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Abstract

The textile industry is a vital industry in the world in which the products serve the basic needs of people, as well as giving a quality enhancement or luxury in our daily life. This includes clothing, home furnishing, automotive textile, and many others. Nevertheless, textile processing is known to bring pollution to the environment and has a major effect on water, air, and soil. Hence, this review paper is divided into several sections. In the first part, factors and impacts of the textile industry on the environment are discussed. Next, the literature which discussed the effects of the pollution caused by the textile industry on others is reviewed. The following part is about the effect of pollution on humans, aquatic life, and plants. Several aspects of water pollution, air pollution, and soil pollution consequences are reviewed and the last part is ways to overcome the pollution. A variety of approaches were suggested and implemented globally such as chemical method, physical method and biological method, soil washing, and organic cotton production to combat the pollution or lessen the damage caused by the industry to the environment. As much as people need to live with textiles around them, they also need to ensure that the environment is not harmed by their actions.

Keywords: Textile Industry, Water Pollution, Air Pollution, Soil Pollution

Introduction

Textile is a general term used to refer to fibres, yarns, fabrics, or anything that is made from them through several processes such as weaving, knitting, and nonwoven. In the textile industry, there are normally several work sectors such as spinning, weaving, dyeing, finishing, apparel, and also research and development. Very often, the fabric manufacturing or processing sector impacts the environment, especially in wet processing such as dyeing and finishing.

One of the basic needs of humans is clothes (Willbanks, 2021). Hence, it makes the textile industry always in high demand. In 2019, the global textile market size was valued at USD 961.5 billion. It is estimated to exhibit a compound annual growth rate (CAGR) of 4.3%

from 2020 to 2027 owing to the increasing demands for apparel, especially in developing countries such as China, India, Mexico, and Bangladesh (Market Analysis Report, 2022). Even though the demand for the products from the textile industry increases, the drawback it gives to the environment is massive as it is one of the main causes of pollution (Imtiazuddin and Tiki, 2018). There are three major types of pollution caused by the textile industry namely water, air, and soil pollution.

Many countries have been impacted by pollution from the textile industry. India is the most contaminated country affected by the textile industry where around 10-25% of textile dyes have been found in wastewater from the textile industry and 2-20% of dyes are directly discharged as aqueous effluents during the process (Saini, 2017). In this paper, a review of the literature regarding the effect of textiles on the environment, humans, aquatic life, and soil, and ways to overcome pollution will be included. About 50 articles which are from high-impact journals, proceedings, and newspaper articles relating to the environmental impact caused by the textile industry will be covered and discussed in this paper.

Impacts of textile industry on the environment

Massive activities in the textile industry create many advantages and disadvantages for people, especially in third-world countries. In reality, the industry does help the local economic growth but somehow the laborious work and impacts do not seem to outweigh the benefits. The biggest disadvantage or the impact of this industry is on the environment which causes pollution to water, air, and soil.

Water Pollution

There are 20.6 million tons of hazardous waste from the garment industry in the water supply (Migo et. al., 2018). It occurs when the dyes are released during the process of dyeing and finishing. Then, a significant volume of water would be used for these processes in which to remove the excessive pigments and chemicals and leave only the fixed-on material.

Dyeing is one of the major contributors to pollution as shown in Figure 1 (Hossain & Khan, 2020). These processes involve colouring fibres, yarns, fabrics or clothes, and giving wet treatments to enhance the appearance, hand, and performance. Usually, the dyes that are widely used are synthetic (Watari et.al., 2021). Synthetic dyes are chosen because of the flexibility for the dyes to stay on the fibres for a long time compared to natural dyes. After the textile process is completed, the material needs to be rinsed and washed off to remove the unused dyes and leave only the fixed dyes by using a high amount of water. Thus, the water is affected by a high concentration of dye residue. The dyes are made from chemical compounds which are possibly harmful to people, as well as the environment. Furthermore, it is not easy to degrade the high-coloured effluent such as reactive, vat, and disperse dyes (Hossain & Khan, 2020; Watari et.al, 2021).

