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Physicochemical and Heavy Metals Analysis of Water from Different Sources in Usen, Edo State, Nigeria.

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***Abstract**: The study investigated the physicochemical properties and heavy metal contents of water samples from three major sources; river (sample A), borehole (sample B), and well (sample C), in Usen using standard procedures. The heavy metal content was analyzed using Atomic Absorption Spectrometer. The results obtained were compared to permissible limits based on WHO standard. The pH of the water samples ranged from 6.80 to 7.00. The nitrate content varied from 2.30 to 2.40 mg/L, which was lower than the maximum limit of 10 mg/L. The conductivity was from 36.52 to 64.61 us/cm. Copper was not detected in all the water sources investigated. There was significant difference in the contents of other metals investigated. The concentration of other metals ranged from 1.84 – 9.12, 0.002 – 0.035, 0.001 – 0.061, 0.074 – 0.263, and 0.055 – 0.243 mg/kg for iron, cadmium, lead, zinc and manganese respectively. The metal contents were in the order: Fe> Zn> Mn> Pb > Cd > Cu. The results of this study also reveals that the water samples under study are contaminated by heavy metals and therefore unfit for human consumption. Thus, it becomes very important to treat these waters to make it safe for the populace.*

***Keywords**: Physicochemical properties, water, heavy metals, river, well and borehole*

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I. Introduction

Water is a universal solvent essential to man for various activities such as drinking, cooking, industrial activities, agricultural processes and human recreation. The quality of water is a reflection of the source environment and human activities, including its use and management measures. The safety of drinking water is important for health, and it is affected by various contaminants from chemical and microbiological sources (Anticó *et al.,* 2017).

Water is considered safe for drinking if it is free from contaminants and has properties within acceptable limits (WHO, 2004). The pollution of the aquatic environment is a global problem especially in developing countries like Nigeria (Rajini *et al.,* 2010) were majority of the populace do not have access to pipe borne water and therefore depend on river and well water for their domestic use ((Shittu *et al.,* 2008). These river and well waters are heavily contaminated as a result of human activities which include washing, bathing and the addition of various kinds of pollutants and nutrients through agricultural runoff. More worrisome is the pollution of aquatic environment by heavy metals because these metals have bioaccumulation properties and toxic effects on living organisms when they are above certain concentrations (Salam *et al*., 2019). Heavy metal is any metallic element that has a relatively high density and is toxic or poisonous even at low concentrations (Desalegn *et al.,* 2017). Heavy metals pollution occurs by various activities such as chemical manufacturing, mining, accidental chemical spills, residues from some agricultural inputs, municipal effluents and other anthropogenic activities which are ultimately transferred to the aquatic environment (Anifewoso and Oyebode, 2019; Anticó *et al.,* 2017). The major routes of heavy metal uptake by man are food, drinking water and air (Abubakar *et al*., 2015).

Access to potable water is also a major problem in Usen, Ovia South-West Local Government Area of Edo State where the Edo State polytechnic is located. The populace depends on the wells and the heavily contaminated river water for domestic use. The river water is contaminated as a result of many human activities such as washing, bathing, pollution through agricultural runoff into the river and dumping of domestic wastes of the community. Water from the Edo State polytechnic borehole which is an alternative source of water in the community is usually light green when freshly fetched and later turns brown after some time, leading to dulling and staining of fabrics and water containers. This also contributes in making the water unfit for human consumption. It therefore becomes very important to determine the physicochemical and heavy metal content of some of the major water sources from Usen, Ovia North –East local Government, Edo State, Nigeria.

II. Materials and Method 2.1 Sampling

Water samples were collected from three different sources in Usen, namely; River water (sample A), borehole water (sample B) and well water (sample C). The river water was collected from Usen River. The borehole source was Edo State polytechnic borehole, which is the only borehole in the community while the well water was collected from Alaba Well all in Usen, Edo State. Samples were collected in triplicate from each source for the purpose of this study. The river water was collected upstream at three different spots, the well water was collected at different depths in the well while the borehole water was collected at the time that the water was being pumped and left to run for about ten (10) minutes before collection. Plastic containers were used for the collection of water samples and were labeled appropriately.

