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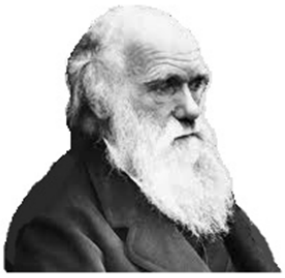

World News of Natural Sciences

An International Scientific Journal

WNOFNS 62 (2025) 17-45 EISSN 2543-5426

Assessing the Potability of Harvested Rainwater in Gas Flaring Zones: A Case Study of Bayelsa State, Nigeria

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ABSTRACT

Rainwater is naturally free from impurities except for atmospheric contaminants absorbed during precipitation. However, water quality may deteriorate during harvesting, storage, and domestic use, particularly in areas affected by industrial activities. This study assessed the potability of harvested rainwater from seven communities in Bayelsa State, Nigeria (Ogboloma, Akaibiri, Gbarantoru, Obunagha, Ekpetiama, Tombia, and Agbai), located near gas flaring and oil exploration sites. Using 1-liter rubber gallons with attached funnels, samples were collected from rooftop runoff systems. Analysis revealed significant water quality variations across communities. Total Suspended Solids (TSS) concentrations ranged from 1 mg/L (Agbia) to 22 mg/L (Akaibiri), with Akaibiri and Ogboloma exceeding the WHO permissible limits for drinking water. Heavy metal analysis showed consistent iron and nickel concentrations (≤0.01 mg/L), well below WHO's iron standards (0.3 mg/L acceptable, 1 mg/L allowable). Turbidity levels varied substantially, from 0.95 mg/L (Agbia) to 6.85 mg/L (Ogboloma), with multiple communities exceeding recommended limits. These findings demonstrate that while harvested rainwater in the region shows low heavy metal contamination, elevated TSS and turbidity levels in several communities indicate the necessity for proper treatment before consumption. The study

(Received 16 June 2025; Accepted 19 July 2025; Date of Publication 21 July 2025)

recommends implementing filtration and purification systems to ensure safe drinking water in these oil-impacted areas.

***Keywords*:** Rainwater harvesting, water potability, gas flaring pollution, Niger Delta, water quality analysis, TSS, heavy metals, WHO standards

1. INTRODUCTION

Gas flaring is still one of the very serious environmental and human health problems in oil-rich areas, especially in Nigeria, where gas flaring is so rampant in spite of the world's efforts to prevent this. New studies, which have made use of state-of-the-art satellite surveillance, have been able to determine that gas flaring volumes in Nigeria were roughly 8.1 billion cubic meters per year and are therefore one of the main gas flaring countries worldwide, with a significant impact on greenhouse gas emissions [1-5]. This chronic flaring can be attributed to various reasons, such as poor infrastructure of gas and economic limitations of the feasibility of capture technologies, as well as fluctuating policies. The effects of this environmental impact are especially severe in the Niger Delta, where sustained flaring activities have been identified to cause acidic precipitation with pH levels habitually registered lower than 4.5 deep into the range that is described as having detrimental effects on both the ecosystem and the infrastructure [6-9]. Their health effects on the nearby communities are becoming better documented as recent epidemiological studies have shown a significant increase in respiratory illness risks, between 37 percent increase in childhood asthma in populations living close to the flare sites, and probably in parasitic infections such as malaria. This health effect is further worsened by the pollution of water resources since, during flaring, heavy metals and hydrocarbons are deposited in the surface water and even the clouds [10-16]. Recent research has found risky concentrations of lead and polycyclic aromatic hydrocarbons in rainwater samples collected at the sites of flares, and in some cases, those are even higher by three or more times than the safety levels established by the World Health Organization.

This paper is concerned exclusively with the quality of the rainwater in the region of Gbarain/Ekpetiama in the Bayelsa State, as this region has the highest intensity of flaring activity, which is higher than 2.5 million cubic meters per day. Based on the consideration of both physicochemical and microbiological parameters in the context of the existing recommendations of the WHO (2022), we explore the question of the potability of harvested rainwater and the risks it poses to health. Our results will be valuable in the body of literature recording the necessity of effective interventions to reduce the effects of flaring, as well as the introduction of precise data to assist in water safety planning in communities affected by flaring. One of the outstanding findings of the research is the way the atmospheric discharges of flaring activities combine with the local hydrologic frameworks to produce compound effects to environmental health that require comprehensive policies to tackle [17-22].

2. MATERIALS AND METHODS

The research work was to find the potability of harvesting rainwater from Ogboloma, Akaibiri, Gbarantoru, Obunagha, Ekpetiama, Tombia, and Agbia communities. Rubber gallons

(35 cl) and a funnel attached to the gallons were used for the harvesting of the rainwater from rooftop run off. The quantities of the samples collected are as shown in Figures 1 to 7 for the various communities, respectively.

Figure 1. Rainwater from Ekpetiama Community.

Figure 2. Rainwater from Akaibiri Community.

Figure 3. Rainwater from Gbarantoru Community.

Figure 4. Rainwater from Obunagha Community.

Figure 5. Rainwater from Agbia Community.

Figure 6. Rainwater from Ogboloma Community.

Figure 7. Rainwater from Tombia Community.

Harvesting Process:

The collected rainwater was from the period of June to August 2021. The samples were collected with containers (35 cl) after the containers had been washed, rinsed with clean water, and dried. This was done to avoid further contamination of the rainwater sample to achieve maximum results from the analysis.

Method of Analysis:

The samples collected were numbered alphabetically from letters A to G to represent the 7 different locations where the rainwater samples were collected. The samples were then taken to the laboratory to analyze the pH values of the different samples and compared with a control sample (Distilled water). The samples were then treated to determine the amount of dissolved and suspended solid components found in the different samples under standard conditions. Some of the apparatus used for the analysis are shown in Figures 8 to 13.

Figure 8. pH meter.

Figure 9. Water temperature meter.

Figure 10. Water turbidity meter.

Figure 11. Water conductivity meter.

Figure 12. Water TDS meter.

Figure 13. Shows a water TSS meter.

The results obtained from the analysis were used to compare with the values from the WHO to ascertain the portability of the rainwater for human consumption.

This experiment comprised the three globally acknowledged methods of water and wastewater analysis: Standard Methods (SM), chapters of American Society for Testing and Materials (ASTM), and those of American Public Health Association (APHA). The applied parameters were analyzed thoroughly regarding World Health Organization (WHO) drinking water standards to analyze potability.

Total suspended solids (TSS) were determined by SM 2540D; particulate matter caught in filters, which includes silt, organic matter, and industrial pollutants, was determined. High TSS levels (>5 mg/L) cause poor water clarity and can be a symbol of pollution (U.S. EPA, 2021). They measured the Dissolved Oxygen (DO) through ASTM D888-12, and the level defining the health of the aquatic ecosystem, since the flowing waters normally experience a higher level of DO than stagnant systems (U.S. EPA, 2017).

Water samples were characterized in four categories in relation to salinity of water samples, which were classified as fresh (<500 mg/L), brackish (1,000 to 2,000 mg/L), saline (2,000 to 10,000 mg/L), and highly saline (10,000 to 35,000 mg/L). The measure of turbidity according to APHA 2130B was selected as one of the primary parameters that determined the condition of the water and its treatment efficiency, where high readings could indicate the possibility of protecting pathogens (WHO, 2021).

The microbiological assurance was assessed by subjecting it to a total coliform test (SM 9223), sensing bacteria of the soil, surface water, and faecal origin (NYSDOH, 2013). Among the inorganic contaminants analyzed include metals (Na, Mg, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd, Pb) and non-metals (F^-, Cl^-, NO_3^-, SO_4^{2-}) using EPA 200.8 (metals) and SM 4500 series (anions).

According to ASTM D1293-18, the pH of every sample was determined, and acidity less than the value of 6.5 was considered to be potentially corrosive to infrastructure (U.S. EPA, 2013). Ascertained reference materials, duplicates, and blanks were imposed by a strict quality control procedure to guarantee data reliability. Such detailed parameter selection will represent very valuable information concerning the safety of water, the dosage of treatment, and regulatory aspects of drinking water sources in oil-affected areas.

Procedures for Testing:

Various laboratory testing procedures were used to ascertain the perfect and most accurate results. Total dissolved solids (TDS) were analysed using the TDS meter (APHA – 209C method). Tests for ammonia (APHA 4500-NH3C method), sulphate (APHA 4500 SO4 2-E method), bicarbonate (APHA 2320B method), phosphate (APHA 4500P-E method), chloride (APHA 4500 B method), nitrates (APHA 4500E method) were also done. The hardness of water samples (calcium and magnesium contents) was tested using the Titrimetric method. Deshpande (2012).

This method is based on the principle that ethylene diamine-tetra-acetic acid and its sodium salt (abbreviated EDTA) form a chelated soluble complex when added to a solution of certain metal cations. The concentration (in mg/l) of metals in the water samples was determined using an atomic absorption spectrophotometer. The metals were analyzed using the direct-air-acetylene flame method (APHA 3111-B).

Oil and grease content was analysed using a spectrophotometric method (AP1– RP 45, APHA 5520B, EPA 1664). TPH assessment was done using a calibrated HP 5890 gas chromatograph equipped with a capillary column. Commercially available TPH Standard, C8-C40 (Hydrocarbon window defining standards, AccuStandard DRH 0085) was used for the calibration of the Gas Chromatograph.

Total coliform count was assessed by most probable number (MPN) presumptive test using the APHA 9221B method, while for faecal coliform MPN confirmatory test using the APHA 9221B method and faecal coliform MPN complete test were done. All QA/QC procedures were strictly adhered to during each process.

3. RESULTS

The results obtained from the analysis are presented graphically as shown in Figures 14 to 42 for the different contents found in the harvested rainwater for the seven locations.

pH Value:

The pH results of the harvested rainwater in the seven selected study communities described in Figure 14 were below the WHO range requirement on drinking water (6.5-8.5) at all times. The maximum pH was taken at Obunagha community (6.01), whereas the acidic conditions were observed in Agbia community (5.52). Such findings exhibit an already alarming trend of high acidity levels in the rainwater of the area, with none of the samples tested passing the WHO potability criterion of pH.

Temperature:

The temperatures of the harvested rainwater were also determined, as shown in Figure 15 for the various communities. The recorded temperatures were within the room temperature ranges. At Obunagha community, the temperature was 24.4 °C, which was the lowest recorded temperature, and at Gbarantoru community, the temperature was about 26.1 °C. The highest temperature that was recorded was about 26.1 °C, which was from the Gbarantoru community.

