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RESEARCH ARTICLE

Quality Assessment of Direct Harvested Rainwater in Parts of Anambra State, Nigeria

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ABSTRACT

Rainwater harvesting has become an alternative water source especially in developing countries where many people lack access to pipe borne water. The build-up of greenhouse gases (GHGs) in the atmosphere has had negative impacts on the quality of rainwater and poses great risks to people who depend on this source of water resources. Hence this study assess the physico-chemical and microbiological parameters of rainwater collected in the open in Oko, Orumba North L.G.A. of Anambra State. In the study, direct harvested rainwater were collected from three stations in Oko community and analyzed to investigate the quality of harvested rainwater within the region. Thirty-one water quality parameters were considered and analyzed in the laboratory. The laboratory results were compared to permissible water quality level as recommended by National Agency for Food and Drug Administration and Control (NAFDAC). The comparative parameters analysis shows that the sample collected rainwater were within the permissible limit except for pH which was slightly acidic.

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INTRODUCTION

Water is one of the most natural valuable resources that are widely distributed all over the world. Rainwater has become an alternative source of water especially for domestic uses where surface water resources are not available. Rainwater harvesting is a simple and low cost water supply technique that involves the capturing and storing of rainwater from roof and ground catchments for domestic, agricultural, industrial and environmental purposes. Harvested rainwater may be the only source of water supply for many rural and remote households where no other water supply is available. Rainwater harvesting for domestic use is becoming increasingly popular as the availability of good quality water is declining (Abdul *et al.*, 2009). This is further exacerbated by the adverse impacts of climate change on water supply sources. Consequently, water authorities around the world are keen to explore alternative water sources to meet ever-increasing demands for potable (that is, drinking) water (Gardner *et al*., 2011).

Harvested rainwater (HRW) has been considered an effective alternative water source for drinking and various non-potable uses in a number of countries throughout the world, the most significant issue in relation to using untreated HRW for drinking or other potable uses, however, is the potential public health risks associated with microbial pathogens (Muhammad and Mooyoung, 2008). Historically, the provision of piped water directly to the household has been associated with improved hygiene and reduction in disease (Christine *et al.*, 2006). Although the "water crisis" tends to be viewed as a water quantity problem, water quality is increasingly recognized in many countries as a major factor in the water crisis. Poor water quality has been principally associated with public health concerns through transmission of water-borne diseases that are still major problems in Africa and in many other parts of the developing world (Ongley, 1999). Hence there is need for proper investigation on quality of water consume by communities in developing countries. The basis of water quality monitoring is to obtain information which will be useful in the management of water resources in any country or community. It would prove useful in management, control and investigation of pollution cases, classification of water resources, and collection of baseline data, water quality surveillance and forecasting water quality (Ekiye and Luo, 2010).

Igwo-Ezikpe and Awodele (2010) conducted investigation of some physico-chemical and microbiological parameters of rainwater collected from Industrial areas of Lagos State. Their result showed that as a result anthropogenic activities, the rainwater samples were heavily contaminated and would be dangerous for human consumption without proper treatment.

Atmospheric contamination of harvested rainwater by various contaminants that harbour in the air has been noted by various researchers (TCEQ, 2007; Shyamala *et al*., 2008; Thomas and Green, 1993; WHO, 2011; RAIN, 2008). Presently in Oko community, the provision of pipe borne water has not been realized. There is need to assess the impact of anthropogenic factors (agricultural practices and vehicular activities) on the quality of harvested rain water in the study area for environmental pollution monitoring. This will help to detect at early stage environmental pollution leading to the incidence of water borne-diseases in the study area. This is the objective of this study.

Regional setting

Study Area

Oko is an autonomous community situated in Orumbah North L.G.A of Anambra state (Fig. 1), comprising five villages: Ezioko, Eziabo, Okeani, Iheagwu, and Ifite and is geographically situated between 6" 02'N, 7" 06'E and 6" 05'N, 7" 09'E. Its climate is humid. The range of its average rainfall is about 2,000 mm/year. Most rainfall occurs in well-defined rainy seasons of six to seven months (April to October) and is typically concentrated in high intensity storms and often causes flooding and erosion leading to the formation of gullies. Oko community is bounded in the North by Aguluezechukwu and Ogbuji, in the South by Nanka, in the east by Ekwulobia and in the West by Ndiowu and Amakpala. The study area is characterized by vast undulating landscape and of alluvial plain. Oko is a rain forest area; greater part of its vegetation is made up of forest (tropical vegetation). Population wise, according to National Population Commission in 2006, the study area population is about 28,980 with 2.8% annual growth rate. The study area location is shown on Figure 1.

