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Physico-chemical Characterization of Textile Mill Effluent: A Case Study of Haryana, India

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Abstract
In the present study, the effluent taken from a textile mill of Sonepat (Haryana) was characterized for its physico-chemical properties and heavy metal content. The results revealed that pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total soluble solids (TSS), were higher than the prescribed permissible limits indicating the toxic nature of the effluent. The BOD concentration showed the highest percent of increase from the permissible limits. The chloride content, total dissolved solids (TDS) and (TSS) showed a significant positive correlation with chemical oxygen demand and biological oxygen demand. The nickel (Ni), chromium (Cr) and cadmium (Cd) concentrations in the effluent were within the permissible limits but lead and copper exceeded the BIS limits of effluent discharge. A significant positive correlation was found to exist between Cd and Cr, Cu and Pb while a significant negative correlation was observed between Ni and Pb, Ni and Cu.
Keywords: Textile mill effluent, BOD, COD, TDS, TSS, heavy metals.

Introduction

Textile industries represent a very diverse sector in terms of raw materials, processes, products and equipments and have very complicated industrial chain (Savin and Butnaru, 2008). A number of dyes, chemicals and other materials are used to impart desired grade and quality to fabrics. These industries generate substantial quantity of effluents, which contaminates the natural water bodies altering their physical, chemical and biological nature. Textile effluents can seep into aquifer, thus, polluting the underground water. The impact of textile industry on environment, both in terms of the discharge of pollutants and of the consumption of water and energy has long been recognized (Lacasse and Baumann, 2006).

Textile processing employs a variety of chemicals, depending on the nature of the raw material and product (Aslam *et al.*, 2004). Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, colour, acidity, and other soluble substances (Dae-Hee *et al.*, 1999). Colour is imparted to textile effluents because of various dyes and pigments used. In addition to dyes, various salts and chemicals are the major sources of heavy metals in wastewater.

Sediments, suspended and dissolved solids are important repositories for toxic heavy metals and dyes causing rapid depletion of dissolved oxygen leading to oxygen sag in the receiving water (Alihameed *et al.,* 2008)The metals and contaminants like dyes tend to persist indefinitely, circulating and eventually accumulating through out the food chain. The dyes and metals have direct and indirect toxic effects in the form of cancers and allergies besides, inhibiting growth at different trophic levels (Kant, 2012).

Therefore, the present study was aimed at physico-chemical evaluation of a local textile mill effluent. The comparison was also made with BIS (Bureau of Indian Standards**)** limits for effluent discharge.

Materials and Methods

The effluent samples were collected from a small scale Textile Dyeing Industry in Kundali Industrial Area, Sonepat, Haryana. Sampling of effluent was carried out in polythene bottles at three sites. The pH and temperature of the effluent were determined at the spot, whereas, rest of the physicochemical parameters were determined instantly after bringing the samples in the laboratory. The BOD, COD, TDS, TSS, Chlorides, Sulphates were measured as per the method given by APHA (1992). Heavy metals were estimated after wet digestion with 1:4 mixtures of $HClO_4$ and HNO_3, followed by the measurements of respective concentrations with the help of atomic absorption spectrophotometer.

The data obtained was subjected to mean and standard deviation. Correlation coefficient between the physico-chemical parameters and metal concentrations were determined and tested for significance following Rao and Richard (2001). The data was analyzed on Microsoft Excel (give the version) and SPSS 7.5 software programs.

Results and Discussion

The textile effluent sample was characterized as shown in table-1. The textile effluent sample was black in colour, with pungent smell and pH (9.4) above the permissible limits. The higher pH indicates the alkaline nature of effluent. Generally, alkaline pH of textile effluents is associated with the process of bleaching and is extremely undesirable in water ecology (Effler et al., 1990). The pH of the effluent alters the physico-chemical properties of water which in turn adversely affects aquatic life, plant and humans. Variation in pH values of effluent can affect the rate of biological reactions and survival of various microorganisms (Sankpal and Naikwade, 2012). The temperature of the effluent was also high and above the permissible limit. The impact of temperature on diffusivities both in the air and water (EPA, 2001) could influence emissions of sulphides detected in the effluents while volatilization of oil and grease that could be induced by the same high temperature could introduce organic compounds into the environment, thus polluting the air. High temperature decreases the solubility of gases in water which leads to high BOD/COD. The observed values of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) were quite high. The BOD concentration showed highest percent of increase from the permissible limits. The high level of BOD/COD represents polluted water which requires significant amount of dissolved oxygen for enhanced intrinsic remediation. The high BOD may deplete dissolved oxygen, causing death of aerobic

organisms and increased anaerobic properties of water (Jody and Dons, 2003).. High COD levels imply toxic conditions and the presence of biologically resistant organic substances (Sawyer and McCarty, 1978). When such type of effluent is used in fields, it clogs the pores of the soil resulting in loss of soil productivity(Kant, 2012).

