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THEME

ADVANCING TECHNOLOGY AND ENVIRONMENTAL BURDENS: CHALLENGES AND SUSTAINABLE SOLUTIONS

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PREFACE

The 1st International Conference on Engineering and Environmental Sciences was the first international conference organized by the Faculty of Engineering and Environmental Sciences, Osun State University. The aims of the conference include to foster interactions and collaborations among members of academia, industries and traditional stakeholders across the globe, with a view to tackling the challenges to sustainable development. To address socio-economic and environmental challenges facing our country and the world at large, the Faculty seeks to position itself strategically, using these formal and intellectual interactions, to proffer ingenious solutions and also initiate same with interested stakeholders. By so doing, the Faculty is promoting its ideals to the society and also fulfilling its part in the town and gown relationship.

As elucidated by the theme of the conference- *ADVANCING TECHNOLOGY AND ENVIRONMENTAL BURDENS: CHALLENGES AND SUSTAINABLE SOLUTIONS*, this conference brought to the fore, the burdens of development borne by the environment as a result of global strives for increased and improved production of building materials, automobiles, agriculture, healthcare, textiles and so on. During this conference, local, national and international participants have demonstrated the various approaches to the solutions theoretically, empirically and numerically.

Having evaluated, revised and edited the various submissions by the participants to produce this proceedings, it is believed that readers will find in this proceedings, intellectual treasures of inestimable values, to further push the frontiers of knowledge to the next level. It is hope that the last participants of the conference and readers of this proceedings will keep up the good work of research and intellectualism and produce qualitative works to qualify for the next edition of the conference.

Finally, our immense appreciations go to the members of the local organizing committee as well as the local, national and international participants for using their time, energy and material resources to make the event worthwhile.

Engr. Dr. A.A. Bello

Ag Dean, Faculty of Engineering and Environmental Sciences

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EVALUATION OF THE EFFECT OF PRECIPITATION VARIATION ON GROUNDWATER QUALITY IN ILORIN METROPOLIS, NIGERIA

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ABSTRACT

Groundwater is an essential part of the hydrological cycle serving as the primary source of water where public water supply is neither available nor adequate. This study evaluated the seasonal variability of water quality with respect to monthly rainfall depth in Ilorin metropolis, Nigeria. This was achieved by the determination of the month with minimum and maximum rainfall depth as well as determination of the concentration of Physico-chemical and bacteriological parameters of water sample in the study area. Twenty years historical data of monthly rainfall depth was obtained and analysed and a total of 32 water samples were collected from Shallow wells in the month with minimum and maximum rainfall depth from 8 different locations in year 2018 to determine their concentration. The Physico-chemical and bacteriological properties of water samples were analysed using Standard Methods. The potability of the water samples were assessed with respect to WHO standard. The study revealed that Turbidity, Fe^{2+}, Dissolved Oxygen, Total Viable Count and Total Coliform Count concentration exceeded the Word Health Organization (WHO) standard in all the samples. Hence, the Shallow well water sources are polluted and the concentration of these pollutants increased in the month with minimum rainfall depth. The reduction in the pollutant concentration during the month with higher rainfall depth might be as a result of dilution through groundwater recharge from precipitation. The study also shows that the wells are not safe sources for drinking purposes and some form of treatment will be required before consumption.

Keywords – well water; rainfall depth; bacteriological; physicochemical

I. INTRODUCTION

Groundwater is an essential resource that cannot be ignored in any part of the world (Llamas, 2005). It is indispensable for human survival and sustaining societal development. Changes in the Earth's climate
or seasonal variation have the potential to affect both the quality and the quantity of available groundwater, primarily through impacts on recharge, evapotranspiration and (indirectly) on pumpage and ABSTRACTion. The provision of clean potable drinking water, especially in developing countries like Nigeria, has always been a major challenge (Raji and Ibrahim, 2011) and many people rely on well and borehole water for their domestic drinking purpose due to the lack of access to potable water (Shittu, *et al*, 2008). According to Gronwall, *et al* (2010), an estimated 269 million urban dwellers depend on wells as their principal source of drinking water. In urban Nigeria, it is estimated that almost 60 per cent of the population rely on local wells. There is an increasing trend of groundwater overexploitation and deterioration at both the regional and global scales, mainly due to anthropogenic activities (MacDonald, *et al*, 2016). Groundwater usually requires less microbiological and physicochemical treatment owing to its good quality and it is better protected against pollution than surface waters. The seasonally different intensities in precipitation considerably influence both water quantity and quality (Sakakibara, *et al*, 2017). Therefore, evaluating seasonal variability effects of groundwater quality has gradually become the focus of research on groundwater source areas.

