REVIEW PAPER: IMPACT OF TEXTILE INDUSTRY ON ENVIRONMENT

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Abstract

Dyeing stages involved in textile processing are considered to be one of the major contributors to Environmental pollution. Dyes being highly persistent due to the chemical composition are considered to be one of the most detrimental groups. Textile manufacturing is one of the largest industrial process that uses water, many hazardous chemicals like formaldehyde, azo dyes chlorinated compounds and man power. Many of these chemicals are poisonous and damaging to environment and human health. Textile industry is hazardous soil, water, air and will pose huge threats to humans and environment if the problems in Textile industries are not countered successfully. This review paper thus emphasizes on the different types of environment pollution caused by Textile Industries.

Keywords: Environmental Pollution, Textile Industry, effluents, Dyes

1. Introduction

After agriculture, the textile sector in India creates the second-highest amount of jobs. The textile industry is the only one to have significantly increased both skilled and unskilled labour employment. It is one of India's oldest industries, having existed for many centuries. One of the sectors of the global economy that produces the greatest pollution is the textile industry. In this industry, about 2000 distinct kinds of chemicals are used. It contaminates and consumes freshwater. (1)

Waste water pollution has been one of the most concerning issues because it is thought to be a cause of terrible illnesses like cancer, intestinal tract infections, skin irritation, and kidney failure. According to Chequer et al., 12 percent of textile dyes are lost during production and processing, and the use of synthetic complex dyes as colouring agents has expanded significantly. However, it is known that 20 percent of lost dyes are present in industrial effluents, which can have a major influence on aquatic life, humans, plants, and the environment by disrupting photosynthesis and other physiochemical processes. Along with other important industries, the manufacturing and trading of textiles play a significant role in our economy. Despite its obvious utility, this industry has grown to be one of the most polluting on the planet and uses a lot of chemicals and fuels. The focus is mostly on the overuse of drinking water in various procedures including washing, bleaching, dyeing, etc. Extreme water contamination is caused by textile dye leftovers, which are either released into the environment directly or omitted by effluents of enterprises, particularly in locations close to textile industries. (2)

A high amount of salts, alkalis, binders, dispersants, volatile organic compounds (VOCs), surfactants, chlorobenzenes, reducing agents, dioxin, phthalates, phenols, pentachlorophenol, detergents, and heavy metals are also present in textile industry wastewater (TIWW), in addition to colour molecules. If this TIWW is dumped directly into water bodies, it poses major risks to the environment and has hazardous impacts on living things. The textile industry uses a variety of highly toxic compounds at various phases, including sizing, brightening, anti-creasing, sequestering, stabilisers, softening, and finishing agents. Additionally, Textile industries make great use of a variety of synthetic dyes include azo, vat, direct, reactive, sulphide, acidic, and basic dyes. During the textile dying process, these dyes are partially detached from the target fibres and are released into aquatic resources such rivers, ponds, streams, and lakes along with wastewater. In order to properly treat TIWW before it is finally disposed of into the environment, it is urgently necessary to develop affordable and environmentally appropriate treatment procedures. (3)

2. Classification of Dyes

The molecules of dyes are soluble organic compounds that contain the chromophore, which gives them colour, the auxochrome, which helps fix the dyes, and the matrix (rest of the atoms of the molecule) Table 1. Natural and synthetic dyes are distinguished based on their sources. Based on their source, which can include plants, animals, or minerals, natural colours are further split into subgroups. The chemical structure of synthetic dyes, such as azo, phthalocyanine, indigo, anthraquinone, aryl methane, and heterocyclic dyes, is used to categorise them. Dyes can also be categorised according to their chromophore, industrial use, and water solubility (Figure 1). Water-soluble dyes include those that are acidic, direct, mordant, basic, metal complex, and reactive, whereas water-insoluble dyes include those that are azoic, disperse, vat, and sulphu. (2)

Table 1. Auxochrom and chromophor groups of textile dyes (2)