Table 1Physico-chemical characteristics of textile effluent

S.No.	Parameters	Mean Value, ±S.D.	BIS Limits	Percentage increase or decrease
1	pH	9.4 ± 2.2	5.5-9	4.2
2	Temperature	44.67 ± 6.43	40	10.31
3	COD	591.33 ± 171.35	250	57.72
4	BOD	210 ± 57.663	30	85
5	TDS	3586.67 ± 2295.03	2100	41.4
6	TSS	1263.33 ± 441.06	100	92
7	Chlorides	1914.33 ± 92.34	1000	47.76
8	Sulfates	239 ± 8.54	1000	-76
9	Chromium	1.83 ± 0.288	2	8.5
10	Copper	3.21 ± 1.06	3	6.54
11	Cadmium	0.61 ± 0.097	2	-69.5
12	Lead	0.343 ± 0.038	0.1	70.8
13	Nickel	0.74 ± 0.4204	3	75.3
14	Phenol	0.147 ± 0.0038	1	85.3

The effluent showed a higher level of total dissolved solids (TDS)(3586 mg/l).The value was much greater than the tolerance limits (2100 mg/l) prescribed by Bureau of Indian Standards. High TSS and TDS detected could be attributed to the presence of high colour and they may be major sources of the heavy metals (Yusuff and Sonibare, 2004). Both TDS and TSS showed a significant positive correlation with chemical oxygen demand and biological oxygen demand (Table-2). The textile effluent had low values of sulphate and very high values of chloride content. Chloride is an indicator of pollution when present in higher concentrations. High chloride content is harmful for agricultural crops if such wastes containing high chlorides are used for irrigation purposes. The chloride content had a significant positive correlation with TDS, TSS, BOD and COD (Table-2) while phenol content showed a significant negative correlation with them. The effluent showed phenolic contents greater than 0.1mg/l which is though within the permissible limit but still toxic to fishes (Nosheen *et al.,* 2000).

Table-2 Correlation coefficient of physico-chemical parameters of textile effluent

	COD	BOD	TDS	TSS	Chlorides	Sulphates	Phenol
COD	1						
BOD	0.9847*	1					
TDS	0.884*	0.9522*	1				
TSS	0.9675*	0.9967*	0.973*	1			
Chlorides	0.941*	0.9855*	0.9902*	0.995*	1		
Sulphates	0.057718	-0.116	-0.414	-0.1963	-0.2832	1	
Phenol	-0.996*	-0.996*	-0.922*	-0.986*	-0.9673*	0.03091	1

*Significant at 5% level r>0.811, n=3

The amount of nickel, chromium and cadmium in the effluent were 0.74 mg/l, 1.8 mg/l and 0.6 mg/l respectively. All these metals were present in lower concentrations compared to the prescribed limits of BIS (2009) (3.0 mg/l, 2.0 mg/l and 2.0 mg/l respectively). Cu and Pb level in raw effluent was found to be 3.2 mg/l and 0.34 mg/l respectively which were slightly higher than the amount prescribed by BIS. The inter-metallic correlation as shown in Table-3 reveals significant positive correlation between Cd and Cr, Cu and Pb. On the other hand, a significant negative correlation was observed between Ni and Pb, Ni and and Cd.

Table-3 Correlation coefficient of heavy metals in textile effluent

	Cr	Cu	Cd	Pb	Ni
Cr	1				
Cu	-0.3370	1			
Cd	0.880*	0.14891	1		
Pb	-0.6099	0.9516*	-0.1621	1	
Ni	0.7004	-0.908*	0.2790	-0.992*	1

*Significant at 5% level r>0.811, n=3

Conclusion

The present study reveals that the studied textile effluent has high pollution potential. A major reduction in the concentration of various compounds and metals is necessary. It should be more properly treated using various physical, chemical and biological methods before its use on agricultural land.

Authors' contributions: Dr. Sunil Chhikara (Assistant Professor) was the project guide and responsible for project design. Poonam(student) performed experiments. Dr. Lalita Rana(Assistant Professor) performed calculations, wrote the manuscript and is the corresponding author.

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