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(RESEARCH ARTICLE)

Investigation of physicochemical parameters of wastewater generated in an industry located in Otta, Ogun State, Nigeria

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Abstract

Discharge of untreated effluents from Industries into the environment has been a major source of environmental pollution. This study focused on the physicochemical analyses of effluent generated from an aluminum producing company in Otta, Ogun State, Nigeria. Different physicochemical parameters as well as heavy metals were determined using various standard analytical methods, Flame Photometer, and Atomic Absorption Spectrophotometer (Spectra AA Varian 400 plus). The pH value was 12.04, TS (162.96 mg/L), TDS (152.60 mg/L), TSS (10.36 mg/L), total hardness (95.6 mg/L), total alkalinity (58.47 mg/L), DO (3.85 mg/L), BOD (5.35 mg/L), COD (7.85 mg/L), and chloride content (13.54 mg/L). The mineral analysis showed that the concentrations of investigated metals ranged from 0.01 mg/L (Cd) which was the lowest value to 21.70 mg/L (Na) which was the highest value. It was observed that many parameters investigated were outside the stipulated standards enacted by WHO and FEPA.

Keyword: Effluent; Wastewater; Pollution; Mineral analysis; Heavy metals

1 Introduction

Water is an essential commodity for the sustainability of human race, animals, and plants. It contributes to large proportions of the weights of living things [1]. With how important water is, it is one of the most poorly handled resources globally. Over 1 billion people in the world cannot boast of access to good and potable water [2]. Water pollution as described by Ewere *et al.* [3] involves all activities of human beings from indiscriminate disposal of wastes from both domestic and industrial activities. Pollution occurs when there is an alteration in the physico-chemical or biological conditions of the environment [4].

Water pollution in riverine communities can be apportioned to industries which discharge various chemical contaminants alongside their generated effluent [5]. Of more concern is the adverse environmental effects posed by sludge, oil spills, leakages, municipal and industrial discharge [6]. Toxic substances from effluent have negative effects on every form of life when discharged as untreated or partially treated [7; 8]. They also adversely affect the quality of groundwater when the components are sipped into the soil [9].

It has been reported that about 70% of all the generated industrial wastes in the developing world are being released in an untreated form [10]. Bacterial, viral, and protozoan diseases are the emanating health hazards linked with untreated drinking water and recreational pools [11; 12; 13].

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With the rate at which industries are being cited and the attendant reality of waste generation, it should be of topmost priority that every industry should have a wastewater treatment plant. This will make the environment safe to certain extent. Therefore, this study was aimed at determining the physicochemical parameters as well as heavy metals concentrations of an effluent from a particular industry in Ogun State, Nigeria.

2 Material and methods

2.1 Collection of Sample

The industrial effluent was collected from an aluminium processing industry located in Otta, Ogun State, Nigeria.

2.2 Determination of Physicochemical Parameters

2.2.1 Turbidity

Turbidimeter (WGZ -1B) was used to analyse the effluent. A standard reagent (Formazine solution) was prepared by measuring 2.5 mL of Formazin and made up to 100 mL using distilled water. The sample in assay bottle was placed into the machine and reading was taken.

2.2.2 Conductivity

The sample conductivity value was taken using a Conductivity Meter (DDS-307). The electrode was dipped into the sample and the value was recorded upon stability.

2.2.3 Determination of pH

The electrode of a pH meter was inserted into the sample and the reading was taken when it was steady.

