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Physicochemical Assessment of Rainwater Harvested from Rooftops in Isuikwuato Local Government Area, Abia State, Nigeria

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Abstract
Knowledge of rainwater quality is very critical as it has been favoured as an alternative source of water supply in most rural communities in Nigeria. The study assessed the physicochemical quality of harvested rainwater from rooftops in Isuikwuato LGA, Abia State. It revealed that greater number of the people gets their water supply from rainfall even though it is not available all the time for man's use. The results showed that the roof harvested rainwater samples were slightly acidic. Also, the pH of samples showed variation from one roofing material to the other. The implication is that rooftop among other factors influences the physicochemical characteristics of rainwater harvested in a particular community. Total dissolved solids (TDS) measured for rainwater samples were observed to be highest in Asbestos and Zinc. The result revealed the presence of dissolved micro-organisms in the water. Thus, the water is not safe for domestic purposes. High lead content were found in SPL 1 (Zn 0.015 and Asb. 0.017), and from all the rooftop catchments in SPL 4. The mean lead value is 0.011 (Table 3) as against 0.01 recommended value by WHO. The high level of lead is attributed to pollution from automobiles fumes and from the mining activities. This assertion is in line with Efe (2006) and Origho (2019). Iron concentration from the sampled rooftops in all communities were higher than the WHO (2011) recommended value. The mean value for all the sampled locations is 0.468mg/l as against 0.3mg/l. This value falls above the WHO permissible standard for drinking water quality. This implies that the water in terms of iron concentration is not fit for human consumption. Public water supply was not captured by the people, though, it was the first listed among the various sources of water in the sampled questionnaire administered. This shows that the State Water Board has failed in its responsibility of providing water to the people in enough quantity and quality.

Keywords: Physicochemical, Harvested Rainwater, Rooftop, Quality.

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Introduction

Water is the life blood of the ecosphere. It is a unique resource that has no substitute. The quality and quantity of water vary in both space and time. Life and civilization cannot survive without water as it is a natural capital, a catalyst and a pre-condition for economic and social development. Water availability plays a critical role in supporting livelihoods, food security and public health (Baguma, *et. al,* 2010).

Current efforts to improve water supplies for domestic and industrial uses have largely focused on exploitation of surface water and groundwater resources. On the other hand, water balance analysis suggest that rainwater from impermeable roof surfaces in both urban and rural areas represents an under-utilized resource currently excluded in existing water policies in sub-Saharan Africa and Nigeria in particular

(Gwenzi and Nyamadzawo, 2014). Consequently, compared to surface water and groundwater resources, there is relatively limited research on the quality and public health risks posed by water harvested from roofs.

Rainwater harvesting is the process of capturing, conveying, and storing rainwater for future use. Ancient societies have developed various rainwater harvesting technologies, and constructions such as; agricultural dams, runoff control methods, and reservoir or cistern construction in urbanized areas (Mays, *et. al.,* 2013). Water captured by rainwater harvesting systems provides a main source of potable water, supplement source of potable water, and a supplement source of non-potable water. The use of rainwater harvesting systems occurs mainly for non-portable water supplies but it has recently become an important alternative water resource to address the water shortage in urban and sub-urban areas among developed countries (Campisano, *et. al.*, 2013).

Developing alternative water sources has become a critical issue for sustainable development in the study area. There is need to initiate new water resource development regulations, which will include wastewater reuse, seawater desalination, and rainwater harvesting as alternative water resources for domestic water supply as applied in other countries such as in Taiwanese Water Law. In Taiwan, a green building policy has been developed, which has included rooftop rainwater harvesting as a water resource indicator for green buildings since 2003 (Architecture and Building Research Institute, 2013). The policy requires that all new buildings with a total floor area greater than 10,000 m^2 must install domestic rainwater harvesting (DRWH) equipment to supply at least 5% of the total water required by the building.

The quality of rainwater is a key determinant of its suitability for various uses. Rainwater has become an important alternative water source to address the water shortage in urban and sub-urban areas. Roof rainwater use for domestic purposes is not new in developing regions like Nigeria, but until recently it was mostly limited to communal areas and is often regarded as safe.

