HEAVY METAL UPTAKE BY ECO-FRIENDLY FABRIC IN WEAR

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THESIS SUBMITTED TO THE
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CERTIFICATE

MS. S. SIRISHA DEEPTHI has satisfactorily prosecuted the course of research and that the thesis entitled **HEAVY METAL UPTAKE BY ECO-FRIENDLY FABRIC IN WEAR** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

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MAJOR ADVISOR

CERTIFICATE

This is to certify that the thesis entitled **"HEAVY METAL UPTAKE BY ECO-FRIENDLY FABRIC IN WEAR"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN HOME SCIENCE** of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **MS. S. SIRISHA DEEPTHI** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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LIST OF ABBREVIATIONS

mg/kg or ppm	-	parts per million
PCP	-	Pentachlorophenol
AAS	-	Atomic Absorption Spectrophotometer
mg	-	milligram
µg	-	microgram
g	-	gram
ml	-	millilitres
10 L	-	10 launderings
20 L	-	20 launderings

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An award of appreciation goes to all my subjects for their smiling countenance and cheery 'Good Morning' which brightened my days.

A special note of recognition to all my fidus Achates' namely Rajitha, Padmalatha, Anamika, Bhargavi, Kalyani, Padmaja, Radhika, Lavanya, for their fidelity and for all the pleasant as well as helpful discussions we have had. Thank you all !

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DECLARATION

I **SIRISHA DEEPTHI. S**, hereby declare that the thesis entitled **HEAVY METAL UPTAKE BY ECO-FRIENDLY FABRIC IN WEAR** is a result of the original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

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ABSTRACT

'German Ban', 'Eco-Standards', 'Eco-Labels' and ' Eco-Textiles' are some of the radical changes sweeping the world and gripping the fancy of consumers, environmental activists and industrialists. So, some circles are trying to utilise this opportunity to make an entire new market segment by offering eco-labels, eg., ECO-TEX, G U T, M.S.T., M.U.T., Steilmann, Clean Fashion etc. Unlike the warning labels in food, chemical and other consumable products, a textile eco-label provides assurance to the buyer, regarding its eco-friendliness. Eco-labelling has emerged as a non-regulatory market-driven policy and is based on Life-Cycle-Assessment [LCA] or Cradle-to-Grave Approach. This concept considers the environmental impacts of a product from the extraction of raw materials to the final waste disposal on all media such as air, water, land and noise. Hence, the textile manufacturer must produce products under an unnatural "cover glass" and is missing out on an even more important phase i.e., end-use. But are all the efforts worth when modern civilization makes the environment less pure than what the eco-logos dictate? To answer this question, the present study was proposed to know the level of awareness regarding eco-friendly fabrics among consumers, to test the uptake of heavy metals by eco-friendly garments after 10 L and 20 L, to analyse the comparative heavy metal uptake between 10 L and 20 L.

Consumer survey was carried out with a sample of 30 respondents to know their level of awareness on eco-friendly clothing. Six eco-friendly knitted cotton T-shirts were procured from the manufacturer. Six subjects were selected for wear study and three eco-friendly T-shirts were subjected to 10 launderings and the other three were continued till 20 launderings. Surf powder was used for laundering. Water supplied by the Hyderabad Metropolitan Supply and Sewerage Board was chosen for the study. Heavy metal analysis was made through Atomic Absorption Spectrophotometer. The values for nine heavy metals at three stages namely, control, 10 L an 20 L stages were analysed and conclusions were drawn.

The findings of the consumer survey indicated that all the respondents were aware of eco-friendliness and believed in it. Majority of them could gain knowledge in this context through - fabrics (70.00%), packaging (63.33%) food and dyes (each 53.33%), forests (50%), water (46.66%), air (40%), fuel (6.66%), bacteria, algae and pencils (each 3.33%). The following media were instrumental in educating consumers - news papers and journals (60% each), books and periodicals (46.66% each), Television (43.33%), seminars (36.66%), discussions (33.33%), radio (23.33%), workshops (16.66%), trade fairs (3.33%). All the respondents purchased their clothes based on color and print, texture, appearance, hand, cost, fashion and labels and had the habit of reading the instructions given on label. Only 76.66 per cent follow these instructions, however, 26.66 per cent came across eco-labelled garments. Among the respondents 3.33 per cent were of the opinion that eco-labels should be given only to children's garments, while 10 per cent felt that eco-labels should be given to only adults garments. Majority (86.66%) of the consumers opined that eco-labels should be given to garments of all age groups. Around 80 per cent of consumers were interested in buying eco-labelled garments while only 66.66 per cent were interested in buying them though the cost was more. Of the consumers 30 per cent opined that eco-labelled garments would be acceptable to masses in contrast to the 70 per cent of the consumers opinion of unacceptability of eco-labelled garments by the masses in India.

The test results of AAS indicated a significant difference in the uptake of three heavy metals viz., lead, nickel and cobalt between 10 L and 20 L at both 5 per cent and 1 per cent levels of significance. But, the metal with the highest uptake could not be determined. The fact that all the AAS values of nine heavy metals of eco-friendly garments crossing the eco-standards of the eco-label MST could be observed.

The above findings lead to the conclusion that exposure of garments to the polluted environment will result in increase of the metal content and that the fact that "All the things are toxic and nothing can be considered non-toxic" is adequately proved, leading to the urgent need for reorientation of eco-scenario.

INTRODUCTION

CHAPTER - I

INTRODUCTION

World is in the age of environmental and ecological consciousness. The environmental pollution is one of the most challenging problems facing the human race at present. Of late, the textile industry has been accused of producing products that are carcinogenic, allergenic and mutagenic to the wearer. In a bid to safeguard the environment and to enable the consumers to buy less hazardous, less polluted 'green' products; especially the textiles, many textile importing countries have fixed stringent quality norms to get the best of the lot in the world market. **'THE GERMAN BAN'** coupled with product related **'ECO-STANDARDS'** is a step in this direction.

Consequently, eco-labelling has emerged as an offshoot of the recent movement of environmental friendly concern. Eco-labelling is an indicative assurance to the buyer of the environmental friendliness of a product. Today, a number of eco-labels are in the market with varied concepts and criteria. The information on eco-friendliness of a product vary from label to label.

Definition:

To define an eco-friendly garment or textile product, the concept of "Intelligent Products" has been developed by the Hamburg - based Environment Protection and Encouraging Agency [APEA]. It defines a product as "Intelligent" if it is at the same time profitable, does not cause damage to health and environment and made by good manufacturing practices.

An eco-label should :

* enumerate and explain the criteria guaranteeing environmentally sound production

* take into account the complete life cycle of the product and

* be controlled by independent organisations

The environment criteria for the eco-label are developed on the basis of cradle - to - grave approach. This implies the analysis of a product's entire life cycle commencing with the extraction of raw materials, progressing through the stages of production, distribution, utilization and concluding with disposal after use.

NEED FOR ESTABLISHING ECO-STANDARDS

The reasons given by the textile importing countries for establishing eco - standards are:

* Increasing awareness about environmental problems posed by the textile industry and its products.

* Increase in the number of textile related allergies being reported.

* Problems faced in the disposal of used textile goods in the European countries.

* Cheap textiles being imported by Europe from China, Brazil and India posed a serious threat to their local markets.

* Fashion designers and marketing personnel have run out of ideas and wanted a new slogan to boost the sales.

ECOLOGY IN THE TEXTILE AND CLOTHING INDUSTRY

To produce and sell textiles and clothing worldwide, manufacturers impart some properties such as protection against cold weather and rain, self-realisation, personality and sportsmanship to enable the consumer choose a product. Clothing must have an individual value for each consumer. Fashionable clothing can be sold with the realisation of these functions. That means that the clothing industry has to develop products which have,

* Aesthetic characteristics [styling, color, structure, material]
* Technological characteristics [protection against cold weather or rain]

* Symbolical characteristics [identification with trade marks, famous idols]

The ecological aspect of a product is an additional quality statement. Products with a purely ecological aim only reach rather a small number of consumers. Fashion in conjunction with ecology creates economy. Textiles and Clothing cannot be an island within the framework of any ecology discussion. Ecology in the Textiles and Clothing industry comprises the following aspects:

* Protection of humans wearing clothing, against toxic and carcinogenic substances and allergies.

* Protection of humans, working in fibre production, in textile and clothing industry against toxic substances and allergies.

* Protection of environment [water, air and soil].

* Proper disposal and recycling of the waste from textile and clothing industry, worn garments and packaging including hangers.

SCOPE OF THE STUDY

Textiles are intended to protect the human body but at the same time should conform to fashion. Textiles have been imparted with all the properties demanded by the consumers, but, people are now considering the price they ought to pay

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SCOPE OF THE STUDY

Textiles are intended to protect the human body but at the same time should conform to fashion. Textiles have been imparted with all the properties demanded by the consumers, but, people are now considering the price they ought to pay for it. 'Right Quality' for the consumer means not only the right tone or depth of color but also the ecological demands which have now reached the wardrobe. There is no doubt that protection of environment is today's trend. Consumers in every major market are waking up to ecological issues and their ecological values are changing. Consequently, manufacturing of eco-friendly textiles through cleaner production methods is attracting greater attention. Consumers all over the world are now considering three factors as important criteria while selecting textiles namely,

* aesthetics
* economics and
* ecology

Of late, the textile industry world over, has been accused that it's products are carcinogenic and mutagenic to the wearer. Many incidents of ecotoxicity of fabrics on man, have been reported by the press. Out of a population of 80 million people in Germany, it was pointed out that the number of health related cases due to harmful textiles was 50-100 a year (Raghavan, 1996). Random tests conducted in Germany on textile products had revealed that 13% of Indian, 19% of Italian, 22% of Indonesian, 34% of Pakistani and 48% of Chinese items contained the prohibited azo dyes (Raghavan, 1997).

So, in the light of these findings, many textile importing countries have come up with stringent quality norms, eco-standards and eco-labels. Since a cradle-to-grave approach is being advocated for issuing eco-labels, every manufacturer is taking precautions during manufacture by using eco-friendly chemicals and processes and is trying to adhere to the standards stipulated in the label. The product is taken care till it comes to the retail stores. The manufacturer is marketing the product under a much publicised label in an effort to attract the "green" consumers. A market survey in Germany has revealed that 80% of households recognize these labels. The products bearing these labels have registered an increase of 40% in sales. There is also a research saying that 75% of consumers would like to have more information on this subject. More than 50% of consumers are ready to pay more money for eco-friendly clothing. [Klinke, 1996]

It is but an undisputable fact that the environment one lives in is more dirtier than the environment of textile manufacture. So, the hazardous free condition in the manufacturing unit may no longer be maintained in the end-use phase ie., wear and tear. The textile manufacturers are missing out on this important fact. The fabric in question is most likely to absorb harmful chemicals and metals from the polluted environment. If a glowing cigarette is placed next to ladies tights in a large closed desiccator then not only is the typical cigarette smell detectable on the article but the already too high cadmium content is further increased 17 fold. Cadmium content in tights before hand was 0.15 ppm, tights in contact with cigarette smoke was 8.7 ppm. The limit value was 0.1 ppm. (Dorning and Sehm, 1995).

Ladies tights were washed at 35°C in stagnant water from a copper containing installation (3 mg/l copper and pH 6) and rinsed twice in similar water and then air dried. Copper content in tights before washing was 0.56 ppm, after washing was 1.12 ppm while the limit value was 50.00 ppm. Even though the limit value is not reached by a long way the value has nevertheless doubled (Dorning and Sehm, 1995). Hence, the fabric may remain eco-friendly till the marketing stage, by the use of eco-friendly technology and eco-friendly packaging. But, whether the fabric really safeguards the health of the wearer, during normal usage, after being exposed to the polluted environment, is the question which is bound to arise in the minds of the consumers.

An endeavour was thus made in the present study, to answer the question of the worthiness of eco-friendly textile processing, when the very property for which it is popularised is likely to be lost if exposed to the polluted environment during normal wear.

The objectives of the study were:

GENERAL OBJECTIVE

To study the uptake of heavy metals by eco-friendly fabrics during normal wear.

SPECIFIC OBJECTIVES

1. To know the level of awareness of eco-friendly fabrics among the consumers.
2. To test the uptake of heavy metals by eco-friendly fabrics after 10 and 20 launderings.
3. To analyse the comparative uptake of heavy metals after 10 and 20 launderings.

LIMITATIONS OF THE STUDY

1. Due to limitation of time, the subjects chosen for wear study were six and the number of launderings were limited to 10 and 20.
2. The wear study was conducted in the twin cities of Hyderabad and Secunderabad.
3. Study was restricted to only one type of garment ie., knitted T-shirts.
4. Eco-friendly garments were procured from one manufacturer only.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

A comprehensive review of literature enables a researcher in getting an up to date information regarding the topic under investigation. Besides unfolding several research findings, it also clarifies concept and helps the researcher in improving focus on the selected area of research.

A considerable number of developments have taken place in the area of eco-friendly processing and finishing of textiles, since environmental regulations are forcing the shift of technology towards pollution free areas of technological development. There is a dearth of information regarding the environmental effect on eco-friendly garments, in India, as very few systematic studies have been made to assess the effect of environment on eco-friendly garments.

The area of the present study is new and an attempt has been made to introduce to the reader the various aspects of textile eco-labels. Hence the relevant literature available has been dealt under the following sub-headings :-

2.1 HISTORY OF ECO - MOVEMENT

In the major industrial countries, there is an increasing demand for eco - textiles and eco - garments. Eco - labels for clean garments have been introduced by German Textile Industry. Infact way back in 1977, Germany introduced Blue Angel Environmental Label providing environmental awareness guidance.

In 1987, the Danish company "Novotex A / S" was the first to introduce an eco - collection with the name "Green Cotton" for which they were awarded Environment

Prize from European Community (EC) commission. Green cotton is a product manufactured from natural fibres cultivated or procured without the application of chemicals.