2.2 Determination of physicochemical parameters of samples

The temperature of the water samples was measured using a mercury thermometer and pH was determined using the pH a meter at field. Conductivity and suspended solids (SS) were determined with a conductivity meter (model Hanna 911). pH was again determined with pH meter (model 600) to compare with the pH value obtained at the field and the values were comparable. Total dissolved solid (TDS) were obtained by multiplying conductivity by 0.53. The total solid was determined by adding suspended solids (SS) and total dissolved solids (TDS). The Chemical oxygen demand was determined according to standard methods (APHA, 1997). Total hardness was determined by titrating with EDTA using Eriochrome black T as an indicator. Sulphate, nitrate, phosphate and chloride were determined using standard methods (Udo *et al.*, 2009).

2.3 Metal analysis of samples

The metals analyzed for were Iron, Cadmium, Lead, Zinc, Manganese and Copper. The samples used for the analysis were acid preserved and digested prior to the analysis. Metal analysis was done by using atomic absorption spectrophotometer (Bulk Scientific VGP 210 model).

2.4 Statistical analysis

One way analysis of variance (ANOVA) was carried out to assess the significant differences in the data obtained. The mean of the data was compared using SPSS (Statistical package for Social Scientist).

III. Results

Table 1: physicochemical Parameters of the water samples

Parameter	Sample A	Sample B	Samples C	WHO (2004) standard
Temperature	$28.00{\pm}0.34^{b}$	$29.40{\pm}0.32^{c}$	$25.45{\pm}0.08^{a}$	-
PH	$6.80{\pm}0.21^{a}$	$7.00{\pm}0.10^{b}$	$6.80{\pm}0.81^{a}$	6.9 – 9.5
Colour	$4.00{\pm}0.16^{a}$	$27.0{\pm}0.92^{c}$	$16.00{\pm}0.01^{b}$	-
Turbidity	$7.00{\pm}0.14^{a}$	$23.00{\pm}0.32^{c}$	$10.00{\pm}1.21^{b}$	5.0 NTU
Total dissolve solids (mg/L)	$68.90{\pm}1.21^{a}$	$121.90{\pm}1.34^{c}$	$95.40{\pm}0.98^{b}$	-
Suspended solids	$12.00{\pm}0.31^{c}$	$4.00{\pm}0.64^{b}$	$3.00{\pm}0.43^{a}$	-
Total solids (mg/L)	$80.90{\pm}0.35^{a}$	$127.90{\pm}0.42^{c}$	$98.40{\pm}1.81^{b}$	1500
Conductivity	$36.52{\pm}0.41^{a}$	$64.61{\pm}0.32^{c}$	$50.56{\pm}0.82^{b}$	1200 us/cm
Alkalinity	-	$30.00{\pm}1.04$	-	10
Hardness	$68.00{\pm}0.21^{c}$	$40.00{\pm}0.32^{a}$	$50.00{\pm}0.21^{b}$	10
Phosphate	$1.02{\pm}0.01^{c}$	$0.42{\pm}0.18^{b}$	$0.01{\pm}0.01^{a}$	-
Sulphate (mg/L)	$5.00{\pm}0.12^{a}$	$15.00{\pm}0.23^{b}$	$4.00{\pm}0.90^{a}$	250
Nitrate (mg/L)	$2.40{\pm}1.01^{a}$	$2.36{\pm}0.34^{a}$	$2.3{\pm}0.91^{a}$	10
Chloride (mg/L)	$56.48{\pm}0.89^{b}$	$36.98{\pm}0.76^{a}$	$56.48{\pm}1.08^{b}$	200
COD (mg/L)	$38.63{\pm}1.01^{b}$	$28.02{\pm}0.87^{a}$	$54.29{\pm}1.89^{c}$	-

Sample A: River water; Sample B: Borehole water; Sample C: Well water Results are expressed as mean of triplicates determinations. Values on same row with the same superscript letters do not differ significantly at $p < 0.05$.