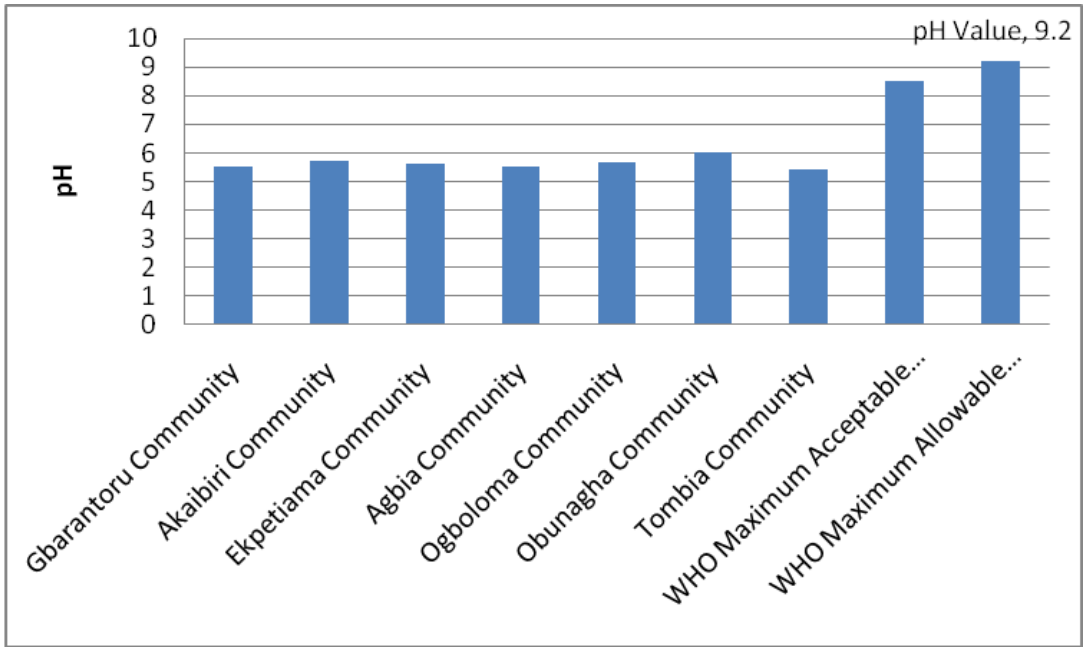

Figure 14. Graph of pH concentration.

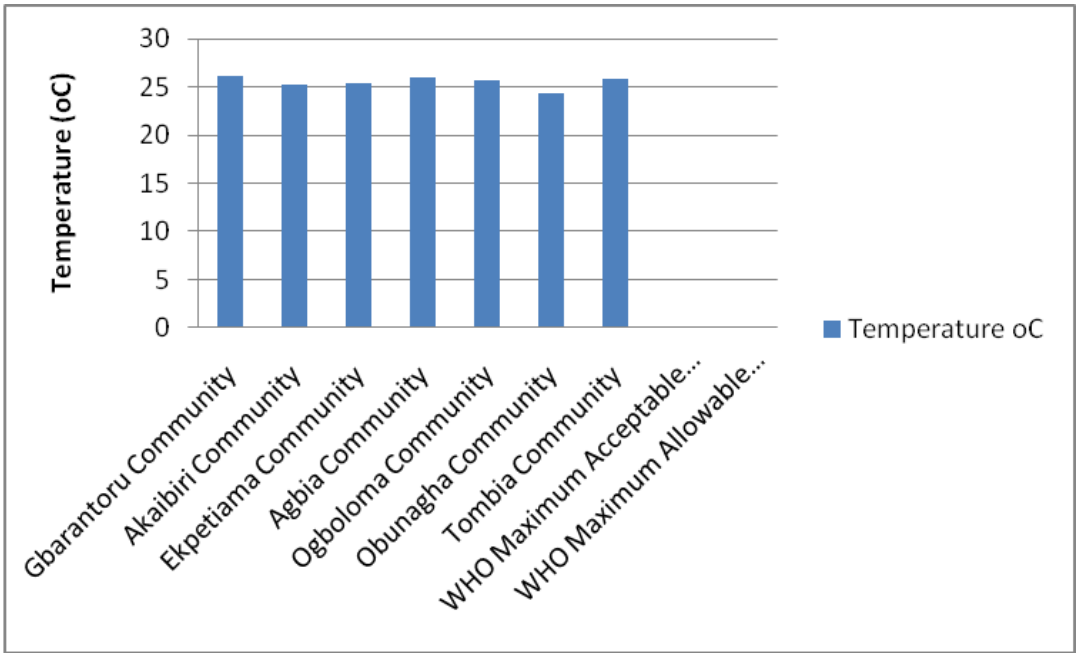

Figure 15. Graph of temperature of the harvested rainwater.

Total dissolved solids (TDS):

The analysis done on the total dissolved solids from the harvested rainwater from the different communities are shown in Figure 16. The TDS increases from community to

community; it was maximum at Gbarantoru community (16.0 mg/l) and minimum at Ekpetiama and Agbia communities (6.0 mg/l). The WHO maximum acceptable and allowable concentration of TDS for potable water was still higher than the concentration found in the harvested rainwater from these locations.

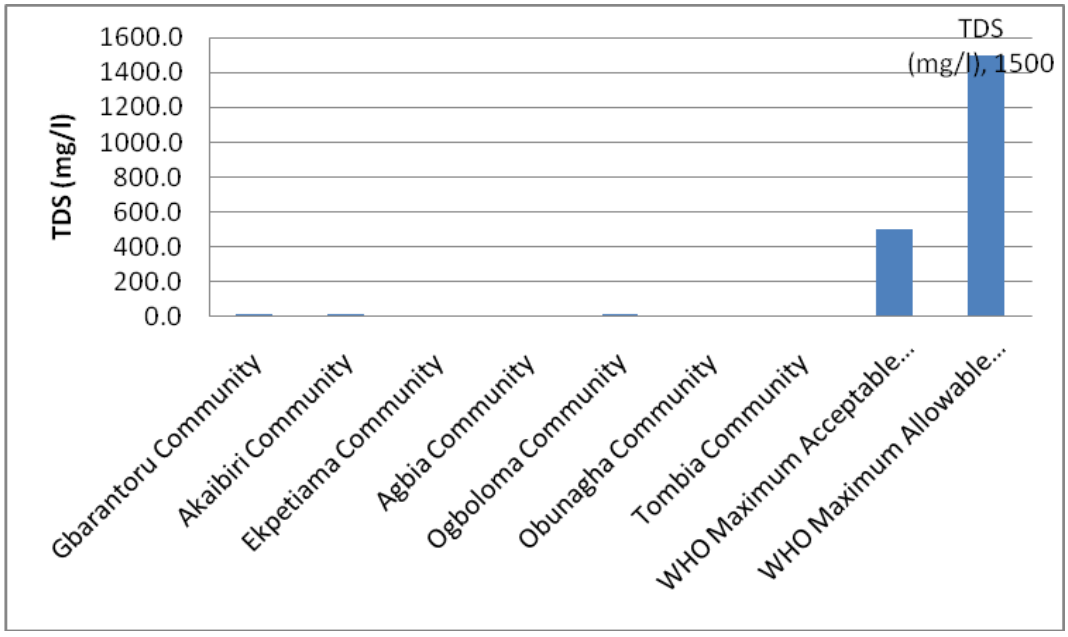

Figure 16. Graph of TDS concentration

Total suspended solids (TSS):

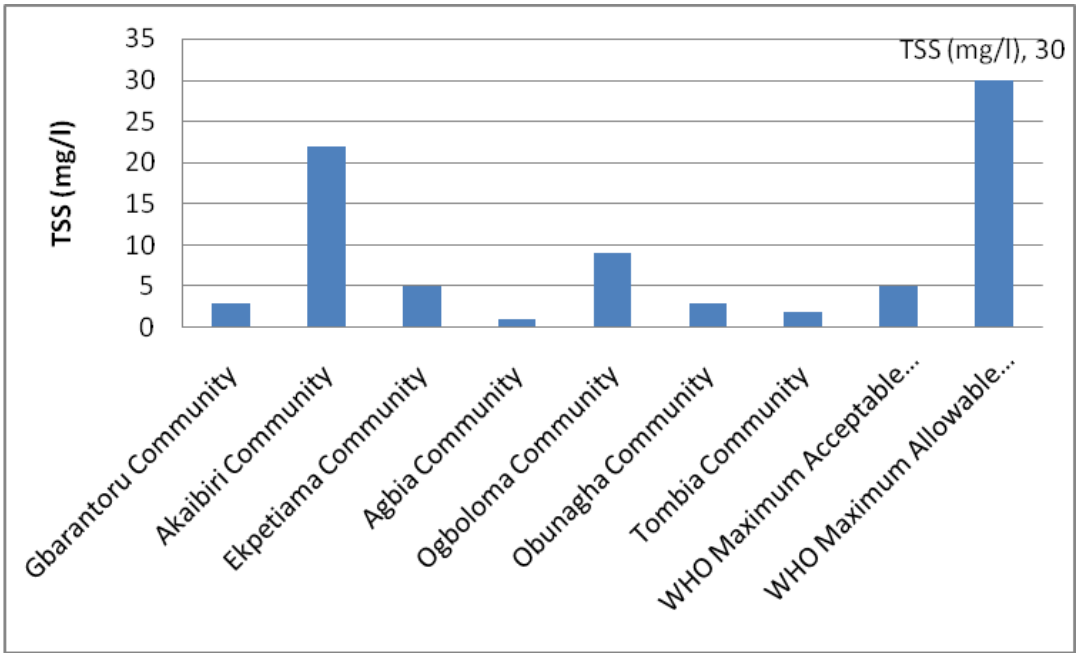

Figure 17. Graph of TSS concentration

Figure 17 shows the analysis of the results obtained from harvested rainwater from seven different communities in the Niger Delta Region (Bayelsa State). These results were the amount of total suspended solids found in the harvested rainwater. At the Akaibiri community, the TSS was highest (22 mg/l) and lowest at the Agbia community (1 mg/l).

The TSS found at Akaibiri and Ogboloma communities was greater than the WHO maximum acceptable and allowable concentration of TSS in potable water. These results of the TSS from the various communities show that the harvested rainwater from Akaibiri and Ogboloma communities is not safe for drinking without proper treatment of the water.

Dissolved oxygen:

The dissolved oxygen found in the harvested rainwater for the seven different communities is shown in Figure 18. The dissolved oxygen was almost the same for the seven communities, which range from 5.5 mg/l to 5.76 mg/l for Ogboloma and Obunagha communities, respectively. The dissolved oxygen concentration from the harvested rainwater is in order when compared with the maximum acceptable and allowable concentration from WHO, which was near saturation and above 3.0 mg/l, respectively.

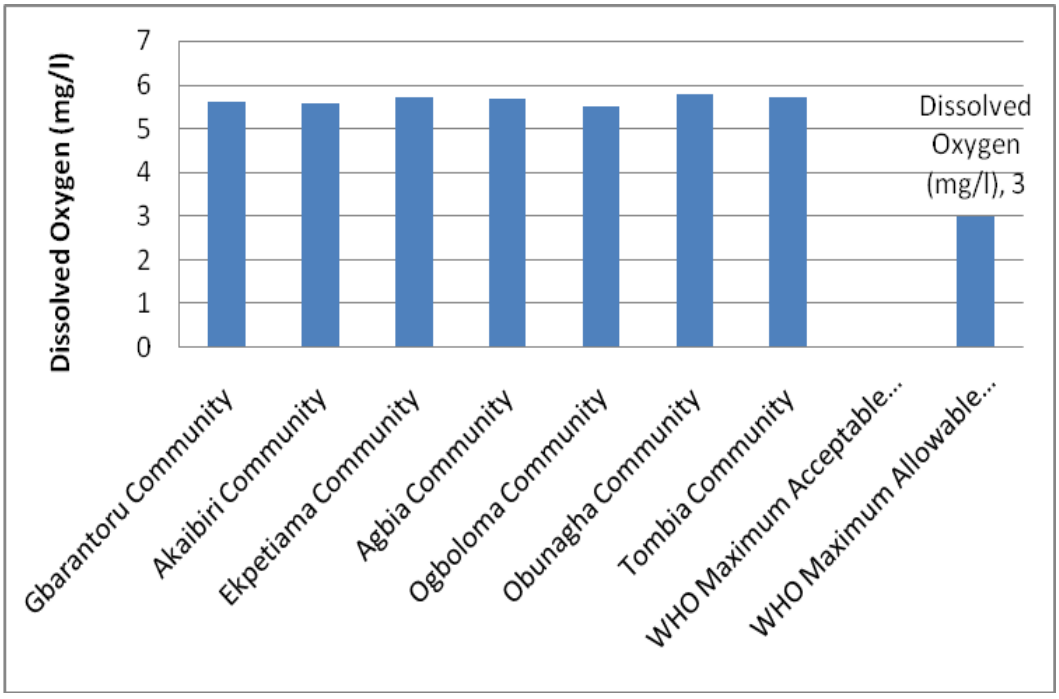

Figure 18. Graph of dissolved oxygen in harvested rainwater

Chemical oxygen demand:

The analysis done on the harvested rainwater chemical oxygen demand is shown in Figure 19 for the various communities. The chemical oxygen demand was less than 1mg/l for the seven communities, but the chemical oxygen demand for the maximum acceptable and allowable concentration for potable water by WHO was not made available.