The European Community directive gave a "Black List" of chemicals that have been prescribed and a "Grey List" of chemicals that are subject to further investigation. The Third North Sea conference issued a directive in March 1990 demanding the reduction in discharge to 50% of certain specific chemicals into river Rhine and hence in North Sea by 1995 [Red Chemicals].

In keeping with the Green Wave an environment conscious EEC issued a "Red List" for various products that should not be used in the processing of textiles. The German Textile Industry took a different approach in early 1993 and issued "labels" namely MST, Eco - Textile, STD. 100, Steilman and Clean Fashion.

In July 1994, the German government banned the use of azo dyes, capable of releasing certain arylamines, proven or suspected to be carcinogenic to humans. This German ban has come into effect from 1st April, 1996.

Geneva - based International Trade Centre [ITC] prepared a report introducing the latest quality requirements in Textiles and Clothing sector, which was well received by developed and developing countries. As a follow-up, International Trade Centre organized a workshop on eco - labelling and other environmental quality requirements for trade with developing countries in June 1995 in Geneva.

The Ministry of Environment and Forests in the Government of India, has through a Gazette Notification, published in the Gazette of India dated October 8, 1996, laid down criteria for labelling textiles as Environment Friendly Products.

2.2 TEXTILE ECO - LABELS

In order to promote the manufacture of eco-friendly textiles, comprehensive eco-labelling systems have been developed for textile goods in European countries. Realising that trade barriers may be established against imports without green labels, different sectors of the textile industry are gearing up to formulate their own environmental labels.

Table 2.1: Eco - labels formed by specific groups in textile industry

Organisations	Philosophy
GUT (Association for Environmentally Friendly carpets)	Provide products manufactured in an environmentally compatible manner.
ECO TEX (SCOTDIC Textile Farben and Textile Design Group)	Consider all ecological para-meters in products and processes.
OEKO-TEX (International Association for Research and Testing in the Field of Textile Ecology and Mark for textiles tested for harmful substances MST)	Ecological criteria in regard to humans and textiles tested for harmful substances.

[Source: Indian Silk, Aug-Sept. 1996]

Individual manufacturers and retailers are also interested in joining the green bandwagon by introducing product lines with environmental concerns.

Table 2.2: A list of Individual manufacturers / retailers with a green product line

Companies	Programmes
Levi Strauss	Natural line of jeans
Esprit	Eco-collection
Courtaulds Textiles	Environmental policy
Ciba - Geigy	Enviro care
Welman	Fortrel EcoSpun
Wrangler	'O' wears (organic or eco -friendly or green)
REEF (Recycled, Environment and Ecological Fashion Cooperative)	Clothing,jewellery,glass-ware and sculpture

[Source: Indian Silk, Aug-Sept 1996]

Table 2.3: Official eco-labels with textile - related products

Countries	Programmes	Product Category
Austria	Eco-label	Textile detergents and textiles
Netherlands	Eco-labelling	Footwear and clothes
Canada	Environmental choice	Cloth diapers
European Union	Eco-label	Textiles
Sweden	Eco-labelling	Fibre production and textile manufacture
India	Eco Mark	Textiles packaging material
Japan	Eco Mark	Textiles made from waste fibre
Nordic Council	White Swan	Textiles and detergents for textiles
Republic of Korea	Eco-label	Non-bleached and non-dyed towels using no bleach or dyes
China	Environmental labelling	Silks

[Source: Indian Silk, Aug-Sept 1996]

Table 2.3 shows that other countries have already established textile - related product as a category in their eco-labels.

2.2.1 Selected eco - labels in overseas countries:

ECO TEX	: Label of eco consortium.
E.P.G	: European product guarantee of ELTAC [European largest Textile and Apparel Companies].
GUT	: Seal of eco-friendly carpets association.
GUW	: Seal of eco-friendly furnishing fabrics association.
M.S.T	: Trademark for textiles tested for harmful substances.
M.U.T	: Trademark for textiles manufactured by environmentally sound production methods.
OKO - TEX	: Label of International Association for Research & Testing in the field of Textile Ecology.
TOX - PROOF	: Criteria list of control international.
CLEAN FASHION	: Label given by the biggest garment wholesalers.
STEILMANN	: Label given by the biggest producer of garments.
OTN 100	: Label by the famous OEKO TEX Institute from Austria.
COMITEXTIL	: Single European label recognised by the co-ordination committee for the textile industries in the East European Countries.
ECO - MARK	: Label of Japan with a symbol of two arms embracing the world.
ENVIRONMENT CHOICE	: Label of Canada.
BLUE ANGEL	: Label in Germany having a symbol of United Nations environmental programme.

More than 30 countries have already set up some format of national eco-labels and Table 2.4 shows a list of some selected programmes.

Table 2.4: Selected countries with eco-labels

Countries	Name	Date established
France	NF-Environment	1991
U.S.A.	Green Seal	1989
Germany	Blue Angel	1977
New Zealand	Environment Choice	1990
Singapore	Green Label	1992
U.S.A.	Science Certification Systems	1990

[Source: Indian Silk, September 1996]

The three basic kinds of eco-labels in the market are labels initiated by,

* Specific groups of industries or their trading unions.
* Private manufacturers or retailers.
* Governmental agencies.

2.2.2 Basic features of eco - labels:

Eco - labels are the passport to export and are achievable through eco - auditing to ensure recognition. While formulating eco - standards, the use of seven different classes of chemicals during different stages of textile manufacture were considered. They are formaldehyde, toxic pesticides, pentachlorophenol, heavy metals, azo dyes releasing carcinogenic amines, halogen carriers and chlorine bleaching.

2.2.2.1 **Formaldehyde:**

Formaldehyde being a toxic chemical is a skin irritant and sensitizer. Controversial animal inhalation tests with very high concentration have shown that it is a nasal carcinogen to rats and mice. Therefore, it is restricted in consumer products such as cosmetics and textiles by law in some countries or by voluntary specifications of textile producers.

Formaldehyde is often used as a dye fixing agent, in pre-shrinkage treatment as a preservative and in the finishing of textiles in order to obtain easy-care properties.

In the eco-standards a distinction is made according to the degree of contact which occurs between the fabric and the consumer's skin.

< 1000 mg/kg for outer fabrics, lining and other clothing fabrics worn well separated from the skin.

< 300 mg/kg for clothing fabrics such as for blouses and shirts and knitted goods and anything worn tightly against the body.

< 75 mg/kg for clothing fabrics which find their application in underwear i.e., for clothes in direct contact with the skin.

< 20 mg/kg for baby clothing and other clothing for people who suffer from irritation to the skin caused by use of formaldehyde.

In the case of formaldehyde content above a quantity of 1500 mg/kg in textiles, these must be marked by the declaration : "........... contains formaldehyde. It is recommended that this garment should be washed before first use for better skin compatibility"

2.2.2.2 Pesticides:

Pesticides are biologically active in compounds which control the growth of organism viz., bacteria, fungus, algae, insects or plants and sometimes a broad spectrum of these organisms. Their objective is to improve crop-yield and quality by controlling the growth of the organisms that may cause damage and loss to the crop. Pesticides are generally sprayed on crops during various stages of their growth. Although they control the growth of organisms, pesticides are extremely harmful to mankind. Hence, their detection and estimation is very important.

It has been observed that 18% of the world's production of pesticides is used in cotton plantations. Almost 50% of the total pesticides used in the country is for the cotton crop. India spends over Rs. 225 crore every year for pest control in cotton. Excessive use of pesticides has caused severe environmental degradation and efforts are being made the world over to curb or find alternatives for these harmful chemicals.

Chemically pesticides can be classified according to the various chemical groups present in them namely, organochlorine, organophosphorus, carbamates, etc. The eco-standards have specified the limit values for organochlorine pesticides such as DDT, HCH, Lindane, Aldrin, Dieldrin, 2,4-D, 2,4,5-T and Toxaphene to less than 1 mg/kg. These values are primarily applicable to natural fibres which do not receive any wet treatment such as boiling off and washing.

Other pesticides registered under OEKO-TEX 100 are DDD, DDE, Heptachlor, Heptachlor epoxide.

2.2.2.3 Pentachlorophenol (PCP):

Pentachlorophenol (PCP) is an important antimildew agent and has been in use all over the world for the preservation of wood, leather, commercial polysaccharides, etc. During scouring or bleaching of textiles as well as during dyeing and printing,it is removed from the fabric and discharged in the effluent. It is also released into the environment as a result of the degradation of pesticides as phenoxyalkanoic acids and hexachlorobenzene.

PCP is relatively stable to natural degradation processes and in humans, its bio-accumulation takes place. Therefore, it is listed as toxic and environmentally unfriendly chemical.

The major sources of PCP contamination on textiles are:

* Degradation of pesticides like phenoxyalkanoic acids and hexachlorobenzene on raw cotton.

* Sized fabric PCP or its sodium salt has been used as size preservative.

* Gums containing PCP as preservatives used as adhesive in sizing and as thickener in printing.

* Latex based finishes e.g., BR latexes (where PCP is known to be used as dispersants).

The concentration limit for PCP on textiles has been fixed at 0.5 mg/kg (0.5 ppm) in the eco-standards.

2.2.2.4 Harmful metals:

These include Arsenic (As), Lead (Pb), Copper (Cu), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Nickel (Ni) and Mercury (Hg) whose limit values have been prescribed in the standards. Presence of cadmium, mercury and lead on textiles are highly unlikely because generally their compounds are not used in the textile industry. However, they may be present as trace impurities. Chromium, copper, cobalt and nickel compounds are commonly used in textile processing as metal complex dye fastness improvers (Cu), oxidizing agent for sulphur and vat dyes or for after chroming of mordant dyes on wool.

The concentration of extractable harmful metals on textiles is restricted. This does not involve the total amount of metals on the fibres when dyed with metal complex dyes; but rather the part which can be extracted with artificial saliva or perspiration solutions used in the corresponding fastness tests. The extractions are carried out in liquor to goods ratio of 20:1 at 40°C for one hour. Metal concentration is determined by means of Atomic Absorption Spectrophotometer (AAS).

2.2.2.5 Azo dyes containing carcinogenic amines:

Azo dyes which release aromatic amines classified under groups III A 1 or III A 2 as well as list of forbidden arylamines have been banned. The reasons for banning these dyes is due to the potential of azo dyes to split into arylamines. The conditions that cause the reductive splitting of azo dyestuffs are :

* A reductive chemical medium (eg., reduction stripping of dyestuff)

* The human organism as a result of the action of intestinal bacteria or azo reductase in the liver on any azo dyestuffs in the body.

* The amines obtained after reduction, exert their effect by causing DNA damage, which leads to tumour formation. The reduction products are electrophilic and are covalently bonded to the nucleic acid of DNA resulting in DNA damage and hence inducing cancer.

* The entire mechanism can be represented as :

Reductive cleavage:

$$R - N = N - R' \xrightarrow[\text{or enzymatic action [azo cleavage]}]{\text{reductive conditions}} R - NH_2 + R' - NH_2$$

Azo dyestuff → Aromatic amines

Covalent bonding to the nucleic acid bases of DNA :

$$R - NH_2 \longrightarrow RNHOH \xrightarrow{ph < 7} RNOH_2 \longrightarrow RNH^+$$

Aromatic amine → Covalent bonding to nucleophilic sites on DNA.

Approximately 20% of all dyes used in the textile industry are azo dyes. In all, about 118 dyes are banned which include 26 acid dyes, 5 azoic dyes, 3 basic dyes, 77 direct dyes, 6 disperse dyes and 1 oxidation base and developer dye.

Table 2.5 The eco-standards for textile production in Europe (ppm)

Parameter	Eco-mark				
	Eco-Tex 100	M.S.T	OTN 100	Clean fashion	Steilmann
Group I					
Free formaldehyde	300 ppm	0.03%	300 ppm	0.03%	500 ppm
-close to skin	75 ppm	0.0075%	75 ppm	0.0075%	300 ppm
-baby clothing	20 ppm	0.002%	20 ppm	0.002%	50 ppm
Group II					
Pesticides					
DDT	---	1.000 mg/kg	---	---	---
HCH	---	0.500 mg/kg	---	---	---
Lindane	---	1.000 mg/kg	---	---	---
Aldrin	---	0.200 mg/kg	---	---	---
Dieldrin	---	0.200 mg/kg	---	---	---
2, 4-D	---	0.100 mg/kg	---	---	---
2,4,5-T	---	0.050 mg/kg	---	---	---
Toxaphene	5 ppm	0.100 mg/kg	---	---	---
Sum Parameter		1.000 mg/kg	5 ppm	1.000 mg/kg	1.00 ppm
Group III					
Pentachloro phenol	---	0.500 mg/kg	---	0.500 mg/kg	Ban

Table 2.5 (contd..)

Group IV					
Heavy metals				Ban in silk products	
As	---	0.010 mg/kg	---	---	---
Pb	---	0.040 mg/kg	---	---	---
Cd	---	0.005 mg/kg	---	---	---
Hg	0.01 ppm	0.001 mg/kg	0.01 ppm	0.01 mg/kg	---
Baby clothing	0.01 ppm	0.001 mg/kg	0.01 ppm	0.01 mg/kg	0.01 mg/kg
Ni	10.00 ppm	0.200 mg/kg	10.00 ppm	10.00 mg/kg	< 0.5 $\mu g/cm^2$/week
Baby clothing	10.00 ppm	0.200 mg/kg	10.00 ppm	10.00 mg/kg	---
Cu	100.00 ppm	0.300 mg/kg	100.00 ppm	50.00 mg/kg	---
Baby clothing	30.00 ppm	0.300 mg/kg	30.00 ppm	10.00 mg/kg	1.00 ppm
Cr (III)	20.00 ppm	0.100 mg/kg	20.00 ppm	20.00 mg/kg	---
Baby clothing	1.00 ppm	0.100 mg/kg	1.00 ppm	1.00 mg/kg	---
Co	2.00 ppm	0.200 mg/kg	20.00 ppm	---	---
Baby clothing	1.00 ppm	0.200 mg/kg	1.00 ppm	---	---
Zn	---	5.000 mg/kg	---	---	---
Group V					
Azoic dyes containing aromatic amines	---	---	---	ban	ban
Group VI					
Halogenic carriers	---	---	---	---	ban
Group VII					
Chlorine bleaching	---	---	---	---	to avoid

[Source : Textile Trends, Sept 1996]

2.2.3 Eco - labelling in India:

Eco - mark is the eco - label in India. Earthen pot is the logo. The scheme of eco-labelling was instituted by the Ministry of Environment and Forests, Government of India. This ministry has classified textile industry into three broad categories namely Red, Orange and Green for the purpose of environmental inspection.

