ISSN: 2641-1784

Review Article

Advance in Environmental Waste Management & Recycling

Impact of Disposal of Textile Effluent on Environment: A Review

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Submitted: 2024, Aug 13; **Accepted:** 2024, Oct 21; **Published:** 2024, Dec 19

Citation: Metkari, S. T., Kale, R. D., Mundker, S. (2024). Imapct of Disposal of Textile Effluent on Environment: A Review. *Adv Envi Was Man Rec, 7*(3), 01-05.

Abstract

The textile industry sectors are necessary for the economic development of every country worldwide. It utilizes vast amounts of water and generates considerable waste. Considering the amount of effluent and its nature, textile factories' wastewater is categorized as the most polluting industrial sector. The textile production process involves several phases, including pretreatment, dyeing, printing, and finishing activities, all generating a substantial volume of wastewater. When disposed of improperly, the chemicals in effluent can have a negative impact on the environment and human health. Thus, effluent from textiles needs to be treated before being released. This investigation aims to gain an overview of the dyes and chemicals used in various stages of textile wet processing and analyze the adverse environmental impact of wastewater from textile factories. The challenges that industries encounter while treating effluents have been addressed. Furthermore, the potential remedial measures to safeguard the natural environment are recommended.

Keywords: Environmental Impact, Textile industry, Wet processing, Wastewater

1. Introduction

The critical element of any nation's growth is industrialization. Textiles have been expanding significantly as one of the world's biggest industries. Textiles were made initially to satisfy humanity's basic need for clothes. However, nowadays, they are used as fashion statements and symbols of status.[1] India's rapid industrialization has significantly increased environmental pollution as industrial wastewater discharges pollute water bodies. Population explosion and fast fashion are the main factors boosting textile industry production. The global rise in demand for textile products eventually contributed to the generation of wastewater and substantial environmental hazards. [2]

The textile industry is one of the largest consumers of water and one of the biggest generators of wastewater effluents. When volume and composition are considered, textile industry effluents are the most polluting industrial sectors. Various pollutants are present in it, including ammonia, heavy metals, surfactants, salts, oxidizing and reducing agents, oil, grease, caustic soda, Glauber salt, and other hazardous substances. [3]

Furthermore, the textile industry produced effluents containing high temperatures, a range of pH ranges, heavy metals, BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TDS (Total Dissolved Solids), powerful pigment, dyestuffs, and synthetic substances. Without sufficient waste treatment facilities, the effluents are released into surrounding lakes, rivers, fields, or landfills. The chemical composition of effluent has been the subject of numerous investigations, and regulations necessitate an ETP (Effluent Treatment Plant). However, the most common approach is still dumping the effluent into the nearby water body. [4] As a result, effluents threaten the health of aquatic life, animals, and plants and the quality of the water and soil. Therefore, the wastewater produced must be sufficiently treated before releasing into the environment.

1.1 Objectives

- To review the environmental issues related to the textile effluent.
- To identify the challenges faced by textile industries while treating effluent.
- To study the strategies being used and recommend ways to protect the environment.

1.2 Textile Industry

The textile sector uses several facilities to collect and organize fibers, convert them into yarn, transform them into fabric, and

wet process these materials during all the steps involved with producing garments. [5] The stages of manufacturing textiles are shown in Figure 1. The textile industry is responsible for various pollutants produced during each production phase, from fibers to fabrics. These contaminants might manifest as noise, water, or air pollution. Since it happens due to the release of untreated effluents, water pollution is considered among the most dangerous of all of them.

Figure 1: Stages Involved in the Production of Fabric from Fiber

1.3 Textile Wet Processing

The wet process involves singing, desizing, scouring, bleaching, mercerizing, dying, printing, and finishing. The volume of water required and waste generated from wet processing depends on the fabric being processed, the chemicals used, operating practices, and the technology employed.Table 1.summarizes some of the chemicals used and the pollutants produced at each step during the wet processing of textiles.

