Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

Determination of the Physicochemical Properties of Three Nigerian Textile Companies' Effluents in Kano, Kano State, Nigeria

***[1]Omotosho, A.O., [1]Oyeleke, S.B., [1]Daniyan, S.Y. and [2]Egwim, E.C.**
*[1]Department of Microbiology, School of Natural and Applied Science, Federal University of Technology, Minna, Nigeria.
[2]Department of Biochemistry, School of Natural and Applied Science, Federal University of Technology, Minna, Nigeria.
*omotazeez@yahoo.com

ARTICLE INFORMATION

Article history:
Received 12 Jul, 2019
Revised 22 Sep, 2019
Accepted 25 Sep, 2019
Available online 30 Dec, 2019

Keywords:
Surface water
Physicochemical
Wastewater
Heavy metals
Textile

ABSTRACT

Textile wastewater contains enormous dyes and chemicals with detrimental environmental effects on both micro and macro fauna and flora due to its chemical compositions. Therefore, wastewater discharges from three Nigeria textile companies (S1, S2 and S3) were analyzed for some physicochemical characteristics such as temperature, pH, suspended solids (SS), total solids (TS), biochemical oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD) and heavy metals concentration using standard laboratory methods. Results obtained revealed the range of values for the above named characteristics as follows: Temperature (20 – 32 ^oC), pH (6.3–9.0), TSS (206 - 420 mg/l), TDS (1537.20 - 3472.50 mg/l), DO (3.5 – 5.2 mg/l), BOD (65 – 85 mg/l), and COD (120 – 195 mg/l). Similarly, heavy metals were detected in various concentrations: Copper (Cu) (4.40-5.60 mg/l), Lead (Pb) (0.42-0.97 mg/l), Cadmium (Cd) (1.80-2.40 mg/l), Chromium (Cr) (0.33 – 0.46 mg/l), Zinc (Zn) (1.20 – 2.20 mg/l) and Iron (Fe) (22.39-24.03 mg/l). These values were higher than the FEPA acceptable limit and indicate that the textile wastewaters were highly polluted. Therefore, urgent attention is needed to protect the quality of the receiving surface water bodies.

1. INTRODUCTION

Textile wastewater includes a large variety of dyes and chemical additions that cause the environmental challenge for textile industry not only as liquid waste but also in its chemical composition (Venceslau et al., 1994). Textile processes are based on chemical reactions in liquid medium, thereby generating large volume of toxic wastewater (Chakraborty et al., 2013). For instance, to dye 1 kg of cotton with reactive dyes, 0.6 - 0.8 kg of NaCl, 30 - 60 g of dyestuff, and 70 - 150 L of water are required (Chakraborty et al., 2005). Textile industries consume over 7 x 10^5 tons of dyes annually and use up to 1 litre of water per kg of dye processed and are one of the largest pollutants of the environment (Mutambanengwe et al., 2007).

Environmental problems of the textile industry are mainly caused by discharges of wastewater. The textile sector has a high water demand. Its biggest impact on the environment is related to primary water consumption (80–100 m^3/ton of finished textile) and waste water discharge (115– 175 kg of COD/ton of finished textile, a large range of organic chemicals, low biodegradability, colour, salinity) (Rosi et al., 2007). Therefore, reuse of the effluent represents an economic and ecological challenge for the overall sector (Rosi et al., 2007). Major pollutants in textile wastewaters are suspended solids, oxygen depleting materials and other soluble substances (Venceslau et al., 1999; Savin and Butnaru, 2008; Kiran et al., 2017). Water pollution is a major global problem which requires evaluation and revision of water resource policy at all levels (Kiran et al., 2017). It is reported to be the leading cause of deaths and disease worldwide (Kiran et al., 2017). Water pollution accounts for the death of more than 14,000 people daily (Ogbu et al., 2016).

Generally, untreated textile wastewater can result in high alkalinity and traces of chromium, where it was employed in dyes, adversely affect the aquatic life as well as interfere with the biological treatment processes (Babu et al., 2000; Robinson et al., 2001; Muda et al., 2012). The aim of this research was to confirm the quality of textile effluents released into the environment and determine their safety or otherwise in our aquatic life.

2. MATERIALS AND METHODS

2.1. Sample Collection and Preservation

Textile effluents were collected from three (3) textile companies in Kano, Kano State Nigeria. The effluent was collected in a sterile 5 liters' plastic container and transported in an ice box to the Microbiology Laboratory, Federal University of Technology, Minna, for analysis within 6 hours of collection. Samples were preserved by refrigeration at 4 °C without any preliminary treatment.