Red category: includes industries connected with synthetic fibres, polypropylene, petrochemicals and pigment dyes which require quarterly inspection.

Orange category: includes cotton spinning, weaving, dyeing, printing, bleaching and washing of fabrics and surgical bandage industries which require inspection once a year.

Green category: includes woollen, apparel, handloom, powerloom, garment making, carpet weaving industries with inspection once in two years.

Ministry of Environment and Forests in the Government of India has published certain criteria for eco-labelling of textiles.

The general requirements are:

i) All the textile products manufactured shall meet relevant standards of Bureau of Indian Standards.

ii) The product manufacturers must produce the consent clearance as per the provisions of Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981, Water (Prevention and Control of Pollution) Cess Act, 1977 respectively along with the authorisation, if required under Environment (Protection) Act, 1986 and the rules made there under to the Bureau of Standards while applying for Eco Mark.

iii) The product packaging may display in brief the criteria based on which the product has been labelled environment friendly.

iv) The material used for product packaging shall be reusable or made from recyclable or biodegradable materials.

v) Fatty alcohol based non-ionics as emulsifier should be used wherever required.

vi) Polyhalogenated based phenolic fire retardents shall not be used.

Table 2.6: The eco-standards for textile production in India

Max. limit mg/kg (ppm)

Parameters	Cotton, wool, man-made fibres and blends			Silk and silk products			Jute and Jute products	
	Baby clothing	Close to skin	Outer fabrics	Baby clothing	Close to skin	Outer fabrics	Home textiles	Hessians & socking
Free & releasable Formaldehyde	20.0	75.0	300.0	20.0	75.0	300.0	75.0 (close to skin fabrics)	N.A. N.A.
Extractable artificial sweat/saliva/heavy metals								
1. Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1	N.A.
2. Chromium	0.1	0.1	0.1	0.1	0.1	0.1	0.1	N.A.
3. Chromium IV	Nil	Nil	Nil	Nil	Nil	Nil	Nil	N.A.
Sum parameter (as lead)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	N.A.
Pentachlorophenol (PCP)	0.5	0.5	0.5	0.5	0.5	0.5	---	---
Volatile hydrocarbon (non-halogens)	150.0	150.0	150.0	150.0	150.0	150.0	10.0	N.A.
Volatile halogenated organics	200.0	200.0	200.0	---	---	---	N.A.	30%
Fatty ester based oil	---	---	---	---	---	---	2%	N.A.
Pesticides (sum parameter)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Banned pesticides	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
pH of aqueous extract	4.0-7.5	4.0-7.5	4.0-7.5	4.0-7.5	4.0-7.5	4.0-7.5	6.0-7.0	6.0-7.0
Coupled amines released from azo-dyes (sum parameter)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0

[Source: Indian silk, Feb 1997]

2.3 TESTING OF TRACE AMOUNTS OF HARMFUL CHEMICALS IN A TEXTILE PRODUCT

Testing and analysis of toxic elements present in the material at a trace level requires sophisticated instrumental analysis.

2.3.1 Preparation of samples:

Representative fabric samples are extracted with appropriate solvent in a soxhlet extraction unit for 6 to 8 hours. The extracts of the fabric are concentrated and subjected to series of clean-up procedure for isolation of the analyte. Finally the cleansed up solution is concentrated.

2.3.2 Estimation of free formaldehyde:

It is standardized using Japanese Law 112/1973 and AATCC sealed Jar method 112/1984. The method involves the extraction of free formaldehyde under standard condition followed by colorimetric estimation of extracted formaldehyde on a UV - spectrophotometer.

2.3.3 Estimation of pesticides:

It is normally determined by Gas Chromatography with Mass Spectrometer using different pesticides. Also Fourier Transforming Infra Red Spectrometer (FTIR) can be used.

2.3.4 Estimation of pentachlorophenol:

It can be measured by Gas Chromatography with Mass Spectrometer and High Performance Liquid Chromatography after a suitable extracting procedure.

2.3.5 Estimation of dyestuff which release aromatic amines:

High Performance Liquid Chromatography and High Performance Thin Layer Chromatography are suitable equipments to estimate the released dyestuff in the extracted liquid.

2.3.6 Estimation of heavy metals:

Atomic Absorption Spectrophotometer and accessories is a widely used technique for trace analysis of metals.

Table 2.7: **Equipment required for the testing of eco-parameters**

Eco-parameter	Equipment required
Free formaldehyde content	UV - visible Spectrophotometer
Presence of pesticides	Gas Chromatography with mass spectrophotometer (GC - MS) Fourier Transforming Infra Red Spectrophotometer (FTIR)
Presence of pentachloro-phenol	Gas Chromatography with mass spectrophotometer (GC - MS)
Presence of heavy metals	Atomic Absorption Spectrophoto-meter.(AAS)
Dyestuff which release amines (carcinogenic)	Infra Red (IR) spectroscopy, Nuclear Magnetic Resonance (NMR) Spectroscopy, Gas Chromatography with mass spectrophotometer, Thin Layer Chromatography (TLC) High Performance Thin Layer Chromatography (HPTLC) High Performance Liquid Chromatography (HPLC).
Fastness to perspiration	Perspirometer
Fastness to water	Launderometer
Biological oxygen demand	BOD & COD monitors
Chemical oxygen demand	

[Source: The Indian Textile Journal, Jan 1997]

2.4 HEAVY METALS AND THEIR TOXICITY IN HUMAN BEINGS

The organic and inorganic salts of heavy metals possess astringent, corrosive and caustic properties on local application. They act as general protoplasmic poisons and impair the cell function. All the heavy metals are cumulative and potentially toxic. In general, toxicity is related to the concentration of the metal in a tissue as a result of route of exposure, route of excretion or physical-chemical properties of metals. There is evidence that arsenic, chromium and nickel cause cancer in human beings; cadmium and beryllium are probable carcinogens. A profile of heavy metals is presented as under:

2.4.1 <u>Arsenic</u>:

HAZARD : The major hazard of arsenic poisoning comes from worker exposure during manufacture of insecticides, weed killers and wood preservatives. It is highly toxic by ingestion and inhalation. The oral toxicity limit for arsenic is 1-2 mg/kg. There is considerable evidence that arsenic is carcinogenic.

ROUTE OF ABSORPTION: Gastrointestinal, skin respiratory [all mucous surfaces]

DISTRIBUTION:

* Red cells (95 - 99% bound to globin) with in 24 hours.
* Subsequently to liver, lung, kidney, wall of gastrointestinal tract, spleen, muscle, nervous tissue within two weeks.
* Then to skin, hair and bone within years.

Symptoms: Signs of acute toxicity include oedema of eyelids, gastrointestinal irritation. Symptoms of chronic intoxication include "gastric breath", skin sensitivity, dermatitis, keratosis and development of transverse white lines in the fingernails known as Mee's lines. The most severe form of toxicity involves erythrocyte haemolysis.

2.4.2 Lead:

HAZARD: Lead is toxic by ingestion and inhalation of fumes or dust. Tolerance limit is 0.15 mg per cubic meter of air. Lead is a cumulative poison. Acute deadly dose for lead is 6-30 g for humans. FDA regulations require zero lead content in foods and 0.05% in house paints.

ROUTE OF ABSORPTION: Skin, respiratory, gastrointestinal tract.

DISTRIBUTION: Bone (90%). Lead deposited in bone does not contribute to the toxicity. Also deposited in teeth, hair, blood (4-8 µg/100ml) liver, kidney.

SYMPTOMS: Symptoms of acute exposure to inorganic lead include gastric irritation, central nervous system toxicity and renal dysfunction.

Chronic lead poisoning may lead to anaemia as a result of impaired haemoglobin synthesis and decreased erythrocyte life span. In addition to these, slow nerve conduction velocity, impaired neuromuscular function and palsy may be present. The kidney is a target for lead toxicity with tubular necrosis, glomerular atrophy, interstitial fibrosis. The appearance of lead line in the gum is an indicative.

2.4.3 <u>Cadmium</u>:

HAZARD: Cadmium is highly toxic, especially by inhalation of dust or fume. Cadmium plating of food and beverage containers results in a number of outbreaks of gastroenteritis. It is flammable in powder form.

Tolerance limit (dust and soluble compounds) 0.2 mg per cubic meter of air; (oxide fume, as Cd) 0.1 mg per cubic meter of air. The fatal dose for cadmium is 30-40 mg. The daily intake is possibly upto 10-30 µg and on smoking 20 cigarettes, it is increased by 4 µg.

USE: Cadmium is used in surface treatment of non-textiles and in dyes as a coloring agent. It is often used as stabilizer in plastics (zippers & buttons)

SYMPTOMS: Acute inhalation of cadmium dusts and fumes can cause pulmonary damage including pneumonitis and oedema. Chronic exposure may result in pulmonary fibrosis and possibly emphysema. Kidney retains higher concentration of cadmium than other tissues.

2.4.4 <u>Mercury</u>:

HAZARD: The main sources of inorganic mercury as a toxic hazard include materials used in herbicides, insecticides, fireworks, batteries etc. A mysterious epidemic occurred in Minimata, a Japanese fishing village, in 1953. The epidemic was traced to the consumption of fish contaminated by the effluent discharged by the factory. Another incident occured in Iraq in 1971 - 1972 where 500 people died from consuming bread made from grains treated with alkyl mercury fungicides.

ROUTE ABSORPTION: Respiratory tract, skin, gastrointestinal tract.

DISTRIBUTION: In central nervous system it is trapped as Hg^{+2}. Also kidney, blood and brain.

SYMPTOMS: Symptoms of acute mercury poisoning are characterised by severe gastrointestinal irritation, metallic taste in mouth, nausea and vomiting. Chronic mercury poisoning is manifested by tremors, headache, stomatitis, colitis, dermatitis, electrolyte imbalance.

2.4.5 Nickel:

HAZARD: Nickel if flammable and toxic as dust or powder. Tolerance limit is 1 mg per cubic meter of air (metal and soluble compounds). Dermatitis is the most frequent response associated with the exposure to nickel salts. Chronic exposure has been implicated in nasal and respiratory cancer.

USE: Nickel is used in electronics, in electrodes, mining of coins. It is also often used to improve the hardness of alloys, which are used in accessories such as zippers, buttons and rivets.

SYMPTOMS: Nickel is one of the most common causes of contact dermatitis. Acute poisoning from nickel carbonyl results initially in headache and vomiting which may be followed by pneumonitis and central nervous system toxicity.

2.4.6 Copper:

HAZARD: Copper is toxic and inflammable in finely divided form. Tolerance limit (fume) is 0.1 mg per cubic meter, (dusts and mists) 1 mg per cubic meter of air. Copper compounds are powerful inhibitors of enzymes.

SYMPTOMS: Symptoms include a metallic taste, increased salivation, burning pain in the stomach with colicky abdominal pain and nausea. Repeated vomitings in blue or green colour can be seen. In severe cases, jaundice and cramps of legs and convulsions occur. Breathing becomes difficult. In some cases, paralysis of limbs is followed by drowsiness, insensibility, coma and death.

2.4.7 Chromium:

HAZARD: Chromium is poisonous, highly allergic metal, non-biodegradable and carcinogenic. Chromium compounds have an irritating and corrosive effect on tissues resulting in ulcers and dermatitis on prolonged exposure. Tolerance limit for chromium dust and fume is 1 mg per cubic meter of air.

The acute toxicity of chromium for rats 1870 mg/kg. For human beings the fatal dose of chromic acid is 1-2 g Cr (VI). Cr (III) is considered to be less toxic because of its low reabsorption tendency.

USE: Chromium is used in dyeing additives and as a dye-fixing agent. Chromium is also used for after-treatment of direct dyes to improve wash fastness.

2.4.8 Cobalt:

HAZARD: Cobalt dust is inflammable and toxic by inhalation. Tolerance limit is 0.1 mg per cubic meter of air.

USE: Cobalt is used in electroplating as a trace element in fertilizers, printing inks, paints and varnishes.

2.4.9 Zinc:

HAZARD: Zinc is flammable, dangerous, fire and explosive risk.

USE: Zinc is used in fungicides, alloys, electroplating, batteries and as an essential growth element.

2.5 SOURCES OF HEAVY METALS IN TEXTILE PROCESSING

All the heavy metals are present in varying amounts in different classes of dyes Viz., acid, basic, direct disperse, fibre reactive and vat dyes. Other metal sources that have been identified in wet processing operation are:

i) Oxidizer (especially for vat and sulphur dyes).

ii) Copper (after treatment of direct dyes).

iii)Metal catalyst used for curing resin (zinc, mercury).

iv) Flame retardant, soil release and water repellant finishes.

v) Grey goods.

vi) Dye stripping agents such as permanganate, zinc sulfoxylate/formaldehyde adducts and dichromate.