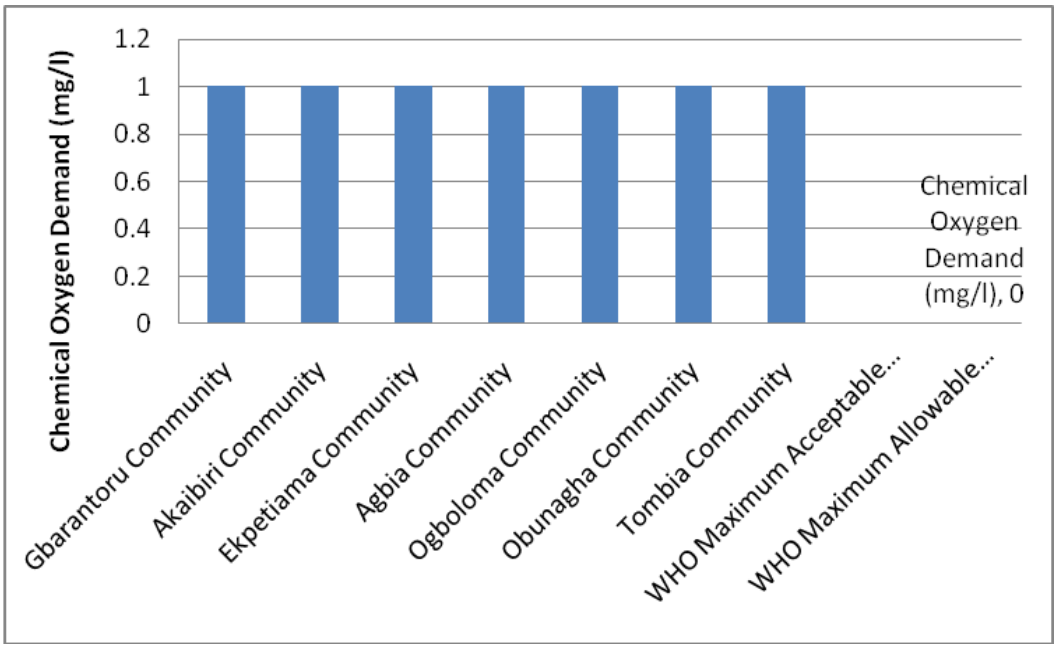

Figure 19. Graph of chemical oxygen demand.

Salinity:

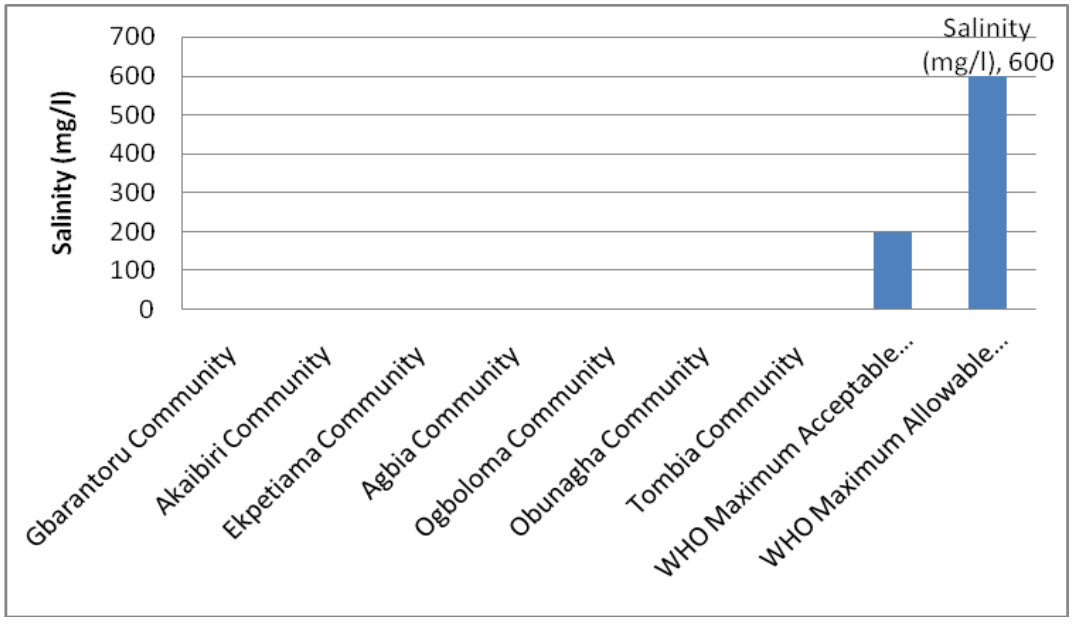

Figure 20. Graph of salinity concentration.

The salinity found during the analysis of the harvested rainwater is shown in Figure 20 for the various communities. The results show that the salinity of the rainwater was less than

0.5 mg/l for the various communities. When compared with the maximum acceptable and allowable salinity concentration for potable water by WHO are 200 mg/l and 600 mg/l, respectively. These WHO concentrations were much higher than the once gotten from the harvested rainwater. This shows that the salinity concentration is suitable for drinking.

Turbidity:

The turbidity concentration of the harvested rainwater is as shown in Figure 21 for the various communities. The concentration increases from community to community, with that of Ogboloma community having the highest turbidity of 6.85 mg/l, Gbarantoru community also has a turbidity concentration of about 5.5 mg/l. The least turbidity concentration was at Agbia community having a concentration of about 0.95 mg/l. The maximum acceptable and allowable turbidity concentrations were 5 mg/l and 25 mg/l, respectively, from WHO. From the analysis, the concentration at Ogboloma and Gbarantoru communities was higher than the maximum acceptable range of turbidity concentration for potable water recommended by WHO.

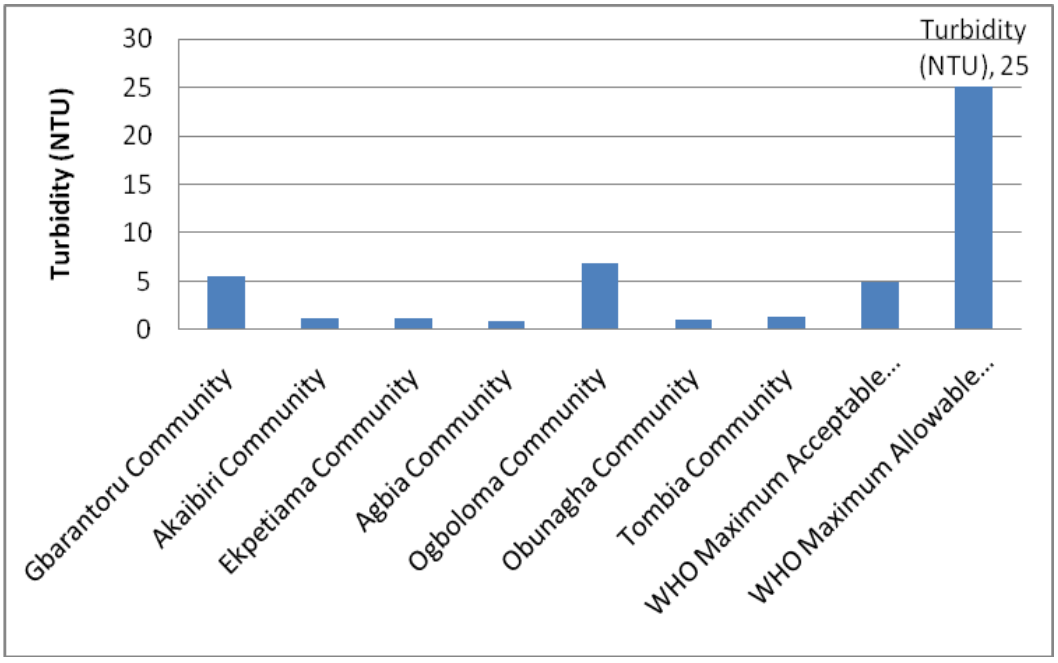

Figure 20. Graph of turbidity concentration.

Ammonia:

The ammonia concentration found in the harvested rainwater is given in Figure 21 for the various communities. The concentration was greater at Tombia community (0.64 mg/l) and least at Agbia and Obunagha communities, having 0.09 mg/l concentration each. The maximum acceptable and allowable concentration from WHO for potable water was less than 0.01 mg/l and 0.5 mg/l, respectively. From the analysis, it can be seen that the ammonia concentration present in the harvested rainwater was more than the maximum acceptable concentration, but the Tombia community shows a greater ammonia concentration than the allowable concentration for potable water by the WHO.

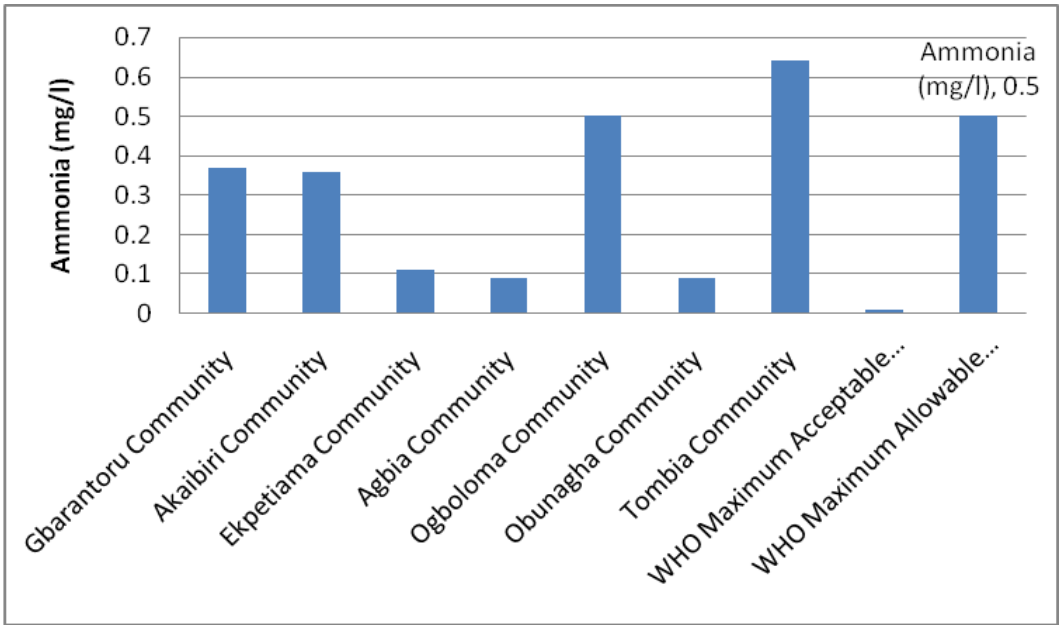

Figure 21. Graph of ammonia concentration

Conductivity:

The conductivity of the harvested rainwater analyzed is shown in Figure 22 for the seven different communities. The conductivity increases from community to community, with Gbarantoru community having the highest conductivity (30 µs/cm), followed by Akaibiri community (26 µs/cm), and least at Ekpetiama community (11 µs/cm). The conductivity recorded for the maximum acceptable and allowable values was not made available by WHO.

