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Evaluation of Lead and Iron Content in Different Stages of Water Treatment Facilities within Otuoke and Yenagoa Metropolis, Bayelsa State, Nigeria

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ABSTRACT: The mechanism of keeping water safe by improving its quality makes it easily accessible for community health. The objective of this work was to evaluate the levels of lead and Iron in the domestic water supply system at Ekeki Housing Estate Yenegoa local government and Otuoke community in Ogbia local government in Bayelsa State, Nigeria. AAS version 5.0 Model was used to analyze Iron and Lead after acid digestion. Results obtained were compared with WHO standard, and statistically inferences were drawn using ANOVA and Spearman correlation matrix. All water sampled presented values of lead between (0.02-0.64) mg/L expect for point I3 and I4 which conformed to 0.01mg/L, while Iron values ranged from (0.01-5.3) mg/L. Most of the results obtained exceeded the WHO standard of 0.01 mg/L for lead and 0.03mg/L respectively. The research findings had shown that most treatment processes adopted were not suitable for treatment of the contaminants, hence the need to review treatment processes, distribution and monitoring of the source.

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Water is a habitat for living and non–living components, soluble and insoluble substances, which are support systems for living organisms. Al-Mashagba (2015). It is said to be the most important and valuable natural resource which is essential for life after air Balan. *et al.,* (2012). The various uses of water have a definite effect on its quality, and the quantity of the water available for drinking. So the management of water contamination becomes essential at national and international levels. Despite its abundance, the quality and accessibility of potable water remains a global challenge especially developing countries like Nigeria, because of poor management (Ohwo and Abotutu). In order to prevent the occurrence of scarcity of potable water in Nigeria, particularly in Bayelsa where Lead and Iron is a challenge, there is need to review and improve the techniques of water treatment and its facilities. Ijaola *et al.,* (2013a) In a bid to make portable water available to all as an essential tool for life sustainability and satisfaction, according to WHO 2017, efforts should be geared toward improving access to safe drinking water that will enhance tangible health benefits. This reduced the rate of sickness; it was reported by World Health Organization 2016, that up 80% of all sickness in the world are caused by poor sanitation or unavailability of safe water (WHO 2016). Hence clean water is a critical issue to increase in world population Ijaola *et al., (*2013b), and to ensure the safety of drinking water it is essential that a framework for safe drinking-water is implemented. The main source of water supply for Africans in rural areas and urban centers is the groundwater, a primary source for domestic, commercial and industrial uses. Lapworth, *et al.,* (2017). However, in the 21st century, reduction of water quality is one of the challenging problems Oki

and Akana (2016). Globally, degradation in groundwater quality as resulted from industrialization to urbanization, and agricultural intensification and commercialization Li *et al.,* (2010), which lay a great demand, on quality water there by the demand for water supply more water is needed in domestic, agriculture and industrial sectors; therefore, water is a key natural resource since it is essential requirement for a stable community Janna *et al.,* (2016) and Hayder *et al.,* (2021).

The primarily groundwater is polluted by the diffusion of natural substances and mineral environments that occur in groundwater. Dissolved minerals such as iron, arsenic, chlorine, phosphorus, lead, calcium (e.t.c.) in excess amount, and acts as pollutants. Ebuete and Barıwenı, (2019). According to water quality regulating bodies (EPA, FEPA, NSDWQ, and WHO, the presence of such contaminants in the groundwater, above the recommended standard set, may result in serious health hazards according to United States Environmental Protection Agency US-EPA (2012). Other forms of contaminants that can render groundwater unfit for consumption are microbiological, chemical, physical or radioactive contamination (Ebuete, and Barıwenı, 2019). Because of this, before being used for drinking or other household or industrial purposes, ground water must also be protected, regularly monitored, and treated Sasakova *et al.,* (2018).

Hence, water treatment is very important; before being distributed to social networks, water must undergo appropriate treatment; a treatment plant uses a variety of treatment techniques to produce drinking water that is hygienically safe (Ebuete, and Barıwenı, 2019). Different treatment processes of flocculation, sedimentation, filtration, and disinfection for water may be used to remove impurities from raw water using various treatment methods (Hayder *et al*, 2021).

A successful operation of the unit depends on the performance of each treatment procedure in the water treatment plant (WTP) being assessed Zhang *et al.,* (2013) In evaluation of a WTP depending on treatment process efficiency, all involved processes could be assessed or a key unit is chosen to decide whether the plant operates in acceptable way or not having selected the disinfection unit to evaluate WTP (Wei, and Yang).

