International Research Journal of Applied Sciences, Engineering and Technology
Vol.8, No. 8, August-2022;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

ANALYSIS AND WATER QUALITY INDEX ASSESSMENT OF SELECTED BOREHOLES WATER IN AGUDAMA-EPIE TO EDEPIE AXIS OF YENAGOA METROPOLIS OF BAYELSA STATE, NIGERIA

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Abstract: Groundwater is a major source of water for human consumption and other activities such as domestic, commercial and agricultural activities. In Bayelsa State, south- South Nigeria, residents depend heavily on boreholes water for their daily needs. In this study, 23 physicochemical and heavy metal water quality parameters in selected boreholes water within Agudama- Epie to Edepie axis of Yenagoa have been analysed and water quality index model used to evaluate the potability of the boreholes water. The results indicate that all the parameters analysed were below the limit recommended by the Nigeria drinking water quality standard (NSDQW, 2015), and the World Health guidelines for water quality (WHO, 2017) except for Cadmium which concentration was above the recommended limit (0.003) at sampling point 1 and 3 in Agudama Epie and point 1 in Edepie .i.e. 0.006mg/l s/cm, 0.005mg/l and 0.004mg/l respectively. The results of the water quality index characterizations presented in Table 3.2 revealed that the quality of waters collected from points 1 and 3 in Agudama Epie are unsuitable for drinking while the one at point 2 is poor for drinking purpose. The quality of waters collected from points 1, 2 and 3 in Akenpai are good for drinking purpose. While the waters collected from points1and 2 in Edepie are unsuitable for drinking and the water from point 3 has poor quality for drinking. The unsuitability and poor quality of the water is attributed to the influence of Cadmium concentration in those areas. It is recommended that boreholes water in this area should be subjected to secondary treatment before selling to the public for consumption purpose.

Keywords: Boreholes. Water, quality, assessment.

1.0 INTRODUCTION

1.1 Background of the study

Water is one of the basic and essential necessities of every living thing. Human beings consume water every day, without which life will be unbearable. Human beings consume water by way of drinking or using it to cook, outside other uses such as washing, irrigation and for industrial purposes.

Surface water remains the most available and accessible source of water, however due to its vulnerability to pollution by human activities, people no longer depend much on surface water for consumption purpose unless in the rural areas were there is no other source of water. In recent times groundwater constitute a major source of domestic and industrial water especially in town and cities.

Groundwater accounts for about 25.7% of the total freshwater and 98.4% of the unfrozen freshwater in the hydrosphere (Mackenzie and Susan, 2009). Groundwater is formed as atmospheric precipitation drains down through the soil and continuous to migrate vertically through unsaturated zone to saturated zone. At the saturated zone, groundwater moves horizontally through

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the underlying rocks or aquifer from zone of high concentration to zone of low concentration or gradient.

In the course of migration of groundwater, it interacts with rocks and dissolved minerals content of rocks which it then carries along and eventually changes the chemical quality of the water. This is why the chemical composition of groundwater is determined by the chemical composition of the underlying rock bearing it.

Water being a good solvent can dissolve a large variety of substances which it comes in contact with (Nada *et al.*, 2018). The amount of dissolved solid or substance is a very important determinant of the suitability of water for drinking, irrigation and industrial uses. In general, waters for drinking should contain less than 500 mg/litre of dissolved solids. The World Health Organization guidelines for water quality and the Nigerian drinking water quality standard (WHO, 2017 and NSDWQ, 2015) peg the maximum permissible limit of dissolved solid at 500mg/l. Higher concentration of dissolved solids in drinking water may lead to impairment of physiological processes in human body.

The ability of water to support aquatic life, as well as its suitability for other uses depends on many trace elements. However if these trace elements concentration in water go beyond certain limit, their presence becomes a treat to human health. For instance, some metals e.g., Fe, Mn, Zn and Cu present in trace quantity are important for life as they help and regulate many physiological functions of the body if they are not present in excess amount. Some metals, however, cause severe toxicological effects on human health and the aquatic ecosystem. Groundwater is very vulnerable to pollution from natural processes and human activities and this put people lives at risk. Groundwater pollution comes from different dimension. F or instance, Christopherson (2002), reported that pollution can enter 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. Alagoa and Eguakun (2020) reported that heavy metals in drinking water present a health risk if consumed without treatment.

