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NJMSE Editorial Board

Editorial Comment

It is a great pressure for the editorial board of the Nigerian Journal of Materials Science and Engineering (NJMSE) to present Volume 10 Number 1 of the journal for 2020 for the world research and development community.

The Materials Science and Technology Society of Nigeria (MSN), as a professional learned body, has made the publication of this research journal to be of very good quality and high standard comparable to any in her class. Our major thrust is to disseminate materials science and engineering and allied research activities from Nigeria, Africa and the world over. We are slowly and gradually impacting on the research community work with this specialised journal from a reputable learned and professional body in Nigeria. We are presently not insisting on number but we very much believe, with the thoroughness of our approach to the review and assessment process, we are convinced that with our resolve to publish quarterly, the board is convinced that more researcher would take advantage of this.

As a journal whose policy is to maintain the standard best practices and in addition to help young researchers to advance in the art and science of scientific findings dissemination, had faced tremendous challenges which were expected. It is heart-warming that we can look back and be glad to see the society publishing the 10th volume. These volumes and the previous ones would be available for FREE downloading on our society website (www.msn.ng) through a link prior to the specialised journal website to be available soon. Arrangements are in advanced stages for the hosting of this journal by reputable international online submission system are being worked on.

Volume 10 (2020) Number 1 consists of eight (8) high standard articles covering different specialised areas of materials research. It is our hope that this humble effort, presently by voluntary efforts of senior members of the Society, at disseminating research findings as put together in this volume which have contributed to the body of knowledge, would have enriched the information base and complemented Materials Research efforts from around the world.

We appreciate all our reviewers and associate editors involved for their prompt action on the manuscripts and cooperation as we look forward to submission of manuscripts which can be forwarded as detailed below.

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AIM: *T*o improve the international exchange of scientific research in materials science and engineering.

INTRODUCTION

The Nigerian Journal of Materials Science and Engineering (NJMSE) publishes reviews, full-length papers, and short communications recording original research results on, or techniques for studying the relationship between structure, properties, and uses of materials. The subjects are seen from international and interdisciplinary perspectives covering areas including metals, ceramics, glasses, polymers, composite materials, fibers, electronic materials, alternative energy materials, nanostructured materials, nanocomposites, biological, biomedical materials, etc. The NJMSE is now firmly established as the leading source of primary communication for scientists investigating the structure and properties of all engineering materials in Nigeria, Africa and the Rest of the World.

UNIQUENESS OF THE JOURNAL

NJMSE is introduced to publish research findings on current topical issues of interest to both public and private sectors. The scope of the Journal focuses on experimental, empirical and theoretical research in Materials Science and Engineering. Findings from multidisciplinary research covering diverse areas of interest with potential impact on the public and private sectors of both the national and international communities will be priorities of the journal. Our major focus is the use of Materials Science and Engineering principles to solve basic problems peculiar to African and the developing world while contributing to knowledge on the global scale.

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Acknowledgements: These should be presented at the end of text and before the references. Technical assistance and advice may be acknowledged. Acknowledgments of financial support can also be stated in this section.

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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 revealed 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: Water, Heavy metals, Coagulation and Alum

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 the human activities, including its use and management measures. The safety of drinking water is important for the 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) where 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 rivers 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.

The fact that the populace do not have access to potable water, the river water being heavily contaminated, and the nature of the Polytechnic borehole necessitated the need to determine the physicochemical and heavy metal content of the major water sources from Usen, Ovia North–East Local Government, Edo State, Nigeria. The findings would provide valuable information on the pollution status of the waters and give indications for their treatment methods.

MATERIALS AND METHOD

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 of about twenty five feet apart, 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.

Determination of Physicochemical Parameters of Samples

The temperature of the water samples was measured using a mercury thermometer at field. Conductivity and suspended solids (SS) were determined with a conductivity meter (Model Hanna 911). pH was determined with pH meter (Fisher Accumet Model 600). 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 turbidity was determined by the use of TUS series turbidity analyzer. The colour was determined by the platinum-cobalt method, by using JENWAY Model 7310 Spectrophotometer. 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 indicator. Sulphate, nitrate, phosphate and chloride were determined using standard methods (Udo *et al.,* 2009).

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 Model 210 Model VGP).

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).

RESULT AND 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 results (27.4 to 28.5 ºC) obtained from other research studies (Anifowose and Oyebode, 2019).

In another study, a temperature range of 26.5 to 33.0 ^{0}C was obtained (Oluyemi *et al*., 2010) 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. Previous studies reported a pH of 6.53 to 8.90

Table 1: Physicochemical Parameters of the water samples

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

Sample A: River water; **Sample B:** Borehole water; **Sample C:** Well water.

Results are expressed as mean of triplicate determinations. Superscripts a, b and c represent statistical significance. Values with the same superscript letters on the same row do not differ significantly at $p < 0.05$.

