



OCCUPATIONAL HEALTH HAZARDS AND SAFETY MEASURES IN TEXTILE DYEING INDUSTRY: A REVIEW

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ABSTRACT

Textile industries in order to give finished cotton, undergo several processes one among them is dyeing process. The dyeing process is the most hazards process among all the textile industry processes. The hazards are caused due to the chemicals used in the dyeing. The chemicals as a common have some hazards which will lead to severe effects when they are exposed continuously as well as leading to fire when not stored properly. The improper treatment of water leads to the effect of water streams thus affecting both aquatic and terrestrial life. Dyes are further classified into several other classes of dyes each dye has its own hazards based on the different chemicals used in the dye class. Some of these very hazard's chemicals include benzidine, hydro's, potassium dichromate, alkyl amine, etc. Thus it's very important to know about the various hazards that we are exposed to due to dyeing process as well hazards that is caused due to usage of substrate that are dyed using highly toxic materials. A key role in the textile process is occupational health and safety. In the textile industry, occupational health and safety is evolving to promote the health and safety for workers in India. People are unaware of health and safety as workers are uneducated, promoting occupational health and safety in the textile industry and so little attention to management. To prevent the health problems of workers in the textile industry, it is important for workers to be aware of the various occupational hazards in the industry. Management must take several control measures to protect the workers from hazardous conditions.

INDEX TERMS: Dyeing process, Textile industry, Occupational health, Hazards, Health problems, Control measures

INTRODUCTION

Growing environmental pollution resulting from rapid industrial development is one of the challenges faced by the modern world. Overpopulation and environmental pollution are two rate-limiting factors for industrialization. Among all the industries, dye manufacturing industries and textile industries are the largest source of dye-containing effluent for which the discharge generates serious environmental threats. Such industrial units are functioning in small or medium scales with high employment generation and foreign exchange potential.

The textile dyeing industry has been in existence for over 4000 years. Since 1856, tens of thousands of dyes have been synthesized. Well over one thousand dyes are commercially available now. Dye is an integral to imparting color to materials. Textile industries consume a major share of dyes in India. Further, the textile industry of India also contributes 14% of the total industrial production of the country. Synthetic dyes are used in many spheres of our everyday life, and their applications are continuously growing in various industries such as textiles, leather, cosmetics, paper, paint, and food. Approximately 10,000 different dyes and pigments are used industrially, and over 0.7 million tons of synthetic dyes are produced annually (*Sujata Mani and Ram Naresh Bharagava, 2018*). It is very important to know about the various hazards that we are exposed to due to dyeing process as well as hazards that are caused due to usage of substrate that are dyed using highly toxic materials (*Sandeep k g1, Dr Subrata das2, 2019*).

OCCUPATIONAL HEALTH

People's health is related to occupation. Occupational health and safety are a complete part of the common notion of health that is a part of socioeconomic development. Occupational health affects everyone directly or indirectly (*Subash K 1, Dr Subrata Das2, 2019*).

OCCUPATIONAL HEALTH IN TEXTILE INDUSTRIES

Occupational health is concerned with the health safety issues of work. The hazards exposure in setting can adversely affect human health. This is a Global burden of occupational diseases and injury in textile industry (*Pl. Sridevi Sivakami, K Janani, 2023*). After farming, the textile is the 2nd largest industry, in terms of the number of workers employed in the industry. In textile industry it is classified into 3 sectors: spinning, weaving and finishing. In the textile industry there are a lot of safety and health problems involved. Three factors are used to promote safety such as probability of the occurrence of injury or illness, severity of the cases preventive and corrective measures. Unsafe act (operates the machines without guards, runes at unsafe speed), Unsafe conditions (high noise, improper ventilation, improper illumination), Improper material handling these are caused by the accidents.