Table 2: Heavy metal content of water samples from different sources

Metal	Sample A	Sample B	Sample C	WHO (2004) standard
Iron	$1.84{\pm}0.11^{a}$	$9.12{\pm}0.32^{b}$	$8.34{\pm}0.18^{b}$	3.0
Cadmium	$0.014{\pm}0.01^{b}$	$0.002{\pm}0.01^{a}$	$0.030{\pm}0.01^{c}$	0.003
Lead	$0.023{\pm}0.02^{b}$	$0.001{\pm}0.001^{a}$	$0.060{\pm}0.03^{c}$	0.01
Zinc	$0.074{\pm}0.01^{a}$	$0.103{\pm}0.03^{b}$	$0.263{\pm}0.02^{c}$	3.0
Manganese	$0.055{\pm}0.02^{a}$	$0.230{\pm}0.12^{b}$	$0.243{\pm}0.12^{b}$	0.1
Copper	ND	ND	ND	2.0

Sample A: River water; Sample B: Borehole water; Sample C: Well water
Results are expressed as mean of triplicates determinations. Values on same row with the same superscript letters do not differ significantly at $p < 0.05$.

IV. Discussion

Table 1 gives the physicochemical properties of the water samples from the three different sources. The temperature of the water varied from 25.45 to 28.00oC. Water from the well had the lowest temperature (25.45oC). The values obtained are comparable to 27.4 to 28.5 oC reported by Anifowose and oyebode, 2019. Oluyemi et al., 2010 in their study had a temperature range of 26.5 to 33.0°C which is also comparable with the value obtained in this study. As water temperature increases, it makes it more difficult for aquatic organisms to get sufficient oxygen to meet their needs due to decrease in solubility of gases with increase in temperature. The pH of the water samples ranged from 6.8 to 7.00. The pH of water samples are considered safe when compared to the permissible range of 6.9 to 9.5 of WHO, 2004. Water from the river and the well sources although within the WHO permissible standard were slightly more acidic than the neutral range. Oluyemi et al., 2010 reported a pH of 6.53 to 8.90 in their study. The extent of turbidity showed significant differences among the various water sources, with water from the borehole being more turbid (23.00 NTU). Shukla et al., 2013 reported a turbidy of 8 – 11 NTU, which was lower than some values from this study. Turbidity >5 NTU is considered unhealthy. There were significant differences in the total dissolved solids present in the water investigated. The lowest (68.90) and highest values (121.90) were found in river and borehole water respectively.

River water had the highest suspended solids among the various water samples studied. The content of suspended solids varied from 3.00 to 12.00mg/L. Oluyemi et al., 2010 reported 34.50 to 794.00 mg/L as the range for suspended solids in their study. The totals solids obtained from this study where all lower than the maximum limit of 1500. Water from borehole contained the highest amount of total solids. Anifowose and oyebode, 2019 in their study reported the total dissolved solid to range from 307 to 612 mg/L which were higher than the values from this study. There were significant differences in the conductivity values for the samples. Borehole water had the highest conductivity (64.61us/cm) which shows the presence of more dissolved salts. This may be due to the presence of high content of anion and cation resulting from the discharge of domestic and agriculture waters (Dinka *et al.,* 2019). The conductivity values were however lower than the maximum limit of 1200us/cm. Oluyemi et al., 2010 reported conductivity values of range 63.0 to 1039.0 us/cm. All the water samples were observed to possess a greater hardness than the WHO standard of 10. River water was found to be harder than water from the other sources. Borehole water possessed the least hardness (40.00 mg/L). Shukla et al., 2013 reported a total hardness of 4-5 mg/L in their work. There was a significant difference in the phosphate level of the water sample. The content of phosphate ranged from 0.01 to 1.02. River water had the highest amount of phosphate. The sulphate content of borehole water was twice that of well water. The content of sulphate varied significantly among the different water sources. The values obtained for Borehole water was 15 while that for others were 5 and 4 mg/L, for river and well water respectively. Shukla et al., 2013 reported a sulphate content ranging from 8-16 mg/L in their study.