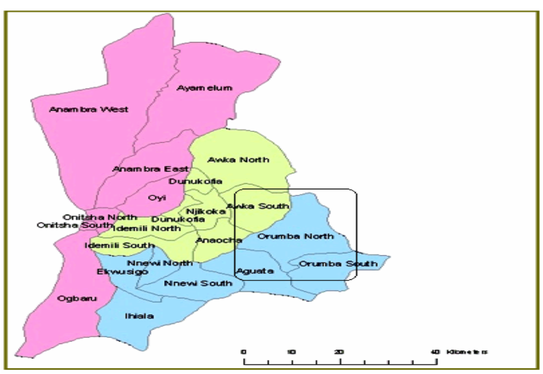

Fig. 1: Orumbah North LGA State of Anambra State

MATERIALS AND METHODS

Data Collection and Analysis

Six samples of rainwater were collected from three different locations (Ezioko, Okeani and Ifite) in Oko, Orumba North L.G.A of Anambra State. The rainwater was collected during rainfall by installing a sterilized rainwater collector in each of the 3 designated sampling stations out in the open. The rainwater samplers were mounted 1.5 meters above the ground to avoid rain splash. Rainwater samples were labeled and transported immidiately after collection to National Agency for Food and Drug Administration and Control (NAFDAC) Zonal laboratory Agulu in Anambra state for examination. Water samples were analyzed for physicochemical and microbiological quality. The appearance was assessed using portable automated colorimeter model (W2553); other physical parameters (odor, taste) were obtained through organoleptic process. The pH, conductivity, Total Solids, Total Dissolved Solid and Suspended Solids was measured using a JENWAY 3540 pH/conductivity meter. Carbon dioxide, phenolphthalein alkalinity, methyl orange alkalinity were measured using titrimetric method. Summation of Phenolphthalein alkalinity and Methyl orange alkalinity gave the Total Akalinity. The trace elements were analysed with Spectrophotometer (SMART Spectro-RS 232). The determination of heavy metals was carried out using the flame atomic spectrometer (NOVAA 400 Analytic Jena) as described in standard method. The media used for microbiological analysis included plate count agar for Aerobic Mesophilic bacteria; laury sulphate broth (liquid medium) was used for coliform determination using multiple tube technique; violet red bile agar-media was used for E-coli determination; while Centrimide Agar was used for pseudomonas.

RESULTS AND DISCUSSION

Thirty-one water quality parameters were considered and analyzed in the rainwater samples collected. The average values of the test results are shown in Table 1 and were compared with water quality parameters standard (expected result) obtained from National Agency for Food and Drug Administration and Control (NAFDAC), an agency of the Nigerian Ministry of Health.

The test results indicate that the physical parameters (appearance, odor, taste) are unobjectionable for the three stations. The pH of the water samples ranged from 5.46-5.98 with an average value of 5.68. This shows that direct harvested rain water within the community is slightly acidic and is less acidic in comparison to research work by Igwo-Ezikpe and Awodele (2010), which shows that the pH of four industrial areas of Lagos state namely: Ilupeju, Costain, Ikeja and Ikorodu are 4.94, 4.20, 4.22 and 4.30 respectively. This was attributed to high vehicular activities as a result of a federal polytechnic being located within the study area, which has equally attracted small scale industries (bakeries, oil mills and agro industries), hospitality industries (hotels and students/staff hostels/accommodation). Brewery industries (Pal Beer and Royal Malt) are also located in Oko community. Therefore, the low pH value of rainwater could be as a result of sulfur and nitrogen released by vehicles and from industrial process into the atmosphere. However, Galloway *et al*. (1982) reported that the reference level commonly used to compare acid precipitation to natural precipitation is pH 5.6 (the pH that results from the equilibrium of atmospheric carbon dioxide with precipitation). Going by Galloway *et al.* (1982) report, Oko community atmospheric rainwater might not be classified as acid rain water.

The mean value of total solid (mg/l) for all the stations is 39.7 (mg/l) while the range is from 35.3-43.6 this is higher than the value of 5.25 ± 1.2 mg/l reported by

Table 1: Results of Physiochemical and Microbiological Assessment of Rainwater Sample from Ezioko, Okeani, and Ifite Villages in Oko Community