Auxochrome Groups		Chromophor Groups	
Alkoxyl	(-OR)	Azo	(-N=N-)
Amino	(-NH2)	Alkenes	(-C=C-)
Aldehyde	(-CHO)	Carbonyl	(>C=O)
Carboxyl group	(-COOH)	Ethylenic	(>C=C<)
Dimethylamino	(-N(CH3)2)	Ketone-imine	(>C=NH)
Halogens	Cl, Br, I, At	Sulphide	(>C=S)
Hydroxyl	(-OH)	Nitro	(-NO2 or =NO–OH)
Methylamino	(-NHCH3)	Nitroso	(-NO or –N-OH)
Methyl mercaptan	(-SCH3)	Polymethine	(=HC-HC = CH–CH =)
Sulfonate	(-SO3H)		

Classification of Dyes

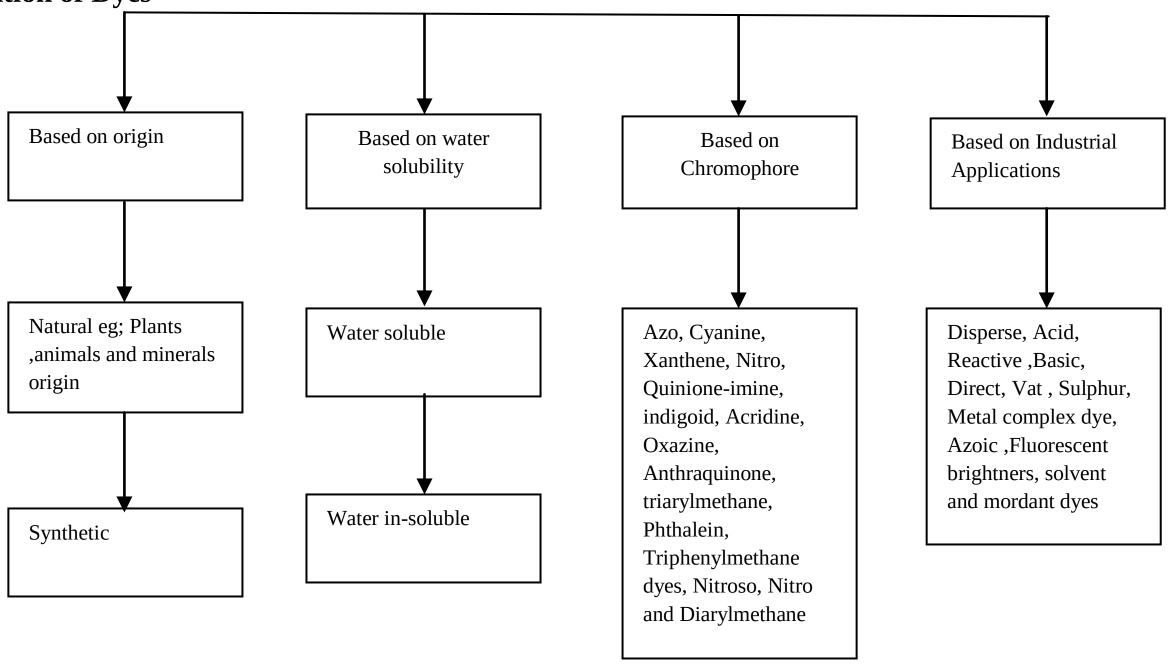

Figure 1. Classification of Dyes (2)

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3. Different stages, Processes and chemicals used in textile industries:

A number of processes and chemicals are used in the intricate process of textile manufacture to create a wide range of goods. Large amounts of water and chemicals are needed at these stages. The several steps in the making of textiles are listed below. (3)

3.1 Sizing

By incorporating unique carboxymethyl cellulose (CMC), polyvinyl alcohol (PVA), polyacetate, and polycyclic acids, it is the first stage in the creation of textile from synthetic or natural fibres like polyester, silk, jute, cotton, and wool. These chemicals give fibres a high level of potency.

3.2 Desizing

Enzymes and several auxiliary chemicals are used in the second phase to eliminate undesirable chemicals and sizing materials and improve the absorbency of fibres. Nowadays, desizing applications use bacterial enzymes and mineral acids more frequently than conventional techniques.