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 turbidly of 8 – 11 NTU, which was lower than some values from this study. Turbidity > 5.0 NTU is considered unhealthy. There were significant differences in the total dissolved solids present in the water investigated. The lowest (68.90 mg/L) and highest values (121.90 mg/L) 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. Higher values for suspended solids (34.50 to 794.00 mg/L) have been reported in previous studies (Oluyemi *et al.*, 2010). The totals solids obtained from this study where all lower than the maximum limit of 1500 mg/L. Water from borehole contained the highest amount of Total Solids.

Previous studies reported the total dissolve solid to ranging from 307 to 612 mg/L (Anifowose and Oyebode, 2019) 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 (64.61 µS/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 1200 µS/cm. Elsewhere, conductivity values of ranging from 63.0 to 1039.0 µS/cm was reported (Oluyemi *et al.*, 2010). All the water samples were observed to possess a higher hardness compared to 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). Lower values for total hardness (4 - 5 mg/L) have been reported in another study (Shukla *et al.*, 2013). There was a significant difference in the phosphate level of the water samples (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. This 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 – 2.4 mg/L) was lower than the permissible limit of 10 based on WHO standard. These values were quite lower than values obtained in a similar study (Oluyemi *et al.*, 2010), where nitrate content ranged from 1.08 to 53.03 mg/L. 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 mg/L). The least chloride content was in borehole water. The chloride content obtained in this study was lower than that obtained in a similar study (Shukla *et al.*, 2013), where chloride content ranged from 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 mg/L.

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 3.0 mg/kg based on WHO standard. In a similar study, (Oluyemi *et al.*, 2010) reported values ranging from 6.00 ± 0.21 to 31.75 ± 0.80 mg/L for iron. Although iron is an essential trace element for human, 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 river and well were higher than the permissible limit of 0.003 mg/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. In a similar study (Anifowose and Oyebode, 2019), the maximum cadmium content of 0.03 mg/L was reported.

The lead content of water from river and well were higher than the permissible limit of 0.01 mg/kg. The content of lead varied from 0.001 to 0.061mg/kg with borehole water having the least. The high lead content

Table 2: Heavy Metal Content of Water Samples from Different Sources

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

Sample A: River water; **Sample B:** Borehole water; **Sample C:** Well water; **ND:** Not detected.
Results are expressed as mean of triplicates determinations. Values on same row with the same superscript letters do not differ significantly at $p < 0.05$. Superscripts a, b and c represent statistical significance.

for well water could be attributed to corroded metal in old lead pipes, lead-based solder, or brass fittings, leached into the well water (University of Rhode, 2020), because lead does not occur naturally in water. The lead content with values lower than 3.67 mg/L has been reported (Abubakar *et al*., 2015) in related studies. Elsewhere, Anifowose and Oyebode, 2019 in their study recorded 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/L. Similar studies reported higher zinc content of 0.95 mg/L (Abubakar *et al*., 2015). However, values obtained in this study were within the range of 0.01 to 0.75 mg/L which was similar to values obtained elsewhere (Anifowose and Oyebode, 2019). In another studies, values ranging from 0.03 ± 2.15 to 0.22 ± 4.64 mg/L which is higher than the values obtained from this study was reported (Oluyemi *et al*., 2010). Maximum value of 1.156 mg/L for Zn also reported in similar studies (Desalegn *et al*., 2017).

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 likely reason for this observation could be that the well water has been in contact with igneous rocks for a longer time than the borehole water, while river water has minimal contact. Igneous rock has two major components, out of which malfic containing manganese and iron is one of the component (Encyclopedia Britannica, 2020). High manganese content in underground water has been associated to long time contact with rocks (Bryan and Sharpe, 2020). Natural substances stored in rocks and soil can also leached down and affect the smell, taste, color, and safety of well water (University of Rhode, 2020). The concentration of Mn in borehole and well water was higher than the permissible limit of 0.1mg/kg based on WHO standard. Higher values of Mn, exceeding WHO permissible limit (0.14 ± 6.12 to 0.23 ± 99.11 mg/L) have also been reported (Oluyemi *et al*., 2010).

Copper was not detected in all the samples analyzed. In a similar previous study, copper was also not detected in all the samples analysed from different sources (Desalegn *et al*., 2017). The physicochemical and heavy metal properties of the water samples under study suggest that they moderately polluted particularly with heavy metals. The health hazard posed by the presence of heavy metals and their bio-accumulative properties demands that the waters should purified before consumption. Several methods that can be deployed to remediate heavy metal from contaminated waters include ion-exchange processes, chemical precipitation, ultra filtration, electrochemical decomposition and solvent extraction technique (Agboinghale, 2006; Gupter *et al.,* 2006; Rana *et al.,* 2009).

CONCLUSION

The present study has examined the physicochemical parameter and heavy metal content of water samples collected from river, well and borehole. The metal contents were in the order: Fe> Zn> Mn> Pb > Cd > Cu. The borehole water had turbidity (23.00 NTU) level that was higher than the WHO set limits (5.0 NTU and 10.00 mg/L respectively) for drinking water. The results of this study also reveals that the water samples under study are moderately 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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