2.2.4 Determination of Total Dissolved Solid

One hundred milliliters of the industrial effluent sample was filtered using a filter paper. An evaporating dish was washed, dried, and weighed (W_1), and the filtrate was transferred into the evaporating dish. Thereafter, the dish with the residue was oven-dried at 105 ^oC. The process of drying was repeated until a constant weight (W_2) was achieved.

$$Total\ dissolved\ solids\ \left(\frac{mg}{L}\right) = \frac{w_2 - w_1}{100} \times 1000 \text{ ………..[14]}$$

2.2.5 Total Solids

A washed evaporating dish was oven-dried at 105^{o}C for 30 min, cooled in a desiccator, and weighed (W_1). 100 mL of the effluent sample was transferred into the dried evaporating dish, the content was left to evaporate until it was dried. The evaporating dish alongside its content was oven-dried and cooled using a desiccator. The process was repeated to obtain a constant weight (W_2).

$$Total\ solids\ \left(\frac{mg}{L}\right) = \frac{w_2 - w_1}{volume\ of\ sample} \times 1000 \text{………..[15]}$$

2.2.6 Total Suspended Solids

The total suspended solids in mg/L was calculated using the difference between total solids (mg/L) and total dissolved solids:

Total Suspended Solids (mg/L) = Totals Solids – Total suspended solids

2.2.7 Acidity

Accurately measured 50 mL of the sample was transferred into a 250 mL conical flask. Few drops of phenolphthalein was added and properly mixed. The solution was titrated using 0.02 M NaOH to obtain a pink solution.

$$Acidity\ \left(\frac{mg}{L}\right) = \frac{Titre\ value \times Molarity\ of\ NaOH}{50} \times 100{,}000 \text{………[16]}$$

2.2.8 Alkalinity

Fifty milliliter of the effluent sample was transferred into a 250 mL conical flask, two drops of methyl orange indicator was added and mixed. The resulting solution was titrated with 0.02 M HCl.

$$Alkalinity\ \left(\frac{mg}{L}\right) = \frac{Titre\ value \times Molarity\ of\ acid}{50} \times 100{,}000 \ldots\ldots\ldots\ldots[17]$$

2.2.9 Total Hardness

This was determined according to Egereonu [18]. Two drops of Erichrome Black T was added to 50 mL of the sample, also added was 2 mL of ammonia buffer solution. The resulting solution was then titrated using 0.01 M EDTA solution until the solution colour changed to blue, and the titre value (A) was recorded. The blank (B) titre value was also determined using similar procedure.

$$Hardness\ as\ CaCO3\ \left(\frac{mg}{L}\right) = \frac{(A - B)\ \times M\ \times\ 50}{volume\ of\ sample} \times 1000$$

M = EDTA Molarity

2.2.10 Calcium and Magnesium Hardness Determination

To determine calcium hardness, 50 mL of the industrial effluent was transferred into a 250 mL conical flask, 2 mL of 1 M NaOH was added and mixed, murexide/NaCl mixed indicator was also added. Upon titration with 0.01 M EDTA, the pink colour changed to purple and the titre value was recorded.

$$Calcium\ hardness\left(\frac{mg}{L}\right) = \frac{Titre\ value \times 0.400}{50} \times 1000$$

Whereas, magnesium hardness was calculated from the difference in total hardness and calcium hardness [19].

2.2.11 Dissolved oxygen and Biochemical Oxygen Demand

The sample was placed in a dissolved oxygen bottle and 5 drops of manganese sulphate were added, also, 5 drops of sodium azide was added. The coagulated solution was shaken together. Thereafter, 10 drops of sulphuric acid were added and the solution turned yellow. 5 mL of the resulting solution was transferred into a conical flask and titrated using sodium thiosulphate to give dissolved oxygen (DO_0). The sample was placed in pre-cleaned bottles and incubated for a period of five days. The procedure stated above was repeated to determine the dissolved oxygen after 5 days (DO_5).

$$BOD\ in\ mg/L = (DO_o - DO_5)\ x\ 10 \ldots\ldots\ldots\ldots[20]$$

2.2.12 Chemical Oxygen Demand

Added to 5 mL of the effluent in a 50 mL round bottom flask with anti-bumping materials were 0.5 mL mercuric sulphate; 2.0 mL potassium dichromate; and 7.5 mL H_2SO_4 solutions. The solution was gently swirled and the flask was attached to a reflux condenser. In the process, water was flowing non- stop as the solution was allowed to boil for about 2 h. After refluxing, the solution was cooled, the condenser was carefully washed into the flask using deionized water. About 2 drops of ferroin indicator was added and subsequently titrated with the solution of ferrous ammonium sulphate until the colour turned red. The same process was used for blank, however, 5 mL of deionised water was used instead of the effluent sample.

