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# Quality of Harvested Rainwater in Owerri, Imo State, Nigeria

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***Abstract***

*There is atmospheric accumulation of greenhouse gases with increasing urbanisation. This contributes to environmental pollution and the quality of rainwater so poses great risks to people who depend on this source of water supply. Hence, the objective of the present study is to analyse the quality of harvested rainwater in different locations in Owerri, Imo state an increasing urban city. Water samples were collected from Douglas road, Imo Housing Estate, New Owerri, Orji and Eziobodo. The physical, chemical and microbial quality of the harvested rainwater were analysed in the laboratory using standard procedures. The laboratory results were compared to permissible water quality level as recommended by WHO. The comparative parameters analysis shows that the rainwater samples collected were not within permissible limits. The THPC (38.25 ± 22.11), TFC (20.50 ± 1.91), colour (56.23 ± 14.59), turbidity (23.92 ± 6.20), phosphate (25.03 ± 20.32), sulphate (484.81 ± 115.02), phosphorus (8 ± 6.59), iron (2.12 ± 1.79), aluminium (1.70 ± 1.83) and lead (0.44 ± 0.36) were significantly high. Escherichia coli was not detected. Wind – blown dirt, air pollution leaves, faecal droppings from birds and animals on roofing materials contributed to the physical, chemical and microbiological quality of the harvested rainwater. It is recommended that the harvested rainwater be treated properly before use.*

***Keywords**: Harvested Rainwater, environmental pollution, quality assessment, comparative analysis*

## 1. Introduction

Water is one of the most natural valuable resources widely distributed all over the world. Rainwater harvesting as an alternative source of water for domestic use is becoming popular as public water supply are not always available and consistent (Abdul *et al*, 2009). Rainwater harvesting is a simple and low cost technique that involves the capturing and storing of rainwater from roof catchments or directly for domestic, agricultural and environmental purposes (Chukwuma *et al*, 2012).

Harvested rainwater may be the only source of water supply for many rural and remote households where no other water supply is available. This is worsened by the adverse impacts of climate change on water supply sources. Water authorities around the world are keen to explore alternative water sources to meet ever-increasing demands for potable water (Gardner *et al*., 2011).

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 the need for proper investigation on quality of water consumed 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 (Ekiye and Luo, 2010).

In the investigation of some physico-chemical and microbiological parameters of rainwater harvested from Industrial areas of Lagos State, Igwo-Ezikpe and Awodele (2010) showed that as a result of 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). Atmospheric deposition is the transfer of atmospheric pollutants (dust, particulate matter containing heavy metals, polycyclic aromatic hydrocarbons, dioxins, furans, sulphates, nitrates, etc.) to terrestrial and aquatic ecosystems (Amodio *et al*., 2014).

Many of these pollutants may be present in urban environments, at variable rates according to the intensity of road traffic and the proximity of industrial clusters. Sources of contaminants deposited from the atmosphere by washout and dust fall may be road traffic, sea spray, industrial and rural activities, local dust and long-range transport from other areas (Fang and Zheng, 2014; Sanchez *et al*, 2015).

Wet deposition refers to the rain washout of the air, which captures the air pollutants inside the rain drops and transfers them to the soil. Atmospheric deposition makes an important contribution to storm water contamination, typically supplying nitrogen and a smaller proportion of suspended solids, phosphorous, dissolved organic carbon (DOC), and heavy metals (Sanchez *et al*, 2015). Sazakli *et al*. (2007) noted that the low fluoride concentrations in rainwater may force consumers to take a fluoride supplement to prevent dental decay if rainwater serves as the primary potable water source.

Presently in Owerri, Imo state the provision of pipe borne water has not been regular and as earlier stated some homes depend on harvested rainwater. Hence, there is need to assess the quality of harvested rain water in the study area. This will help to detect at early stage environmental pollution and prevent the incidence of water borne-diseases in the study area.

## 2. Methodology

### *2.1 Background to Study and Study Area*

Owerri became the capital of Imo state in 1976 following the creation of the old Imo state, which was carved out from East central state. Upon assumption of the status of a state capital, most private, state and Federal institutions started establishing their offices in Owerri. It lies within the 5°29′06″N 7°02′06″E and 5.485°N 7.035°E Coordinates. Owerri consists of three Local Government Areas including Owerri Municipal, Owerri North and Owerri West. It has approximately 100 square kilometers (40 sq mi) in area and estimated population of about 400,000 as of 2006 National population census of Nigeria. Owerri is bordered by the Otamiri River to the east and the Nworie River to the south. Its mean annual temperature ranges from 25 - 30°C and mean annual rainfall range of 2500 – 3500mm.

