INVESTIGATION OF PHYSICOCHEMICAL AND TRACE METAL LEVEL IN DRINKING WATER SOURCES WITHIN THE NIGERIAN INSTITUTE OF LEATHER SCIENCE AND TECHNOLOGY, ZARIA, NIGERIA

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ABSTRACT

Tannery effluent is harmful when untreated and released into communities. This study collected groundwater samples from the bore and open wells within NILEST, Zaria and control samples from outside the study area to investigate trace element levels. The physical and chemical parameters were determined using standard analysis methods, while the trace elements were determined using an atomic absorption spectrometer. The results were compared with those of drinking water standards recommended by the World Health Organisation (WHO) and the Standard Organization of Nigeria (SON). The results obtained for physical parameters reveal a pH of 5.1 and 5.5 for the bore and open well water samples, respectively, compared to the 5.5 and 5.7 control samples. These indicate some level of acidity. However, the electrical conductivity and total dissolved solids were within permissible limits. For chemical parameters, the chloride levels were 851 mg/l and 709 mg/l for bore and open well water, respectively, compared to 1418 mg/l and 1702 mg/l control, indicating a high level of chloride content. However, the total hardness and total alkalinity were within the permissible limit. Heavy metals analysis showed low copper, lead, chromium, and cadmium levels in both sample and control water. Groundwater pH and chloride levels are generally within permissible limits, although treating the water for pH and high chloride content is recommended. A microbiological assessment is necessary to determine if the water is safe to drink, and regular monitoring is essential. Treating effluents before discharge is highly recommended.

KEYWORDS
Drinking water, trace element, physicochemical, WHO, SON, NILEST

INTRODUCTION

Water, a prime natural resource and precious natural asset forms the chief constituent of the ecosystem (Sivaranjani *et al*., 2015). Water covers 71% of the earth's surface and is a vital natural resource for people. Besides the need for water for drinking, water resources play a vital role in various sectors of the economy, such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries and other related activities (Sivaranjani *et al*., 2015).

Water sources may be mainly rivers, lakes, glaciers, rainwater, groundwater, etc. (Sivaranjani *et al*., 2015). Groundwater is generally presumed to be suitable for human consumption and is used as a primary source of drinking water (Ruthearvel, 2012). Groundwater consumption is increasing daily in areas where surface water sources are insufficient to meet the demands (Ruthearvel, 2012). However, in recent decades, groundwater pollution has been considered an essential agenda for various research activities because of its significant role in affecting human health and its risks. Although there are numerous reasons for groundwater pollution, anthropogenic sources are considered the prime ones (Rutharvel, 2012).

Tanning industries convert raw hides into flat leather through a series of chemical treatments in leather processing known as tanning. The prime stages in leather processing are curing, soaking, liming, dehairing, detaining, deliming, bating, pickling, degreasing and tanning. All these steps use chemicals like sodium sulphide, sodium bicarbonate, chromate and chloride, sodium sulphite, chromium sulphate, calcium salts, ammonium salts, acids, alkalis, fat liquor, organic dyes, hydrogen peroxide and formate, which in turn release toxic chemicals of organic chlorinated phenols, inorganic pollutants of Cr(vi), and other toxic pollutants like sulphides, phenolic compounds, magnesium, sodium, potassium, azo dyes, cadmium compounds, cobalt, copper, antimony, barium, lead, selenium, mercury, zinc arsenic, formaldehydes resins, dyes, solvents, pesticides residues and other mineral salts that cause severe health hazards and environmental problems to the entire ecosystems (Geremew & Tekalign, 2017).

Also, tanning industries tend to consume a large amount of water for the various processing steps, and these water bodies are discarded as waste containing a complex mixture of synthetic chemicals (Rutharvel, 2012). According to Mondal *et al*. (2005), the minimum level of effluent

tanneries produced is 3000 to 3200 litres per 100 kg of hide processed. The release of ineffectively treated wastewater onto the surface leads to the contamination of ground and surface water sources (Rutharvel, 2012). This article investigates whether or not the underground water sources within NILEST, Zaria comply with the World Health Organisation (WHO) standards in order to ascertain their suitability for the designated use and for public health, especially for drinking.

MATERIALS AND METHODS

Sample Collection

A drinking water sample was collected from two major open and borewell sources in the study area of NILEST, Zaria Kaduna State. One litre of each water sample was collected in a one-litre polyethene bottle from an open well. Bore and open well waters were collected in NILEST, Zaria, at the tanning area 20 m away. Similarly, Bore and open well samples used as control samples were collected 1 km outside the study area.

Method for Physical Parameters

pH:

Ten millilitres of sample and control each were dispensed into a beaker, and the pH was determined with a previously standardized pH meter. The pH meter was calibrated using a phosphate buffer of pH 4.0 and 7.0 (Ekanem & Ekanem, 2018).

