PHYSICO-CHEMICAL CHARACTERISTICS OF GROUNDWATER IN NILEST, ZARIA, NIGERIA

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ABSTRACT

This work was carried out to assess the physico-chemical characteristics of the groundwater in NILEST, Zaria. Groundwater was analyzed for Dissolved oxygen (DO), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Total Dissolved Solid, pH, Temperature, Total Hardness and selected heavy metals. Atomic absorption spectrophotometer was used to analyze for heavy metals, while a multi-meter was used to determine the pH, conductivity, and total dissolved solid. The groundwater samples were gotten from four different collection points: Hostel bore-hole, Tannery bore-hole, Mosque Well and Staff Quarters Well, using standard methods. Total dissolved solid value at the Hostel was 1231 mg/l, while at the Tannery it was 703 mg/l, at the mosque it was 448 mg/l and at the staff quarters it was 428 mg/l. Chemical Oxygen Demand, Total hardness and selected heavy metals were measured and found to be above the permissible limit of the World Health Organization (2017). It is recommended that the tannery wastes should be treated before being discharged into the environment because it constitutes the major industrial activity at NILEST.

Keywords: Groundwater, atomic absorption spectrophotometer, physico-chemical properties, NILEST, Zaria

INTRODUCTION

Water is a naturally occurring resource which is of fundamental importance because it supports all forms of life and serve vital socio-economic functions like job creation, tourism, recreation as well as fisheries [1]. Without water, life as it exists on our planet will be impossible [2]. It is an important geomorphic structure playing a significant role in the formation of soil (weathering) which is the most important energy regulator in the heat budget of the earth [3]. The demand for fresh water has increased along with the ever-increasing population in the world [4]. About half of the people that live in developing countries do not have access to safe drinking water and 73% have no proper sanitary system such that some of their wastes will contaminate their drinking water supply leading to a high risk of water-borne diseases [5].

Pollution and contamination of this essential resource is primarily associated with domestic and industrial wastes which eventually find their way into the underground water table. It occurs when unwanted materials enter the water resources. Some of these pollutants are decomposed by the action of microorganisms through oxidation and other processes. Each day, about 25,000 people are said to die from use of contaminated water and many millions suffer from devastating water borne illness [6]. Industries are the major sources of pollution in all environments. Water from industries includes employee sanitary waste, processed waste from manufacturing washed water and relatively contaminated water from heating and cooling operation [7]. Various levels of pollutants can be discharged into the environment directly or in indirectly through public sewage lines.

High level of pollution in river water system causes an increase in biological oxygen demand (BOD), Chemical oxygen demand (COD), Total Dissolved solid (TDS), Total suspended solid (TSS), toxic metals such as cadmium (Cd), Chromium (Cr), Nitrate (NO_3), Lead (Pb), and faecal coliform hence make it unsuitable for drinking.

Water moving over or under the land surface can undergo physical and chemical changes. These changes may be caused by either natural factors or human activities.

Groundwater is hidden resources. At one time, its purity and availability were taken for granted. Now contamination and availability are serious issues [8]. Scientists estimate groundwater accounts for more than 95% of all fresh water available for use. In fact, approximately 50% of Americans obtain all or part of their drinking water from ground water, while nearly 95% of rural resident rely on groundwater for their drinking supply and about half of irrigated crop land uses groundwater [9]. In Africa, about 85% of the water is used in agriculture. Only 10% is used in household and only 5% in the industry. Growing population in the continent is expected to place increasing demand on water usage in agriculture.

Okpanchi [10] conducted a research on the effects of solid waste dumpsite on ground water quality in Samaru, Zaria. Groundwater samples were collected from 24 different Wells from three different areas that have major dumpsite in Samaru. He concluded that the ground water of Samaru is not fit for drinking without proper treatment. Furthermore, Igbehinadun [11] researched into water hardness within CHELTECH (College of Chemical and Leather Technology), Zaria, environment and concluded that the hardness of water at that time was within acceptable standard requirement for tannery water. He however did not look into other uses of underground water.

Water have no limit of uses, hence it is being used all the time. It is being used by the students, staff and the tannery located in the Nigerian Institute of Leather and Science Technology. The use of water by the students is for different purposes e. g, drinking, bathing, cooking and washing, while the tannery uses it in washing out of dirt of the hide/skin used in making of finished leather product.

NILEST underground water is natural water that is supposed to be safe for drinking and other uses in the institution. But recently students have been complaining on the taste, appearance, colour and safety of the water. Knowledge of physiochemical parameters of groundwater in NILEST will be helpful for appropriate use of the available water.