$$COD\left(\frac{mg}{L}\right) = \frac{(x - y)\ \times N}{volume\ of\ sample} \times 8000$$

Where x is the volume (mL) of $Fe\ (NH_4)_2(SO_4)_2$ used for blank; y is the volume (mL) of $Fe(NH_4)_2(SO_4)_2$ used for the real sample; and N is the Normality of $Fe(NH_4)_2(SO_4)_2$ used [21].

2.2.13 Chloride Content Determination

In determining the chloride content, 1 mL of potassium chromate as an indicator was added to 50 mL of the sample in a conical flask. The solution was therefore titrated against 0.0141M silver nitrate, which at equilibration turned from green to reddish brown. The same procedure was used for the blank titration [22].

$$\mathit{Chloride\ content}\left(\frac{mg}{L}\right) = \frac{(A - B)\ \times 0.0141}{50} \times 35.45$$

Where A is the $AgNO_3$ volume used for sample titration (mL) while B is the $AgNO_3$ volume used for blank.

3 Results and discussion

3.1 Physicochemical Parameters of Tower Aluminum Effluent

The results of the physico-chemical parameters are presented in Table 1. The pH of the industrial effluent was found to be 12.04, this implies that the effluent was highly alkaline. This was far away from the permissible limits (6.0-8.5) specified by WHO. The high pH value could be as a result of the constituents added together in making the finished product. Discharge of wastewater with extremely high pH is injurious to the environment [23].

The turbidity value for the wastewater was 5.65 NTU. Turbidity is a measure of cloudiness/haziness of fluids owing to the availability of suspended particles, it gives an insight of the state of water quality, high turbidity increases the chances of contamination which will invariable constitute to water-borne diseases [24]. The conductivity value of the effluent was 266.10 µS/cm, similar report was submitted by [25]. Conductivity is an important factor employed in the quality control of effluent/wastewater as it predicts the level of mineralization and salinity of wastewater [26]. The values of total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS) were 162.96, 152.60, and 10.36 mg/L, respectively. Water may be adjudged based on the level of *TDS*: for drinking purpose (500 mg/L); for irrigation (about 2,000 mg/L), not suitable for drinking and irrigation purposes (> 3000 mg/L) [27]. The obtained value for TDS in this study was less than WHO permissible limits of 2000 mg/L allowable for discharge into the environment. TDS is a function of all the dissolved matters such as dissolved ions of resins, organic/inorganic solvents, surfactants, etc. [28]. The value of total suspended solids in this sample was relatively low, Osobamiro and Atewolara [25] reported that industrial effluent of high TSS causes handling problems for agricultural purposes, if discharged into water bodies, it will make life unbearable for aquatic lives. The values of TSS (10.36 mg/L) and TS (162.96 mg/L) were within the maximum permissible limits of 30 and 500 mg/L which have been set for TSS and TS, respectively by WHO and NESREA [29]. TSS is used to describe the extent of pollution in wastewater and it serves as a good indicator for turbidity [30].

Table 1 Physicochemical parameter of the sample

Parameters	**Value**
pH	12.04
Turbidity (NTU)	5.65
Conductivity (µS/cm)	266.10
Total solids (mg/L)	162.96
Total dissolved solids (mg/L)	152.60
Total suspended solids (mg/L)	10.36
Total hardness (mg/L)	95.90
Total alkalinity (mg/L)	58.47
DO (mg/L)	3.85
BOD (mg/L)	5.35
COD (mg/L)	7.85
Chloride (mg/L)	13.54
Bicarbonate (mg/L)	18.30