In Nigeria and particularly in Ilorin, groundwater is an important source of water for drinking and other purposes. Ifabiyi and Ashaolu (2013) reported that the coverage of public water supply in Ilorin is limited to some area while others lack access to this service. Based on all these evidences, greater portion of the city rely more on groundwater (shallow, borehole and deep well) to meet their domestic and drinking water needs since groundwater is often potable at source and does not require heavy investment.

II. DESCRIPTION OF THE STUDY AREA

Ilorin, the capital of Kwara State is located on latitude 8º30’ and 8º50’N and longitude 4º20’ and 4º35’E of the equator (Figure 1). It occupies an area of about 468sqkm and it is situated in the transitional zone within the forest and the guinea savannah regions of Nigeria. It is about 300 kilometers away from Lagos and 500 kilometers away from Abuja the federal capital of

Nigeria. The climate of Ilorin is tropical under the influence of two trade winds prevailing over the country. Ilorin metropolis experiences two climatic seasons (rainy and dry season). The rainy season is between March and November and the annual rainfall varies from 1000 mm to 1500 mm, with the peak between September and early October. The total annual rainfall in the state ranges from 800mm to 1,200mm in the northwest and 1,000mm to 1,500mm in the southeast. Ilorin had a population of 847,582 making it the 13th largest city in Nigeria by population (The World Gazzetter, 2013).

1. MATERIALS AND METHODS

Historical daily rainfall data of Ilorin Metropolis spanned from 1999 to 2018 was obtained from the Nigerian Metrological Agency (NIMET) in oreder to determine the month with average minimum and maximum rainfall depth. Water samples from selected wells in the study area were then obtained in the months with average minimum and maximum rainfall depths earlier determined.

A total of 32 waters samples were collected from open wells for the month with maximum and minimum rainfall depth within ilorin metrpolis (16 samples each) in the months of Septemer and December, 2018. The analyses was done at the chemistry and bateriological Laboratory of University of Ilorin. Water samples were collected using standard method as described by Aminu annd Amadi (2014) and tested according to Standard Methods (APHA, 2002). Water parameters considered include temperature, pH, Total Dissolved Solide (TDS), Total Dissolved Oxygen (TDO), Total Solid (TS), Total Suspended Solid (TSS), Total Hardness (TH), Alkalinity, Electrical Conductivity (EC), turbidity, iron (Fe^{3+}), chloride, magnesium, Nitrate (NO_3^{2-}), Sulphate (SO_4^{2})' calcium and zinc. The occurrence of Fecal Coliform, Total Viable Counts (TVC) and Total Coliform Counts (TCC) were also rxamined.

Laboratory results of the samples were subjected to statistical analysis and the results were then compared with the standards set by WHO.