However, little studies were carried out to examine the performance of these WTP by evaluating the quality of treated water and the effectiveness of the treatment units inside WTP Hayder *et al.,* (2021). The different water sources used in these WTP make it difficult to identify water quality factors (Hayder *et al*., 2021).

In Nigeria, conventional WTP evaluation works have been severally concentrated on, while other investigations used water quality as one of the physicochemical parameters to evaluate the efficacy of WTP Hayder *et al.,* (2021). In view of all the above, the objective of this work was to evaluate the levels of lead and Iron in domestic water supply system at Ekeki Housing Estate Yenegoa local government and Otuoke community in Ogbia local government in Bayelsa State, Nigeria

MATERIALS AND METHODS

Study area: Groundwater in form of boreholes has been seen as major source of potable instead of municipal or other water source in major towns and cities of Bayelsa State. The two study areas which are Ekeki Housing Estate, sited in Ekeki metropolis in Yenagoa is located at 4.912774, 6.2928757 coordinate and of latitude and longitude 4°54'46.0"N 6°17'34.4"E. Yenagoa LGA is geographically located within latitudes 4°49'N and 5°23'N and also within longitudes 6°10' E and 6°33' E Churchill and Ijaola, (2022) Otuoke community in Ogbia Local Government Area is geographically located at 442.418N 6 19’44.472E where Federal University Otuoke is sited Ogunlowo and Somina (2022). See figure 1 and 2 respectively.

Fig 1: Map of Ekeki Housing Estate and surrounding areas

Water Sampling Techniques and Analysis: A total of 12 samples were randomly collected at three different treatment points of each treatment plant investigated

at Ekeki Housing Estate, Yenagoa, and Otuoke community in Ogbia Local Government Area.

Fig 2: Map of Otuoke Community

Water samples were taken with 75 ml amber bottles, preserved before analysis for heavy metals [Lead (Pb) and Iron (Fe)]. Concentrated hydrochloric acid (HCl) and distilled water were used to sterilize and rinse the sample bottles respectively, at respective sampling stations, before sampling.

The sample bottles were well labeled, sealed, and placed in ice-crested cooler box filled ice packs (Dry ice was avoided because of the tendency to freeze samples, which may affect samples) at temperatures approximately of 4ºC before they were taken to the laboratory for further analysis.

All sampling, preservative and sample handling techniques were in accordance with APHA 2012 for Examination of Water and Wastewater (20th Edition) according to Standard Method for the Examination of Water and Wastewater, 21st ed.

Samples at Ekeki Housing Estate were collected randomly because of the similarity in Geology and Hydrogeology formation of the area after examination of data obtained from the GIS center in the State. Portable GPS was used to determine the coordinate of each sampling station on location as presented in table 1.

Samples at Otuoke community were taken at different locations in Otuoke namely; Boys hostel, the Girls hostel, PA Road lodge and the (Community) Anglican Church on the same day. Lead and Iron was analyzed using Flame Atomic Adsorption Spectrophotometer machine, concentrated HNO, and water samples, according to the standard methods E (Leizou *et al*, 2017). Results obtained were compared with water quality standards of WHO and USPH (United States Public Health Drinking Water Standards).

Table 1: GPS Coordinate of Each Sampling Locations at Ekeki Housing Estate

S/n	Station code	Location	Latitudes	Longitudes
1	Point A	Ekeki Housing Estate road 1 block 10	4° 54' 51" N	6° 17' 25" E
2	Point B	Ekeki Housing Estate road 1 block 11	4° 54' 50" N	6° 17' 35" E
3	Point C	Ekeki Housing Estate road 8 block 6	4° 54' 48" N	6° 17' 38" E
4	Point D	Ekeki Housing Estate road 2 block 11	4° 54' 43 " N	6° 17' 42" E

Source: Field work data 2022

Statistical Analysis: The statistical analysis of lead and iron was performed using SPSS software version 20. One-way analysis of variance (ANOVA) was performed at a significance level of 0.05, and Duncan's multiple range test (DMR) was used to identify the source of the detected differences. The connection between the leads and irons in the various stations or water treatment plants sampled was also determined using a Spearman correlation matrix. At the 95% range level, the standard error bar was calculated.