### *2.2 Data Collection*

Water samples were harvested with a sterile basin, transferred into polyethylene bottles sterilised with HCL and Ethanol. The time of sample taking were June (3 events) and July (1 event) in 2015. Without preservation the samples were collected from four different locations (Douglas road in Owerrri municipal, Imo housing estate in New Owerri, Orji in Owerri – North and Eziobodo in Owerri - west) in the study area. Rainwater samples were labelled and transported after collection to New Concept Chemical Engineering and Environmental Services, Obinze, Imo state for analysis of the physicochemical and microbiological quality.

Heavy metals were determined using flame Atomic Absorption Spectrophotometer. Anions detected included nitrate (NO3), phosphate ($PO_{4)}$, phosphorus and sulphate (SO4) using HI83200 multipara meter bench photometer at a wavelength of 525mm.

The pH was determined using hand held PH meter model HI98107 (HANNA). Turbidity was determined by photometric method using HACH DR/2010 spectrometer at a wavelength of 860nm and programme number 750. The colour of water was determined at 420nm with HI83200 multipara meter bench photometer by colorimetric platinum cobalt method. The media used for microbiological analysis included Nutrient agar for total heterotrophic count; MacConkey agar for coliform determination; Eosin Methylene Blue agar was used for E-coli determination; while Sabroud Dextrose Agar was used for total fungal count using membrane filtration technique.

### *2.3 Data Analysis*

Data obtained from rainwater sample analysis and observations were collated and analysed by the computer using Microsoft Excel 2013 version 15.0.4420.1017 for mean, median, range, standard deviation and variance.

## 3. Results and Analysis

**Table 1:** Analysis of Physicochemical and Microbiological Quality of different locations in Owerri, Imo state

| Parameter, Unit | WHO Standard | Douglas Road | Imo Housing Estate | Orji | Eziobodo |
|---|---|---|---|---|---|
| Ph | 6.5 – 8.5 | 6.6 | 7.6 | 6.2 | 6.3 |
| Colour, PCU | 5 | 37 | 53 | 69 | 66 |
| Turbidity, NTU | 5 | 20.93 | 18.23 | 32.52 | 23.98 |
| Total Solids, mg/l | 250 | 194 | 80 | 88 | 142 |
| Total Dissolved Solids mg/l | 250 | 9.55 | 1.72 | 18.65 | 68.05 |
| Calcium Hardness, mg/l | 100 – 300 | 0.39 | 0 | 0.22 | 0.3 |
| Magnesium Hardness, mg/l | 250 | 0 | 0 | 0 | 0.23 |
| Nitrate $NO_3^-$, mg/l | 50 | 81.1 | 43 | 18 | 27.1 |
| Phosphate ($PO_4^{3-}$), mg/l | 5 | 45.4 | 38 | 1.3 | 15.4 |
| Phosphorus, mg/l | 0.3 | 14.6 | 12.2 | 0.3 | 4.9 |
| Sulphate, mg/l | 250 | 506.6 | 571.22 | 544.5 | 316.9 |
| Iron, mg/l | 0.3 | 1.18 | 1.27 | 1.236 | 4.8 |
| Aluminium, mg/l | 0.1 – 0.2 | 1.022 | 1.516 | 4.272 | 0 |
| Copper, mg/l | 1 | 0.23 | 0.237 | 0.22 | 0.22 |
| Zinc, mg/l | 3.0 – 5.0 | 0.184 | 0.045 | 2.015 | 0.994 |
| Lead, mg/l | 0.01 | 0.913 | 0.495 | 0.047 | 0.322 |

| | | | | | |
|---|---|---|---|---|---|
| **Total Heterotrophic Plate Count** | 0 - 30 | 45 | 30 | 13 | 65 |
| **Total Coliform Count** | 0 - 10 | 2 | 2 | 0 | 0 |
| **E.coli Count** | 0 | 0 | 0 | 0 | 0 |
| **Total Fungal Count** | 0 | 19 | 21 | 23 | 19 |