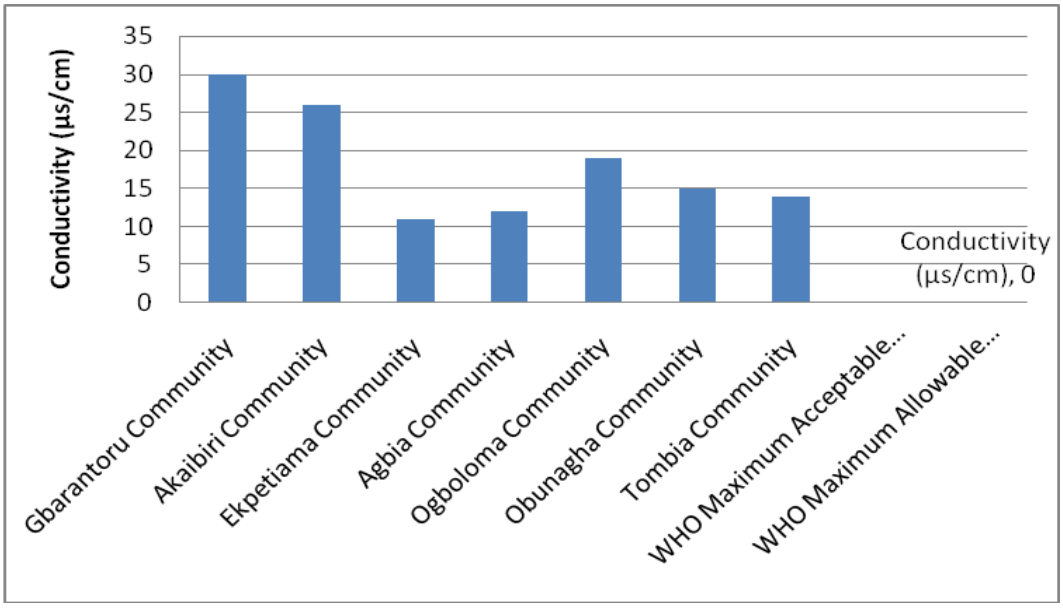

Figure 22. Graph of conductivity of harvested rainwater.

Total hardness:

The total hardness present in the harvested rainwater for the different communities is shown in Figure 23. The hardness value is different from community to community, with the Akaibiri community having a hardness value of about 7.19 mg/l, being the highest of the seven communities, and the Tombia community having a total hardness of 0.9 mg/l, being the least recorded. The maximum acceptable and allowable total hardness from WHO for potable water are 100 mg/l and 150 mg/l, respectively, which is much higher than the once obtained from the different communities.

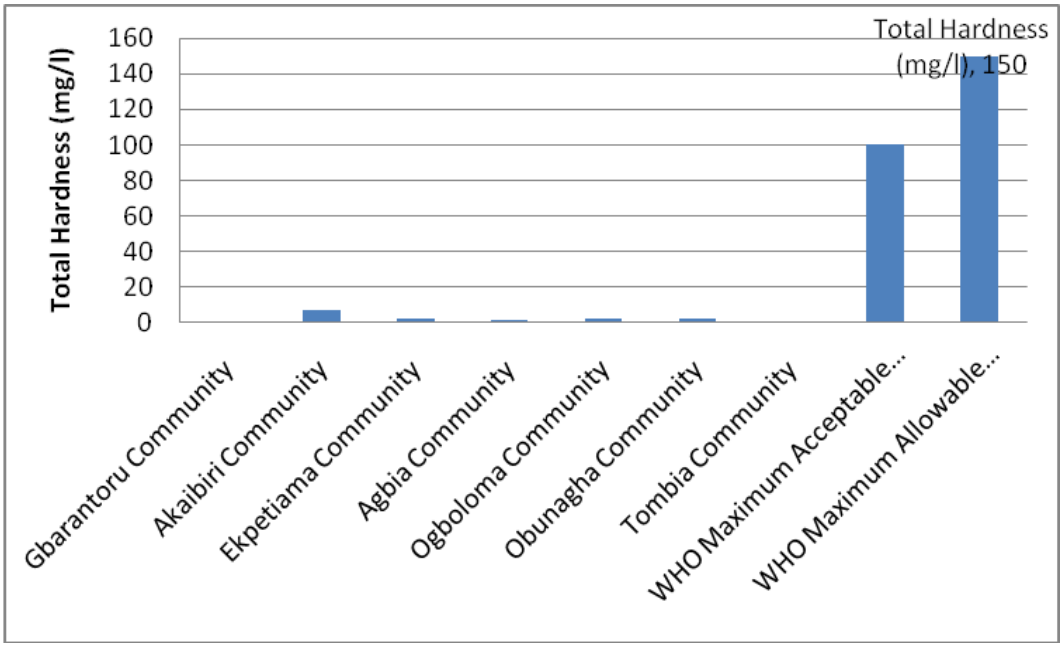

Figure 23. Graph of total hardness of harvested rainwater

Nitrate:

The nitrate concentration found in the harvested rainwater for the different communities is shown in Figure 24. The nitrate values are different for the various communities, with Agbia community having the highest concentration of nitrate (1.46 mg/l) while the lowest concentration of nitrate was found at the Gbarantoru community (0.03 mg/l). When the nitrate concentration was compared with that from the WHO maximum acceptable concentration (10 mg/l) and allowable concentration (45 mg/l), it was discovered that the WHO concentrations were greater than the once found in the harvested rainwater.

Sulphate:

Figure 25 shows the sulphate concentration of the harvested rainwater for the different communities. The sulphate concentration found in the rainwater in the different communities was less than 1mg/l. But from the WHO for the maximum acceptable and allowable sulphate concentration for potable water was not available.

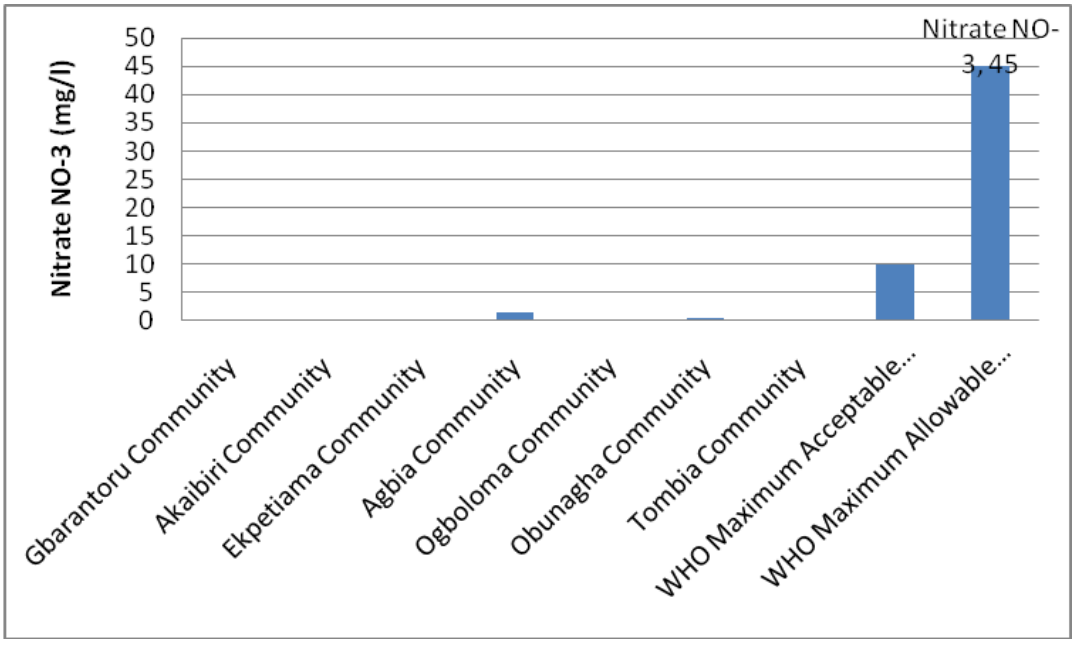

Figure 24. Graph of nitrate concentration

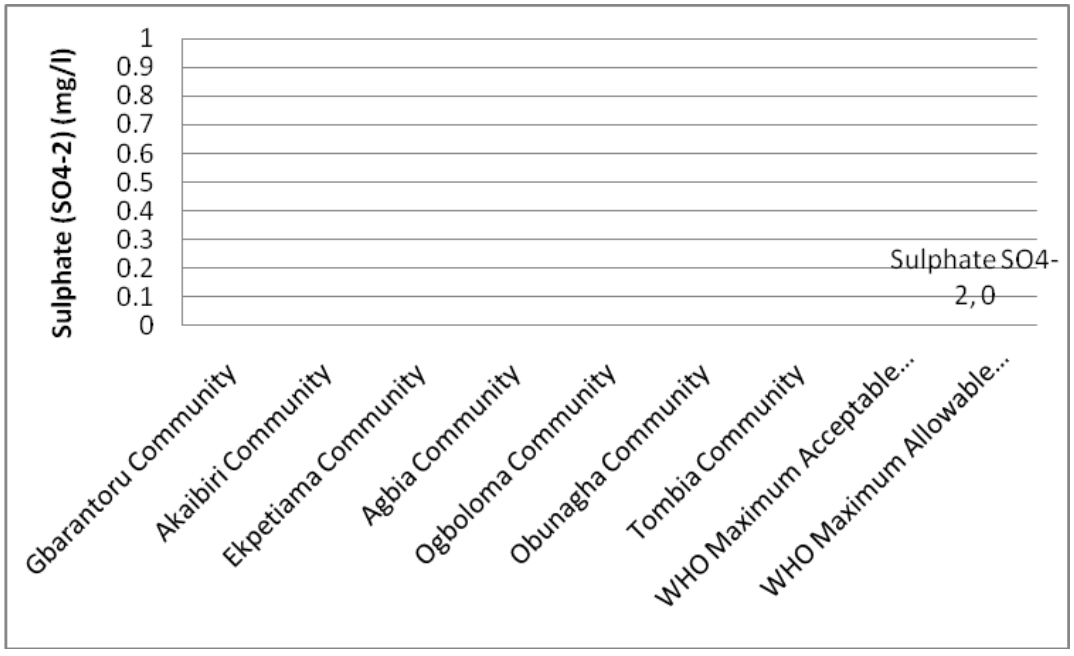

Figure 25. Graph of sulphate concentration

Bicarbonate:

Figure 26 shows the bicarbonate concentration found in the harvested rainwater during the analysis. The bicarbonate concentration for the different communities is quite different from

community to community, with the Akaibiri community having the highest concentration of bicarbonate (3.9 mg/l) and the Agbia community having the least concentration of bicarbonate, which was less than 0.1 mg/l. The of WHO maximum acceptable and allowable bicarbonate concentration was not available.

