GROUNDWATER QUALITY ANALYSIS IN ELEME METROPOLIS: A PHYSIOCHEMICAL PERSPECTIVE

1.0 Abstract

This study aims at assessing the physiochemical variation of groundwater quality in Eleme metropolis, rivers state Nigeria. The level of chemical concentration in the groundwater samples was analysed using the flame atomic absorption spectrophotometry. The quality of the borehole was analysed using a physical visibility survey. Groundwater samples from five (5) locations in Eleme metropolis was collected from public boreholes namely Alesa, Alode, Ogale, Ebubu and Agbonchia. Analysis of the groundwater samples was carried out in the Laboratory to ascertain the physical, chemical and microbiological characteristics. After due analysis, it was observed that most of the groundwater samples were still within permissible limits with little differences across the different locations. The temperature of the groundwater samples was different in Alode and Ogale as their temperatures were not within the permissible limits of WHO. The groundwater samples were also slightly different in Alode, Ogale and Ebubu with pH values of 5.20, 5.34 and 5.28 respectively. It was discovered that little treatment is needed in the study area since most of the values fall within the permissible limits of WHO.

Keywords: Groundwater, physiochemical, analysis, samples, temperature.

1.1 Introduction

Water is very essential for the sustenance of life; it occupies 71% of the entire Earth surface and biologically makes up a large percentage of the total body fluid of all living things [1]. The importance and need for quality drinking water supplies for all generations cannot be overstressed as its importance outweighs every limitation. Globally, there is a drawback in its availability and this is increasing and duplicating itself thereby, intensifying the struggle for scarce water resources as discussed by Olukanni *et al.* (2015). Water has a lot of uses among which are for hydration, cooking and food preparation, personal hygiene and cleaning, agriculture, industrial processes, Energy production, recreation, ecosystem support, cooling and heat exchanges, healthcare and medical procedures and so on.

Groundwater serves as a major source of water resources and readily available in many countries (Amadi *et al.*, 2013; Prasad and Kumar 2008). Increasing demand of surface water supplies has caused enormous pressure on freshwater ecosystems worldwide (Gleick, 2003). It is anticipated that around 50% of the population in developing regions suffer from health concerns due to inadequate water supply and sanitation (Khawas, 2006). Groundwater is typically less polluted than surface water because of its self-cleansing ability and ease of treatment (Marghade *et al.*, 2021; Subba *et al.,* 2020).

In the Heart of Eleme metropolis lies a vital resource that sustains life livelihoods-groundwater. This concealed aquifer, shrouded beneath the surface, holds the promise of purity, yet conceals potential perils. Groundwater as an indispensable natural resource, plays a pivotal role in sustaining communities worldwide. In the context of Eleme metropolis, a burgeoning urban centre, the reliance on groundwater for domestic, agricultural and industrial purposes is substantial. However, the quality of this vital resource is not always guaranteed as it can be influenced by various natural and anthropogenic factors. As urbanization continues to grow, it becomes imperative to conduct a thorough analysis of the groundwater quality in Eleme metropolis to access its suitability for various applications and identify potential contaminants that may pose risks to public health and the environment.

This research work aims to comprehensively evaluate the physiochemical groundwater quality in Eleme metropolis, utilizing a combination of field measurements, laboratory analysis and statistical modelling techniques. Factors such as pH levels, temperature, turbidity, electrical conductivity, total dissolved solids, total suspended solids, level of sulphate, nitrate and zinc will be examined to provide a holistic overview of the groundwater composition. By gaining a nuanced understanding of the groundwater quality in Eleme metropolis, this research seeks to provide valuable insights for policy makers, urban planners, and environmental agencies to implement effective strategies for sustainable groundwater management and safeguarding public health in this rapidly developing urban centre. Furthermore, the findings of this study will serve as a baseline for future monitoring efforts and will contribute to the broader discourse on urban groundwater quality assessment.

2.0 Methodology

2.1 Description of Study Area

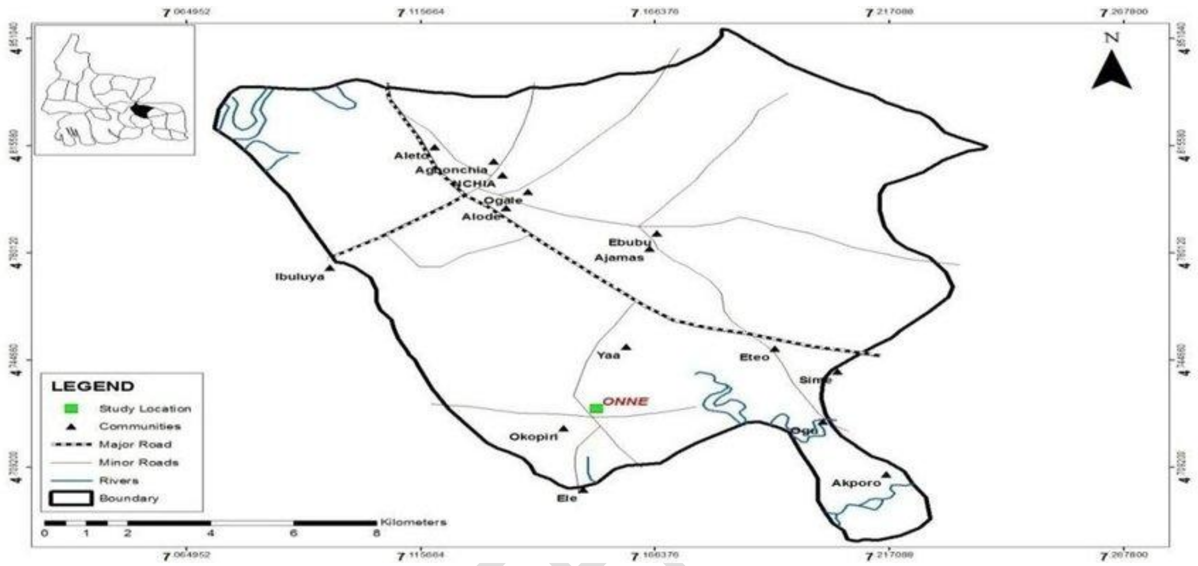

Fig. 1: Geographical Maps Showing the Location of the Study Area (Eleme). (Google Engine)

2.2 Materials Collection

2.2.1 Materials

The following materials were used; Water samples were collected at five (5) different locations in Eleme namely: ;

i. Alesa

ii. Alode

iii. Ogale

iv. Ebubu

v. Agbonchia

- Blank; a solution of no metal consisting of 450 mL of distilled water and 2 mL of nitric acid.