This study looked at the sources of rural water supply, various methods/techniques of harvesting rainwater, and rainwater quality for domestic uses. However, the main focus was on rainwater quality with respect to drinking purposes. There is the need to ascertain the quality status of harvested rainwater in order to safeguard the people against water related diseases. This is particularly important in Nigeria, Isuikwuato in particular, considering the atmospheric pollution currently going on due to atmospheric activities such as quarrying, mining and construction. This prompted this research aimed at assessing the quality of rainwater harvest in Isuikwuato LGA, Abia State.

Justification:

It is important to note that a large number of people in rural areas still lack social services particularly potable water. The sources of rural water supply in most settlements in the developing countries include rainwater, ponds, streams/rivers, wells and boreholes. Virtually all the sources are prone to water pollution. In rural areas, the settlements are few and far between, people either reside in clustered communities or in scattered settlements where urban services like potable water are scarce or completely lacking. Running of water pipelines for potable water supply to the scattered rural settlements may be uneconomical and the cost is prohibitive. Also, the cost of sinking boreholes is enormous and the local government councils alone cannot provide funding for water supply adequately.

Hence, for the area under study, the harvested rainwater provides a cheap and readily available alternative within and off season for those that may have large storage tanks. Though useful, a lot of complications have been ascribed to the use of harvested rainwater especial bacterial and fungal diseases. There is the need to ascertain the quality status of harvested rainwater in order to safeguard the people against water related diseases. This is particularly important in Nigeria, Isuikwuato in particular and other developing countries, where water treatment facilities are unavailable. This prompted this research aimed at assessing the quality of rainwater harvest in Isuikwuato LGA, Abia State.

Literature Review:

Rainwater harvesting for domestic and agricultural uses is a very old practice dating back to 4500 BC. The practice originated in arid and semiarid areas, but increasing water demand for industrial and domestic uses is forcing most developing countries including those in sub-Saharan Africa to consider RWH. Rainwater harvesting involves collection of rainwater from a catchment, storage and subsequent use for domestic and/or livelihoods uses. A basic roof rainwater harvesting system typically consists of a roof catchment, storage facilities, conveyance system and a delivery system and subsequent use for multiple household purposes. Roof rainwater use for domestic consumption is not new even in developing regions like Nigeria, but until recently it was mostly limited to communal areas and is often regarded as a safe, despite the lack of laboratory analytical data.

However, increasing water shortages in cities and towns have seen the practice of roof water harvesting spread to towns. Compared to conventional piped water supplies rainwater harvesting provides an alternative source of low-cost decentralized water for poor and vulnerable communities in urban and peri-urban areas (Gwenzi & Nyamadzawo, 2014). In large parts of Asia and sub-Saharan Africa including Zimbabwe, Malawi, Tanzania and South Africa (Mamuse, *et. al;* 2003), where groundwater with high fluoride concentration is prevalent the use of rainwater for domestic supplies may reduce the risk of dental and skeletal fluorosis.

In principle, the collection of rainwater before it hits the ground mostly from roofs implies that is safer than surface water in lakes and rivers, and groundwater from shallow wells. However, several recent studies suggest that roof rainwater can be contaminated, thereby posing public health risk if consumed without treatment (Ahmed, *et. al.*, 2010a, 2014; Lim & Jiang, 2013; Alves *et. al.*, 2014; Dobrowsky, *et al..*, 2014a,b; Jesmi, *et. al.*, 2014; Lye, 2014). For example, consumption of untreated rainwater has been linked to bacterial diseases and other forms of pathogen induced health challenges. A study in Australia also showed that untreated roof-harvested rainwater samples tested positive for *Salmonella, Giardia lamblia, Legionella pneumophila, and Campylobacter jejuni*, thereby posing public health risks to consumers (Ahmed, *et. al.*, 2010a).

In Nigeria, Adeniyi and Olabanji (2005) revealed that direct leaching of roof materials by chemical reactions was the main source of contamination on Al and Fe-Zn sheets. In addition, concrete tiles and asbestos were found to be more prone to colonization by various plants leading to softening of the roofing material. Although some studies did not establish clear correlations between contaminants and roof types (Mendez *et. al.*, 2010; Meera & Ahammed, 2011). Adeniyi & Olabanji (2005) separated their roof types into two clusters. One cluster consisting of asbestos and concrete tiles significantly correlated with Ca and bicarbonate ions, while the other cluster comprising of thatch, Al and Fe–Zn sheets were significantly correlated with K, Cl, sulphates and nitrate contaminants.