Table 2.8: Average metal content of dye classes (ppm)

METAL	DYE CLASS					
	Acid	Basic	Direct	Disperse	Reactive	Vat
Arsenic	< 1	< 1	< 1	< 1	1.4	< 1
Cadmium	< 1	< 1	< 1	< 1	< 1	< 1
Chromium	9	2.5	3	3	24	84
Cobalt	3.2	< 1	< 1	< 1	< 1	< 1
Copper	79	33	35	45	71	110
Lead	37	6	28	37	52	6
Mercury	< 1	0.5	0.5	< 1	0.5	1
Zinc	< 13	< 32	8	3	4	4

[Source: Colourage , Sept 1994]

2.6 REPORTED CASES OF TOXICITY IN WORKERS OF TEXTILE INDUSTRY

In 1895, **Rehn** reported a high incidence of hemorrhagic cystitis, recurrent papillomas and urinary bladder cancers in workers employed in the manufacture of dyes based on benzidine, β - naphthylamines etc. [Lokhande and Naik, Jan 1997]

For about half of the working life, **Theresa Schullmeir**, a tailor in Bayern [Germany] had no idea what was causing conjuctivitis, scratching sensation all over the body, loss in weight and swelling of bones. These troubles were more while cutting or ironing silk or velvet fabrics. Detailed examination in 1989 [48years] has shown the presence of residues of toxic chemicals - formaldehyde, lindane pesticide and pentachlorophenol preservative, used in sizing or finishing. [Achwal, May 1996]

Gottfried Frank worked for 20 years in a textile warehouse in folding ready made shirts, blouses and bedsheets. The place was full of formaldehyde smell which caused irritation in nose, eyes, mucous membrane and breathing problems. Mr. Frank was analysed to be psychic and made to retire early. [Achwal, May 1996]

Helga Meinecke, a head tailor in boutique in Munich, felt giddy particularly during ironing. After 10 years of

work, doctors diagnosed lindane and pentachlorophenol not only in her blood and urine but also brain.
[Achwal,May1996]

Some of the trade unions also report that there are increasing cases of health problems from cutters, tailors, folders and salesman. Consumer organizations also report complaints of allergy and skin irritations on wearing certain under garments, hoses, slips and blouses. There were also complaints about eczema by ladies on wearing black velvet trousers. Two of the four pairs analysed contained heavy metals 120 times more than the permitted limits.
[Achwal, May 1996]

2.7 STUDIES ON ECO-FRIENDLY PROCESSING

Lewis (1993) studied the methods of conferring reactivity on the fibres for producing a lesser dye house effluent. The modification of fibres for dye application, in the absence of salt, was studied to combat the problem of limited fixation and high salt consumption during reactive dyeing.

Raghavan (1993) reports about a study conducted by Century Textiles Ltd., Bombay conducted on dyeing of sulphur black colour by eco-friendly chemicals. Conventional dyeing process of sulphur black contributes sulphides in the effluent, which has an adverse effect on the environment. Sodium sulphide was replaced by a product "Hydol" containing

50% of reducing sugars. It was possible to reduce the sulphide concentration in the effluent from 30 ppm to less than 2 ppm and eliminate the foul smell.

Tholen and Zinser (1993) conducted a study on low cost resin finish on cotton poplin fabric to make it 100% compatible with ECO-TEX standard. In the ECO-TEX standard the maximum level of formaldehyde in apparel and home furnishings that come in contact with close skin is 75 ppm. The major use of formaldehyde is in anti-wrinkle finishes. Thor chemie has developed a new reactive resin called Quecodur SLF with a very low level of formaldehyde. The use of this resin in anti-wrinkle finishing permits compliance with the ECO-TEX standard and eliminates after treatment scouring. More over the cost of this finish is low.

Holme (1994) reports that though no appropriate eco-friendly substitutes are available, so far, to the phosphorus - based flame retardent finishes, manufacturers of flame retardents are considering alternative routes of finishing which could contribute to less environmental damage.

Roongta (1994) reports about MAPS, an Ahmedabad based company which has developed eco-friendly enzymes, Palkofeel - s and Palkowash for ensuring fabric quality. Palkofeel-S is an enzyme complex derived from selected strains of Aspergillus Niger, containing hemicellulose and betaglutanase active ingredient. It is available in powder form. It works as a bio-polishing agent on cellulosic fabrics. Palkowash is a powder readily soluble endo-glucanase enzyme obtained from non-pathogenic mould through fermentation. It aids in finishing of blue denim garments.

Wadham (1994) studied environmental friendly methods to improve the soft handle of cellulosic fibres through biopolishing, using cellulosic enzymes. Biopolishing is an enzymatic process by which the cotton fabric is treated with cellulose enzyme, which degrades the surface layer of the fabric leading to reduced pilling, less fuzz and improves drape and handle.

Anon (1995) reports the development of "E control" jointly by Zeneca colors and Montforts a new environmentally-friendly process for continuous dyeings of cellulose fibres using reacitve dyes. "E control" is easy to use, economical and energy saving.

Dorning and **Sehm** (1995) studied the wear properties of ladies hosiery which has been tested for hazardous materials. The complicated list for hazardous material tested textiles by ladies hosiery goods was demonstrated. Six samples demonstrate that the hazardous material free condition attained with hosiery can no longer be maintained in the latter end-use phase due to environmental influences.

At the moment, environment is even less clean than the textiles tested for hazardous materials.

Dutta (1995) examined the viability of calling "Tencel" as an environmental friendly cellulose fibre. "Tencel" is the world's first green man made fibre because the solvent used is completely recoverable, while carbon di sulphide (CS_2) in viscose ends up as a waste. Moreover the amine oxide is non-toxic and does not pollute the environment.

Oijusluoma et al., (1995) studied the use of formic acid as an environmentally safe alternative for acetic acid in the textile industry. In the laboratory tests, the effects of these acids were compared in dyeing process, in neutralising after bleaching and in water repellent finishing. When used for neutralisation after bleaching of cotton fibres, formic acid gave a sufficient degree of neutralisation in a shorter time than acetic acid.

Ward (1995) reports that lyocell fibre may environmentally replace the viscose fibre. The advantages of lyocell fibres are that the manufacturing method is environmentally friendly; the fibres offer higher performance characteristics and the production method is more cost effective than viscose rayon.

BTRA, Bombay (1996) developed 4 ecofriendly products and processes for chemical processing of textiles.

* Silicate-free simplified "All-in" process for dyeing of vinyl sulphone reacitve dyes on cotton fabric.

* Mixed alkali system for enhanced fixation of triazine reactive dyes on cellulosic fabrics.

* Development of eco-friendly product for dyeing synthetic fibres, wool and silk. This product replaces acetic acid in dyeing of synthetic fibres.

* Development of cost effective and eco-friendly product for printing of polyester fabric with disperse dyes. This is known as BTRA print acid, which replaces the costly citric acid.

Heine. et al., (1996) developed a simulator to study its suitability for simulating the transfer of chemicals from textiles to the human skin. The results of DIN and Eco-Tex standard. 100 tests are compared with the simulatory tests to see whether a simple and rapid method can be established for determining the migration of chemicals from textiles. Textiles dyed on a laboratory scale with selected dyes are used for the purpose in the simulator and fastness tests. The dye migration to the skin during wear is so low that a wide range of variation has to be reconciled with. Used in connection with metal-complex dyes, the simulator is found to yield reproducable results using wool fabrics dyed with 4% navy blue and metal-complex dyes. The DIN fastness tests give values, which are considerably higher than those yielded by the simulator. Results are also given of how the dye, which migrates to the skin is distributed in the epidermis and fatty tissue.

Hobohm (1996) studied the ways of optimizing textile finishing processes from the point of view of cost and ecology. The study refers specifically to operations carried out in dye works in Austria. A comparison between the current method of bleaching a knitted cotton/elastomeric fabric with a new method was made. The aims of the study were to change the process without affecting production and to improve the process in small steps, accompanied by laboratory tests. Of particular importance were reduction in water consumption and reduction in the organic load of the waste water.

Soster and Jeler (1996) examined the ecological acceptability of natural thickeners from diversely substituted guar gum, which is an alternative to sodium alginate. Apart from the thickeners, the printing paste comprised sodium bicarbonate, mild oxidizing agent and the reactive dye (CI Reactive Blue 220). A viscose rayon woven fabric was printed. The ecological parameters, such as COD, BOD and TOC were determined for the waste water in the washing bath. It was found that of all the thickeners examined, the guar gum of the substitution grade 1, 1 was most acceptable, because it is biodegradable and very yielding.

MATERIALS & METHODS

CHAPTER-III

MATERIALS AND METHODS

The different materials used and the methods adopted in conducting the research are dealt with, in this chapter, under the following sub-headings.

3.1 SELECTION OF MATERIALS

3.1.1 Selection of T-shirts

3.1.2 Selection of detergent

3.1.3 Selection of water

3.2 SELECTION OF METHODS

3.2.1 Research design

3.2.2 Consumer survey

3.2.2.1 Sampling procedure

3.2.2.2 Formulation of Interview Schedule

3.2.2.3 Data collection

3.2.3 Wear study

3.2.4 Laundering procedure

3.2.5 Testing for the presence of heavy metals using Atomic Absorption Spectrophotometer

3.2.6 Statistical analysis

3.1 SELECTION OF MATERIALS

3.1.1 Selection of T-Shirts :

The aim of the study was to assess the uptake of heavy metals by eco-friendly garments. Hence eco-friendly garments ie., six knitted Cotton T-shirts, for ladies, have been procured from the manufacturer.

3.1.2 Selection of detergent :

Surf detergent powder was selected for the study as it is the oldest and most frequently used detergent powder for home laundering.

3.1.3 Selection of water :

Water is the most important material used in laundering, not only because of the large quantity required but also because the success or failure of the washing process depends upon the suitability of the water supply. Hence, a steady source of water was sought after. Accordingly, the water supplied by the Hyderabad Metropolitan Water Supply and Sewerage Board was selected for the purpose of laundering. The water was also chemically analysed in the Institute of Preventive Medicine, Hyderabad. [Appendix A]

3.2 SELECTION OF METHODS

3.2.1 Research Design :

The research design selected for the study was experimental research design which included both consumer survey and laboratory experiment.

3.2.2 Consumer survey :

To fulfill the objective of knowing the level of awareness of consumers regarding eco-friendly fabrics, a survey was carried out.

3.2.2.1 Sampling procedure :

The respondents were selected by purposive sampling and the sample size was limited to 30. The locale of the study was Hyderabad and Secunderabad.

3.2.2.2 Formulation of Interview Schedule :

An interview schedule was prepared basing on the objectives. It has two sections, general information and specific information. A copy of the schedule is appended (Appendix B)

3.2.2.3 Data collection :

Data collection was carried out personally by the investigator using the pretested schedule, from the consumers who were familiar with eco-friendliness.

3.2.3 Wear Study :

Six subjects having similar activity and residing at Hyderabad and Secunderabad were selected for the wear study. All the six T-shirts were given code numbers for identification. The T-shirts were given to subjects to wear for 8 hours a day. After each wear, the T-shirts were laundered using the standard procedure.

Three T-shirts were subjected to 10 launderings (10 L) and the other three T-shirts were continued till 20 launderings (20 L).

3.2.4 Laundering Procedure :

The home laundering procedure was modified following AATCC standards No. 88A 1964 T. A washing liquor was prepared using water at room temperature with 0.2% concentration of soap. The garments were soaked in the liquor for 30 minutes. The fabric weight to liquor ratio for washing and rinsing was selected as 1:25, as opposed to 1:20 [woven fabrics] since there is no established standard for knitted garments.

The garments were washed by kneading and squeezing method. The garment was kneaded for 10 times in 5 minutes followed by rinsing in three changes of water each time dipping and raising for 10 times. Excess moisture was squeezed out and the garment was dried in shade, on a flat surface. Three of the six T-shirts were subjected to 10 launderings and other three T-shirts were continued till 20 launderings.

3.2.5 Testing for the presence of heavy metals using Atomic Absorption Spectrophotometer :

For testing the uptake of heavy metals from a textile material, at a trace level (ppm), a sophisticated instrument namely Atomic Absorption Spectrophotometer (AAS) is required. The metal content can be extracted with acid perspiration solution which is used in the color fastness to perspiration (BIS 971-1983).

Preparation of Acid test solution:

0.5 g of 1-HISTIDINE MONOHYDROCHLORIDE MONOHYDRATE [$C_6HgO_2N_3Hcl.H_2O$], 5 g of SODIUM CHLORIDE [Nacl] and 2.2 g of SODIUM DIHYDROGEN ORTHPHOSPHATE DIHYDRATE [$NaH_2PO_4.2H_2O$] per litre is taken. pH of the acid test solution should be 6.5.

Material : Liquor ratio should be 1:20. Five grams of sample is extracted and dipped in 100 ml acid test solution

Plate No. 1 Atomic Absorption Spectrophotometer at $50^{o}C$ for one hour. After one hour the sample is removed from the test solution. The extract is collected by filtration and 1 ml of concentrated HNO_3 is added to it. The solution is then concentrated to 25 ml by evaporation. Sample solution is now ready.

From the stock solution of 1000 ppm of standard metal solution, different concentrations of standard solutions like 0.1 ppm, 1 ppm and 5 ppm are prepared. Then,

(i) Aspirate initially the blank solution ie., distilled water in the instrument.

(ii) Aspirate different standard solutions.

(iii) Finally sample solution is aspirated.

Since the atomic absorption spectrophotometer is connected to a computer software, the levels of each heavy metal can be read off from the computer's monitor.

3.2.6 STATISTICAL ANALYSIS

The data obtained was tabulated, analysed and presented in tables and graphs in order to make the findings meaningful and understandable. The following statistical tools were used for analysis of data (Rao, 1983):

* One way analysis of variance and means, for analysis of uptake of heavy metals between 10 L and 20 L (Appendix-C).

* Two way analysis to find out a significant difference between metals (which showed significant uptake) and the number of launderings i.e., 10 and 20 .

* Percentages, for analysis of data collected through interview schedules.

RESULTS AND DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

The present study was undertaken to know the level of awareness regarding eco-friendly fabrics, among consumers and to study the heavy metal uptake by eco-friendly garments. The findings of the study are discussed in this chapter under the following sub-headings:

4.1 CONSUMER SURVEY

4.2 UPTAKE OF HEAVY METALS BY ECO-FRIENDLY GARMENTS

4.1 CONSUMER SURVEY

The knowledge of consumers regarding eco-friendliness, acquired through interview schedule was gathered, tabulated and presented here.

4.1.1 An overview of consumer awareness on eco-friendliness:

All the respondents were aware of eco-friendliness and believed in it. The reasons mentioned by the respondents for this belief in eco-friendliness were:

* Health and safety of the environment is ensured.