- World health organization limit and Nigerian standard for drinking water policy. The equipment used during the project work includes;
- Solar 969 AA Spectrometer
- Electric Orion pH Meter
- Turbidity Meter.

2.2.2 Methods

i. Data was collected in five (5) different locations in Eleme local government metropolis. The data was collected through the use of physical assessment and distribution of questionnaires. From the results gathered information of the following was achieved. They include:

- The depth of the borehole when drilled;
- Yield of the borehole initially recorded;
- The period the drilling took place;
- The static water level of the area.

ii. Analysis of parameters used. Twelve (12) parameters were analysed which include Total dissolved solids (TDS), total suspended solids (TSS), Temperature, pH, Turbidity, Total Hardness, Biological Oxygen Demand, Chemical Oxygen Demand, Dissolved oxygen, Salinity, Zinc and Lead (Pb).

iii. Digestion of the samples was carried out at Pymotech Laboratory, Enugu state. 80 mL of the sample was put in a beaker and 0.2 mL of concentrated nitric acid was added. The concentrated sample was subjected to heating in a water bath. This is to keep it warm and reduce its volume. The heating was done at a temperature of 75° C. The reason for heating was to remove its metal molecule bond to a free state. After some time, the volume of the sample being treated reduced to 10 mL. It was then removed and subjected to cooling after which it was transferred into a volumetric flask. After the sample was cooled, about 70% of distilled water was added to the sample and the resulting solution was transferred into a bottle and analysed using the infrared spectrophotometer to test for metals. The twelve (12) parameters were analysed according to the standard of WHO.

iv. Preparation of standards by using the concentration/volume formula $C_1V_1=C_2V_2$, this is used to calculate quantities in a mixture that are not known. The calculated values are entered into the machine. These values entered into the machine take the form of test standards during the analysis.

3.0 Results and Discussion

This research was carried out to investigate the various biological and chemical characteristics of underground water by analysing different boreholes in different parts of Eleme to see if they fall within permissible limits of clean portable water with reference to WHO standards. It is also aimed at determining the levels of concentration and the dangers they pose on siting underground or borehole water in these areas.

Table 1: Laboratory analysis results of water quality parameters of Alesa, Alode, Ogale, Ebubu, Agbonchia and WHO limits analyzed in the study.

S/N	PARAMETER	A	B	C	D	E	WHO LIMIT
1	TDS (mg/L)	24.2	17.42	38.5	32.3	29.0	500
2	TSS (mg/L)	0.02	0.013	0.003	0.002	0.008	<10
3	Temp (°C)	27.5	25.2	26.4	27.3	27.4	27.0-29.0
4	~~PH~~ pH	7.40	5.20	5.34	5.28	6.80	6.5-8.5
5	Turbidity (NTU)	2.43	1.35	2.34	3.56	3.18	10
6	Total Hardness (mg/L)	42.0	11.8	5.0	16.0	57.4	500
7	BOD (mg/L)	7.32	5.33	7.42	5.23	6.74	200
8	COD (mg/L)	14.3	11.00	13.29	9.38	9.22	200
9	DO (mg/L)	4.4	2.5	6.36	7.28	6.3	5.0-7.5
10	Salinity (mg/L)	32.8	15.4	9.3	38.4	27.2	250
11	Zinc (mg/L)	1.38	0.423	0.611	1.042	1.22	5.0
12	Pb(mg/L)	0.002	0.035	0.338	0.004	0.002	350

3.1 Total Dissolved Solid (TDS)

This is used to give an insight into inorganic salts and small amounts of organic matter that are present in a liquid.

Table 2: Laboratory analysis results of quantity of Total Dissolved Solids in the water samples.

S/N	LOCATION	TOTAL DISSOLVED SOLIDS
1	Alesa	29.2
2	Alode	17.42
3	Ogale	38.5
4	Ebubu	32.3
5	Agbonchia	29.0

Authors should centred the values of the table.

From the analysis underground water samples from Ogale has the highest concentration of dissolved solids (38.5), this was closely followed y Ebubu (32.3), Agbonchia (29.0), Alesa (24.2) and Alode (17.42).

Invariably, from the above it is clear that the values of total dissolved solids in all the locations fall below the WHO Limit (500 mg/L) and as such are fit for drinking. Fig 2 shows the graph of TDS plotted against location.

From the graph Ogale has the highest concentration of dissolved solids and Alode has the lowest concentration of dissolved solids. Total dissolved solids must be at its barest minimum for the water to be declared fit for drinking in order to prevent among adverse effects.

