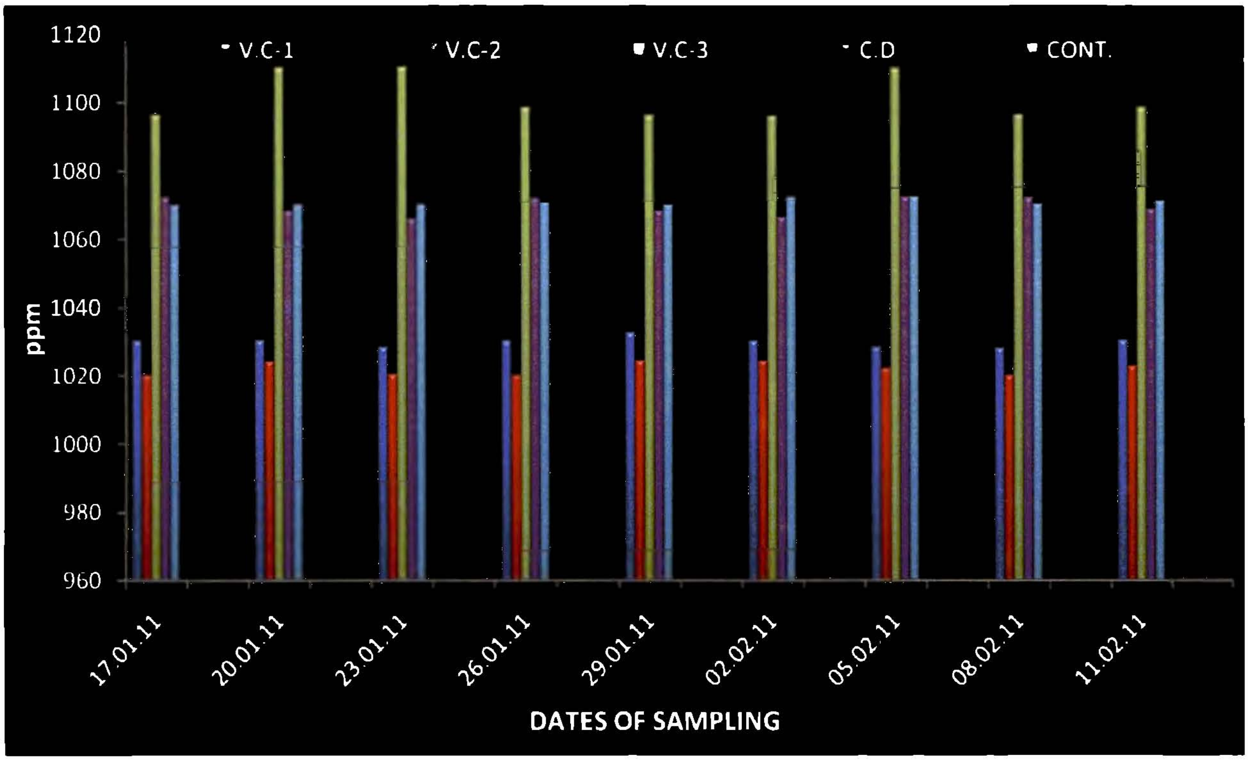


Fig-6: Fluctuations of average values of Alkalinity during different sampling days of the experimental period

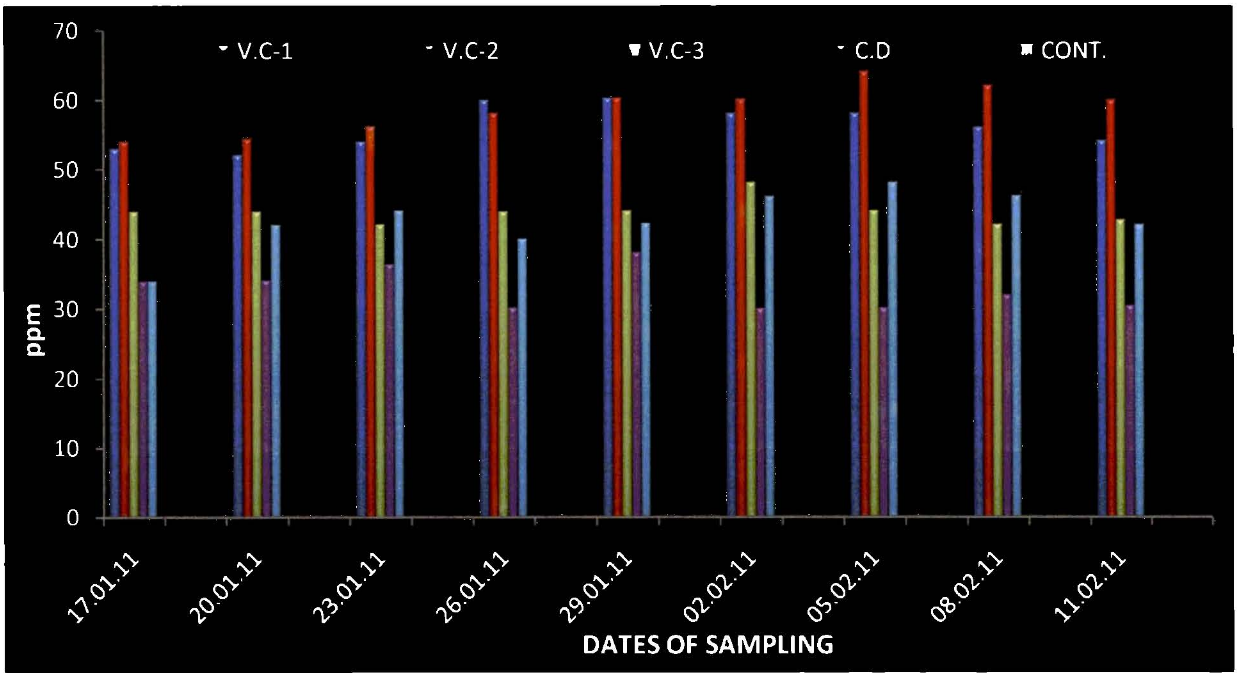
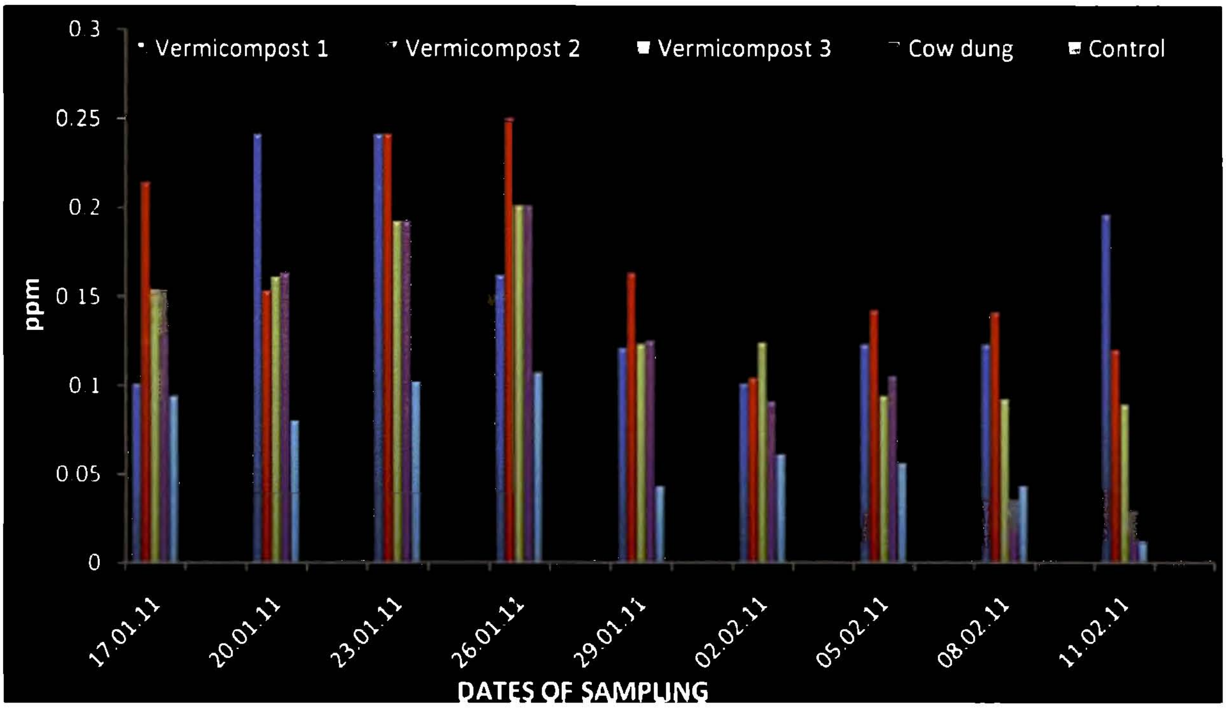


Fig-7: Fluctuations of average values of phosphate during different sampling days of the experimental period



Experiment - 2

The second phase of experiment was different from first phase in terms of application of manures. In this phase the dose of manure was same but it was applied in three intervals with a time gap of 72 hrs. The physico-chemical parameters of water in different treatments for phase 2 of the experiment has described below.

4.1.11 Water temperature

This phase of experiment was conducted during the end winter seasons from 24.02.2011 to 24.03.2011.The air as well as water temperature was gradually increasing from the temperature of phase-1 experiment. The highest water temperature recorded during this phase of experiment was 31.9±0.05°c whereas the lowest temperature was 23.1±0.2°c. The temperature was in an increasing order towards the end of the experiment.

4.1.12 pH

The pH values of the water were reflected in the (Fig-8). The value of pH found in an alkaline condition throughout the experiment. The minimum and maximum water pH recorded during the experiment from control group was 8.41±0.02 and 8.52±0.01 and from treatment group was 8.02±0.02 and8.32±0.04 in V.C-1, 8.01±0.02 and 8.24±0.03 in V.C-2, 8.35±0.03 and 8.52±0.03 in V.C-3, 8.01±0.01 and 8.22±0.03 in cow dung. pH of control group was almost same with the treatment tanks.

4.1.13 Dissolved Oxygen

The highest DO value was found in V.C-2 treatment and the lowest DO value was found in cow dung which value was also less than the control tank. The minimum and maximum dissolved oxygen recorded from control was 5.62±0.04 mg/l and 9.04±0.02 mg/l and from treatment group was 5.82±0.03 mg/l and 8.2±0.02 mg/l in V.C-1, 6.02±0.03 mg/l and 9.1±0.05 mg/l in V.C-2, 5.81±0.03 mg/l and 8.7±0.03 mg/l in V.C-3, 4.2±0.6 mg/l and 9.01±0.03 mg/l in cow dung respectively. DO of control group and other treatment groups were significantly varies from each other throughout the experiment.

4.1.14 Hardness

Hardness represents the calcium and magnesium content of water. The hardness of the experimental water during the phase-2 was found to be in higher range than it required. The highest value of hardness was recorded in tank treated with V.C-1. The minimum and maximum values encountered during the experiment are 1060.62±0.03 and 1064.42±0.03 ppm in V.C-1, 1044.42±0.03 ppm and 1050.62±0.03 ppm in V.C-2, 1040.31±0.02 ppm and 1048.62±0.03 ppm in V.C-3, 1030.31±0.02 ppm and 1036.63±0.01 ppm in cow dung and 1036.42±0.04 ppm and 1040.66±0.01 ppm in control tank respectively. There was not much fluctuation found in any tank during the experiment.

4.1.15 Alkalinity

Alkalinity is the carbonate and bicarbonate content of water. The alkalinity was found in a suitable range during the experiment as required for production. The maximum and minimum ranges of alkalinity in different tanks during experiment are 46.31±0.5 ppm and 40.1±0.04 ppm in V.C-1, 50.42±0.02 ppm and 44.24±0.03 ppm in V.C-2, 50.52±0.02 ppm and 44.24±0.03 ppm in V.C-3, 58.61±0.01 ppm and 54.1±0.04 ppm in cow dung and 58.61±0.01 ppm and 52.82±0.04 ppm in control tank respectively. The alkalinity has not showed much variation during the experiment.

4.1.16 Phosphate

The phosphate value was found in an optimum level during the experiment and it was found suitable for plankton production. From the graphs it has been seen that the phosphate level was gradually increased after the treatment with compost. The maximum and minimum ranges of phosphate in different treatments were 0.273±0.006 ppm and 0.09±0.016 ppm in V.C-1, 0.253±0.007 ppm and 0.122±0.007 ppm in V.C-2, 0.243±0.004 ppm and 0.089±0.004 ppm in V.C-3, 0.253±0.007 ppm and 0.098±0.003 ppm in cow dung and

0.032±0.002 ppm and 0.011 ±0.001 ppm in control tanks. The value of phosphate was found in an increasing trend in almost all treatments, except in control.

4.1.17 Nitrate

It is another important element for production and growth of primary producer or planktons. During this experiment the nitrate quantity was found to be in a suitable amount as it required for the growth of planktons. The maximum and minimum value of nitrate encountered during the experiment in various treatments is 0.492±0.003 ppm and 0.225±0.002 ppm in V.C-1, 1.143±0.001 ppm and 0.251±0.006 ppm in V.C-2, 1.748±0.002 ppm and 0.46±0.02 ppm in V.C-3, 1.686 ±0.002 ppm and 0.42±0.003 ppm in cow dung and 0.252±0.004 ppm and 0.008±0.0007 ppm in control tanks. The highest value of nitrate was found in V.C-3 and the lowest was in control as it was free from manure. From graphical presentation it can observed that the value of nitrate in V.C-2 and cow dung was increased sharply after 7 days of application or during the 3rd sampling but in V.C-1 a steady increment was there. The nitrate value in control tanks was very trace towards the end of the experiment.

4.1.18 Gross Primary Productivity (GPP)

The fluctuations in the GPP for experiment phase-2 of control and treatment water were reflected in the (Fig-10). From the graphical presentation and analysis it was found that the GPP in vermicompost-1 was found much better than other treatments. In control the minimum and maximum value of GPP recorded were 52.86±0.03 mg $C/m^3/hr$ and 114.61±0.03 mg $C/m^3/hr$ respectively. The minimum and maximum value of GPP recorded in other treatments were 80.21±0.07 mg $C/m^3/hr$ and 243.02±0.49 mg $C/m^3/hr$ in V.C-1, 80.214±0.07 mg $C/m^3/hr$ and 138.8±0.02 mg $C/m^3/hr$ in V.C-2, 72.91±0.02 mg $C/m^3/hr$ and 138.8±0.02 mg $C/m^3/hr$ in V.C-3, 62.33±0.03 mg $C/m^3/hr$ and 173.72±0.03 mg $C/m^3/hr$ in cow dung respectively. From the graphical presentation it can be seen clearly that the peak of GPP was observed during the 3rd sampling of the experiment and the highest value of GPP was found in V. C-1 and the lowest value was in control groups.

4.1.19 Net Primary Productivity (NPP)

From the graphical representations it has been found that the NPP has a sharp decrease from the 3rd sampling up to the end. However the highest value of NPP was observed in V. C-1 tank and the lowest in control tanks. The maximum and minimum value of NPP recorded in treatment groups were 208.04±0.48 mg $C/m^3/hr$ and 57.48±0.09 mg $C/m^3/hr$ in V.C-1, 97.1±0.03 mg $C/m^3/hr$ and 41.62±0.03 mg $C/m^3/hr$ in V.C-2, 81.82±0.01 mg $C/m^3/hr$ and 50.06±0.04 mg $C/m^3/hr$ in V.C-3, 90.21±0.03 mg $C/m^3/hr$and

52.22±0.03 mg C/m³/hr in cow dung respectively. The maximum and minimum values recorded from control group are 104.22±0.02 mg C/m³/hr and 41.82±0.04 mg C/m³/hr respectively.

4.1.20 Qualitative and quantitative analysis of plankton

Though the biological parameters in this phase of experiment were found in an optimum level showing the good primary productivity, but it was less than the production of phase-1 experiment. The phytoplankton quantity was found to be less in cow dung as compare to the other compost treatment tanks. The commonly encountered phytoplankton groups are Chlorophyceae, Bacillariophyceae and Cyanophyceae, while the dominant Zooplankton belongs to the group of Copepoda and Cladocera. Out of these groups the most dominant group having more number of species is Chlorophyceae. From the quantitative studies it was found that the number of planktons in this phase was less than phase-1 experiment. The different species observed under different group in different treatments are illustrated in table (26-30) in annexure.

Fig-8: Fluctuations of average values of pH during different sampling days of the experimental period

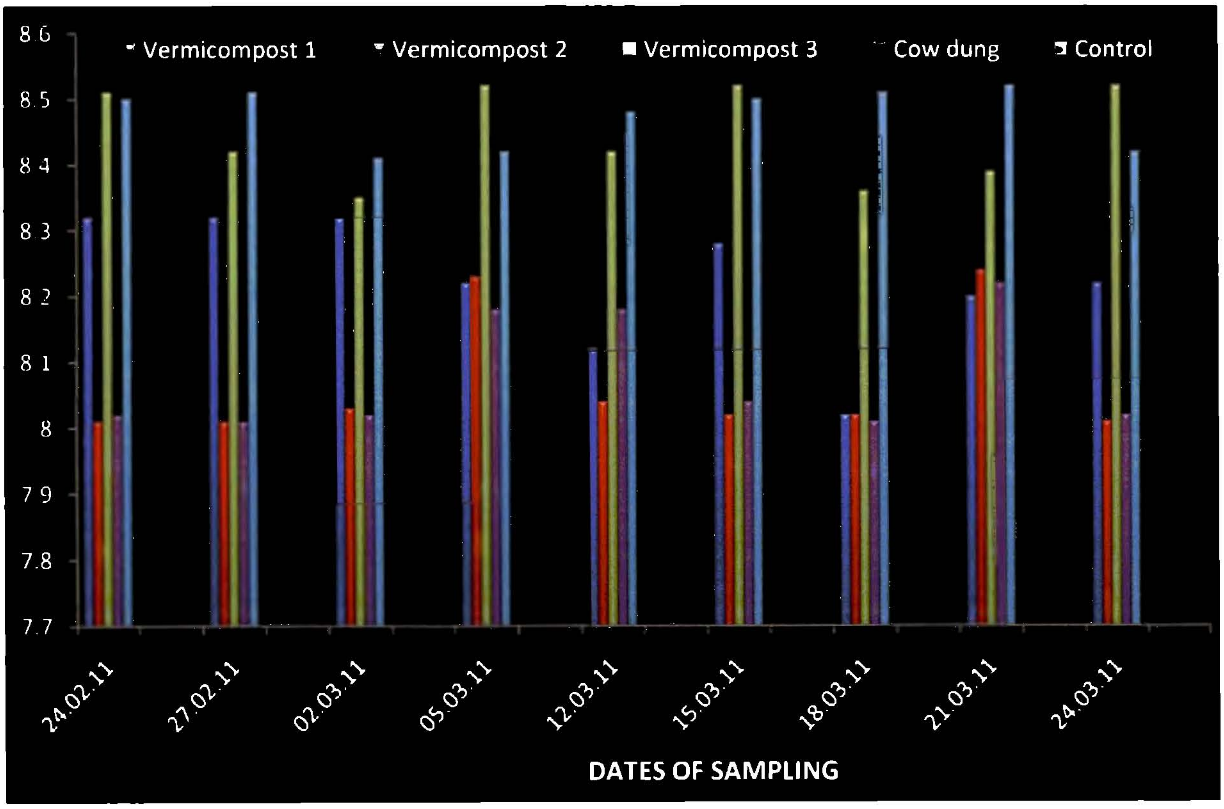


Fig-9: Fluctuations of average values of DO during different sampling days of the experimental period

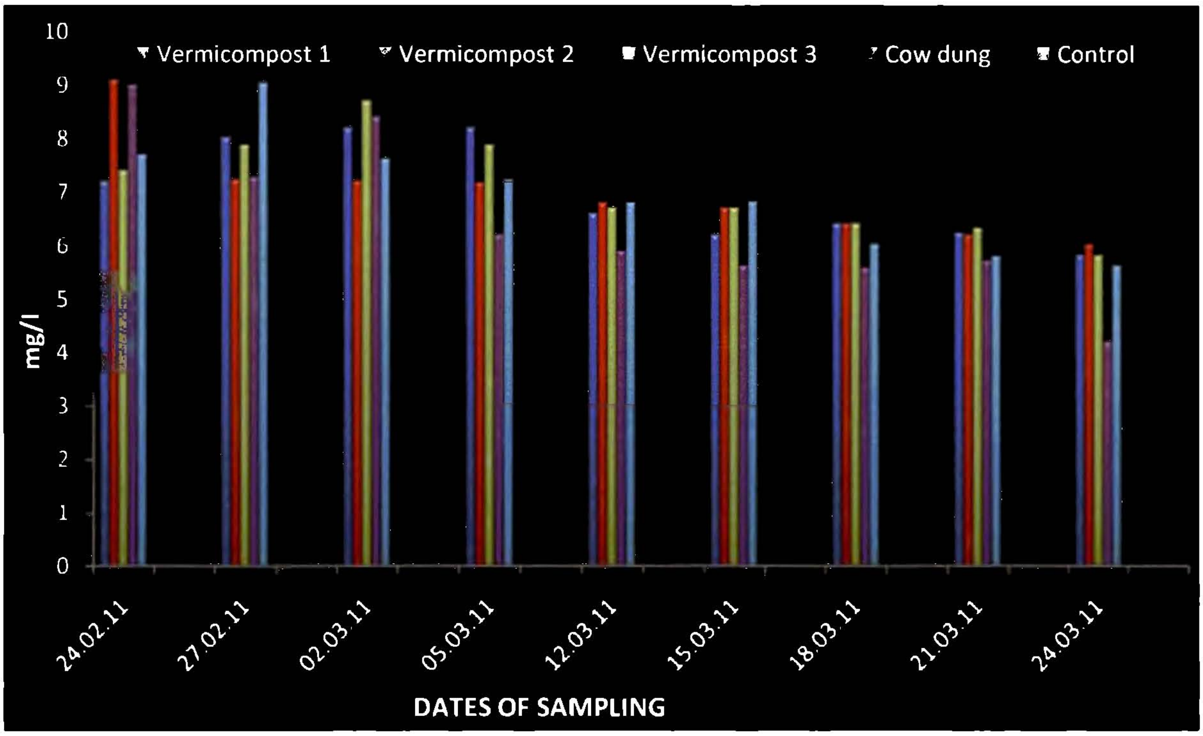


Fig-10: Fluctuations of average values of GPP during different sampling days of the experimental period