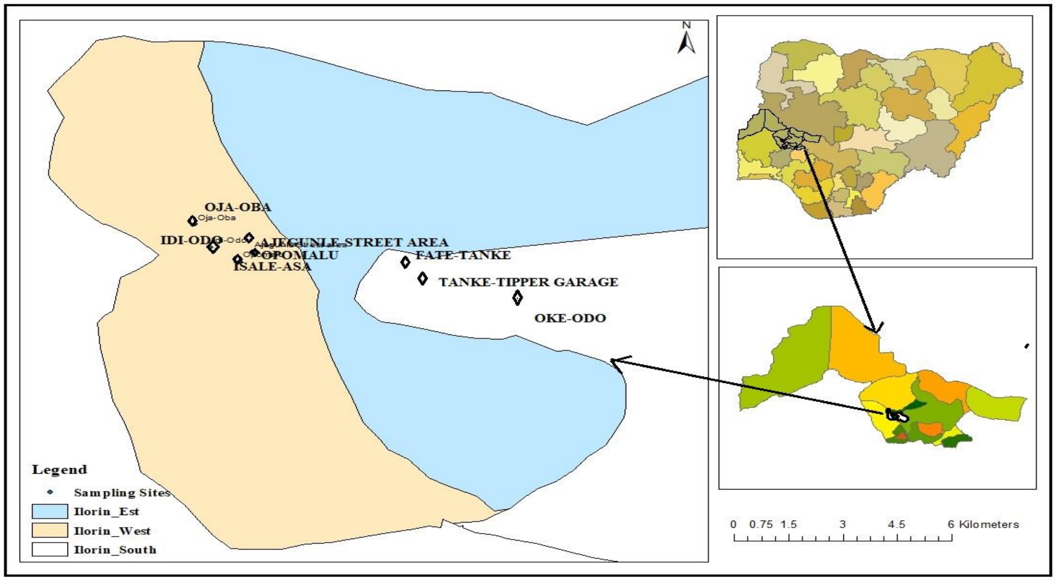

Figure 1: Geographical map of Ilorin showing the sampling sites.

III. RESULTS AND DISCUSSION

A. Monthly Rainfall Variation

The monthly variation of rainfall depth analysis shows that the minimum and maximum rainfall depths occured in the months of December and September respectively between years 1999 and 2018. This is the reason why the samples were obtained for the study in the months of December and September respectively for dry and wet season.

B. Physico-chemical Parameters

The statistical summarry of Physico-chemicalParameters of the water sample for the months with minimum and maximum rainfall depth for the study area is as shown in Table 1.

The monthly physicochemical analysis results indicate that the temperature of all the water samples falls within recommended values set by the WHO for groundwater (0-30°C). The temperature of groundwater is lower in the month with minimum rainfall depth than in the month with maximum rainfall depth. The higher temperature values recorded may be due to the prevalent atmospheric conditions. On the other hand, pollutants, among many other factors may cause temperature increase in water in the present situation and similar result was also recorded by Al Sabahi, *et al.* (2009)

The results of analyses of water samples show that the pH of groundwater is all within the WHO allowable limit of 6.5-8.5 for drinking water for both months. The concentration of pH was found slightly high in December than September in each sample respectively from A to H except in samples E, G and H for the month of September. This lower pH of the groundwater in wet season may not be unconnected with dillution of rainfall with carbon dioxide as a result of aquifer recharge. The increased pH in samples E, G and H may be due to the increase of pollutant concentration occuring in these point sources of water. However, the result is in consonant with the finding of Ogbona, *et al* (2010) for various groundwater samples.

Electrical conductivity (EC) is viewed as a valuable indicator of the amount of dissolved materials in water (Olajire and Imeppeoria, 2011). Potable water should not have high electrical conductivity as opined by Hutton (1983). The analyses show that electrical conductivity in all the water samples was below 1000 µS/cm recommended by the WHO for potable water. EC in the wells are noted to be higher in December than in the month of September. Conductivity in groundwater is disctated primarily by the geology of the area through which the water flows.

Table 1: Descriptive Statistics of Physico-chemicalParameters of Water samples for the month with maximum and minimum rainfall depth Ilorin metropolis.

	Month of September					Month of December					
Code	Min	Max	Mean	STD	CV	Min	Max	Mean	STD	CV	WHO
TP	27	28.5	27.88	0.5	1.79	26	29	27.19	0.83	3.06	0-30
PH	5.98	7.5	6.93	0.67	9.7	6.65	7.55	7.19	0.3	4.16	6.5-8.5
TBD	5.33	6.38	5.82	0.42	7.14	5.53	6.84	6.05	0.41	6.75	5
TDS	1.97	3.93	2.84	0.64	22.61	2.94	3.5	3.29	0.2	6.05	500

TSS	1.73	2.39	1.88	0.23	12.44	2.25	3.94	2.82	0.58	20.37	500
EC	40.3	41.81	41.09	0.54	1.31	40.42	41.98	41.28	0.55	1.33	1000
TS	3.75	5.75	4.72	0.72	15.29	5.65	6.87	6.12	0.39	6.37	1500
Cl^-	2.36	8.26	5.53	2.09	37.76	1.48	8.38	5.2	2.21	42.43	200
Ca^{2+}	0.51	1.41	1.07	0.33	30.37	0.65	2.36	1.4	0.62	44.36	75
Mg^{2+}	0.57	2.36	1.37	0.59	43.09	0.81	2.55	1.64	0.55	33.38	50
TH	1.08	3.74	2.44	0.88	36.1	1.46	4.14	3.04	0.97	31.95	500
Fe^{2+}	0.42	0.79	0.54	0.14	26.37	0.63	0.83	0.76	0.07	9.1	0.1
NO_3^{2-}	0.88	1.54	1.09	0.23	21.2	1.2	1.35	1.26	0.05	4.01	50
SO_4^{2-}	39.26	41.97	40.76	1.04	2.55	41.02	44.8	42.49	1.33	3.13	200
Zn^{2+}	0.36	0.56	0.42	0.06	15.13	0.51	0.67	0.59	0.05	9.12	5
DO	88.8	145.6	116.94	21.29	18.2	86.8	125.2	109.2	13.32	12.2	7.5
AKL	3.18	5.55	4.62	0.96	20.91	3.81	4.36	4.21	0.21	5	50