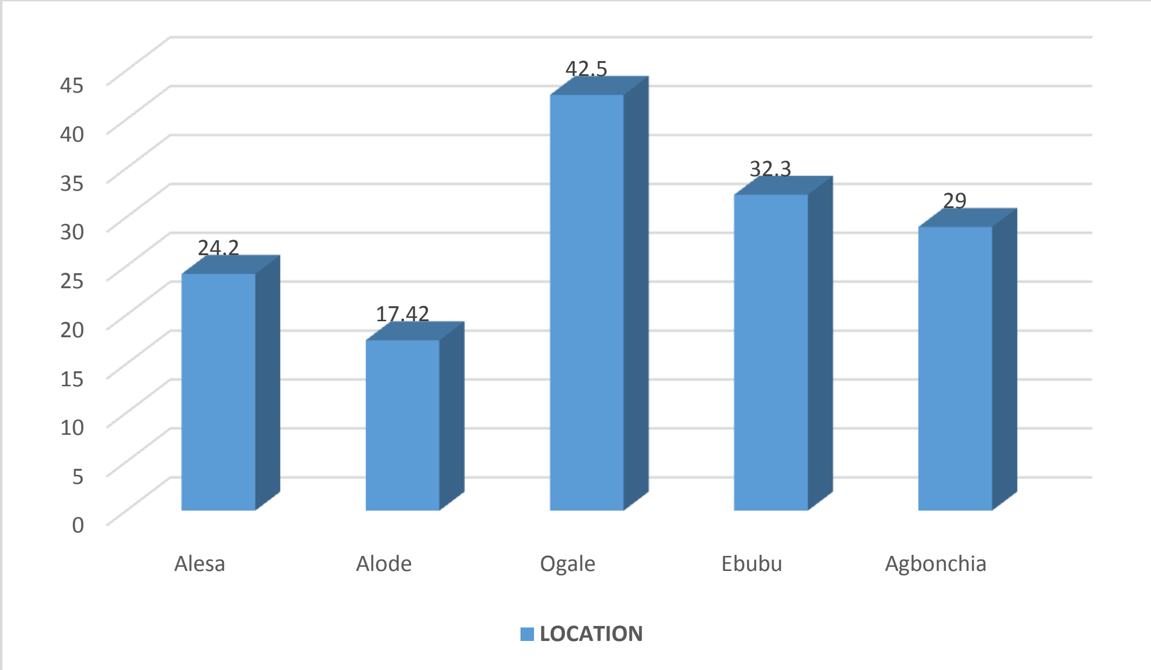

Fig. 2: Graphical representation of Total Dissolved Solids in the water samples

3.2 Total Suspended Solids (TSS)

Total suspended solids (TSS) is regarded as the dry weight of suspended particles that are not dissolved in a sample of water that can be filtered using a filtration apparatus.

Table 3: Laboratory Analysis Results of a Total Suspended Solids.

S/N	LOCATION	TOTAL SUSPENDED SOLIDS (unit?)
1.	Alesa	0.02
2.	Alode	0.013
3.	Ogale	0.003
4.	Ebubu	0.002
5.	Agbonchia	0.008

Authors should centred the values of the table.

Table 3 shows a tabular presentation of the result gotten from the water quality test for the determination of total suspended solids in underground water of the study area. Samples from Alesa had the highest concentration of total suspended solids whereas samples from Ebubu had the lowest but all location fall within the permissible limit of WHO (<10) and as such are fit for drinking.

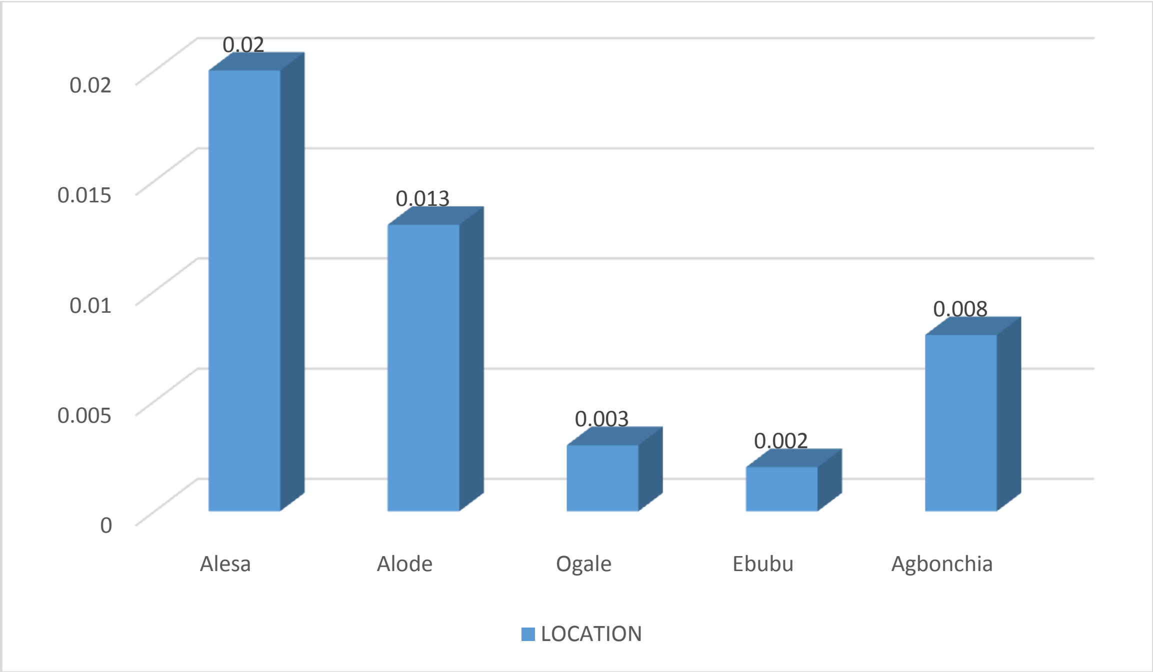

Fig. 3: Graphical presentation of Total Suspended Solids in the water samples

3.3 Temperature

From the results collected at the various locations, it was discovered that Alode and Ogale did not fall within the permissible limits by WHO and as such need some treatment before drinking.

Table 4:Laboratory analysis results values of temperature

S/N	LOCATION	TEMPERATURE (°C)
1	Alesa	27.5
2	Alode	25.2
3	Ogale	26.4
4	Ebubu	27.3
5	Agbonchia	27.4