3.3 Scouring

It is a method of cleaning used to get rid of contaminants from fibres. In this procedure, contaminants such fats, waxes, oils, and detergents as well as non-cellulosic materials are removed and washed using alkali agents like glycerol, ethers, sodium hydroxide, detergent, or soap.

3.4 Bleaching

Unwanted colouring components are taken out of fibres using a chemical procedure. H_2O_2 and peracetic acid are the bleaching agents now utilised to improve the whiteness of textiles.

3.5 Mercerization

This procedure makes heavy use of cold or hot caustic soda (NaOH) to enhance the physical and chemical characteristics of fibres, specifically their sheen, strength, dye compatibility, and aesthetic appeal.

3.6 Dyeing and printing

Various auxiliary chemicals are utilised at this point to strengthen the bond between the dye molecules and the fibres. The main method for giving materials colour in the textile production industries is dyeing. Around the world, TIs utilise a variety of dyes, including azoic dye, vat dye, reactive acid dye, sulphur dye, basic dye, direct dye, pigments, and metal complex dyes. In the printing stage, phthalates, dyes, metals, solvents, formaldehyde, and urea are frequently employed.

3.7 Finishing

It is the last stage of the textile manufacturing process, where various types of protecting and maintenance chemicals, such as biocides, synthetic organic or inorganic chemicals, are employed to enhance and maintain the unique properties of fibres, such as stain resistance, softening, water resistance, flame retardance, and protection from microbial activities as well as UV damage.

4. TEXTILE PROCESSING

The textile industry is made up of a diverse group of businesses that manufacture and/or process goods related to textiles (such as fibres, yarn, and fabric) in preparation for further processing into apparel, household goods, and industrial products. As part of the numerous processes involved in textile manufacturing, textile industry facilities collect and arrange fibres, change them into yarn, thread, or webbing, turn the yarn into fabric or related goods, and then colour and finish those goods. The four steps in the manufacture of a textile are as follows: (4)

- Yarn formation,
- Fabric formation,
- Fabric processing (wet processing), and
- Textile fabrication.

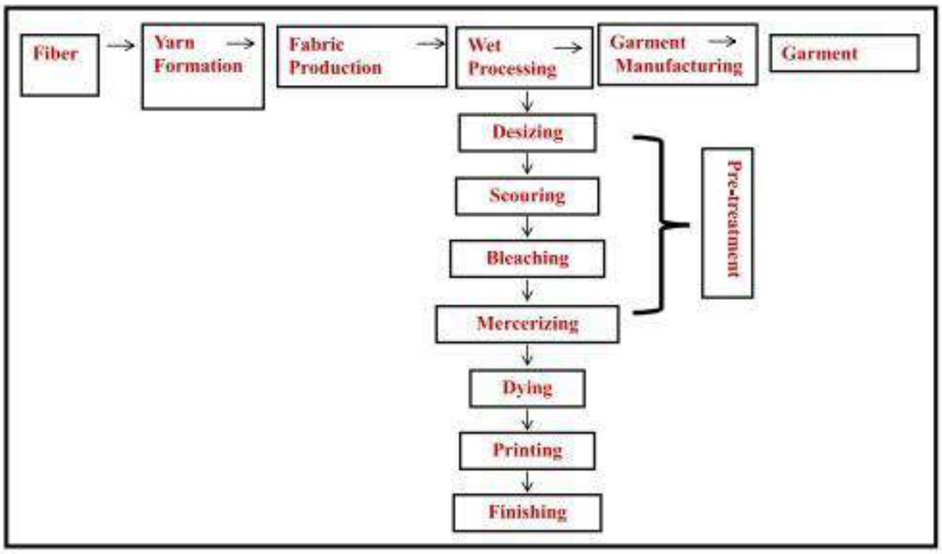

Figure 2: A flow diagram for diverse stages involved in textile production operations (4)

5. Environmental impact of Dyes:

Air pollution: Most of the operations carried out in textile mills emit gases into the atmosphere. The textile industry's second worst environmental issue has been identified as gaseous emissions. These emissions typically contain contaminants like sulphur dioxide and suspended particles. In addition to this, the opening and beating processes used in cotton fibre trash removal in spinning mills release fibre fluff into the environment. The amount of fibre fluff released varies from part to section, with blow room liberating the most and the cone winding area liberating the least. (1)

