Environmental Challenges of Groundwater Contamination: An Assessment of Boreholes Water Quality in Ovom, Yenibebel and Yenaka Axis of Attisa Clan, Yenagoa, Bayelsa State

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Abstract

Groundwater and surface water pollution are among the prominent environmental challenges facing humanity globally in this 21st century. Groundwater is vulnerable to natural and anthropogenic pollution. In this study, groundwater collected from selected boreholes in Ovom, Yenibebel and Yenaka communities in Attisa Clan within Yenagoa metropolis were assessed for their physicochemical and heavy metals qualities, using standard analytical procedures of the World Health Organisation guidelines. The aim of the study was to determine the suitability of the boreholes water for human consumption with view to protecting public health and wellbeing. The physical parameters measured include; Electrical conductivity (EC), total dissolved solid (TDS), total suspended solid (TSS) and total hardness (TH). Chemical parameters analysed include; total alkalinity (TA), pH, Dissolved oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Chloride (Cl), Fluoride (F), Nitrate (NO_3), Phosphate (PO_4), Sulphate (SO_4). Heavy metals analysed include; Calcium (Ca), Magnesium (Mg). Iron (Fe), Copper (Cu) Chromium (Cr), Cadmium (Cd) and Lead (Pb). The results of the analysis of the water quality parameters are presented in Table 3.1. The results indicate that the physical parameters measurements were lower than the limits set in the Nigeria standard quality for drinking water (NSDQW) and the world Health Organisation (WHO) standard, in all the sampling points. However HPI evaluation revealed that water samples collected from Ovom and Yenibebel are unsafe for human consumption due to high Cadmium concentration above the recommended level of (0.003mg/l).while the boreholes water from Yenaka are safe for human consumption. It is recommended that quality of boreholes water In Yenagoa should be monitored regularly in order to protect public health.

Keywords: *Groundwater, quality, assess, public and heath*

1.0 INTRODUCTION

2.0 Background of the study.

Water pollution, Solid waste management and climate change are among the environmental challenges facing the world in the 21st Century. Water pollution includes both groundwater and surface water pollution. Groundwater is earth's most accessible and fresh water source but is being depleted and contaminated at a rate that has triggered global concern (Upmanu *et al*., 2020).

Groundwater accounts for 99% of liquid fresh water on earth and represents the world's most accessed freshwater reservoir. Groundwater provides almost half of all the drinking water for humans, 40% of irrigation water and one-third water available for industrial purpose (United Nations water, 2018 and Upmanu *et al*., 2020) The twin problems of groundwater depletion and contamination is a global concern for sustainable access and availability of drinking water. Significant populations of the world depend on groundwater for domestic, industrial and agricultural purposes. However, this important resource is vulnerable to pollution from natural and artificial sources.

Natural contamination of groundwater occurs as groundwater interact with soils and rocks on it flow path thereby dissolving substance such as sulphate, iron, fluorides, arsenic, radionuclides and manganese which defiles its natural quality (Basu *et al*., 2014; Pandey *et al*., 2016; Suba Roa *et al*., 2020; He *et al*., 2020a and Peiyue *et al*., 2021). Another Natural cause of groundwater contamination is salt water intrusion due to rise in sea water level

Anthropogenic causes of groundwater pollution come from different dimension (Egbo and Eremasi, 2022). (Christopherson,2002 ; Egbo and Eremasi, 2022) reported that pollution enters ground water from industrial injection wells (wastes pumped into the ground, septic tanks outflow, seepage from hazardous-waste disposal sites, industrial toxic wastes sites, agricultural residues (pesticides, herbicides, fertilizers) and urban waste landfills leachate migration. Guanxing and Dongya (2021) reported that high level of nitrate in ground water originates mainly from the leakage of domestic sewage and industrial waste water. Another challenge to groundwater is changing climate which is characterize by frequent and negative hydrological extreme conditions that poses threat to groundwater recharge.

Groundwater contamination can impact negatively on human health, environmental quality and socioeconomic development (Peiyue *et al*., 2021). For instance, (Wu *et al*., 2020) reported that studies have shown that high levels of fluoride, nitrate, metals and persistent organic pollutants in water are serious health risk for human populations. Consumption of polluted groundwater is reported to cause dangerous illness such as hepatitis and cholera. Limus, (2017) reported that one serious health condition caused by groundwater pollution is nitrate induced illness called Methemoglobinemia or blue baby syndrome. Alagoa and Eguakun (2020) reported that heavy metals in drinking water present a health risk if consumed without treatment.