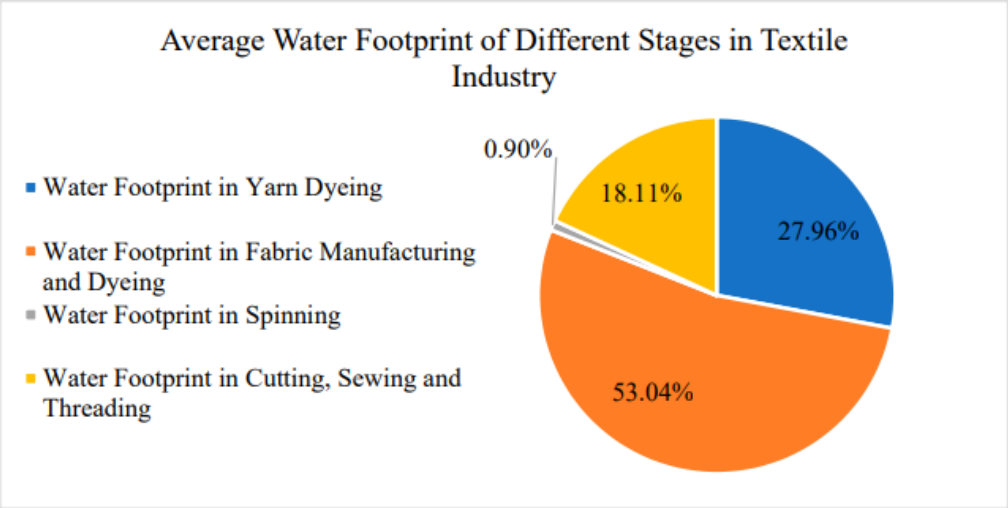

Figure: Percentage of the water footprint in different stages in the textile industry (Hossain & Khan, 2020)

The use of synthetic fabrics in garments and home textiles also leads to water pollution as they may create synthetic microfibres (Sait et. Al., 2021). It is found that microfibres also result in pollution in which the fibres are too small to be filtered out and end up in the waterways and ocean which affects marine animals and the environment. The microfibres are used for finishing nets and carpeting (Deng, 2020) which can also give irritation to the skin. Apart from that, foreign material also has been found which flows directly into the water (Awomeso, 2010) and is not being soluble in an exceeding solution such as solid waste (Arachchige, 2019). Malaysia contributes textile waste for 4% of overall solid waste that is approximately 2 million kilograms (kg) of textile waste generated daily (Nadiah, 2018).

Air Pollution

Air pollution occurs as ambient contaminants are created by most operations in textile mills such as carbon dioxide, carbon monoxide, sulphur dioxide, and nitrogen gasses that are generated by boilers, thermo packs, and diesel generators (Imtiazuddin and Tiki, 2018; Islam, 2020; Chinta et. Al., 1995; Jaganathan, 2014; Zubair, 2017; Haseeb, 2020). The generators produce the combustion of fossil fuel based on the heat engines (Mu, 1998; Ardusso and Fernández-Caldas, 2018). This caused harmful emissions to the air due to the mixture of several gasses in the process that is performed in textile manufacturing. The irresponsible manufacturers do somehow release the chemical vapours into the atmosphere through the chimney (Mia, 2019). Other than that, they could also spread the dust that contains mixtures of things such as organic matter, viruses, fungi, pesticides, and other toxins into the air during cleaning and cotton processing (Sangeetha et.al., 2013; Brysson et.al., 1967; Silverman and Viles, 1950).

Soil Pollution

Every year, textile factories produce about 280,000 tons of industrial effluents in the world, causing a significant effect on the soil (Annamalai et.al., 2018). Many factors lead the textile industry to contaminate the soil which is mainly due to azo dyes, heavy metals, and organic compounds. The toxicity of azo colorants contaminates the soil (Kolekar et. al., 2008; Betianu et. al., 2020; Imran et. al., 2015; Parvin et. al., 2015). Some azo dyes can be carcinogenic without being cleaved into aromatic amines (Kolekar et. al., 2008). Besides,

contaminated soil also can happen because of the biotransformation of bacterial dye from azo dyes (Sriram et al., 2013).

Another critical global environmental issue is soil contamination from heavy metals. The textile industry consists of huge amounts of heavy metals which can influence the soil other than reducing the quality of air and water (Gupta & Srivastava, 2020; Singh et al., 2020; Manzoor, 2006; Dheeba & Sampathkumar, 2012). A high concentration of organic compounds affects soil health so that the living ecosystems such as plants, animals, and humans are not preserved (Singh, Glick, & Rathore, 2020). In other research, the organic compound also can contribute to several adverse environmental problems, especially in urban areas (Yaylali-Abanuz, 2011).