Process	Chemicals Used	Wastewater contaminates
Sizing	Starch, Waxes, C.M.C., P.V.A.	High BOD and COD
Desizing	HCl, Detergent, Glycerol.	High BOD, COD, TSS, and TDS.
Scoring	Caustic soda, Waxes, Grease, Soda ash, Sodium silicate, fibers, Surfactants, Sodium phosphate.	Dark colored, High pH, COD, dissolved solids.
Bleaching	Hypochlorite, Caustic soda, Sodium silicate, Hydrogen peroxide, Surfactants, Sodium phosphate.	Alkaline pH, High T.S.S.
Mercerization	NaOH	High pH, low COD, and High TDS.
Dyeing	Various dyes, Mordants, Salt, Surfactants,Reducing agents, Acetic acid, and Soap.	Intensely colored, High COD, TDS, Low TSS.
Printing	Pigment, Starch, Gums, Oil, Urea, Mordants, Acids, Soaps.	Highly colored, High COD, oily appearance, S.S.
Finishing	Inorganic salts.	Slightly Alkaline, Low BOD.

Table 1: Chemicals Used and Pollutants Generated at Each Level of Textile Wet Processing [6]

The textile industry is the most environmentally damaging and polluting part of the global economy. Although effluent treatment is an ongoing debate these days, relatively few people are aware of the adverse environmental impacts of textile effluent. The primary objective of this study is to raise public consciousness about the impacts of textile effluent on numerous environmental parameters. The paper attempts to cover relevant information concerning the textile industry, the limitations of effluent treatment, and prescribed remedial measures.

2. Impact of Textile Effluent on the Environment

Water pollution caused by the textile industry's disposal of untreated effluent has always been responsible for environmental issues. The processing of textiles demands a large number of non-biodegradable, environmentally harmful chemicals, and this makes it exceptionally chemically intensive. Effluents are being released into the surrounding environment without adequate treatment to make them safe. This is because most textile wet processing units are situated in developing or underdeveloped nations, where processing is carried out by small facilities with inadequate financial resources to purchase and operate costly machinery for the appropriate handling of wastewater. The detrimental impact of untreated textile effluents on various elements of the environment, such as soil, water, plants, and human health, is discussed. [7]

2.1 Plants

A substantial quantity of wastewater is discharged through the drainage systems into surface waters, where it generally penetrates the groundwater and is absorbed by plants.The wastewater produced by brightly colored fabric affects the ability of plants to photosynthesize. [8] It has been found that water with high TDS and electrical conductivity causes stress in plant roots, making it more difficult for a plant to absorb water for growth. High levels of E.C. and TDS in irrigation water also significantly impact crop productivity and plant growth. [9] Thus, lower crop production acts as an alarm warning for water pollution. [10] This, in turn, will be a threat to food security.

Research that experimented on a crop that utilized textile wastewater to grow wheat revealed that utilizing textile wastewater

hurts wheat growth. Compared with a control group that obtained regular water, the most significant decrease in wheat growth characteristics resulted in the plant height, spike length, root mass, and root length of the wheat. [11] Because of the rise in soil salinity and concentration of toxic metals, effluent has an adverse effect on the growth parameters. [12]

2.2 Soil

The natural body of soil is comprised of a combination of organic and inorganic elements. It indirectly preserves the environment by promoting the growth of plants and trees that support the ecosystem's native flora and fauna. Contamination of the soil results from the direct dumping of textile wastewater into rivers and groundwater. The presence of organic and inorganic contaminants in wastewater impacts soil's physicochemical characteristics, leading to soil erosion, reduced productivity, sustainability, and lowered food chain quality. [13] Furthermore, industrial effluents and organic contaminants have a negative impact on soil quality. It has been discovered that the natural soil constituents, such as phosphorus, potassium, iron, and manganese, are present in more significant concentrations and are, therefore, poisonous. As a result, soil fertility generally declines. [14]