The aim of this study is to assess the physico-chemical characteristics of Nigerian Institute of Leather and Science Technology (NILEST) underground water samples. The stated aim was achieved through the following objectives:

i. to assess the quality of the groundwater in terms of pH, COD, DO, TDS, water hardness, temperature and the concentration of selected heavy metals
ii. to compare the concentration of the physio-chemical parameters in the water samples with the acceptable limit of World Health Organization (2017) [12] standards.

THE STUDY AREA

Nigeria Institute of Leather and Science Technology (NILEST) is located at Samaru, Sabon–Gari, Zaria, Kaduna State, Nigeria. It houses staff and students as well as an industrial out-outlet (Tannery).

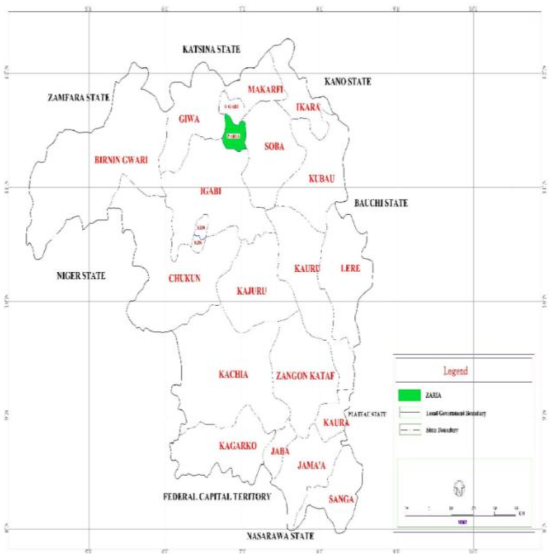

Figure 1: Map of Nigeria Showing Kaduna State and Map of Kaduna Showing Zaria where the study area is located

MATERIALS AND METHODS

Materials

Sample Bottles**,** Beaker, pH Meter**,** Measuring Cylinder**,** Filter Paper**,** Test Tube, Conical Flask**,** Atomic Absorption Spectrophotometer (AAS), Calorimeter, Digital Thermometer and pH meter.

Chemicals

Nitric acid, Sodium Thio Sulphate, Iodine, Magnesium sulphite, Calcium chloride, Alkalis, Sulphuric acid and Distilled water. These reagents were sourced from the National Research Institute for Chemical Technology, Zaria (NARICT).

SAMPLING TECHNIQUES

The water samples were collected from Boreholes and Wells, with sampling bottles. The samples were taken from four different locations having either Well or Borehole. Samples were collected from Well using water container having a rope tied to its handle for letting it down into the Well, while the Borehole samples were collected from the tap, from the four named locations.

METHODOLOGY

Underground water samples from Boreholes and Wells from four selected areas in NILEST which were: Hostel (Borehole water), Tannery (Borehole Water), Mosque (Well water) and Staff quarters (Borehole water) were collected using different sterilized sampling bottles which were coded. The choice of these locations was based on the purpose to which the underground water source was serving. The samples were then taken to the Environmental Laboratory in National Research Institute for Chemical Technology for analysis.

To determine the Chemical Oxygen Demand: Dichromate reaction digestion methods were used. Small volumes of ground water sample (2 cm^3) were pipetted into vials containing the premeasured reagents including catalysts and chloride. The vial was incubated at 150 °C for 2 hours for digestion to take place and allowed to cool. The COD measurement was carried out using HACH 890 DR Calorimeter.

Atomic absorption spectrophotometer was used to analyse for heavy metals.

Total Hardness was obtained by titration with the sodium salt of ethylenediaminetetraethanoic acid (EDTA). The detection was carried out with a Cu electrode and Cu-EDTA. The sum of EDTA complexable ions was then determined.

Dissolved Oxygen was measured by titration method.

pH and Temperature were measured by the use of digital pH meter and thermometer respectively.

RESULTS AND DISCUSSION

pH is a good indicator of whether water is hard or soft. The pH of pure water is 7. In general water with a pH lower than 7 is considered acidic and a pH greater than 7 is considered basic [13]. Figure 2 gives a bar chart illustration of the pH of groundwater samples from the sample points. pH values for Hostel, Tannery, Mosque and Staff Quarters were found to be 07.7, 07.1, 07.6, and 07.1 respectively.