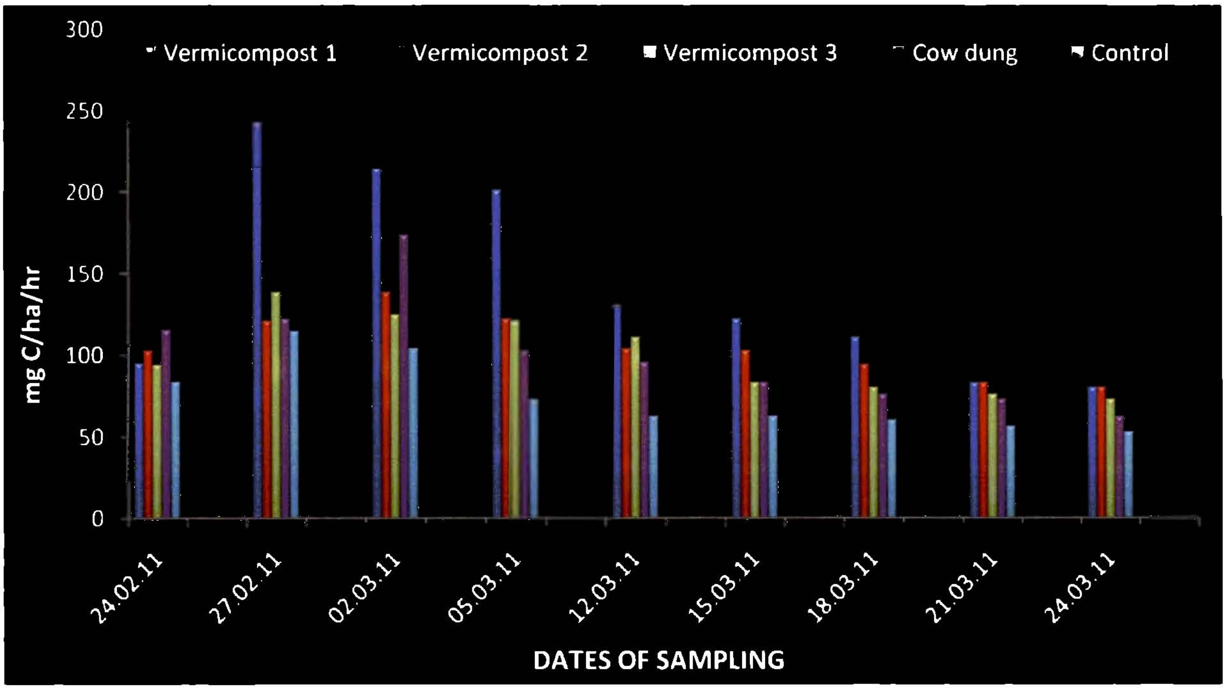


Fig-11: Fluctuations of average values of NPP during different sampling days of the experimental period

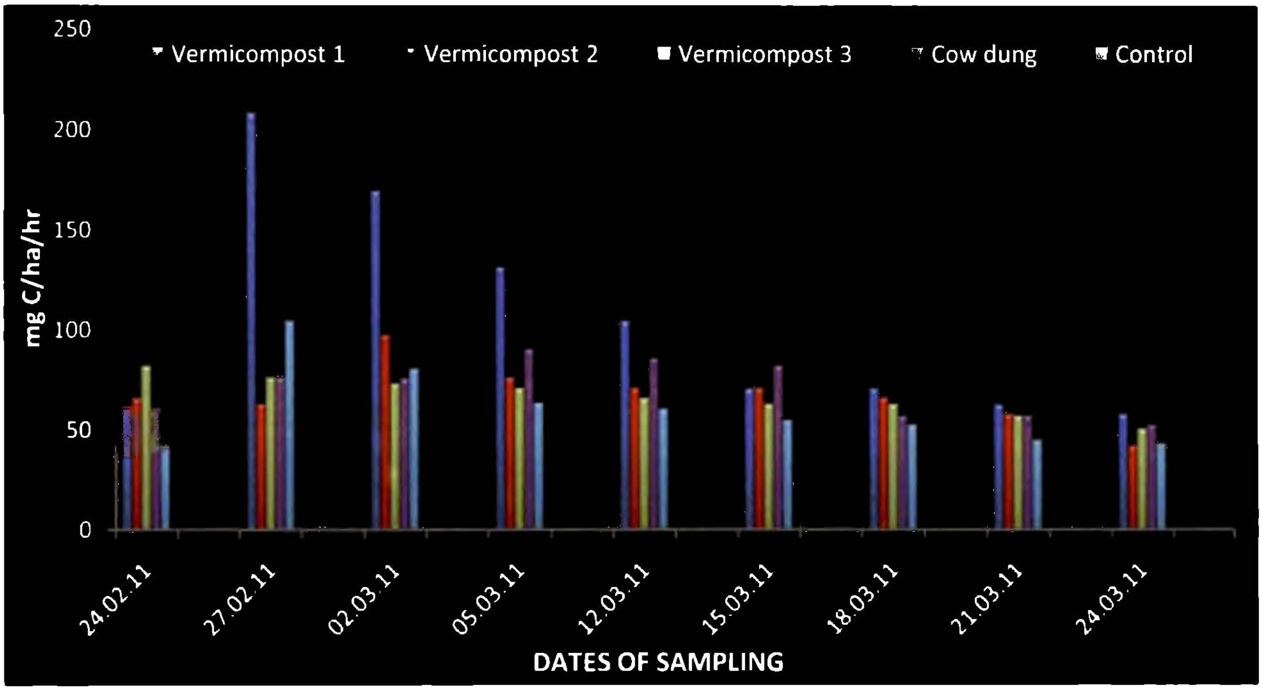


Fig-12: Fluctuations of average values of Hardness during different sampling days of the experimental period

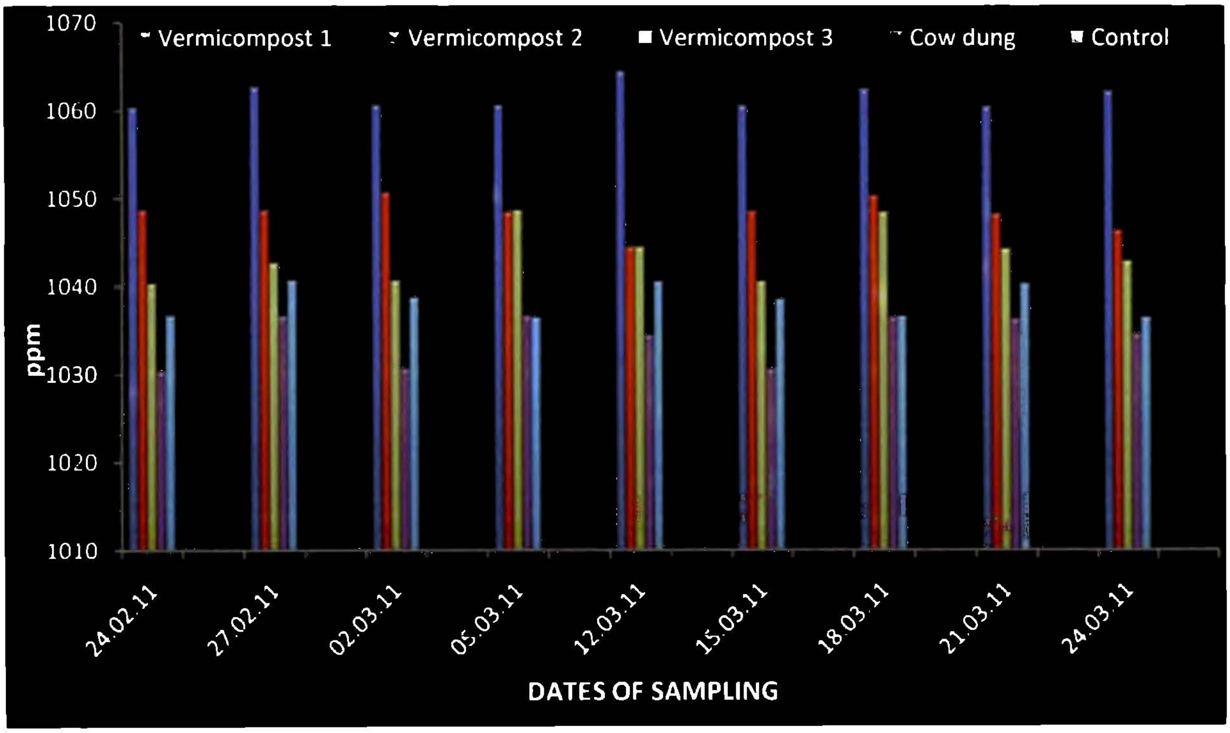


Fig-13: Fluctuations of average values of alkalinity during different sampling days of the experimental period

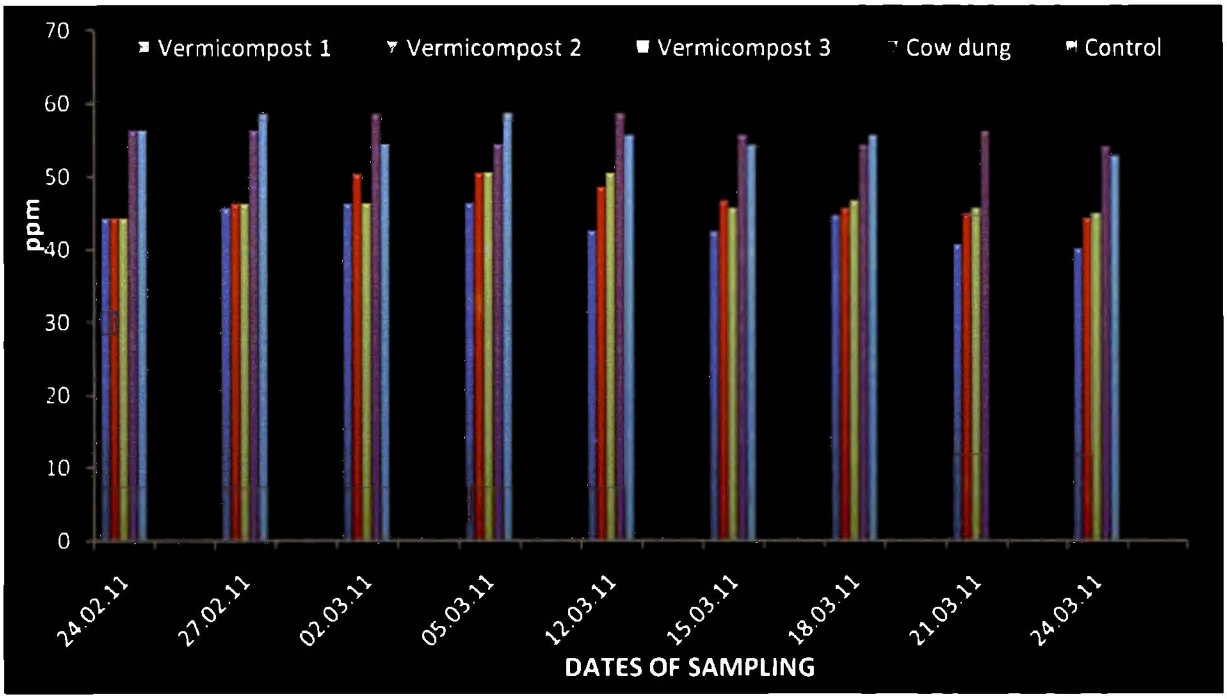


Fig-14: Fluctuations of average values of phosphate during different sampling days of the experimental period

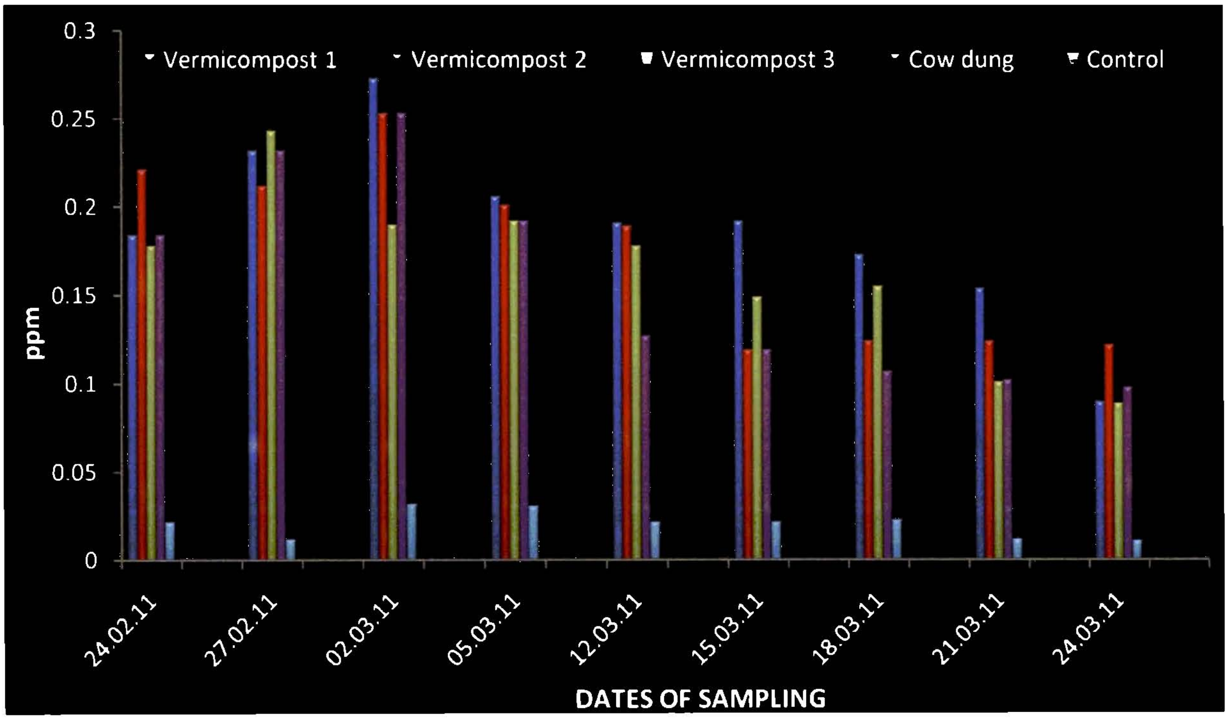
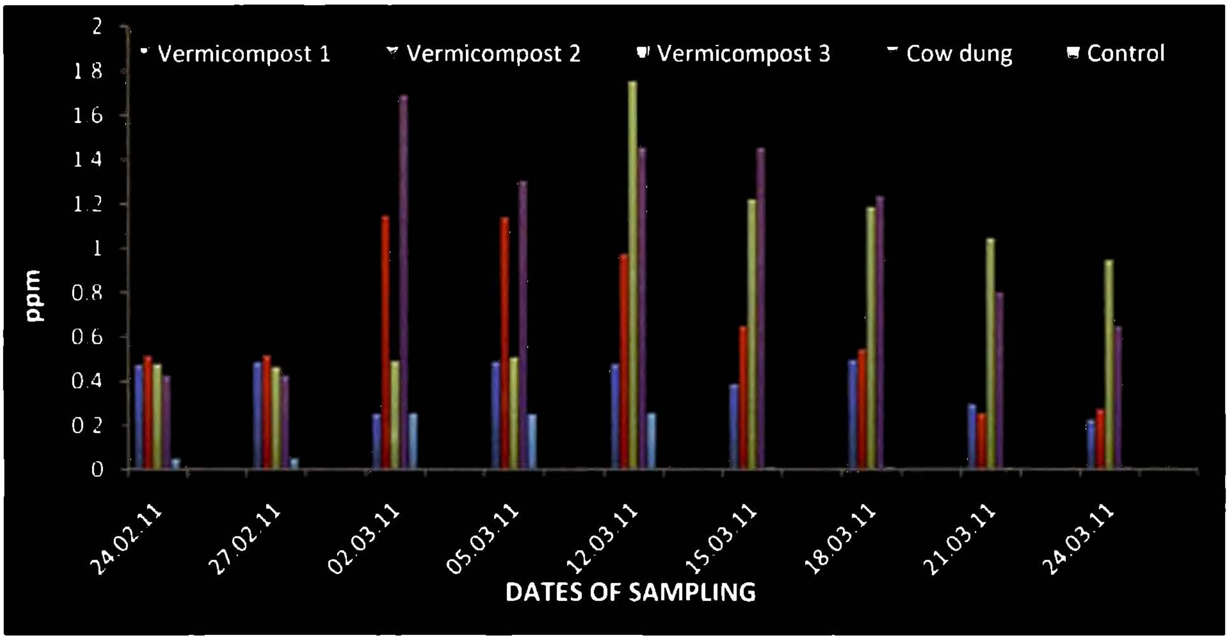


Fig-15: Fluctuations of average values of nitrate during different sampling days of the experimental period



Experiment - 3

The third phase of experiment was different from first two phases in terms of area of experiment. In this phase the dose of manure was same as the first phase means a single dose was applied with a soil base in cemented tanks. Here both the soil and water source was from the culture pond and the dose was same as phase-1 experiment. The physico-chemical parameters of water in different treatments for phase 3 of the experiment were described below in details

4.1.21 Water temperature

This phase of experiment was conducted during the early summer seasons i.e. from 13.04.2011 to 12.05.2011, so the air as well as water temperature was gradually in increasing condition from that of the temperature of phase-1 & 2 experiments. But due to frequent rain the temperature was in a controlled condition. The lowestwater temperature recorded during this phase of experiment was 31.4±0.14°c whereas the highesttemperature was 34.5±0.01°c. The temperature during this experiment was in a fluctuated condition throughout the experiment as it was affected by rain.

4.1.22. pH

The pH values of the water were reflected in the (Fig-16). The value of pH found was alkaline condition throughout the experiment. The minimum and maximum water pH recorded during the experiment from control group was 8.32±0.02 and 8.44±0.01 and from treatment group was 8.41±0.01 and8.53±0.02 in V.C-1, 8.02±0.01 and 8.15±0.02 in V.C-2, 8.3±0.007 and 8.44±0.02 in V.C-3, 8.02±0.02 and 8.14±0.02 in cow dung. pH of control group was almost same with the treatment tanks. The pH has not shown much variation.

4.1.23. Dissolved Oxygen

The highest DO value was found in V.C-1 treatment and the lowest DO value was found in control. The minimum and maximum dissolved oxygen recorded from control was 4.58±0.3 mg/l and 7.86±0.1 mg/l and from treatment group was 5.22±0.03 mg/l and 6.28±0.11 mg/l in V.C-1, 3.54±0.05 mg/l and 6.54±0.08 mg/l in V.C-2, 3.73±0.09 mg/l and 6.08±0.09 mg/l in V.C-3, 3.83±0.1 mg/l and 5.27±0.2 mg/l in cow dung respectively. DO of control group and other treatment groups were significantly varies from each other throughout the experiment. In this experiment it was observed that the DO value during the application of manure i.e. the initial value was in optimum level but after three days of application DO value was found to be decreasing and then again it was in an increasing order. Initially the DO level was high in control level but afterwards it was found more in treatment tanks.

4.1.24. Hardness

The hardness of the experimental water during the phase-3 was found to be in a maintained range as it required. The highest value of hardness was recorded in tank treated with cow dung. The minimum and maximum values encountered during the experiment are 480.12±0.04 ppm and 484.78±0.02 ppm in V.C-1, 478.54±0.02 ppm and 480.22±0.02 ppm in V.C-2, 478.01±0.04 ppm and 480.8±0.03 ppm in V.C-3, 498.22±0.02 ppm and 500.66±0.02 ppm in cow dung and 448.02±0.04 ppm and 450.4±0.04 ppm in control tank respectively. There was not much fluctuation found in any tank during the experiment.

4.1.25. Alkalinity

The alkalinity was found in a suitable range during the experiment as required for production. The maximum and minimum ranges of alkalinity in different tanks during experiment are 32.62±0.04 and 30.22±0.04 in V.C-1, 46.6±0.04 and 44.22±0.04 in V.C-2, 50.81±0.03 and 48.26±0.06 in V.C-3, 30.61±0.17 and 28.02±0.07 in cow dung and 24.33±0.03 and 22.01±0.04 in control tank respectively. The alkalinity has not showed much variation during the experiment. A high value of alkalinity was observed in treatment tanks after application of manure than the control tanks. The highest value of alkalinity was observed in V.C-3 and the lowest value was in control tanks.

4.1.26. Phosphate

The phosphate value was found in an optimum level during the experiment and it was found suitable for plankton production. From the graphs it has been seen that the phosphate level was gradually increased after the treatment with compost. A good range of phosphate was found to be maintained in V.C-2 than the other treatments. The maximum and minimum ranges of phosphate in different treatments were 0.172±0.004 ppm and 0.148±0.001 ppm in V.C-1, 0.225±0.003 ppm and 0.169±0.002 ppm in V.C-2, 0.184±0.001 ppm and 0.083±0.0007 ppm in V.C-3, 0.193±0.0007 ppm and 0.051±0.002 ppm in cow dung and 0.043±0.002 ppm and 0.005±0.0007 ppm in control tanks. The value of phosphate was found in an increasing trend in almost all treatments, except in control, where the value was high initially but afterwards it was in a decreasing trend.

