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PHYSICOCHEMICAL AND WATER QUALITY INDEX EVALUATION OF BOREHOLES WATER QUALITY IN IMIRINGI, ELEBELE AND EMEYAL II COMMUNITIES IN OGBIA LOCAL GOVERNMENT AREA OF BAYELSA STATE, NIGERIA

BY

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Abstract

Water for human consumption is required to be of high standard because of the negative of effects of contaminated water on human health. This is why regular water quality monitoring is a key component of water quality management. This study evaluated quality of selected bore holes water in Imiringi, Elebele and Emeyal II communities in Emeyal clan in Ogbia Local Government Area of Bayelsa. Fifteen physicochemical water quality parameters and six heavy metals concentration in the bore holes water samples were analyzed following WHO guideline. The results indicate that EC measurements in all the sampled locations range between 67.9µscm-1 and 131.5µscm-1.TDS range between 40.74mg/l and 80.76 mg/l. TSS range between 0.04 and 0.30mg/l. pH range 6.52 and 6.84. TA range between 20.81mg/l and 36.08mg/l. Cl range between 73.52mg/l and 120.33mg/l. Fluoride range between 0.03mg/l and 0.17mg/l. NO3 range between7.98mg/l and 17.75mg/l. SO4 range between 87.68mg/l and 128.13mg/l. PO4 range0.013mg/l and 0.074mg/l. DO range between 2.0mg/l and 4.2mg/l. COD range between 111.7mg/l and 127.2mg/l. BOD range between 0.80mg/l and 1.68mg/l. Ca ranges between 3.14mg/l and 17.28mg/l. Mg range 2.13mg/l and 5.31mg/l. The results also show that Fe concentration range between 1.356mg/l and 3.120mg/l. Mn range between 0.125mg/l and 1.032mg/l. Cd concentration range between 0.002mg/l and 0.008mg/l. Cr concentration range between 1.043mg/l and 2.458mg/l. Cu range between 1.463mg/l and 4.130mg/l. Pb range between 0.017mg/l and 0.325mg/. Water quality index (WQI) evaluation based on the physicochemical properties showed that the sampled bore holes water are of excellent quality for drinking. However, Heavy metal Polluting index (HPI) values in all sampling points are higher than the critical value (>100) hence the water are not suitable for human consumption. It is recommended that government should provide pipe born water in Yenagoa metropolis and environs and neighbourhood water schemes in the rural area in order to protect public health.

Keywords: Water quality, index, assessment and evaluation.

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1.0 INTRODUCTION

Availability and accessibility to quality water for drinking and other domestic use is a key indicator of state of development of a people. This underscores why the United Nations identified and established water, sanitation and hygiene as one of the Sustainable Development Goals (SDGs) to be achieved by member's nations by 2030. Water plays a crucial role in the development of any nation. In spite of the fact that over 75% of the earth surface is filled with water, literature evidence reveals that, availability of potable water remains a major problem in Africa in general and particularly in Nigeria (Ohimain et al., 2013; Ohimain and Angaye, 2014 in Tariwari et al., 2015 in Egbo Eremasi, 2022).

Water is important to the cultural, social, economic, technological and industrial live of people as well as human health all over the world. In terms of human health, the importance of good quality water cannot be over emphasized. This is because the proper physiological and biochemical functions of the human body system depend heavily on availability of good quality water to circulate vital mineral elements to all body organs and systems. However, In Africa, Over 300 million people lack access to potable water (Idoko, 2010 and Amangabara, 2012 in Egbo and Yaguo, 2022). Literature report suggest that some factors responsible for shortage of potable water include rapid urbanization and increasing population, agricultural and industrial activities (Ekong and Ebong, 2012; Amadi *et al*., 2012, and Egbo and Yaguo, 2023).

Despite the need for good quality water for the sustenance of human health and well-being, good quality water for human consumption in many parts of the world is as scarce as gold in contemporary times. (UNEP, 2002) reported that freshwater quality and availability remains the most critical environmental and sustainability issues of the twenty Ist century. This is due to wide spread environmental pollution caused by human activities. Surface and groundwater in many parts of the world have been inundated with pollutants from industrial, agricultural, domestic and commercial activities.