Total dissolved solid:

A portion of the water sample was filtered and stirred with a magnetic stirrer. It was pipetted to a weighed evaporating dish. After completely evaporating water from the residue in a steam bath, it was transferred to an oven at 103-105°C and dried to constant mass. As soon as it cooled, the dish was weighed, and the filterable residue was calculated as

Filterable residue mg/L $= \frac{1000M}{v}$ …………………………………………………………. (1)

Where:

M = mass in mg of filterable reside

V = volume in mL of the sample (Food Safety and Standards Authority of India, 2016).

Electrical conductivity:

A 100 ml amount of water was transferred to a suitable container, and the test sample was vigorously agitated while the conductivity was periodically observed. When the change in conductivity (due to uptake of atmospheric carbon dioxide) is less than 0. cm per 5 minutes, the conductivity was noted. However, when the conductivity was less than 2.1cm, the water under examination met the test requirement.

Method for Chemical Parameters

Chloride

A hundred (100) ml of the water sample was measured using a measuring cylinder and then diluted with water to a final volume of 100 ml. Next, 1 ml of hydrogen peroxide was added to the solution and stirred for 1 minute. The sample was then titrated in the pH 7-10 range by adjusting it with either sulphuric acid or sodium hydroxide.

A 1.0ml potassium chromate indicator solution was added and titrated with a standard silver nitrate solution to a pinkish-yellow endpoint. The titration method was used to standardize silver nitrate solution and establish reagent blank value (Food Safety and Standards Authority of India, 2016).

Calculations

$$Chloride, mg/l = \frac{(V1 - V2) \; X \; 35450}{V3}$$

…………………………………………………………..……………………………. (2)

Where:

V1 = volume in ml of silver nitrate used by the same people

V2 = volume in ml of silver nitrate used in the blank titration

V3 = volume in ml of a sample taken for titration

N = Normality of silver nitrate solution

Total hardness:

Using a pipette, 50 ml of the water sample was pipetted into a beaker and 1ml hydroxylamine hydrochloride solution was added. 2 ml buffer solution was added to achieve a pH of 10.0 to 10.1, followed by 2 ml Eriochrome black T indicator solution. The solution was titrated with standard EDTA solution, stirring rapidly in the beginning and slowly towards the end until the endpoint was reached when all solution was sky blue.

Blank titration was carried out in the same way as that for the sample for comparison (Food Safety and Standards Authority of India, 2016)

$$Total\ hardness\ as\ [CaCO3]\ mg/l = \frac{[1000\ (V1-V2]}{V3}\ x\ CF$$

…………………………………………………. (3)

Where:

V_1 = volume in ml of the EDTA standard solution used in the titration for sample

V_2 = volume in ml of the EDTA solution used on the titration for blank

V_3 = volume in ml of the sample taken for the test

CF = X1/X2 correction factor for standardization of EDTA

X1 = volume in ml of standard calcium solution taken for standardization

X2 = volume of ml of EDTA solution used in the titration

Total alkalinity:

Using a pipette, 20ml of sample was carefully added to a beaker. In order to achieve a pH of above 8.3, 2 to 3 drops of phenolphthalein indicator were introduced, and the solution was titrated with standard sulphuric acid until the pink colour observed by the indicator just disappeared, with the volume of standard sulphuric acid solution used recorded.

Following this, 2 to 3 drops of mixed indicator were added to the solution to determine phenolphthalein alkalinity. The solution was titrated with standard acid until it reached a light pink colour, indicating an equivalence of pH 3.7. Finally, the volume of standard acid used after phenolphthalein alkalinity was recorded (Food Safety and Standards Authority of India, 2016).

Calculation:

The alkalinity of the sample was calculated as follows.

$$Phenolphthalein\ alkalinity\ (as\ mg/l\ of\ CaCO3 = \frac{A\ X\ N\ X\ 5000}{V}$$ …………………… (4)

$$Total\ alkalinity\ (as\ mg/l\ CaCO3) = \frac{(A+B)\ X\ N\ X\ 5000}{V}$$ ……………………….. (5)

Where:

A = ml of standard sulphuric acid was used to titrate to pH 8.3

B = ml of standard sulphuric acid used to titrate from pH 8.3 to 3.7

Sample digestion and chemical analysis:

Using a measuring cylinder, 50 ml of each sample was digested with 10 ml aqua regia (3:1 HCl: HNO_3). These samples were heated for thirty minutes. After heating, the samples were cooled to room temperature and diluted to 50 ml with distilled water; they were filtered through Whatman no.41 filter paper. The sample solutions were analysed for copper, lead, chromium and cadmium using atomic absorption spectrophotometer (Riyadh, 2020).