* The risk of pollution of environment is reduced.

* Ecological balance of the environment is maintained.

* Health related problems of people are minimised.

* The natural resources are preserved thereby enhancing nature's productivity.

* Healthy development of human beings in the future is ensured, with the adoption of eco-friendly technology.

* Belief in the fact that 'nature is the ultimate saviour' and that man cannot be harsh towards it.

From a sample of 30 respondents, information collected in this context was from two areas viz., through some common sources and through different mass media.

4.1.1.1 Common sources of information on eco-friendliness:

Table 4.1A: Common sources of information on eco-friendliness.

n = 30

S.No.	Sources	Weightage
1.	Fabrics/garments	21 (70)
2.	Packaging	19 (63.33)
3.	Foods	16 (53.33)
4.	Dyes	16 (53.33)
5.	Forests	15 (50)
6.	Water	14 (46.66)
7.	Air	12 (40)
8.	Fuel	2 (6.66)
9.	Bacteria	1 (3.33)
10.	Algae	1 (3.33)
11.	Pencils	1 (3.33)

[Multiple responses possible]

[Figures in parentheses indicate percentages]

It is apparent from Table 4.1A that 70 per cent of consumers knew about eco-friendliness through fabrics, 63.33 per cent through packaging, 53.33 per cent each through foods and dyes, 50 per cent through forests, 46.66 per cent through water, 40 per cent through air, 6.63 per cent through fuel, 3.33 per cent through bacteria, algae and pencils, individually.

4.1.1.2 Mass media:

Table 4.1B: Consumer awareness on eco-friendliness through mass media

n = 30

S.No.	Sources	Weightage
1.	Newspapers	18 (60)
2.	Journals	18 (60)
3.	Books	14 (46.66)
4.	Periodicals	14 (46.66)
5.	Television	13 (43.33)
6.	Seminars	11 (36.66)
7.	Discussions	10 (33.33)
8.	Radio	7 (23.33)
9.	Workshops	5 (16.66)
10.	Trade fairs	1 (3.33)

[Multiple responses possible]

[Figures in parentheses indicate percentages]

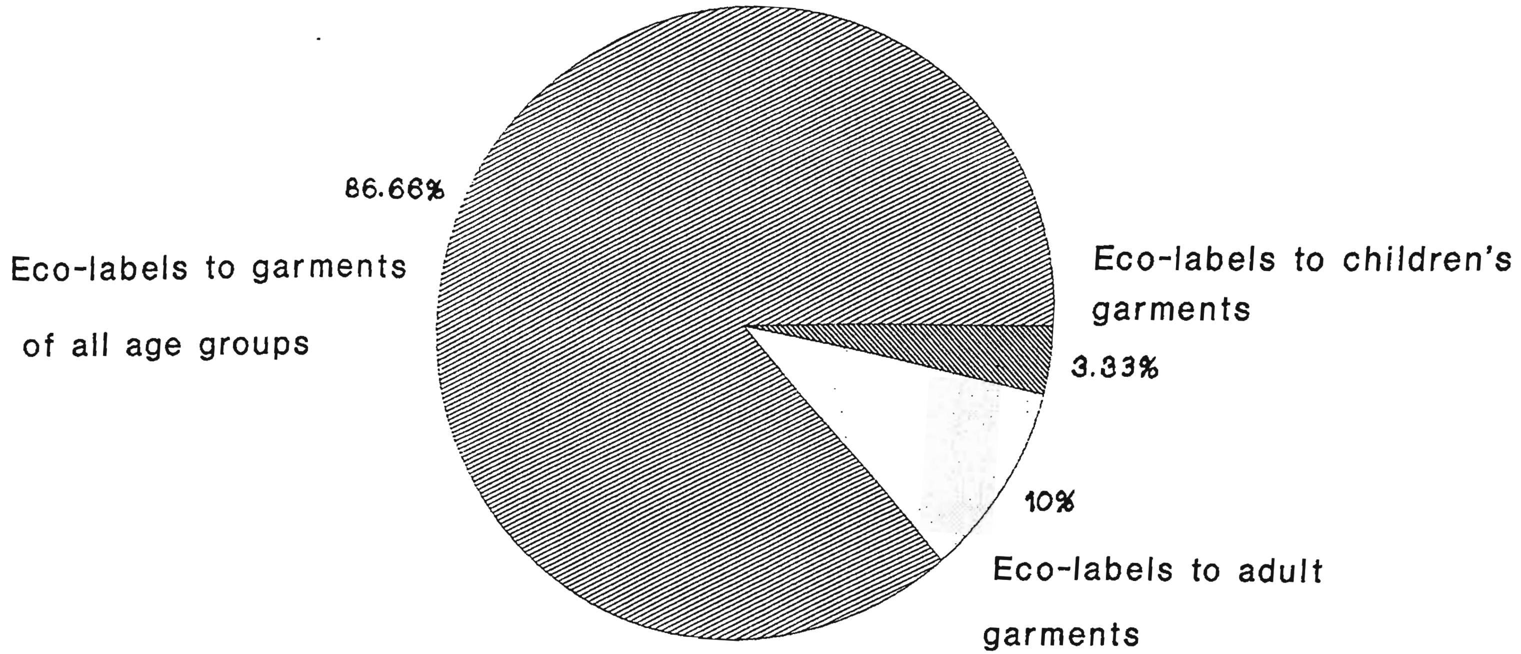
The newspapers and journals were wide in their coverage of eco-friendliness as is distinct from the consumer response (60 per cent each) indicated in Table 4.1B. It is also quite noticeable that books and periodicals were each responsible in educating 46.66 per cent of consumers. Television, the most popular entertainment media was instrumental in enlightening 43.33 per cent of consumers, seminars and discussions each were accountable in updating the knowledge of 36.66 per cent and 33.33 per cent of consumers, respectively. Radio, the one-way communication tool was able to reach 23.33 per cent of consumers. Workshops served to increase the awareness of 16.66 per cent of consumers, while trade fairs were proficient in improving the knowledge of 3.33 per cent of consumers.

4.1.2 Consumer's opinion on labels:

From the information gathered, it was found that all the respondents purchased their clothing based on color and print, texture, appearance, hand, cost, fashion and labels.

All the respondents (100 per cent) had the habit of reading the instructions given on the label. Only 76.66 per cent of the respondents followed the instructions given on the labels since they had confidence in the labelled products. However, only 26.66 per cent of the respondents came across eco-labelled garments, though all the respondents knew about eco-friendliness. Only about a fourth of them came across eco-labelled garments. A small portion of the respondents, i.e., 3.33 per cent felt that eco-labels should be given to only children's garments as this age group needs more protection because of their easy susceptibility to infections (Fig 4.1). Among the respondents, 10 per cent opined that eco-labels should be given to adults garments because they can appreciate the eco-labels and can give a conscious effort in promoting eco-friendliness. Majority of the respondents i.e., 86.66

Fig. 4.1 : Consumer opinion on allocation of eco-labels to different age groups



per cent were of the view that garments of children, adults and elderly should be given eco-labels because,

* All the people are affected by an imbalance in the ecosystem.

* The health aspect of the people can be improved and ensured.

* Eco-friendly clothing offers protection to both the user and the environment.

* Eco-friendly clothing is like a solution to the inverse input of toxic chemicals.

4.1.3 Buying behaviour of consumer:

Most of the respondents i.e., 80 per cent were interested in buying eco-friendly garments. Only 66.66 per cent of the respondents were interested in buying even if the cost was more when compared to other garments, inspite of there being no visible change in the look of the garment.

4.1.4 Consumer's opinion on eco-labelled garments:

From the respondents 30 per cent were of the opinion that eco-labelled garments would be acceptable to masses, in India, the reasons being,

* Increased awareness about the importance of eco-friendliness.

* A possibility of reduction in health risks and consequent increase in longivity.

* Hazards to the environment could be minimised.

* People would accept these clothing as something new, if the cost is reasonable.

* Enlightened consumers or the ' green consumers' would readily accept the eco-friendly clothing as it is environ-friendly.

* People would accept eco-friendly clothing as it is an effort for a good cause namely 'protection of mother nature'.

In contrary to the above observations, 70 per cent of the respondents felt that eco-labelled garments would not be acceptable to masses, in India as,

* Information gap exists between industrialists and consumer.

* Eco-labelled garments may be costly and most of the people in India are below poverty line. So these garments may not reach them, cost wise.

* Lack of awareness among most people due to inaccessability to eco-information.

* Existance of a misconception among people, that labels are for public attraction.

* This being a new innovation, people need time to accept it.

4.2 UPTAKE OF HEAVY METALS BY ECO-FRIENDLY GARMENTS

The heavy metal content is one of the most important eco-parameters. The eco-friendly garments were subjected to heavy metal analysis through Atomic Absorption Spectrophotometry (AAS) at three stages viz., control, after 10 L and after 20 L. The values obtained at the three stages and their respective means along with MST and ECO-TEX limit values are given in Table 4.2. The uptake of all the nine heavy metals namely arsenic, lead, cadmium, mercury, nickel, copper, chromium, cobalt and zinc has been discussed separately, in this chapter.

Plate No. 2

T - shirts before laundering

Table 4.2: AAS values of heavy metals (ppm) at three stages-control, 10 L and 20 L, as compared to limits of MST and ECO-TEX 100.

S.NO.	Heavy Metal	Limit Values		Control				10 L				20 L			
		ECO-TEX 100	MST	I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
1.	Arsenic	--	0.01	3.12	2.28	3.50	2.96	1.85	0.80	2.12	1.59	0.90	1.30	2.90	1.7
2.	Lead	--	0.04	2.15	9.99	16.16	9.43	23.41	0.90	20.93	15.08	1.00	0.80	1.90	1.23
3.	Cadmium	2.00	0.005	3.70	11.76	5.01	6.82	15.10	0.10	24.24	13.14	0.08	0.15	0.20	0.14
4.	Mercury	0.01	0.001	10.88	8.56	9.56	9.66	5.40	1.10	4.80	3.76	1.00	17.42	32.00	16.80
5.	Nickel	10.00	0.20	5.32	10.25	7.8	7.79	0.83	0.64	0.65	0.70	0.67	1.30	2.19	1.38
6.	Copper	100.00	3.00	13.38	12.55	5.19	10.37	0.60	0.20	1.27	0.69	0.59	2.50	27.25	10.11
7.	Chromium	20.00	0.10	2.15	8.23	3.97	4.78	2.10	0.36	1.46	1.30	0.58	0.78	0.40	0.58
8.	Cobalt	--	0.20	3.52	2.06	2.46	2.68	0.06	0.25	0.06	0.12	0.22	0.27	0.25	0.24
9.	Zinc	--	5.00	7.60	4.47	16.16	9.41	4.34	0.01	4.96	3.10	0.01	0.01	0.01	0.01

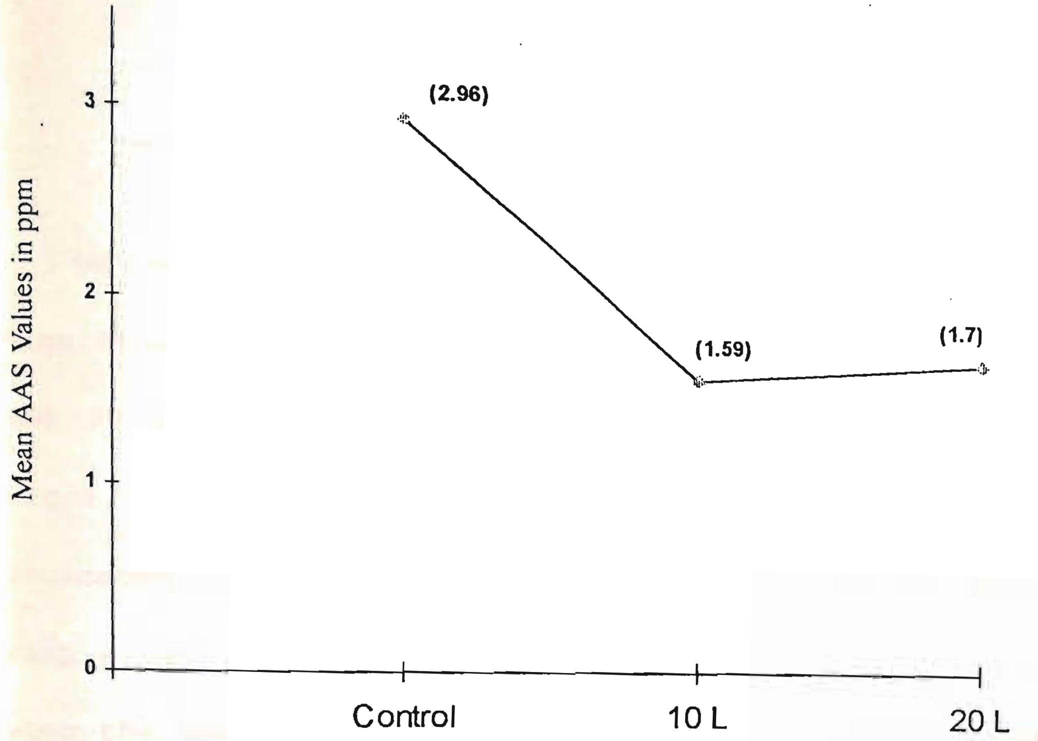
4.2.1 Arsenic:

Table 4.3: AAS values of arsenic (ppm)

S.No.	Control	10 L	20 L
1.	3.12	1.85	0.9
2.	2.28	0.80	1.30
3.	3.50	2.12	2.90
Mean	2.96	1.59	1.70

One way analysis of variance has revealed that there was no significant difference, in arsenic uptake between 10 L and 20 L at 5 per cent and 1 per cent levels of significance. But the readings in Table 4.3 indicate a high content at the control stage, a gradual decrease at tenth laundering and a slight increase at twentieth laundering (Fig 4.2). It is also apparent that AAS values of arsenic are exceeding MST limit values.

