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Physico-Chemical Analysis of Heavy Metal Concentration in Textile Effluent in Sanganer , Jaipur

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ABSTRACT: The printing and dyeing industries in the area of Sanganer (Jaipur) have been imposing harmful effects on the environment. This study is aimed to compare the physico-chemical properties of textile effluents collected from different sites of Sanganer (Jaipur) with the discharge limits prescribed by World Health Organization. Various parameters like pH, color, temperature, electrical conductivity (EC), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, chloride and Total dissolved solids have been determined by prescribed methods. The temperature range was found from 40 ° C to 43 ° C, pH from 6.7 to 9.3 and electrical conductivity from 3.42 to 4.67 $\mu\text{S/m}$. Total suspended solids (TSS) total dissolved solids (TDS) were found in the range of 4509 to 6370 mg/l and 2300 to 3200 mg/l respectively. Level of chloride content found from 425.7 to 528.2 mg/l and hardness from 535 to 760 mg/l. Thus all the parameters are in the high range as compared to the limits prescribed by WHO guideline for textile industrial effluent. Hence, there is a need for the treatment of textile effluents before discharging them into the environment.

KEYWORDS-physico-chemical, heavy metal, textile, effluent, Sanganer, Jaipur

I.INTRODUCTION

A significant threat to the ecosystem and the variety of life forms is posed by the massive amount of garbage that has been produced as a result of rapid industrialisation. Up to 20% of industrial water pollution is contributed by the textile industry, one of the largest industries in the world. Rajasthan occupies a unique position in the textile dyeing and printing industry as a significant economic sector. The textile sector is also regarded as one of the major environmental risks. Many dyes, chemicals, and other substances are used by the textile industry to give fabrics the properties they need. Because textile industries use a lot of water and chemicals, their dyeing units produce a huge amount of effluents that are harmful. The volume of effluents produced by these operations is substantial. They not only have detrimental impacts on the soil and water quality, but they also endanger the health of plants and animals. In this investigation, the physicochemical parameters of industrial effluents from four different sites at the Sanganer textile industrial area were studied to assess the quality of effluents and results were compared to textile effluent standards prescribed by the Rajasthan State Pollution Control Board. The samples were alkaline besides having high chemical oxygen demand. Two different vegetation areas near Sanganer industrial drainage were also identified and studied to analyse the effects of effluents on the growth of plants. It has been noted from the study that the textile wastewaters exhibit extreme variations from the CPCB guidelines in terms of pH, TDS, and EC. The outcomes also show that the effluents have a pollutant load that is significantly larger than the raw water utilised.

Among the important desires of human life, textiles are second only to food. India is the greatest manufacturer of textiles and apparel in the world. A little less than 14 percent of all industrial production, 4 percent of the nation's gross domestic product (GDP), and 27 percent of its foreign exchange are generated by the textile industry [1]. The textile industry changes fibres into yarn, converts the yarn into fabrics or related goods, and then finishes and dyes these materials using a variety of

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production processes. During various phases of the textile production process, the textile industry uses a sizable amount of potable water and a wide variety of synthetic chemicals. These include bleaching agents, detergents, surface active agents (softeners, wetting agents, emulsifiers), salts, acids, and bases, sequestering agents, oxidising and reducing agents (hydrogen peroxide, sodium nitrate, sodium sulphides), carriers (phenyl, phenols, chlorinated benzenes), mordants (alum, iron, tin, tannic acid), defoaming agents, crease inhibitors, dispersing agents, ultraviolet (UV) protective agents, and so on. This results in the generation of wastewater that may pose problems to all living organisms and the ecosystem [2], [3]. These pollutants offer significant health concerns to living things due to their long-range transport and long-term persistence in the environment (water, soil). Additionally, they reduce the fertility of the soil and the capacity of aquatic plants for photosynthetic activity, which results in the emergence of anoxic conditions for aquatic fauna and flora. Textile wastewater compositions are incredibly diverse. Effluents contain significant amounts of hazardous and challenging-to-treat materials that are produced during the dyeing and finishing processes [4], [5]. In addition to other pollutants, effluents contain surfactants, salts, heavy metals, enzymes, oxidizing agents, and reducing agents. When these effluents are released into soil and water, they negatively affect the resources of groundwater and surface water, as well as the qualities of the soil [6], [7]. Pali, Balotra, Jodhpur, Sanganer, and Bagru are the locations where the majority of the state's textile dyeing businesses are concentrated. Over 600 textile dyeing businesses are located in Sanganer and Jaipur, respectively, and both are renowned for their traditional clothing printing and dyeing techniques. These companies produce a lot of waste water effluent that is chemically rich since they use a lot of water and chemicals for wet operations like dyeing. Not all of the dye applied to the fabric during the dyeing process is fixed; some dye is left over and is found in the wastewater. Chromium (Cr), arsenic (As), copper (Cu), and zinc (Zn) are only a few of the trace metals found in dyeing plant wastewater. In addition to these, 75% of used salts are lost to the environment. The effluent also contains a sizable amount of acids, alkalis, inorganic contaminants, caustic soda, and soda ash. The diverse contaminants give the waste water effluent unfavourable characteristics. The pH of the water varies depending on the proportion of acids and alkalis in the effluents, going from acidic to alkaline and occasionally being close to neutral. Because the wastewater contains significant amounts of ions from various salts, its electrical conductance (EC) is high [8]. Several studies have shown that the textile effluents from Sanganer are highly polluted. Azo dyes and copper were the most common pollutants in the textile waste water of Sanganer [9], [10]. Joshi and Shrivastava (2012) showed that the effluent was alkaline, rich in total dissolved solids (TDS) and total suspended solids (TSS), total hardness, alkalinity, chlorides, sulphates, and nitrates [11]. Hussain et al. (2012) studied waste water samples of the effluents in Sanganer, which showed high concentrations of sodium, chloride, and sulphate and also remarkable concentrations of copper, chromium, and iron [12]. Sharma et al. (2012) studied the textile effluent from Sanganer and reported that various physicochemical parameters were not in compliance with the standards set by the Central Pollution Control Board (CPCB). The textile wastewater is also directly discharged into the Dravayavati River and finds its way into the groundwater. It is used for irrigation, where dissolved toxicants are carried to the flora and fauna, including crops and vegetables being grown in the adjoining area [13], [14]. The impact of waste water on agricultural crops reveals crops, plants, and vegetables grown in agricultural fields by using untreated textile effluent were adversely affected both qualitatively and quantitatively [15]. The continuous application of textile effluent also degrades the quality of the soil. The high alkalinity and sodality of the polluted water have been detrimental to several crops and impaired their growth due to hard and barren soils [16]. The study is based on the analysis of the physiochemical properties of industrial dye effluent from the Sanganer textile industry, which can help in the identification of environmental impacts due to the dumping of textile wastewater in water bodies.