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The turbidity of all the water sample collected in the study area did not comply with the standard requirements. Their values exceeded the 5-NTU recommended by WHO (2006). Turbidity concentrations in groundwater are noted to be higher in December (dry season) than in the month of September (wet season). This may be due to parental rock activities and the level of water in the wells. Excessive turbidity, in drinking water, may represent a health concern.

The results of Total dissolved solids (TDS), total suspended solids (TSS) and Total solids (TS) in the study area fall all within the prescribed limit set by WHO. But their values are higher in the month with minimum rainfall than the month with maximum rainfall depth. High total dissolved solids give objectionable odour or offensive taste in water (Aydin, 2007). Also the highest concentrations of TSS in sample H and F respectively in September and December may be attributed to accidental discharges entering the water from local drainages.

As for chloride ion, all the samples were below the WHO limit of 200 mg/l for drinking water. The chloride concentration is higher in September than December. High concentrations of chloride make water unpalatable and unfit for drinking and livestock watering.

The Calcium and Magnesium concentration is high in December than in the month of September but all the wells sampled have calcium and magnesium concentration below the WHO's highest permissible limit of 75mg/l and 50mg/l respectively. Higher concentrations of calcium and magnesium in water causes poor lathering during washing and deterioration of the quality of clothes. High intake of magnesium causes gastro-intestinal irritations and it also contributes to the hardness of water (WHO, 2006).

Total hardness in water samples as shown by the analyses have concentrations all below the WHO guideline (500mg/l) for drinking water both for the month of September and December. From the mean concentration of total hardness, concentration in water is higher for the month of minimum rainfall depth than the month with maximum rainfall. The water in the study area is soft. Hard water is useful and also detrimental to the human health. Hard water causes poor lathering with soap, deterioration of the quality of clothes, scale forming, skin irritation, and boiled meat and food become poor in quality. Soft water also increases the chances of heart failure in humans.

The iron concentration was higher for the month with minimum rainfall than the month September and the analyses result did not comply with the maximum permissible limit set by the WHO. The iron occurs naturally in the aquifer but levels in groundwater can be increased by dissolution of ferrous borehole and handpump components. Long term consumption of drinking water with a high concentration of iron can lead to liver diseases (hemosiderosis).

High concentration of iron in water is not suitable for processing of food, beverages, ice, dyeing, bleaching and many other items.

The results showed that nitrate level in water sampled was higher for the month of December than the month of September. However, the values obtained in this study were well below the maximum permissible limits set by WHO. Water that is contaminated with nitrate is harmful especially to infants causing methemoglobinemia, otherwise called infantile cyanosis or blue baby syndrome if consumed.

From the result, sulphate concentrations have a mean and coefficient of variation of 40.76mg/l and 2.55% against 42.49mg/l and 3.13% respectively for the month of September and December. The sulphate concentration is higher for the month of December than the month of September. Sulphates are a compound containing Sulphur and oxygen ions and are a part of naturally occurring minerals in some formations of soil and rock that contain groundwater. The minerals dissolve over a period and are released into groundwater (Okpokwasili, *et al*, 2013). The sulphate levels of the water samples were below the 200mg/l recommended value by WHO (2006).

The concentrations of Zinc have a mean and coefficient of variation of 0.42mg/l and 15.13% against 0.59mg/l and 9.12% respectively for the month with maximum and minimum rainfall depth. Its values is higher in December than September but fall below the maximum permissible limit of 5.0mg/l standardized by WHO. Higher zinc application appears to protect people from cadmium poisoning. Zinc may also decrease lead absorption.