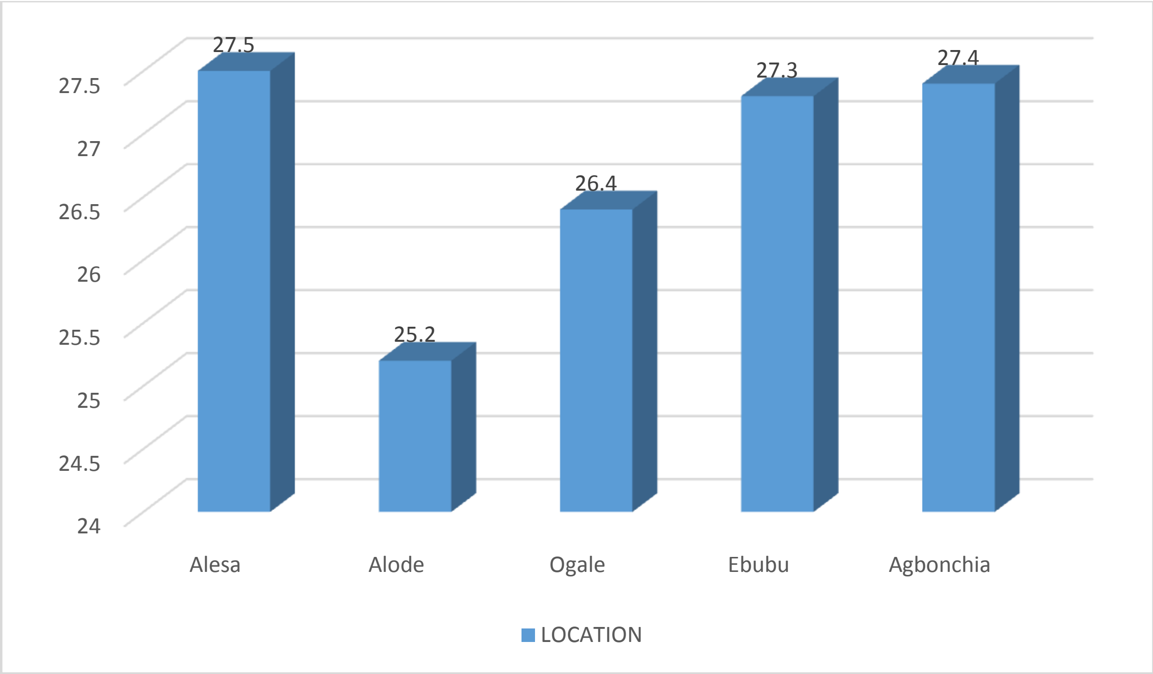

Fig. 4: Graphical presentation of temperature in the water samples

3.4 pH

The pH was within WHO Limits for Alesa and Agbonchia. The ~~PH~~ pH value fell below the permissible limits of WHO in Alode (5.20),Ogale (5.34) and Ebubu (5.38).

Table 5: Laboratory analysis results values of pH

S/N	LOCATION	pH
1	Alesa	7.40
2	Alode	5.20
3	Ogale	5.34
4	Ebubu	5.38
5	Agbonchia	6.80

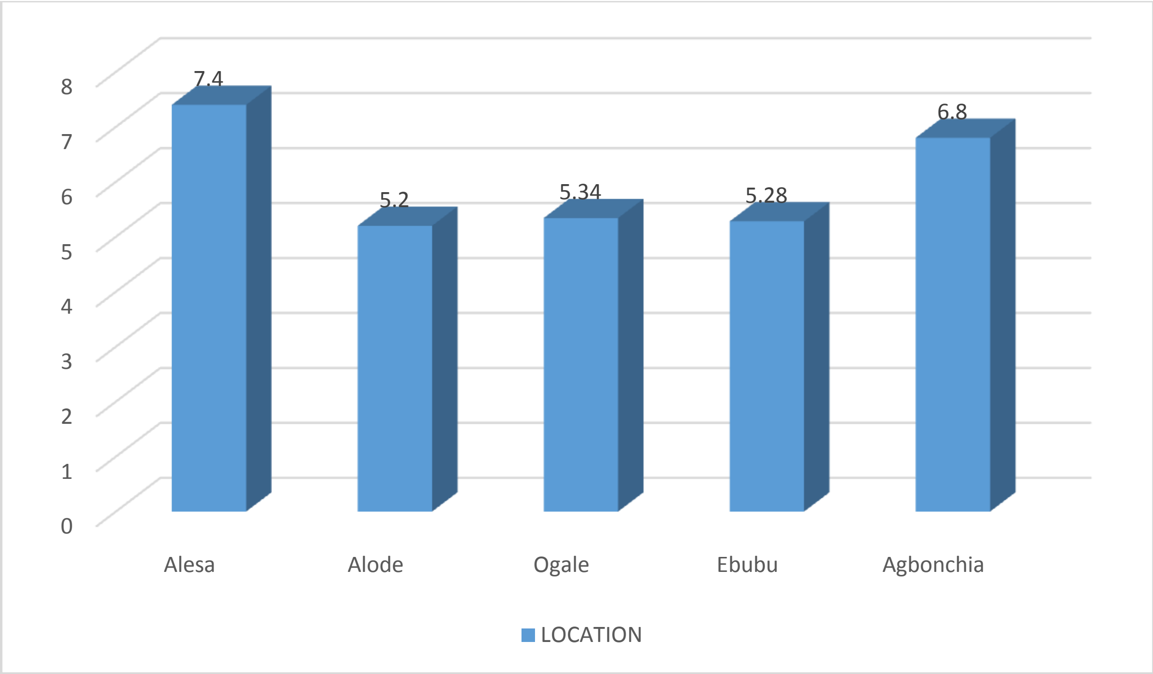

Fig. 5: Graphical presentation of pH in the water samples

3.5 Turbidity

Turbidity can be said to be the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye.

Table 6: Laboratory analysis results of the values of Turbidity in Alesa, Alode,Ogale, Ebubu and Agbonchia .

S/N	LOCATION	TURBIDITY (NTU)
1.	Alesa	2.43
2.	Alode	1.35
3.	Ogale	2.34
4.	Ebubu	3.56
5.	Agbonchia	3.18

Table 6 signifies that Ebubu has the highest turbidity whereas Alode has the lowest turbidity