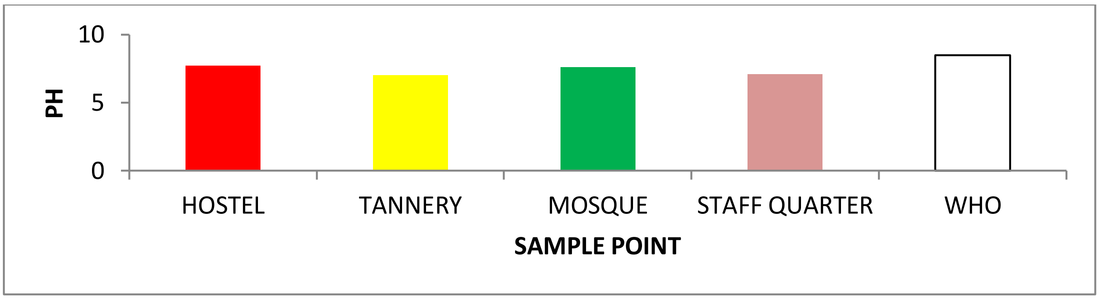

Figure 2: pH values of ground water from selected sample points

Total Dissolved Solid refers to any minerals, salts, metals, cations or anions. The bar chart in Figure 3 gives a representation of obtained values from water samples collected in the Institute. TDS result were 1231 mg/l for Hostel, 703 mg/l Tannery, 448 mg/l for Mosque and 428 mg/l for Staff quarter Well samples.

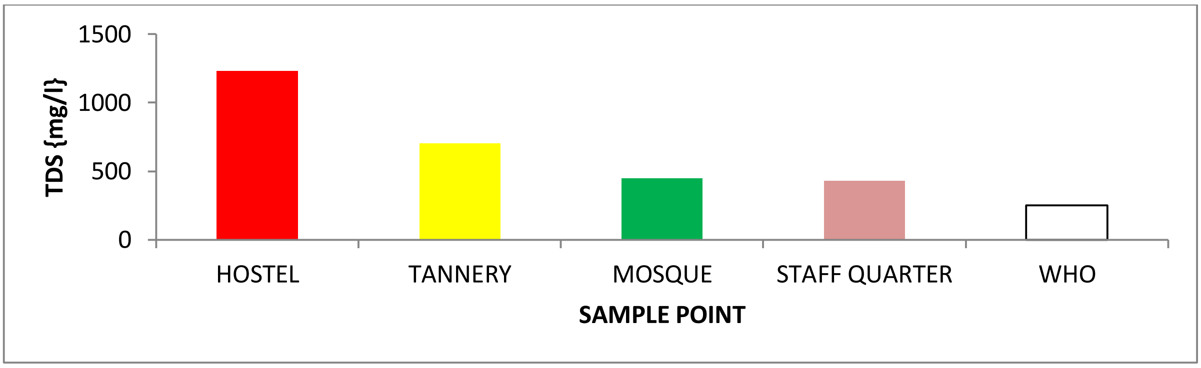

Figure 3: Total Dissolved Solids of water samples at different sample points in NILEST

Temperature is the degree or intensity of heat present in a substance or object especially according to a comparative scale and measured with a thermometer. The values found were: Hostel 25.9 °C, Tannery 26.1 °C, Mosque 25.2 °C, Staff quarter 26.0 °C as shown in Figure 4.