COMMON HAZARDS DUE TO DYEING PROCESS:

FIRE HAZARD:

Fire hazards are one of the common hazards that prevail in the dyeing industries. The use of flammable liquids without any prior precautions such as improper storage facilities; not properly designed storerooms, not constructed of fire resistance materials with a raised and ramped sill in the doorway thus letting all the liquid to flow to the ignition region and causing a massive fire. The presence of oxidizing agents such as hydrogen peroxide may lead to an increase in the intensity of the fire by fueling with oxygen. The presence of large quantities of dry fabrics and paper may also lead to huge fires. Insulation damage in electrical wiring may also cause fire.

ACCIDENTS:

When a hot liquor is admitted in to the kier where the worker has been arranging the clothes that are to be treated may be affected by serious burn injuries(scalding). This mostly occurs when the valves are accidentally opened or when the hot liquor is discharged through the common duct.

CHEMICAL HAZARDS:

The use of chemicals such as hypochlorite used as bleaching solution possess gaseous chlorine substances. When the workers meet dangerous levels of chlorine they develop skin irritation, mucous membrane gets affected and thus leads to pulmonary tissue damage thus causing lung edema. The acid and alkalis used in dying process for treatment of cloth with boiling liquor exposes the workers are risk to the burns and scalds. The chips flying from metals like chromium become hazardous when it strikes the person. Aromatic amines used in dying industries have the capability of DNA mutation. Most of the dye stuff used in the industries are skin irritants.

HAZARDS BASED ON CLASSES OF DYES

Acid or base dyes are used for wool, silk or cotton. Direct dyes are very fast and used in wool and rayon. The Sulphur dyes are used on cellulosic materials. Next is azo type dye this is created by dissolving naphthol in aqueous caustic soda. The Vat dyes are made into leuco compounds with sodium hydroxide and sodium hydrosulphite. Disperse dye is used for all synthetic fibers. While the mineral dyes are inorganic pigments which

are salts of iron and chromium. Reactive dyes are used in hot or cold baths of soda ash and common salt for cotton. Each class of dyes has its own hazards associated with them based on the chemicals used.

SULFUR DYE:

Sulfur dyes are synthetic organic substantive materials dyes for cellulosic. Sulphur dyes are water insoluble dyes hence they're made soluble by addition of alkaline compounds such as sodium sulphide or sodium hydrosulphide which acts as a reducing agent. It also uses oxidizing agents such as sodium dichromate and hydrogen peroxide. The oxidizing agents used are mostly bleaching agents, the chemical reaction of peroxide bleaching must be controlled by adding the agents constantly rather at a single flow which may lead to oxygen evolution due to decomposition of hydrogen peroxide. When the oxygen level increases than that of the relief device can withstand it leads to severe vessel failure. Thus, the reducing agents generate more heat leading to explosion. Formaldehyde is also one of the reducing agents, the exposure of formaldehyde will lead to cancer on nose, lung and brain. It also causes respiratory difficulties and eczema (patches on skin with bleeding).

AZO DYES:

These dyes are the most used colorants in the textile industries. The main constitute of azo dyes are aromatic amines. The azo dyes are formed by diazotization in which the aromatic amines are converted to diazonium salts further which undergoes a coupling reaction. The azo dyes contain $-N=N-$. These $-N=N$ undergoes the bond breakage to form $-NH_2$ which is called as amine. Amines are carcinogenic in nature thus causing cancer. There are 24 banned amines which are considered very hazardous when a person meets these kinds of amines. Humans get exposed to banned amines either by direct or exposure of skin to these garments. Ingestion occurs due to sweating which leads the amines to migrate in the body. These thus cause mutagenic changes in the human body.

REACTIVE DYES

Reactive dyes are used for cotton. They possess a high degree of wetness. Due to this property this acts the similar way on fibers when ingested into the body. Two common hazards caused due to reactive dyes are respiratory sensitization and skin sensitization. Symptoms of respiratory sensitization are watering eyes, running nose and blocked airway and it causes symptoms of asthma like unusual breathlessness. When the exposure level of reactive dyes continues even after unusual breathlessness problems it may cause occupational asthma which may lead to death.

