POLLUTION POTENTIAL OF UNTREATED TANNERY EFFLUENTS DISCHARGED FROM CHALLAWA INDUSTRIAL ESTATE IN KANO STATE, NIGERIA

Supported by tetfund
TERTIARY EDUCATION TRUST FUND

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Received: January 09, 2018 **Accepted:** June 17, 2018

Abstract: The pollution potential of untreated tannery effluents discharged from Challawa industrial estate in Kano state, Nigeria through drains and canals into Challawa River was considered in this study. Samples were collected along the canal through which tannery effluents from Challawa industrial areas are channelled to River Challawa. The first point (sample station 1) was at the confluence where the different drains converge, the second point (sample station 2) was located 200 meters from the confluence point, the third point (sample station 3) was at 200 meters from the second point and the fourth point (sample station 4) was at the point just before the effluent is discharged into the river. The samples were analyzed for electrical conductivity (EC), total dissolved solids (TDS), total suspended solid (TSS), temperature, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride, alkalinity, and sulphide. The values of the parameters ranged: 8.87-7.54 for pH, 28.1-30.1 ^{O}C for temperature; 2476-3819 mg/L for TDS; 3077 - 4102 mg/L for TSS, 1870-6473 µs/cm for EC; 71.9-148.7 mg/L for sulphide; 219.5 – 353.9 mg/L for chloride; 107.9-283.1 mg/L for BOD and 285.4-814.7 mg/L for COD. Only values of pH and temperature were within the maximum permissible limits set by the regulatory bodies. The values of sulphide, chloride, EC, TDS, TSS, COD and BOD of effluents across the four sampling stations were higher than the limits set by the regulatory bodies. This implies that, if the effluent is discharged untreated into river Challawa, it will constitute potential threat to aquatic life.

Keywords: Aquatic life, River Challawa, sampling, toxicity, tannery effluents

Introduction

Wastes are unwanted, useless or discarded materials generated from residential, industrial and commercial activities. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional); contents (organic material, glass, metal, plastic, paper, etc.); or hazard potential (toxic, non-toxic, flammable, radioactive, infectious, etc.) (UNEP, 2000). These wastes frequently accumulate in the environment creating an increasing number of environmental problems with far reaching consequences on land, water and air. The problems and major environmental concerns associated with the dispersal or disposal of anthropogenic (industrial, agricultural and urban municipal) wastes is the contamination of the soil, water and air (Udiba *et al.*, 2012).

Industrial effluents are major pollutants which contaminate not only water bodies but also the entire biosphere. Tannery effluent ranked as high pollutant among all other industrial waste (Babu, 2011). Tanning is a chemical process that converts hides and skin to leathers, which serves as raw materials in footwear and leather industry (UNEP, 2000). Tanning involves processing of raw leather in order to make it more resilient and strong for use in a variety of different products (Akan *et al.*, 2007). The operations involved in transformation of hides and skin to leather generate large quantities of wastewater that contains toxic pollutants. This considerable amount of organic and inorganic pollutants when discharged into the environment destroys the natural balance that exists in the ecosystem. Environmental pollution caused by tannery wastewaters has become an acute problem as a result of the rapid expansion of the industry, leading to increased use of chromium sulphate as the mineral tanning material in urban areas.

In this study, the pollution potential of tannery effluents discharged from Challawa industrial estate in Kano and its implications on the receiving water body will be thoroughly assessed.

Materials and Methods

Sample collection and preservation

Procedure for sample collection, preservation and preparation were adopted from APHA, (2005). Four sample points were established along the canal of River Challawa. The first point (sample station 1) was at the confluence where the different drains converge. The second point (sample station 2) was located 200 meters from the confluence point, the third point (sample station 3) was located 200 meters from the second point and the fourth point (sample station 4) was at the point just before the effluent is discharged into the sea. These samples were collected monthly for a period of six months, and their mean values determined. Effluent samples were collected by simple scooping into sterile plastic bucket and stored in poured into 2 litres plastic containers previously cleaned by washing with detergent, rinsed with distilled water before soaking in 10% Nitric acid for 24 h (APHA, 2005).

Study area

Kano city (Latitude. 12^0 02'N, Longitude 08^0 30'E) is in the Northern part of Nigeria. Industries are concentrated in three industrial estates, namely Bompai, Challawa and Sharada. Effluent from Challawa and Sharada industries are discharged through drains and canal that empties into River Challawa.