In Bayelsa State, South –South Nigeria, there are many rivers, creeks, lakes and pond as source of water, but due to their obvious pollution from human activities, the water from these surface sources have become detestable. This couple with the absence of pipe born water in the state capital and the rural areas have made residents to rely on private water bore holes for their daily water needs. This is not just peculiar to Bayelsa State but in almost all the Niger Delta States. Most of the Niger Delta relies on groundwater for both domestic and industrial uses (JICA, 2014; Abam and Nwankwoala, 2020). The Niger Delta region has been tagged the most polluted spot on earth (Mbachu, 2020).

Bore holes water is taped or drilled from groundwater aquifers. The groundwater is not absolutely free from pollution. Groundwater is polluted from a number of sources which include, landfill leachate migration, salt water intrusion, infiltration from septic tanks and storm water surface run off, leakages from chemical underground storage tanks, pesticide pollution from agricultural practices as well as industrial effluents.

In the light of the above, it is very important for bore holes water quality to be monitored regularly in order to protect public health and wellbeing. The aim of this study was to analyze the physicochemical characteristics of bore holes water in Imiringi, Elebele and Emeyal II communities, all in Emeyal Clan in Ogbia Local Government Area of Bayelsa State, South-South Nigeria and to evaluate the overall water quality index (WQI) using the weighted Arithmetic water quality index model as well as Heavy Metal Pollution index (HPI) to ascertain the potability of the boreholes water in the area..

2.0 MATERIALS AND METHODS

2.1 The study area

The study area is Imiringi, Elebele and Emeyal II communities in Emeyal clan. Emeyal clan is one of the three clans in Ogbia Local Government of Bayelsa State. The clan is very strategic to Nigeria, as it hosts some strategic oil and gas infrastructure in the country. These include the Kolo Creek oil and Gas flow station operated by Shell and NNPC joint venture, the Nigeria oil and gas industrial park (NOGAS) in Emeyal I. Ogbia is located in located between Latitudes 4o33'NI and 5o00'N and Longitudes 6o15'E and 6o29'E (Udom et al., 2017). The main water drainage outlet in the area is the Kolo Creek. The area has been known for poor water quality as a result of undesirable high level of some groundwater quality parameters and salt water intrusion (Udom et al., 2017)

2.2 Method

2.2.1 Boreholes water sample collection.

Boreholes water samples were collected into pre-washed plastic sampling bottles from 9 different sampling locations in the three communities of Imiringi, Elebele and Emeyal II communities, all in Emeyal Clan of Ogbia Local Government Area of Bayelsa State. Three water samples were collected from each community. All the samples collected were properly labeled and put in a cooler stuffed with ice block and then transported to the laboratory for analysis.

2.2.3 Analytical procedures.

All water samples were analyzed according to standard analytical procedure of the World Health Organization (WHO). pH measurements was undertaken using table top digital pH meter. The pH meter was standardized with standard buffer solution. The Electrical Conductivity (EC) of water sample was determined using digital EC meter. Heavy metals were analysed with Atomic Absorption spectrophotometer. Total Hardness (TH), Total Alkalinity (TA), Chloride (Cl) and Fluoride (F), Nitrate (NO_3), Sulphate (SO_4), and PO_4 were determined by titrimetric method following standard analytical procedures of (WHO).While, Total Dissolved Solid (TDS), Total Suspended Solid (TSS) were determined by gravimetric method. Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) were measured by electrochemical method (WHO).

2.2.3 Data analysis

Groundwater quality index (GWQI)

The groundwater quality index (GWQI) which reflects the composite influence of the different water parameters was evaluated using the weighted arithmetic water quality index equation

$$[(WQI = \sum Qi\ WI/\sum Wi);\quad (Qi = 100[Vi\text{-}v0]/[si\text{-}v0])(\ Wi=k/s_i\quad k= 1/\sum 1/s_i)].$$

(1)Where,

Q_i = Sub-index for the water quality parameter;

W_i = Weight Associated with the ith water quality parameter;

V_i = Observed or measured value

V_0 = Ideal values of ith parameter.