MINERAL DYES

Natural dyes obtained from any minerals like red rock are known as mineral dyes. These mineral dyes do not have the property of mordant towards the fabrics hence they use metals like chromium and inorganic pigments of salt iron. Mostly the metals are micronutrients, but in soluble form they become poisonous on organisms. Thus, depending on the dosage level, the metal deposits on bones or tissues and blocks the activity of enzymes further replacing elements like calcium by lead. This also causes damage to DNA protein. Chromium used in textile industry becomes very hazards when people meet the continuous exposure. They might lead to skin rashes, respiratory problems, kidney and liver damage and on a continuous exposure it may lead to lung cancer also.

DISPERSE DYE:

Disperse dyes are only insoluble dyes they are used in polyester. It's basically based on azobenzene. These dyes are possible to create some reactions when they meet human bodies. This allergy towards disperse dyes was noticed in 1868. In 1940 nylon stockings were introduced in America which on continuous survey lead to many allergic contact dermatitis problems due to use of disperse dyes like disperse blue 124. Due to improper effluent treatment this lead to many aquatic problems by increasing the toxic levels of water stream making aquatic life a pathetic situation.

VAT DYES

Dyes like indigo are applied after alkaline reduction which are classified as vat dyes. The effluent from this process contains residuals like dyestuff, reducing agents and oxidizing agents. This dyestuff creates skin irritation. The reducing agent like sodium hydrosulphite used when contaminated with water generates heat and might lead to ignition. Among all the classes of dyes, vat dyes are less toxic to the environment.

DIRECT DYES

As the name suggests, the dye is directly applied to the cellulosic material without any use of mordants. Dyeing with direct dyes requires salt thus the wastewater obtained from this process contains a dyestuff of 5% to 20% thus affecting the water streams. Some direct dyes are made of nitrogen compounds which are considered to possess carcinogenic agents in them thus leading to cancer on continuous exposure.

HAZARDS IN WATER STREAM:

Improper effluent treatment in the textile industries is a major reason for water pollution. The sludges that are formed are not treated properly and let in to the water stream thus not letting sunlight pass through the surface of the water body thus providing required oxygen level to the aquatic creatures. Azo dyes if they are not properly treated, may be carcinogenic or mutagenic thus endangering human health (*Sandeep K G1, Dr Subrata Das2, 2019*).

WATER CONSUMPTION IN TEXTILE INDUSTRY

The textile dyeing and finishing industry has created a huge pollution problem as it is one of the most chemical intensive industries on earth, and the No. 1 polluter of clean water (after agriculture). More than 3600 individual textile dyes are being manufactured by the industry today. The industry is using more than 8000 chemicals in various processes of textile manufacture including dyeing and printing. A fraction of these is listed in **Table 1**. Many of these chemicals are poisonous and damaging to human health directly or indirectly. Large quantities of water are required for textile processing, dyeing and printing. The daily water consumption of an average sized textile mill having a production of about 8000 kg of fabric per day is about 1.6 million liters. 16% of this is consumed in dyeing and 8% in printing. Specific water consumption for dyeing varies from 30 - 50 liters per kg of cloth depending on the type of dye used. The overall water consumption of yarn dyeing is about 60 liters per kg of yarn. Dyeing section contributes to 15% - 20% of the total waste water flow. Water is also required for washing the dyed and printed fabric and yarn to achieve washing fastness and bright backgrounds. Washing agents like caustic soda-based soaps; enzymes etc. are used for this purpose. This removes the surplus color and paste from the substrate. Water is also needed for cleaning the printing machines to remove loose color paste from printing blankets, printing screens and dyeing vessels. It takes about 500 gallons of water to produce enough fabric to cover one sofa. The World Bank estimates that 17 to 20 percent of industrial water pollution comes from textile dyeing and finishing treatment given to fabric. Some 72 toxic chemicals have been identified in water solely from textile dyeing, 30 of which cannot be removed. This represents an appalling environmental problem for the clothing and textile manufacturers (*Rita Kant, 2012*).

Table 1. Major chemicals and dyes used in synthetic textile mills.