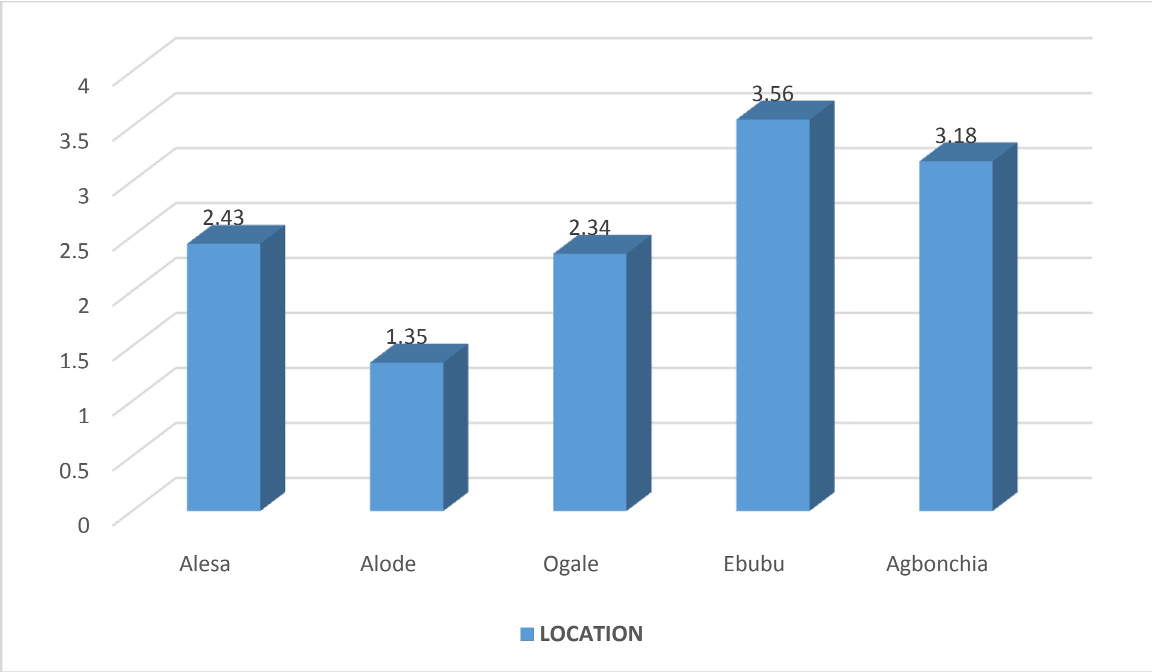

Fig. 6: Graphical presentation of turbidity in the water samples

3.6 Total Hardness

Total hardness can be referred to the overall level of mineral content, present in water. It is a measure of the water's capacity to form insoluble deposits(like scale) when heated or treated with chemicals.

Table 7: Laboratory Analysis Results Values of Total Hardness

S/N	LOCATION	TOTAL HARDNESS
1	Alesa	42.0
2	Alode	11.8
3	Ogale	5.0
4	Ebubu	16.0
5	Agbonchia	57.4

From the table above it can be deduced that total hardness was highest in Agbonchia, followed by Alesa and it was lowest in Ogale.

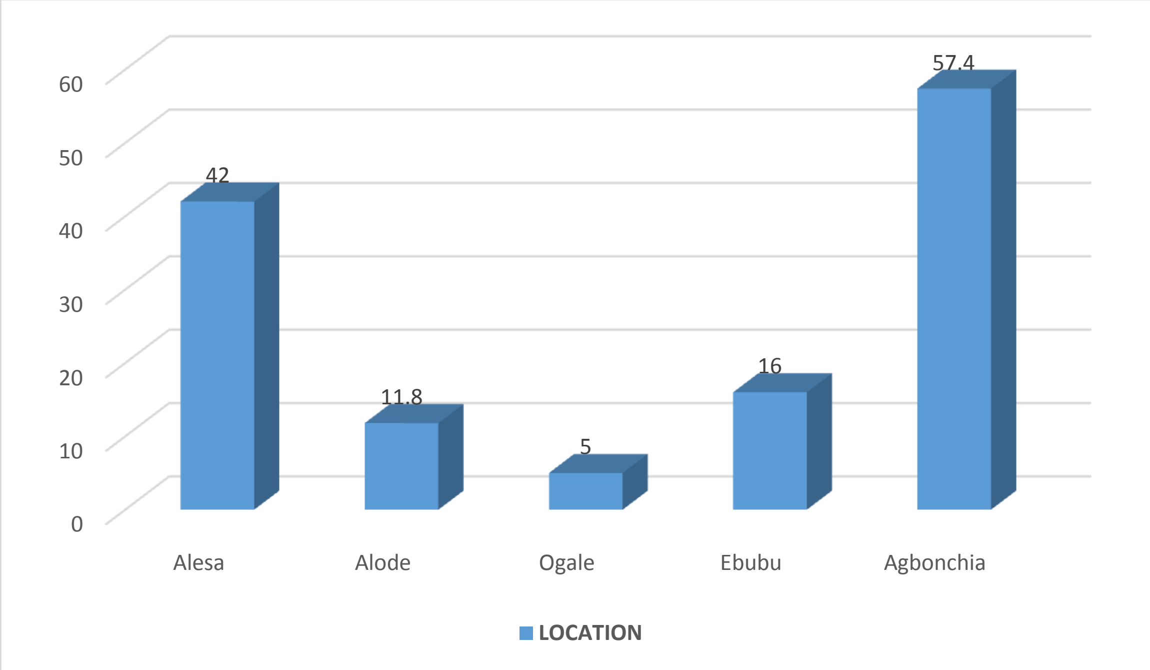

Fig. 7: Graphical presentation of Total Hardness in the water samples

It can be deduced from the graph that the highest level of hard water was at Agbonchia. The values of hardwater gotten from the five (5) different places. All samples fall below the 500 mg /L benchmark for drinking water by WHO. So it is deduced that water obtained in the five areas not hard water.

3.7 Biological Oxygen Demand

This is referred to the amount of oxygen required by aerobic biological organisms in a water samples, at a particular temperature and at a particular period.

Table 8: Laboratory analysis results of the BOD present in the water samples.

S/N	LOCATION	BOD (mg/L)
1	Alesa	7.32
2	Alode	5.33
3	Ogale	7.42
4	Ebubu	5.23
5	Agbonchia	6.74