Fig. 4.2 : Uptake of Arsenic



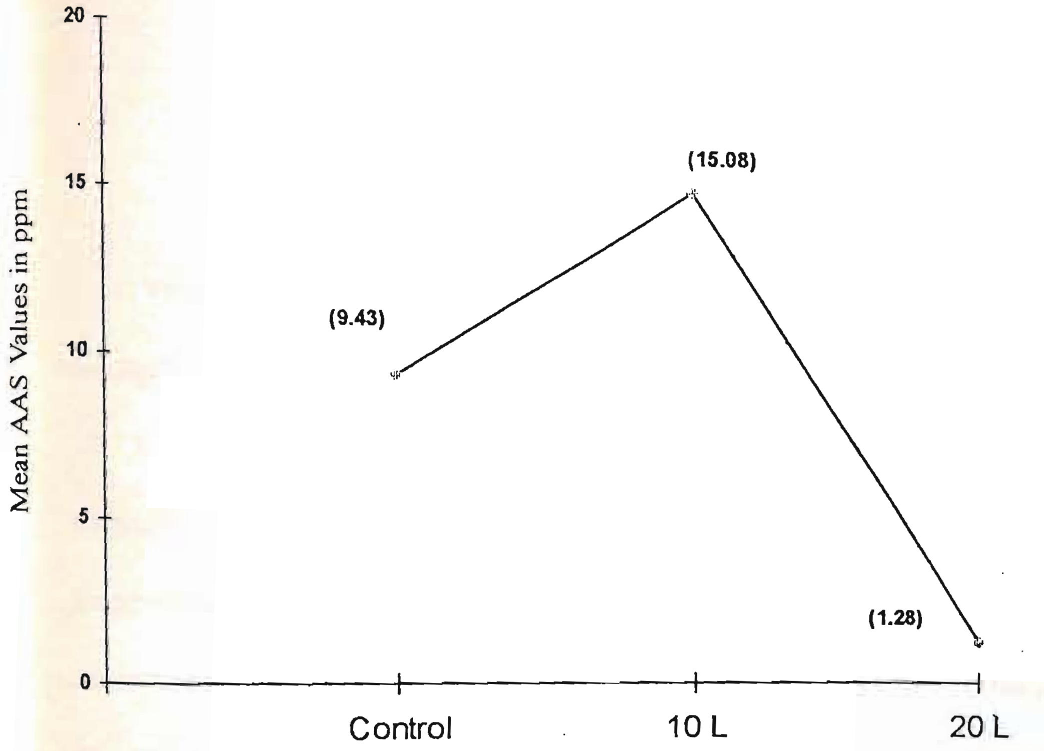
4.2.2 Lead:

Table 4.4: AAS values of lead (ppm)

S.No.	Control	10 L	20 L
1.	2.15	23.41	1.00
2.	9.99	0.90	0.80
3.	16.16	20.93	1.90
Mean	9.43	15.08	1.23

One way analysis of variance has shown that there was a significant difference, in the uptake of lead, between 10 L and 20 L at both 5 per cent and 1 per cent levels of significance. Further analysis with C.D. values has indicated significant difference between control and 20 L sample (at 5%) and control and 10 L sample (at 1%). But when the means of the readings in Table 4.4 were compared, a high content, at the control level was observed followed by an increase at 10 L stage. The lead content at the 10 L stage has drastically been reduced at the 20 L stage (Fig 4.3). In case of lead also, it can be noted that the AAS values have crossed the limit values of MST.

Fig. 4.3 : Uptake of Lead



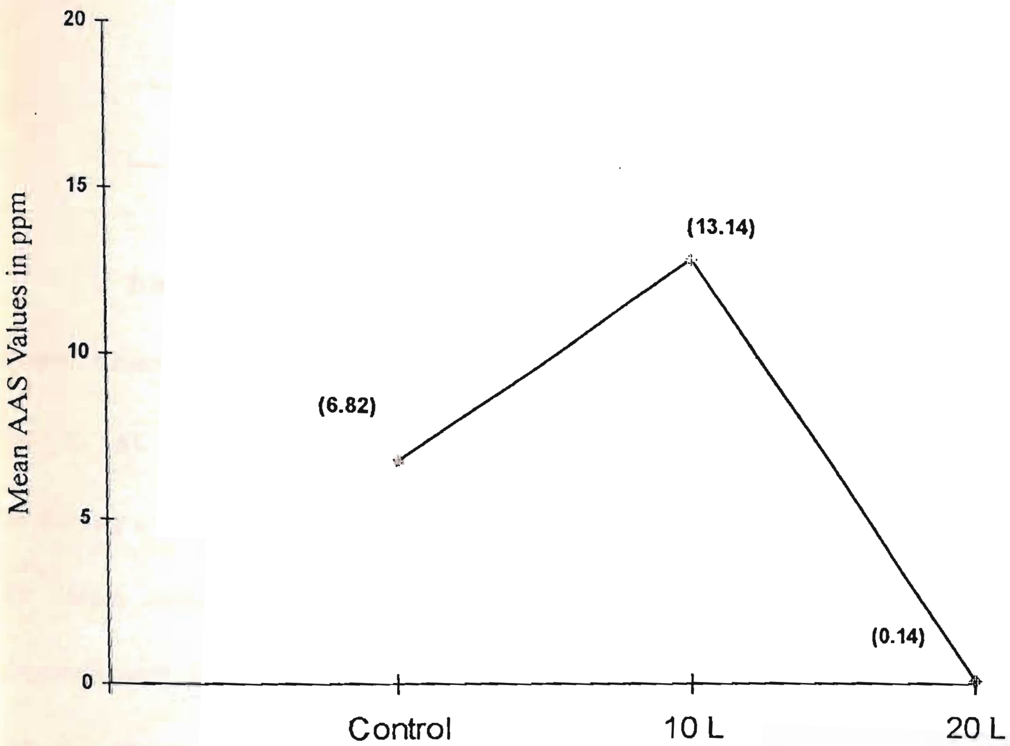
4.2.3 Cadmium

Table 4.5: AAS values of cadmium (ppm)

S.No.	Control	10 L	20 L
1.	3.70	15.10	0.08
2.	11.76	0.10	0.15
3.	5.01	24.24	0.20
Mean	6.82	13.14	0.14

Statistical analysis has revealed that there was no significant difference, in the uptake of cadmium between 10 L and 20 L at both 5 per cent, 1 per cent levels of significance. It is evident from Fig 4.4 that there was an increase in the cadmium content at 10 L stage and a drastic decrease at 20 L stage (Table 4.5). The cadmium level at 20 L stage was within ECO-TEX limit in contrary to the cadmium levels at control and 10 L stage. However, the cadmium levels at three stages were far above the MST limit values.

Fig. 4.4 : Uptake of Cadmium



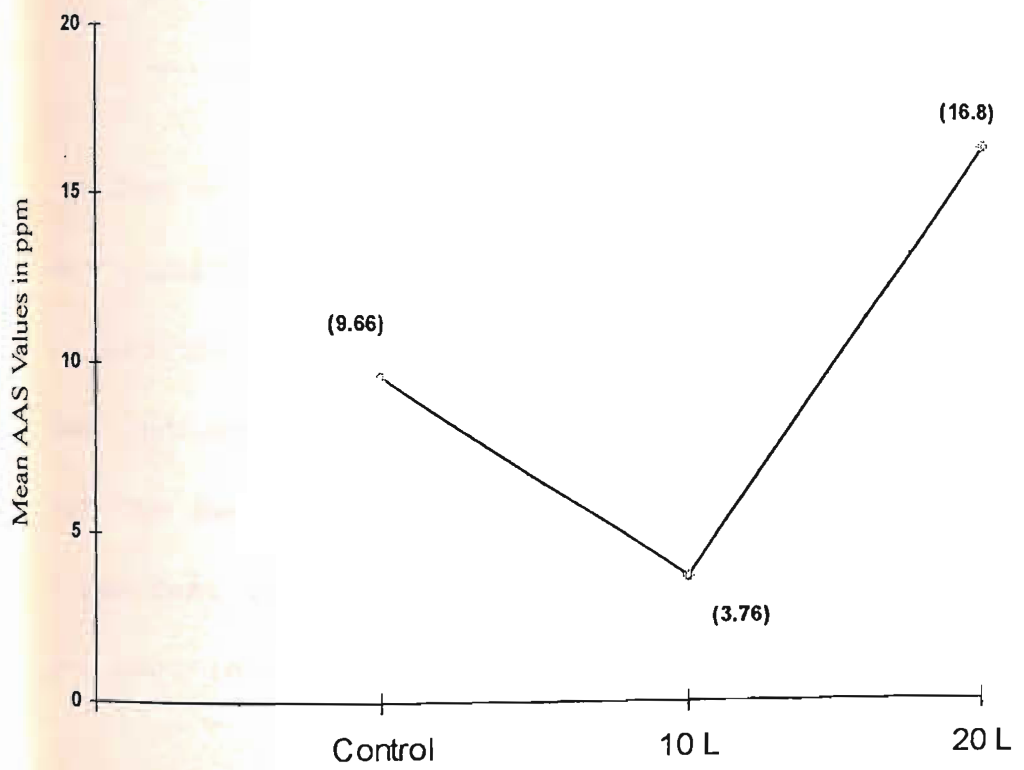
4.2.4 Mercury:

Table 4.6: AAS values of mercury (ppm)

S.No.	Control	10 L	20 L
1.	10.88	5.40	1.00
2.	8.56	1.10	17.42
3.	9.56	4.80	32.00
Mean	9.66	3.76	16.80

It has been inferred from one way analysis of variance that there was no significant difference between 10 L and 20 L at 5 per cent and 1 per cent, in the uptake of mercury. However, on comparison with the means in Table 4.6 it was observed that the high level of mercury has decreased at 10 L stage and has shown a sharp increase at 20 L stage, thereby depositing an alarming amount (16.80 ppm) of mercury on the garments as compared to the limit value of 0.001 ppm in MST and 0.01 ppm in ECO-TEX 100 (Fig. 4.5). It can also be inferred that AAS values of mercury at all stages are exceeding the limit values in both ECO-TEX 100 and MST.

Fig. 4.5 : Uptake of Mercury



4.2.5 **Nickel:**

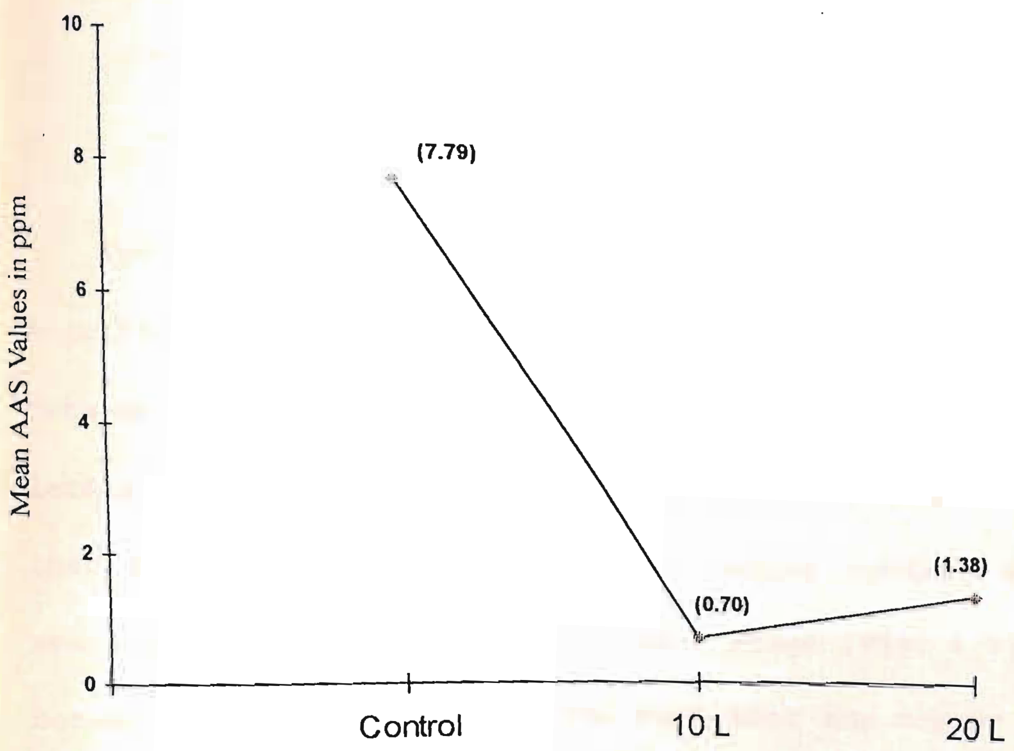
Table 4.7: AAS values of nickel (ppm)

S.No.	Control	10 L	20 L
1.	5.32	0.83	0.67
2.	10.25	0.64	1.30
3.	7.8	0.65	2.19
Mean	7.79	0.70	1.38

One way analysis of variance has revealed that there was significant difference in the uptake of nickel, between 10 and 20 launderings. Further analysis with C.D. values has indicated a significant difference between the tenth and the twentieth laundered sample (at both 5 per cent and 1 per cent levels) and between control and 20 L sample at 1 per cent level of significance.

A comparison of the means in Table 4.7 show a sudden decrease at 10 launderings and a gradual increase at 20 launderings (Fig 4.6). However, it can be observed that the nickel content was far out of the limit (0.20 ppm) prescribed in MST and within the limit of 10 ppm in ECO-TEX 100.