Fig. 1: Map of Kano metropolis showing the study area

Sample analysis

The values of EC, TDS and temperature were determined on site electronically using HACH conductivity/TDS meter (model 44600.00, USA), pH was determined on site electronically using Zeal–tech digital pH meter (model 03112, India). The samples were kept in cooler stock with ice block at a temperature of < 4°C before analysis.BOD and Alkalinity were determined according to standard methods for the examination of water and waste water (APHA, 2005). COD and TSS were determined according to the method described by Ademoroti (1996). Chloride (mg/l) was calculated according to standard methods (APHA, 2005), sulphide was determined using HACH DR 2400 spectrophotometer, and total solid by evaporation on water (APHA, 2005). The samples for metal determination were digested according to Standard Methods for the Examination of Water and Waste Water, American Public Health Association (APHA, 2005).

Results and Discussion

Result obtained from the determination of physicochemical characteristics of untreated tannery effluents across the different sampled points discharged from Challawa industrial estate through canals are given in Table 1.

Table 1: Physicochemical parameters of tannery Effluents from Challawa Industrial Layout, Kano

Parameter	Effluent Station 1	Effluent Station 2	Effluent Station 3	Effluent Station 4
pH	8.87	8.81	8.74	7.54
Temperature (°C)	30.1	29.9	28.7	28.1
TDS (mg/L)	3819	3697	3473	2476
TSS (mg/L)	4102	3855	3739	3077
EC (µs/cm)	6473	5849	5615	1870
Sulphide (mg/L)	148.7	141.5	136.9	71.9
Chloride (mg/L)	353.9	307.8	332.5	219.5
BOD (mg/L)	283.1	276.0	264.2	107.9
COD (mg/L)	814.7	765.4	710.3	285.4

From Table 1 the mean pH values of effluent observed in this study is in range 7.54-8.87 from sampling stations 4 to 1. The effluent pH values were found to decrease gradually from the point of entry into the canal and were lowest at the discharge point into the river which could be due to carbon (IV) oxide from the atmosphere or from biological processes in surface water systems which tend to lower pH levels very effectively to neutral conditions as explained elsewhere (Prasanna and Ranjan, 2010). The pH values of tannery effluent in this study were within the NESREA acceptable limit for the discharge of waste water to surface water and land application of between 6 and 9. A lower mean pH value of 7.56 was previously reported for major tanneries in Kano (Ezike *et al.,* 2012).

The mean temperature of the effluents recorded in this study is in the range 28.1 - 30.7°C, from sampling stations 4 to 1, and were found to be within the permissible limit set by NESREA for tanning and leather finishing industries which stipulate that temperature must be less than 40^{0}C within 15 meters of out fall. The notable difference in effluent temperature observed between effluent station 1 and 4, could be attributed to the influence of the ambient temperature as well as the dilution of the effluent as it flows down the drains. Higher water temperature lowers the amount of dissolved oxygen available for the aquatic life present and promotes excessive growth of aquatic plants and algae (Diya'uddeen *et al.,* 2014). Adedokun and Agunwamba (2014) reported similar temperatures ranging from 29.0 to 31.3°C for River Challawa. Mean temperatures ranging from 23.27 to 26.15 have also been reported for different sampled points along Challawa River (Wakawa *et al.,* 2008). A mean temperature of 28.5^{0}C was reported for downstream area of River Galma while 25.7°C was recorded for upstream area of river Galma (Nnaji *et al.,* 2011). Udiba *et al.* (2012) reported a range of 25.5-31.4 for the Calabar river estuary. A range of 18.6 - 30.3°C have been reported for drains receiving waste water from tanneries in India (Sahu *et al.,* 2007).

From Table 1 the mean concentrations of sulphide in effluents observed in this study is in the range 71.9 – 148.7 mg/L, from sampling stations 4 to 1 and are far above the effluent discharge standard maximum permissible limit of 1 mg/L set by NESREA for tanning and leather finishing industries. Under alkaline conditions, sulphides remain largely in solution, when the pH of the effluent drops below 9.5, hydrogen sulphide evolves from the effluent: the lower the pH, the higher the rate of evolution (Bosnic *et al.,* 2000). This was responsible for the decrease in sulphide level observed from sampling station 1 to 4 and it also accounts for the notable difference in sulphide concentration between effluent station 1 and 4. The continuous action of microorganism on the effluent may also contributes to the decrease in sulphide levels observed. The primary biochemical effects arising from H_2S exposure according to Nicholson *et al.* (1998) are inhibition of the cytochrome oxidase and other oxidative enzymes, resulting in cellular hypoxia or anoxia. A mean sulphide concentration of 143.94 mg/l was reported for effluent from major tanneries in Kano (Ezike *et al.*, 2012).

The mean values of chlorides in effluents observed in this study is in the range 219.5 - 353.9 mg/L from sampling stations 4 to 1. The values of chloride across the effluent stations in this study were higher than the WHO maximum permissible limit of 150 mg/L for effluent discharged into surface water. The high values of chloride could have resulted from the large quantities of common salt (sodium chloride) used in hide and skin preservation or the pickling process. Due to its high solubility and stability, they are unaffected by effluent treatment and nature, thus remaining as a burden on the environment (Akan *et al*., 2009). Chlorides inhibit the growth of plants, bacteria and fish in surface waters; high levels can lead to breakdown in cell structure and can easily render aridity to exposed terrestrial ecosystems (Mwinyihija, 2010).