Results of Gikas and Tsihrintzis (2012) show that the risk of contamination of roof runoff could be high even in low industrialized rural areas due to animal and plant activity warrants future research on the subject. A case study of rainwater quality conducted in Zimbabwe showing that the concentrations of heavy metals (Zn, Cu, Pb and Ni) and basic cations (Mg, Ca, K and Na) were below the WHO guideline limits for drinking water represents one such efforts in Africa.

Geography of the Area
Isuikwuato is a local government area in Abia State in southeastern Nigeria. It's geographical coordinates are Lat: $5^0 48^{'} 25^{''}$N and Long: $7^0$28'53''E. Three major clans which also harbour various communities in each of them make up the present day Isuikwuato. It has an estimated population of over 150,000 people. Isuikwuato has natural resources such as granite, iron ore and kaolin (Abia Facts). In some areas, atmospheric pollution is currently going on due to atmospheric activities such as quarrying, mining and construction. Oil lines flow through Isuikwuato and there have been cases of bursting pipe which have had severe effects on the local economy and environment. The major cash crops are palm oil and cassava. They lack the needed government backing to build drainages around the area to guide the flow of water without further harming the already degraded soil. Isuikwuato is also home to Abia State University Uturu.

Method of Study

a. Research Design/Sources of Data
This study adopted the survey research design. For a good analytical background, observations were taken and recorded, structured questionnaire were administered and interviews conducted. Existing literature, publications and journals were also used to give a comprehensive study. The population of study comprises all households in the four selected communities. A closed-ended questionnaire survey of eight hundred (800) households, two hundred (200) from each of the communities were conducted through systematic sampling to elicit responses from respondents on the sources of water supply in the study area. Sixteen (16) field assistants were used to conduct the questionnaire administration and retrievals and this made us have one hundred percent (100%) response rate. Purposive/judgment sampling was employed for the water sampling to ascertain the quality of rainwater harvest in Isuikwuato, L.G.A, Abia State. The pilot and the reconnaissance survey of the study environment helped the researchers on this judgment as we were familiar with the relevant characteristics of the buildings with the chosen rooftops to be studied.

b. Collection of water samples
Rainwater was randomly collected from three types of roof materials from the various communities. These include; Aluminium sheets, Asbestos and Corrugated Iron sheets (zincs). These roof sheets were the predominant roofing sheets in the area, hence their choice. A total of sixteen (16) water samples were collected from the various communities in each clan. The water samples were collected in sterilized 1 litre plastic container, rinsed with the water to be collected and then filled with the water samples. In addition, clean-catch rainwater samples were also collected as control. This was done by placing the collection container on a 2.0m high stool in the open where the rainwater was collected directly from the study. The samples were properly labelled to show the different points for the analysis of physicochemical parameters. Samples for heavy metal analysis were collected with nitric acid pre-rinsed 1-litre containers and treated with 2ml nitric acid (assaying 100%, trace metal grade) prior to storage. This was done to stabilize the oxidation states of the metals. The samples were placed in coolers before transferring them to the Central Services Laboratory of the National Root Crop Research Institute, Umudike (NRCRIU) within two (2) hours for the analysis.

c. Analysis of the Rainwater
Water samples were analysed for physical and chemical content using standard methods for the examination of water. The parameters that were analysed include:

Physicochemical Parameters
Temperature: Centigrade thermometer capable of reading from O^0C to 100^0C was used. The thermometer was dipped into the surface of the water and the reading taken after equilibrium.