The cotton fibre, which dominates the Indian textile industry, is thought to be renewable, biodegradable, and environment-friendly, and it has numerous benefits over the course of its lifespan. However, the production of natural fibre places a high priority on the use of pesticides, fungicides, and fertilisers. Defoliants, among other lethal chemicals, have been applied to cotton plants before harvest in order to prevent stains on the fibre. (5)

Nitrous oxide, a byproduct of the manufacture of synthetic fibres, is a potent greenhouse gas that has 300 times the potential to destroy the stratospheric ozone layer than carbon dioxide. In contrast, fume or dust produced during the thermal treatment of nylon or synthetic fibers can irritate the skin, eyes, and mucous membranes in the respiratory tract, as well as causing mechanical eye irritation and gastrointestinal distress if inhaled. (1)

Due to effluent evaporation, chemical Treatment of textile materials is a major contributor to local air pollution. It has been established that high temperatures near Rajasthan's Bandi River could enhance the likelihood that textile mill discharged effluents will pollute the air in the surrounding area. Evaporation rate relies on the ambient temperature. (5)

Water Pollution: Given that it is one of most chemically demanding businesses on earth and uses a significant amount of water, the textiles dyeing and finishing sector has greatly increased pollution problems. A significant source of pollutants is waste water. In wet processing of textiles, textile manufacturers need enormous amounts of water and chemicals. These industries typically release their processed effluents into the nearby drains untreated. There is significant penetration and percolation of harmful chemicals into the soils during the flow of the effluents, which pollutes the soil, underground water, ponds, and vegetation. Chemical composition of the chemical reagents utilised is quite varied, ranging from inorganic materials to polymeric materials and organic products. (1)

Textiles can be chemically processed through dyeing, printing, and finishing. As the name suggests, a variety of harmful chemicals, such as dye, acid, alkali, surfactants (such as salts, acid, alkali, bleaching, and finishing agents), and softeners, among others, are employed to make these processes effective. the record

Table 2 provides a list of common compounds used during chemical processing of textiles. The main source of risks resulting from the process is the unutilized chemicals with large amounts of water discharged as effluent. Unused colours, acid, soap, detergent, enzyme, dye-fixing chemical, chlorinated stain removers, chromium complex, heavy metals, and various auxiliary chemicals are among the harmful substances in effluent. Oil, fat, wax, seed grains, spinning oils, amines produced by the degradation of colours, natural starch, and other impurities all contribute to the growth of pollution-indicating factors in effluent and harm its environmental effects. Due to effluent evaporation, chemical synthesis of textiles is a major contributor to local air pollution. It has been established that high temperatures near Rajasthan's Bandi River could enhance the likelihood that textile mill discharged effluents will pollute the air in the surrounding area. Evaporation rate relies on the ambient temperature. (5)

Table2. Different chemicals used in textile chemicals processing (5)

Type	Example
Acid	Acetic acid, Formic acid
Alkali	Sodium Hydroxide, Potassium Hydroxide, Sodium Carbonate
Bleach	Hydrogen Peroxide, Sodium Hypochlorite, Sodium Chlorite
Dyes	Reactive, Direct, Disperse, Pigment, Vat
Salt	Sodium Chlorite
Size	Starch, PVA
Stabilizer	Sodium Silicate, Sodium Nitrate, Organic Stabilizers
Surfactant	Detergents
Auxiliary finishes	Fire Retardant, Softener

6. Impact of Textile Dyes on the Aquatic Environment

Due to the widespread use of of synthetic organic compounds as dyes, the main issue with textile effluent is colour. Due to their lower binding efficacy, studies have shown that up to 200000 tonnes of dye are wasted in industrial discharge. Depending on their chemical structure, this quantity can range from 2 to 50 percent. Due to its thermal and light stability, which prevent biodegradation and promote persistence in the environment, dyes pose a number of environmental risks. The ability of dyes to absorb and reflect sunlight that enters the water reduces the effectiveness of aquatic producers' photosynthetic processes, which has an impact on the food chain. Furthermore, a high concentration of textile dyes in water bodies reduces the water's capacity to absorb oxygen, which impedes the biological activity of aquatic life. (2)

