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Toxic textile dyes

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ABSTRACT

This article provides a brief view about toxicity of textile dyes. This article discusses health hazards associated with textile dyes used throughout the world. Mutagenicity of azo and non-azo dyes has been considered these days. The discussion in the article also concerns the harmful activities of the dyes containing formaldehyde, heavy metals, halogen carriers etc. The data about permissible limit of these chemicals has also been discussed here

Key Words : Toxicity, Textile dyes, Azo dyes, Mutagenicity heavy metals, Formaldehyde

INTRODUCTION

Color is an important aspect of human world. We like to wear clothes of all kinds of colors and hues, eat food decorated with colors, even our medicines are colorful (Ratna and Padhi, 2012). Textiles can be colored by means of synthetic or natural dyes. India's dye industry produces every type of dyes and pigments. Production of dyestuffs in India is close to 80,000 tones. India is the second largest exporter of dyestuffs and intermediates developing countries after China (Jahnavi, 2012). Thus; textile dyeing industry plays a very important role in textile processing industry. Findings of researches conducted in recent years showed that chemicals used in synthetic dyes may contain toxic elements. Toxicity of dye adversely affects health of human being as well as other living being so study related to toxicity of dyes is very important.

Toxicology is the study of the adverse effects of various agents on human beings and other living organisms. A simple way to think about it is the science of poisons. So it can be said that toxicity is the Sum of adverse effects or the degree of danger posed by a substance or mixture of substance to living organisms over the length of time. Medical research has expanded the knowledge of how toxic agents and toxic levels of toxic agents do damage to the body's cells, organs and biochemical (the substances needed to maintain body functions). It is now widely recognized that virtually all toxic effects are caused by alterations in specific molecules in cells and biochemical, doses or length of exposure, presence of other chemicals in the affected body part, route of exposure to a toxic substance.

Thus, toxicity is expressed generally as a dose response relationship involving

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the quantity of substance to which the organism is exposed and the route of exposure like skin (absorption), mouth (ingestion), or respiratory tract (inhalation). The route of exposure to a toxic substance is important. Ingested chemicals may be completely neutralized by the liver, but the same substance absorbed by the skin may be harmful as toxic agents would enter the blood stream directly, circulate throughout the body first before being detoxified by the liver.

There can be different target organs depending on the route of exposure. The adverse effects take place in an organism through a single or short-term exposure. Sometimes they last the entire life of an exposed organism. During the last decade, environmental issues associated with dyestuff production and application have grown significantly and are indisputably among the major driving forces affecting the textile dye industry today. The textile dyes disposed off can be found in dissolved state or in suspension in the waste water. These dyestuffs are highly structured polymers and are very difficult to decompose biologically (Bruin, 1976).

Toxicity is classified usually as:

– **Acute**: harmful effects produced through a single or short-term exposure.

– **Chronic**: harmful effects produced through repeated or continuous exposure over an extended period.

– **Sub-chronic**: harmful effects produced through repeated or continuous exposure over twelve months or more but less than the normal lifespan of the organism.

Dye toxicity :

Some dyes are toxic and others are non-toxic. Various textile items which come in contact with the human body must not be dyed which are known or suspected to release toxic elements beyond the permissible limit. According to some research findings the banned dyes and their permissible limits are as follows:

Azo dyes :

Azo dyes are the largest and most versatile class of dyes, which share more than 50% of the dyes produced annually. These are extensively used because they give brilliant colors with good fastness properties at lower cost. For dye manufacturing, textile dyeing, color paper printing and leather dyeing, benzidine based azo dyes are used.

The International Agency for Research on Cancer (IARC) has classified various dyes like Benzidine as being associated with cancer in human (Jamuna, 2008). Benzidine has long been recognized as a human urinary bladder carcinogen and tumorigenic in living being. Benzidine is known to be carcinogenic to a variety of mammalian species, including human. A number of dyes have been tested for mutagenicity of DNA. Several of them have been found to be carcinogenic (Lowry *et al.*,1951).

When azo dyed textile materials come in contact with human skin it releases aryl amines that are allergic and poisonous in nature. Reactive azo dyes occur in textile dye-house wastewater in concentrations ranging from 5 to 1500 mg l^{-1} due to their poor fixation to fabrics (Pierce, 1994). But if azo dyes are used within permissible limit (30 mg/kg) they do not leave toxic effect.

Table 1 : Eco parameters of textile materials

Parameter	Permissible limit	Potential health effects	Sources
Azo dyes	30 mg/kg	Increased risk of cancer	Cleavage of azo dyes, azoic dyes and azoic diazo components used in azoic dyeing
Pentachlorophenal	0.5 mg/kg	Cause irritation to upper respiratory tract and eyes	Preservatives used in printing gum, sizing ingredients etc.
Halogen carriers	----	Affects the nervous systems	Carrier dyeing of synthetics fibre.
Heavy metals	0.01 mg/kg	Skin damage, circulator systems problems, increased risk of cancer	Dyes, mordants and finishing agents.
Arsenic			
Lead	0.04 mg/kg	Delays in physical and mental development in children, kidney problems high blood pressure.	
Cadmium	0.005 mg/kg	Kidney damage	
Zinc	5.0 mg/kg	……	
Mercury	0.01 mg/kg	Kidney damage	
Nickel	0.2 mg/kg	Increased risk of cancer	
Chromimum	0.1 mg/kg	Allergic dermatitis, increased risk of cancer	
Cobalt	0.2 mg/kg	Increased risk of cancer	
Copper	3.0 mg/kg	Liver or kidney damage	
Formaldehyde			Formaldehyde used as dye fixing agents, urea formaldehyde resins used in textile finishing
Baby clothing	20 mg/kg	Skin irritation	
Close to skin	75 mg/kg	Skin irritation	
Outer wear	300 mg/kg	Skin irritation	