II.DISCUSSION

Sanganer is famous for textile dyeing and printing industries. Water pollution caused by the textile industry is mainly by the release of wastewater coming out from the wet processing operations like bleaching, dyeing and printing etc. During the

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present study, the physico-chemical characteristics of the textile effluent contaminated soil samples of Sanganer region were analysed by standard methods and found to have great variation. Soil samples were highly coloured, foul smelling and alkaline (pH 8.8) and contained trace metal ions with concentrations values which were not in compliance with standards. The pH of the samples was alkaline in nature (8.0-8.8). The values of electrical conductivity ranged from 0.19-0.81 mmhos/cm. The amount of % organic matter and % organic carbon ranged from 0.31 - 0.41% and 0.18 - 0.24% respectively. The effluent from the textile industry was the major source of pollution which will affect the flora and fauna existing in such environment. Thus, there is need for treatment of textile effluent before they are discharged into the environment.

Toxicity of textile wastewaters (untreated and treated) and their ingredient chemicals was quantified in terms of their chemical characteristics, fish (*Gambusia affinis*) mortality and end point growth responses of duckweed (*Lemna aequinoctialis*) in short-term bioassays. Other parameters of fish bioassay were erythrocyte morphology and its counts. Despite of a definite correlation between data of biological tests (LC/EC₅₀ values) with that of chemical tests, biological tests were found to be relatively more sensitive to both wastewaters and ingredient chemicals. Amongst all the examined parameters of test organisms, fish RBCs (morphology and counts) sensitivity to pollutants in the wastewaters was usually maximum and therefore, their study should be included in the routine fish bioassay. Other advantage of biological test such as on *Lemna* is even detection of eutrophic potential of wastewaters, as noted at their higher dilutions. The ingredient chemicals (major) contributing maximum toxicity to textile dye wastewater were, acids (HCl and H₂SO₄), alkali (Na₂O SiO₂), salt (NaNO₂) and heavy metal (Cu), whereas dyes (4) were relatively less toxic.

Textile wastewaters released at different steps of printing in Sanganer, Jaipur were collected separately in clean plastic cans and transported immediately to the laboratory. These were: bleach wastewater (chlorine bleaching using CaOCl₂), screen wash (released during washing of screen after manual printing) and wastewaters discharged at different steps of fixing dyes by diazotization and silicate processes. During diazotization process, indigo and rapid dyes are fixed on the printed cloth

Physical parameters of effluent samples

Parameter	S-1	SD	S-2	SD	S-3	SD	S-4	SD
Temperature(°C)	36	±2.29	32	±2.20	37	±2.54	36	±2.48
pH	7.7	±0.52	8.0	±0.55	6.8	±0.47	6.5	±0.45
TDS(mg/L)	1056	±66.22	1268	±87.21	1276	±87.76	1142	±78.54
DO(mg/L)	5.2	±0.39	5.0	±0.34	5.7	±0.39	4.8	±0.33
TSS(mg/L)	387	±20.94	498	±34.25	486	±33.42	548	±37.69
TS(mg/L)	1443	±99.24	1766	±121.46	1762	±121.18	1690	±116.23
Salinity (mg/L)	1442	±46.25	1376	±94.64	1124	±77.30	1236	±85.01
Turbidity (NTU)	26	±0.83	18	±1.24	41	±2.82	53	±3.65
EC(S)	1.55	±0.05	1.21	±0.08	1.82	±0.13	2.10	±0.14