According to a study by Khan and Malik, the effluent discharged from the textile industries contains substances with a hydrosulfide group that also prevent light from penetrating the water body, leading to an imbalance in the levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The leftover textile industrial water contained higher BOD and COD levels, according to a study done by Setiadi et al.21. Another issue with a resistant nature is oxidative stress, which is caused by the chromium in textile dyes. It significantly harms plant growth and development, particularly photosynthesis and Carbon dioxide assimilation. The recalcitrant property of dyes, which causes the buildup of these synthetic dyes and their intermediates in sediments and aquatic organisms, which may promote toxicity, mutagenicity, and carcinogenicity, is another effect of dyes on the environment after instability in the processes of oxygen supply of water bodies and photosynthesis. The majority of non-biodegradable chemical molecules, particularly colours and their intermediates, are to blame for water pollution. These xenobiotics begin to increase in the fatty tissues of marine and terrestrial species after being ingested through any route due to their non-biodegradability and tendency to infiltrate the food chain. Fish and algae are the main recipients of these harmful pollutants discharged by the textile dyeing industry. Fish and algae are the main recipients of these harmful pollutants discharged by the textile dyeing industry. (2)

Algae grow quickly and easily, and they are highly sensitive to chemical stresses. Microalgae have thus been employed as markers of water quality to assess environmental disturbances. According to recent studies, microalgae have also been used to test the toxicity of chemicals such as metals, herbicides, and insecticides in addition to dyes. Chlorophyll a production, cell density, and dry weight production were all reported to be negatively impacted by the heavy concentration of indigo dye effluent. It has also been shown that the growth of the algae Spirulina platensis and its nutritional level are affected by the rising amount (25-100 mg/l) of Congo Red, Metanil Yellow, and Mordant Green dyes.(2)

Fish are very responsive to and sensitive to changes in their aquatic environment, and any unfavourable alteration may be seen in the biochemical, physiological, and histological characteristics of fish. The toxic effects of textile effluents poses a direct and indirect hazard to fish biota due to the direct buildup of pollutants and the increase in physical characteristics including colour, turbidity, temperature, and total solids, which affect the fish food chain. Several investigations have shown that dyes also contribute to the irreversible structural change of fish DNA, which occurs even at toxic levels which are otherwise healthy for living. According to the research done by Kaur et al., Cirrhinus mrigala exhibits altered behavioural responses when subjected to sublethal concentrations of dyeing industry effluent (24.48 percent, 12.24 percent, and 6.12 percent). These behavioural responses include gulping air on the surface, jumping out of the water, erratic movements, and fast opercular movements. The fish Oreochromis niloticus showed altered behaviour after being exposed to the metal complex deep green azo acid dye, according to Amwele et al. After 90 minutes of exposure to the metal complex deep green azo acid dye, the alternations, such as fish, sunk to the bottom with little activity. Fish exhibit increased air gulping, which is probably a reaction to chemical respiratory suppression. Additionally, subchronic toxicity in all chemical treatments showed variations in a quantity of erythrocytes, leukocytes, and thrombocytes. (2)

7. Noise pollution

An environment monitoring activity that has been thoroughly designed must be added to the preparation of material balances. To evaluate their impact on workplace health and safety, measurements of variables such VOC in air from finishing processes and sound levels while weaving on looms should be conducted routinely. Every industry contributes to environmental pollution, and the spinning and weaving industries are no different. Workers who are subjected to industrial noise of a potentially harmful quality and intensity have varying degrees of hearing impairment as well as other physiological problems. Since the maximum allowable noise level for an 8-hour exposure should be roughly 96.5 dB, prolonged exposure to noise levels above 90 dB may result in hearing impairments. (1)

Table3. **Noise level in textile industry (Texturing, spinning and Weaving) (1)**

Process	Noise level (dB)
Texturizing Plant	95-100
Spinning	
1. Ring Frame	80
2. Rotor spinning	84
3. Two for one twister	100-110
4. Weaving	100-120