4.1.27. Nitrate

During this experiment the nitrate quantity was found to be in a suitable amount as it required for the growth of planktons. The maximum and minimum value of nitrate encountered during the experiment in various treatments is 0.5298±0.0004 ppm and 0.3781±0.001 ppm in V.C-1, 0.5568±0.0001 ppm and 0.0087±0.0002 ppm in V.C-2, 0.6754±0.0004 ppm and 0.00151±0.0001 ppm in V.C-3, 1.1441±0.0004 ppm and 0.5112±0.0004 ppm in cow dung and 0.686±0.003 ppm and 0.301±0.2 ppm in control tanks. The highest value of nitrate was found in cow dung and the lowest was in V.C-2. From graphical presentation it was observed that the value of nitrate in cow dung was increased sharply after 21 days of application or during the 4th sampling but in V.C-2 a steady increment was towards the end of the experiment. In control the value was in a controlled level.

4.1.28. Gross Primary Productivity (GPP)

The fluctuations in the GPP for experiment phase–3 of control and treatment water were reflected in the (Fig-18). From the graphical presentation and analysis it was found that the GPP in vermicompost-1 was found much better than other treatments. In control the minimum and maximum value of GPP recorded were 104.21±0.4 mg C/m^3/hr and 190.87±0.03 mg C/m^3/hr respectively. The minimum and maximum value of GPP recorded in other treatments were 122.34±0.02 mg C/m^3/hr and 266.06±0.02 mg C/m^3/hr in V.C-1, 125.48±0.2 mg C/m^3/hr and 262.14±0.01 mg C/m^3/hr in V.C-2, 151.72±0.04 mg C/m^3/hr and 250.07±0.02 mg C/m^3/hr in V.C-3, 104.2±0.04 mg C/m^3/hr and 229.24±0.02 mg C/m^3/hr in cow dung respectively. From the graphical presentation it can be seen clearly that the peak of GPP was observed during the 4th sampling of the experiment in almost all tanks and the highest value of GPP was found in V. C-1 and the lowest value was in control groups.

4.1.29. Net Primary Productivity (NPP)

From the graphical representations it has been found that the NPP has a sharp decrease from the 4th sampling up to the end. However the highest value of NPP was observed in V. C-1 tank and the lowest in control tanks. The minimum and maximum value of NPP recorded in treatment groups were 58.48±0.09 mg C/m^3/hr and 187.56±0.04

mg C/m³/hr in V.C-1, 62.524±0.001 mg C/m³/hr and 187.58±0.05 mg C/m³/hr in V.C-2, 80.5±0.04 mg C/m³/hr and 145.88±0.05 mg C/m³/hr in V.C-3, 58.48±0.09 mg C/m³/hr and 145.88±0.02 mg C/m³/hr in cow dung respectively. The maximum and minimum values recorded from control group are 125.05±0.04 mg C/m³/hr and 41.68±0.04 mg C/m³/hr respectively.

4.1.30. Qualitative and quantitative analysis of plankton

The biological parameters in this phase of experiment were found in an optimum level showing the good primary productivity, and it was more than the production of both phase-1 & 2 experiments. The phytoplankton quantity was found to be less in cow dung as compare to the other compost treatment tanks. The commonly encountered phytoplankton groups are *Chlorophyceae*, *Bacillariophyceae* and *Cyanophyceae*, while the dominant Zooplankton belongs to the group of *Copepoda* and *Cladocera*. Out of these groups the most dominant group having more number of species is *Chlorophyceae*. From the quantitative studies it was found that the number of planktons in this phase was good. The different species observed under different group in different treatments are illustrated in tables (26-30) in annexture.

Fig-16: Fluctuations of average values of pH during different sampling days of the experimental period

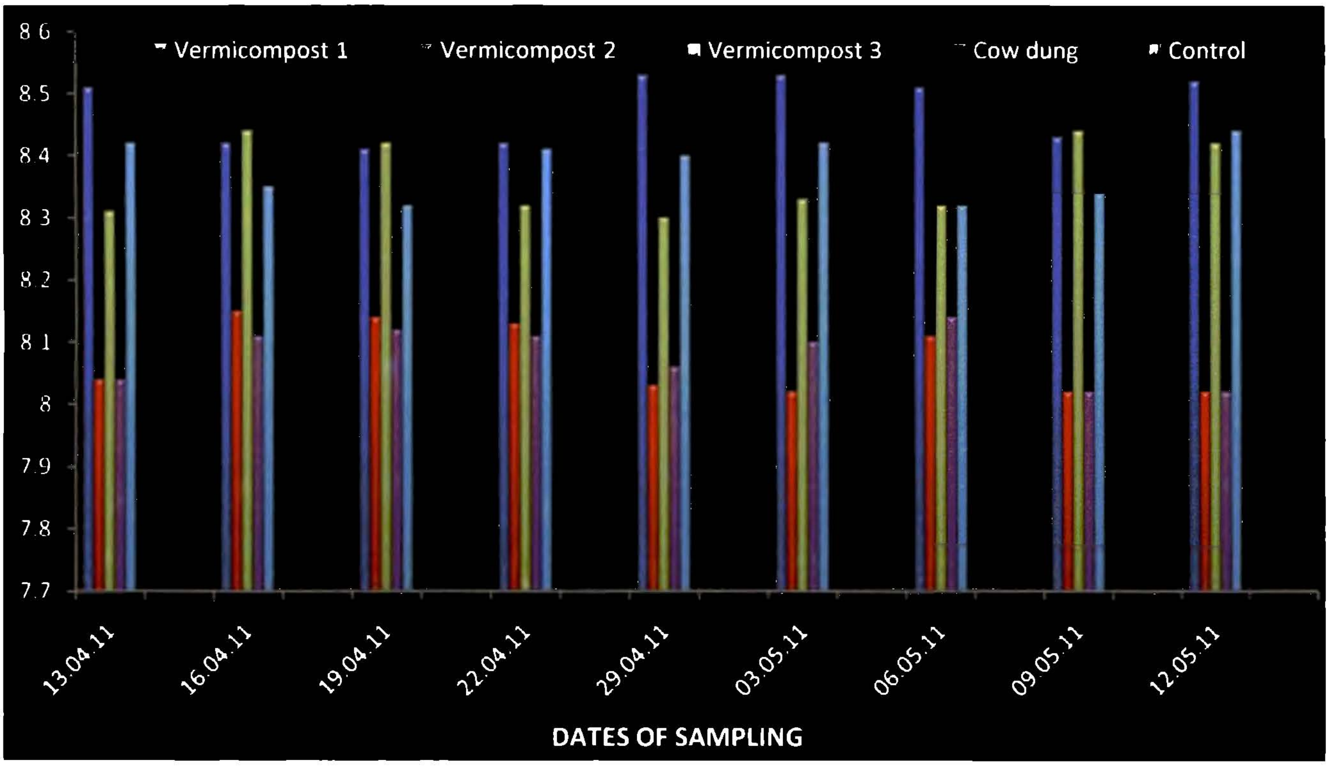


Fig-17: Fluctuations of average values of DO during different sampling days of the experimental period

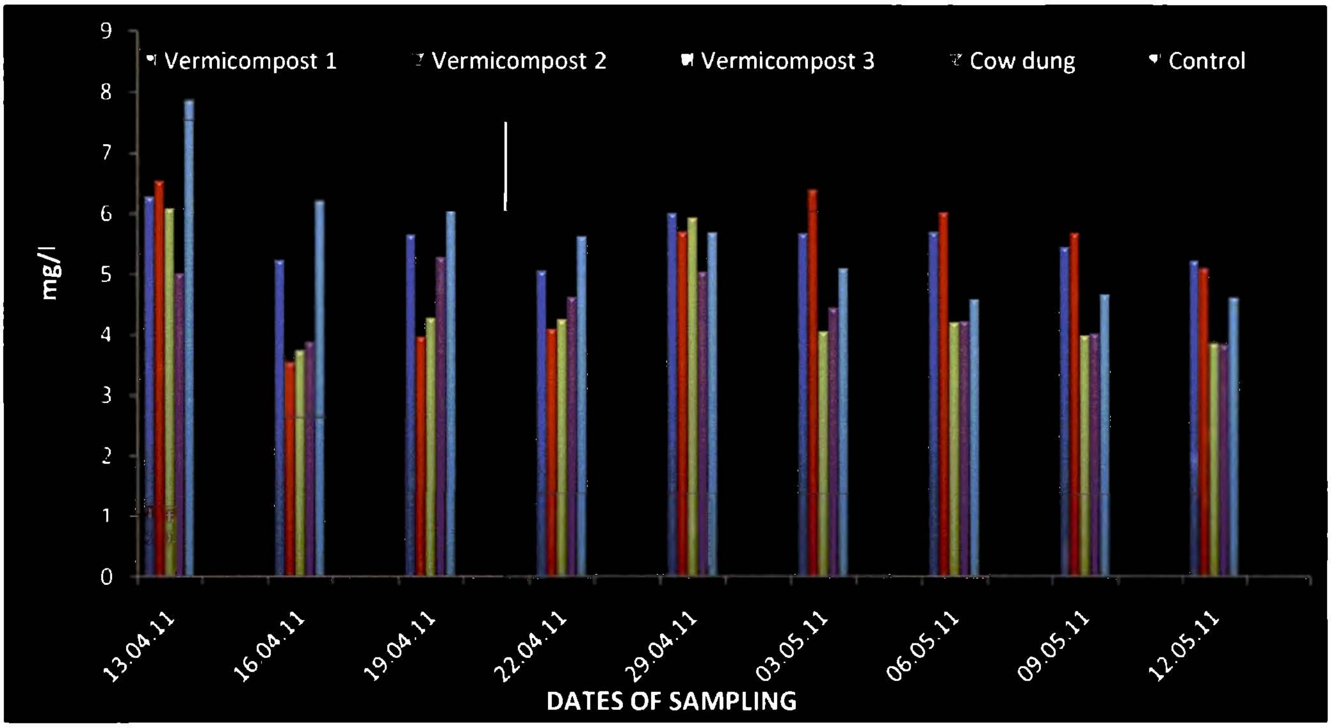


Fig-18: Fluctuations of average values of GPP during different sampling days of the experimental period

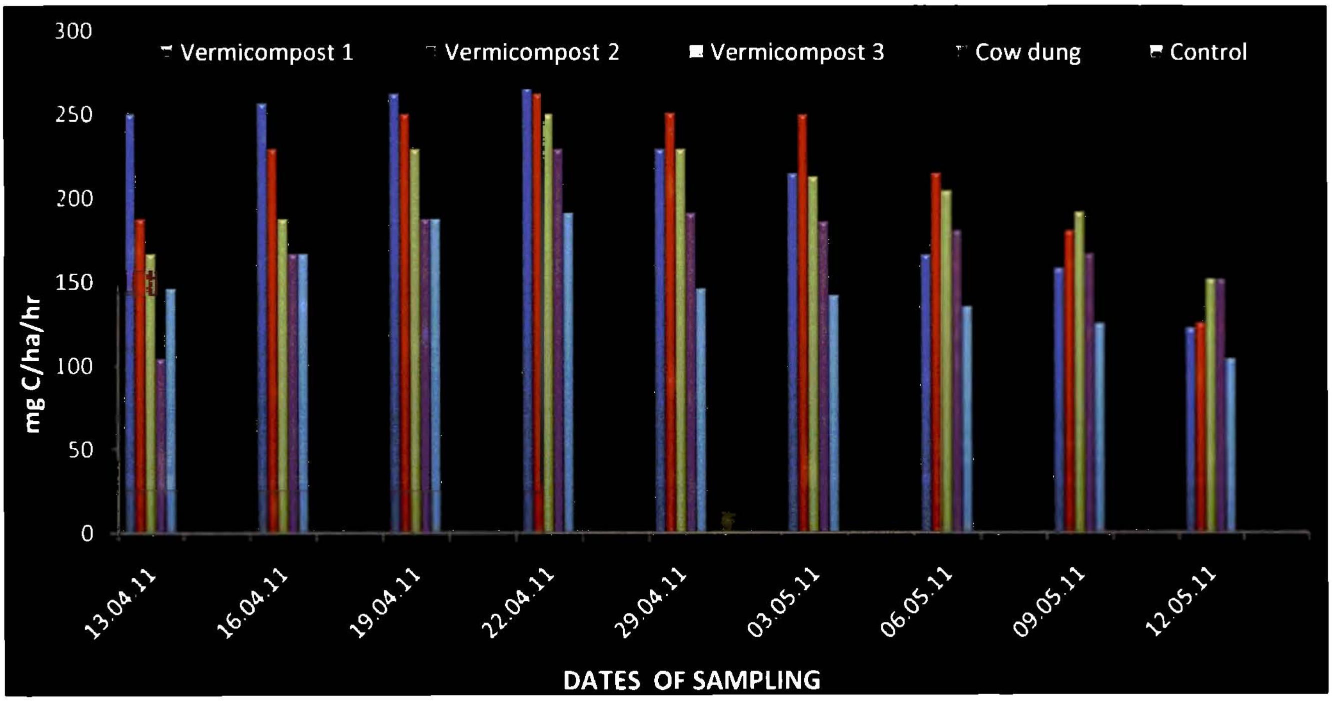


Fig-19: Fluctuations of average values of NPP during different sampling days of the experimental period

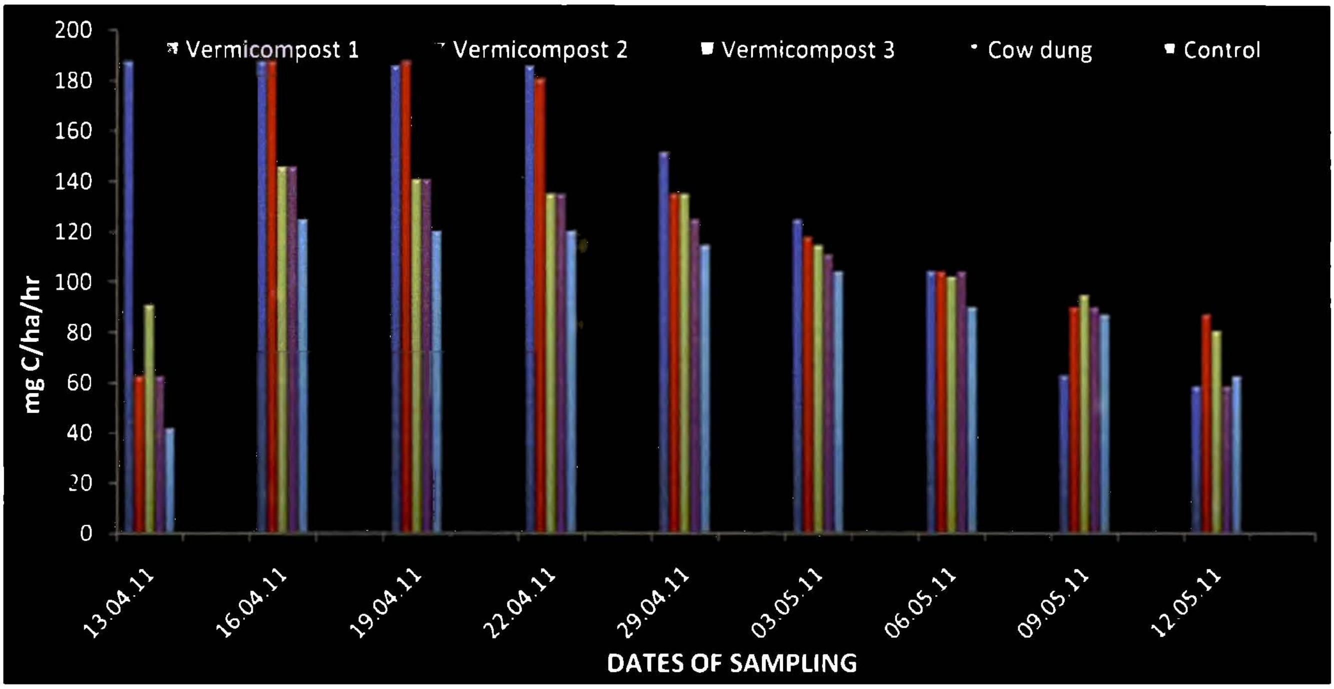


Fig-20: Fluctuations of average values of Hardness during different sampling days of the experimental period

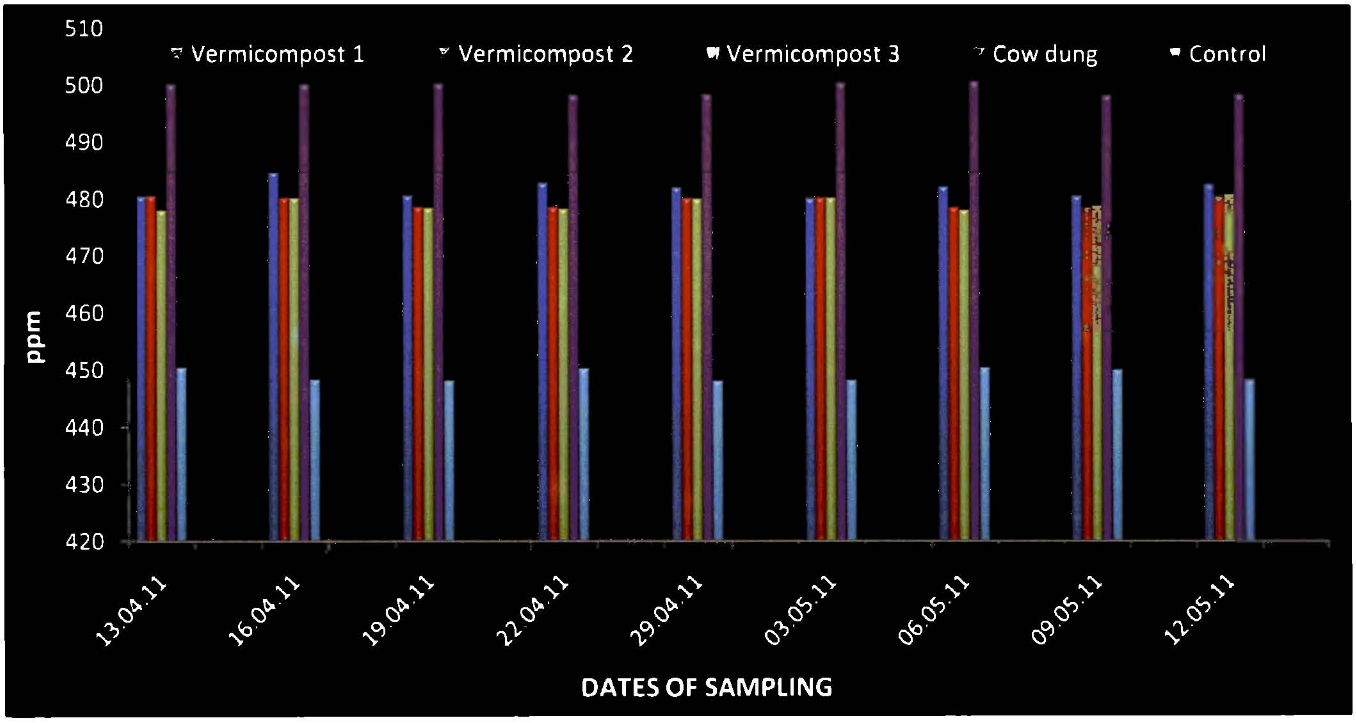


Fig-21: Fluctuations of average values of alkalinity during different sampling days of the experimental period

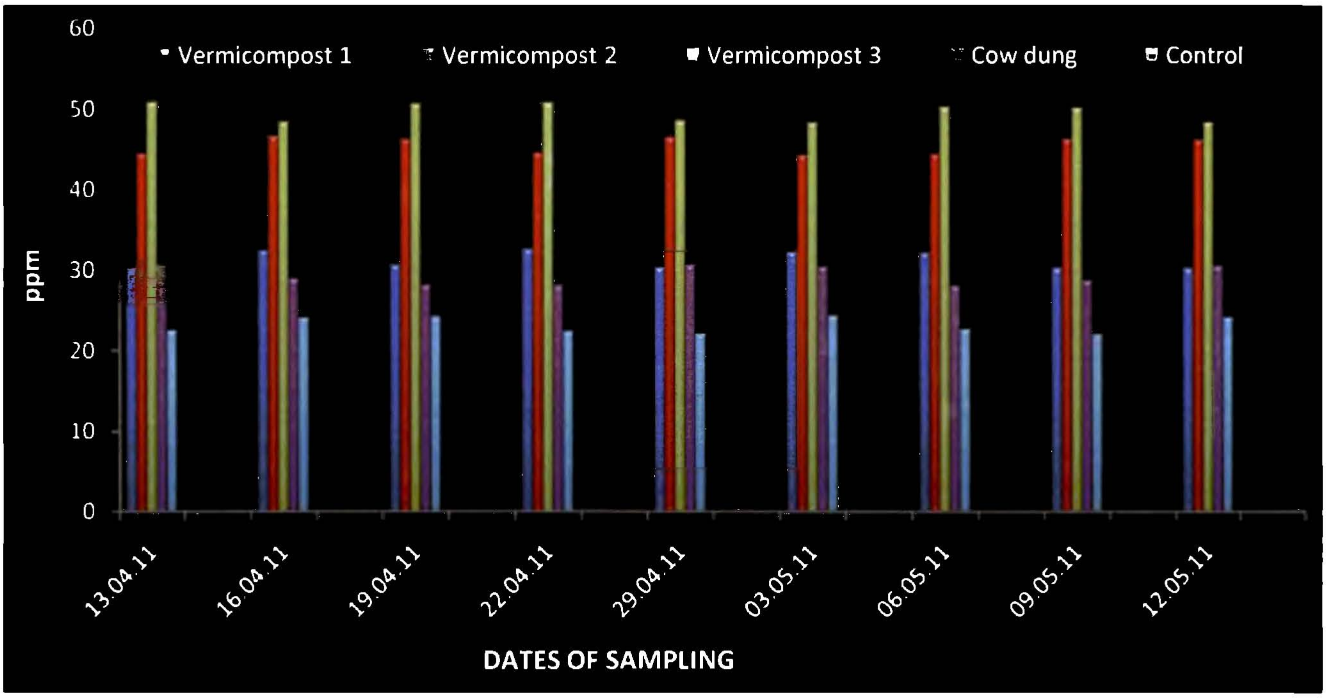


Fig-22: Fluctuations of average values of phosphate during different sampling days of the experimental period