The mean values of EC, TDS and TSS for effluents were all found to decrease significantly from effluent station 1to 4. The range of mean values of EC,TDS and TSS across the sampling stations were 1870 µs/cm - 6473 µs/cm, 2476 mg/L-3697 mg/L and 3077 mg/L -4102 mg/L respectively. The decrease in TSS could be attributed to continuous deposition as the effluent flow down the canal. Decrease in temperature may account for decrease in TDS as most solute tend to come out of solution as temperature decreases which leads to decrease in dissolved solutes, which may also be responsible for the decrease in EC values. The mean values of EC and TDS of effluents across the sampling stations were higher than the WHO maximum permissible limit of 1000 µs/cm and 2000 mg/L respectively (Bernard and Ogunleye, 2015). Mean effluent EC and TDS values of 3020 µs/cm and1537.50 mg/L respectively were previously recorded for effluents from major tanneries in Kano (Ezike *et al*., 2012). EC is the measure of the ability of water to conduct electricity due to the presence of ionic solutes is referred as its electrical conductivity. The magnitude of conductivity therefore is a useful indication of the total concentration of ionic solute. The high EC values recorded in this study indicate high concentration of dissolved ions solutes and could be attributed to the large amount of chemicals used in the tanning process (Ezike *et al.,* 2012). TDS in water consist of dissolved mineral salts that change the physical and chemical properties of the water. High concentration of TDS in this study is a concern for water purveyors because it alters the taste, it also exert osmotic pressure in water purification systems in hospitals, industries and on the stream ecosystem. Although fish can acclimate slowly to higher TDS concentrations than they are accustomed, they cannot survive a sudden exposure to a high

TDS concentration. High concentration of TSS in this study will negatively affect the surface water's ecosystem and aesthetics. Fish and shellfish can be injured or killed from the TSS by abrasive injuries, clogging gills and respiratory passages, and by blanketing the bottom, killing eggs, young, and destroying spawning beds. The water become cloudy and the system can develop noxious conditions, reducing the aesthetic value of the waters. The mean values of TSS recorded in this study across the effluent stations were far above the maximum permissible limit of 25 mg/L set by NESREA for TSS in tanning and leather finishing industries. Lower mean effluent TSS value of 1217.35 mg/L was previously recorded for effluents from major tanneries in Kano (Ezike *et al*., 2012).

The mean COD and BOD values for effluents were all found to decrease from effluent station 1, 2, 3 and 4. The mean values across the sampling stations were 814.7, 765.4, 710.3 and 285.4 mg/L for COD and 283.1, 276.0, 264. and 107.9 mg/L for BOD. The mean values of COD and BOD of effluents across the sampling stations were consistently higher than the WHO maximum permissible limits of 160 and 50 mg/L, respectively set by NESREA for tanning and leather finishing industries. The decrease in BOD and COD levels observed from sampling station 1 to 4 could be attributed to continuous action of micro-organism as well as reaction between chemicals on the effluent as it flows down the canal. Untreated tannery effluents discharged from Challawa industrial estate Kano through drains and canals into Challawa River can be classified as heavily polluted by organic matter since its BOD value is higher than 10 mg/L. Lower BOD values ranging from 4.3-5.7 mg/L and 4.5-6.0 mg/L were previously reported for the upstream and downstream areas of river Galma (Nnaji *et al.,* 2011). A mean COD value of 129.3 mg/L was reported for river Gorax, Mina, Nigeria (Idris *et al.*, 2013). Discharge of effluent with a high oxygen demand directly into surface water, overloads the sensitive balance maintained in the water. Oxygen is stripped from the water causing oxygen dependent plants, bacteria, fish as well as the river or stream itself to die. The outcome is an environment populated by non-oxygen dependent (anaerobic) organisms leading to toxic water conditions.

Conclusion

This study investigated the pollution potentials of tannery effluents from Challawa which were discharged into River Challawa. Selected physicochemical parameters of the tannery effluent were analyzed to see the pollution potentials of the effluent to the water body. The selected parameters were pH, temperature, sulphide, chloride, EC, TSS, TDS, COD and BOD. The effluent pH and temperature were respectively within the acceptable limits of 6 and 9 and 40^{0}C as prescribed by Nigerian Environmental Standards and Regulations Enforcement Agency (NESREA) for tanning and leather finishing industries; while the mean concentration of chloride, chloride, EC, TDS, sulphide, TSS, BOD and COD across effluent stations were far above the effluent discharge standard of WHO/NESREA for tanning and leather finishing industries. These effluents pose a threat to aquatic life if discharged into the river without prior treatment.

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