S_i = recommended standard value

This method is adopted because it incorporate the most commonly measured water quality parameters prescribed by water standards.

Heavy metals Pollution Index (HPI)

The heavy metal pollution Index (HPI) was evaluated using the equation of Mahan et al. (1996)

$$[(HPI=\sum_{ni} = \sum Qi\ WI/\sum Wi)$$

(2)Where,

Q_i = Sub-index for the water quality parameter;

W_i = Weight Associated with the ith water quality parameter;

HPI = Heavy metals pollution index.

3.0 RESULTS AND DISCUSSIONS

3.1 Results

Results of the laboratory analysis of boreholes water from Imiringi Elebele and Emeyal II including summary of water quality index evaluation based on the weighted Arithmetic water quality index are presented in Table 3.1

Table 3.1: Results of boreholes water quality analysis and summary water quality evaluation based on weight Aritmetic water quality index for Imiringi**, Elebele** and Emeyal II

Parameter	**IMIRINGI**			**ELEBELE**			**EMEYAL II**			**Drinking Water Standards**	
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	NSDQW	WHO
EC	70.9	156.9	123.9	74.3	67.9	69.1	134.6	124.3	131.5	1000	
TDS	42.54	94.14	66.3	44.58	40.74	45.67	80.76	74.58	76.67	500	1000
TSS	0.08	0.10	0.29	0.18	0.17	0.15	0.04	0.30	0.13		
pH	6.84	6.35	6.80	6.68	6.58	6.73	6.67	6.52	6.50	6.5-8.5	
TA	24.19	36.08	29.14	20.81	26.49	24.65	28.94	32.61	28,77		
Cl	120.33	113.04	119.68	84.65	73.52	80.09	78.63	91.47	83.05	250	250
F	0.17	0.13	0.15	0.05	0.03	0.03	0.08	0.03	0.06	1.5	1.5
NO_3	13.46	17.75	14.76	10.93	14.54	15.28	10.52	7.98	8.31	50	10
SO_4	94.17	120.62	110.40	93.01	87.68	88.35	128.13	113.45	119.97	100	250
PO_4	0.025	0.038	0.032	0.057	0.063	0.071	0.013	0.074	0.025	1.0	
DO	2.6	2.3	3.1	4.2	3.9	3.8	2.0	2.8	2.6	5	
COD	116.3	111.7	121.2	127.2	118.3	117.45	124.5	125.4	123,95		
BOD	1.40	1.68	1.36	1.29	1.05	1.32	0.80	1.13	1.11	5	
Ca	5.79	3.14	3.67	4.81	7.25	5.67	10.58	17.28	15.93	25	
Mg	2.13	2.97	2.31	1.96	5.31	3.44	4.18	3.64	2.81	20	
∑Wi											**0.9765**
∑QiW	- 31.94	- 129.93	-31.94	-63.93	-83.93	-53.93	-65.94	-95.94	-99.94		
WQI	**- 31.94**	**- 129.93**	**-31.94**	**-63.93**	**-83.93**	**-53.93**	**-65.94**	**-95.94**	**-99.94**		

The water quality characterization and rating of the drinking suitability of the water sampled collected from Imiringi, Elebele and Emeyal II as per the weighted Arithmetic water quality index method are presented in Table 3.2

Table 3.2: Water Quality Rating as per Weight Arithmetic Water Quality Index Method for water from Imiringi, Elebele and **Emeyal II**

WQI Value	**Grading**	**Rating of water quality**	**Communities**	**Rating of water quality of the various sampling points**		
0 – 25	A	Excellent water quality		Point 1	Point 2	Point 3
26 – 50	B	Good water quality	Imiringi	Excellent water quality	Excellent water quality	Excellent water quality
51 – 75	C	Poor water quality	Elebele	Excellent water quality	Excellent water quality	Excellent water quality
76 – 100	D	Very poor water quality	Emeyal II	Excellent water quality	Excellent water quality	Excellent water quality
Above 100	E	Unsuitable for drinking				

The results of the computation of the Heavy metal pollution index (HPI) of the boreholes water samples from Imiringi, Elebele and Emeyal II are presented in Table,3.3.