Literature reports revealed that acute exposure to high dose or chronic exposure to low level of heavy metals can cause gastrointestinal and kidney dysfunction, nervous system disorders, skin lesions, vascular damage, immune system dysfunction, birth defects, and cancer. Simultaneous exposure to two or more metals may have cumulative effects (Fernandes Azevedo *et* *al*., 2012; Cobbina *et al*., 2015; Costa, 2019; Gazwi *et al*., 2020; Egbo and Eremasi, 2022). Exposure to a high-level of heavy metals, particularly mercury and lead, can result to severe complications such as abdominal colic pain, bloody diarrhea, and kidney failure (Bernhoft, 2012; Tsai *et al*., 2017). Water remains one of the common source of heavy metals entry into the human body

One of the indicators of sustainable development is wellbeing which implies creation of condition in which the ecosystem maintains its diversity and quality and thus capacity to support people and other life forms (Robert *et al*., 2005). Availability and accessibility to potable water is a key factor to ensure people wellbeing and health are protected. In Yenagoa the capital of Bayelsa State, because of the absence of pipe born water, residents depend heavily on boreholes water for their daily needs. However, these boreholes water quality cannot be ascertain even though the boreholes are vulnerable to sources of groundwater contamination. The objective of this study is to determine the potabilty of selected boreholes water in Ovom, Yenibebel and Yenaka communities in Attisa Clan in Yenagoa metropolis the capital of Bayelsa State.

2.1 MATERIAL AND METHOD

2.1 **Area of the study**.

The area of the study is Ovom, Yenibebel and Yenaka communities in Attisa Clan of Yenaoa Local Government Area of Bayelsa State. Attisa of one of the four Clans in Yenaoa L. G. A. Yenagoa city is the capital of Bayelsa State, located in South-South region of Nigeria. The city is situated on the bank of Ekoli River, which is one of the major river courses making up the Niger Delta Rivers, according to (Koinyan, Nwankwoala and Eludoyin, 2013). Yenagoa city is geographically located in latitude $4^{o}55^{I}$ 36.30N and Longitude $6^{o}16^{I}$3.50E according to satellite map (www.latitude.to) .

2.2 Methods.

Boreholes water samples were collected into pre-washed sampling plastic bottles from nine different sampling locations in Ovom, Yenibebel and Yenaka communities in Attisa Clan of Yenagoa metropolis. Three Water samples were collected from three different sampling locations in each community. All the samples collected were properly labeled and put in cooling box stuffed with ice block and then transported to the laboratory for analysis. Samples were analysed following standard analytical procedure of the World Health Organisation (WHO)

2.2 **Data analysis**.

2.3 **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

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

Where: *Qi* is the sub-index of the *i*th parameter and *Wi* is unit weight of the *i*th parameter, V_i, v_0 *and* s_i *are the analysed value, ideal value and the standard values of the i*th parameter respectively.

The weighted arithmetic model was adopted for this study because it incorporate the most commonly measured water quality parameters prescribed by water standards.

2.4 Heavy metals Pollution Index (HPI)

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

$$[(HPI=\sum_{ni} = \sum Qi\ WI/\sum Wi) \quad 2$$

Where each of the terms in the equation is as described in equation (1) above

3.1 RESULTS AND DISCUSSIONS

3.1 Results

Results of the laboratory analysis of boreholes water from **Ovom, Yenibebel** and **Yenaka** communities and a summary of water quality index assessment 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 of water quality index evaluation of water from Ovom, Yenibebel and Yenaka

Parameters	**Ovom**			**Yenibebel**			**Yenaka**			**Drinking Water Standards**	
	Point 1	**Point 2**	**Point 3**	**Point 1**	**Point 2**	**Point 3**	**Point 1**	**Point 2**	**Point 3**	**NSDQW**	**WHO**
EC	397.0	401.0	398.30	217.30	144.0	162.33	179.0	579.0	479.0	1000	
TDS	198.50	200.50	201.50	108.50	72.0	99.38	88.50	289.50	138.75	500	1000
TSS	0.05	0.04	0.06	0.07	0.06	0.063	0.05	0.04	0.04		
TH	88.0	98.0	95	62.0	39.0	56.25	50.0	140.0	130.0	150	
Ph	6.60	6.50	6.30	8.0	6.90	7.18	6.10	6.70	6.30	6.5-8.5	
TA	65.0	75.0	72.0	61.0	62.0	60.23	60.0	91.0	67.75		
Cl	58.0	54.0	57.0	10.0	11.0	11.03	11.0	40.0	32.75	250	250
F	0.95	1.20	1.13	0.97	0.80	0.89	0.68	1.50	1.43	1.5	1.5
NO_3	0.137	0.135	0.140	0.140	0.143	0.142	0.131	0.124	0.123	50	10
SO_4	3.20	3.21	3.17	3.25	2.52	3.18	.2.91	2.90	2.87	100	250
PO_4	1.20	1.21	1.24	2.55	2.57	2.64	1.32	1.30	1.34		
DO	4.30	4.35	4.51	3.84	3.90	3.78	2.76	3.43	3.31.		
COD	156.95	158.78	155.90	140.16	142.35	137;81	100.74	125.20	106.86		