Fig. 4.6 : Uptake of Nickel



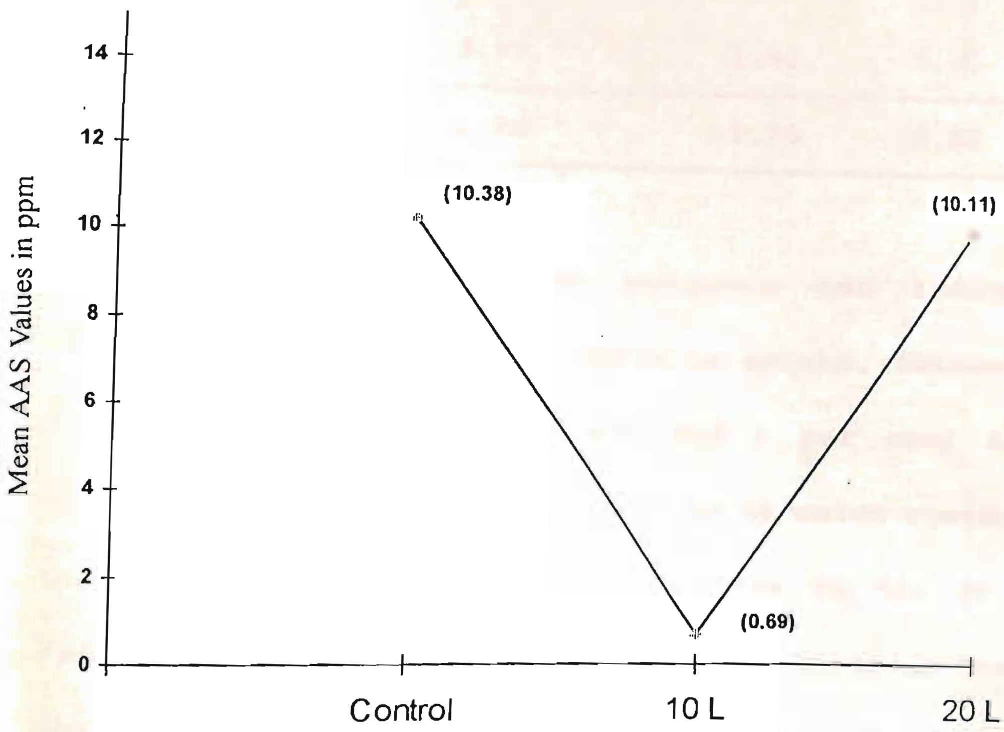
4.2.6 Copper :

Table 4.8: AAS values of copper (ppm)

S.No.	Control	10 L	20 L
1.	13.38	0.60	0.59
2.	12.55	0.20	2.50
3.	5.19	1.27	27.25
Mean	10.37	0.69	10.11

Statistical analysis has shown that there was no significant difference, in the uptake of copper, between 10 L and 20 L both at 5 per cent and 1 per cent levels of significance. It can be observed from Table 4.8 that there was a sudden drop in copper content at 10 L stage and a sudden increase at 20 L stage (Fig. 4.7). It is noteworthy here to mention the fact that the copper content in the samples was exceeding prescribed limit of 3 ppm in MST but was within the limit value of 100 ppm in ECO-TEX 100.

Fig. 4.7 : Uptake of Copper



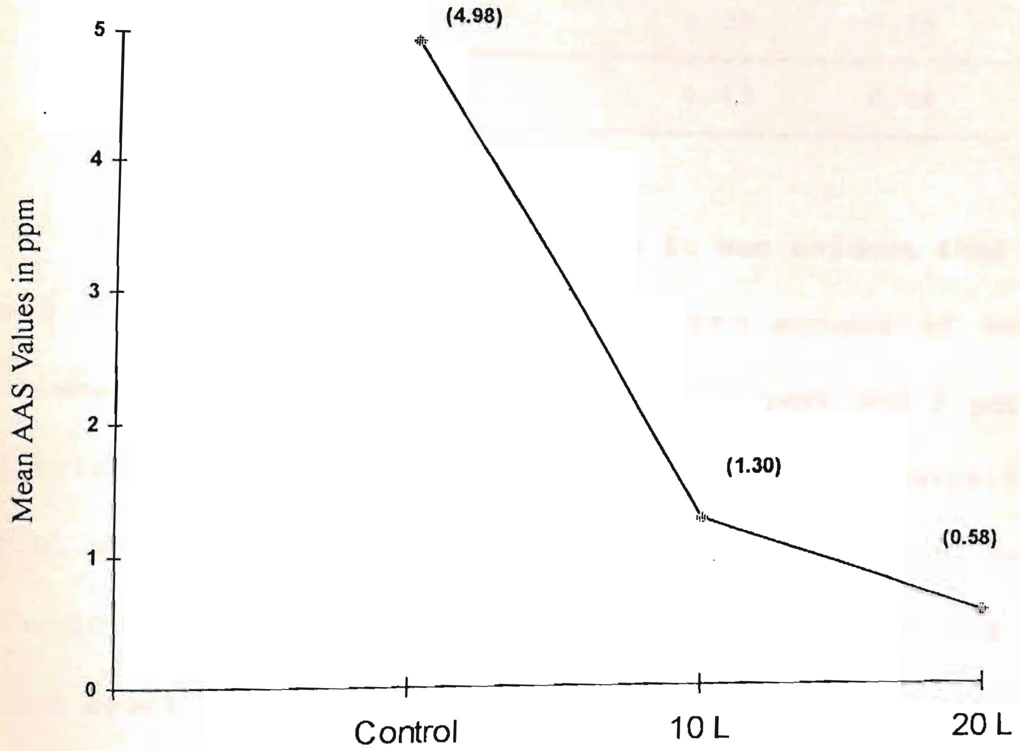
4.2.7 Chromium :

Table 4.9: AAS values of chromium (ppm)

S.No.	Control	10 L	20 L
1.	2.15	2.10	0.58
2.	8.23	0.36	0.78
3.	3.97	1.46	0.40
Mean	4.78	1.30	0.58

One way analysis of variance has indicated no significant difference in chromium uptake, between 10 and 20 launderings at 5 per cent and 1 per cent levels of significance. A gradual decrease in chromium content can be seen in Table 4.9 from control stage to the 20 L stage (Fig. 4.8). It can be noticed that the chromium levels were out of the limit value of 0.1 ppm as in MST but within the limit of 20 ppm in ECO-TEX 100.

Fig. 4.8 : Uptake of Chromium



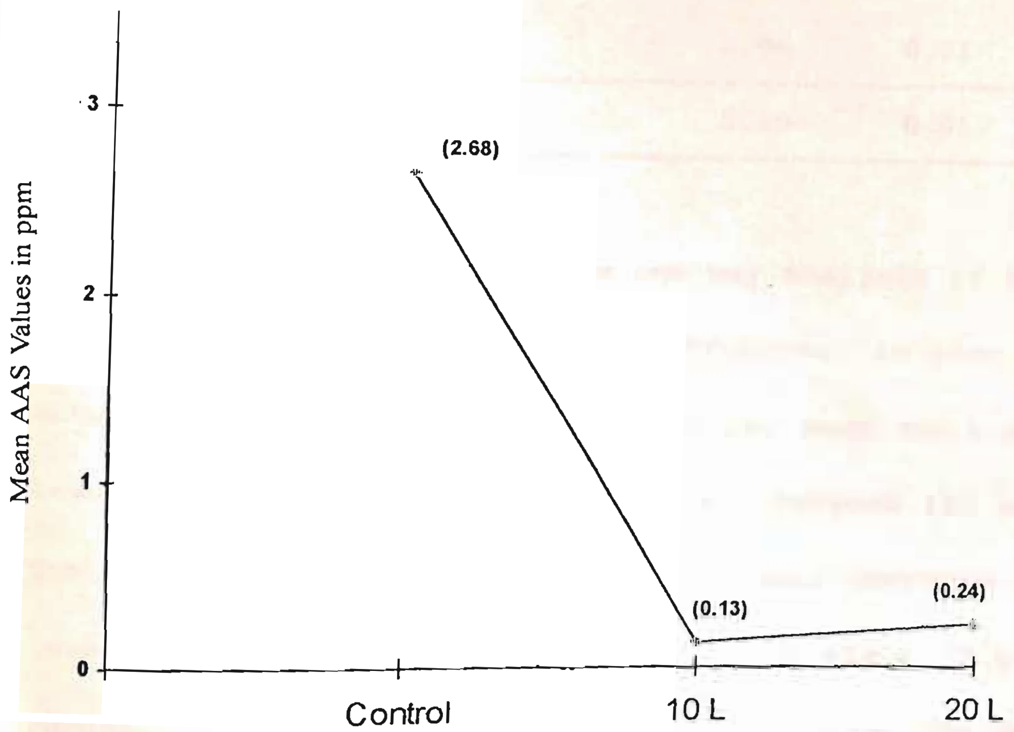
4.2.8 Cobalt:

Table 4.10: AAS values of cobalt (ppm)

S.No.	Control	10 L	20 L
1.	3.52	0.06	0.22
2.	2.06	0.25	0.27
3.	2.46	0.06	0.25
Mean	2.68	0.12	0.24

From the statistical analysis it was evident that there was a significant difference in the uptake of cobalt, between a 10 L and 20 L both at 5 per cent and 1 per cent levels of significance (Table 4.9). Further analysis with C.D. values has exhibited a significant difference between the 10 L and the 20 L stages at both 5 per cent and 1 per cent level of significance. It can be noticed from Fig. 4.9 that a decrease in the cobalt levels could be seen between control and 10 L stages and a slight increase between 10 L and 20 L stages. It is clear from Table 4.2 that mean AAS value of cobalt was beyond the limit (0.20 ppm) of MST at control stage, but within the limit of MST at 20 L stages and even less than the limit of MST at 10 L stage.

Fig. 4.9 : Uptake of Cobalt



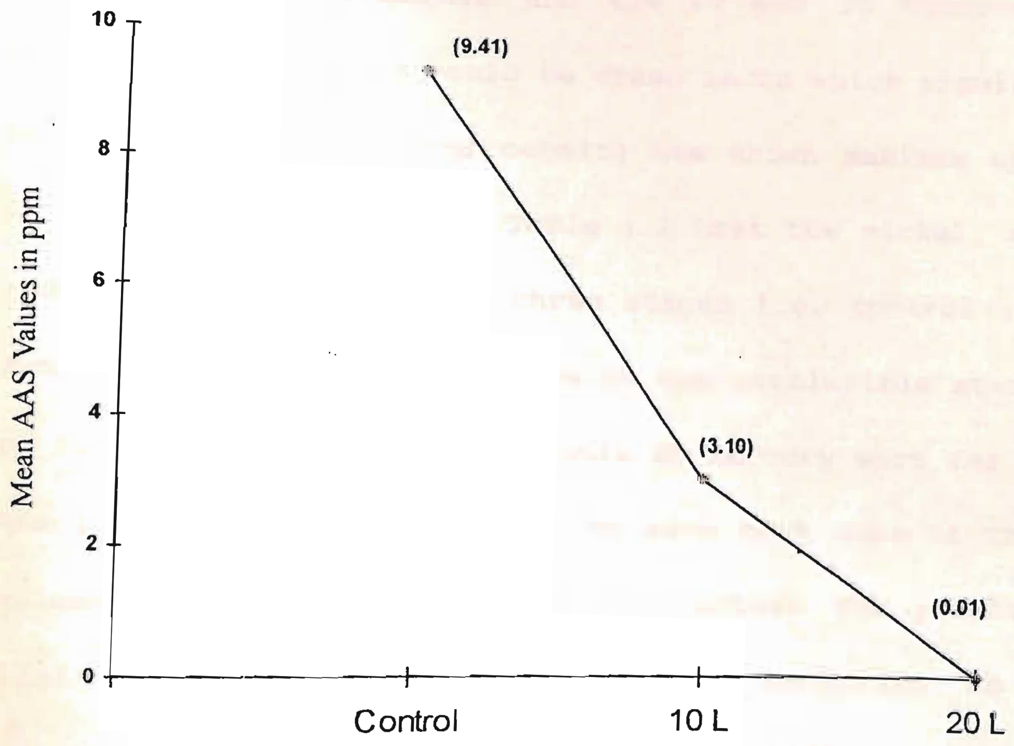
4.2.9 Zinc:

Table 4.11: AAS values of zinc (ppm)

S.No.	Control	10 L	20 L
1.	7.60	4.34	0.01
2.	4.47	0.01	0.01
3.	16.16	4.96	0.01
Mean	9.41	3.10	0.01

It could be observed from one way analysis of variance that there was no significant difference, in Zinc uptake, between 10 and 20 launderings at 5 per cent and 1 per cent levels of significance. A comparison between the means in Table 4.11 show that there was a gradual decrease in Zinc levels from control stage to the 20 L stage (Fig. 4.10) because zinc could easily be removed from the garments through frequent launderings. It can be noted that mean AAS values at both 10 L and 20 L stages were less than limit value (5 ppm) of MST. However, the control AAS value has crossed the limit value (5 ppm) of MST.

Fig. 4.10 : Uptake of Zinc



On an overview of the uptake of heavy metals, it can be deduced that for only three heavy metals viz., lead, nickel and cobalt, there has been significant difference in their uptake, between 10 and 20 launderings. Further, two-way analysis of variance has revealed that there was no significant difference between the three heavy metals viz., lead, nickel and cobalt and the 10 and 20 launderings. Hence, no conclusion could be drawn as to which significant metal (lead, nickel and cobalt) has shown maximum uptake. It is quite obvious from Table 4.2 that the nickel, copper and chromium contents at three stages i.e. control , 10 L and 20 L were in compliance with the permissible standards of ECO-TEX 100, while the levels of mercury were far above the limit value. It can also be seen that none of the AAS values of nine heavy metals were within the permissible limit values of MST. However, an exception to this observation is the mean AAS values of cobalt at 10 L stage.

The results of the present study are unlike those of a study conducted by Dorning and Sehm (1995) where in the levels of lead, cadmium, copper and chromium showed an increase, on exposure to polluted environment. This was demonstrated by means of six case examples taken from everyday wear.