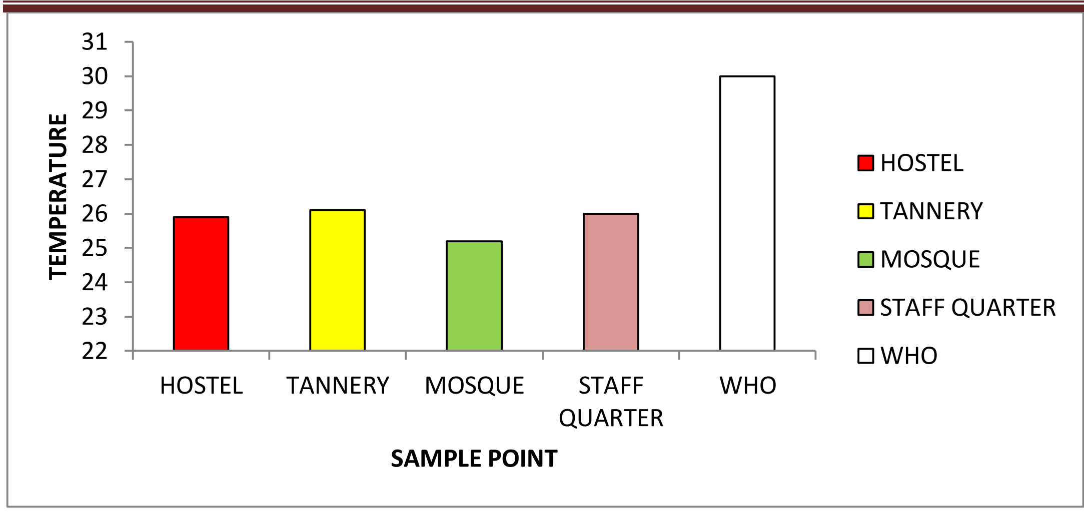

Figure 4: Temperature of water samples collected at different sample points (state the source, borehole or well samples)

Dissolved Oxygen is the amount of gaseous oxygen (O_2) in the water. The DO concentration was found in the four samples were: 5.42mg/l for Hostel, 5.51mg/l for Tannery, 6.04mg/l for Mosque, 5.24 mg/l for Staff quarter water samples as seen in the bar chart in Figure 5.

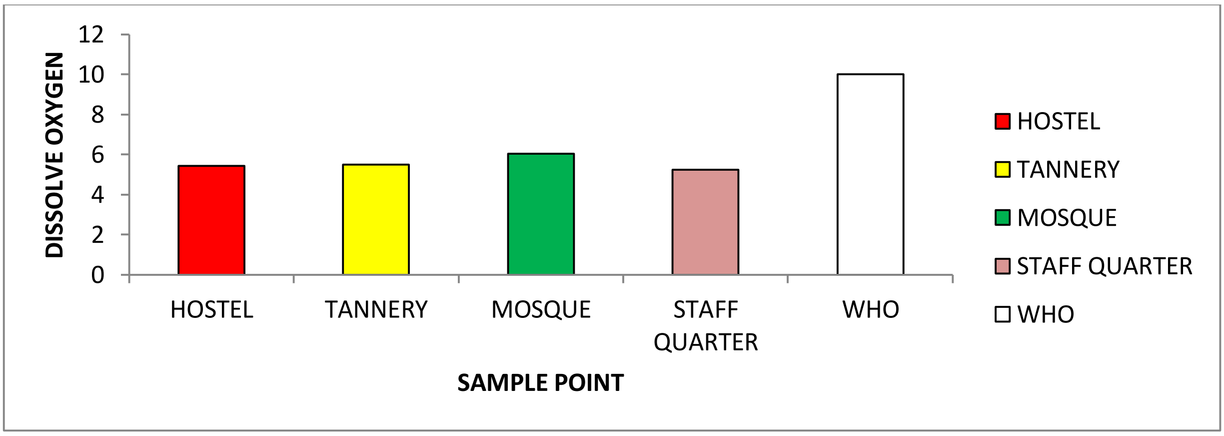

Figure 5: Dissolved Oxygen (in milligram per litre) at the sample points in NILEST

Chemical Oxygen Demand (COD) is the measure of the capacity of water to consume oxygen. COD was 190 mg/l for Hostel, 90 mg/l for Tannery, 110 mg/l for Mosque and 110 mg/l for Staff quarter well samples as represented in Figure 6.