Authors should centred the values of the table

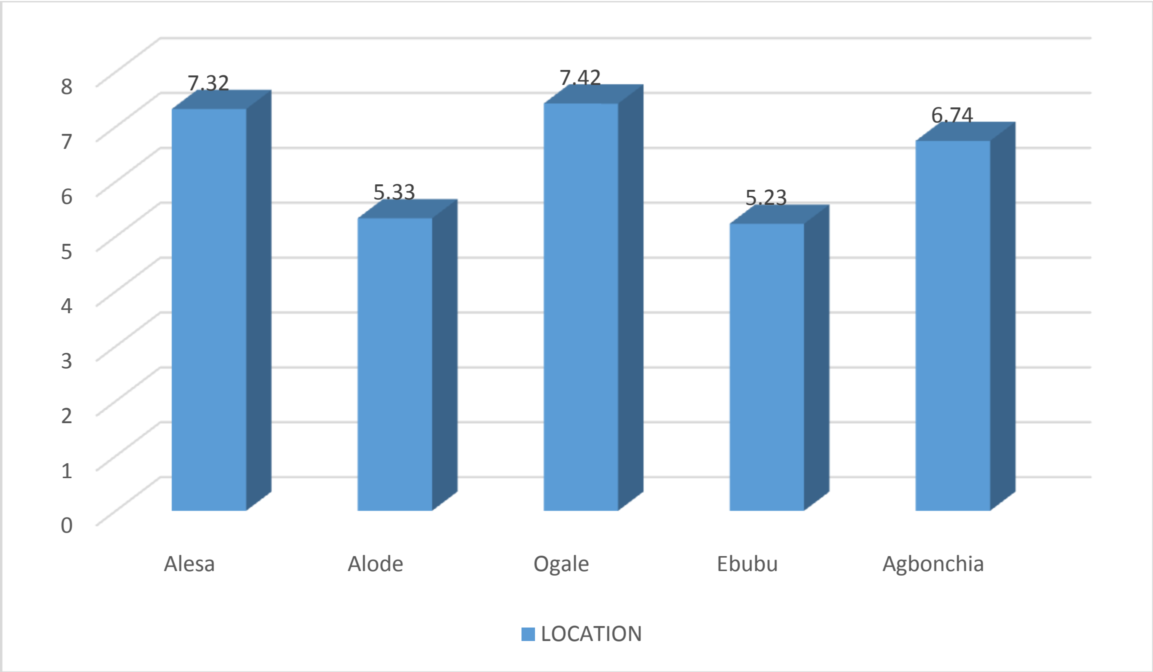

Fig. 8: A graphical representation of the BOD in the water samples

It can be deduced from Fig. 8 that the highest BOD value is 7.42 mg/L. The underground water at Agbonchia is the most concentrated. It is deduced that in all the five locations the BOD all fell within the permissible limits of WHO standards of drinking water. Though the values fall within the permissible limits of WHO they should still be treated as the amounts of BOD present were not moderate.

3.8 Chemical Oxygen Demand

Chemical oxygen demand (COD) is a measure of water and chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution.

Table 9: Laboratory analysis results of CODs present in the tested water samples.

S/N	**LOCATION**	**COD (mg/L)**
1	Alesa	14.3
2	Alode	11.00
3	Ogale	13.29
4	Ebubu	9.38
5	Agbonchia	9.22

From the graphical result (Fig.9), the level of COD is highest in Alesa (14.3 mg/L). All the different locations fall within the permissible limit of COD for drinking water which is 200 mg/L. Although they all fall within the permissible limit, the water should be treated for values of COD greater than 8 mg/L.

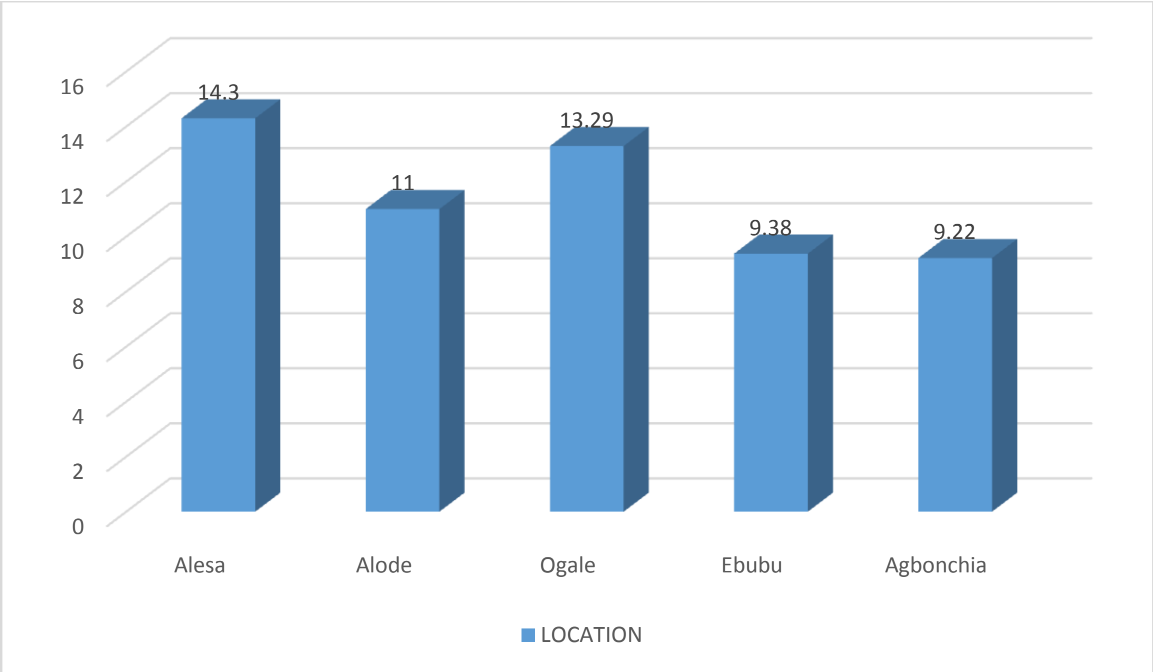

Fig. 9: Graphical representation of CODs present in the water samples.

3.9 Dissolved Oxygen

Dissolved oxygen is the amount of oxygen that is present in water.

Table 10: Laboratory analysis of Dissolved Oxygen Values between the Locations of the Study Area.

S/N	LOCATION	DISSOLVED OXYGEN (mg/L)
1	Alesa	4.4
2	Alode	2.5
3	Ogale	6.36
4	Ebubu	7.28
5	Agbonchia	6.3

From table 10 Ebubu has the highest amount of dissolved oxygen followed by Ogale. Enough oxygen is required for good water quality. Water samples from Ogale, Ebubu and Agbonchia all from within the permissible limit of dissolved oxygen for good portable water (5-7.5) and so underground water at Alesa and Alode should be subjected to some treatment.