2.2. Sample Analysis

Temperature and pH of the samples were recorded on the spot from where the samples were collected using mercury thermometer and portable pH meter respectively. Chemical oxygen demand (COD) and biological oxygen demand (BOD) were determined immediately after the arrival of the samples to laboratory. COD was directly measured using a COD instrument. The Winkler method was adopted for measurement of BOD values of the collected effluent samples (APHA, 2005). Electrical conductivity was measured with a Philips PW 9526 digital conductivity meter using the method of Lenore et al. (2005). Total suspended solid (TSS) and Total dissolved solid (TDS) were evaluated using filtration and evaporation (at 105 ºC) extraction process respectively with hot air oven as contained in APHA (1998). Analysis of different metal ions in the effluent samples was determined by Atomic Absorption Spectrophotometer as per the standard methods.

3. RESULTS AND DISCUSSION

The physico-chemical parameters of effluents prior to treatment revealed the characteristics of the effluents collected from the three (3) sites as shown in Table 1. The initial pH values of effluent for the three sites were near alkaline ranging from 6.3 to 9.0. Temperature values of the effluents for sites S1, S2 and S3 was between 20 °C to 32 °C. Total suspended solid (TSS) for Site S1 was 206 mg/l, S2 recorded the highest TSS of 420 mg/L. Total dissolved solid (TDS) value recorded for site S3 was 3472.5 mg/L while site S2 had 2354.0 mg/L while site S1 had the lowest value of 1537.20 mg/L. The result for electrical conductivity (EC) showed levels ranging from 2440 to 4500 µS/cm.

Table 1: The Physico – chemical parameters of effluent sample

Parameters	S1	S2	S3	FEPA Standard
pH	9.00±1.23[a]	6.30±1.12[b]	6.50±1.57[a]	6 – 9
Temperature (°C)	25.00±2.23[b]	32.00±1.25[a]	20.00±1.63[c]	30
Conductivity (uS/cm)	2440.00±10.65[c]	3100.00±15.25[b]	4500±11.26[a]	1000
TSS (mg/L)	206.00±6.25[c]	350.00±13.22[b]	420.00±7.25[a]	30
TDS (mg/L)	1537.20±7.95[c]	2354.00±10.25[b]	3472.50±8.35[a]	2000
TS (mg/L)	2043.00±1.23[b]	2704.00±12.23[a]	1292.00±15.23[c]	N. A
DO (mg/L)	3.50±0.25[c]	4.30±0.45[b]	5.20±1.00[a]	20
$BOD_{(5)}$ (mg/L)	65.00±4.25[c]	75.00±5.68[b]	85.00±7.25[a]	10
COD (mg/L)	120.00±6.24[c]	150.00±12.25[b]	195.00±8.29[a]	30
NO_3^{2-} (mg/L)	28.00±1.45[c]	34.00±4.20[b]	42.00±3.25[a]	20
Cl^- (mg/L)	297.84±10.28[a]	248.20±15.29[b]	141.83±11.23[c]	250
SO_4^{2-} (mg/L)	18.38±6.23[ab]	14.05±8.23[c]	19.32±7.23[b]	50
PO_4^{2-} (mg/L)	97.00±5.22 [b]	110.50±11.23[a]	95.00±9.30[b]	100

Values are mean ± SEM of 3 determinations. Values along the same row with different superscripts are significantly different ($p < 0.05$).

Table 2: Heavy metal analysis of effluent sample

Site	Cu (mg/L)	Pb (mg/L)	Cd (mg/L)	Cr (mg/L)	Zn (mg/L)	Fe (mg/L)
A	5.60 ±0.25[a]	0.42±0.04[c]	1.80±0.01[c]	0.46±0.03[a]	2.20±0.00[a]	23.70±1.29[b]
B	4.40±0.03[b]	0.97±0.00[a]	2.20±0.04[b]	0.33±0.01[b]	1.90±0.03[b]	24.03±2.26[aa]
C	4.50 ±0.29[b]	0.70±0.03[b]	2.40±0.02[a]	0.45±0.01[a]	1.20±0.02[c]	22.39±1.95[c]
FEPA Standard	<1.00	0.05	>1.0	<0.1	<1.0	20

Values are mean ± SEM of 3 determinations. Values along the same row with different superscripts are significantly different ($p < 0.05$). Cu = copper, Pb = Lead, Cd = Cadmium, Cr = Chromium, Zn = Zinc, Fe = Iron

Temperature from sites S1 and S3 are below the permissible limits (30 °C) for industrial effluent discharge, while that of S2 was above the limit. These findings agree with the previous reports of mean temperature of 27 °C for textile effluent (Siyanbola *et al.,* 2011). Chemical reactions in water bodies are known to be increased by increase in temperature, thereby resulting into effect such as bad odour and taste due to solubility of gases (Siyanbola *et al.,* 2011).