Excessive levels of BOD and COD cause the soil pores in the fields to become obstructed, which reduces soil productivity. [15] Excessive salt content in textile effluents deteriorates soil quality and renders it unusable for farming. Salts dissolved in water raise the osmotic pressure of the soil, which raises the respiration rate and decreases the permeability, ventilation, and soil building essential for plant growth. [16] The use of river water for irrigation has caused the suspended colloidal particles to clog the soil's pores and impair its permeability. Applying highly salinized, specific absorption rate contaminated groundwater to agricultural areas has significantly lowered production. [17]

2.3 Aquatics

Fish are considered an excellent biological indicator because of their high responsiveness and sensitivity to changes in their aquatic environment. [18] Because of the direct buildup of pollutants and the increase in physical features like colour, turbidity, temperature, and total solids that impact the fish food chain, the toxic impacts of textile effluents constitute a direct and indirect hazard to fish biota. Untreated industrial effluent disposal into water bodies has caused serious concerns about aquatic contamination in the area, often resulting in fish mortality. It impacts both species' abundance and species richness within the particular aquatic ecosystem. [14]

In addition to harming one's aesthetic sense, dye colour causes turbidity, absorbs sunlight, and obstructs transparency in water bodies, which prevents aquatic plants and animals from growing. [19] Hazardous waste materials like grease and colloidal matter dumped in the effluent create a film layer on the water's surface that makes it look awful, smell bad, and block sunlight, essential for photosynthesis. [20] It tampers with the air-water interface's oxygen transfer mechanism, which impacts the water's natural purifying process.

The acidity or alkalinity of water is determined by its pH. Aquatic life would be destroyed by anything extremely alkaline or acidic because the pH is necessary for all metabolic activities. The tendency of synthetic dyes to accumulate in sediments and aquatic creatures due to their refractory nature may lead to toxicity, carcinogenicity, and mutagenicity. Numerous studies have demonstrated that dyes, even at hazardous concentrations, play a role in the irreversible structural alteration of fish DNA. Fish gulp more air than usual, most likely in response to chemical respiratory suppression. [21] Fish that have suspended particles in their effluent may choke to death. Textile wastewater contains higher than allowed quantities of chlorides. It affects freshwater creatures' longevity and rates of reproduction.[22] Many fish species develop tumors stimulated by dyes. Alkyl phenol ethoxylates, or APEOs, are widely used as detergents and wetting agents in dye factories. Because APEOs contain hormone disruptors, they pose a threat to aquatic life.

2.4 Human Beings

Since the public water supply is inadequate, most people rely on hand-dug wells and boreholes for their water supplies. However, improper handling of the trash can have detrimental effects on the environment, like contaminating groundwater and surface water. Because of how these effluents are combined with groundwater, the concentration of pollutants in the water rose, and drinking became unsafe. The health of those who live near textile manufacturers is impacted by contaminated effluents from these organizations, specifically those who reside close to the manufacturing plants and downstream along the discharge canals.

For many households, livestock is a primary source of income. During the protracted dry season and on the fields following harvest, livestock are released to graze in the open terrain. People who depend on milk and milk products may have significant health effects if they come into touch with tainted wastewater. [23] Chemicals that our skin absorbs or evaporates into the air during textile manufacturing are present in textile effluents. If breathed, it can cause mechanical eye irritation, gastrointestinal upset, and irritation of the skin, eyes, and mucous membranes in the respiratory tract. [24] The harmful properties of textile effluent interfere with cells' ability to operate normally, which can alter an animal's physiology and biochemical systems and harm essential processes, including breathing, osmoregulation, reproduction, and even death.