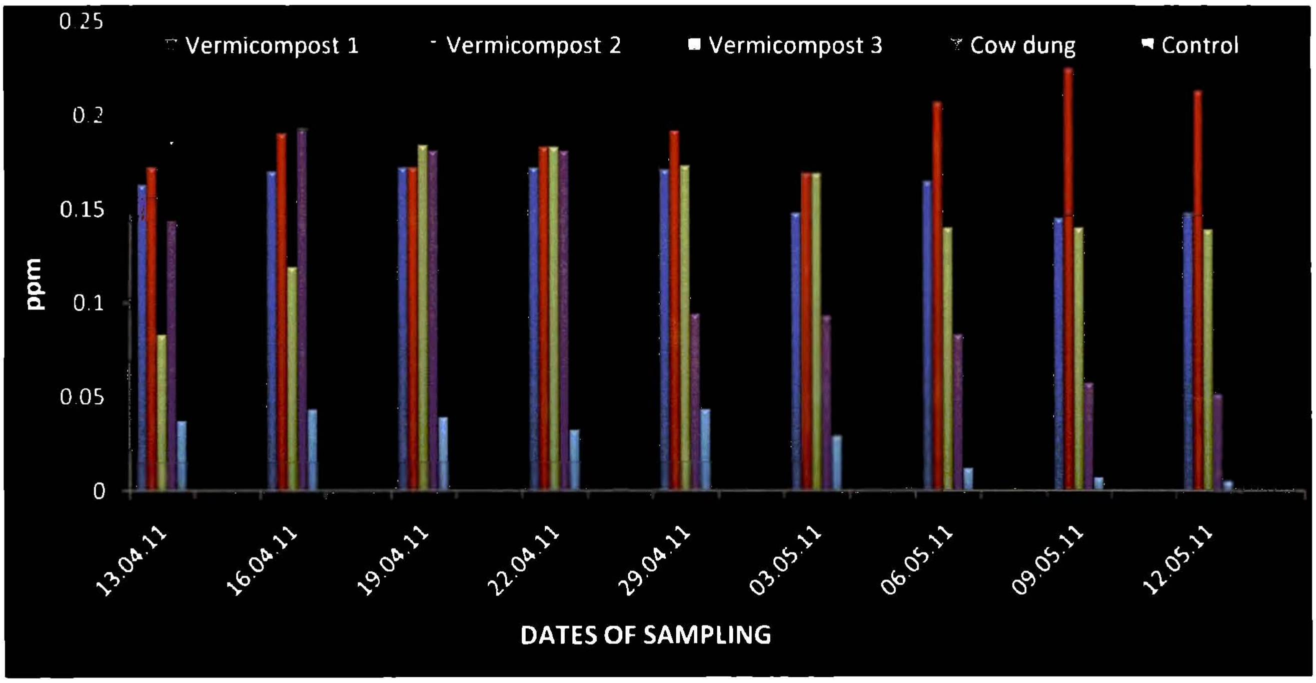
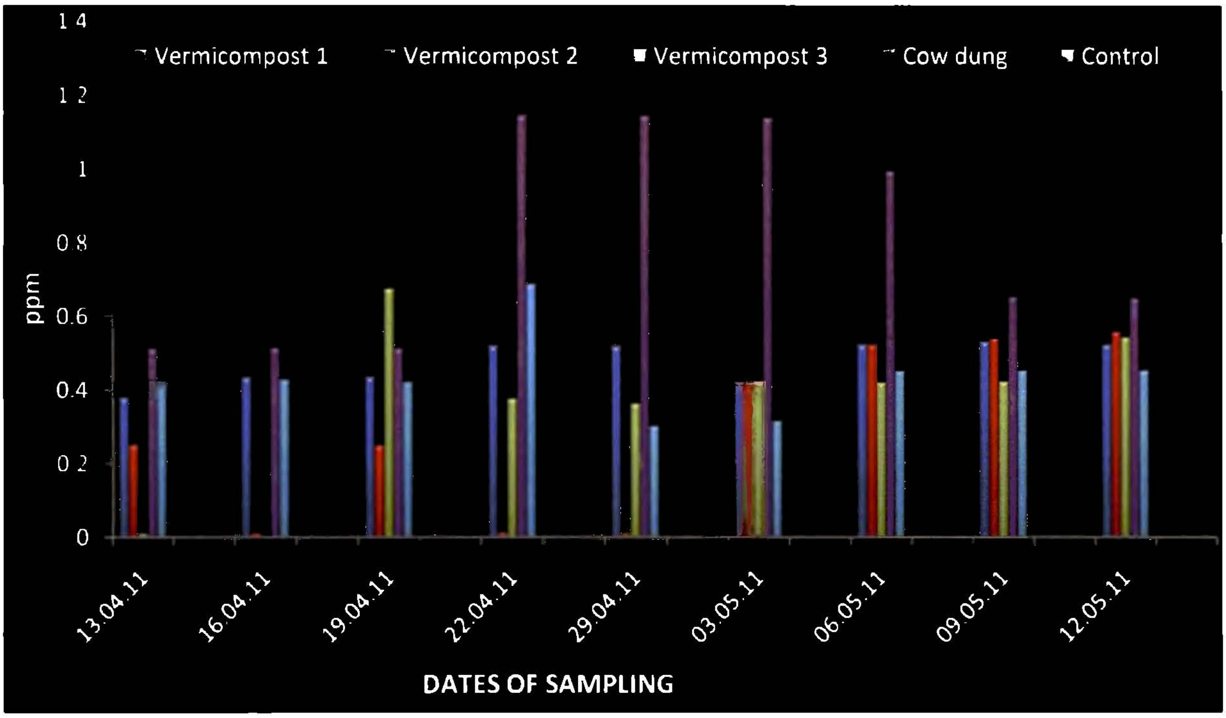


Fig-23: Fluctuations of average values of nitrate during different sampling days of the experimental period



4.1.31 Analysis of experimental Soil

Soil is the important parameter from culture aspect and if the soil will be productive then the production will be automatically more. The analysis of soil before application of manures in this phase of experiment showed good values of different parameters. The values obtained are 1.50% for organic carbon, 1.40 ppm for available phosphorus and 159.5 kg/ha for nitrogen.

4.1.31.1 Soil organic carbon (OC)

Organic Carbon is the most important parameter from the angle of productivity. During this experiment the OC content was found to be very good and so the productivity was also in a good range during this phase. The minimum and maximum values obtained in different treatments after the application of manure are 2.998±0.002%and 3.11±0.004% in V.C-1, 3.001±0.002% and 3.204±0.003% in V.C-2, 2.972±0.003% and 3.328±0.004% in V.C-3, 1.655±0.001% and 2.931±0.004% in cow dung and 1.484±0.002% and 1.632±0.004% in control tanks. From the graphs it can observed that the value was more in V.C-3 followed by V.C-2, V.C-1, C.D and control tank

4.1.31.2 Soil available phosphorus

As the water phosphate is required for plankton production the soil phosphorus is also required for good productivity. The maximum and minimum soil phosphorus value after application of manure is 1.512±0.004ppm and 1.396±0.0007ppm in V.C-1, 1.935±0.002ppm and 1.812±0.004ppm in V.C-2, 1.595±0.006ppm and 1.101±0.002ppm in V.C-3, 1.88±0.002ppm and 1.659±0.002ppm in cow dung and 1.459±0.006ppm and 0.84±0.006ppm in control tanks. From the graphs it was found that the highest value of phosphorus was in V.C-2, followed by CD, V.C-2, and V.C-1 and control tanks.

4.1.31.3 Soil available nitrogen

It is an important parameter as it also contributes for increasing the productivity. The maximum value of nitrogen was found in case of V.C-1. The maximum and minimum values found are 392.13±0.02kg/ha and 179.41±0.04kg/ha in V.C-1, 375.07±0.02kg/ha and 170.25±0.02kg/ha in V.C-2, 380.86 ±0.02kg/ha and 182.47±0.02kg/ha in V.C-3, 342.16 ±0.02 kg/ha and 160.43±0.04kg/ha in cow dung and 159.5±0.02kg/ha and 152.31±0.05kg/ha in control. From graph the highest value was found in V.C-1 followed by V.C-2, V.C-3, C.D and finally the control. During this sampling it was found that in the control tank the value was continuously decreasing towards the end of experiment.

Fig-24: Fluctuations of average values of organic carbon during different sampling days of the experimental period

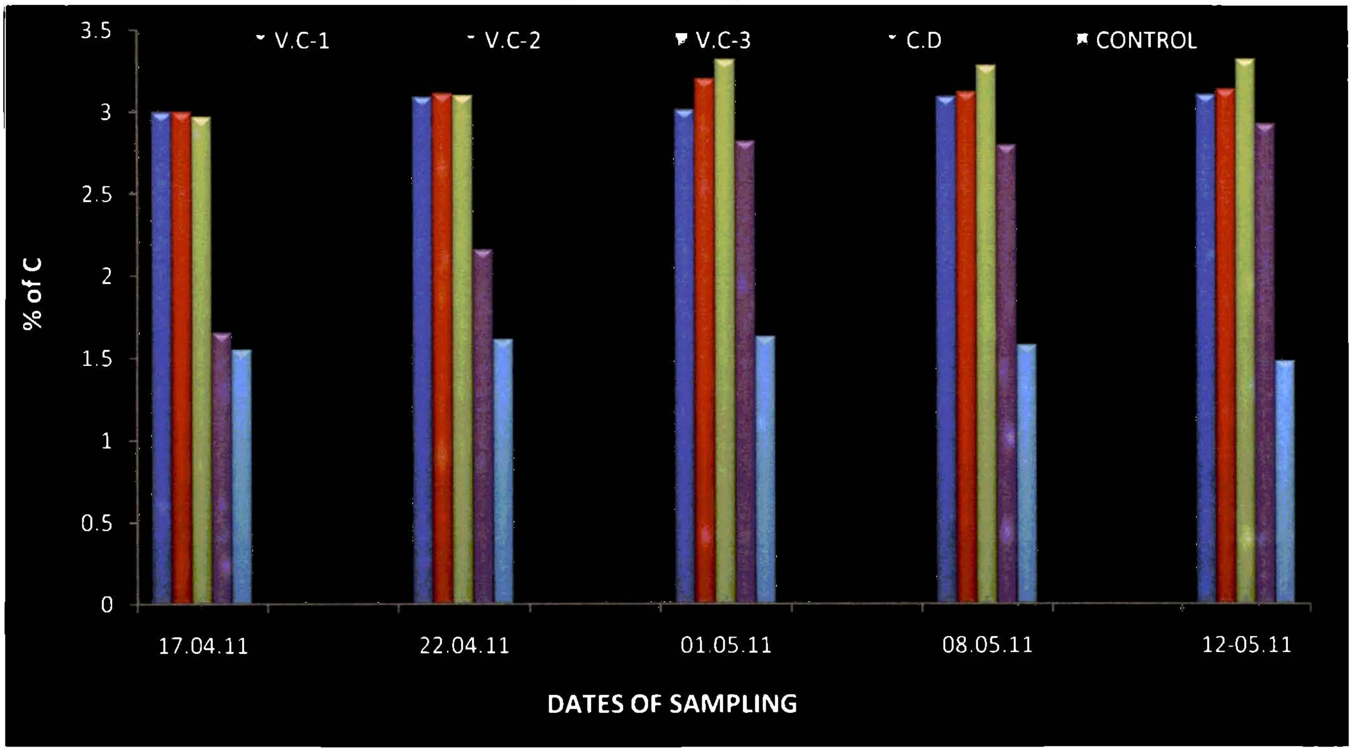


Fig-25: Fluctuations of average values of available phosphorus during different sampling days of the experimental period

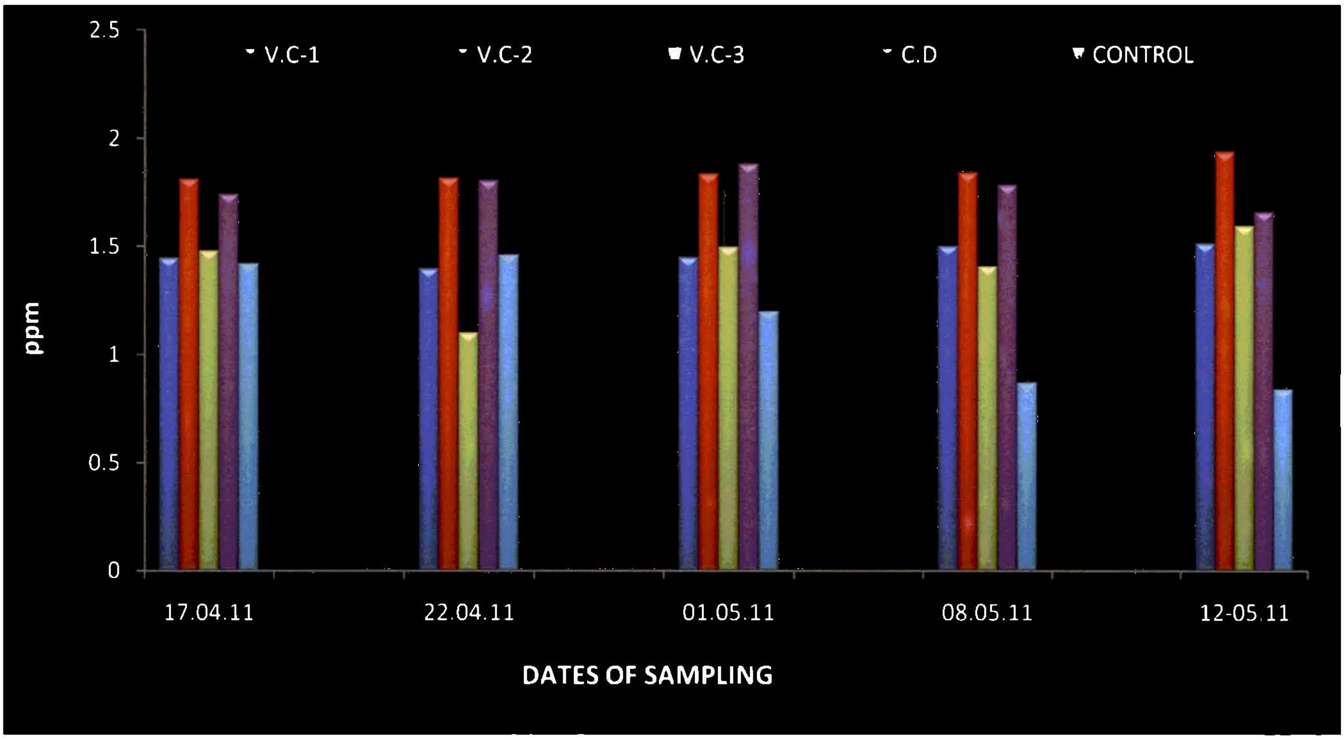
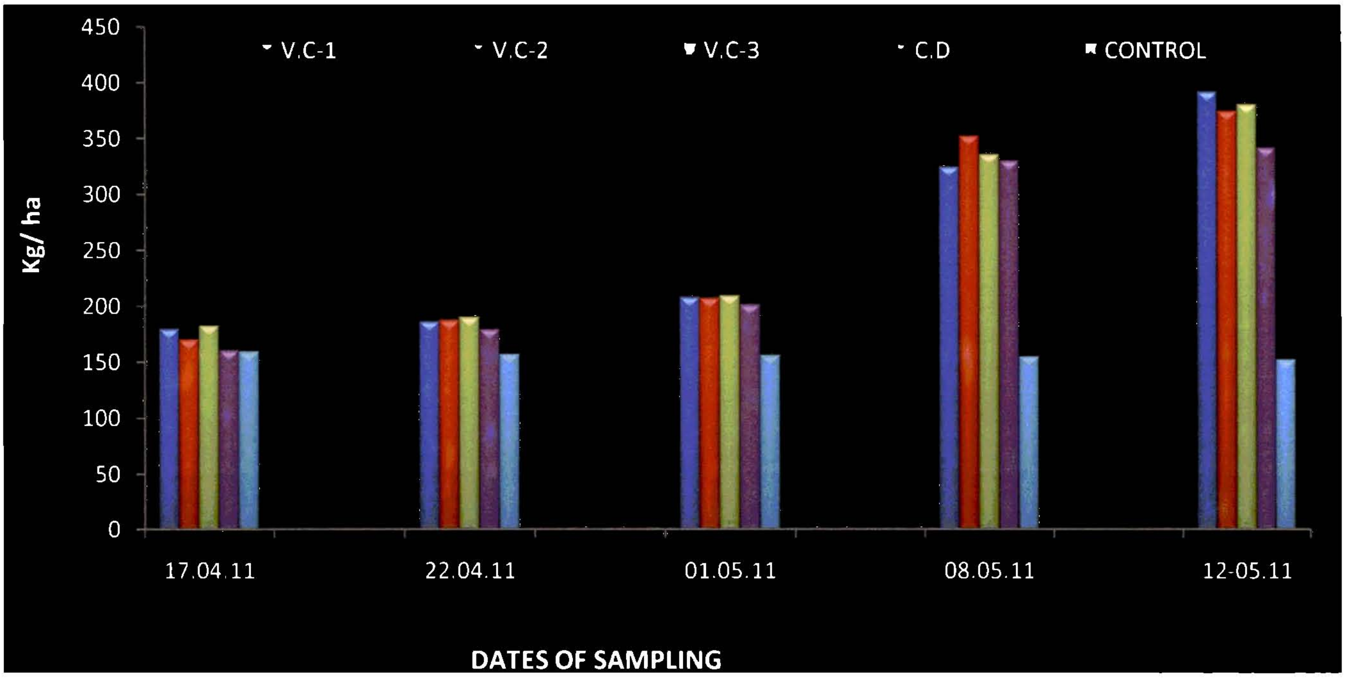
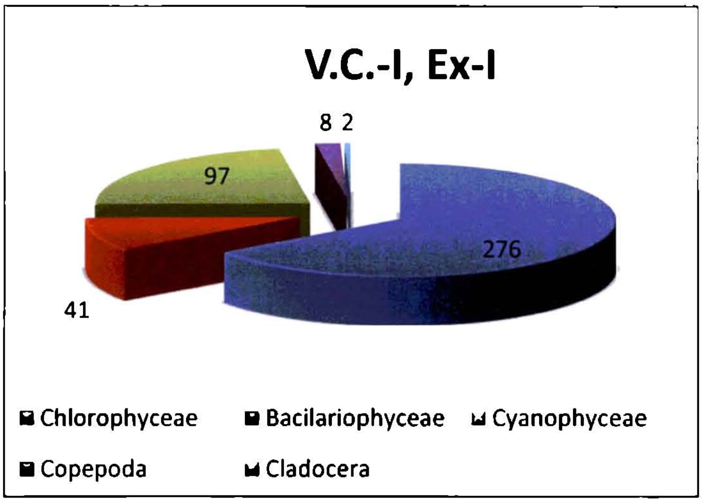
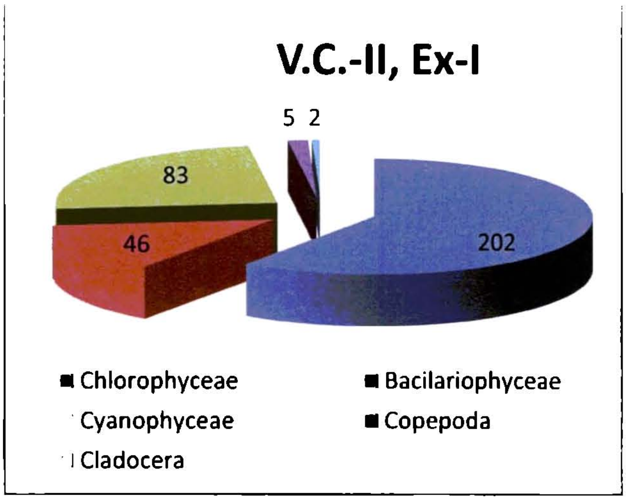