RESULTS AND DISCUSSION

Table 2 and 3 show the result of heavy metals (Pb and Fe) obtained in water samples from the study areas, while table 5 and 6 report the correlation matrix of Pb and Fe. Figures 3 and 4 illustrate the individual value plot of Pb and Fe respectively at Ekeki Housing Estate while Figure 5 gives a combined Pb and Fe plot level for Otuoke community for all ANOVA analysis carried out. The results obtained for lead concentrations as observed in table 2 and 3 affirmed the conclusion drawn from Udom *et al*, 2018 and confirmed by Vivian *et al* 2017 that the pH and sulphate content ranges from (6.4-71) and (7.3-200) mg/L respectively. Confirming that sampled water is slightly acidic in nature and its high acid content corrodes the lead distribution pipes hence the increasing values of 0.03-0.11mg/L from water source to first treatment chamber which are mostly sand filters when observed. The deflection in Pb values reductions on table 3 for G3, G4; I2, I3 and I4 Were resulting from additional treatment chambers of stage three and four where activated carbon and chlorination were added. Lead enters drinking water when plumbing materials that contain lead corrode, especially when the water has high acidity and low mineral content as seen in the result above. All water samples presented values of lead between 0.02-0.64

mg/L except for point I3 and I4 which conformed to 0.01mg/L. The results obtained are way above the 0.01 mg/l as stated by 'WHO' standard, and as such, require particular attention. This is extremely troubling because lead in water presents a serious threat to people's health. Adults who are exposed to lead in drinking water may eventually develop cardiovascular diseases, decreased renal function, increased blood pressure and the prevalence of hypertension, impaired kidney function, and issues with both male and female reproduction. As their brains and nervous systems are still developing, children's exposure to lead doses that have little to no effect on adults may have a major impact on them.

Table 2: Range value of Lead and Iron concentration in Water Sampled at Ekeki Housing Estate with mean and standard deviation.

Metals	Concentration mg/L			
	Sampling Stations			
	A	B	C	D
Pb	0.04-0.19; 0.13±0.001	0.08-0.19; 0.16±0.100	0.30-0.64; 0.49±0.320	0.49-0.62; 0.54±0.563
Fe	0.90-5.27; 2.61±0.336	1.89-5.30; 3.10±0.179	1.03-4.95; 2.66±0.320	0.44-5.06; 3.09±0.176

Point A rep. Ekeki Housing Estate road 1 block 10, at 1: Source, 2: Treatment, and 3: Outlet. Point B rep: Ekeki Housing Estate Road 1 block 11, at 1: Source, 2: Treatment, and 3: Outlet. Point C rep: Ekeki Housing Estate road 8 block 6, at 1: Source, 2: Treatment, and 3: Outlet. Point D rep: Ekeki Housing Estate road 2 block 11, , at 1: Source, 2: Treatment, and 3: Outlet

Table 3: Range value of Lead and Iron concentration in Water Sampled at Otuoke Community with mean and standard deviation.

Metals	Concentration mg/L			
	Sampling Stations			
	A	B	C	D
Pb	0.04-0.19; 0.13±0.001	0.08-0.19; 0.16±0.100	0.30-0.64; 0.49±0.320	0.49-0.62; 0.54±0.563
Fe	0.90-5.27; 2.61±0.336	1.89-5.30; 3.10±0.179	1.03-4.95; 2.66±0.320	0.44-5.06; 3.09±0.176

Point G rep. girl hostel, at 1: Source, 2: Treatment, 3: Treatment and 4: Outlet. Point H rep: Boy hostel, at 1: Source, and 2: Outlet. Point I: PA Road lodge at 1: Source, 2: Treatment, 3: Treatment and 4: Outlet. Point J: (Community) Anglican church at 1: Source, and 2: Outlet.

Results observed on table 3 indicate that iron content within sampled water was low when compared to those of table 2 but. Iron concentration was generally high in the entire sample analyzed when compared to WHO guidelines values for maximum contamination levels of 0.3 mg/L (water) are acceptable. Figure 4 and 5 illustrate the reduction rate of Fe when passed through a treatment chamber. Based on the assessment, it is drawn that at point B1 there was a significantly discharging of high levels of iron, which may occur when pipes are exposed to oxygen which can produce rust and frees up iron particles. It is a well-known fact that iron is essential for the human body. Hence, it can be concluded that those within the low limit as indicated by the standards has no health significance, and the limits are based on aesthetic and taste considerations according to Indian Standards Institution 2012.