BOD	92.67	93.74	94.12	82.75	84.05	82.57	59.48	73.92	80.31		
Ca	31.143	29.273	30,21	7.170	7.232	7.400	7.36	22.26	11.09	25	
Mg	15.572	14.636	15.10	3.585	3.616	3.605	3.68	11.131	9.27	20	
Fe	0.119	0.210	0.12	0.420	0.320	0.345	0.364	0.268	0.292	0.3	0.3
Cd	0.044	0.036	0.041	0.019	0.009	0.020	0.001	0.003	0.003	0.003	0.003
Cr	0.003	0.002	0.002	0.001	0.002	0.002	0.003	0.002	0.002	0.05	
Cu	0.100	0.019	0..067	0.032	0.024	0.030	0.043	0.010	0.035	1	2
Pb	0.032	0.024	0.028	0.00	0.010	0.001	0.003	0.006	0.004	0.01	0.01
∑Wi											0.9821
∑QiW$_i$	0.0275	0.0351	0.0260	0.0316	0.0271	0.0283	0.0241	0.0283	0.0263		
WQI	**0.0275**	**0.0351**	**0.0260**	**0.0316**	**0.0271**	**0.0283**	**0.0241**	**0.0283**	**0.0263**		

The water quality characterization and rating of the drinking suitability of the water samples collected from Ovom, Yenibebel and Yenaka 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 of water samples from Ovom, Yenibebel and Yenaka.

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	**Ovom**	Excellent water quality	Excellent water quality	Excellent water quality
51 – 75	C	Poor water quality	**Yenibebel**	Excellent water quality	Excellent water quality	Excellent water quality
76 – 100	D	Very poor water quality	Yenaka	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 Ovom, Yenibebel and Yenaka are presented in Table 3.3.

Table 3.3: Heavy metal pollution index (HPI) of water samples from Ovome, Yenibebel and Yenaka

	Ovom			Yenibebel			Yenaka			$W_i = \frac{k}{Sn}$
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	
Mg	15.572	14.636	15.10	3.585	3.616	3.605	3.68	11.131	9.27	
Fe	0.119	0.210	0.12	0.420	0.320	0.345	0.364	0.268	0.292	0.007
Cd	0.044	0.036	0.041	0.019	0.009	0.020	0.001	0.003	0.003	0.7
Cr	0.003	0.002	0.002	0.001	0.002	0.002	0.003	0.002	0.002	0.042
Cu	0.100	0.019	0..067	0.032	0.024	0.030	0.043	0.010	0.035	0.0021
Pb	0.032	0.024	0.028	0.00	0.010	0.001	0.003	0.006	0.004	0.21
$\sum Wi$)										0.9821
$\sum Qi\ WI$	1,094.43	890.91	1,0159.30	444.40	231.92	469.75	30.74	83.40	79.26	
$\sum Qi\ WI / \sum WI$	1,137.54	926.01	1,055.95	462.95	241.06	488.25	31.95	86.69	82.38	
HPI	**1,094.43**	**890.91**	**1,0159.30**	**444.40**	**231.92**	**469.75**	**30.74**	**83.40**	**79.26**	