The reasons that have contributed to the metal uptake could be attributed to the combined effects of the detergent powder, the water used for laundering and also the exposure of the T-shirts to the polluted environment, during wear. Chemical analysis of water has not shown any presence of three heavy metals namely Arsenic, chromium and lead (Appendix A). So, water has not played any role in their uptake. Hence, the reason for metal uptake could be attributed to the exposure of garments to polluted environment. This is especially true for lead as its uptake was found to be significant in statistical analysis. This fact has been established in a study conducted by Dorning and Sehm (1995). In pantihose larger than permitted metal content was detected. Pantihose exposed to car exhaust gas for 5 seconds showed a value of 0.44 ppm for lead in contrast to a value of 8.72 ppm on exposure to the same car exhaust gas for 60 seconds while the limit value was 1.0 ppm. This reasoning could further be strengthened from the study of Chinta *et. al* (1995) which says that 40-60% of air pollution was due to means of transportation, 15-25% due to process emissions and industrial fuel burning, 15-20% due to power houses, 5% due to domestic fuel, 1-3% due to refuse burning.

SUMMARY & CONCLUSION

CHAPTER-V

SUMMARY AND CONCLUSION

Rapid industrialisation and various technological developments have added more and more pollutants both to the products and to the environment, without much concern for the protection of the environment and human resources. The rampant usage of chemicals has led to the widespread pollution and a stage has arrived where the environment can no more accept any pollutant without showing a negative impact. Many of these chemicals have been found to be hazardous. Environmentalists are now unanimous in setting up restriction on the unrestricted use of chemicals. These restrictions have taken the form of **'German Ban'**. One of the solutions towards this end has been the production of eco-friendly textiles. These eco-friendly textiles are those products which do not transmit during use under various conditions any toxic products that may directly damage the environment (Banerjee, 1996). This also includes the products from degradation of such eco-friendly textiles. The textile industry has conceived the production of eco-friendly clothing as a strategy to combat pollution. However, the problem of the modern civilization making the natural environment less pure than what eco-logos dictate through their Life-Cycle-Assessment (LCA), remains unanswered. Hence in an attempt to answer the above question, the present study was visualised and planned with the following objectives :

* To know the level of awareness of eco-friendly fabrics among the consumers.

* To test the uptake of heavy metals after 10 L and 20 L.

* To analyse the comparative uptake of heavy metals between 10 L and 20 L.

A consumer survey was carried out with a sample of 30 respondents to know the level of awareness on eco-friendly clothing. For the purpose of the study, six eco-friendly knitted cotton T-shirts were procured. The garments were subjected to a wear study involving six subjects. After a period of 8 hours of wear per day, the garments were home laundered using detergent powder - surf and a steady source of water was used. Three T-shirts were subjected to 10 launderings and the other three were continued till 20 launderings. Heavy metal analysis was done through Atomic Absorption Spectrophotometer at three stages i.e., control, 10 L and 20 L.

The salient findings that emerged from the study were :

All the consumers were aware of eco-friendliness and believed in it because,

* Health and safety of the environment is ensured.
* The risk of pollution of environment is reduced.
* Ecological balance of the environment is maintained.
* Health related problems of people are minimised.
* The natural resources are preserved thereby enhancing nature's productivity.
* Healthy development of human beings is ensured, with the adoption of eco-friendly technology.
* Belief in the fact that 'nature is the ultimate saviour' and that man cannot be harsh towards it.

b) Majority (70 per cent) of the consumers were knowledgeable in eco-friendliness through fabrics, 63.33 per cent through packaging, 53.33 per cent each through foods and dyes, 50 per cent from forests, 46.66 per cent through water, 40 per cent through air, 6.66 per cent through fuel, 3.33 per cent each through bacteria, algae and pencils.

c) About 60 per cent of consumers could become aware of eco-friendliness through exposure to newspapers and journals, 46.66 per cent each through books and periodicals, 43.33 per cent through television, 36.66 per cent through seminars, 33.33 per cent through discussions, 23.33 per cent through radio, 16.66 per cent through workshops and 3.33 per cent through trade fairs.

d) All the respondents chose their clothes depending on color and print, texture, appearance, hand, cost, fashion and labels. All the respondents had the habit of reading the instructions on the label, 76.66 per cent follow these instructions. While only 26.66 per cent came across eco-labelled garments.

About 3.33 per cent of the respondents were of the opinion that eco-labels should be given only to children's garments as they are the most sensitive of all people. Of all the respondents 10 per cent felt that eco-labels be given to adult garments as they can appreciate their worthiness though majority (86.66 per cent) of the consumers opined that eco-labels should be given to garments of all people irrespective of their age as :

* All the people are affected by an imbalance in eco system.

* Health conditions of the people can be improved and ensured.

* Eco-friendly clothing offers protection to both the user and the environment.

* Eco-friendly clothing is like a solution to the inverse input of toxic chemicals.

Among the consumers 80 per cent were interested in buying eco-labelled garments of whom 66.66 per cent were interested to buy them even if they costed more.

) Around 30 per cent of the respondents opined that eco-labelled garments would be accepted by the Mass in India, because,

* Increased awareness about the importance of eco-friendliness.

* Possibility of reduction in health risks and consequent increase in longivity.

* Minimisation of hazards to the environment.

* Eco-friendly clothing would be accepted as something new, if the cost is reasonable.

* 'Green consumers' would readily accept because they are environ-friendly.

* As it is an effort for a good cause namely 'protection of mother nature', eco-friendly clothing would be acceptable.

In contrary, 70 per cent felt that it would not be accepted by the mass because:

* Eco-labelled garments could be costly.
* Existence of information gap between the industrialists and the consumers.
* Poor purchasing power of people.
* Lack of awareness among people due to inaccessibility to eco-information.
* As it is a new idea, people need time to accept it.
* Existence of a misconception among the people that labels are just a window-dressing.

h) For only three of the nine heavy metals namely, lead, nickel and cobalt, there was a significant difference in their uptake between 10 L and 20 L. Among the three metals, no inference could be drawn regarding the metal with highest uptake.

i) It is obvious from the results that nickel, copper and chromium contents were within the prescribed limits of

ECO-TEX 100, excepting of mercury. However, the same cannot be said for all the nine metals, when MST values are taken into consideration.

IMPLICATIONS OF THE STUDY:

1. The study may be useful to consumers in providing information in the field of eco-textiles.

2. The study may be useful to the agencies issuing eco-labels, by helping them restructure the Life-Cycle-Assessment approach.

3. The study may help the environmentalists to intensify their campaign against pollution.

4. The study may prove to be useful for the researchers or research organisations and the industrialists or technologists to reassess the eco-scenario.

SUGGESTIONS FOR FURTHER RESEARCH:

1. As the study was restricted to only eco-friendly cotton garments, further research can be carried out by using other types of fibres, individually or collectively for comparision.

2. The same topic is open for investigation in densely polluted areas (near industries, agricultural farms etc)

and less polluted areas either individually or collectively for comparison.

3. A similar study can be carried out by using water from different sources.

4. Further research can be done in the same area by using various detergent powders.

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APPENDICES

APPENDIX- A

DEPARTMENT OF WATER AND WASTE WATER EXAMINATION
INSTITUTE OF PREVENTIVE MEDICINE, NARAYANGUDA: HYDERABAD 29
ANDHRA PRADESH

REPORT ON CHEMICAL ANALYSIS OF WATER (DRINKING)

Source of water: metro water

RESULTS

Colour....................		clear
Turbidity (J.T.Us).......		Nil
Odour....................		None
pH.......................		8.3
Electrical conductivity... (microhms/cm at ^{o}C)		430

(The following results in milligrams per litre)

	Total Solids	340
Alkalinity as $CaCO_3$	Phonolphthaline....	20
	Methyl Orange......	148
Total hardness (as $CaCO_3$).......		170
Carbonate hardness (as $CaCO_3$)...		148
Calcium (as $CaCO_3$).............		65
Ammonical Nitrogen.............		Nil
Albunoid Nitrogen...............		---
Oxygen consumed from $KMnO_4$...... (In 4 hours at $37^{o}C$)		0.5
Chloride (as Cl)................		30
Flouride (as F).................		0.4

Nitrate (as NO_5)................	Nil
Nitrites	Nil
Phosphate (as PO_4)..............	Nil
Sulphate (as SO_4)...............	Nil
Iron (as Fe)...................	Nil
Manganese (as Mn)..............	Nil
Poisonous metals (As, Cr^+, Pb)..	Nil

APPENDIX-B

INTERVIEW SCHEDULE

Measuring the level of awareness regarding eco-friendly fabrics.

A. GENERAL INFORMATION:

1. Name :
2. Age :
3. Education : Secondary / Higher Secondary / Intermediate/ UG / PG / Ph.D / MBA / MCA
4. Occupation :
5. Residential Address :

B. SPECIFIC INFORMATION :

1. Are you aware of eco-friendliness ? Yes / No
2. In what context have you heard about it ? (Please tick)
   - Water
   - Air
   - Forests
   - Foods
   - Packaging
   - Fabrics / Garments
   - Any other (specify) -------------

3. How did you come to know about eco-friendliness ? (Please tick)

- Television
- Newspapers
- Journals
- Periodicals
- Books
- Discussions
- Seminars
- Workshops
- Any other (specify) ---------------

4. Do you believe in eco-friendliness ?

If yes, why --

If No, why --

----

5. Which of the following criteria would you look for, while purchasing clothes (Please tick).

- Labels
- Colour & Print
- Texture
- Appearance
- Hand
- Cost
- Fashion
- All

6. Do you have the habit of reading the indications in the labels ? Yes / No

7. Do you generally follow the instructions given in the label ? Yes / No

8. Do you have confidence in the labelled products ?

Yes / No

9. Have you come across any eco-labelled garment? Yes / No

10. To what age group, in your opinion, should eco-labels be given (Please tick).

- Babies / Children
- Adults
- Elderly
- All

Give reasons --

----

11. If you come across any eco-friendly garment / fabric

a. Would you be interested in buying them ? Yes / No

b. Would you buy them even if the cost is more when compared to other garments, inspite of there being no visible change in the look of the garment ?

Yes / No

12. Do you think that eco-labelled garments will be acceptable to the masses, in India. Yes / No

If yes why ---

If no why --

-Thank You-

APPENDIX - C

ANALYSIS OF VARIANCE - ONE WAY CLASSIFICATION

Null Hypothesis : There is no significant difference in cobalt uptake, between 10 L and 20 L, of the eco-friendly garments.

Table-4.10: AAS values of cobalt (ppm)

S.NO.	Control	10 L	20 L	Grand Total
1.	3.52	0.06	0.22	
2.	2.06	0.25	0.27	
3.	2.46	0.06	0.25	
Total	8.04	0.37	0.74	9.15
Mean	2.68	0.12	0.24	

Grand Total 'G' = 9.15

Total Number of Observations 'N' = 9

Correction Factor [C.F] $= \frac{G^2}{N}$

$= \frac{(9.15)^2}{9}$

= 9.30

T.S.S. $= (X^2_1 + X^2_2 + \ldots\ldots\ldots + X^2_9) - C.F$

= 22.91 - 9.30

= 13.61

Tr.S.S $= \frac{1}{3} (t^2_1 + t^2_2 + t^2_3) -- C.F$

= 21.77 - 9.30

= 12.47

E.S.S. = T.S.S. - Tr.S.S.

= 13.61 - 12.47

= 1.14

ANOVA

Source	d.f.	S.S.	M.S.S	F (cal)	F(tab) 5%	F(tab) 1%	t(tab) 5%	t(tab) 1%
Between launderings	2	12.47	6.23	32.78	5.14	10.92	2.45	3.71
Error	6	1.14	0.19					
Total	8	13.61						

Conclusion : As the F calculated value (32.78) is greater than F tabulated value at 2, 6 degrees of freedom 5.14 (at 5% level) and 10.92 (at 1% level), the null hypothesis is rejected. Hence, there is significant difference between 10 and 20 launderings.

The means of the samples were arranged in the descending order of magnitude and the difference between each pair of means was compared with the critical difference (C.D.) value.

$$\text{C.D.} = t_{2,6} \times \sqrt{\frac{2 \cdot (\text{E.M.S.})}{3}}$$

C.D. (at 5% level) $= 2.45 \times \sqrt{\frac{2 \times 0.19}{3}}$

$= 0.85$

C.D. (at 1% level) $= 3.71 \times \sqrt{\frac{2 \times 0.19}{3}}$

$= 1.29$

The means of the samples :

Control	20 L	10 L
2.68	0.24	0.12

As the C.D value at both 5 per cent and 1 per cent level of significance was less than the difference between the means of control and 10 L, there was a significant difference between the control and 20 L.

APPENDIX-D

(ANALYSIS OF VARIANCE-TWO-WAY CLASSIFICATION)

Null Hypothesis : There is no significant difference between ASS means of launderings at 10 L and 20 L stages and the metals cobalt, nickel, and lead.

Table-I AAS values at three stages for cobalt, nickel and lead

S.NO.	Metal	Control	10 L	20 L	Total
1.	Cobalt	2.68	0.12	0.24	3.04
2.	Nickel	7.79	0.70	1.38	9.87
3.	Lead	9.43	15.08	1.23	25.74
Total		19.9	15.9	2.85	38.65

Grand Total 'G' = 38.65

Total number of observations 'N' = 9

$$C.F. = \frac{G^2}{N} = \frac{(38.65)^2}{9} = 165.98$$

$$T.S.S. = (X^2{}_1 + X^2{}_2 + \ldots\ldots.. + X^2{}_9) - C.F = 222.16$$

$$Tr.S.S. = \frac{1}{3}[(3.04)^2 + (9.87)^2 + (25.74)^2] - 165.98 = 90.41$$

$$B.S.S. = \frac{1}{3}[(19.9)^2 + (15.9)^2 + (2.85)^2] - 165.98 = 53$$

$$E.S.S. = T.S.S. - [Tr.S.S. + B.S.S.] = 78.75$$

ANOVA

Source	d.f.	S.S.	M.S.S	F (cal)	F(tab) 5%	F(tab) 1%
Between launderings	2	53	26.50	1.34	6.94	18.00
Between metals	2	90.41	45.20	2.29		
Error	4	78.75	19.68			
Total	8	222.16				

Conclusion : As the F calculated value is less than the F tabulated value at 2,4 degrees of freedom, the null hypothesis is accepted. Hence, there is no significant difference between the three metals and 10 L and 20 L.