RESULTS AND DISCUSSIONS

Table 1: Physical parameters for bore well water and control sample

Water sample	pH	Electrical conductivity	Total dissolved solids (mg/l)
Bore well	5.1	4.3	2.6
control	5.5	4.7	3.2

Table 2: Physical parameters for open well and control sample

Water sample	pH	Electrical conductivity	Total dissolved solids (mg/l)
Open well	5.5	4.6	3.0
control	5.7	4.5	3.3

pH measures the hydrogen or hydroxide ion concentration in a solution. From the result in Table 1, the pH for the Bore well compared to the control were 5.1 and 5.5, respectively. Similarly, open well pH compared to the control sample in Table 2 was 5.5 and 5.7, respectively. The sample pH for Bore and open well water is higher than the control sample pH for Bore and open well water. However, the pH for both sample and control were not within the standard, the acceptable range of 6.5-8.50 by WHO. This shows that some acidity levels and consumption of such acidic water can adversely affect humans' digestive and lymphatic systems (Shalom *et al*., 2011).

Electrical conductivity indicates the amount of minerals present in water samples. From the results in Table 1, the Bore well compared to the control shows an electrical conductivity of 4.3 µS/cm and 4.7 µS/cm, respectively. Similarly, compared to the control in Table, the open well water 2 shows an electrical conductivity of 4.6 µS/cm and 4.5 µS/cm, respectively. These results are far below the Nigerian standard for drinking water of 1000.

According to WHO and SON, water should have a total dissolved solid concentration of 500 mg/L; samples tested for bore well water and control have a total dissolved solid of 2.6 mg/l and 3.2 mg/l, respectively, in Table 1.0. Similarly, the open well and control total dissolved solid are 3.0 mg/l and 3.3 mg/l, respectively, in Table 2. These results are far below the recommended standards for water quality.

Table 3: Chemical parameter for bore well and control sample

Water sample	Chloride (mg/l)	Total hardness (mg/l)	Total alkalinity (mg/l)
Bore well	851	120	1.4
control	1418	155	1.1

Table 4: Chemical parameters for open well and control sample

Water sample	Chloride (mg/l)	Total hardness (mg/l)	Total alkalinity (mg/l)
Open well	709	180	1.4
Control	1702	180	2.2

The chloride content in Table 3 for bore well water and control samples shows 851 mg/l and 1418 mg/l, respectively. Similarly, the open-well water and control in Table 4 are 709 mg/l and 1702 mg/l, respectively. Comparatively, the control chloride for well and borehole water is higher than the sample chloride. The reason may be due to some effect on the control other than the tannery. However, the results indicate an extremely high value of chloride, which is above the ten mg/l WHO standard. High sodium content can be associated with thereby causing salty taste and can speed up corrosion in plumbing (Byron *et al*., 2009).

Table 3 shows the total hardness of bore well water and control sample, which is 120 mg/L and 155 mg/l, respectively. It is worth noting that the total hardness values do not exceed the desirable limit of 300 mg/l, as stated by Rutharvel *et al*. (2012). Table 4 shows the total hardness for open-well and control is 180 mg/l. Both the control open well water and sample have the same total hardness. However, the total hardness of the Bore well water samples is lower than that of the control sample. It is worth noting that the total hardness for both the sample and control did

not exceed the WHO standard. Therefore, it implies that the water has no significant impact on human health and is safe for drinking, as Sengupta (2013) stated.

The total alkalinity for bore and control samples was 1.4 mg/l and 1.1 mg/l, respectively, in Table 3. Similarly, 1.4 mg/l and 1.2 mg/l for the open well and control sample, respectively, in Table 4. These values were below the WHO standard.

Table 5: Concentration of heavy metals in borewell and control sample

Water sample	Copper (mg/l)	Lead (mg/l)	Chromium (mg/l)	Cadmium (mg/l)
Bore well	0.0005815	-0.001785	0.0010475	-0.0000125
control	0.00111	0.00000475	0.0013575	0.00001725

Table 6: Concentration of heavy metals in open well and control sample

Water sample	Copper (mg/l)	Lead (mg/l)	Chromium (mg/l)	Cadmium (mg/l)
Open well	0.0009475	0.000353	0.0006	0.0003225
control	0.0005725	0.0008575	0.00104	-0.0002825

The results shown above in Table 5 and Table 6 indicate that all the heavy metals, i.e. Cu, Pb, Cr and Cd, assessed for water and control samples are below the regulatory body standard for drinking water. Lead and cadmium were below the detection limit for the borehole water sample in Table 5. Similarly, cadmium was below the detection limit in the open well water of the control sample in Table 6. However, the water is considered safe for drinking.

CONCLUSION

According to WHO standards, the pH values for the sample and control in the physical parameters in this study did not fall within the acceptable range of 6.5-8.5. Electrical conductivity and total dissolved solids were below the Nigerian standards for drinking water. Total hardness and alkalinity did not surpass WHO standards for chemical parameters. However, chloride levels exceeded WHO standards. Copper, lead, and chromium were below regulatory standards in both

the sample and control. Based on the scientific findings of this investigation, the water can be considered moderately safe for drinking.

Nevertheless, local authorities strongly advise urgent intervention to address the pH and chloride levels and restore the groundwater sources' quality. It is imperative to expand groundwater studies to include dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, and microbiological assessment to determine the overall suitability of these water sources for drinking. Regular monitoring is essential, and the treatment of effluents before discharge is highly recommended.

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