Not all of the dye is fixed to the fabric during the dyeing process; the dye left unfixed is found in the wastewater. Various metals can be found in the dye's structure or the manufacture of dyes. The aqueous system allows the released heavy metals to get dangerously close to human health, impacting it negatively. Heavy metals like mercury, cadmium, and chromium can bioaccumulate, magnify, and harm people. Since the body cannot break down these heavy metals, they can lead to several illnesses, including bone disorders, cancer, renal failure, nervous system disorders, brain damage, gastrointestinal disorders, memory issues, neurotoxicity, abnormalities, and other issues. [25]

3. Problems Faced by Industries While Treating Effluent

• **Complex Process:** A combination of the enormous amount and complex composition of textile effluent—which comprises an extensive number of seasonally-varying dyes, additives, and derivatives—the main issue is its complicated nature.

• **Cost:** Treating wastewater presents textile industry players with yet another significant challenge. The expense covers the necessary energy, chemicals, and land. The typical treatment procedures are costly, making the process unaffordable for small-scale enterprises.

• **Lack of treatment knowledge:** The textile sector also faces the issue of inadequate treatment knowledge when treating wastewater.

• **Time:** The process of treating wastewater takes a long time.

• Developing simple, low-cost, and ecologically sound textile effluent remediation techniques is essential in lowering water pollution and supporting ecological and economic growth

4. Sustainable Conservation, Interventions, and Recommendations

The following suggestions are provided to shield Mother Nature and ourselves from the harmful consequences of the environment.

• Lack of awareness and inadequate knowledge about ETP are significant obstacles. The government and pollution control boards must start awareness-raising programs for small—and medium-scale industries. This will help improve attitudes and increase responsibility levels.

• A provision must be made to monitor effluent, and properimplementation of environmental regulations for the discharge system and ETP is necessary.

• Enforcing laws that forbid the use of eco-friendly dangerous chemicals and encourage the replacement of safer alternatives is crucial. All chemical suppliers should mandatorily provide MSDS Containing adequate information about hazards.

• The conventional aqueous dyeing process utilizes a substantial amount of water; with the development in research, some innovative dyeing techniques are being applied, such as printing, plasma dyeing, foam dyeing, microwave-assisted dyeing, laser coloration, enzymatic processing, and ultrasound-assisted dyeing. [26]

• Developing a more efficient dye that can be fixed fiber with higher efficiency or by modifying substrate, which helps reduce losses on tailings waters and the amount of dye required in the dyeing process, would be an alternative to minimize the issues related to the treatment of textile effluents. This would improve the cost and quality of the effluent without a doubt. [27]

• Every process house needs to implement the 3R Concept (Reduce, Reuse, and Recycle) to reduce ETP and ecological burden. This can be done by reusing the bath and separating less contaminated streams. This may reduce water requirement and effluent volume and help preserve ecosystems.

• To reduce water pollution and promote ecological and economic development, simple, cost-effective, and environmentally friendly treatment methods for textile effluent remediation must be developed. [28]

5. Conclusion

Environmental impact is undoubtedly one of the primary issues facing industrialized and developing nations. This is caused by various factors, including the mishandling of natural resources, ineffective laws, and a lack of environmental awareness, which are to blame for the environment degradation. Wet procedures in the textile sector substantially contribute to water pollution, making it one of the biggest culprits. These processes produce effluent containing various chemicals and dyes that are toxic to human health and aquatic life. Pollutants consequently impact ecosystems, the food chain, and agriculture output. That is why taking every measure needed to maintain the ecological balance is essential.

In order to minimize the adverse effects of effluents on the environment, several effluent treatments have been developed. The textile industry's Effluent Treatment Plants (ETPs) aim to apply technology that provides little or no water contamination. It is a widely accepted approach to ensuring environmental safety. The currently available effluent treatments have restrictions concerning textile effluents. The expanding complexity and difficulty of dealing with textile wastes results in an ongoing hunt for feasible novel approaches that improve the efficiency of the process and become more commercially attractive.

To protect the environment, all textile industries urgently need to continually monitor and control waste generation and effluent output and treat wastewater appropriately before discharging it into water bodies. The Ministry of Environment, Government of India, has set standards for wastewater discharge after treatment into the environment; compliance and regular monitoring are essential.

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