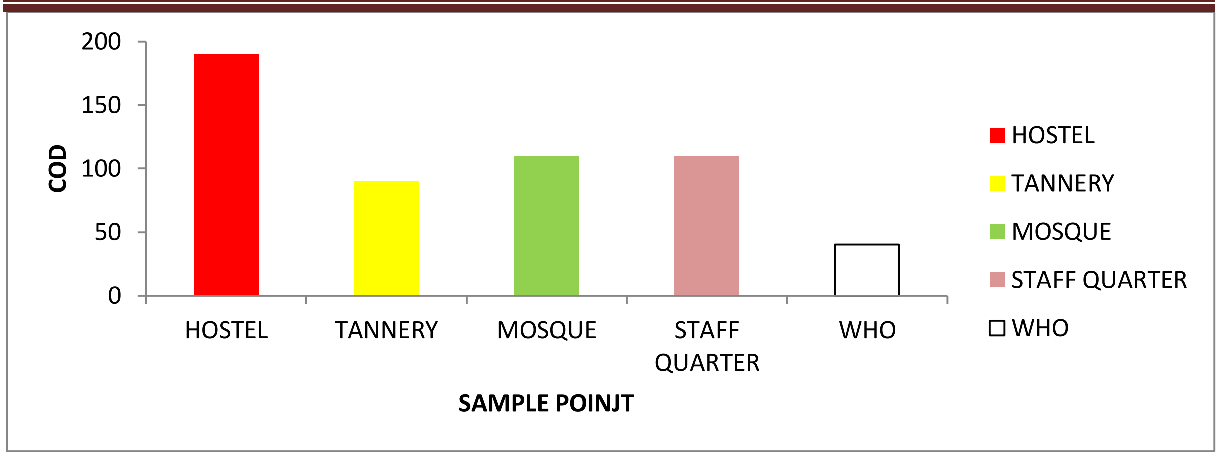

Figure 6: Chemical Oxygen Demand (in milligram per litre) at sample points in NILEST

TOTAL HARDNESS is one of the factors that establish the quality of a water supply. It is the degree of hardness. Hardness is defined as calcium and magnesium ion contents. Most analysis do not distinguish between Ca^{2+} and Mg^{2+}, and most hardness is caused by carbonate minerals deposits, hardness is reported in parts per million (ppm). Hard water forms scales in steam boiler and interior of pipes. High amount of hardness in drinking water also leads to heart diseases and kidney stone formation. As shown in Figure 7, groundwater in the hostel have the highest value for Total hardness (1707.4 ppm) followed by the Mosque (707.6 ppm), Staff quarters (646.45 ppm) and then the Tannery (515.14 ppm)

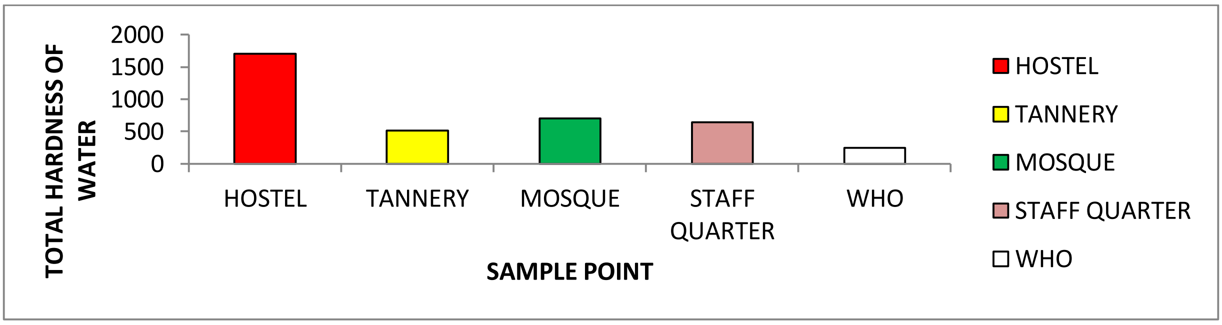

Figure 7: Total Hardness at sample points in NILEST

HEAVY METALS levels above World Health Standard pose a number of health challenges. The concentration of the heavy metals of Lead and cobalt are presented in Figure 8.

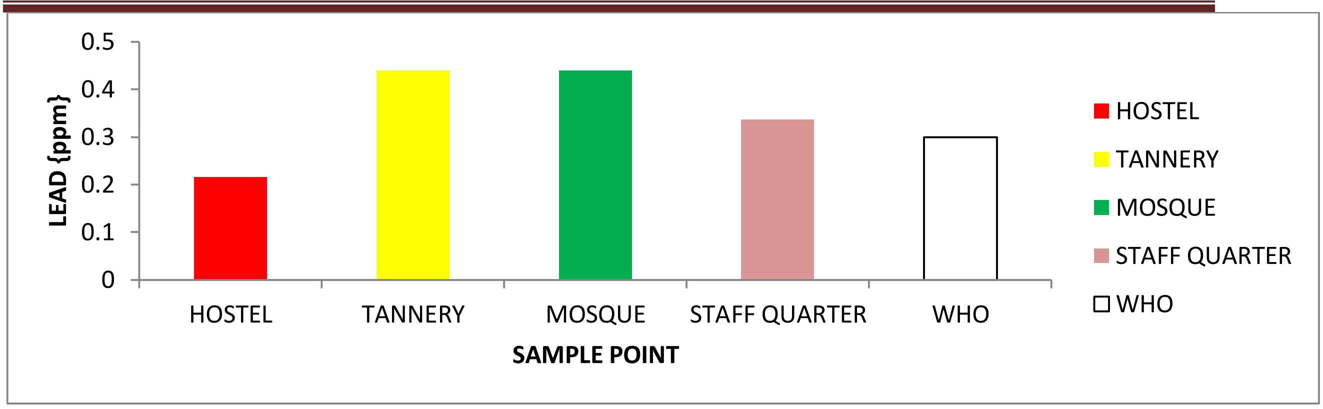

Figure 8: Sample Point Concentration of Lead in parts per million

Excess lead in the human body can cause developmental delays, abdominal pain, neurological changes and irritability. From the analysis, ground water from the tannery and the mosque each has the highest concentration of Lead (0.44 ppm each) followed by the staff quarters (0.33 ppm) and the Hostel (0.22 ppm).