Total Dissolved Solids: $100cm^3$ of the sample filtered through a membrane filter kit was placed in a clean weighed crucible and evaporated on a hot plate. The dish and the residue were dried in a 103^0C oven for an hour and dish reweighed. The difference in weight was obtained by subtraction.
Calculation:

$$\text{Mg/dm3, dissolved solids} = \frac{\text{Increase in wt X } 10^6}{\text{Vol. of filtered sample}}$$

Biochemical Oxygen Demand (BOD_5): BOD bottles, thoroughly cleaned with detergent and rinsed with warm water and other materials as per dissolved oxygen were employed in determination. Procedure: the DO of the samples was determined according to the procedure for DO. Then, the BOD bottles were carefully filled with water samples in such a way that no air bubbles was trapped. Samples were then left to incubate in the dark for five days at ambient temperature. At the end of the fifth day, the dissolved oxygen content of the samples was redetermined using the axide-iodometric modification method. Calculation: if the initial and final (after incubation) dissolved oxygen content were D1 and D2 in the absence of dilution, then,

$$BOD_5 \ (Mg/dm^3) = D1 - D2$$

pH: The pH of the water samples was determined using the HANNA pH meter (model HI 8424). It was calibrated using buffer solutions 4.7 and 10.

Turbidity: Turbidity was read using a visible spectrophotometer VS721G. The cuvettes were were washed and rinsed with distilled water. One of the cuvettes was filled to mark with the sample and the other was filled to mark with distilled water which was used to standardize the spectrophotometer. The sample was read at a wavelength of 420nm.

Total Suspended Solids: This is obtained by a simple subtraction method. The total solid was first determined and the total dissolved solid obtained was subtracted from it.

TSS = TS – TDS

The total solid was obtained by gravimetric method: 10ml of the sample was measured into a pre-weighed evaporating dish which was oven dried at a temperature of 103^oC to 105^oC for two and half hour. The dish was cooled in a desiccator at room temperature and was weighed. The total solid was represented by the increase in the weight of the evaporating dish.

$$\text{Total solids (mg/l)} \quad \frac{\text{(W2-W1)mgx1000}}{\text{ml of sample used}}$$

Where W1 = initial weight of evaporating dish; W2 = final weight of the dish (evaporating dish + residue).

Sulphate: Was determined according to the procedures of UNEP (2004).

Samples for trace/heavy metals (iron, lead, zinc and calcium) analyses were preserved with 3 ml concentration of HNO_3. The concentrations of these metallic components of the rainwater were determined using Atomic Absorption Spectrophotometer as outlined by UNEP (2004).

Results and Discussion

a. Sources of Water Supply - Two sources of rural water supply exist in the area; **Private** (roof catch and streams) and **Commercial** (borehole, hawkers, truck-tankers and owners of large storage tanks). See Table 1.

Table 1: Sources of Water Supply in the Study Area

Sampled Locations	Private Sources				Commercial Sources								Total
	Rain catch		Streams		Boreholes		Hawkers		Truck Tanker		Storage Tanks		
	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	
SPL1													
Total	141	-	5	30	45	70	-	-	20	60	16	42	
Both Seasons	**141**		**35**		**115**		**-**		**80**		**58**		**429**
Percentage	**32.9%**		**8.2%**		**26.8%**		**0%**		**18.6%**		**13.5%**		
% on various sources	**41.1%**				**58.9%**								
SPL 2													
Total	152	-	10	42	31	83	-	10	11	58	21	49	
Both Seasons	**152**		**52**		**114**		**10**		**69**		**70**		**467**
Percentage	**32.5%**		**11.1%**		**24.4%**		**2.1%**		**14.8%**		**15.0%**		
% on various sources	**43.6%**				**56.3%**								
SPL 3													
Total	148	-	7	39	40	79	-	20	15	54	18	51	
Both Seasons	**148**		**46**		**119**		**20**		**69**		**69**		**471**
Percentage	**31.4%**		**9.8%**		**25.3%**		**4.2%**		**14.6%**		**14.6%**		
% on various sources	**41.2%**				**58.7%**								
SPL 4													
Total	160	-	15	43	39	81	-	15	8	51	14	47	
Both Seasons	**160**		**58**		**120**		**15**		**59**		**61**		**473**
Percentage	**34.0%**		**12.3%**		**25.3%**		**3.2%**		**12.4%**		**12.9%**		
% on various sources	**46.3%**				**53.8%**								
Grand Total	**601**		**191**		**468**		**45**		**277**		**258**		**1840**
Overall %	**43.0%**				**57%**								**100**

Source: Researchers' fieldwork, 2022
Key: RS ---- RAINY SEASON DS ---- DRY SEASON

Information on the pattern of the water supply sources were got from the questionnaire samples administered to the respondents. It is important to note that the values in the Table indicate the number of respondents that get their water supply from a particular source and not the number of water sources in the area.