Available literature 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). Exposure to a high-level of heavy metals, particularly mercury and lead, can cause severe complications such as abdominal colic pain, bloody diarrhea, and kidney failure (Bernhoft, 2012; Tsai et al., 2017).

In Yenagoa, the Bayelsa state capital, residents depend on boreholes water for consumption and other commercial activities as a result of the absence of pipe borne water in the town. Consequent upon the health risk of consuming polluted water, there is a need to regularly monitor boreholes water which is now the predominant source of drinking water in Yenagoa in order to protect public health and wellbeing. the aim of this study is to analyse the physicochemical qualities of boreholes water in Agudama-Epie, Akenpai and Edepie communities in Yenagoa metropolis and use water quality index to characterize the potability of the boreholes water.

2.0 MATERIALS AND METHOD

2.1 **Area of the study**.

The area of the study is Agudama-Epie, Akenpai and Edepie communities in Yenagoa metropolis. Yenagoa lies within latitudes 04°4N and 05°, 02N and longitudes 006°,

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15E and 006°, 24E and situated in the southern part of the Niger according to (Agbalagba *et al*., 2011). The terrain of Yenagoa consist basically of fresh water swamp,

mangrove swamps, beaches, bars and estuaries. It falls within the zone of five regional levels of aquifers in the Niger Delta delineated by Etu-Efeotor and Akpokodje (1990) in (Agbalagba *et al*., 2011; Mansi and Eremasi , 2022.

The study area hosts some strategic Federal government offices. For instance, Agudama – Epie is the host of the Nigeria Law School, Yenagoa campus of the Nigeria Law School and the headquarters of the Eastern command of the Nigeria Navy. Akenfa is the host community of the State headquarters of the Nigeria mobile police force. While Edepie is the host community of the Federal fire service Bayelsa State Office. Map showing the study area is presented in Fig 2.1