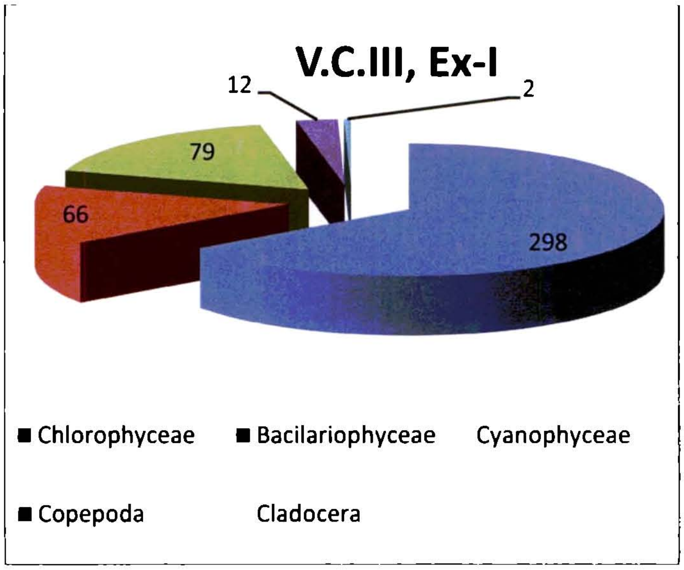
Fig-26: Fluctuations of average values of nitrogen during different sampling days of the experimental period

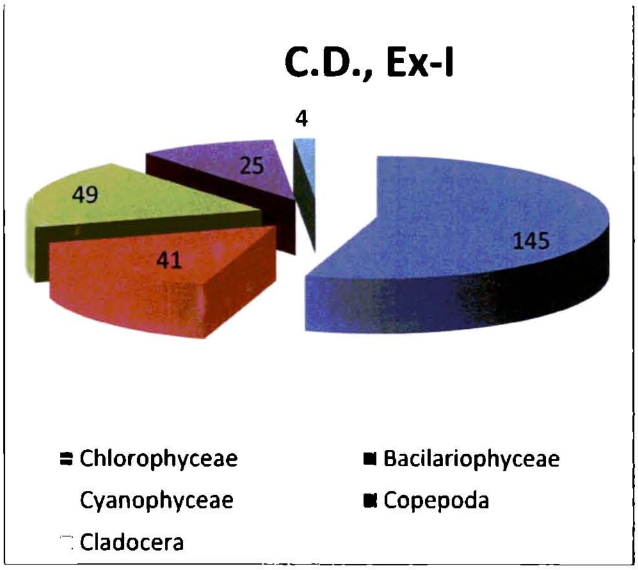


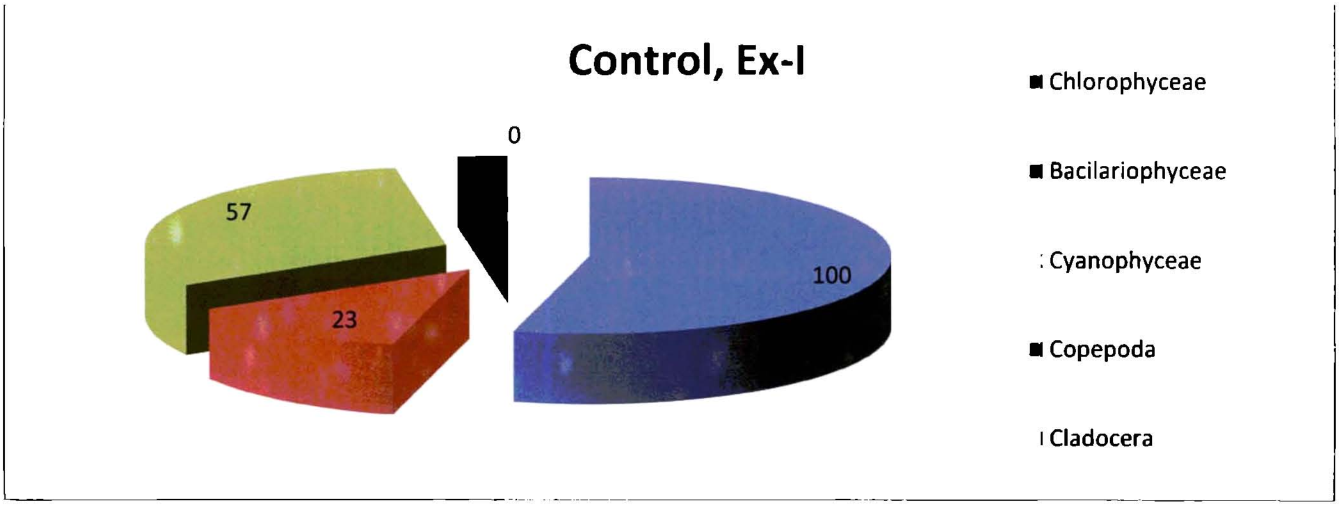
Graphical presentation of plankton count in Exp-1



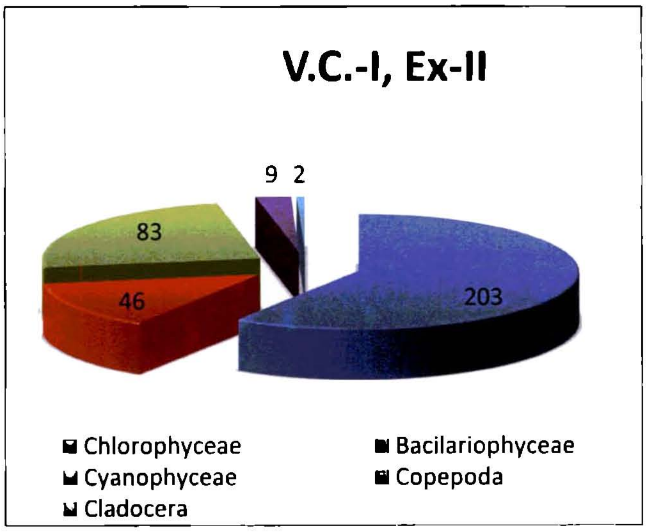


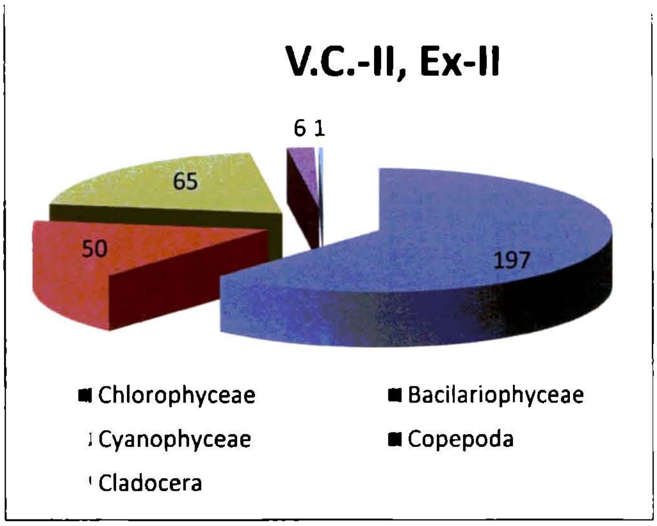


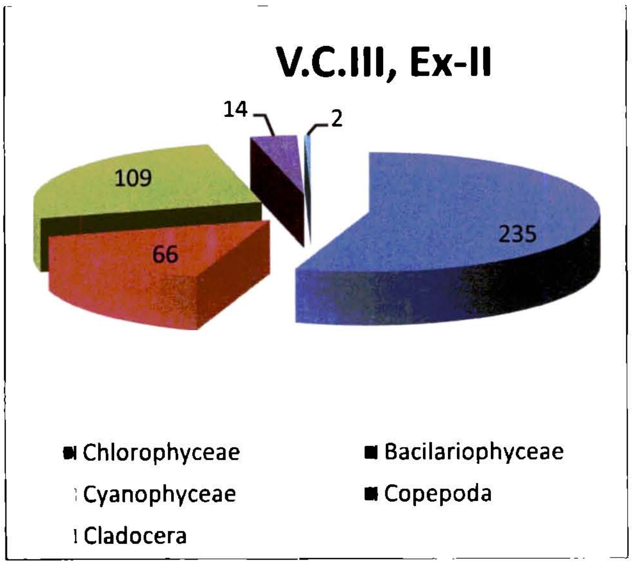


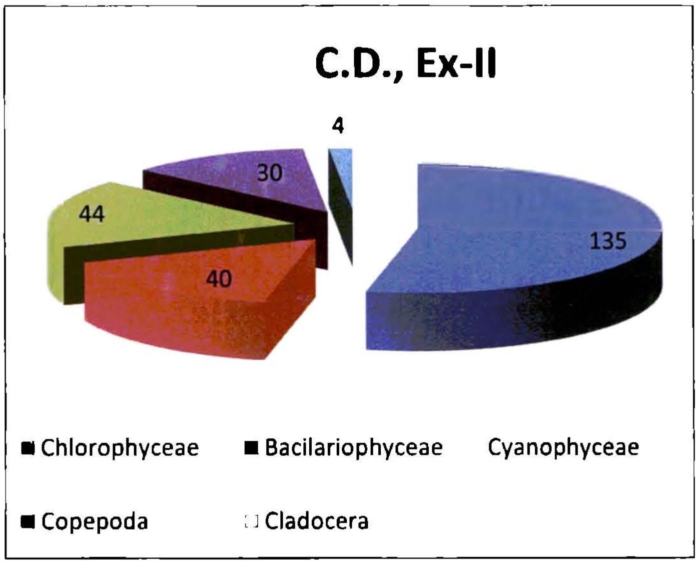


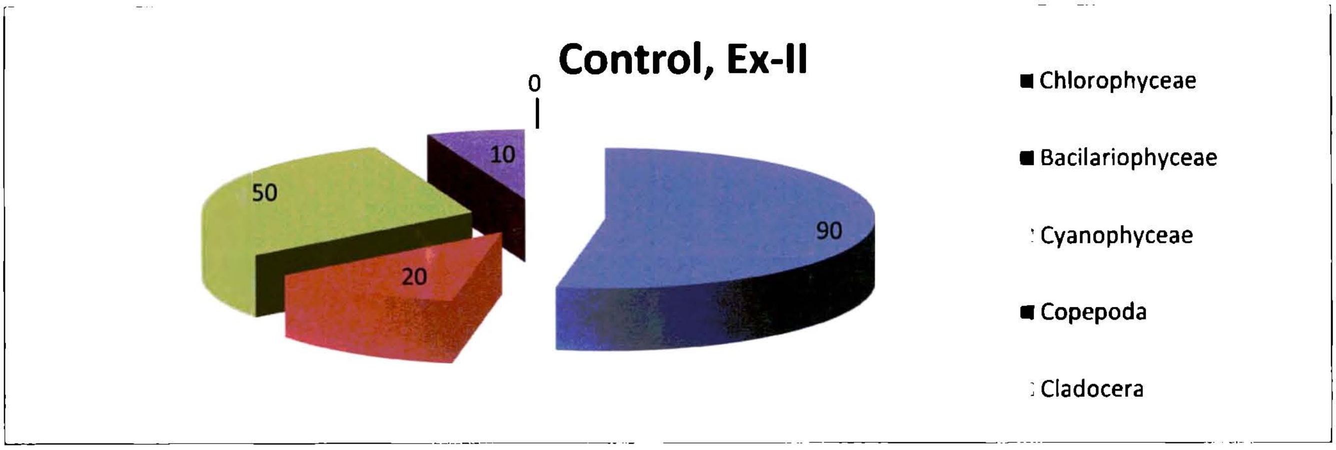
Graphical presentation of plankton count in Exp-2



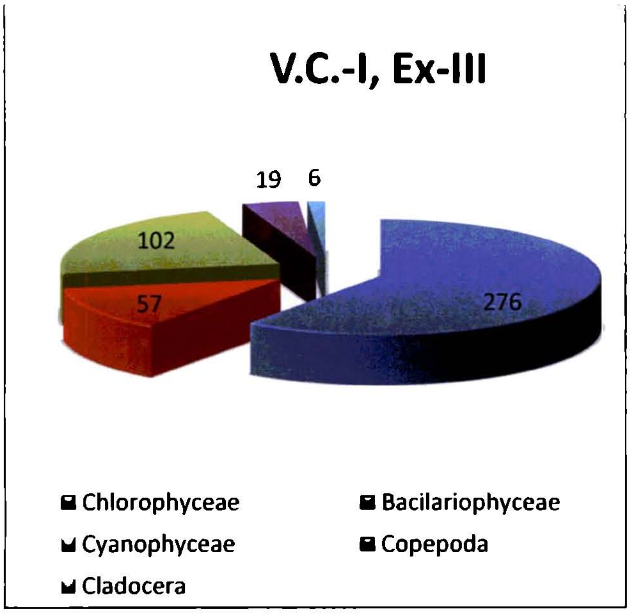


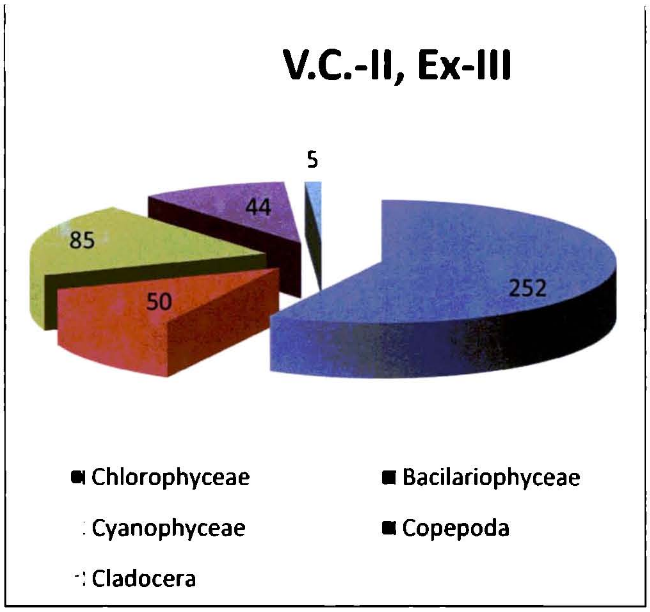


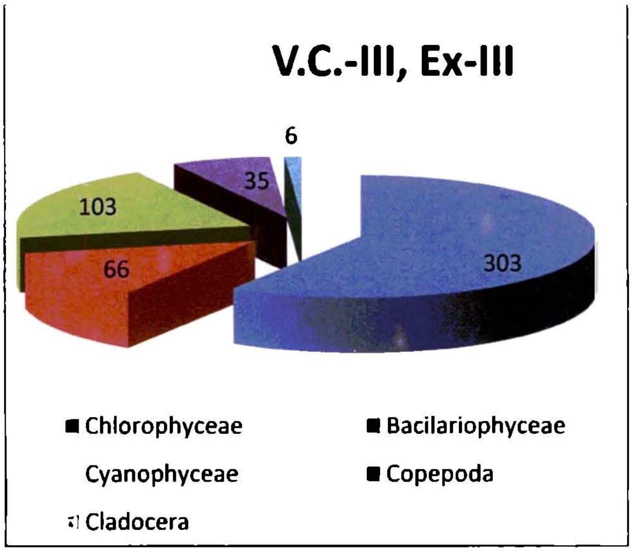


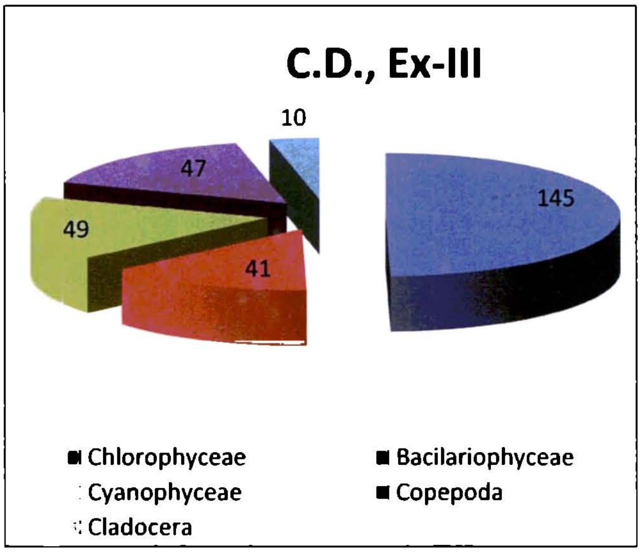


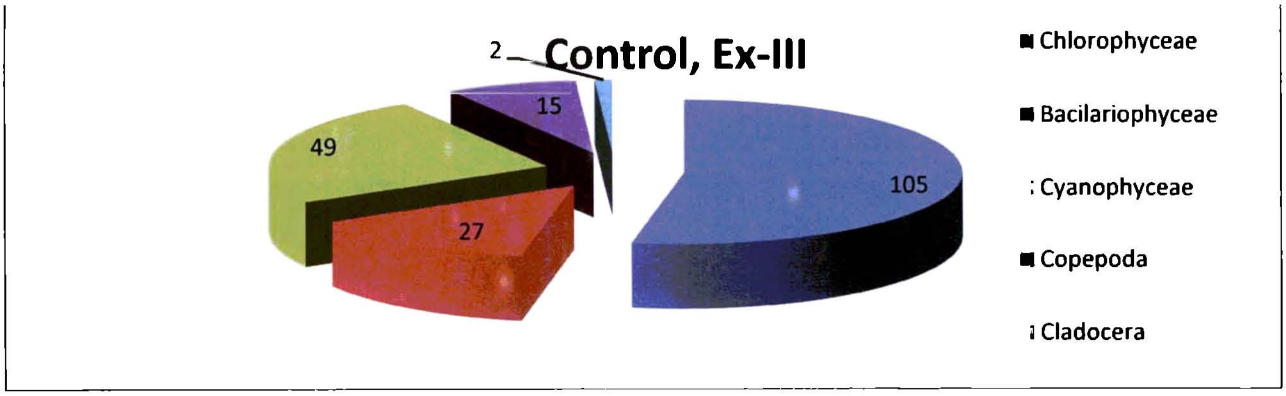
Graphical presentation of plankton count in Exp-3











CHAPTER - 5

DISCUSSION

Results obtained during the present study are discussed below in order to understand different conditions of the water bodies and their interactions in better ways for its future management.

5.1: Water quality parameters

5.1.1:pH

It is the indicator of hydrogen ion concentration expresses the intensity of an acidity or alkalinity depending upon its dissociation and total amount that is present. The pH value of water under different treatment remained under alkaline range. Importance of such alkaline pH range in maintaining productivity of fish pond water is long known and has been reported by workers like Alikunhi (1957), Hickling (1971), Boyd (1984) and others.

Such results were attributed to high rates of photosynthesis under different combinations of organic inputs which helped to consume the CO_2 and maintain high pH value in water. Mandal and Chhatopadhyay (1992) discussed that this importance of neutral to slightly alkaline pH range lies in larger availability of most of the plant nutrients to primary fish food organisms and also in maintenance of congenial environment for different physiological activities lives. This finding of pH showed similarity with the findings of Chattopadhyay, Banerjee and Guin*et al.* (2009).

5.1.2: Dissolved Oxygen

In the present study the DO concentration in water was found to be very high after the application of manure. The DO in range was much wide during the phase-1 experiment and the range was narrow during 3rd phase. As the 3rd phase was supplied with soil and the water was from pond, so may be a less variation was observed in DO concentration.

During all three phases of experiment a significant increase of DO was found in all treatments than the control tank. The decay of organic manure caused decrease in DO content of water (Schroeder, 1974; Collis and Smitherman, 1978), so in all experiments the tank with cow dung treatment showed the lowest DO value and this was attributed to larger amount of oxygen consumption by the CD during the course of decomposition. Since the VC was added to water system in decomposed form, the treatment with different doses of VC tended to exhibit significantly higher status DO in all of the treatment. This finding of pH showed similarity with the findings of Guin*et al.* (2009).

5.1.3: Total Hardness

During the experiment a wide value of hardness concentration was recorded during the 1st and 2nd phase of experiment, when the stored tap water was used for study and in control. In all the three phases of experiment the manure has no effect on hardness. During the 1st and 2nd phase a high value of hardness was observed both in treatment and in control, but it was in a normal range in 3rd phase of experiment. It might be due to a change in water source for experiment.

5.1.4: Total Alkalinity

Boyd (1979) reported that the alkalinity is related with the availability of free CO_2. During this experiment the range of alkalinity was found in a quite suitable range. This was only bicarbonate means the phenolphthalein alkalinity. The value was not much more and it might be due to unavailability of free CO_2 in all the treatments.

5.1.5: Gross Primary productivity

GPP values indicate the total production of organic carbon by primary producers and the value has been reported to be positively related to increased production.

The values of GPP varied differently in different composition of manure. The highest value of GPP in all experiment was obtained from the V.C-1 treatments. This V.C-1 is the compost made from neem leaves and this neem leaf is known to have good productive nature with additional antibacterial protection for the soil as compost. After V.C-1, good GPP was obtained from V.C-2 and V.C-3 respectively. Though the V.C-2 showed good production than V.C-3, but in some samplings both of them showed very good GPP value.

The highest value obtained from all treatments during the 1st phase of experiment followed by 3rd and 2nd phase. In 3rd phase the addition of soil medium acted as the store house of nutrients and where the manures get a media to mineralize.

In all experiments the highest level of DO was found to coincide with peaks of GPP, which supports the view of Srisumantach*et al.* (1982). The results obtained for this GPP applying the manure showed similarity with the findings of Guin*et al.* (2009)and Singh and Sharma (1999).

5.1.6: Net Primary Productivity

NPP of water indicates the residual amount of primary production after meeting the requirement of organic carbon through respiration.

In this present investigation the NPP value was found to be higher in case of V.C-1 followed by V.C-2, V.C-3 and CD. This higher value in V.C-1 was maintained in all experiments. From result it was noticed that the NPP was more in 2nd phase, though the

GPP was less than other phase of experiment. The NPP in CD was less from all treatments in every experiment.

The result emphasizes that net availability of primary food material to the fishes may be improved considerably if vermicompost is integrated as organic input.

5.1.7: Water Soluble Phosphate

Phosphorus is considered to be the most important nutrient element in fish pond nutrition (Hickling, 1971) owing to its significant influence on the growth of primary fish food organism and also it's wide spread deficiency in pond environment.