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III.RESULTS

Today, pollution of aquatic habitats is a universal phenomenon, which is more serious in the developing countries on account of discharge of mostly untreated or partially treated municipal and industrial wastewaters into them. The relatively higher toxicity of industrial wastewaters to living organisms, especially plants, is of greater concern since they clean aquatic ecosystems. The industries of concern are; textile printing industry, tanneries, distilleries, sugar industry and paper and pulp industry, since they discharge large volume of wastewater in the environment. Amongst them, the textile printing industry which grew at much faster pace in the developing countries due to cheaper labour and less stringent waste disposal norms is of greater concern. For example, the magnitude of this industry in India can be adjudged from the fact that it contributes almost one-third of the total export and employ 35 million people directly (Chavan, 2001).

Textile wastewater, which is a by-product of textile industry, is a mixture of colorants (dyes and pigments) and various organic compounds used as cleaning solvents, plasticizers etc. It also contains high concentrations of heavy metals, total dissolved solids, and has higher chemical as well as biological oxygen demand. Thus, textile wastewater is chemically very complex in nature. Its discharge had led to complete disappearance of submerged and free-floating hydrophytes, and also selected marshy species in the pools and a wastewater drain in the industrial area of Sanganer town, Jaipur. Algal species richness also decreased markedly in them. These water bodies were also devoid of fauna (Chaturvedi et al., 1999, Sharma et al., 2001). Thus, textile wastewaters are highly toxic to both flora and fauna.

The highly complex nature of textile wastewaters may prove to be a limitation factor for complete assessment of toxicity with chemical analysis. Biological tests in combination with chemical analysis may however, be useful in deciphering toxicity as they express living material response to the total effect of actual and potential disruption (Chen et al., 1999). Besides, such tests also assist in developing precautionary measures and strategy for environmental management (Slabbert, 1996).

Biological tests made on organism at different trophic levels in the food chain may prove to be useful in forecasting impacts at ecosystem level. Phytoplankton, duck weeds (Blinova, 2000) and submerged macrophytes (Lee et al., 1998, Rai et al., 2003, Kumar and Prasad, 2004) are the test materials for monitoring toxicity of man-made chemicals on primary producers in the aquatic ecosystems, which have an additional advantage of detecting even stimulatory role of pollutants. However, duckweed such as Lemna is the first choice of ecotoxicologists because it is wide spread, fast growing and reproduce faster. It is sensitive to many pollutants, which are assimilated from the growing medium (or aquatic environment) through the underside of the leaf (Greenberg et al., 1992, Becker et al., 2002, Sharma et al., 2006).

Among aquatic fauna, fish is favoured over other animals and their mortality is the sole criteria for quantifying pollutant toxicity (Sharma et al., 2005a, Sharma et al., 2005b). Recently, Sharma et al. (2006) reported higher sensitivity of fish RBCs (their counts and morphological abnormalities) to an azo dye methyl red in comparison to their mortality, and hence they may also be explored for quantifying textile wastewaters toxicity. With this background, we have detailed physico-chemical characteristics of textile wastewaters (untreated and treated) of Sanganer, Jaipur, including of ingredient chemicals, in relation to their toxicity to duckweed and fish (mortality and RBC), to quantify potential threats in terms of discharge limits imposed by the regulatory authority for conventional parameters.

The darkening of body and pronounced secretion of mucous (a defensive mechanism) were the two most noticeable fish response in the textile wastewaters and ingredient chemicals. Dyes were deposited over the external (gills) and internal organs (lateral line and digestive system) of fish only in methyl red, and screen and silicate wastewaters. The gills were hemorrhaged at higher concentrations in all treatments.

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From the analysis of raw water and effluent samples from textile industries, it has been observed that the textile wastewaters show extreme fluctuations from the CPCB standards in terms of pH, TDS, and EC. Also, the results indicate that the pollution load in the effluents is much higher than that of the raw water used. The high pollution load of effluents affects the water quality, which in turn leads to significant environmental problems and health risks for the rural communities.

IV.CONCLUSION

In recent years, India has emerged as a promising industrial hub. It has a cluster of textile, dyeing, and printing industries. The adjoining rivers/water bodies receive mostly untreated discharge from these industries. Textile industrial effluent contains various contaminants (dyes, heavy metals, toxicants, and other organic/inorganic dissolved solids) that alter the physico-chemical properties of adjoining land and waterbodies in which it is discharged, thereby degrading the water quality and subsequently affecting the landscapes in the vicinity. This ultimately affects the flora and fauna of the locale and has adverse effects on human health. Out of the total dyes (approximately 10,000 dyes) exploited in the textile dyeing and printing units, azo dyes possess a complex structure and are synthetic in origin. They contribute nearly 70% to the total effluent discharge. Biological processes are based on the ability of inhabiting indigenous microorganisms in these contaminated environments to tolerate, resist, decolorize/degrade, and mitigate the recalcitrant compounds. Exploring microbes with higher efficacy of azo dye degradation can reduce the amount of chemical discharged from the process. The present review explores the potential of microbial diversity for the development of an effective bioremediation approach.

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