The nitrate content of waters (2.3 – 2.4mg /L) was lower than the permissible limit of 10 based on WHO standard. These values were quite lower than values obtained by Oluyemi et al., 2010 who reported nitrate content ranging from 1.08 to 53.03 mg/L in a similar study. High nitrate level in water could cause methemoglobin in infant (blue baby syndrome) therefore reducing the oxygen carrying capacity of the blood (Ademoroti, 1996). The river and well water were observed to contain the same amount of chloride (56.48). The least chloride content was in water from borehole. Shukla et al., 2013 obtained a chloride content of 60 – 84 mg/L. There were significant differences in the chemical oxygen demand of the water samples investigated. The values ranged from 28.02 to 54.29.

Table 2 shows the physicochemical parameters of the water samples from the three sources considered. The iron content varied from 1.84 to 9.12 mg/kg. The content showed significant differences among the different water sources. River water had the least amount of iron when compared to other sources. The iron content of water from borehole and well were higher than the permissible limit of 3.0mg/kg based on WHO standard. Oluyemi et al., 2010 in their study reported 6.00 ± 0.21 to 31.75 ± 0.80mg/L for Fe. Although iron is an essential trace element for humans, high concentration can lead to bad taste, reddish colour of the water, thus causing staining and discolouration of water containers, and fabrics.

The cadmium content of water from the river and well were higher than the permissible limit of 0.003mg/kg based on WHO standard. This shows contamination of these sources by cadmium. River water however had the least content of Cd and this was considered safe based on comparison with standard. Anifowose and oyebode, 2019 reported the maximum cadmium content of 0.03mg/L in their study.

The lead content of water from the river and well were higher than the permissible limit of 0.01mg/kg. The content of lead varied from 0.001 to 0.061mg/kg with river water having the least. The lead content was lower than 3.67 mg/L reported by Abubakar *et al*., 2015 in related study. Anifowose and Oyebode, 2019 in their study had a lead content of 0.08 which is higher than the value from this study.

All the samples were safe with respect to zinc content. The concentration varied from 0.074 to 0.263 mg/kg. The zinc content was lower than 0.95 reported by Abubakar et al., 2015. The value obtained in this study is within the range of 0.01 to 0.75 obtained by Anifowose and oyebode, 2019 in their study. Oluyemi *et al.,*

2010 reported 0.03 ± 2.15 to 0.22 ± 4.64 mg/L which is higher than the values from this study. Desalegn et al., 2017 reported a maximum value of 1.156mg/L for Zn in their study.

The content of manganese in borehole and well water did not differ significantly at $p < 0.05$. Well water had the highest amount of Mn while river water had the least. The concentration of Mn in borehole and well water were higher than the permissible limit of 0.1mg/kg based on WHO standard. Oluyemi et al., 2010 reported 0.14 ± 6.12 to 0.23 ± 99.11 mg/L.

Copper was not detected in all the samples analyzed. Desalegn *et al.,* 2017 in their study on water from different sources also did not detect copper in all the samples they analysed.

V. Conclusions

The present study has examined the physicochemical parameters and heavy metal content of water samples collected from the river, well and borehole. The metal contents were in the order: Fe> Zn> Mn> Pb > Cd > Cu. The borehole water turbidity (23.00 NTU) level was higher than the WHO set limits (5.0NTU) for drinking water. The results of this study also reveals that the water samples under study are contaminated by heavy metals and therefore unfit for human consumption, thus, it becomes very important to treat these waters to make it safe for the populace.

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