S/No	Test Performed	Station 1 (Ezioko)	Station 2 (Okeani)	Station 3 (Ifite)	NAFDAC (Maximum allowed limits)
1	Appearance	Colorless with Particles	Colorless with Particles	Colorless with Particles	colorless
2	Odor	Unobjectionable	Unobjectionable	Unobjectionable	odorless
3	Taste	Unobjectionable	Unobjectionable	Unobjectionable	tasteless
4	Conductivity (µs)	$5.1*10^2$ @ 23^oc	$4.17*10^2$ @ 23^oc	$4.55*10^1$ @ 23^oc	1000 µs max
5	pH	5.46@23^oc	5.59@23^oc	5.98@23^oc	6.5 - 8.5
6	Total Solids (mg/L)	43.6	35.3	40.2	500mg max
7	Total Dissolved Solid (mg/L)	42.6	31.3	35.2	500mg max
8	Suspended Solids (mg/L)	1	4	1	-
9	Carbon Dioxide (mg/L)	3	3	4	50mg max
10	Phenolphthalein Alkalinity (mg/L)	0	0	0	100mg max
11	Methyl Orange Alkalinity (mg/L)	8	4	8	100mg max
12	Total Alkalinity (mg/L)	8	4	8	100mg max
13	Total Hardness (mg/L)	0	0	0	100mg max
14	Chloride (mg/L)	8	16	10	200mg max
15	Sulphate (mg/L)	5	5	3	200mg max
16	Nitrate (mg/L)	0.26	1.98	0.13	50mg max
17	Nitrite (mg/L)	0	0	0	0.02mg max
18	Potassium (mg/L)	0.6	0.7	0.6	10mg max
19	Calcium (mg/L)	0	0	0	75mg max
20	Magnesium (mg/L)	0	0	0	30mg max
21	Iron (mg/L)	0	0	0	0.3mg max
22	Zinc (mg/L)	0.02	0.02	0.02	5.0mg max
23	Copper (mg/L)	0	0	0	1mg max
24	Lead (mg/L)	0	0	0	0.01mg max
25	Cadmium (mg/L)	0	0	0	0.003mg max
26	Residual Chlorine (mg/L)	0	0	0	0.1mg max
27	Vinyl Chlorine (mg/L)	0	0	0	0.1mg max
28	Aerobic Mesophilic (cfu/ml)	17	10	18	Max not stated
29	Coliform (cfu/ml)	0	0	0	1 max
30	E. coli (cfu/ml)	0	0	0	0 max
31	Pseudomonas/ml	Negative	Negative	Negative	0 max

Okoye *et al.* (2011) in physicochemical and trace metal levels of rain water for Ile-Ife, Southwestern Nigeria. Total dissolved solid (TDS) of 3.02 ± 1.0 mg/l was reported by the same authors, while the mean value in this research work is 36.36 mg/l, which also is higher than the reported value of Okoye *et al*. (2011). The palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/l is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l (WHO, 2011). Therefore, the rain water from the study area could be classified as good water. Pathogens are often aggregated or adherent to suspended solids in water (WHO, 2011), the mean value of suspended solids (mg/l) in all the stations is 2mg/l while Okoye *et al*. (2011) reported 2.23 ± 0.3 this low value indicates low pollution level. The total solids (mg/l), total dissolved solids (TDS) (mg/l), and suspended solids (mg/l) are all within the permissible limit.

The levels of ions such as Chloride, Sulphate, Nitrate, Nitrite, Potassium, Calcium and Magnesium were all below the recommended limits. Nitrite, Calcium, Magnesium and Iron were totally absent, while the values of Chloride, Sulphate, Nitrate and Potassium were rather low. The presence of Sulphate in drinking-water can cause noticeable taste. It is generally considered that taste impairment is minimal at levels below 250 mg/l. No health-based guideline value has been derived for Sulphate (WHO, 2011). The absence of essential trace elements like Calcium, Magnesium and Nitrite may indicate that nutrient supplement is of great need if the water is harvested for the purpose of human consumption. However, there is insufficient scientific information on the benefits or hazards of long-term consumption of very low mineral waters to allow any recommendations to be made (WHO, 2011).

The table further shows that heavy metals were totally absent in the water samples, except for Zinc which has a uniform value of 0.02 in all the stations. Zinc imparts an undesirable astringent taste to water at a taste threshold concentration of about 4 mg/l (as zinc sulfate). Zinc is not of health concern at levels found in drinking-water. No health-based guideline value has been proposed for zinc in drinking water (WHO, 2011). The micro-biological paratmeters assessed showed negative confirmation test to pseudomonas, E-coli and coliform (cfu/ml).

Conclusion

The result of the investigation of quality assessment of direct harvested rainwater for environmental pollution monitoring in Oko community shows that the elemental concentrations and levels of all the water parameters examined were all within the permissible level recommended by NAFDAC except pH which is slight acidic. The direct harvested rainwater within the study area could be classified as good quality due to minimal industrial activities in the area. Further research in this area should be on the impact of roof system, storage system, sanitary measures etc on harvested rainwater.

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