In the present study the concentration of phosphate was highest under the treatment V.C-2 followed by V.C-1 and V.C-3. Overall it was observed that the phosphate concentration was more in VC treatment rather than the CD. This finding of phosphate showed similarity with the findings of Guin*et al.* (2009).

This indicates the efficiency of vermicompost in maintaining higher level of phosphorus in water soluble form and also in helping to reduce the application of phosphatic fertilizers, which are predominantly expensive imported items. The transformation of higher amount of P from organic to available form during vermicomposting has been described by Ghosh*et al.*, (1999).

5.1.8: Water Soluble Nitrogen

Chandrasekhar and Jafar (1998) reported that the chief source of nitrogen in water is domestic sewage, agricultural runoff, metabolic waste of aquatic community and dead organisms.

During this present study the value of nitrate was quite optimum for a better productivity but with slight fluctuations. In result the nitrate value was recorded from 2nd and 3rd phase of experiment. The comparison result between these two experiments showed that the value of nitrate was high in V.C-3 treatment among VC treatment but the CD shoed better result than VC. As expected the control has the minimum value from both the treatments. The values were substantially higher than the threshold values, as suggested by Banerjee (1967) for fresh water fish ponds of India. This finding of nitrate showed similarity with the findings of Guin*et al.* (2009).

5.2: Soil parameters

5.2.1: Soil Organic Carbon (OC)

In this present study the value of OC was found to be much more than the optimum level. The value was increased after the application of manures and a constant value was observed in case of control, and this might be due to that the OC content of VC is much more. The result showed that the OC value do not showed much variation after treatment and in both CD and VC it was increased from the control.

5.2.2: Soil Available Phosphorus

The highest value of phosphorus obtained in the study is 1.935 ppm in case of V.C-2 treatment followed by CD, V.C-3 & 1. As usual the control gas minimum but it was not less than optimum value. In case of CD treatment the value was increased after the application of manures more than the V.C treatments, and towards the end of the experiment a good phosphorus value was maintained in CD treatment.

5.2.3: Soil Available Nitrogen

Highest value was recorded in V.C-1 and lowest in control. This parameter was found in a continuously decreasing level as there was no manure in control tanks and the available amount was may be used by planktons. The value before any application of manure was recorded as 159.8 kg/ha and the highest value after application of manure during final sampling was 392.13 kg/ha. This value showed similar results with

5.3: Biological Parameters

The culture tanks were observed to be rich in plankton which supported good GPP and NPP. Proper application with appropriate dose of manure generate conducive environment for growing natural fish food organism which accelerated the production rate of the water body. According to Ovie and Adenji (1991) the controlled application of fertilizers increases the level of primary production.

In the present investigation higher rate of phytoplankton primary production were observed in all treatments except in CD. The plankton volume was found to be different in various treatments. However the tank treated with V.C-1 had relatively more amount of GPP than other treatments.

In each composition of V.C, the plankton production was found better than CD, which further proved the superior nutrient status of three V.C than C.D. But in all treatments dry weight and population of plankton was significantly higher than control.

In this experiment a total of 23 spp of planktons were recorded which can be grouped under 5 groups out of which 3 are phytoplankton i.e. *Chlorophyceae, Bacillariophyceae* and *Cyanophycese* and 2 zooplankton groups i.e. *Cladocera* and *Copepoda*. The highest spp was recorded under*Chlorophyceae*group, followed by *Bacillariuophyceae* and *Cyanophycese*. In case of phytoplankton the dominant spp found was *Spirogyra*, which was found in all treatments even in control tank also. Among zooplankton groups the dominant was *Copepoda* with 1 dominant spp i.e. Cyclops.

During this study in case of CD application the zooplankton quantity was found to be more than phytoplankton in comparison to others. May be due to this reason the phytoplankton productivity was less in CD treatments than V.C treatments. The peak of plankton was also supported by a denser concentration of phosphate and nitrate both from soil and water. This findings was similar to the findings ofBhaumik*et al.* (2010), and

CHAPTER - 6

SUMMARY

Environment pollution has become a serious concern of the day. By recycling the available organic waste through production in our culture we can reduce the pollution load from the environment. This will also be beneficial from different point of view, particularly its low cost, fitting to the farmers' capacity.

Organic farming is a way to sustainable farming and to the nature, without disrupting its balance as much as it is possible. The pond water naturally is in equilibrium and is a reflection of its bottom soil quality. Organic farming always needs multidisciplinary approach. Aquaculture management in association with other fisheries education institution should be started and special grant or subsidy by government agency should be promoted in perusing the organic aquaculture.

Organic farming is a new approach in aquaculture sector and is still in the early stage of development. Moreover, it is very difficult proposition to do such farming following true organic ethics.

This primary study indicates that V.C may be considered to be an effective organic input, produced through recycling of organic wastes, for increasing the productivity of aquatic environment. While the quantum of organic manuring may be curtailed substantially through use of V.C thus reducing the organic load of the aquatic environment, use of V.C may be effective in reducing the doses of mineral fertilization also. Among different treatments, use of vermicompost composed with neem leaves was found to be most effective in increasing net primary productivity of waters as compared to the traditional nutrient management practice using recommended dose of mineral fertilizers and 10t cow dung ha^{-1} yr^{-1}.

A perusal of the foregoing results reveals that primary productivity and water quality characteristics are considerably affected by the type of manure used for fertilization. V.C-1 followed by V.C-2 has better manurial value than conventionally used cow dung in carp culture.

The present study indicates that organic fertilizer may serve as food for fish food organisms or they may get decomposed to release inorganic nutrients that stimulate plankton growth.

For popularization of organic aquaculture rather aquaculture with organic wastes in the rural areas for sustainable development, appropriate extension activities *viz.* trainings, massive awareness campaigns and demonstrations are required to be organized in the rural areas in mass scale.

CHAPTER - 7

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CHAPTER - 8

ANNEXURE

Experiment-1

Table- 5: Average values (Mean ±SD) of Primary Productivity (GPP & NPP)during the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	GPP				
17.01.11	211.62 ±0.034641	163.08 ±0.278388	141.85 ±0.017321	130.1 ±0.343948	22.56 ±0.212132
20.01.11	215.32 ±0.358097	182.32 ±0.220303	232.85 ±0.005774	128.32 ±0.351046	45.18 ±0.021213
23.01.11	326.05 ±0.43715	319.36 ±0.100167	250.23 ±0.233024	215.1 ±0.441928	115.13 ±0.502046
26.01.11	249.16 ±0.319531	284.22 ±0.37314	305.12 ±0.111355	191.21 ±0.329596	104.11 ±0.035355
29.01.11	166.34 ±0.190351	281.24 ±0.36756	242.15 ±0.384318	145.67 ±0.108167	82.96 ±0.098995
02.02.11	159.38 ±0.187172	180.52 ±0.069282	236.45 ±0.285715	122.3 ±0.04	83.16 ±0.035355
05.02.11	159.14 ±0.264071	180.64 ±0.017321	151.16 ±0.386825	111.02 ±0.485077	75.68 ±0.113137
08.02.11	158.14 ±0.264071	180.64 ±0.017321	125.48 ±0.264575	104.1 ±0.079373	62.26 ±0.19799
11.02.11	122.3 ±0.04	159.14 ±0.264071	122.3 ±0.04	74.58 ±0.131149	57.62 ±0.035355
	NPP				
17.01.11	195.15 ±0.39	97.51 ±0.178	104.25 ±0.334	122.32 ±0.372	20.82 ±0.028
20.01.11	138.06 ±0.343	34.55 ±0.176	221.13 ±0.254	104.2 ±0.032	35.02 ±0.594
23.01.11	90.06 ±0.132	249.36 ±0.131	235.14 ±0.392	87.26 ±0.341	80.32 ±0.028
26.01.11	88.06 ±0.275	118.66 ±0.101	251.12 ±0.130	76.21 ±0.365	52.36 ±0.261
29.01.11	76.22 ±0.270	104.13 ±0.399	208.12 ±0.416	74.58 ±0.131	62.48 ±0.035
02.02.11	62.8 ±0.041	91.74 ±0.069	207.43 ±0.204	57.48 ±0.098	62.48 ±0.035
05.02.11	57.48 ±0.098	91.74 ±±0.069	111.14 ±0.397	62.48 ±0.05	41.63 ±0.035
08.02.11	55.48 ±0.098	62.24 ±0.295	104.21 ±0.364	41.62 ±0.032	20.48 ±0.261
11.02.11	48.18 ±0.322	58.48 ±0.098	57.48 ±0.0985	20.48 ±0.186	20.63 ±0.155

Table-6: Average values (Mean±SD) of Dissolved oxygenduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	DO				
17.01.11	9.54 ±0.041633	9.41 ±0.116	8.11 ±0.071	7.22 ±0.094	9.44 ±0.120
20.01.11	8.25 ±0.08	7.16 ±0.025	8.43 ±0.121	8.05 ±0.098	8.23 ±0.134
23.01.11	9.16 ±0.041	8.41 ±0.128	10.41 ±0.139	8.21 ±0.215	9.01 ±0.177
26.01.11	12.21 ±0.035	9.01 ±0.150	9.43 ±0.100	8.22 ±0.123	9.67 ±0.113
29.01.11	12.83 ±0.047	12.31 ±0.134	12.79 ±0.025	9.44 ±0.102	9.62 ±0.134
02.02.11	12.34 ±0.066	10.22 ±0.100	13.03 ±0.130	8.23 ±0.117	9.44 ±0.169
05.02.11	11.62 ±0.147	10.47 ±0.095	11.6 ±0.110	8.46 ±0.098	8.82 ±0.155
08.02.11	9.41 ±0.108	8.42 ±0.126	9.42 ±0.113	7.1 ±0.07	8.8 ±0.219
11.02.11	9.12 ±0.030	8 ±0.030	8.8 ±0.030	6.8 ±0.042	7.72 ±0.042

Table-7: Average values (Mean ±SD) of Alkalinityduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	Alkalinity				
17.01.11	53.02 ±0.052	54.02 ±0.069	44.02 ±0.052	34.02 ±0.069	34.02 ±0.063
20.01.11	52.13 ±0.069	54.46 ±0.011	44.02 ±0.300	34.12 ±0.393	42.13 ±0.084
23.01.11	54.06 ±0.046	56.21 ±0.029	42.14 ±0.040	36.46 ±0.011	44.14 ±0.042
26.01.11	60.06 ±0.052	58.14 ±0.011	44.03 ±0.127	30.14 ±0.063	40.06 ±0.063
29.01.11	60.32 ±0.312	60.32 ±0.312	44.12 ±0.427	38.14 ±0.011	42.32 ±0.049
02.02.11	58.14 ±0.011	60.15 ±0.046	48.14 ±0.011	30.06 ±0.052	46.14 ±0.014
05.02.11	58.15 ±0.046	64.12 ±0.081	44.14 ±0.063	30.14 ±0.011	48.15 ±0.056
08.02.11	56.14 ±0.011	62.15 ±0.046	42.14 ±0.058	32.02 ±0.062	46.23 ±0.035
11.02.11	54.22 ±0.136	60.02 ±0.258	42.81 ±0.036	30.42 ±0.041	42.06 ±0.028

Table-8: Average values (Mean ±SD) of Hardnessduring the experiment

Tanks → / Days	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Hardness				
17.01.11	1030.2 ±0.02	1020.1 ±0.026	1096.3 ±0.03	1072.21 ±0.026	1070.05 ±0.028
20.01.11	1030.31 ±0.025	1024.22 ±0.026	1110.21 ±0.026	1068.3 ±0.03	1070.2 ±0.007
23.01.11	1028.41 ±0.035	1020.31 ±0.026	1110.4 ±0.01	1066.02 ±0.021	1070.24 ±0.014
26.01.11	1030.22 ±0.030	1020.11 ±0.05	1098.51 ±0.02	1072.11 ±0.030	1071.11 ±0.035
29.01.11	1032.62 ±0.02	1024.41 ±0.03	1096.21 ±0.021	1068.32 ±0.02	1070.13 ±0.021
02.02.11	1030.2 ±0.032	1024.31 ±0.030	1096.06 ±0.444	1066.51 ±0.021	1072.35 ±0.007
05.02.11	1028.52 ±0.030	1022.21 ±0.026	1110.11 ±0.02	1072.4 ±0.021	1072.41 ±0.014
08.02.11	1028.1 ±0.02	1020.03 ±0.03	1096.41 ±0.025	1072.22 ±0.015	1070.38 ±0.014
11.02.11	1030.44 ±0.021	1022.82 ±0.028	1098.6 ±0.030	1068.81 ±0.025	1071.2 ±0.028

Table-9: Average values (Mean ±SD) of pHduring the experiment

Tanks → / Days	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	pH				
17.01.11	8.01 ±0.015	8.51 ±0.021	8.02 ±0.02	8.56 ±0.01	8.01 ±0.007
20.01.11	8.22 ±0.021	8.31 ±0.021	8.31 ±0.015	8.52 ±0.030	8.03 ±0.007
23.01.11	8.21 ±0.015	8.31 ±0.015	8.31 ±0.015	8.22 ±0.030	8.01 ±0.028
26.01.11	8.22 ±0.02	8.51 ±0.025	8.02 ±0.020	8.52 ±0.015	8.02 ±0.035
29.01.11	8.03 ±0.021	8.51 ±0.03	8.03 ±0.026	8.52 ±0.030	8.21 ±0.028
02.02.11	8.02 ±0.011	8.52 ±0.015	8.01 ±0.035	8.24 ±0.015	8.23 ±0.007
05.02.11	8.01 ±0.021	8.51 ±0.015	8.04 ±0.02	8.22 ±0.030	8.01 ±0.035
08.02.11	8.22 ±0.025	8.51 ±0.02	8.02 ±0.020	8.21 ±0.015	8.04 ±0.028
11.02.11	8.21 ±0.017	8.31 ±0.021	8.31 ±0.025	8.52 ±0.015	8.23 ±0.021

Table-10: Average values (Mean ±SD) of Phosphateduring the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Phosphate				
17.01.11	0.101 ±0.0005	0.214 ±0.001	0.154 ±0.002	0.154 ±0.002	0.094 ±0.009
20.01.11	0.241 ±0.001	0.153 ±0.002	0.161 ±0.004	0.163 ±0.002	0.08 ±0.010
23.01.11	0.241 ±0.002	0.241 ±0.003	0.192 ±0.001	0.192 ±0.001	0.102 ±0.004
26.01.11	0.162 ±0.001	0.25 ±0.004	0.201 ±0.007	0.201 ±0.003	0.107 ±0.002
29.01.11	0.121 ±0.002	0.163 ±0.002	0.123 ±0.001	0.125 ±0.002	0.043 ±0.006
02.02.11	0.101 ±0.003	0.104 ±0.002	0.124 ±0.002	0.091 ±0.001	0.061 ±0.002
05.02.11	0.123 ±0.002	0.142 ±0.003	0.094 ±0.002	0.105 ±0.002	0.056 ±0.002
08.02.11	0.123 ±0.002	0.141 ±0.001	0.092 ±0.003	0.035 ±0.002	0.043 ±0.003
11.02.11	0.196 ±0.002	0.12 ±0.004	0.089 ±0.004	0.029 ±0.002	0.012 ±0.002

Experiment-2

Table-11: Average values (Mean ±SD) of Primary Productivity (GPP & NPP)during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
			GPP		
24.02.11	95.101 ±0.393	102.82 ±0.041	94.101 ±0.393	115.36 ±0.041	83.64 ±0.01
27.02.11	243.02 ±0.49	120.91 ±0.02	138.8 ±0.02	122.34 ±0.03	114.61 ±0.03
02.03.11	215.1 ±0.43	138.8 ±0.02	125.08 ±0.49	173.72 ±0.03	104.21 ±0.03
05.03.11	201.24 ±0.13435	122.3 ±0.04	120.91 ±0.025166	102.64 ±0.020817	72.9 ±0.02
12.03.11	131.11 ±0.39	104.1 ±0.07	111.02 ±0.48	95.6 ±0.041	62.54 ±0.02
15.03.11	122.3 ±0.04	102.82 ±0.04	83.173 ±0.38	83.3 ±0.04	62.5 ±0.042
18.03.11	111.02 ±0.48	94.101 ±0.39	80.214 ±0.07	76.01 ±0.35	60.22 ±0.02
21.03.11	83.17 ±0.38	83.173 ±0.38	76.01 ±0.35	72.91 ±0.02	56.4 ±0.042
24.03.11	80.21 ±0.07	80.214 ±0.07	72.91 ±0.02	62.33 ±0.03	52.86 ±0.03
			NPP		
24.02.11	62.015 ±0.32	65.61 ±0.02	81.82 ±0.01	60.5 ±0.02	41.82 ±0.042
27.02.11	208.04 ±0.48	62.71 ±0.03	76.01 ±0.35	76.01 ±0.48	104.22 ±0.02
02.03.11	169.17 ±0.29	97.1 ±0.03	72.91 ±0.02	75.4 ±0.041	80.32 ±0.02
05.03.11	131.11 ±0.39	76.01 ±0.48	70.61 ±0.02	90.21 ±0.03	63.41 ±0.04
12.03.11	104.11 ±0.06	70.61 ±0.02	65.61 ±0.02	85.5 ±0.03	60.42 ±0.042
15.03.11	70.314 ±0.16	70.61 ±0.02	62.71 ±0.03	81.8 ±0.03	54.62 ±0.042
18.03.11	70.314 ±0.17	65.61 ±0.02	62.61 ±0.02	56.7 ±0.03	52.11 ±0.02
21.03.11	62.48 ±0.05	57.48 ±0.09	56.7 ±0.036056	56.7 ±0.041	44.6 ±0.05
24.03.11	57.48 ±0.09	41.62 ±0.03	50.06 ±0.04	52.22 ±0.03	42.68 ±0.042

Table-12: Average values (Mean ±SD) of Dissolved oxygenduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	Dissolved oxygen				
24.02.11	7.21 ±0.026	9.1 ±0.055	7.41 ±0.025	9.01 ±0.035	7.7 ±0.014
27.02.11	8.02 ±0.052	7.23 ±0.041	7.88 ±0.02	7.28 ±0.04	9.04 ±0.028
02.03.11	8.2 ±0.020	7.21 ±0.026	8.7 ±0.030	8.41 ±0.026	7.62 ±0.028
05.03.11	8.2 ±0.02	7.18 ±0.119	7.88 ±0.02	6.2 ±0.025	7.23 ±0.014
12.03.11	6.6 ±0.020	6.8 ±0.02	6.7 ±0.036	5.9 ±0.041	6.8 ±0.028
15.03.11	6.2 ±0.025	6.7 ±0.036	6.7 ±0.030	5.62 ±0.04	6.82 ±0.014
18.03.11	6.41 ±0.141	6.41 ±0.03	6.41 ±0.03	5.58 ±0.02	6.02 ±0.042
21.03.11	6.24 ±0.02	6.2 ±0.030	6.33 ±0.026	5.72 ±0.030	5.8 ±0.0565 69
24.03.11	5.82 ±0.032	6.02 ±0.030	5.81 ±0.035	4.2 ±0.006	5.62 ±0.042

Table-13: Average values (Mean ±SD) of Alkalinityduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	Alkalinity				
24.02.11	44.24 ±0.036	44.24 ±0.0360	44.24 ±0.036	56.26 ±0.110	56.31 ±0.042
27.02.11	45.62 ±0.043	46.26 ±0.110	46.26 ±0.110	56.31 ±0.055	58.52 ±0.014
02.03.11	46.26 ±0.110	50.31 ±0.055	46.31 ±0.055	58.52 ±0.02	54.42 ±0.028
05.03.11	46.31 ±0.055	50.42 ±0.02	50.52 ±0.02	54.42 ±0.02	58.61 ±0.014
12.03.11	42.52 ±0.02	48.52 ±0.02	50.42 ±0.02	58.61 ±0.011	55.62 ±0.007
15.03.11	42.42 ±0.02	46.61 ±0.011	45.62 ±0.043	55.62 ±0.043	54.24 ±0.014
18.03.11	44.61 ±0.011	45.62 ±0.043	46.61 ±0.011	54.24 ±0.036	55.62 ±0.007
21.03.11	40.62 ±0.030	44.92 ±0.02	45.62 ±0.043	56.21 ±0.04	56.8 ±0.042
24.03.11	40.1 ±0.041	44.24 ±0.036	44.92 ±0.02	54.1 ±0.04	52.82 ±0.042

Table-14: Average values (Mean ±SD) of Hardnessduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	Hardness				
24.02.11	1060.31 ±0.026	1048.63 ±0.017	1040.31 ±0.026	1030.31 ±0.026	1036.63 ±0.021
27.02.11	1062.63 ±0.017	1048.62 ±0.030	1042.63 ±0.017	1036.63 ±0.017	1040.66 ±0.014
02.03.11	1060.62 ±0.030	1050.62 ±0.030	1040.62 ±0.030	1030.62 ±0.030	1038.64 ±0.028
05.03.11	1060.62 ±0.030	1048.42 ±0.032	1048.62 ±0.030	1036.62 ±0.030	1036.42 ±0.042
12.03.11	1064.42 ±0.032	1044.42 ±0.032	1044.42 ±0.032	1034.42 ±0.032	1040.53 ±0.035
15.03.11	1060.53 ±0.025	1048.53 ±0.025	1040.53 ±0.025	1030.53 ±0.025	1038.42 ±0.042
18.03.11	1062.42 ±0.032	1050.31 ±0.026	1048.42 ±0.032	1036.42 ±0.032	1036.53 ±0.035
21.03.11	1060.4 ±0.02	1048.21 ±0.025	1044.2 ±0.04	1036.2 ±0.030	1040.22 ±0.042
24.03.11	1062.2 ±0.04	1046.35 ±0.127	1042.82 ±0.030	1034.54 ±0.02	1036.42 ±0.042