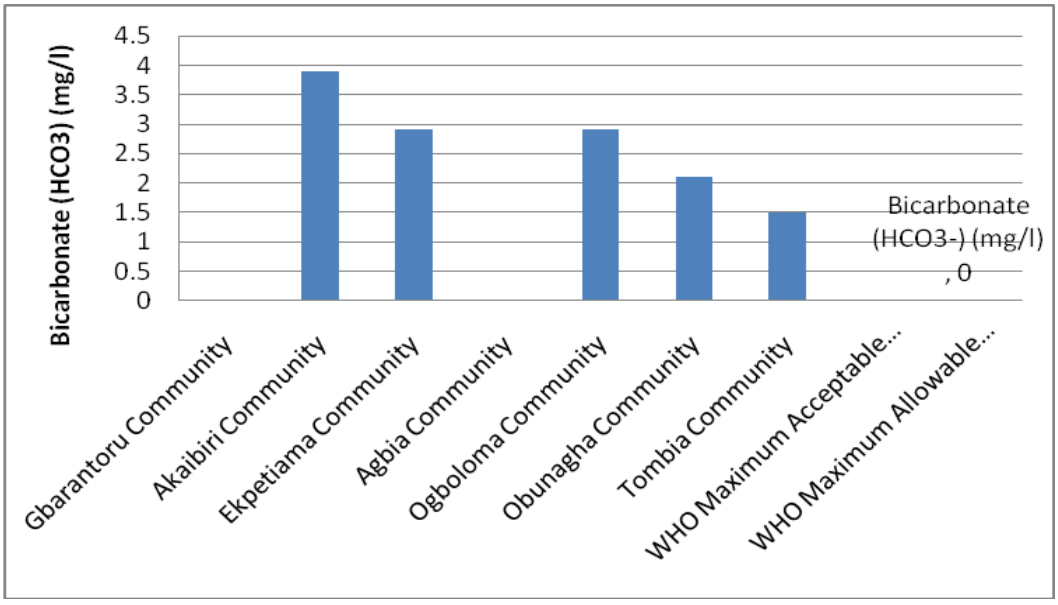

Figure 26. Graph of bicarbonate concentration.

Carbonate:

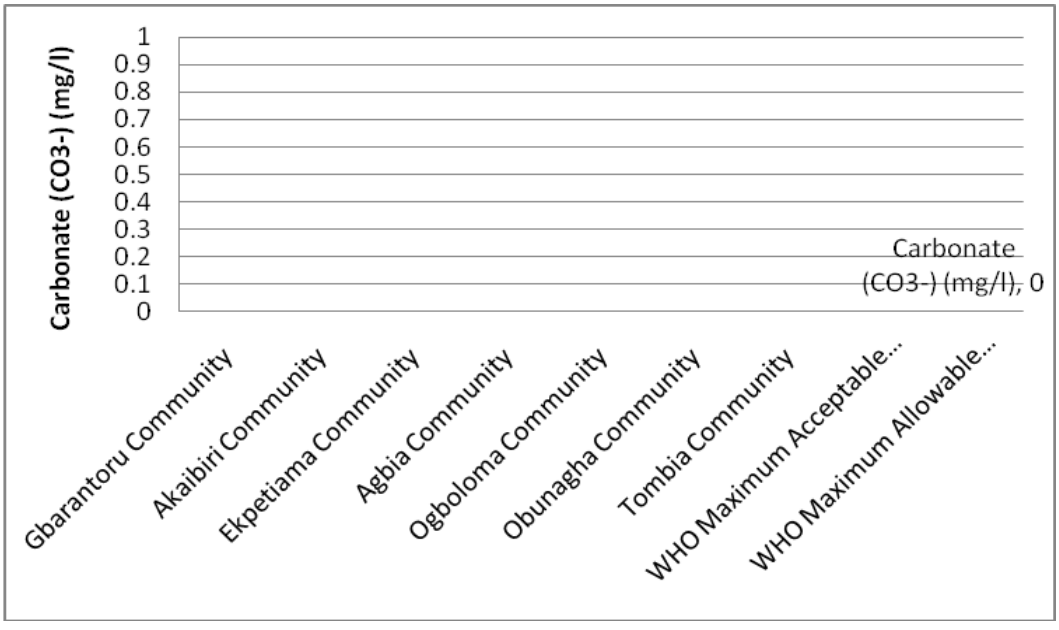

Figure 27. Graph of carbonate concentration.

The carbonate concentration found in the harvested rainwater for the seven different communities is shown in Figure 27. The carbonate concentration is less than 0.1 mg/l for the seven communities, while the maximum acceptable and allowable concentration from WHO is not available.

Sulphide:

The concentration of sulphide found in the harvested rainwater for the different communities is shown in Figure 28. The sulphide concentration found is less than 0.001 mg/l for the communities, but the WHO maximum acceptable and allowable sulphide concentration for potable water were not available.

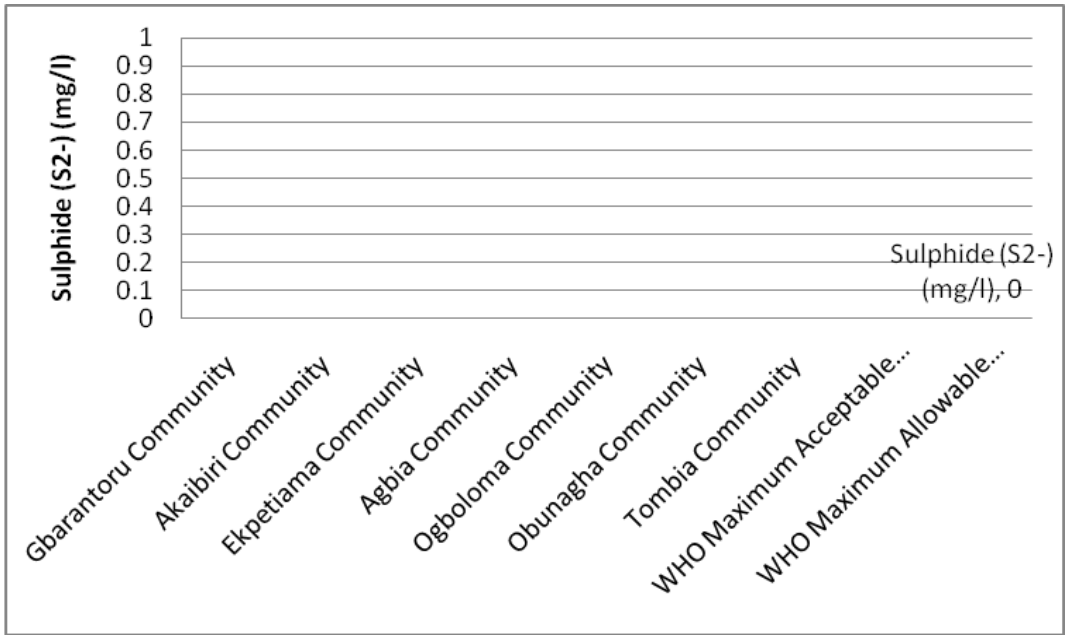

Figure 28. Graph of sulphide concentration

Nitrite:

Figure 29 shows the concentration of nitrite found in the harvested rainwater for the seven different locations. The concentration was the same for the communities, which was less than 0.01 mg/l. Those for the maximum acceptable and allowable nitrite concentration for potable water were not available from the WHO for the recommended concentration.

Phosphate:

The phosphate concentrations for the seven different communities are shown in Figure 30. the analysis done on the harvested rainwater shows a phosphate concentration ranges from 0.04 mg/l to 0.1 mg/l for Agbia and Gbarantoru communities respectively. The WHO maximum acceptable and allowable phosphate concentration for potable water is 200 mg/l and 150 mg/l respectively which was more than the concentration found for the different locations.

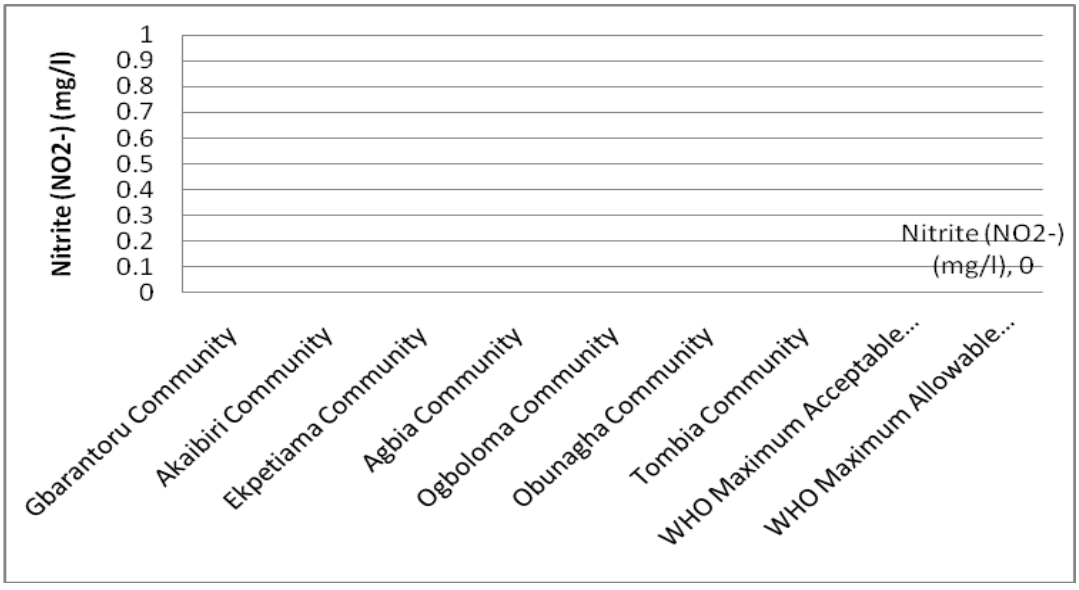

Figure 29. Graph of nitrite concentration.

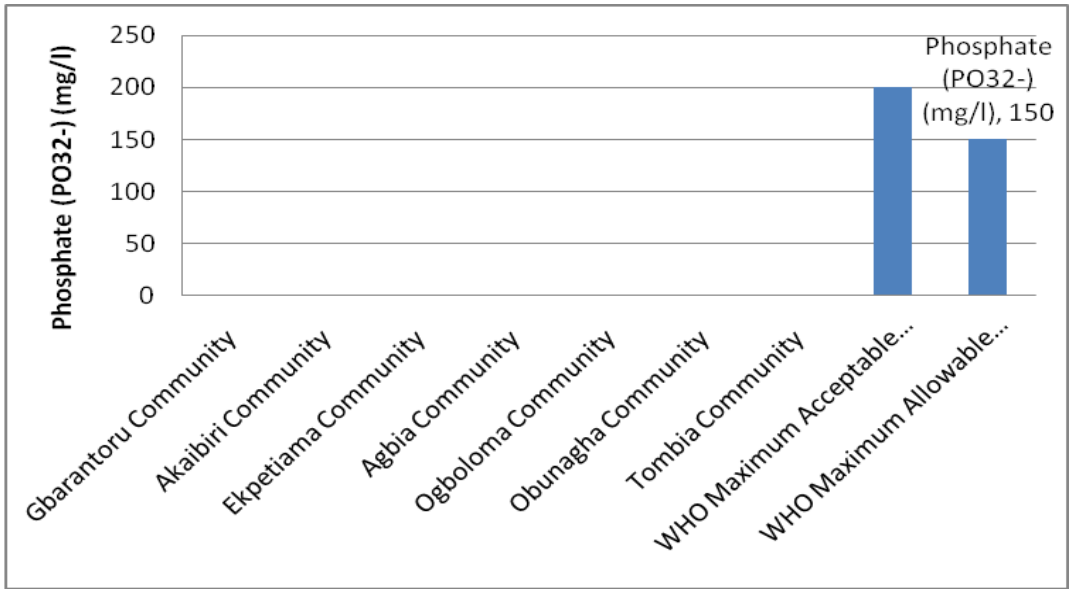

Figure 30. Graph of phosphate concentration.

Sodium:

Figure 31 shows the concentration of sodium ions present in the harvested rainwater for the different communities. These concentrations are different form community to community with Akaibiri community having the highest sodium ion concentration (4.47 mg/l) and least at Agbia community (less than 0.01 mg/l). These concentration values are way less than that by WHO maximum acceptable (50 mg/l) and allowable (150 mg/l) concentration for potable water.