Table 3.3: Heavy metal pollution index (HPI) of water samples from Imiringi , Elebele and Emeyal II

	IMIRINGI			**ELEBELE**			**EMEYAL II**			$W_i=\frac{k}{Sn}$
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	
Fe	2.480	3.012	3.120	2.287	2.827	2.321	1.750	1.356	1.532	0.007
Mn	0.494	1.032	0.562	0.324	0.708	0.453	0.513	0.125	0.214	0.7
Cd	0.003	0.008	0.004	0.007	0.004	0.005	0.004	0.002	0.003	0.042
Cr	2.074	2.458	2.024	1.043	1.347	1.436	3.103	1.785	2.105	0.0021
Cu	4.130	2.964	2.886	1.587	1.964	1.463	2.472	2.021	2.112	0.21
Pb	0.057	0.017	0.043	0.274	0.257	0.325	0.024	0.125	0.026	
$\sum Wi$										0.9821
$\sum Qi\ WI$	302.52	440.10	362.29	833.14	755.67	927.14	410.78	226.86	312.91	
HPI	**308.03**	**448.12**	**368.89**	**848,33**	**769.44**	**944.04**	**418.27**	**230.99**	**318.61**	

4.2 Discussion

Water quality monitoring is a key process in water quality management. This study investigated 15 physicochemical parameters of water quality and 6 heavy metals concentrations in bore holes water samples collected from the study area. The results of the Laboratory analysis and summary of water quality index (WQI) evaluation are presented in

Table 3.1.The physicochemical parameters include; Electrical conductivity (EC), Total dissolved Solid (TDS), Total Suspended Solid (TSS), pH, Total Alkalinity (TA), Chloride, Fluoride(F), Nitrate (NO3), Sulphate (SO_4), Phosphate (PO_4), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) Biochemical Oxygen Demand (BOD) Total Calcium (Ca) and Total Magnesium (Mg). Heavy metals analyzed include; Iron (Fe), Manganase (Mn), Cadmium (Cd), Chromium (Cr), Copper (Cu) and Lead (Pb). The results indicate that EC measurements in all the sampled locations range between 67.9µscm^{-1} and 131.5µscm^{-1}.TDS range between 40.74mg/l and 80.76 mg/l. TSS range between 0.04 and 0.30mg/l. pH range 6.52 and 6.84. TA range between 20.81mg/l and 36.08mg/l. Cl range between 73.52mg/l and 120.33mg/l. Fluoride range between 0.03mg/l and 0.17mg/l. NO_3 range between7.98mg/l and 17.75mg/l. SO_4 range between 87.68mg/l and 128.13mg/l. PO_4 range0.013mg/l and 0.074mg/l. DO range between 2.0mg/l and 4.2mg/l. COD range between 111.7mg/l and 127.2mg/l. BOD range between 0.80mg/l and 1.68mg/l. Ca ranges between 3.14mg/l and 17.28mg/l. Mg range 2.13mg/l and 5.31mg/l.

The lowest EC measurement was recorded at Point 2 in Elebele, while the highest level was recorded at Point1 in Emeyal II. The lowest TDS measurement was recorded at Point2 in Elebele, while the highest level was recorded at Point1 in Emeyal II. The lowest TSS measurement was recorded at Point1 in Emeyal, while the highest level was recorded at Point3 in Imiringi. The lowest pH measurement was recorded at Point 2 in Elebele, while the highest level was recorded at Point1 in Elebele. The lowest TA measurement was recorded at Point1 in Elebele, while the highest level was recorded at Point1 in Imiringi. The lowest CL concentration was recorded at Point 2 in Elebele, while the highest concentration was recorded at Point1 in Imiringi. The lowest F concentration was recorded at Point 2 and 3 in Elebele, while the highest level was recorded at Point2 in Emeyal II.The lowest NO_3 concentration was recorded at Point 1 in Emeyal II, While the highest level was recorded at Point2 in Imiringi. The lowest SO_4 concentration was recorded at point2 in Elebele. While the highest concentration was recorded in point 1 in Emeyal II. The lowest PO4 concentration was recorded at Point 1in Emeyal II, while the highest level was recorded at Point1 in Elebele. The lowest DO concentration was recorded at Point 3 in Imiringi, while the highest level was recorded at Point1 in Elebele. The lowest COD concentration was recorded at Point 2 in Imiringi, while the highest level was recorded at Point1 in Elebele. The lowest BOD concentration was recorded at Point 1 in Emeyal II, while the highest level was recorded at Point2 in Imiringi. The lowest Ca concentration was recorded at Point 2 in Imiringi, while the highest level was recorded at Point2 in Emeyal II. The lowest Mg concentration was recorded at Point 1 in Elebele, while the highest level was recorded at Point2 in Elebele. The results of water quality index evaluation in use to classify the suitability of the waters for drinking. The results of the classification are presented in Table 3.2. The classification revealed that all the bore holes water sample are of excellent water quality for drinking based on the physicochemical parameters analyzed.