Table-15: Average values (Mean ±SD) of pHduring the experiment

Tanks →	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
Days ↓	pH				
24.02.11	8.32 ±0.040	8.01 ±0.025	8.51 ±0.03	8.02 ±0.015	8.5 ±0.014
27.02.11	8.32 ±0.045	8.01 ±0.02	8.42 ±0.035	8.01 ±0.025	8.51 ±0.014
02.03.11	8.32 ±0.03	8.03 ±0.02	8.35 ±0.030	8.02 ±0.02	8.41 ±0.021
05.03.11	8.22 ±0.041	8.23 ±0.026	8.52 ±0.030	8.18 ±0.03	8.42 ±0.035
12.03.11	8.12 ±0.030	8.04 ±0.02	8.42 ±0.030	8.18 ±0.025	8.48 ±0.014
15.03.11	8.28 ±0.049	8.02 ±0.03	8.52 ±0.030	8.04 ±0.02	8.5 ±0.007
18.03.11	8.02 ±0.02	8.02 ±0.023	8.36 ±0.02	8.01 ±0.015	8.51 ±0.014
21.03.11	8.2 ±0.040	8.24 ±0.036	8.39 ±0.045	8.22 ±0.030	8.52 ±0.014
24.03.11	8.22 ±0.021	8.01 ±0.037	8.52 ±0.030	8.02 ±0.030	8.42 ±0.014

Table-16: Average values (Mean ±SD) of Phosphateduring the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Phosphate				
24.02.11	0.184 ±0.004	0.221 ±0.011	0.178 ±0.004	0.184 ±0.004	0.022 ±0.004
27.02.11	0.232 ±0.004	0.212 ±0.015	0.243 ±0.004	0.232 ±0.004	0.012 ±0.002
02.03.11	0.273 ±0.006	0.253 ±0.007	0.149 ±0.008	0.253 ±0.007	0.032 ±0.002
05.03.11	0.09 ±0.016	0.124 ±0.004	0.178 ±0.004	0.127 ±0.003	0.031 ±0.004
12.03.11	0.191 ±0.007	0.124 ±0.007	0.19 ±0.008	0.192 ±0.007	0.022 ±0.004
15.03.11	0.173 ±0.006	0.119 ±0.006	0.192 ±0.009	0.102 ±0.004	0.022 ±0.002
18.03.11	0.206 ±0.007	0.122 ±0.004	0.155 ±0.005	0.119 ±0.003	0.023 ±0.003
21.03.11	0.192 ±0.003	0.201 ±0.005	0.101 ±0.004	0.107 ±0.002	0.012 ±0.002
24.03.11	0.154 ±0.003	0.189 ±0.001	0.089 ±0.004	0.098 ±0.003	0.011 ±0.001

Table-17: Average values (Mean ±SD) of Nitrateduring the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Nitrate				
24.02.11	0.471 ±0.005	0.511 ±0.002	0.474 ±0.004	0.422 ±0.004	0.048 ±0.001
27.02.11	0.482 ±0.012	0.512 ±0.003	0.46 ±0.028	0.42 ±0.003	0.047 ±0.002
02.03.11	0.25 ±0.018	1.143 ±0.001	0.485 ±0.003	1.686 ±0.002	0.251 ±0.002
05.03.11	0.482 ±0.011	1.136 ±0.003	0.504 ±0.003	1.301 ±0.009	0.247 ±0.006
12.03.11	0.474 ±0.004	0.971 ±0.070	1.748 ±0.002	1.45 ±0.004	0.252 ±0.004
15.03.11	0.384 ±0.050	0.646 ±0.003	1.216 ±0.032	1.452 ±0.003	0.009 ±0.0007
18.03.11	0.492 ±0.003	0.541 ±0.010	1.184 ±0.008	1.23 ±0.004	0.009 ±0.0007
21.03.11	0.294 ±0.009	0.251 ±0.006	1.042 ±0.004	0.8 ±0.004	0.008 ±0.003
24.03.11	0.225 ±0.002	0.268 ±0.007	0.942 ±0.004	0.646 ±0.003	0.008 ±0.0007

Table-18: Average values (Mean ±SD) of Primary Productivity (GPP & NPP)during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
			GPP		
13.04.11	250.082 ±0.002	187.56 ±0.070	166.72 ±0.077	104.2 ±0.042	145.88 ±0.035
16.04.11	256.432 ±0.004	229.243 ±0.003	187.56 ±0.070	166.72 ±0.056	166.72 ±0.070
19.04.11	262.352 ±0.004	250.08 ±0.007	229.22 ±0.014	187.5 ±0.042	187.56 ±0.014
22.04.11	266.06 ±0.028	262.14 ±0.014	250.07 ±0.021	229.24 ±0.028	190.87 ±0.035
29.04.11	229.24 ±0.056	250.85 ±0.077	229.24 ±0.070	190.87 ±0.035	145.88 ±0.056
03.05.11	214.62 ±0.056	249.72 ±0.091	212.64 ±0.098	185.83 ±0.063	141.72 ±0.070
06.05.11	166.34 ±0.120	214.85 ±0.021	204.22 ±0.042	180.62 ±0.021	135.03 ±0.049
09.05.11	158.14 ±0.167	180.52 ±0.084	191.47 ±0.035	166.72 ±0.084	125.04 ±0.070
12.05.11	122.34 ±0.028	125.48 ±0.282	151.72 ±0.042	151.66 ±0.014	104.21 ±0.152
			NPP		
13.04.11	187.56 ±0.042	62.524 ±0.001	90.84 ±0.056	62.52 ±0.056	41.68 ±0.042
16.04.11	187.56 ±0.034	187.58 ±0.056	145.88 ±0.056	145.88 ±0.028	125.05 ±0.042
19.04.11	185.88 ±0.028	187.58 ±0.056	140.78 ±0.035	140.83 ±0.035	120.22 ±0.014
22.04.11	185.83 ±0.014	180.63 ±0.077	135.08 ±0.028	135.03 ±0.007	120.24 ±0.014
29.04.11	151.66 ±0.014	135.03 ±0.049	135.03 ±0.049	125.04 ±0.070	114.62 ±0.113
03.05.11	125.04 ±0.056	118.01 ±0.014	114.62 ±0.056	111.01 ±0.007	104.21 ±0.152
06.05.11	104.25 ±0.131	104.21 ±0.152	102.14 ±0.042	104.21 ±0.152	90.06 ±0.063
09.05.11	62.8 ±0.056	90.06 ±0.063	94.82 ±0.042	90.06 ±0.063	87.26 ±0.063
12.05.11	58.48 ±0.098	87.26 ±0.063	80.5 ±0.049	58.48 ±0.098	62.46 ±0.042

Table-19: Average values (Mean ±SD) of pHduring the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	pH				
13.04.11	8.51 ±0.021	8.04 ±0.014	8.31 ±0.035	8.04 ±0.028	8.42 ±0.021
16.04.11	8.42 ±0.028	8.15 ±0.021	8.44 ±0.028	8.11 ±0.014	8.35 ±0.014
19.04.11	8.41 ±0.014	8.14 ±0.014	8.42 ±0.014	8.12 ±0.021	8.32 ±0.028
22.04.11	8.42 ±0.021	8.13 ±0.021	8.32 ±0.014	8.11 ±0.021	8.41 ±0.014
29.04.11	8.53 ±0.021	8.03 ±0.021	8.3 ±0.007	8.06 ±0.014	8.4 ±0.014
03.05.11	8.53 ±0.021	8.02 ±0.028	8.33 ±0.021	8.1 ±0.007	8.42 ±0.035
06.05.11	8.51 ±0.007	8.11 ±0.021	8.32 ±0.028	8.14 ±0.021	8.32 ±0.042
09.05.11	8.43 ±0.014	8.02 ±0.028	8.44 ±0.028	8.02 ±0.028	8.34 ±0.014
12.05.11	8.52 ±0.014	8.02 ±0.014	8.42 ±0.035	8.02 ±0.028	8.44 ±0.014

Table-20: Average values (Mean ±SD) of Dissolved oxygenduring the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Dissolved oxygen				
13.04.11	6.28 ±0.113	6.54 ±0.084	6.08 ±0.091	5.01 ±0.134	7.86 ±0.106
16.04.11	5.23 ±0.268	3.54 ±0.056	3.73 ±0.091	3.88 ±0.091	6.21 ±0.169
19.04.11	5.65 ±0.113	3.96 ±0.042	4.27 ±0.127	5.27 ±0.247	6.06 ±0.120
22.04.11	5.05 ±0.169	4.09 ±0.063	4.25 ±0.120	4.62 ±0.169	5.61 ±0.183
29.04.11	6 ±0.022	5.69 ±0.077	5.93 ±0.084	5.04 ±0.120	5.68 ±0.091
03.05.11	5.67 ±0.098	6.39 ±0.056	4.05 ±0.155	4.44 ±0.141	5.09 ±0.106
06.05.11	5.69 ±0.106	6.02 ±0.134	4.2 ±0.197	4.22 ±0.155	4.58 ±0.311
09.05.11	5.44 ±0.318	5.67 ±0.106	3.98 ±0.077	4.01 ±0.134	4.66 ±0.155
12.05.11	5.22 ±0.311	5.09 ±0.091	3.85 ±0.169	3.83 ±0.134	4.61 ±0.056

Table-21: Average values (Mean ±SD) of Hardness during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Hardness				
13.04.11	480.44 ±0.028	480.48 ±0.014	478.01 ±0.049	500.06 ±0.042	450.34 ±0.028
16.04.11	484.78 ±0.028	480.22 ±0.028	480.14 ±0.035	500.11 ±0.035	448.26 ±0.021
19.04.11	480.62 ±0.028	478.6 ±0.014	478.46 ±0.042	500.21 ±0.049	448.11 ±0.049
22.04.11	482.82 ±0.028	478.54 ±0.028	478.27 ±0.049	498.22 ±0.028	450.24 ±0.028
29.04.11	482.02 ±0.042	480.1 ±0.042	480.04 ±0.049	498.3 ±0.0565 69	448.02 ±0.042
03.05.11	480.12 ±0.042	480.2 ±0.056	480.21 ±0.056	500.41 ±0.049	448.12 ±0.042
06.05.11	482.24 ±0.028	478.54 ±0.028	478.11 ±0.056	500.66 ±0.021	450.4 ±0.042
09.05.11	480.62 ±0.028	478.6 ±0.014	478.84 ±0.049	498.24 ±0.028	450.02 ±0.042
12.05.11	482.62 ±0.049	480.48 ±0.014	480.8 ±0.035	498.31 ±0.049	448.24 ±0.028

Table-22: Average values (Mean ±SD) of Alkalinity during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Alkalinity				
13.04.11	30.21 ±0.049	44.42 ±0.028	50.81 ±0.035	30.61 ±0.176	22.53 ±0.042
16.04.11	32.43 ±0.014	46.6 ±0.042	48.41 ±0.056	28.92 ±0.035	24.07 ±0.035
19.04.11	30.63 ±0.021	46.2 ±0.028	50.62 ±0.056	28.14 ±0.035	24.22 ±0.042
22.04.11	32.62 ±0.042	44.54 ±0.028	50.71 ±0.056	28.08 ±0.021	22.41 ±0.056
29.04.11	30.3 ±0.169	46.44 ±0.028	48.49 ±0.049	30.6 ±0.042	22.09 ±0.035
03.05.11	32.22 ±0.042	44.22 ±0.042	48.26 ±0.063	30.42 ±0.049	24.33 ±0.035
06.05.11	32.12 ±0.042	44.32 ±0.028	50.21 ±0.063	28.02 ±0.070	22.61 ±0.049
09.05.11	30.2 ±0.070	46.18 ±0.014	50.08 ±0.042	28.67 ±0.049	22.01 ±0.042
12.05.11	30.22 ±0.042	46.1 ±0.035	48.29 ±0.042	30.48 ±0.049	24.12 ±0.042

Table -23: Average values (Mean ±SD) of Phosphate during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Phosphate				
13.04.11	0.163 ±0.0007	0.172 ±0.001	0.083 ±0.0007	0.187 ±0.001	0.037 ±0.001
16.04.11	0.17 ±0.0007	0.19 ±0.0007	0.119 ±0.0007	0.193 ±0.0007	0.043 ±0.0007
19.04.11	0.172 ±0.004	0.172 ±0.0007	0.184 ±0.001	0.181 ±0.0007	0.039 ±0.001
22.04.11	0.172 ±0.001	0.183 ±0.002	0.183 ±0.0007	0.181 ±0.002	0.032 ±0.002
29.04.11	0.171 ±0.004	0.192 ±0.001	0.173 ±0.003	0.094 ±0.001	0.043 ±0.002
03.05.11	0.148 ±0.001	0.169 ±0.002	0.169 ±0.003	0.093 ±0.0007	0.029 ±0.001
06.05.11	0.165 ±0.002	0.207 ±0.001	0.14 ±0.001	0.083 ±0.001	0.012 ±0.002
09.05.11	0.145 ±0.0007	0.225 ±0.003	0.14 ±0.001	0.057 ±0.001	0.007 ±0.0007
12.05.11	0.148 ±0.001	0.213 ±0.002	0.139 ±0.002	0.051 ±0.002	0.005 ±0.0007

Table-24: Average values (Mean ±SD) of Nitrate during the experiment

Tanks → / Days ↓	Vermicompost 1	Vermicompost 2	Vermicompost 3	Cow dung	Control
	Nitrate				
13.04.11	0.3781 ±0.001	0.511 ±0.002	0.0081 ±0.0001	0.5112 ±0.0004	0.422 ±0.004
16.04.11	0.4332 ±0.0005	0.512 ±0.003	0.00151 ±0.0001	0.5135 ±0.0003	0.427 ±0.002
19.04.11	0.4345 ±0.0004	1.143 ±0.001	0.6754 ±0.0004	0.5121 ±0.0003	0.42 ±0.003
22.04.11	0.5198 ±0.0008	1.136 ±0.003	0.3754 ±0.0003	1.1441 ±0.0004	0.686 ±0.003
29.04.11	0.5181 ±0.001	0.971 ±0.070	0.3621 ±0.0004	1.1432 ±0.0004	0.301 ±0.074
03.05.11	0.4218 ±0.0002	0.646 ±0.003	0.4217 ±0.005	1.1379 ±0.0002	0.315 ±0.002
06.05.11	0.5227 ±0.0002	0.541 ±0.010	0.4191 ±0.0006	0.992 ±0.0004	0.45 ±0.005
09.05.11	0.5298 ±0.0004	0.251 ±0.006	0 4218 ±0.0002	0.6521 ±0.0004	0.451 ±0.003
12.05.11	0.5225 ±0.0002	0.268 ±0.007	0.5422 ±0.0002	0.6487 ±0.0002	0.452 ±0.004

Table-25: Average values (Mean ±SD) of different soil parameters during the experiment

TANKS	V.C-1			V.C-2			V.C-3			C.D			CONTROL		
DAYS	OC	P	N	OC	P	N	OC	P	N	OC	P	N	OC	P	N
17.04.11	2.998 ±0.002	1.446 ±0.002	179.41 ±0.042	3.001 ±0.002	1.812 ±0.004	170.25 ±0.028	2.972 ±0.003	1.479 ±0.002	182.47 ±0.02	1.655 ±0.001	1.742 ±0.02	160.43 ±0.042	1.552 ±0.004	1.419 ±0.001	159.5 ±0.028
22.04.11	3.093 ±0.003	1.396 ±0.0007	186.23 ±0.035	3.112 ±0.002	1.816 ±0.002	187.46 ±0.028	3.103 ±0.003	1.101 ±0.002	190.21 ±0.049	2.163 ±0.003	1.804 ±0.016	179.21 ±0.042	1.614 ±0.003	1.459 ±0.006	156.8 ±0.042
01.05.11	3.016 ±0.002	1.449 ±0.004	208.01 ±0.056	3.204 ±0.003	1.835 ±0.002	207.1 ±0.042	3.323 ±0.003	1.496 ±0.002	209.44 ±0.035	2.826 ±0.002	1.88 ±0.002	201.34 ±0.035	1.632 ±0.004	1.2 ±0.001	156.01 ±0.056
08.05.11	3.097 ±0.002	1.501 ±0.005	324.82 ±0.042	3.124 ±0.002	1.839 ±0.004	352.81 ±0.049	3.286 ±0.000 2	1.407 ±0.002	336.01 ±0.035	2.803 ±0.002	1.782 ±0.004	330.41 ±0.035	1.582 ±0.003	0.871 ±0.004	155.01 ±0.042
12.05.11	3.11 ±0.004	1.512 ±0.004	392.13 ±0.028	3.141 ±0.002	1.935 ±0.002	375.07 ±0.021	3.328 ±0.004	1.595 ±0.006	380.86 ±0.028	2.931 ±0.004	1.659 ±0.002	342.16 ±0.021	1.484 ±0.002	0.84 ±0.006	152.31 ±0.056

Table-26: Qualitative analysis of planktons in V.C – 1 during three phases of experiment

Sl No	Weeks / Organism	Experiment - 1								Experiment - 2								Experiment - 3							
		1st		2nd		3rd		4th		1st		2nd		3rd		4th		1st		2nd		3rd		4th	
Chlorophyceae		***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***	***I***	***II***
1.	*Spirogyra*	08	10	10	13	14	18	20	[illegible]	08	06	08	10	09	10	12	11	08	10	10	13	14	18	25	21
2.	*Volvox*	--	02	--	--	--	04	--	04	--	--	--	--	--	04	--	04	--	02	--	--	--	04	--	04
3.	*Phacus*	01	--	--	--	06	--	--	09	--	--	--	--	05	--	--	09	01	--	--	--	06	--	--	09
4.	*Clostridium*	--	--	04	02	--	07	--	10	--	--	--	02	--	05	--	07	--	--	04	02	--	07	--	10
5.	*Pediastrum*	02	--	--	03	02	--	--	03	--	--	--	03	02	--	03	--	02	--	--	03	02	--	--	03
6.	*Eudorina*	--	--	--	02	03	--	03	04	--	--	02	--	03	--	03	03	--	--	--	02	03	--	03	04
7.	*Chlorella*	--	01	03	--	--	04	05	04	--	01	03	--	04	--	05	03	--	01	03	--	--	04	05	04
8.	*Zygnema*	02	--	04	02	--	--	--	02	--	--	04	02	--	--	--	02	02	--	04	02	--	--	--	02
9.	*Cladophora*	--	--	01	04	03	05	06	04	--	--	--	03	03	05	06	04	--	--	01	04	03	05	06	04
10.	*Chaetophora*	02	04	04	05	03	06	04	06	--	04	04	05	--	06	04	05	02	05	04	05	05	06	04	06
11.	*Ulothrix*	--	--	01	--	--	02	--	--	--	--	--	--	--	--	--	--	--	--	01	--	--	02	--	--
Bacillariophyceae																									
1.	*Pleurosigma*	--	--	--	--	--	02	03	02	--	--	--	--	--	--	03	02	--	--	--	--	--	02	03	02
2.	*Coscinodiscus*	--	--	--	--	--	01	--	02	--	--	--	--	--	03	--	--	--	--	--	--	--	01	--	02
3.	*Nitzchia*	--	01	03	--	--	05	04	--	--	01	03	--	--	--	04	05	--	01	03	--	--	05	04	--
4.	*Navicula*	02	--	03	--	--	05	--	04	--	--	03	--	--	05	--	04	02	--	03	--	--	05	--	04
5.	*Melosira*	--	--	04	02	--	06	--	08	--	--	04	02	--	--	--	07	--	--	04	02	--	06	--	08
Cyanophyceae																									
1.	*Oscillatoria*	--	04	03	05	03	06	04	06	--	--	03	05	--	05	04	06	--	04	03	05	03	06	04	06
2.	*Anabaena*	02	--	04	05	03	04	07	04	--	--	04	04	03	05	07	06	02	--	04	05	03	04	07	04
3.	*Nostoc*	--	--	04	02	--	07	--	07	--	--	01	02	--	05	--	07	--	--	04	02	--	07	--	07
4.	*Microcystis*	01		03	--	--	04	05	04	--	--	03	--	--	04	05	04	01	05	03	--	--	04	05	04
	Copepoda																								
1.	*Cyclops*	02	--	--	--	--	02	02	03	--	--	--	--	--	01	02	02	02	04	--	--	03	02	02	03
2.	*Diaptomous*	--	--	--	01	--	--	01	01	--	--	--	--	--	--	--	--	--	--	--	01	--	--	01	01
	Cladocera																								
1.	*Daphnia*	--	--	--	01	--	01	--	--	--	--	--	01	--	01	--	--	--	--	--	01	--	01	--	04

Table-27: Qualitative analysis of planktons in V.C –2 during three phases of experiment