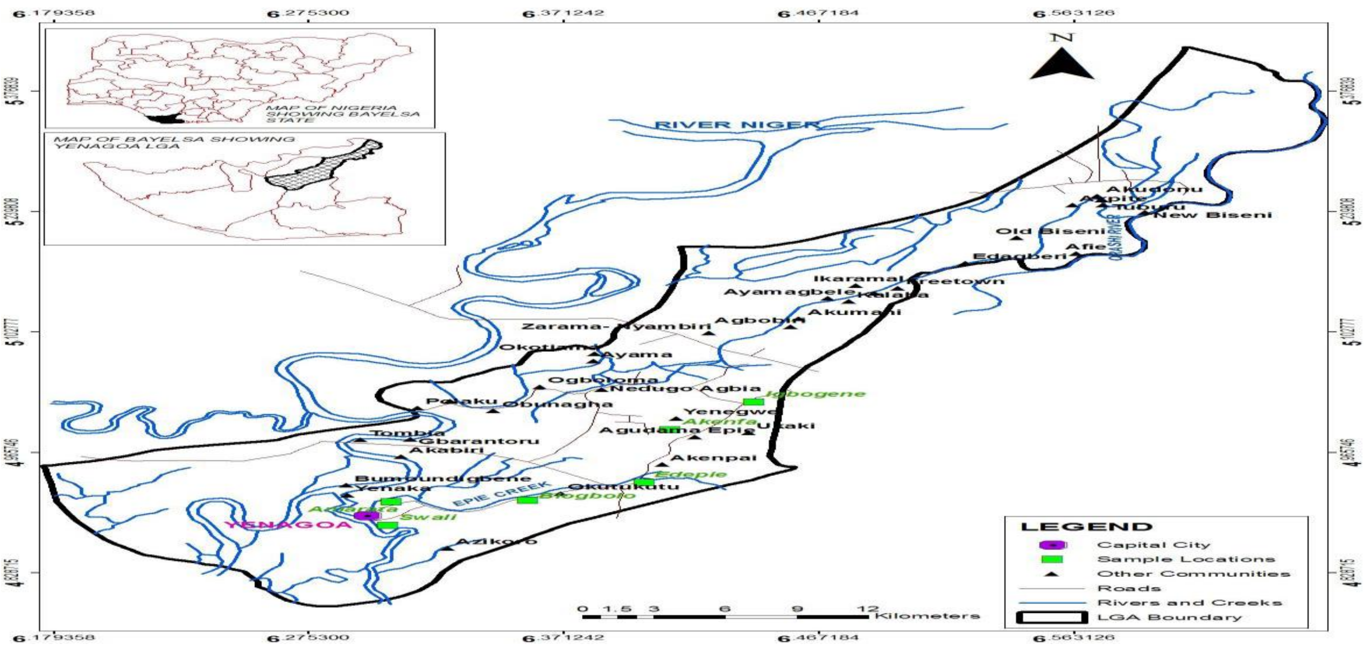

Fig 2.1: Map of the area of study. Source (Koinyan *et al*., 2013 in Mansi and Eremasi, 2022)

2.2 Methods.

Nine boreholes water samples were collected from Agudama – Epie, Akenpai and Edepie communities in Yenagoa metropolis the capital of Bayelsa State. Three water samples were collected from each community. The water samples were collected into pre-washed sampling plastic bottles stuffed with ice block and transported to the Laboratory for analysis. All the samples were analysed according to standard analytical procedure of the World Health Organization (WHO, 2017)

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

$$[(WQI\ (Q_i = 100[V_i - v_0]/[s_i - v_0])(\ W_i = k/s_i \quad k = 1/\textstyle\sum 1/s_i)]. \qquad (1)$$

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

This method is adopted 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)

$$[(HPI = \textstyle\sum_{ni} = \sum Q_i\, WI / \sum W_i) \qquad 2$$

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

3.0 RESULTS AND DISCUSSIONS

3.1 **Results**

The results of the laboratory analysis of the physiochemical and heavy metals parameters of water samples collected from Agudama- Epie, Akenpai and Edepie communities in Yenagoa metropolis and the summary of the water quality index (WQI) evaluation 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 Agudama-Epie, Akenpai and Edepie

Parameters	**Agudama-Epie**			**Akenpai**			**Edepie**			**Drinking Water Standards**	
	Point 1	**Point 2**	**Point 3**	**Point 1**	**Point 2**	**Point 3**	**Point 1**	**Point 2**	**Point 3**	**NSDQW**	**WHO**
EC	117.21	125.15	122.51	88.54	100.36	95.72	352.21	243.50	295.86	1000	
TDS	58.60	62.57	60.75	44.27	50.18	47.21	176.10	123.25	147.68	500	1000
TSS	0.38	0.31	0.30	0.05	0.0	0.02	0.05	0.03	0.04		

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TH	96.0	88.0	86.74	75.0	48.0	51.1	36.0	45.0	38.5	150	
pH	6.44	6.45	6.34	6.12	6.32	6.23	6.31	6.28	633	6.5-8.5	
TA	88.00	62.00	61.01	52.00	32.00	35.2	11.00	30.00	18.5		
Cl	22.0	40.0	37.0	14.0	20.0	15.6	16.0	40.0	29	250	250
F	0.072	0.134	0.108	0.052	0.040	0.05	0.38	0.142	0.25	1.5	1.5
NO_3	0.117	0.121	0.114	0.054	0.172	0.13	0.312	0.121	0.22	50	10
SO_4	0.69	0.62	0.63	0.32	0.84	0.56	1.82	0.76	1.26	100	250
PO_4	0.68	0.92	0.86	0.36	0.42	0.34	0.52	0.30	0.43		
DO	3.54	3.88	3.56	2.94	3.86	3.18	4.40	3.49	3.75		
COD	100.18	109.80	103.81	83.20	109.24	98.22	124.52	98.77	113.55		