In SPL 1, greater number of the people gets their water supply from rainfall. This has 32.9% patronage even though it is not available all the time for man's use. It is only available during the rainy season and there are no fixed rainy days even within that season. The boreholes are the second most patronized with a value of 26.8%. Truck-Tankers had a value of 18.6% followed by owners of large storage tanks (13.5%), who either stores water during the rainy season or buy water from Truck tankers at a cost and re-sell them to the public for gains. It was discovered that very few persons (8.2%) of the people still rely on streams for their household needs.

Other sampled locations (SPLs 2, 3, and 4) followed same trend. Harvested rainwater had the highest patronage of 32.5%, 31.4% and 34.0% for sample locations 2, 3 and 4 respectively. Boreholes, which is one among the four of commercial sources had the second highest value. Same trend applied to others.

Conclusively from the study areas, public water supply was not captured by the people, though, it was the first listed among the various sources of water in the sampled questionnaire administered. This shows that the State Water Board has failed in its responsibility of providing water to the people in enough quantity and quality. Collectively, the commercial sources of water supply are the most patronized. This is because, water from these sources contributed 57% patronage. Of the six (6) identified sources of water supply which were categorized into Private and Commercial, Rain catch (private) had the highest patronage despite the fact that it is seasonal. This increasing number of patronage of harvested rainwater as a major alternative to meeting the water supply needs of the people informed the need to analyse the rainwater samples from three different rooftops to determine the quality and spatial variability in physicochemical properties.

b. Methods/Techniques of Harvesting Rainwater

Rainwater harvesting technologies are simple to install and operate. Rainwater harvesting provides water at the point of consumption, and family members have full control of their own systems. The feasibility of rainwater harvesting in a particular locality is dependent on the amount and intensity of rainfall. Other variables, such as catchment area and the type of catchment surface can be adjusted according to household needs.

A basic roof rainwater harvesting system typically consists of a roof catchment, storage facilities and the conveyance system. For the collection of rainwater, the 'roof catch' method, about 5-10 minutes are allowed for the rain to wash away dust particles from the roofs (especially when it has not rained for a long time normally during the on-set of the rainy season) before water collection starts.

Fieldwork shows that there are two methods of roof catch or rainwater harvesting in the study areas. These are: ***direct collection from roofs to containers***, and ***channelling to ground level/sunken storage tanks***. In direct collection from roofs, the containers are positioned were raindrops can easily enter them. The containers used for collecting water directly from the roof include aluminium and plastic buckets, pots, basins, gourds and drums. In some cases, corrugated iron eaves are put on some parts of the edge of the corrugated iron roofs to channel water to the water containers. In the case of channelling water to ground level/sunken storage tanks, the edges of the corrugated iron roofs are eaved round (or part of it) with corrugated metals to collect and channel the rainwater to the storage tanks. Plate 1 and 2 depicts rainwater harvesting through roof catch.

Plate 1: Rainwater harvesting channelled to ground level storage tank.

These storage tanks may be made of concrete or metal. The stored water is later drawn for use when there are water shortages; some people pipe the stored water from storage tanks to their houses to provide modern piped water systems with taps, shower taps and basins, and water closets. However, there is a limit to which people of the study areas can depend on rainwater for their domestic and other activities since rainwater is seasonal, occurring between mid-March and early November. A further limit to rainfall utilization in the area is the fact that rain does not fall every day, even during the rainy season.

The analysis in (Table 1) shows that; of the six (6) identified sources of water supply which were categorized into **Private** and **Commercial**, Rain catch (private) had the highest patronage despite the fact that it is seasonal. Collectively, the commercial sources of water supply are the most patronized. This is because, water from these sources contributed 57% patronage. From the foregoing, it is evident that the residents in the study areas make use of water from rainfall even though it is not available all the time for man's use. It is assumed that a good rainwater harvesting culture can help go a long way in solving the people's water problem.