Sl No	Weeks / Organism	Experiment - 1								Experiment - 2								Experiment - 3							
		1st		2nd		3rd		4th		1st		2nd		3rd		4th		1st		2nd		3rd		4th	
Chlorophyceae		*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*
1.	*Spirogyra*	08	06	08	10	09	10	12	11	08	07	05	10	09	10	10	10	07	06	09	12	09	11	22	21
2.	*Volvox*	--	--	--	--	--	04	--	04	--	--	--	--	--	04	--	04	--	--	03	--	--	04	--	04
3.	*Phacus*	--	--	--	--	05	--	--	09	--	--	--	--	05	--	--	09	--	--	--	--	05	--	--	09
4.	*Clostridium*	--	--	--	02	--	05	--	07	--	--	--	02	--	05	--	07	--	04	--	02	--	05	--	07
5.	*Pediastrum*	--	--	--	03	02	--	03	--	--	--	--	03	02	--	03	--	--	--	--	03	02	--	03	--
6.	*Eudorina*	--	--	02	--	03	--	03	03	--	--	02	--	03	--	03	03	--	--	02	--	03	--	03	03
7.	*Chlorella*	--	01	03	--	04	--	05	03	--	01	03	--	04	--	05	03	--	04	03	--	04	--	07	03
8.	*Zygnema*	--	--	04	02	--	--	--	02	--	--	04	02	--	--	--	02	--	--	04	02	--	--	--	02
9.	*Cladophora*	--	--	--	03	03	05	06	04	--	--	--	03	03	05	06	04	--	--	--	03	03	05	06	04
10.	*Chaetophora*	--	04	04	05	--	06	04	05	--	04	04	05	--	06	04	05	--	04	04	08	--	09	04	07
11.	*Ulothrix*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	01	--	--	05	--
Bacillariophyceae																									
1.	*Pleurosigma*	--	--	--	--	--	--	03	02	--	--	--	--	--	--	03	02	--	--	--	--	--	--	03	02
2.	*Coscinodiscus*	--	--	--	--	--	03	--	--	--	--	--	--	--	03	--	--	--	02	--	--	--	03	--	--
3.	*Nitzchia*	--	01	03	--	--	--	04	05	--	01	03	--	--	--	04	05	--	01	03	--	--	--	04	05
4.	*Navicula*	--	--	03	--	--	05	--	04	--	--	03	--	--	05	--	04	--	--	03	02	--	05	--	04
5.	*Melosira*	--	--	04	02	--	--	--	07	--	04	04	02	--	--	--	07	--	--	04	02	--	--	--	07
Cyanophyceae																									
1.	*Oscillatoria*	--	--	03	05	--	05	04	06	--	--	03	05	--	05	04	06	--	--	03	05	--	05	04	06
2.	*Anabaena*	--	--	04	04	03	05	07	06	--	--	04	04	03	05	07	06	02	--	04	04	03	05	07	06
3.	*Nostoc*	--	--	01	02	--	05	--	07	--	--	01	02	--	05	--	07	--	--	01	02	--	05	--	07
4.	*Microcystis*	--	--	03	--	--	04	05	04	--	05	03	--	--	04	05	04	--	--	03	--	--	04	05	04
	Copepoda																								
1.	*Cyclops*	--	--	--	--	--	01	02	02	--	01	--	--	--	01	02	02	--	03	--	--	05	07	04	08
2.	*Diaptomous*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	04	--	--	06	--	07
	Cladocera																								
1.	*Daphnia*	--	--	--	01	--	01	--	--	--	--	--	--	--	01	--	--	--	01	--	01	--	01	--	02

Table-28: Qualitative analysis of planktons in V.C -3 during three phases of experiment

Sl No	Weeks / Organism	Experiment - 1								Experiment - 2								Experiment - 3							
		1st		2nd		3rd		4th		1st		2nd		3rd		4th		1st		2nd		3rd		4th	
Chlorophyceae		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1.	*Spirogyra*	08	10	14	13	16	18	20	21	08	07	04	03	06	08	10	13	08	10	14	13	16	18	20	23
2.	*Volvox*	--	02	--	--	--	04	--	04	--	02	--	--	--	04	--	04	--	02	--	--	--	04	--	04
3.	*Phacus*	01	--	--	--	06	--	--	09	01	--	--	--	06	--	--	09	01	--	--	--	06	--	--	09
4.	*Clostridium*	--	--	04	02	--	07	--	10	--	--	04	02	--	07	--	10	--	--	04	02	--	07	--	10
5.	*Pediastrum*	--	--	--	03	02	--	--	03	--	--	--	03	02	--	--	03	--	--	--	03	02	--	--	03
6.	*Eudorina*	--	--	--	02	04	--	03	04	--	--	--	02	04	--	03	04	--	--	--	02	04	--	03	04
7.	*Chlorella*	--	05	06	--	--	06	05	04	--	05	06	--	--	06	05	04	--	05	06	--	--	06	05	04
8.	*Zygnema*	02	--	04	02	--	--	--	02	02	--	04	02	--	--	--	02	02	--	04	02	--	--	--	02
9.	*Cladophora*	--	--	03	04	03	07	06	04	--	--	03	04	03	07	06	04	--	--	03	04	03	07	06	04
10.	*Chaetophora*	03	04	06	05	07	06	07	06	03	04	06	05	07	06	07	06	03	04	06	05	07	06	07	06
11.	*Ulothrix*	--	--	01	--	--	02	--	--	--	--	01	--	--	02	--	--	--	--	01	--	--	02	--	--
Bacillariophyceae																									
1.	*Pleurosigma*	--	--	--	--	--	04	03	03	--	--	--	--	--	04	03	03	--	--	--	--	--	04	03	03
2.	*Coscinodiscus*	--	--	--	--	--	03	--	02	--	--	--	--	--	03	--	02	--	--	--	--	--	03	--	02
3.	*Nitzchia*	--	02	--	03	--	--	04	05	--	02	--	03	--	--	04	05	--	02	--	03	--	--	04	05
4.	*Navicula*	02	--	03	--	--	05	--	04	02	--	03	--	--	05	--	04	02	--	03	--	--	05	--	04
5.	*Melosira*	--	--	04	--	05	06	--	08	--	--	04	--	05	06	--	08	--	--	04	--	05	06	--	08
Cyanophyceae																									
1.	*Oscillatoria*	--	04	05	05	06	08	05	06	--	04	05	05	06	08	05	06	--	04	05	05	06	08	05	06
2.	*Anabaena*	02	--	04	05	--	04	07	04	02	--	04	05	--	04	07	04	02	--	04	05	--	04	07	04
3.	*Nostoc*	--	--	04	02	--	07	04	07	--	--	04	02	--	07	04	07	--	--	04	02	--	07	04	07
4.	*Microcystis*	--	--	06	--	--	04	06	04	--	--	06	--	--	04	06	04	--	--	06	--	--	04	06	04
Copepoda																									
1.	*Cyclops*	02	--	--	--	--	03	02	03	02	--	--	--	--	03	02	03	02	--	06	03	--	08	05	09
2.	*Diaptomous*	--	--	--	--	--	--	01	01	--	--	--	--	--	--	01	01	--	--	--	--	--	--	01	01
Cladocera																									
1.	*Daphnia*	--	--	--	01	--	01	--	--	--	--	--	01	--	01	--	--	--	--	--	01	--	01	--	04

Table-29: Qualitative analysis of planktons in C.D during three phases of experiment

Sl No	Weeks / Organism	Experiment - 1								Experiment - 2								Experiment - 3							
		1st		2nd		3rd		4th		1st		2nd		3rd		4th		1st		2nd		3rd		4th	
Chlorophyceae		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1.	*Spirogyra*	--	--	08	10	09	10	12	11	--	--	--	10	09	10	12	11	--	--	08	10	09	10	12	11
2.	*Volvox*	--	--	--	--	--	03	--	03	--	--	--	--	--	03	--	03	--	--	--	--	--	03	--	03
3.	*Phacus*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4.	*Clostridium*	--	--	--	01	--	02	--	04	--	--	--	01	--	02	--	04	--	--	--	01	--	02	--	04
5.	*Pediastrum*	--	--	--	03	02	--	03	--	--	--	--	03	02	--	03	--	--	--	--	03	02	--	03	--
6.	*Eudorina*	--	--	--	--	--	--	03	03	--	--	--	--	--	--	03	03	--	--	--	--	--	--	03	03
7.	*Chlorella*	--	01	03	--	04	--	05	03	--	--	03	--	04	--	05	03	--	01	03	--	04	--	05	03
8.	*Zygnema*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9.	*Cladophora*	--	--	--	--	03	05	06	04	--	--	--	--	03	05	06	04	--	--	--	--	03	05	06	04
10.	*Chaetophora*	--	--	04	05	--	06	04	05	--	--	04	05	--	06	04	05	--	--	04	05	--	06	04	05
11.	*Ulothrix*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bacillariophyceae																									
1.	*Pleurosigma*	--	--	--	--	--	--	--	02	--	--	--	--	--	--	--	02	--	--	--	--	--	--	--	02
2.	*Coscinodiscus*	--	--	--	--	--	03	--	--	--	--	--	--	--	03	--	--	--	--	--	--	--	03	--	--
3.	*Nitzchia*	--	01	03	--	--	--	04	05	--	--	03	--	--	--	04	05	--	01	03	--	--	--	04	05
4.	*Navicula*	--	--	03	--	--	05	--	04	--	--	03	--	--	05	--	04	--	--	03	--	--	05	--	04
5.	*Melosira*	--	--	04	02	--	--	--	05	--	--	04	02	--	--	--	05	--	--	04	02	--	--	--	05
Cyanophyceae																									
1.	*Oscillatoria*	--	--	02	04	--	--	03	04	--	--	02	04	--	--	03	04	--	--	02	04	--	--	03	04
2.	*Anabaena*	--	--	04	--	03	--	05	02	--	--	--	--	03	--	05	02	--	--	04	--	03	--	05	02
3.	*Nostoc*	--	--	--	02	--	05	--	05	--	--	--	02	--	05	--	05	--	--	--	02	--	05	--	05
4.	*Microcystis*	--	--	--	--	--	04	02	04	--	--	--	--	--	04	02	04	--	--	--	--	--	04	02	04
Copepoda																									
1.	*Cyclops*	01	--	04	--	04	05	03	04	01	--	04	--	04	05	03	04	04	--	06	--	05	06	07	10
2.	*Diaptomous*	--	--	02	--	--	03	--	04	--	--	02	--	--	03	--	04	--	--	02	--	--	03	--	04
Cladocera																									
1.	*Daphnia*	--	--	--	01	--	01	--	02	--	--	--	01	--	01	--	02	--	--	--	04	--	01	--	05

Table-30: Qualitative analysis of planktons in Control tanks during three phases of experiment

Sl No	Weeks / Organism	Experiment - 1								Experiment - 2								Experiment - 3							
		1st		2nd		3rd		4th		1st		2nd		3rd		4th		1st		2nd		3rd		4th	
Chlorophyceae		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1.	*Spirogyra*	--	--	--	05	08	04	07	10	--	--	--	05	08	04	07	10	--	--	--	05	08	04	07	10
2.	*Volvox*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3.	*Phacus*	--	--	--	--	--	--	--	04	--	--	--	--	--	--	--	04	--	--	--	--	--	--	--	04
4.	*Clostridium*	--	--	--	--	--	--	--	06	--	--	--	--	--	--	--	06	--	--	--	--	--	--	--	06
5.	*Pediastrum*	--	--	--	--	02	--	03	--	--	--	--	--	02	--	03	--	--	--	--	--	02	--	03	--
6.	*Eudorina*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7.	*Chlorella*	--	01	03	--	--	--	03	03	--	01	03	--	--	--	03	03	--	01	03	--	--	--	03	03
8.	*Zygnema*	--	--	--	02	--	--	--	02	--	--	--	02	--	--	--	02	--	--	--	02	--	--	--	02
9.	*Cladophora*	--	--	--	03	03	05	02	03	--	--	--	03	03	05	02	03	--	--	--	03	03	05	02	03
10.	*Chaetophora*	--	--	04	05	--	03	04	05	--	--	04	05	--	03	04	05	--	--	04	05	--	03	04	05
11.	*Ulothrix*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bacillariophyceae																									
1.	*Pleurosigma*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2.	*Coscinodiscus*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3.	*Nitzchia*	--	--	03	--	--	--	02	04	--	--	03	--	--	--	02	04	--	--	03	--	--	--	02	04
4.	*Navicula*	--	--	--	--	--	03	--	04	--	--	--	--	--	03	--	04	--	--	--	--	--	03	--	04
5.	*Melosira*	--	--	04	--	--	--	--	07	--	--	04	--	--	--	--	07	--	--	04	--	--	--	--	07
Cyanophyceae																									
1.	*Oscillatoria*	--	--	03	05	--	02	04	0	--	--	03	05	--	02	04	0	--	--	03	05	--	02	04	0
2.	*Anabaena*	--	--	--	04	03	03	04	06	--	--	--	04	03	03	04	06	--	--	--	04	03	03	04	06
3.	*Nostoc*	--	--	--	02	--	05	--	--	--	--	--	02	--	05	--	--	--	--	--	02	--	05	--	--
4.	*Microcystis*	--	--	03	--	--	04	05	04	--	--	03	--	--	04	05	04	--	--	03	--	--	04	05	04
Copepoda																									
1.	*Cyclops*	--	--	--	--	--	01	02	02	04	02	03	--	--	--	01	--	05	02	02	--	--	--	--	04
2.	*Diaptomous*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cladocera																									
1.	*Daphnia*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 31: Correlation Co-efficient (r) between different physico chemical parameters of V.C-1 during Exp-1

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE
ph	1						
DO	-0.56525	1					
GPP	0.329975	-0.20601	1				
NPP	-0.16549	-0.3567	0.398815	1			
ALKALINITY	-0.32431	0.943986	-0.21012	-0.5356	1		
HARDNESS	-0.2979	0.410379	-0.25552	0.167738	0.292311	1	
PHOSPHATE	0.74571	-0.61617	0.525033	0.037579	-0.52347	-0.14541	1

Table 32: Correlation Co-efficient (r) between different physico chemical parameters of V.C-2 during Exp-1

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE
ph	1						
DO	0.684804	1					
GPP	-0.07546	0.237127	1				
NPP	-0.16141	0.11036	0.777347	1			
ALKALINITY	0.42701	0.442144	-0.14042	-0.19549	1		
HARDNESS	-0.13465	0.304992	-0.1925	-0.41451	0.136882	1	
PHOSPHATE	-0.03743	-0.10611	0.683364	0.656969	-0.54012	-0.66833	1

Table 33: Correlation Co-efficient (r) between different physico chemical parameters of V.C-3 during Exp-1

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE
Ph	1						
DO	-0.4022	1					
GPP	-0.00145	0.309729	1				
NPP	0.035063	0.311559	0.970817	1			
ALKALINITY	-0.42563	0.56251	0.306332	0.280928	1		
HARDNESS	0.587517	-0.0948	0.1369	0.227808	-0.26877	1	
PHOSPHATE	0.171966	-0.23248	0.770968	0.768384	-0.03353	0.246478	1

Table 34: Correlation Co-efficient (r) between different physico chemical parameters of C.D during Exp-1

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE
ph	1						
DO	-0.04956	1					
GPP	-0.05253	0.476726	1				
NPP	0.338765	0.255812	0.509115	1			
ALKALINITY	0.204313	0.44287	0.430472	0.498207	1		
HARDNESS	0.135341	-0.29344	-0.24895	0.033301	-0.38663	1	
PHOSPHATE	0.255088	0.463003	0.862805	0.797241	0.379905	-0.10143	1

Table 35: Correlation Co-efficient (r) between different physico chemical parameters of Control during Exp-1

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE
ph	1						
DO	-0.10328	1					
GPP	0.039289	0.342607	1				
NPP	0.101046	0.496119	0.835682	1			
ALKALINITY	0.156476	-0.21235	0.469858	0.291851	1		
HARDNESS	0.268283	-0.01869	0.246406	0.110103	0.567827	1	
PHOSPHATE	-0.68884	0.526048	0.241806	0.395149	-0.39429	-0.24217	1

Table 36: Correlation Co-efficient (r) between different physico chemical parameters of V.C-1 during Exp-2

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	0.478482	1						
GPP	0.398481	0.885317	1					
NPP	0.409503	0.832535	0.969742	1				
ALKALINITY	0.222535	0.900067	0.807985	0.710088	1			
HARDNESS	-0.52255	-0.19852	0.047988	0.16368	-0.13082	1		
PHOSPHATE	0.183456	0.172481	0.266462	0.405425	0.197158	0.134195	1	
NITRATE	-0.26793	0.280703	0.233366	0.166567	0.484786	0.304689	-0.21999	1

Table 37: Correlation Co-efficient (r) between different physico chemical parameters of V.C-2 during Exp-2

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	-0.21107	1						
GPP	-0.06463	0.420569	1					
NPP	0.024086	0.329283	0.857872	1				
ALKALINITY	0.257878	0.0176	0.798114	0.814646	1			
HARDNESS	-0.00542	0.201613	0.404229	0.461925	0.099356	1		
PHOSPHATE	-0.14442	0.359688	0.262161	0.122237	-0.14728	0.318694	1	
NITRATE	0.099859	0.226832	0.808343	0.853786	0.957145	0.08435	-0.16735	1

Table 38: Correlation Co-efficient (r) between different physico chemical parameters of V.C-3 during Exp-2

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	-0.2022	1						
GPP	-0.19545	0.85415	1					
NPP	-0.02954	0.802147	0.697363	1				
ALKALINITY	-0.05088	0.202581	0.464676	0.069334	1			
HARDNESS	-0.15443	-0.1914	-0.026	-0.23606	0.624899	1		
PHOSPHATE	0.053554	0.517687	0.699018	0.716421	0.304017	-0.07912	1	
NITRATE	-0.12779	-0.67766	-0.44992	-0.56559	0.302763	0.194907	-0.13919	1

Table 39: Correlation Co-efficient (r) between different physico chemical parameters of C.D during Exp-2

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	-0.26456	1						
GPP	-0.26262	0.832679	1					
NPP	0.307962	0.169441	0.395188	1				
ALKALINITY	0.166304	0.526785	0.646126	0.372689	1			
HARDNESS	0.403544	-0.49662	-0.42654	-0.06356	-0.40553	1		
PHOSPHATE	-0.25732	0.77043	0.891147	0.329544	0.750857	-0.25263	1	
NITRATE	0.205335	-0.09711	0.254104	0.547096	0.330976	-0.22381	0.047088	1

Table 40: Correlation Co-efficient (r) between different physico chemical parameters of CONTROL during Exp-2

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	0.045882	1						
GPP	-0.08833	0.922858	1					
NPP	-0.07683	0.799686	0.844265	1				
ALKALINITY	0.298578	0.544328	0.407273	0.438264	1			
HARDNESS	0.398888	0.30928	0.29405	0.505099	0.248392	1		
PHOSPHATE	-0.46814	0.200545	0.207644	0.104412	0.064763	-0.32577	1	
NITRATE	-0.60159	0.293677	0.289791	0.342869	0.195977	0.129897	0.717265	1

Table 41: Correlation Co-efficient (r) between different physico chemical parameters of V.C-1 during Exp-3

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	0.536163	1						
GPP	-0.42155	0.169966	1					
NPP	-0.35277	0.209183	0.974751	1				
ALKALINITY	-0.22291	-0.46811	0.330472	0.319162	1			
HARDNESS	-0.25668	-0.5783	0.071471	0.163525	0.455508	1		
PHOSPHATE	-0.33711	0.09965	0.751257	0.821095	0.28786	0.409449	1	
NITRATE	-0.0057	-0.46919	-0.57048	-0.59859	-0.03831	0.277163	-0.13372	1

Table 42: Correlation Co-efficient (r) between different physico chemical parameters of V.C-2 during Exp-3

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	-0.7663	1						
GPP	0.496056	-0.26138	1					
NPP	0.792273	-0.85504	0.710648	1				
ALKALINITY	0.060377	-0.52844	-0.16854	0.319087	1			
HARDNESS	-0.46132	0.25765	-0.31781	-0.31928	0.107756	1		
PHOSPHATE	-0.26615	0.053974	-0.61891	-0.35914	0.369129	-0.23181	1	
NITRATE	0.498916	-0.39239	0.824854	0.70486	-0.06429	-0.34644	-0.62164	1

Table 43: Correlation Co-efficient (r) between different physico chemical parameters of V.C-3 during Exp-3

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	-0.65955	1						
GPP	-0.36362	0.039594	1					
NPP	0.002545	-0.04192	0.733676	1				
ALKALINITY	-0.16692	0.215584	0.254197	-0.05007	1			
HARDNESS	0.298117	-0.25974	-0.30011	0.011902	-0.96814	1		
PHOSPHATE	-0.07918	-0.24989	0.807419	0.519188	-0.07061	0.105559	1	
NITRATE	0.173382	-0.34971	0.318865	-0.05512	0.039713	0.053661	0.740758	1

Table 44: Correlation Co-efficient (r) between different physico chemical parameters of C.D during Exp-3

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	0.18483	1						
GPP	0.554495	0.075312	1					
NPP	0.729947	0.243434	0.725515	1				
ALKALINITY	-0.60726	0.075205	-0.52327	-0.53091	1			
HARDNESS	0.621487	0.143839	-0.24244	0.163857	-0.13481	1		
PHOSPHATE	0.434269	0.463162	-0.00037	0.48581	-0.25721	0.34225	1	
NITRATE	0.292994	0.108636	0.669539	0.243565	0.049857	-0.19468	-0.30462	1

Table 45: Correlation Co-efficient (r) between different physico chemical parameters of CONTROL during Exp-3

	pH	DO	GPP	NPP	ALKALINITY	HARDNESS	PHOSPHATE	NITRATE
ph	1							
DO	0.164667	1						
GPP	-0.27714	0.447146	1					
NPP	-0.40314	-0.20178	0.662048	1				
ALKALINITY	0.062122	-0.04516	0.064776	0.169622	1			
HARDNESS	-0.13991	0.098036	-0.00137	-0.40247	-0.67917	1		
PHOSPHATE	0.0224	0.726584	0.727853	0.465878	0.102612	-0.33112	1	
NITRATE	0.003618	-0.03816	0.392743	0.075682	-0.23996	0.585995	-0.1842	1

* Correlation is significant at the 0.01 level

* *Correlation is significant at the 0.05 level