Measures of dissolved oxygen (DO) refers to the amount of oxygen contained in water. All the water sampled have a high concentration of dissolved oxygen. The result exceeded the recommended 5mg/l set by WHO (2006). Dissolved oxygen is one of the most important parameters of water. Direct and indirect information such as nutrient availability, the level of pollution, metabolic activities of microorganisms, stratification, and photosynthesis can be deduced from its correlation with water body [17. The concentration of DO is higher for the month with maximum rainfall depth than the month with minimum rainfall.

The results of analyses of water samples for alkalinity have a mean and coefficient of variation of 4.62 mg/l and 20.91% against 4.21mg/l and 0.21% respectively for September and December. alkalinity concentration in the sampled water in the study area was below the WHO allowable limit (50mg/l) for drinking water but higher in the month with maximum rainfall than in the month with minimum rainfall depth.

C. Bacteriological Parameters

The Total Viable Counts (TVC) of the water samples within the eight (8) different sampling sites range from 1.30 $x10^5$ to $7.00x10^5$ cfu/ml and from 3.10 $x10^5$ to $5.20x10^5$ cfu/ml for the month of September and December respectively (Table 2). The mean of TVC is higher in the month of December (4.19 $x10^5$ cfu/ml) than in the month of September ($3.68x10^5$ cfu/ml). The Total Coliform Count (TCC) in water increase also from 1.20 $x10^5$ to $4.00x10^5$ cfu/ml for the month of September and from 1.60 $x10^5$cfu/ml to 3.55 $x10^5$cfu/ml for December (Table 2). FCC was totally absent for both the month with maximum and minimum rainfall depth in the study area. This result contradicts the conclusion of Afolayan and Kolawole (2017), who reported that detected coliforms, primary bacterial indicator for fecal pollution in all samples. The absences of activities that leads to the the sources of coliforms in groundwater such as agricultural runoff, effluent from septic systems or sewage discharges, infiltration of domestic or wild animal fecal matter may be responsible for the result (Somaratne and Hallas, 2015). The microbial load observed in the well water samples are much higher than the recommended values set by WHO. However, the results comply with other studies across Nigeria which showed the presence of coliforms in most freshwater sources (Aminu and Amadi, 2014; Anyanwu and Okoli, 2012). The alarming increase in microbial loads may be as a result of increasing nutrients and aeration during the decomposition of organic matter. Coliforms are the most abundant bacteria in water responsible for water-borne diseases such as typhoid, dysentery, diarrhea and have also been implicated in mortality across the world (WHO, 2000), therefore drinking from any of the open wells used for this study will lead to serious health conditions.

Table 2: Descriptive Statistics of Bacteriological Parameters of the Water samples in the month of September and December

	Month of September			Month of December		
Parameters						FCC

	TVC (cfu/ml) x 10^5	TCC (cfu/ml) x 10^5	FCC (cfu/ml) x 10^5	TVC (cfu/ml) x 10^5	TCC (cfu/ml) x 10^5	(cfu/ml) x 10^5
Minimum	1.3	1.2	-	3.1	1.6	-
Maximum	7	4	-	5.2	3.55	-
Mean	3.68	2.5	-	4.19	2.37	-
WHO Standard	100	0 - 10	0	100	0 - 10	0
Standard Deviation	1.84	1	-	0.84	0.66	-
Coefficient of Variation	50.11	39.83	-	20.09	27.7	-

IV. **CONCLUSION**

The physicochemical and bacteriological properties of the well water samples examined in this study are on the reflection of man-made materials, country rocks through which has come into contact with and the influence of rainfall depth. The results of bacterial loads were higher in all the water samples especially in the month with minimum rainfall depth in Total Viable Counts and lower in Total Coliform Counts for the same month, but the results exceeded the maximum permissible limits recommended by WHO except for Fecal Coliform Counts that was totally absent in the study area. It was also found out that dissolved oxygen is the most abundant element found in all the sampled wells followed by turbidity and iron, and their values did not comply with the WHO Standards. Their occurrence in groundwater can be traced to their abundance in the earth crusts, through pollution by human impact on the environment and the intensity rain that falls. It is confirmed from the analyses that open well of Ilorin metropolis is more polluted in the month with minimum rainfall depth than the month with maximum rainfall. The life of residents in Ilorin Metropolis is endangered as long as people depend on ABSTRACTion of polluted water from open wells for domestic and drinking purposes.

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