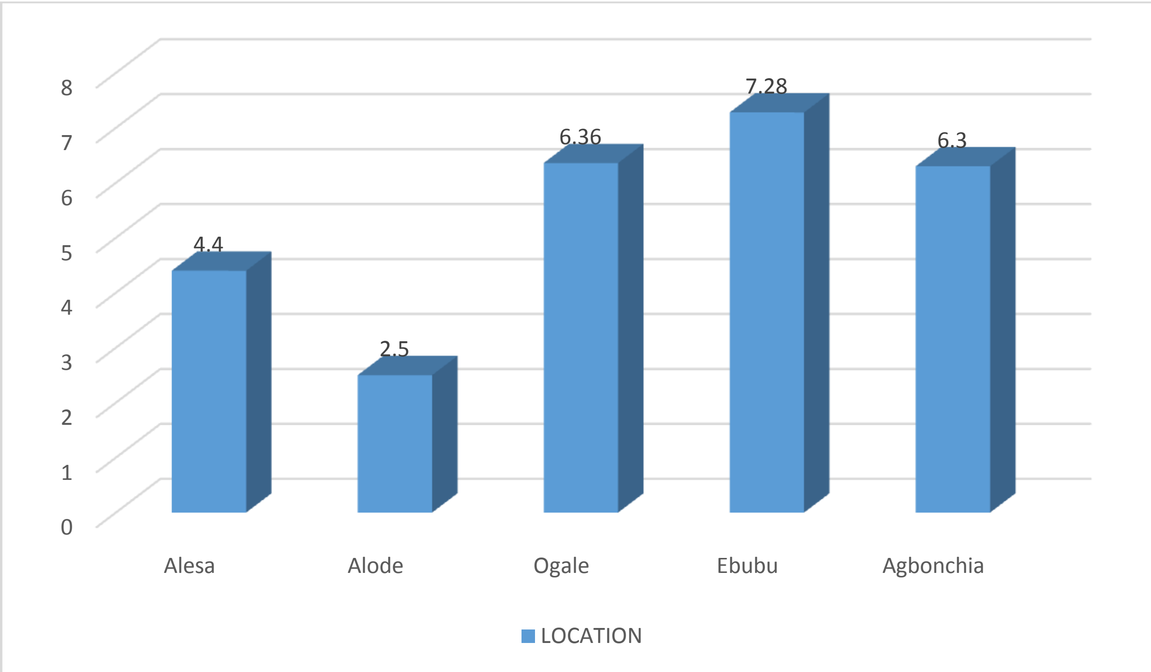

Fig. 10: Graphical Representation of water samples.

3.10 Salinity

Salinity is the measure of dissolved salts in water.

Table 11: Laboratory analysis results values of salinity

S/N	LOCATION	SALINITY (%)
1	Alesa	32.8
2	Alode	15.4
3	Ogale	9.3
4	Ebubu	38.4
5	Agbonchia	27.2

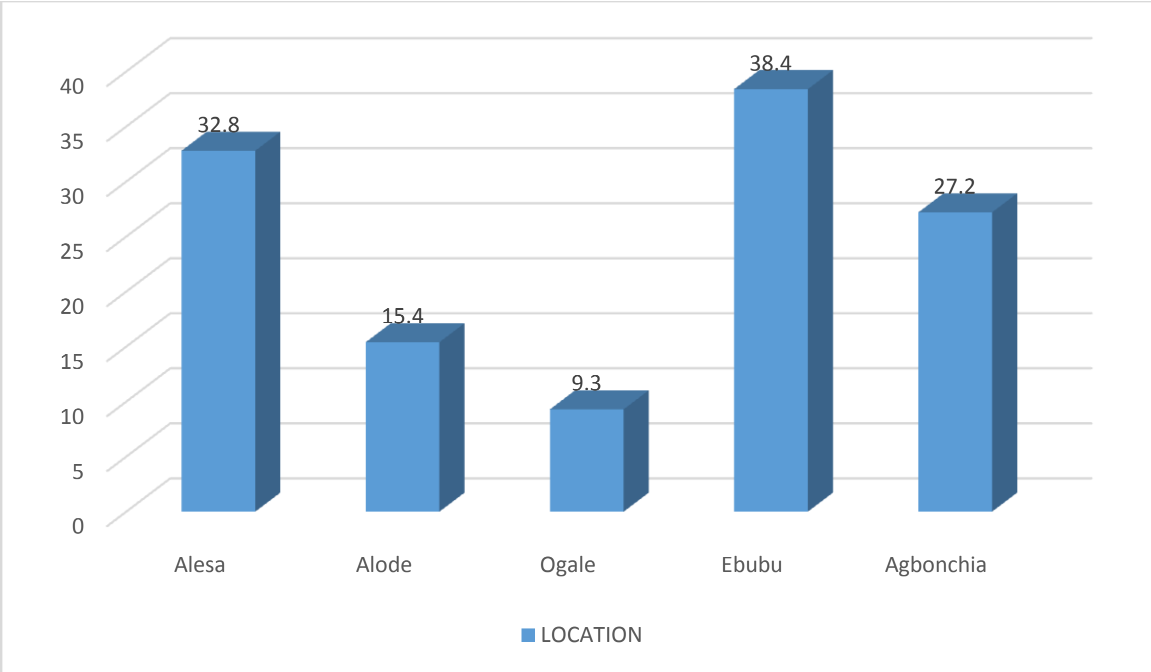

Fig. 11. A graphical representation of the results of salinity in the water samples

From the above graph, it can be deduced that Ebubu has the highest level of salinity and the lowest is Ogale with a salinity level of 9.3. All the values of salinity fall within the permissible limits of drinking water for salinity (250 mg/L) and as such are fit for drinking.

3.11 Zinc

Table 12: Laboratory analysis of concentration of zine in the specified water samples.

S/N	LOCATION	ZINC
1	Alesa	1.38
2	Alode	0.423
3	Ogale	0.611
4	Ebubu	1.042
5	Agbonchia	1.22