The value of total hardness of the sample was 95.90 mg/L. This value was far below the WHO permissible standard of 500 mg/L as described by Kumar and Puri [31]. The levels of Ca and Mg salts contribute to its total hardness. Presence of these salts in high concentrations interact with other parameters such as alkalinity and pH causes hardness of water [24]. Total alkalinity of the sample was 58.47 mg/L. The alkalinity level in this work was below the maximum permissible limit (600 mg/L) as reported by Kale and Bandela [32]. The low alkalinity value could be due to the low levels of salts in the sample [33]. Alkalinity in water sample is often due to the availability of natural salts and other ionic species which include bicarbonates, phosphates, and organic acids [34]. The concentration of bicarbonate present in this effluent was 18.30 mg/L.

The levels of DO, BOD, and COD in this study were 3.85, 5.35, and 7.85 mg/L, respectively. These parameters are useful in water quality determination as BOD and COD are functions of DO. DO is a measure of pollution degree and decomposition of organic matters, and self-purification capacity of water body. 5 mg/L is the standard for keeping aquatic lives, concentration below 2 mg/L poses hazard to aquatic life in general and could cause death of vulnerable fishes [35]. BOD is the rate at which oxygen is used by microorganisms for the aerobic degradation of dissolved organic matters in a period of 5 days [6]. COD test is useful in pinpointing toxic condition and presence of biological resistant substances [36].

The chloride content in this study was 13.54 mg/L. Chloride levels outside permissible limits may threaten the sustainability of ecosystem and thus pose a risk to the survival of many species, their growth and reproduction [37]. According to World Health Organization, chloride content in wastewater should not exceed 350 mg/L [13].

3.2 Mineral analyses of the sample

The results of the metal analysis of the sample are presented in Table 2. The concentrations of Na, Ca, K, and Mg were 21.70, 14.25, 9.85, and 6.17 mg/L, respectively. The heavy metals under investigation were Fe (1.53 mg/L), Mn (0.41 mg/L), Cu (0.17 mg/L), Zn (0.62 mg/L), Pb (0.09 mg/L), Cd (0.01 mg/L), Ni (0.05 mg/L), and Cr (0.12 mg/L). Heavy metals are inorganic elements that are very toxic in relatively higher amounts [38]. The highest amount of all the investigated metals was Na (21.7 mg/L) while the lowest amount was Cd (0.01 mg/L). High concentration of Cd will inhibit the bio-uptake of P and K by plants [39]. Among the heavy metals, only the concentrations of Cu and Zn were within the permissible limits of FEPA [40]. However, the concentrations of Fe, Pb, Cd, Ni, and Cr were well above the permissible limits allowable for discharge by WHO. The implication is that such effluent if discharged into the environment untreated poses a great risk to humans and animals altogether. Similar report was made by Siyanbola *et al.* [41] whereby the concentrations of Pb, Cr, Cd, and Fe in some effluents were away from the standards stipulated by FEPA [40].

Table 2 Mineral components of the sample

Parameter	Concentration (mg/L)	Standards
Na	21.70	-
Ca	14.25	-
K	9.85	-
Mg	6.17	-
Fe	1.53	0.30 [42]
Mn	0.41	-
Cu	0.17	1.00 [41; 42]
Zn	0.62	1.00 [41]
Pb	0.09	0.01 [42]
Cd	0.01	0.003 [42]
Ni	0.05	0.02 [42]
Cr	0.12	0.05 [42]

4 Conclusion

In the current industrialized world, generation of wastewater/effluent and its subsequent discharge either treated or untreated into the environment is inevitable. This is why there is a need to treat industrial wastewater before being released into the environment to safeguard the ecosystem. Although the effluent sample under investigation in this study was collected before being treated. The data obtained in this study revealed that some of the physicochemical parameters and mineral analyses were not within the stipulated standards set by WHO and FEPA. So, it is dangerous to discharge such effluent in an untreated form. It is recommended that industries should have effluent treatment set-up for their wastewater. Also, recycling of wastewater is a good alternative. Government should also enact laws to enforce treatment or recycling of wastewater.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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