Effects of pollution from the textile industry on others

Unnecessary materials and residues from the textile industry are released into the environment during textile processing. Some of the residues are unconverted raw materials and some are created during the manufacturing or processing of products. In industrial development, pollution relates to the inefficiency of processes. Human, aquatic life, and plantation can be affected by water, soil, and air pollution caused by the inefficiency in the textile industry (Berradi et.al., 2019). This creates a domino effect; as the environment gets affected, humans and other living species will also be threatened.

Effect on Human

Contamination of chemicals in the textile industry give an impact on human health. Water pollution and air pollution can cause respiratory problems in humans. Respiratory disease is a form of disease that can cause lung cancer, asthma, and chronic obstructive pulmonary disease (COPD) that endanger the lungs or respiratory system.

Air pollution has a dangerous effect on human health e.g., lung cancer. Lung cancer occurs with the chemical activation of chlorine and methane (Arachchige et.al., 2019) in the form of air. Nitrogen oxide pollutants (NOx) originally came in some non-toxic types in smaller amounts but oxidized and formed pollutant gases by reacting with hydrocarbons in the presence of sunlight which cause asthma and respiratory problems (Jaganathan et.al., 2014). According to a survey that was conducted in cluster control areas with 639 villagers, it is reported from the survey data that 67% of the villagers have flu, cough, bronchitis, COPD, and asthma, 56% have respiratory problems and 77% have fever (Roy et.al., 2020). Decreased lung function or changes in respiratory symptoms such as cough, runny nose, shortness of breath, wheezing, and asthma have been associated with increased levels of particulate air pollution (Yaseen & Scholz, 2018; Sen et.al., 2019; Ananthashankar, 2013). In addition, significant respiratory morbidity can also occur as a result of heavy air pollution. Studies have previously identified reinforced respiratory symptoms that can increase mortality and cancer rates in a short term (Roy et.al., 2020).

Chromium and copper overdose from soil pollution from the textile industry could lead to a concentration that risks human health by causing anaemia, kidney failure, and cortical edoema (Deng et.al., 2020; Sriram et al., 2013; Manzoor, 2006). Besides that, allergies, dermatitis, skin inflammation, tumors, and human mutations may also be caused by water contamination in this industry (Saini, 2017; Parvin et.al., 2015; Berradi et.al., 2019; Roy et.al., 2020; Tripathi et.al., 2014; Sakamoto et.al., 2019). In addition, polluted water often causes diarrhoea, food poisoning, and gastrointestinal problems in the short term affecting human

health (Sakamoto et.al., 2019). Not only that, eye soreness is also a consequence attributable to water contamination (Watari et.al., 2021).

Effect to Aquatic Life

As mentioned earlier, azo dye is one of the causes of water pollution. Azo dyes can decrease the photosynthetic activity of algae through light absorption and can affect the food chain (Gita et al., 2017). This contamination also affects the ecosystem as it increases the toxicity of textile waste hence affecting the fish, sewage and plant bacteria, and other aquatic organisms. Besides, suspended solids from textile waste can clog fish gills and kill them (Tufekci & Toroz, 2007). In addition, it can also reduce the dissolved oxygen in the water and caused the water to smell like foul and bad appearance due to the scum (Mia et.al., 2019; Kant, 2012; Turhan et.al., 2012).

Effect to Plantation

The unavailability of the ionic nutrients of the plant has been exacerbated by the intolerable volume of heavy metal and high concentration of organic compound as a result of textile dyes waste and enhance the hardness of soil leading to the changes in soil texture (Gupta & Srivastava, 2020; Pokhriya et.al., 2020). In Turkey, due to the limitation of water supply, they have been using industrial wastewater for their agriculture. The solid dissolved in the wastewater induces substantial changes in the soil biological properties (Manzoor et.al., 2006). Heavy metals can have harmful effects on plant health, soil microbial diversity, and activity, and tend to have a greater impact on the genetic structure. As a result, textile wastewater increases soil dehydrogenase activity. This caused a major transition in soil microbial biomass carbon (MBC). Toxic metal traced in textile effluent has been used in the plant and vegetation, thus causing serious geo-environmental pollution and anthropogenic hazard (Singh et al., 2020; Chhonkar et.al., 2000).