BOD	54.16	59.36	55.76	44.98	59.06	52.83	67.32	53.40	62.36		
Ca	5.84	7.36	6.47	4.27	5.38	4.72	4.32	8.40	5.24		
Mg	2.24	3.77	3.32	2.10	1.86	3.01	0.97	3.56	2.47	20	
Fe	0.18	0.05	0.14	0.12	0.27	0.21	0.24	0.16	0.19	0.3	0.3
Cd	0.006	0.002	0.005	0.001	0.002	0.001	0.004	0.010	0.002	0.003	0.003
Cr	0.002	0.00	0.00	0.001	0.001	0.00	0.002	0.001	0.001	0.05	
Cu	0.002	0.004	0.002	0.010	0.008	0.002	0.0180.	0.012	0.003	1	2
Mn	0.003	0.002	0.001	0.001	0.00	0.001	0.001	0.002	0.001	0.2	0.1
Pb	0.008	0.012	0..2	0.003	0.001	0.001	0.003	0.001	0.002	0.01	0.01

Al	0.001	0.00	0.001	0.001	0.002	0.001	0.00	0.010	0.00	0.2	0.2
∑Qi	347.97	223.08	404.21	63.029	107.68	39.13	241.49	380.26	146.19		
∑Wi	0.9840	0.9840	0.9840	0.9840	0.9840	0.9840	0.9840	0.9840	0.9840		
∑QiWi	157.39	71.98	158.98	29.96	49.45	25.89	100.21	235.88	51.19		
∑*Qi WI*/∑ *Wi*	159.94	73.15	161.57	30.45	50.25	26.31	101.84	239.72	52.02		
WQI	159.94	73.15	161.57	30.45	50.25	26.31	101.84	239.72	52.02		

The water quality characterization and rating of the drinking suitability of the water samples collected from Agudama – Epie, Akenpai and Edepie 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 Agudama – Epie, Akenpai and Edepie.

WQI Value	**Grading**	**Rating of water quality**	**Communities**	**Rating of water quality of the various sampling points**

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0 – 25	A	Excellent water quality		Point 1	Point 2	Point 3
26 – 50	B	Good water quality	Agudama–Epie	Unsuitable for drinking	Poor water quality	Unsuitable for drinking
51 – 75	C	Poor water quality	Akenpai	Good water quality	Good water quality	Good water quality
76 – 100	D	Very poor water quality	Edepie	Unsuitable for drinking	Unsuitable for drinking	Poor 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 Agudama – Epie, Akenpai and Edepie are presented in Table 3.3.

Table 3.3: Heavy metal pollution index (HPI) of water samples from Agudama – Epie, Akenpai and Edepie

	Agudama-Epie			**Akenpai**			**Edepie**			**$W_i = \frac{k}{Sn}$**
	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	
Fe	0.18	0.05	0.14	0.12	0.27	0.21	0.24	0.16	0.19	0.007
Cd	0.006	0.002	0.005	0.001	0.002	0.001	0.004	0.010	0.002	0.7
Cr	0.002	0.00	0.00	0.001	0.001	0.00	0.002	0.001	0.001	0.042

Cu	0.002	0.004	0.002	0.010	0.008	0.002	0.0180.	0.012	0.003	0.0021
Mn	0.003	0.002	0.001	0.001	0.00	0.001	0.001	0.002	0.001	0.0105
Pb	0.008	0.012	0..2	0.003	0.001	0.001	0.003	0.001	0.002	0.21
Al	0.001	0.00	0.001	0.001	0.002	0.001	0.00	0.010	0.00	0.0105
$\sum Wi$)										0.9821
$\sum Qi\ WI$	157.41	72.00	159.06	30.01	49.49	25.93	100.26	235.90	51.20	
HPI	157.41	72.00	159.06	30.01	49.49	25.93	100.26	235.90	51.20	