Plate 2: The edges of the corrugated iron roofs are eaved round and channelled to the storage tank.

c. **Rainwater Quality for Domestic uses:** Results of the physicochemical parameters are shown in Tables 2 and 3.

Table 2: Physicochemical characteristics of the harvested rainwater
(See attached on a separate page)

Table 3: Mean physicochemical characteristics of the harvested rainwater samples from 3 different rooftops in Isuikwuato LGA, Abia State

Parameters	SPL 1	SPL 2	SPL 3	SPL 4	Mean value	WHO standard	Remarks
pH	6.13	5.44	6.02	5.40	5.75	6.5-8.5	Safe
Temp ^oC	29.80	29.87	29.86	29.83	29.84	29.80	Safe
Turbidity NTU	0.05	0.055	0.045	0.058	0.052	5.00	Safe
TSS (mg/l)	0.013	0.013	0.023	0.038	0.022	5.00	Safe
TDS (mg/l)	0.21	0.03	0.01	0.03	0.07	0.05	Not safe
Acidity (mg/l)	16.09	16.32	16.81	19.78	17.25	?	Safe
DO (mg/l)	6.60	6.81	7.44	7.58	7.11	5.00	Not safe

BOD (mg/l)	1.21	1.03	1.01	1.02	1.07	NA	Safe
Sulphate (mg/l)	14.01	12.28	11.69	15.33	13.33	200	Safe
Calcium (mg/l)	9.23	9.60	9.75	13.30	10.47	100	Safe
Lead (mg/l)	0.009	0.003	0.005	0.025	0.011	0.01	Not safe
Zinc (mg/l)	0.539	0.458	0.526	0.596	0.530	3.0	Safe
Iron (mg/l)	0.434	0.388	0.440	0.608	0.468	0.3	Not safe

Source: Author's Laboratory Analysis (2022), apart from WHO values

The pH of all harvested water samples ranged from 4.21 – 7.20 in all the sampled communities with a mean of 5.75, which is within the WHO (2011) acceptable limit for drinking water quality. The results showed that the roof harvested rainwater samples were slightly acidic. Also, the pH of samples collected showed variation from one roofing material to the other. Samples from Asbestos and Aluminium rooftops had the least results of 4.21 and 5.23 respectively. The low pH value from this study was similar to values obtained by Udemesue (2012). Although, Chukwuma, et. al. (2014) in Anambra state reported higher pH value. The implication is that rooftop among other factors influences the physicochemical characteristics of rainwater harvested in a particular community.

The temperature value for all water samples were generally satisfactory. Water temperature often affects the inorganic constituents and chemical contaminants that may affect the taste of drinking water. High water temperature is known to enhance the growth of micro-organism and corrosion of pipes (WHO, 2008).

Turbidity measurements in rainwater samples were well below the WHO recommended value of 5NTU. According to Ovrawah and Hymone (2001), the low turbidity values as also recorded in this study could be that the harvested water were sampled from rural communities with minimal mining activities or other major particulate producing anthropogenic activities.

The values of total suspended solids (TSS) were very low compared to WHO (2011) recommended value. Except in Uturu (SPL 4), which had 0.06 total suspended value, samples (SPL 1, SPL 2 and SPL 3) had no values in the control. This could be attributed to the accumulation of particulates from the air especially in SPL 4 (mining community). Total suspended solids is known to reduce water transparency. Thus, one can rightly say that the water is safe as regards to total suspended solids.

Total dissolved solids (TDS) measured for rainwater samples were observed to be highest in Asbestos and Zinc. SPL 1 and SPL 4 had the highest count for the TDS. It is observed that the mean value for total dissolved solids was slightly above the WHO minimum recommended value of 500mg/l but far below the WHO maximum recommended value of 1500mg/l. The presence of high levels of TDS in water may become objectionable to consumers owing to excessive scaling in heaters, boilers and other household appliances (WHO 2004 & 2011).

Rainwater samples collected from Aluminium roofing sheets had higher acidity level than the Zinc rooftop catchments. Asbestos was generally lower in the sampled locations. However, the control had higher level of acidity especially in SPL 4 (quarrying community). The high acidity could be attributed to air pollution coupled with the acid rain (Nwaugo, et. al., 2012).