The pH values of the industrial effluents sampled were within the FEPA standard for discharge effluent (6-9). This implies that the receiving waste water bodies' properties such as alkalinity and hardness may not be altered by these effluents (Wang *et al.,* 2002). However, previous studies reported acidic values from discharge effluent from Nigerian textile industries (Wang *et al.,* 2002; Siyanbola *et al.,* 2011). The differences in sampling location as well as the types of fabrics produced by these industries may be responsible for the difference observed in the pH values.

Increase in TSS (206, 350 and 420 mg/L) results in increase in conductivity (2440, 3100 and 4500 uS/cm) respectively. The TSS and conductivity values are above the maximum limit (FEPA, 1991). This may result in laxative effect on the water bodies and harm aquatic life of the receiving water bodies (Wang *et al.,* 2002; Siyanbola *et al.,* 2011).

The high electrical conductivity according to Humnabadkar et al., (2008) is a sign that the effluents contain enough ions and can be easily treated by physicochemical method. The increased conductivity values of all the samples are not uncommon due to the excessive usage of sodium chloride (Venkatesh and Venkatesh 2009; Sathiyaraj et al., 2017).

Dissolved oxygen (DO) was very low in the three-effluent sampled, and was below the FEPA allowable limit. This indicates high pollution strength of the sampled wastewater and could create an anaerobic condition in the receiving water bodies making the water inhabitable for aquatic animals especially the gill breathing aquatic organisms (Yusuff, and Sonibare, 2004). Yusuff, and Sonibare, (2004) reported that the minimum DO for the survival and growth of aquatic organisms is 8.0 mg/L. BOD and COD are function of DO and are useful parameter in determining water quality. Decrease in DO result into corresponding increase in BOD and COD values (Wynne *and* Buckley, 2001). The ratio of the BOD to COD were estimated to be approximately 1:2 in this study. These highlights a significant level of toxicants e.g. heavy metals may possibly be present in the wastewater (Chavan, 2001). Therefore, the biological activities of the aquatic life in the receiving water bodies will obviously be altered due to insufficient available oxygen, suggesting that the effluent is capable of causing death of some fish and macro-invertebrates (Siyanbola *et al.,* 2011).

Sulphate level was lower compared to the FEPA standard. Similarly, phosphates ions were lowered compared with the FEPA limit except in S2. Though, these two parameters are lower compared to the acceptable limit for safe injection of textile effluent to the environment. The fact that it may lead to eutrophication thereby reducing the available oxygen for biological activity of the aquatic life makes it undesirable (Siyanbola *et al.,* 2011).

Results of the heavy metal analysis carried out in sampled industrial effluents are as shown in Table 2. The result show mean values obtained for the heavy metal concentration in all the sampled effluents. Most of the heavy metal concentration measured had high values, indicating high pollution level. The possible explanation for the increment observed for the various heavy metal characteristics may be linked to the various chemicals used in processing as well as the nature of the raw materials for example, different enzymes, detergent dyes, acid sodas and salts used during processing (Uwidia and Ejeomo, 2016).

These heavy metals are non-degradable and are harmful to the environment (Sekhar *et al.,* 2003). Heavy metals such as copper (Cu), zinc (Zn), from the sampled effluent were higher than the FEPA standard and this is usually due to the various dyes used during the finishing process and chemicals used in the production of the dyes (Siyanbola *et al.,* 2011). Therefore, the use of wastewater treatment becomes necessary to reduce their concentration to acceptable levels before discharging them into the environment. In this way the detrimental effect of polluted water and general pollution of the environment caused by such discharges will be reduced (Siyanbola *et al.,* 2011).

4. CONCLUSION

This research has shown that the sampled effluents has pH 6-9, high BOD, COD and extremely low DO values which are not in conformity with set standards by FEPA. The environment becomes unsafe if these companies continue to release such waste, and this may pose serious threat to both the aquatic habitat and human beings that consume these aquatic animals. Government agencies should become active in ensuring that environmental laws are enforced in order to curb this menace.

5. ACKNOWLEDGMENT

The authors wish to acknowledge the support and contributions of the staff of Microbiology Laboratory, Center for Genetic Engineering and Biotechnology (Step B) Federal University of Technology, Minna, toward the success of this work.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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