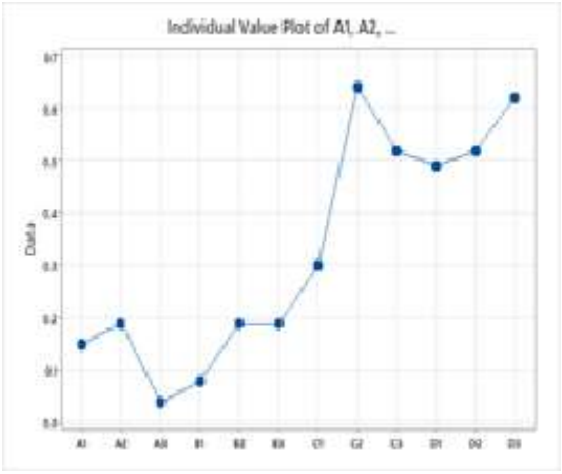

Fig 3: showing Pb individual value plot Ekeki Housing Estate

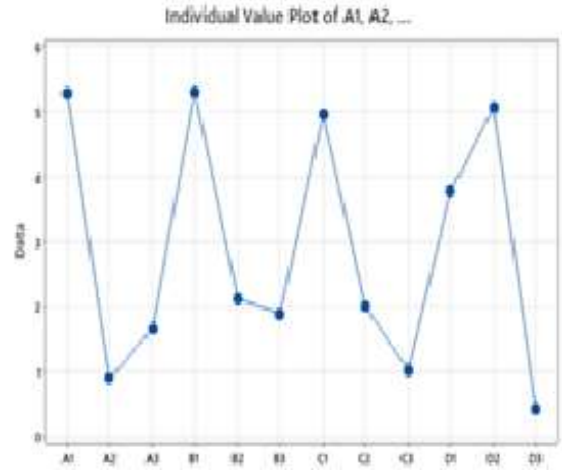

Fig 4: showing Fe individual value plot for Ekeki Housing Estate

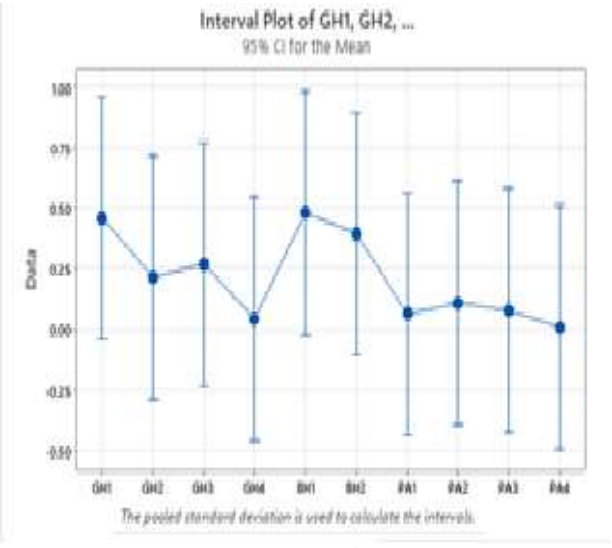

Fig 5: Pb and Fe combine plot Level for Otuoke community

The lowest value of 0.01mg/L was observed at points I4 on table 3 where there were 3 stage treatment chambers. Iron concentration was generally high in the entire sample analyzed, as confirmed by Leizou, 2017 and Udom *et al* 2018. Although, iron is one of the essential elements in human nutrition, however, small amount of iron may allow Bacterial grow and in turn dangerous to human health, its presence at elevated concentration in water can damage internal organs since Fe can be store in the heart, pancreas and liver resulting to diabetes and iron poisoning.

Table 4 below showed the results of one way Anova, it was deduced that the significant level is at 0.02 when compared to 0.05 significant level considered, meaning there are no significant changes in the concentration of Pb and Fe over time or the data collected is not sufficient to deduce significant level

Table 4. One way ANOVA analysis for Lead and Iron concentration

Score	Sum of squares	df	Mean square	F	Sig
Between Groups	339.800	2	169.900	4.545	.020
Within Groups	1009.400	27	37.385		
Total	1349.200	29			

Conclusions: The Two major heavy metals (Pb and Fe) of concern in Bayelsa were assessed. These heavy metals were investigated at sources, treatment stages and distributions, with all above the WHO guideline levels for domestic usage. This is because most treatment processes adopted were not suitable for treatments of the contaminants. Since water is essential and must be provided in its cleanness for consumption, hence the need to review treatment processes, methods of distribution and regular monitoring of water of the study areas. Therefore a suitable treatment processes is recommended to be adopted

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