3.2 Discussions

The quantitative measure of water parameters are the determinants of water quality for human use. In this study, four physical, ten chemical and six heavy metals water quality parameters where analysed in water samples collected from nine boreholes randomly selected from Ovom, Yenibebel and Yenaka communities in Attisa Clan of Yenagoa metropolis the Bayelsa State capital. The physical parameters measured include; Electrical conductivity (EC), total dissolved solid (TDS), total suspended solid (TSS) and total hardness (TH). Chemical parameters analysed include; total alkalinity (TA), pH, Dissolved oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Chloride (Cl), Fluoride (F), Nitrate (NO_3), Phosphate (PO_4), Sulphate (SO_4). Heavy metals analysed include; Calcium (Ca), Magnesium (Mg). Iron (Fe), Copper (Cu) Chromium (Cr), Cadmium (Cd) and Lead (Pb). The results of the analysis of the water quality parameters are presented in Table 3.1. The results indicate that the physical parameters measurements were lower than the limits set in the Nigeria standard quality for drinking water (NSDQW) and the world Health Organisation (WHO) standard, in all the sampling points. The EC measurement ranges between 144.0 and 579.0µscm$^{-1.\ 1}$ .The TDS measurements ranges between72.0 mg/l and 289.50 mg/l. TH ranges between 39.0 and 140.0 mg/l. TSS ranges between 0.04mg//l and 0.07mg/l. pH, TA, Cl, F, NO_3, SO_4, PO_4, Mg, DO, COD and BOD in all the boreholes water analysed were also lower than the standard limit set by the Nigeria Drinking water quality standard. The pH measurements range between 6.10 and 8.0. The total alkalinity (TA) ranges between 60mg/l and 91.0mg/l. The Chloride (Cl) concentrations range between 10.0 mg/l and 58.mg/l. The Fluoride (F) measurements range between 0.80mg/l and 1.5mg/l.The nitrate (NO_3) measurements range between, 0.123mg/l and 0.143mg/l. The sulphate (SO_3) measurements range between 2.52mg/l and 3.21mg/l. The Phosphate measurements range between, 1.20 mg/l and 2.64mg/l. The Dissolved Oxygen (DO) measurements range between, 2.76 mg/l and 4.51mg/l. The chemical Oxygen demand (COD) measurements range between 100.74 mg/l and 158.78mg/. The Biochemical Oxygen demand (BOD) measurements range between 59.48mg/l and 94.12 mg/l. Ca range between 7.170 mg/l and 31.14 mg/l.

The results of the heavy metals analysis are presented in Table 3.2. The results indicated that Mg concentration range between 3.585 mg/l and 15.57 mg/l, Fe range between 0.119mg/l and 0.420 mg/l, Cd range between 0.001 mg/l and 0.044 mg/l, Cr range between 0.001mg/l and 0.003 mg/l, Cu range between0.010 mg/l and 0.10 mg/l. While Pb range between 0.00 mg/l and 0.032 mg/l. These results show that Cd concentration exceeded the recommended limit. Followed by Pb. The results of heavy metals analysis of the study varies with that reported by Tariwari (2015) who reported heavy metals concentration higher than Nigeria standard and WHO limits, in Epie Communities. However the results of the study agree with the results of (Agbalagba *et al*., 2011). The results also aligned with Egbo and Eremasi (2022) who conducted similar studies in Epie Communities.

Heavy metal pollution index (HPI) evaluation for borehole water in all the sampled locations in (Ovom, Yenibebel and Yenaka) indicate that (Ovom has HPI of **1,094.43**, **890.91** and **1,0159.30** at points 1, 2, and 3 respectively, showing they are all above the critical value of 100.The results also show that water sampled from Yenibebel have HPI values of**444.40**, **231.92** and **469.75** at points 1, 2 and 3 respectively. Waters samples from Yenaka have HPI of **30.74**, **83.40** and **79.26** at points 1, 2 and 3 respectively. These results indicate that all the boreholes water samples from Ovom and Yenibebel are unsafe for drinking with respect to heavy metals pollution. While the samples collected from Yenaka all have HPI lower than the critical value of (100) meaning they are all safe for drinking The higher HPI recorded at Ovom and Yenibebel are due to impact of Cadmium which exceeded the limit in these two communities. The results of HPI evaluation in Ovom and Yenibebel are significantly higher than the results reported by (Alagoa and Eguakun, 2020). Egbo and Eremasi, (2022a) and Egbo and Eremasi, (2022b) who reported HPI of (107.51, 41.43, 56.25 and 157.41, 72.00, 159.06, in Akenfa and Agudama-Epie respectively. 30.01, 49.49, 25.93 and 100.26, 235.90, 51.20 in Akenpai and Edepie respectively.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 **Conclusions**

Physicochemical and biological characteristic are key indices for measuring the quality of water for human consumption. The physicochemical measurements obtained in this study followed by the water quality index evaluation is a clear indication that boreholes water sampled from Ovom, Yenibebel and Yenaka communities have excellent qualities for drinking. However, heavy metals pollution index (HPI) evaluation indicates that the water samples collected from Ovom and

Yenibebel are not safe for drinking due to high Cadmium concentration. The waters from Yenaka are good and safe for human consumption.

4.2 **Recommendations**

The researchers recommend that private boreholes water quality should be monitored regularly to detect any variation from the recommended standard with view to protecting public health and wellbeing. Water Boreholes owners in Bayelsa State should up scale their water treatment process with view to reducing the Cadmium concentration in order to protect public health.

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