Dissolved oxygen (DO) had the highest value of 7.58 in SPL 4, followed by SPL 3. SPLs 1 and 2 had values of 6.81 and 6.60 respectively. A mean value of 7.11 was obtained as against 5.0 recommended by WHO (2011). This implies the presence of dissolved micro-organisms in the water. Thus, the water is not safe for domestic purposes.

The mean values of biochemical oxygen demand (BOD) concentration in the water samples range from 1.01 (SPL 2), 1.02 (SPL 4), 1.03 (SPL 2) and 1.21 (SPL 1). The mean of all the values is 1.07. Although, no health based guideline value for BOD has been proposed, its presence might be objectionable for domestic uses. In this study, the values are small and could thus be regarded as safe.

Sulphate concentration for asbestos were highest in all sampled locations. This is followed by aluminium rooftops. However, the mean value for sulphate is 53.31 which is far below the minimum permissible limit recommended by WHO (2011). Therefore, the water from the sampled rooftops is regarded as being safe.

The concentration of Calcium in samples collected from asbestos rooftop catchments had the highest calcium content. The highest concentration of calcium is found in the control (SPL 4), the mining community. However, the mean concentration of calcium content of 10.47 (Table 3) is far below the WHO recommendation.

High lead content are found in SPL 1 (Zn 0.015 and Asb. 0.017), and from all the rooftop catchments in SPL 4. The mean lead value is 0.011 (Table 3) as against 0.01 the recommended value by WHO. The high level of lead is attributed to pollution from automobiles fumes and from the mining activities. This assertion is in line with Efe (2006) and Origho (2019).

Zinc concentration in the studied communities were generally lower than the WHO (2011) recommended value of 3.0mg/l. The three rooftops sampled showed little or no variation in the values. Zinc concentration had a mean value of 0.530 which is far below the minimum recommended standard. Zinc is an essential element, yet it gives undesirable astringent taste to water at levels above the standard limit of 3.0mg/l. The low level of zinc from this study in the analysed rainwater was probably due to the zero industrial and motor vehicular activities in the study area. In SPL 4 (mining community), the concentration of zinc were higher than the others though lower than the WHO recommended value.

Iron concentration from the sampled rooftops in all communities were higher than the WHO (2011) recommended value. The mean value for all the sampled locations is 0.468mg/l as against 0.3mg/l. This value falls above the WHO permissible standard for drinking water quality. This implies that the water in terms of iron concentration is not fit for human consumption.

Conclusion and Recommendations:

The study assessed the physicochemical quality of harvested rainwater from three rooftops in Isuikwuato Local Government Area, Abia State. The study revealed that rooftop among other factors influences the physicochemical characteristics of rainwater harvested in a particular community. Total dissolved solids (TDS) measured for rainwater samples were observed to be highest in Asbestos and Zinc. The presence of high levels of TDS in water may become objectionable to consumers owing to excessive scaling in heaters, boilers and other household appliances (WHO 2004 & 2011). A mean dissolved oxygen (DO) value of 7.11 was obtained as against 5.0 recommended by WHO (2011). This implies the presence of dissolved micro-organisms in the water. Thus, the water is not safe for domestic purposes. High lead content are found in SPL 1 (Zn 0.015 and Asb. 0.017), and from all the rooftop catchments in SPL 4. The mean lead value is 0.011 (Table 3) as against 0.01 the recommended value by WHO. Iron concentration from the sampled rooftops in all communities were higher than the WHO (2011) recommended value. The mean value for all the sampled locations is 0.468mg/l as against 0.3mg/l. This value falls above the WHO permissible standard for drinking water quality. This implies that the water in terms of iron concentration is not fit for human consumption. The study shows that the State Water Board has failed in its responsibility of providing water to the people in enough quantity and quality. This led to increasing number of patronage of harvested rainwater as a major alternative to meeting the water supply needs of the people informed the need to analyse the rainwater samples from three different rooftops to determine the quality and spatial variability in physicochemical properties. It is however recommended that harvested rainwater be further treated before consumption.

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