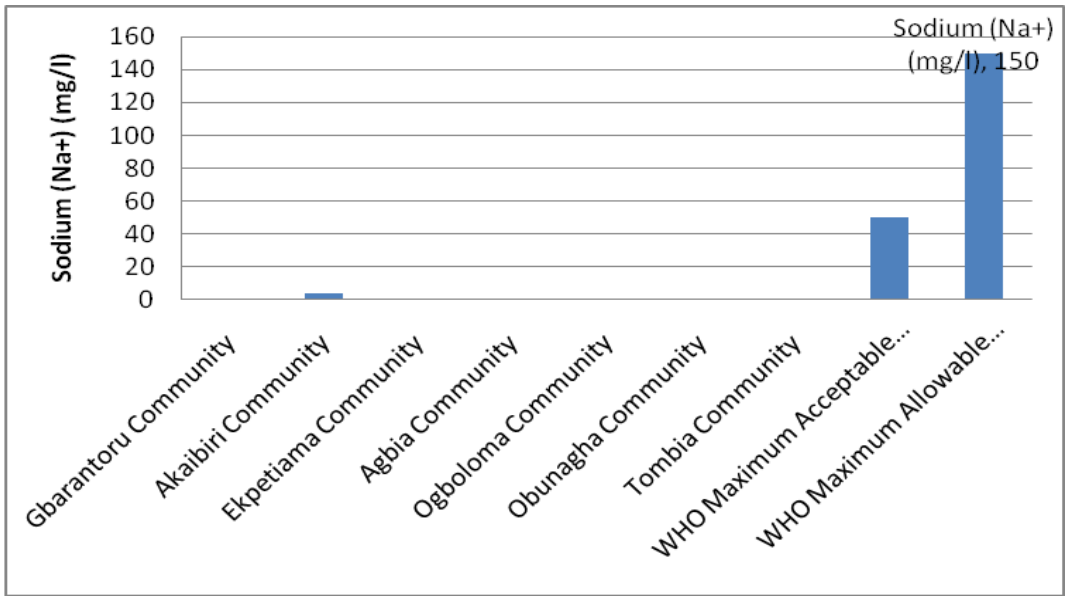

Figure 31. Graph of sodium concentration.

Potassium:

The concentration of potassium ions present in the harvested rainwater is shown in Figure 32 for the different communities. The potassium ions are different for each community ranging from the highest 0.84 mg/l (Gbarantoru) to the least concentration of about 0.09 mg/l (Ekpetiama). The maximum acceptable and allowable potassium concentration in potable water by WHO were not available for this analysis.

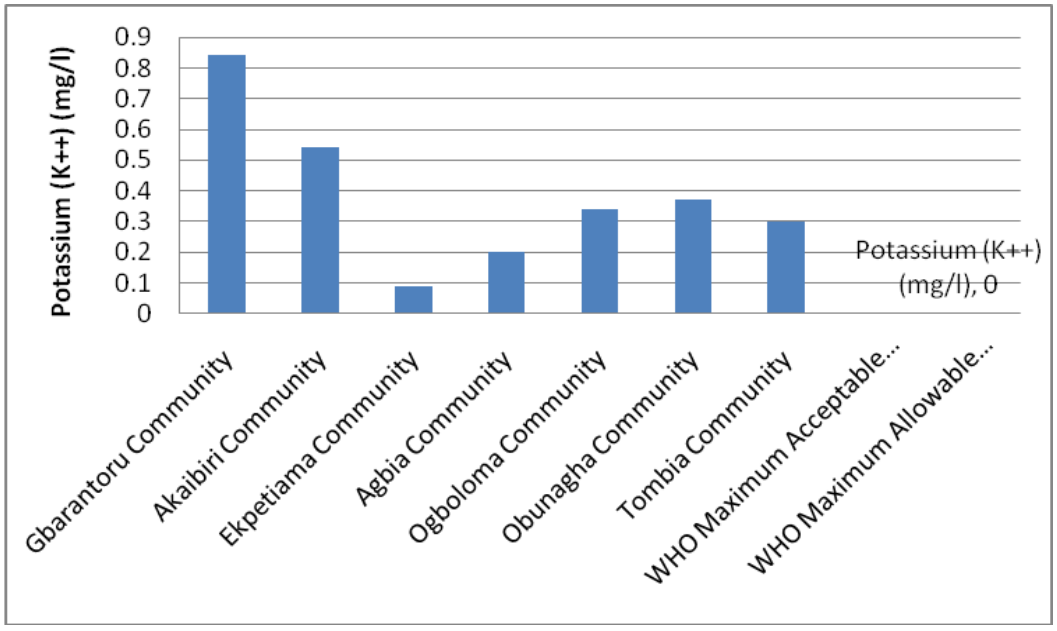

Figure 32. Graph of potassium concentration.

Calcium:

The calcium concentration found in the harvested rainwater for the different communities is shown in Figure 33. The calcium concentration differs from location to locations ranging from 2.2 mg/l for Akaibiri community, having the highest concentration followed by Ognoloma and Obunagha communities having concentrations of 0.7 mg/l each. But the least calcium concentration was from the Tombia community, with a concentration of about 0.29 mg/l. When used to evaluate the maximum acceptable and allowable concentration, from WHO shows that the concentration recommended by WHO was more from 75 mg/l and 200 mg/l, respectively, for the potable water concentration of calcium ions.

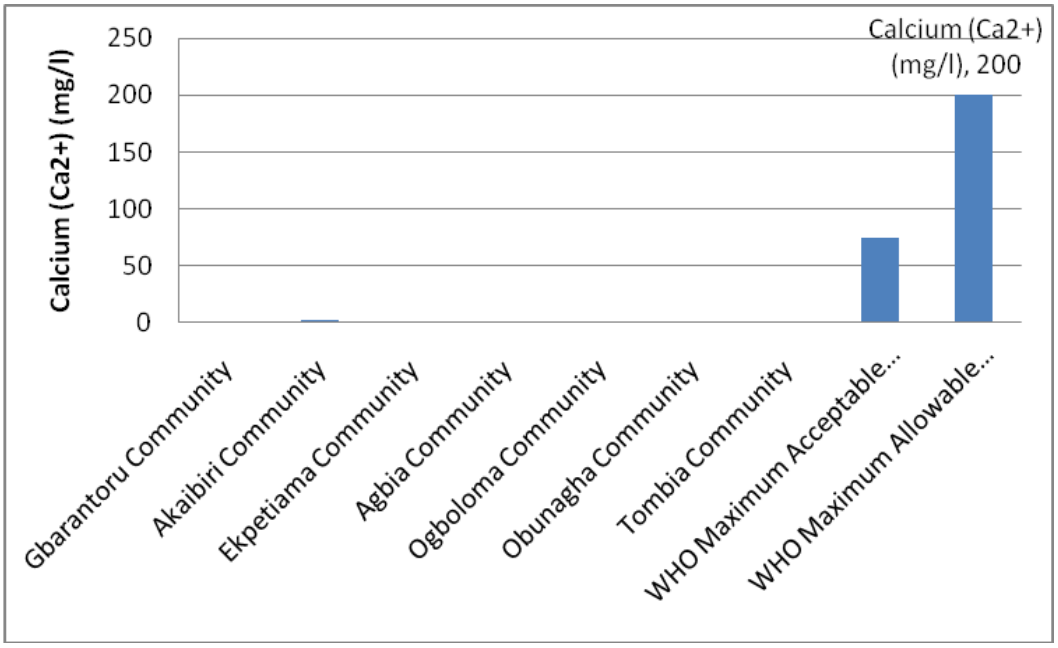

Figure 33. Graph of calcium concentration

Magnesium:

Figure 34 shows the magnesium concentration from the harvested rainwater from seven different communities. The magnesium concentration is quite different from community to community, with the highest concentration obtained from Akaibiri community (0.4 mg/l) while the least was from the Tombia community (0.05 mg/l). The maximum acceptable and allowable concentration by WHO for potable water is 50 mg/l and 150 mg/l, respectively. This shows that the concentration of magnesium present in the harvested rainwater was much lower than the acceptable and allowable concentration by the WHO.

Lead:

The lead concentration found in the harvested rainwater for the different communities is shown in Figure 35. The lead concentration was highest at Epketiama community (0.02 mg/l) and least at Akaibiri and Agbia communities, having less than 0.01 mg/l lead concentration in the rainwater.

The lead concentration found in the harvested rainwater was lower compared to the maximum acceptable and allowable lead concentration for potable water from WHO, which were 0.05 mg/l and 0.1 mg/l, respectively.

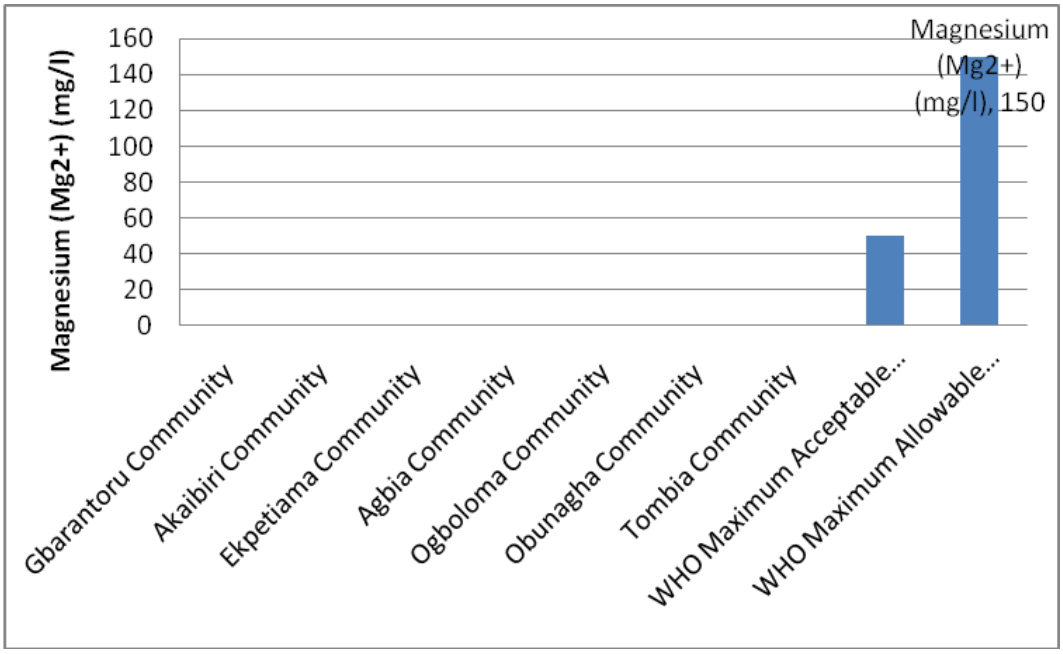

Figure 34. Graph of magnesium concentration.