S No.	Chemical	Quantity Kg/month
1	Acetic Acid	1611
2	Ammonium Sulphate	858
3	P V Acetate	954
4	Wetting Agent	125
5	Caustic Soda	6212
6	Softener	856
7	Organic Solvent	247
8	Organic Resin	5115
9	Formic Acid	1227
10	Soap	154
11	Hydrosulphites	6563
12	Hydrochloric Acid	309
13	Hydrogen Peroxide	1038
14	Leveling & Dispersing Agent	547
15	Solvent 1425	321
16	Oxalic Acid	471

17	Polyethylene Emulsion	1174
18	Sulphuric Acid	678
19	Disperse Dyes (Polyester)	1500
20	Vat Dyes (Viscose)	900
21	Sulphur Dyes	300
22	Reactive Dyes	45

ADOPTION OF BEST PRACTICES

REDUCING AND RECYCLING WATER

It is important to remove the various pollutants from wastewater before their final disposal. By reducing all forms of wastewater industries can cut costs and improve profits. It has been suggested that most companies can save 20% - 50% expenditure on water and effluent treatment charges by reducing their water use. After identifying where the potential water savings can be made the next step is to introduce appropriate water saving measures like reuse of water. This consists of rinsing the product in a series of tanks, each using progressively clean water. The rinse water is reused by moving it progressively from the last rinse tank towards first. Wash water may also be suitable for reuse elsewhere on the site such as for floor washing, rinsing containers etc.

AWARENESS TO GO GREEN

We must change the ways fabric is made and finished. We need to produce luxurious, sensuous fabric in ways that are non-toxic, ethical and sustainable. Environmentally appealing technologies should be made available to mainstream manufacturers. Efforts are needed to raise people's consciousness about the far-reaching implications of their textile choices. We can see the growing consumer consciousness to purchase eco-friendly clothing, drapes, or even carpets. A company cannot claim to sell a "green" shirt if the dyeing process used to color the garment wastes and pollutes water. Thus, this new wave for eco friendly products is throwing a major challenge to several apparel manufacturers. Some companies have taken action and stopped using dyes on certain garments, but again, it everyone would not be happy with only off-white and beige colors to choose from. Consumers want color and variety in their clothing (*Rita Kant, 2012*).

AIR DYEING TECHNOLOGY

This technology seems to be a permanent method, which uses air instead of water for dyeing garments and ultimately allows companies to create vivid designs and colors of garments without polluting the water and environment. As air is an ideal transport medium, airflow is the main key element in this technology. This replacement of dye liquor with air in jet-dyeing machines was a big step toward reducing water and chemical consumptions. The air dyeing technology works on the principle of using mass flow, which provides a major improvement in the fabric hank lying, which prevents creasing (*Sujata Mani and Ram Naresh Bharagava, 2018*).

CHALLENGES AND FUTURE PROSPECTS

The complex nature of wastewater is the major problem in its treatment because of the presence of complex dye groups and other poor or non-biodegradable recalcitrant pollutants. Textile wastewater not only consists of recalcitrant molecules but also toxic heavy metals with powerful inhibitory and antimicrobial activity. For complete degradation and detoxification, the nature and toxicity of the recalcitrant pollutants should be explained. Further, studies should also be conducted on the toxicity of the decolorized wastewater (*Sujata Mani and Ram Naresh Bharagava, 2018*).

CONCLUSION

The use of synthetic dyes in place of natural dyes due to their cost effectiveness, substantivity on fabrics, easy dispersion of dyes, etc., lead to the depletion of natural dyes. Though the synthetic dyes possess the most advantages than the natural dye it withholds the severe disadvantage, that's the hazardous nature of it, towards the environment. There are several chemicals used in each class of dyes and no chemical is proven eco-friendly. Though the natural dyes are evolving now a days they don't have important property of mordant on fibers. Thus, this leads to the use of mineral dyes and making natural dyes also hazardous. Thus, in no way dyeing process can be considered an eco-friendly process. To prevent the health problems of workers in the textile industry, it is

important for workers to be aware of the various occupational hazards in the industry. Management must take several control measures to protect the workers from hazardous conditions.

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