The results of the heavy metal analysis and Heavy metals Pollution Index (HPI) evaluation are presented in Table 3.3. The results show that Fe concentration range between 1.356mg/l and 3.120mg/l. Mn range between 0.125mg/l and 1.032mg/l. Cd concentration range between 0.002mg/l and 0.008mg/l. Cr concentration range between 1.043mg/l and 2.458mg/l. Cu range between 1.463mg/l and 4.130mg/l. Pb range between 0.017mg/l and 0.325mg/l. The lowest Fe concentration was recorded at point 2 in Emeyal, while the highest concentration was recorded at point 3 in Imiringi. The lowest Mn concentration was recorded at point 2 in Emeyal, while the highest concentration was recorded at point 2 in Imiringi. The lowest Cd concentration was recorded at point 2 in Emeyal, while the highest concentration

was recorded at point 2 in Imiringi. The lowest Cr concentration was recorded at point 1 in Elebele, while the highest concentration was recorded at point 2 in Imiringi. The lowest Cu concentration was recorded at point 3 in Elebele, while the highest concentration was recorded at point 1 in Imiringi. The lowest Pb concentration was recorded at point 2 in Imiringi while the highest concentration was recorded at point 3 in Elebele.

The Heavy metals Pollution index (HPI) evaluation indicates that the waters are not good for consumption due the high level of heavy metals concentration in the waters. HPI values of the water in all the sampling points are higher than the critical value (> 100). Heavy metals concentrations in most of the waters sample are far above the World Health Organization (WHO) guideline limits. The result of this study agree with (Prasad and Singita, 2008; Prasad and Mondal, 2008; Egbo and Eremasi, 2022). While it slightly varies from (Nwankwoala and Omemu, 2019). The results also agrees with (Udom., Nwankoala and Daniel, 2016) in respected of categorization of groundwater in Ogbia.

4.0 CONCLUSION AND RECOMMENDATIONS.

4.1 Conclusion

Residents of the three communities of Imiringi, Elebele and Emeyal II in Ogbia Local Government Area of Bayelsa depend on bore water for all their domestic and commercial activities. This is due to the heavy pollution of the Kolo Creek which is the major source of surface of water in the area. The pollution in the Creek is due to Crude oil spillage from the activities of illegal oil refineries and sand dredging activities in the area. Some water quality parameters analyzed are within the WHO limit, while some are above the limit. However overall water quality index evaluation show that the bore holes water sampled are of excellent quality for drinking. On the other hand, heavy metals Pollution Index (HPI) show that the waters are not good for drinking due to heavy metal pollution. According to the Holy Scripture “A little leaven leavens the whole lump” therefore, based the high heavy metal concentrations in the waters sampled, the waters are not suitable for human consumption.

4.2 Recommendations.

I. The Bayelsa State government should provide pipe born water to residents of Yenagoa and nearby communities and neighbourhood water scheme in the rural areas of state to prevent incidents of water born disease.
II. Regular monitoring of bore holes water quality should be undertaken by the Bayelsa State ministry of environment in conjunction with ministry of health with view to protecting public health.
III. Residents of the study area should in corporate tertiary treatment in their water system to reduce heavy metal concentration in their water to the barest minimum.
IV. The ministry of health should carry out public enlightenment campaign on the health implication of heavy metal pollution in bore holes water

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