3.2 Discussions.

Availability and accessibility of safe drinking water is very important for the protection of public health and wellbeing. However, the safety of drinking water is determined by its physical, chemical and biological characteristics. There are certain chemicals that their presence in water or when present beyond certain level in drinking water make the water unsafe for drinking. As a measure to control water quality in order to protect public health, the world Organization (WHO) has produced guidelines for water quality which prescribes permissible limits of the physicochemical parameters of drinking water. The Nigerian standard for drinking water quality (NSDQW, 2015) also prescribes maximum limits of the physicochemical parameters of drinking water. Regular monitoring of drinking water quality is critical to ensure that standards are complied with. In this study, the physicochemical qualities of selected boreholes water in Agudama- Epie, Akenpai and Edepie communities in Yenagoa metropolis were assessed and the results obtained used to characterise the suitability of the boreholes water as per the weighted arithmetic water quality index model. Three physical parameters which include electrical conductivity (EC), Total dissolved solid (TDS) and Total suspended solid (TSS), eleven inorganic chemical parameters which include Total hardness (TH), Total alkalinity (TA), pH, Chloride (Cl), Fluoride (F), Nitrate

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(NO_3), Sulphate (SO_4), Phosphate (PO_4), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) and nine trace heavy metals parameters which include Calcium (Ca), Magnesium (Mg), Iron (Fe), Cadmium (Cd), Chromium (Cr), Manganese (Mn), Copper (Cu), Lead (Pb) and Aluminum (Al) were analysed.

The results of heavy metal analysis were used to compute the heavy metals pollution index (HPI) of the various water samples. The results of the laboratory analysis of the physiochemical and heavy metals parameters of the water samples and the summary of the water quality index (WQI) evaluation are presented in Table 3.1. The results indicate that all the parameters analysed were below the limit recommended by the Nigeria drinking water quality standard (NSDQW, 2015), and the World Health guidelines for water quality (WHO, 2017) except for Cadmium which concentration was above the recommended limit (0.003) at sampling point 1 and 3 in Agudama Epie and point 1 in Edepie .i.e. 0.006mg/l s/cm, 0.005mg/l and 0.004mg/l respectively. The minimum EC level is 88.54s/cm and the maximum is 352.21, recorded at point1 in Akenpai and point 1in Edepie respectively. The minimum TDS is 44.27 mg/l and the maximum is 176.10 mg/l recorded at point 1 in Akenpai and point 1in Edepie respectively. The minimum TSS level is 0.0 mg/l and the maximum is 0.38 mg/l, recorded at point2 in Akenpai and point 1 in Agudama - Epie respectively. The minimum TH level is 36.0mg/l and the maximum is 96.0 mg/l, recorded at point1 in Edepie and point 1 in Agudama - Epie respectively. The minimum pH is 6.12 and the maximum is 6.45 recorded at point1 in Akenpai and point 2 in Agudama - Epie respectively. The minimum TA level is 11.00 mg/l and the maximum is 96.0 mg/l, recorded at point1 in Edepie and point 1 in Agudama - Epie respectively. The minimum Cl level is 14.0 mg/l and the maximum is 40.0 mg/l, recorded at point1 in Akenpai and point 2 in Agudama - Epie and Edepie. The minimum F level is 0.040 mg/l and the maximum is 0.142 mg/l, recorded at point 2 in Akenpai and point 2 in Edepie respectively. The minimum NO_3 level is 0.054 mg/l and the maximum is 0.312 mg/l, recorded at point1 in Akenpai and point 1 in Edepie respectively. The minimum SO_4 level is 0.32 mg/l, was recorded at point1 in Akenpai and the maximum is 1.82 mg/l recorded point 1 in Edepie. The minimum PO_4 level is 0.30 mg/l, was recorded at point 2 in Edepie while the maximum is 0.92 mg/l recorded point 2 in Agudama-Epie. The minimum DO level is 2.94mg/l, was recorded at point1 in Akenpai while the maximum is 4.40 mg/l recorded point 1 in Edepie. The minimum COD level is 83.20 mg/l, was recorded at point1 in Akenpai while the maximum is 124.52 mg/l recorded point 1 in Edepie. The minimum BOD level is 44.98 mg/l, was recorded at point1 in Akenpai while the maximum is 67.32 mg/l recorded point 1 in Edepie. The minimum Ca concentration is 4.27 mg/l, was recorded at point1 in Akenpai while the maximum is 7.36 mg/l recorded point 2 in Edepie. The minimum Mg concentration is 0.97 mg/l, was recorded at point1 in Edepie while the maximum is 3.77 mg/l recorded point 2 in Agudama-Epie. The minimum Fe concentration is 0.05 mg/l, was recorded at point2 in Agudama-Epie while the maximum is 0.27 mg/l was recorded point 2 in Akenpai. The minimum Cd concentration is 0.001 mg/l, was recorded at point1 and3 in Akenpai while the maximum is 0.006 mg/l was recorded at point 1 in Agudama-Epie. The minimum Cr concentration is 0.00 mg/l, was recorded at points 2, 3 in Agudama and point 3 in Akenpai, while the maximum is 0.002 mg/l was recorded at points 1 in Agudama-Epie and 1 in Edepie. The minimum Cu concentration is 0.002 mg/l, was recorded at points1, 3 in Agudama-Epie and point 3 in Akenpai, while the maximum is 0.0180 mg/l recorded point1 in Edepie. The minimum Mn concentration is 0.00 mg/l, was recorded at point2 in Akenpai while the maximum is 0.003 mg/l recorded point1 in Agudama-Epie. The minimum Pb concentration is 0.001 mg/l, was recorded at points 2, 3 in Akenpai and point 2 Edepie while the maximum is 0.2 mg/l recorded point 3 in Agudama-Epie. The minimum Al concentration is 0.00 mg/l, was recorded at points 2 in Agudama-Epie and 1and 3 in Edepie, while the maximum is 0.002 mg/l recorded point 2 in Akenpai. This results agree with (Koinyan et al., 2013) and partially agrees with (Agbalagba et al., 2011) who reported that Lead ion (Pb) was detected in water from boreholes Well 5, 6 and 7 in Yenagoa and the concentration of other heavy metals (Copper, Chromium, Cadmium and arsenic) analyzed in the same water samples were below detection limits.