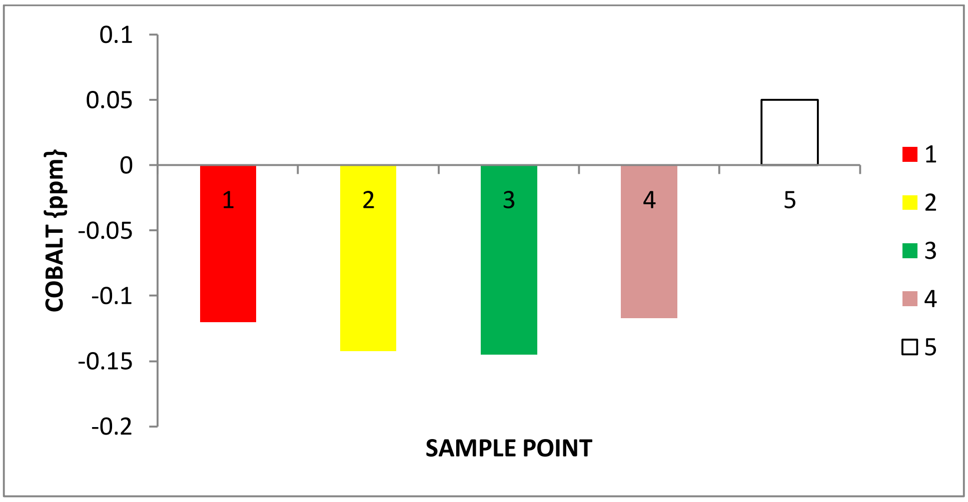

Figure 9: Concentration of Cobalt (in parts per million) at sample points in NILEST

The bar chart in Figure 9 shows negative concentration of cobalt in all the sample points as the bars appear below the Y- axis. From the graph the concentration of Cobalt in all sample points is well within the permissible limits as set by WHO.

Table 1: Comparison of physiochemical parameters with World Health Organization Standards

PARAMETERS	HOSTEL	TANNERY	MOSQUE	STAFF QTRS	WHO
Ph	07.7	07.	07.6	07.1	6.5-8.5
Temperature	25.9	26.1	25.2	26.0	30
Total dissolved solid	1231	703	448	428	250
Dissolved oxygen	5.42	5.51	6.04	5.24	10
COD	190	90	110	110	40
Total hardness	1707.04	515.14	707.06	646.45	250
Lead	0.2149	0.4402	0.4407	0.3362	0.3
Cobalt	-0.1199	-0.1420	-0.1451	-0.1173	0.05

From Table 1, the pH value for underground water gotten from the hostel is within the WHO acceptable limit of 6.5-8.5 for safe drinking water. Temperature was observed to be 26.1 °C which is below the standard limit of WHO 30°C, Dissolved Oxygen is lower than stipulated 10 mg/l of WHO which agrees with the findings of Lekwot *et al*[14]. The COD was above the standard (40mg/l) of WHO. Total hardness was measured to be three times greater than the permissible standard of 250mg/l of WHO while the concentrations of lead in Tannery and mosque were above the permissible standard WHO of 0.3 ppm. The concentration of cobalt was also found to be beyond the World Health Organisation standard set limit of 0.05 ppm.

CONCLUSION

Having analyzed some of the physio-chemical properties of the ground water from the Nigerian Institute of Leather and Science Technology, it can be concluded that most of the parameters analyzed were highest in the School hostel and Tannery, which may be likely as a result of dumpsite and tanning activities therein. Most of the parameters were compared with the World Health Organization standards and were above the acceptable limit for safe drinking water. Therefore, the underground water in the Nigerian Institute of Leather and

Science technology is not potable. In order to meet the requirements of WHO regulatory guidelines and standards, it is recommended that the Institute rehabilitates and maintains the existing tannery waste water treatment plant so that water can be treated to reduce the concentration of pollutants before discharging it out into drainages.

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