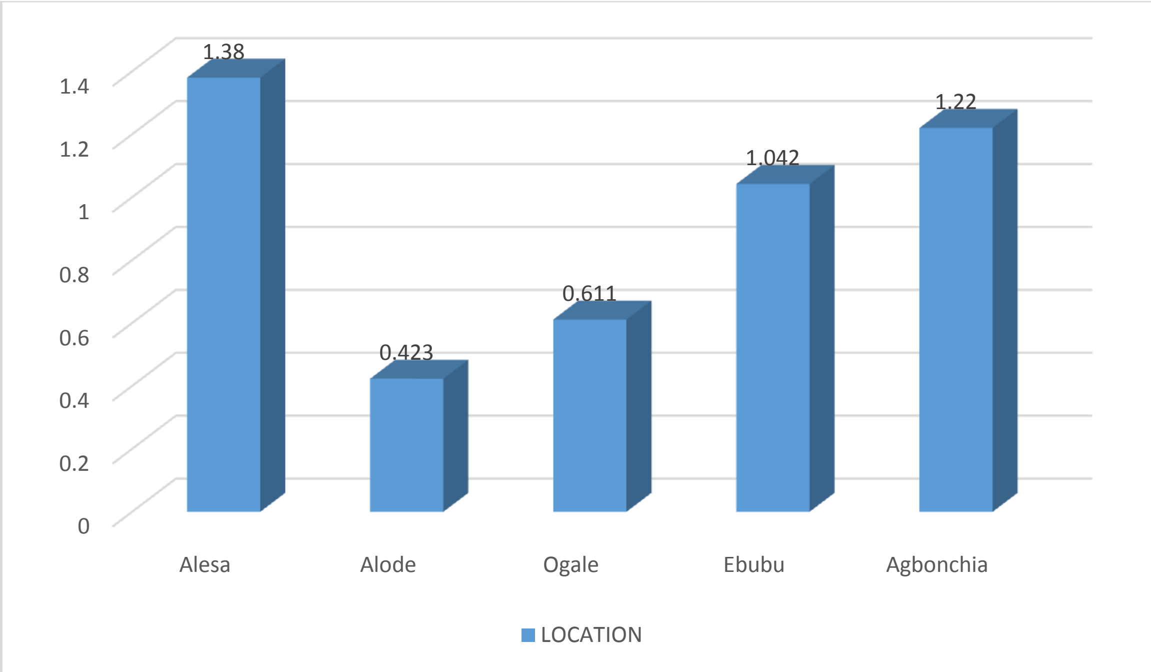

Fig. 12. A graphical representation of the results of Zinc in the water samples

From the above graph, it is deduced that underground water at Alesa (1.38) had the highest level of zinc and the lowest at Ogale (0.611). all the values for zinc fall within the permissible limit of WHO for good quality water.

3.12 Lead (Pb)

Table 13: Laboratory analysis result of concentration of Pb in the specified water samples.

S/N	LOCATION	Pb
1	Alesa	0.002
2	Alode	0.035
3	Ogale	0.338
4	Ebubu	0.004
5	Agbonchia	0.002

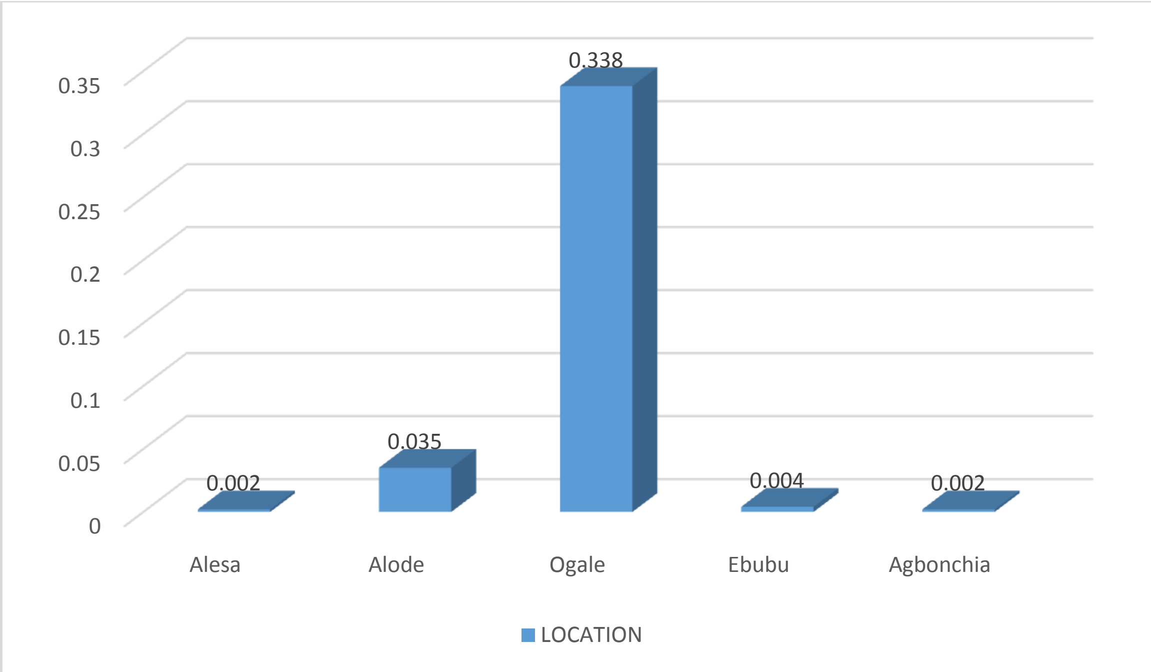

Fig. 13: A graphical representation of the Result of Pb concentration in the water samples.

Fig. 13 indicates that the underground water from Ogale was the highest concentration followed by Alode, followed by Ebubu and lastly by Alesa and Agbonchia with equal levels of lead (Pb).All the values fall within the permissible limits of WHO of good quality water.

4.1 Conclusion

In conclusion, the outcome of this research work signifies that the majority of the measured parameters align with the stringent standards set by the World Health Organization (WHO). This is a testament to the commendable efforts in maintaining a high level of water quality within the region such a positive assessment holds profound implication for the well-being of the Elem community.

Access to groundwater that complies with WHO standards ensures that residents have a reliable and safe source of drinking water. Thus, in turn, mitigates the risks associated with water borne diseases and contributes to the overall health and prosperity of the population.

Furthermore, this achievement reflects the efficacy of existing water management and treatment systems in Eleme metropolis.

4.2 Recommendations

1. Regular maintenance of infrastructure should be carried out.
2. Sedimentation and filtration processes should be implemented to reduce turbidity and suspended particles in groundwater.
3. coagulation – Flocculation techniques should be employee to reduce heavy metal concentrations (e.g arsenic, lead, mercury) to fall within WHO limits.
4. Awareness campaigns should be conducted to educate residents about responsible chemical use, waste disposal, and practices that safeguard groundwater quality.
5. A contingency plan to address sudden water quality issues should be developed, including procedures for notifying the public and implementing corrective measures.

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