Source: Central Silk Technological Research Institute. 2003. "Eco parameters of textile materials" Central Silk Board, Bangalore. pp 17-19. (Central Silk Technological Research Institute, 2003)

Heavy metals :

Heavy metals are chemical elements that have a specific gravity (a measure of density) at least five times that of water[3]. The heavy metals most often implicated in human poisoning are lead, mercury, arsenic, and cadmium. Heavy metals may enter the body in food, water, air, or by absorption through the skin. Once in the body, they compete with and displace essential minerals such as zinc, copper, magnesium, and calcium, and interfere with organ system function. People may come in contact with heavy metals in industrial work, pharmaceutical manufacturing, and agriculture.

Children may be poisoned as a result of playing in contaminated soil (Anonymus, 2004). Children exposed to lead at a young age are more likely to suffer from shorter attention spans and are less able to read and learn than their peers (Anonymus, 2000). Excess of chromium (more than 0.1mg/kg) causes allergic dermatitis and cancer. Cadmium may lead to kidney damage while copper may damage both kidney and liver.

Textile products contain some organic and inorganic substance including trace metal ions. Especially, reactive and pigment dyes contain trace heavy metals at high level. Trace metals may be health risks for human even at low concentrations in textile products (Nylor, 1995). Traces of heavy metals are often present in different textile process such as metal complex dyes, dye stripping agents oxidizing compounds, antifungal, odor preventive agents and mordant reactive (Nemerow and Dasgupta 1991). Toxic and allergic metals including cadmium, copper, nickel zinc, and chemicals like formaldehyde and chlorinated hydrocarbons can exist in natural structures of textiles or they can penetrate into the textiles during the production, dyeing process or via the protection agents used for the storage of these textiles (Nettles, 1983 and Nordberg, 1987).

Because of positive and negative effects and the toxicity of trace heavy metals on human health and the environment, many researchers have studied the analysis of the trace metal contents of environmental and industrial samples including textile products (Rao, 1955 and Somnath, 2002).

Formaldehyde :

Formaldehyde is dye fixing agent used in dyeing of textile fabrics. Urea formaldehyde resins are applied during textile finishing. Permissible limit of Formaldehyde for baby clothing is 20mg/kg. For other population the permissible limit of formaldehyde for inner wear is 75mg/kg while for outer wears it is 300 mg/kg. Excess amount of formaldehyde over than permissible limit results in skin irritation and skin allergy.

Halogen carriers:

Halogen carriers include iron, iron chloride, aluminium chloride. They are used as carrier in dyeing of synthetic fibre. Presence of halogen carrier affects nervous system. That is why they are banned.

Pentachlorophenol (PCP)

To prevent mold spots caused by fungi, chlorinated phenols like PCP are applied directly on textiles and leather. It is mainly used in outdoor textile like tents, sails, tarpaulins, ropes and army uniforms made from textile fibers such as wool, cotton, linen and jute. The PCP treated textile is dyed and processed further. In these instances, PCP will remain in the finished textiles.

PCP is toxic when it is inhaled, swallowed or come in contact with human skin. When level of PCP in textile is more than 0.5 mg/kg it causes irritation to upper respiratory track, eyes and damage the cardiovascular system, blood and liver when inhaled by humans. Additionally, PCP has impacts on the immune system and central nervous system.

Decomposition of the sodium salt in PCP (NaPCP) into PCP and bioaccumulation depends heavily on pH value. The effects of hazardous substances are very serious because they are persistent, they bioaccumulation and/or are toxic (for example, they can cause harm to the reproductive system and be carcinogenic). This means that the effects must be deemed irreversible. Hazardous substances are a serious threat to the health of future generations, to the environment and future food safety. Hazardous substances accumulate

in nature and in the food we eat and possess properties that make it too late to take measures once the damage is done (Norway, 2010).

Conclusion :

The textile industries use synthetic dyes. These chemicals are used in an attempt to make more attractive popular shades of fabrics for a competitive market. The textile industries are to satisfy the ever growing demands in terms of quality, variety, fastness and other technical requirements, but the use of dye stuffs has become increasingly a subject of environmental concern. Colorfastness properties of dye, though do not form the part of eco character, have a direct bearing on the eco norms as the bleeding of color due to washing, perspiration, exposure to sunlight, rubbing etc. can contribute for hazardous features.

These quality parameters need to be tested as per standard methods of testing so that harmful effect of the dye on living being can be estimated and when a dye is found having harmful effects need to be banned. Therefore, various regulations have been designated to improve the health and safety of the human and natural environment. Many of the dyes and their intermediates have been banned in countries like U.K. and Germany. Their manufacture is now prohibited or closely regulated.

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