The main phase in the processing of cotton fibres that separates the fibres from the cotton balls is known as ginning, which is the interface between firming and industry. The process requires high-speed equipment that produces a lot of noise and cotton particles in the workspace. The primary noise source is a high-speed doffing brush that produces noise at a frequency of 500–1000 cycles/sec, which is incredibly high when compared to the typical noise frequency of 31.5–250 cycles/sec. According to a study on the ginning sector in Maharashtra, workers were exposed to noise levels of 89 to 106 dBA per day for at least eight hours. Another study found that noise in gin press house lies in between 79.3 to 93.5 dBA and in ginning house it was 96.0 dBA. The everyday exposure of the ginning employees to high noise levels for eight to twelve hours causes noise-induced hearing damage in the workforce. Studies have shown that individuals exposed to noise levels higher than 85 dBA have NIHL. (5)

Different kinds of equipment are also used during the spinning process, which creates yarn from raw fibre. These machines' high speed operation generates unwanted noise and cotton dirt in the workspace, and it has been determined that noise levels in the spinning room remain between 80 and 100 dBA. The noise produced by various spinning industry machines is listed in Table 4, and it continuously surpasses the level that is acceptable for 2 to 8 hours of work in the engineering and administrative departments. Furthermore, numerous studies have shown that more than 30% of spinners are exposed daily to noise levels greater than 90 dBA. (5)

Employees' physical and mental health are negatively impacted by noise levels over 90 dBA. It was discovered that people who operate in environments with noise levels above 90 dBA have severe hearing loss. The extent of hearing loss depends on how long a person works; for example, those who work for more than sixteen years may suffer hearing loss at even low frequencies, whereas office employees may experience very little or no effect. A research at the Boroujerd Textile Factory indicated that office workers may develop hearing damage after more than 10 years of working at high frequency. (5)

The process of weaving creates fabrics, and it is the noisiest textile business. The obsolete equipment, poor design, shoddy construction, and overcrowding in the workplace are the main causes of noise in the weaving business. It was discovered that noise levels in the weaving preparation area are modest, compared to how loud they are in front of the loom shed. The actual noise levels produced by the textile looms ranged from 85 to 104 dBA, with the shuttle loom producing the highest levels and the air jet loom producing the lowest levels (Table 4).

The inevitable cotton dust affects the weaving business in a similar way to how it affects ginning and spinning. The permitted limit as shown in Table 5 is tremendously exceeded by the concentration of cotton dust in the weaving sector, which continues to range between 1820 and 1960 g/m3. (5)

Table4. Noise level in textile industry (5)

Section	Noise level, dBA
Ginning	88-92
Blowroom	80-83
Carding	84-89
Draw frames	84-88
Speed frames	82-86
Ring frame	86-90
Rotor	85-100
Winding	82-86
Warping	80-86
Sizing	73-86
Loom shed (No-auto)	94-99
Loom shed (Auto)	95-97
Shuttle loom	99-104

Table5. Standard exposure limit with actual level of cotton dust in textile industry (5)

Defined body	Exposure limit		Actual level μg/m³
	Processing stage	Standard Limit μg/m³	
OSHA PEL TWA	Yarn Manufacturing	200	1900-2700
	Weaving	750	1820-1960
	Ginning and waste recycling	1000	2000-6000

8. Conclusion:

The textile industry is a significant contributor to environmental pollution. Numerous textile processes lose large amounts of fresh water both during and after the process. Water is an extremely valuable resource that is becoming more and more scarce daily. In addition to contributing to water pollution, the textile industry also pollutes the air and the land, which will be a major concern for humanity. The present tendency of mass production and quick fashion has accelerated the rate of environmental contamination. Chemical processing of textiles results in toxic effluent and gaseous emissions that damage land, water, and the environment and pose serious health risks. The imbalance and contamination of both terrestrial and marine life, which ultimately has a detrimental impact on people and the environment, is largely caused by the discharge of textile industry effluents into open spaces and rivers. In order to make textiles in a way that is more environmentally friendly and consumes less water, we must find ways to substitute chemical colours with natural dyes. A more sustainable approach to reducing textile waste should be used instead of mass manufacturing, which naively promotes a "use it and dump it" way of life and pollutes the environment by filling landfills with textile waste.

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