Ways to overcome the pollution

Treatments for Polluted Water

Chemical Method

Chemical treatment can force pollution to dissolve in water to separate more easily. It is effective to conjugate double bonds of dye chromophores breaking down (Holkar et.al, 2016). This treatment aimed to avoid ecosystems and the environment being more affected. Other than that, ozonation treatment is capable to reduce the impact of water contamination. Ozone causes the cleavage of conjugated double bonds of the chromophore in organic dyes resulting in decolorization but this process is accompanied by the formation of toxic products. It may be used along with a physical method to prevent this (Saini, 2017). However, the short half-life, that is 10 minutes, destabilisation by the presence of salts, pH, and temperature, are the drawbacks of ozonation (Holkar et.al., 2016).

Physical Method

Physical treatment is used to remove the solid in wastewater e.g., the adsorption technique. This technique is one of the effective and proven treatments in textile industries in which the soluble organic compound from the wastewater is transferred to the surface of adsorbent materials (Saini, 2017). This treatment normally uses activated carbon as the adsorption agent that can be regenerated or incinerated. With high removal rates, the

cationic mordant and acid dyes from the wastewater are eliminated, while dispersed, vat, direct, pigment, and reactive dyes have modest removal rates (Holkar et.al, 2016). Other studies suggest the use of adsorbents from agricultural waste such as rice husk, sugarcane, bagasse, and corncobs (Holkar et.al, 2016). The benefit of using these materials is largely due to their widespread and low-cost availability.

Biological Method

Biological treatment to remove suspended solids by microorganisms such as fungi and bacteria are involved in the biological technique. Aerobic biological treatment is often used for large-scale treatment of activated sludge in textile effluent. Bacteria, fungi, and algae are the most important microorganisms responsible for the biodegradation of organic compounds. It was found that certain bacteria, white-rot fungi, and mixed microbial cultures were able to dissolve dyes (Saini, 2017). By adding activated carbon (PAC) or bentonite to the aeration tank, approximately 80% colour removal by degradation of azo dyes (acid Red 151; Basic Blue 41; Basic Red 46, 16; Basic Yellow 28, 19) can be improved to more than 90% (Saini, 2017). Aerobic is a stable and efficient process. This treatment ensures the pollution will be fully degraded and safely discharged with the environment.

a) Treatment for Polluted Soil

Soil washing is known as an ex-situ remediation technique (Hubler & Metz, 2013). The main reason for using soil washing is to overcome the problem of nutrients that are in the soil. The part that is used for soil washing is a chemically synthesized compound. It is a chemical complex of lipids in nature that binds the soil metals and makes them available to plant roots for uptake (Singh, Glick & Rathore, 2020). The benefit of it is to remove the hazardous contamination from the soil by washing the soil with a liquid and scrubbing the soil. Not only that, it makes the plant much healthier (Hubler & Metz, 2013).

b) Organic Cotton Production Initiative

Cotton plants are classified as harmful agricultural goods in the world due to the textile clothing industry. The common cotton plantation involved the use of pesticides and chemical fertilizers. Hence, an initiative was made to change to organic cotton production which does not allow the use of harmful chemicals, hence avoiding contamination of water, air, and soil. Organic cotton is renewable and biodegradable and the production cost is cheaper. Most importantly, the process can save the environment from being polluted (Islam, 2020).

Conclusion

Based on the review, the impacts of the textile industry on the environment were presented and classified into three major groups; water, air, and soil pollution. Dyeing and finishing industries are mostly discussed as they are the main textile sectors that contribute to pollution. The review also presented the domino effects of the pollution in which it attracts diseases to humans and endangers the aquatic life and plantation. Apart from that, the reviews are made on the global ways the pollution is being treated. Some physical, chemical, and biological methods were implemented to treat wastewater induced by the industry, other than soil treatment and organic cotton production initiated to combat the pollution issues.

Despite all the issues on pollution derived from the textile industries and the initiatives taken to inhibit the impacts, it seems that the strategies still far to outweigh the consequences, perhaps due to lack of implementation or enforcement by law. Therefore,

legislative actions need to be imposed in order to penalise irresponsible industry players. However, most importantly, the key to such a penalty is to make them rational and sensible towards their actions which will create an imbalance towards the mother nature.

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