The results of the water quality index characterizations presented in Table 3.2 revealed that the quality of waters collected from points 1 and 3 in Agudama Epie are unsuitable for drinking while the one at point 2 is poor for drinking purpose. The quality of waters collected from points 1, 2 and 3 in Akenpai are good for drinking purpose. While the waters collected from points1and 2 in Edepie are unsuitable for drinking and the water from point 3 has poor quality for drinking. The unsuitability and poor quality of the water is attributed to the influence of Cadmium concentration in those areas.

The results of the heavy metals pollution index evaluation presented in Table 3.3 revealed that water samples collected from points 1, and 3 in Agudama Epie and points 2 and 3 in Edepie have HPI values of 157.41, 159.06 and 100.26, 235.90 respectively and these values are above the critical level of 100 and therefore unsafe for drinking with respect to heavy metals pollution. While waters from point2 in Agudama- Epie, points 1, 2, 3 in Akenpai and point 3 in Edepie have HPI values of 72.00, 30.01, 49.49, 25.93 and 51.20l respectively and less than the critical value of 100, therefore safe for drinking with respect to heavy metals pollution**.** Alagoa and Eguakun (2020) reported HPI values of 461.23, 50.40 and 127.84 in Water samples collected Tombia road axis, Opolo and Green villa road in Yenagoa metropolis.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Assessment of the physicochemical qualities of boreholes water from Agudama-Epie, Akenpai and Edepie in Yenagao metropolis of Bayelsa state has been undertaken in this study. Twenty tree water quality parameters were analysed and weighted arithmetic water quality index based on the Nigeria Standard for drinking water quality (NSDQW, 2015) was used to characterize the drinking suitability of the boreholes water samples. Heavy metals pollution index of the water samples was also evaluated. From the results obtained in this study it is concluded that water treatment method generally apply in Bayelsa is effective in removing water pollution to acceptable level, however, Cadmium is an heavy metal of concern in Yenagoa that even with the treatment, concentration of Cadmium in some of the water samples is above the acceptable limit.

4.2 Recommendations.

Based on the results obtained in this study, it is recommended that:

- There should be regular monitoring of boreholes water in Yenagoa metropolis with view to protecting public health.
- Study on the biological quality of boreholes water should also be undertaken to prevent water borne microbial diseases.
- Boreholes water in this area should be subjected to secondary treatment before

selling to the public for consumption purpose.

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