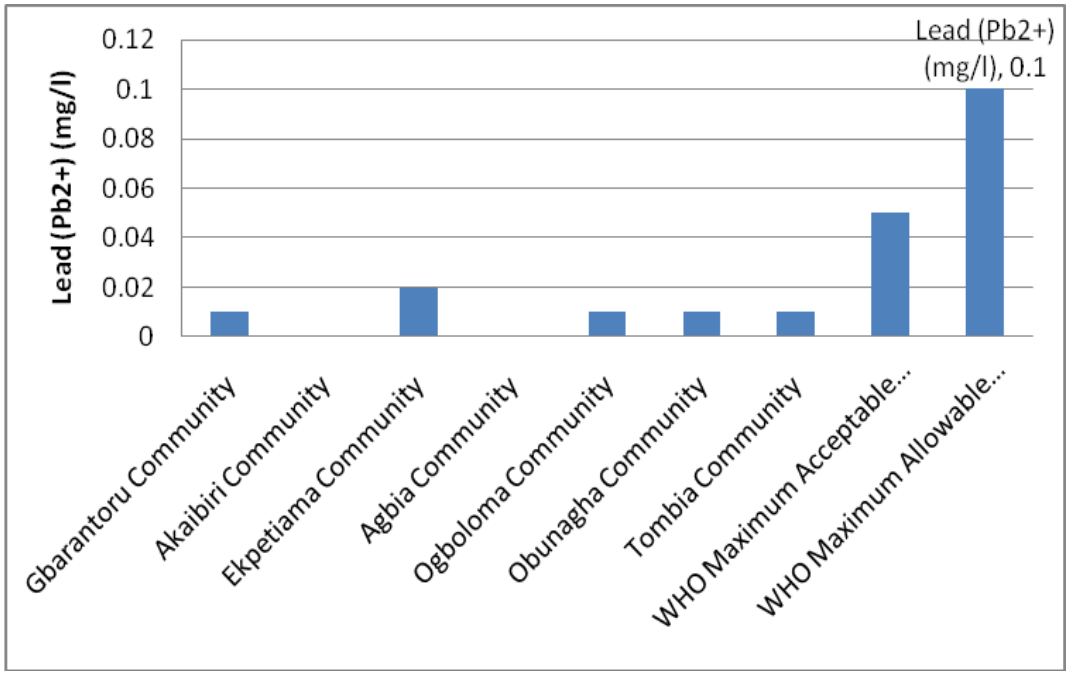

Figure 35. Graph of lead concentration.

Cadmium:

Figure 36 shows the concentration of cadmium ions found in the harvested rainwater for the seven different communities. The cadmium ion concentrations are different from community to community, with the highest concentration obtained from both Agbia and Ogboloma communities (0.02 mg/l), while the other communities had the same cadmium ion concentrations of 0.01 mg/l. The cadmium ion concentrations were less than what was recommended by WHO for both the allowable cadmium concentration (0.05 mg/l) for potable water.

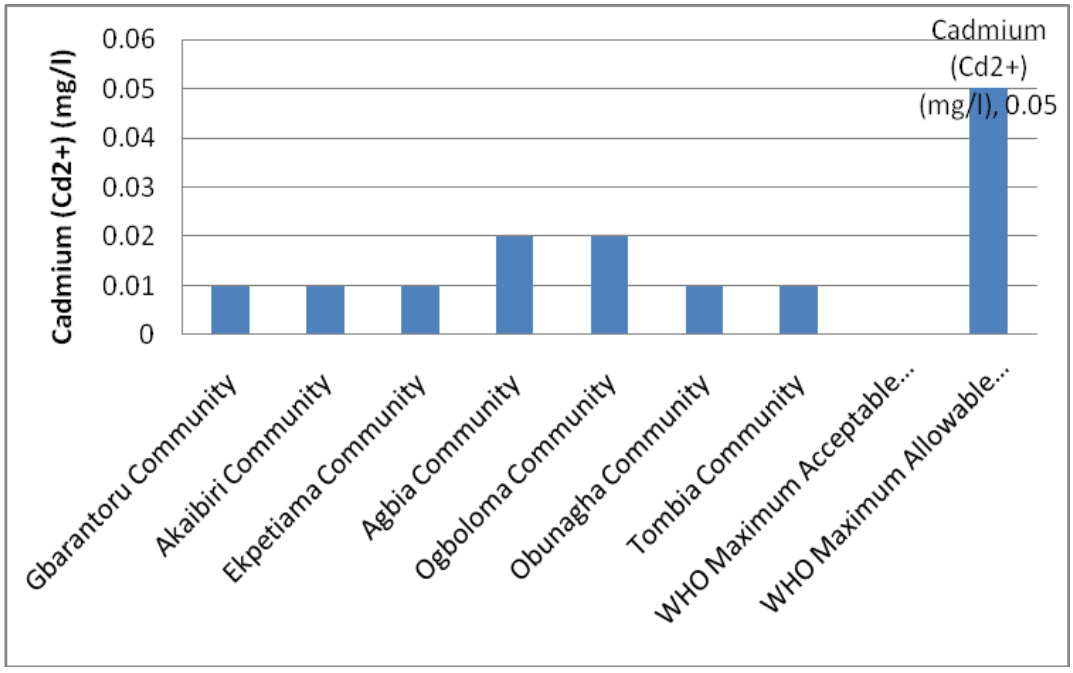

Figure 36. Graph of cadmium concentration.

Zinc:

The concentration of zinc ions present in the harvested rainwater for the different communities is shown in Figure 37. The zinc concentrations differ from location to location, with the highest recorded concentration of 0.54 mg/l from Gbarantoru community, followed by a concentration of 0.51 mg/l from Obunagha community. The least recorded concentration was from both Ogboloma and Tombia communities, with a concentration of less than 0.01 mg/l. The maximum acceptable and allowable zinc concentrations in potable water are 5 mg/l and 15 mg/l, respectively, from WHO. The harvested rainwater zinc concentrates for the seven communities were far less than the recommended values by WHO.

Copper and Chromium:

Figures 38 and 39 show the copper and chromium concentrations found in the harvested rainwater for seven different locations. The concentrations are all the same for the different locations, which were less than 0.01 mg/l, except that of Obunagha community, in which the

copper concentration was 0.01 mg/l. The maximum acceptable and allowable copper concentrations for potable water from the WHO were 0.1 mg/l and 0.5 mg/l, respectively, which are greater than the one recorded from the harvested rainwater. But that of Chromium was not available for comparison.

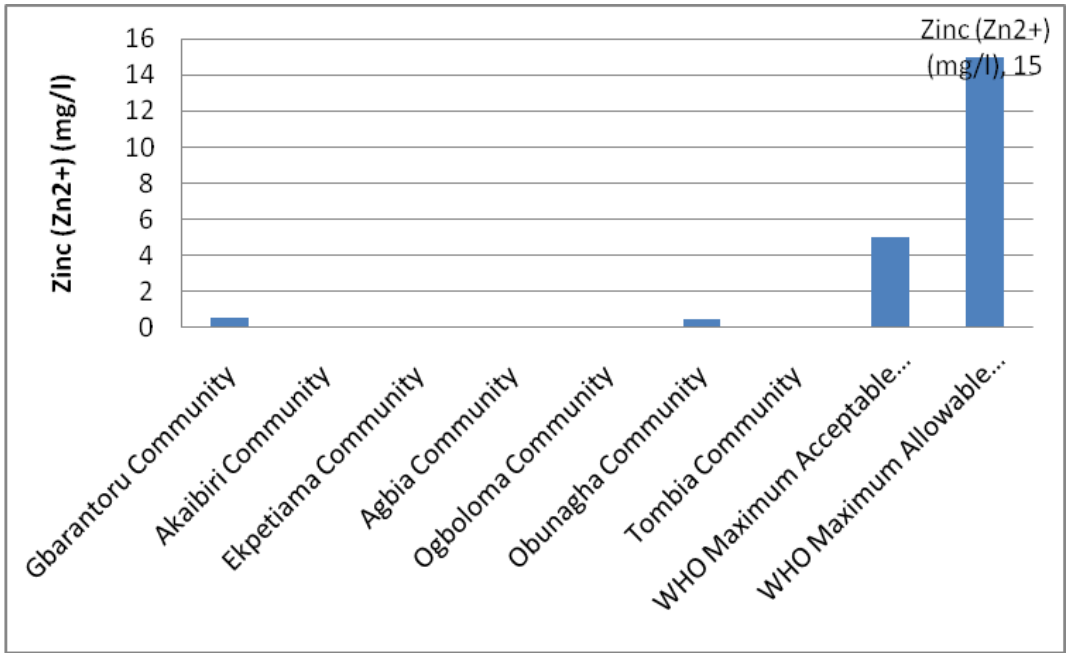

Figure 37. Graph of zinc concentration.

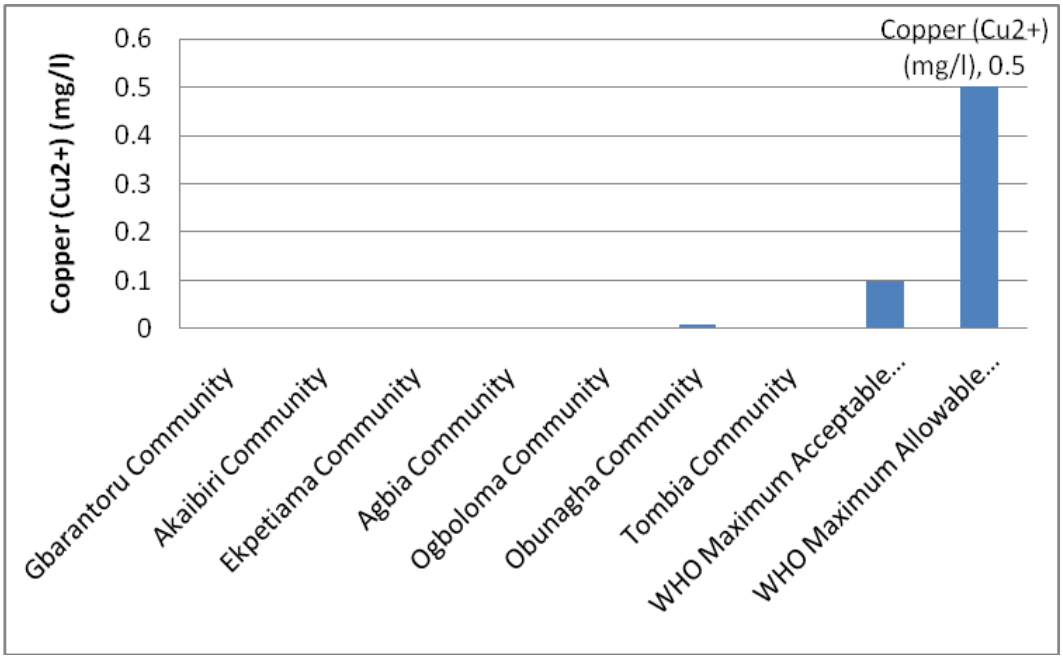

Figure 38. Graph of copper concentration.

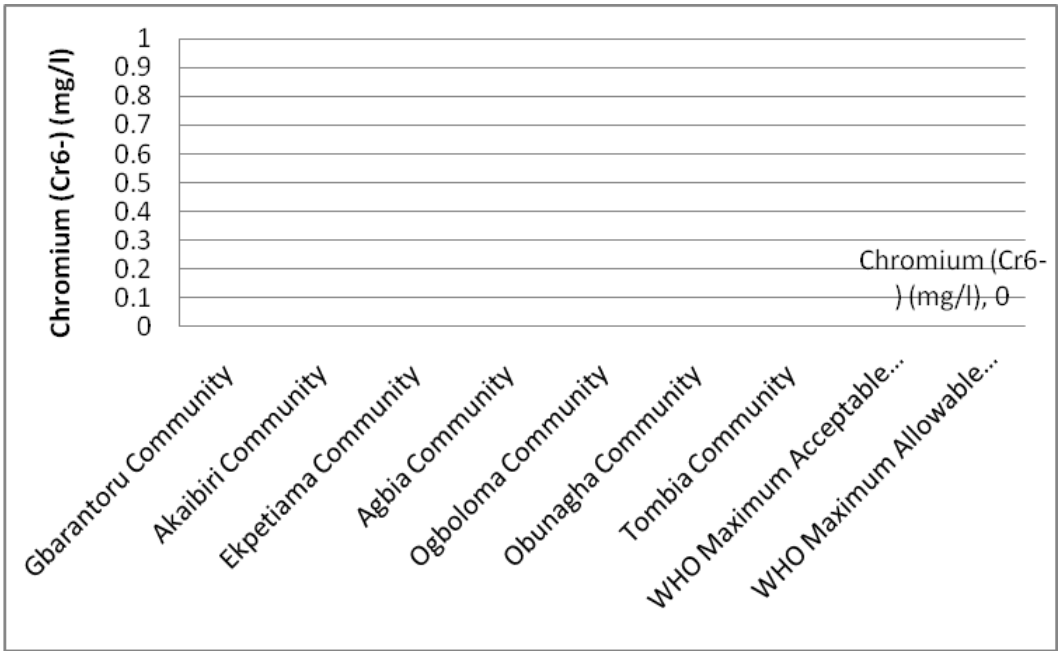

Figure 39. Graph of chromium concentration.

Manganese:

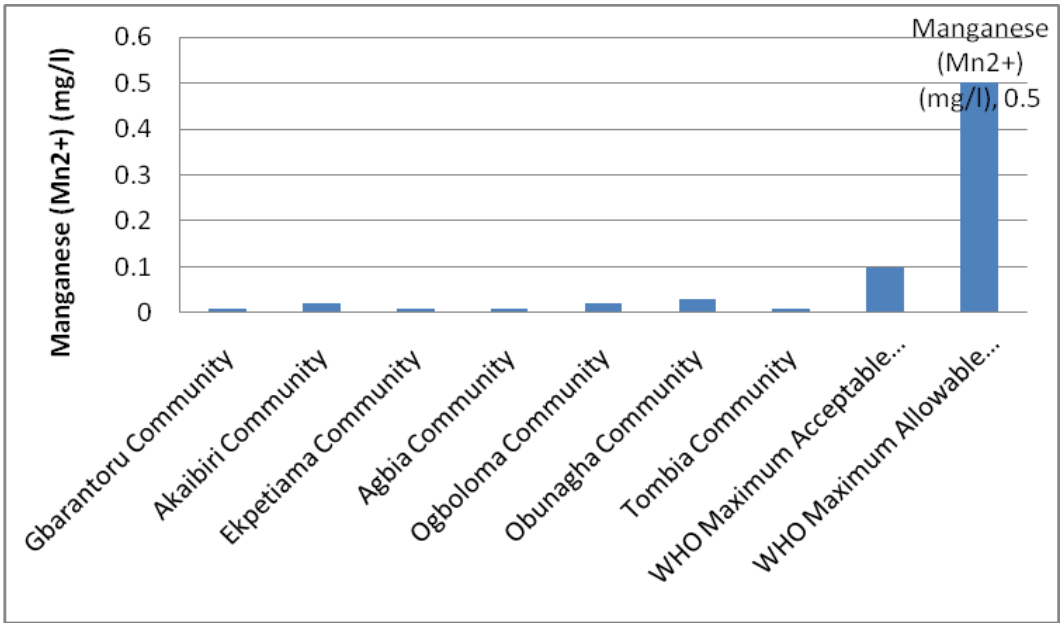

Figure 40. Graph of manganese concentration.

The manganese concentration from the harvested rainwater is shown in Figure 40 for the seven different communities. The manganese concentration was slightly different from

community to community, with the highest concentration obtained from Obunagha community (0.03 mg/l while the least was obtained from Gbarantoru, Ekpetiama, Agbia, and Tombia communities (0.01 mg/l). These concentrations were compared to the WHO maximum acceptable and allowable manganese concentration for potable water. It was observed that, that from WHO were far higher than the once gotten from the harvested rainwater, 0.1 mg/l and 0.5 mg/l for the maximum acceptable and allowable concentration, respectively.

Total iron and Nickel:

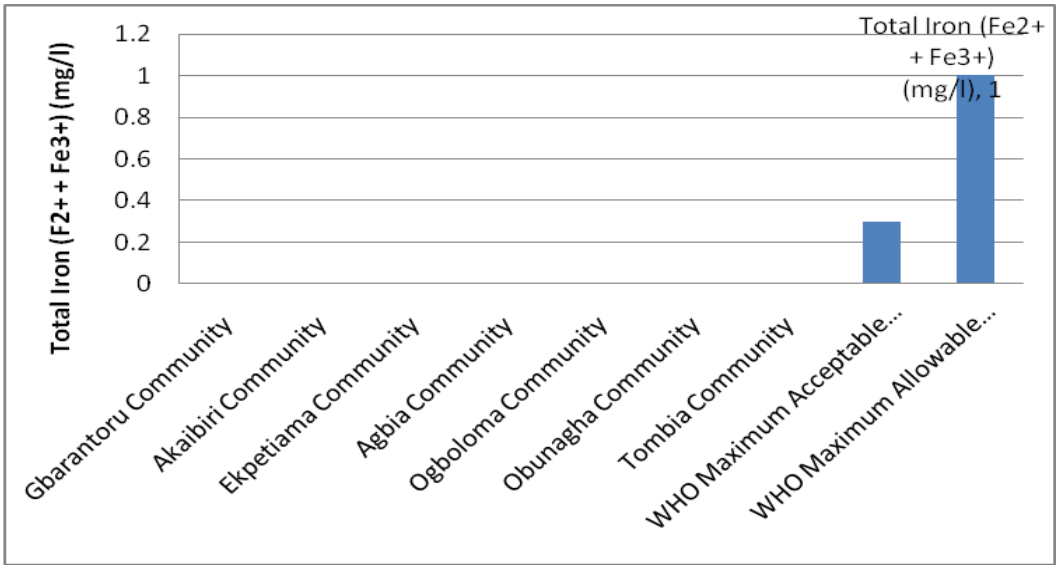

Figure 41. Graph of total iron concentration.

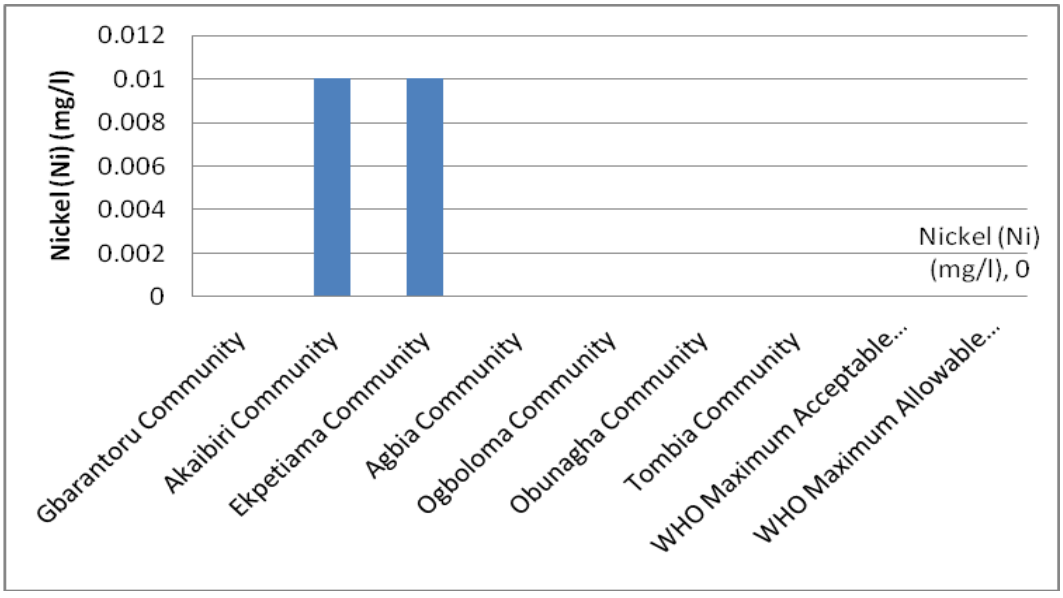

Figure 42. Graph of nickel concentration.

The total iron and nickel concentrations found from the harvested rainwater are shown in Figures 41 and 42, respectively. The concentration for both ions is almost equal in quantities ranging from 0.01 mg/l and less than 0.01 mg/l for the different locations, with the highest nickel concentration found in Ahaibiri and Ekpetiama communities (0.01 mg/l). The WHO maximum acceptable and allowable concentrations for the total iron concentration in potable water are 0.3 mg/l and 1 mg/l, respectively.

This is far above the concentration found in the harvested rainwater. The maximum acceptable and allowable nickel concentrations were not made available by WHO.

4. DISCUSSION

The results of this research express serious issues as regards the drinkability of the rain water harvested in the oil exploration regions of Bayelsa State of Nigeria. Whereas certain parameters of water quality met the WHO standards, others like Total Suspended Solids (TSS), turbidity, and pH were of great concern pointing to unsafe use of untreated rainwater as a drinking source.

PH levels of collected rainwater in different communities were not within the WHO acceptable range (6.5-8.5) with the values ranging between (5.41 and 6.01). Such acidity is possibly attributed to the practice of gas flaring that introduces sulfur dioxide (SO_2) and nitrogen oxides (NO_2) into the atmosphere and leads to the formation of acid rain, as was also found by Ezenwaji et al. (2020) in which the Niger Delta area reported pH of 4.96. The acidity might rust the storage systems and even leach heavy metals from the roof materials further polluting the water.

Most noteworthy were the high TSS concentration of Akaibiri (22 mg/L) and Ogboloma (9 mg/L), which exceeded WHO regulation of 5 mg/L, and turbidity values of Ogboloma read to 6.85 NTU. These situations, presumed to be due to the atmospheric particulate matter presented by gas flaring and oil activities, are identical to those reported by Nwankwo and Ogagarue (2021) and are highly dangerous in terms of human health as it is able to contain the pathogens and negatively impact the results of disinfection.

Although the concentrations of heavy metal (lead, cadmium, and nickel) did not surpass the WHO level, the concept of their presence contributes to that; could be industrial run off and atmospheric deposition) once again triggers the fears of chronic effect impact, as there are no established parameters provided by the WHO regarding nickel.

Readings that were more satisfactory were those of salinity and Total Dissolved Solids (TDS) which were within the lower limit of safety (6-16 mg/L of TDS), meaning that there was no high presence of seawater intrusion, but it might cause nutrient-deficient water. The presence of the coliform bacteria did not have comparisons with the past cases of the Niger Delta, which could be due to the disparities in the methods which necessitate a standard measurement protocol.

Taken together, these findings highlight the potential need of specific water treatment solutions, and decentralized options such as solar disinfection and ceramic filters, as well as areas where harvesting methods can be enhanced through first-flush diversion systems need to be further promoted.

The paper reveals the prospects and challenges of rainwater harvesting in this eco-stressed area where water still needs to be treated to deliver safe drinking water.

5. CONCLUSIONS

Analysis of the rainwater collected by the oil-producing communities in Bayelsa State demonstrated high degrees of variation in the parameters of the water quality relative to the WHO standards. Although the concentration of Total Dissolved Solids (TDS) was much lower than the allowable limit in all the locations, high concentrations of Total Suspended Solids (TSS) in the community of Akaibiri (22 mg/L) and Ogboloma (9 mg/L) were higher than the recommended maximum limit of WHO putting it out of limits to consume, yet it can be safe to ingest with treatment. A high turbidity score based on the predominance of turbidity in Ogboloma (6.85 NTU) and Gbarantoru (5.51 NTU) also exceeded the recommended maximum levels, whereas the salinity range (<0.5 mg/L) and the range of hardness of water (57.60 mg/L) fell within the allowed boundaries. The concentration of heavy metals such as lead and iron was always low compared with the maximum allowable concentrations by the WHO. Such conclusions indicate that despite the potential of rainwater harvested in the area to serve as a source of drinking water, its safety depends on the application of proper treatment processes, especially filtration on suspended solids and turbidities, and pH correction to fix acidity. Rainwater harvesting can be used as a potential drinking water source in these communities with such interventions, but close monitoring should be done as it is an essential requirement that will ensure that it is a good water source.

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