**Table 2:** The mean, SD, range, median and variance of the physical parameters of harvested rainwater in Owerri

| Parameter, Unit | WHO Standard | MEAN ± SD | RANGE | MEDIAN | VARIANCE |
|---|---|---|---|---|---|
| **Ph** | 6.5 – 8.5 | 6.675 ± 0.639661 | 6.2 - 7.6 | 6.45 | 0.409166667 |
| **Colour, PCU** | 5 | 56.25 ± 14.59166 | 37 – 69 | 59.5 | 212.9166667 |
| **Turbidity, NTU** | 5 | 23.915 ± 6.198917 | 18.23 - 32.52 | 22.455 | 38.42656667 |
| **Total Suspended Solids, mg/l** | 250 | 126 ± 53.04086 | 80 – 194 | 115 | 2813.333333 |
| **Total Dissolved Solids mg/l** | 250 | 24.4925 ± 29.85105 | 1.72 - 68.05 | 14.1 | 891.085225 |
| **Calcium Hardness, mg/l** | 100-300 | 0.2275 ± 0.166808 | 0 – 0.84 | 0.26 | 0.27825 |
| **Magnesium Hardness, mg/l** | 250 | 0.0575 ± 0.115 | 16 – 102 | 0 | 0.013225 |

**Table 3:** The mean, SD, range, median and variance of the chemical parameters of harvested rainwater in Owerri

| Parameter, Unit | WHO standards | MEAN ± SD | RANGE | MEDIAN | VARIANCE |
|---|---|---|---|---|---|
| **Nitrate $NO_3^-$, mg/l** | 50 | 42.3 ± 27.85355 | 18 - 81.1 | 35.05 | 775.82 |
| **Phosphate ($PO_4^{3-}$), mg/l** | 5 | 25.025 ± 20.32246 | 1.3 - 45.4 | 26.7 | 413.0025 |
| **Phosphorus, mg/l** | 0.3 | 8 ± 6.585337 | 0.3 - 14.6 | 8.55 | 43.36666667 |
| **Sulphate, mg/l** | 250 | 484.805 ±115.0336 | 316.9 - 571.22 | 525.55 | 13232.71877 |

**Table 4:** The mean, SD, range, median and variance of the heavy metals of harvested rainwater in Owerri

| Parameter, Unit | WHO standards | MEAN ± SD | RANGE | MEDIAN | VARIANCE |
|---|---|---|---|---|---|
| **Iron, mg/l** | 0.3 | 2.1215 ± 1.786052 | 1.18 - 4.8 | 1.253 | 3.189982333 |
| **Aluminium, mg/l** | 0.1 – 0.2 | 1.7025 ± 1.825623 | 0 - 4.272 | 1.269 | 3.332899667 |
| **Copper, mg/l** | 1 | 0.22675 ± 0.008302 | 0.22 - 0.237 | 0.225 | 6.89167E-05 |
| **Zinc, mg/l** | 3.0 – 5.0 | 0.8095 ± 0.906087 | 0.045 - 2.015 | 0.589 | 0.820993667 |
| **Lead, mg/l** | 0.01 | 0.44425 ± 0.362884 | 0.047 - 0.913 | 0.4085 | 0.131684917 |

**Table 5:** The mean, SD, range, median and variance of the microbiological indicators of harvested rain water in Owerri

| Parameter, Unit | WHO standards | MEAN ± SD | RANGE | MEDIAN | VARIANCE |
|---|---|---|---|---|---|
| **Total Heterotrophic Plate Count** | 0 – 30 | 38.25 ± 22.11146 | 13 – 65 | 37.5 | 488.9166667 |
| **Total Coliform Count** | 0 – 10 | 1 ± 1.154701 | 0 – 2 | 1 | 1.333333333 |
| **E.coli Count** | 0 | 0 ± 0 | 0 – 0 | 0 | 0 |
| **Total Fungal Count** | 0 | 20.5 ± 1.914854 | 19 - 23 | 20 | 3.666666667 |

1. Table 1 shows the results from the analysis of the various microbiological and physicochemical parameters in different locations in Owerri. The microbial load from the rainwater samples from Douglas road in Owerri municipal and Imo Housing Estate in New Owerri did not meet the WHO standard for potable water.
2. Table 2 shows a comparison of the physical parameters analysed on rainwater harvested in Owerri with WHO standards. The mean ± SD values of Colour, and turbidity exceeded the limits. Other parameters like pH, TSS and TDS were within limits.
3. Table 3 shows a comparison of the chemical parameters analysed on harvested rainwater In Owerri with WHO Standards. The mean ± SD values of phosphorus, sulphate and phosphate exceeded limits.
4. Table 4 shows a comparison of the heavy metals of harvested rainwater in Owerri with WHO standards. Zinc and copper were within limits while iron, aluminium and lead exceeded.
5. Table 5 shows a comparison of the microbiological indicators analysed in harvested rainwater in Owerri with WHO standards. *Escherichia coli* was not detected but other indicators such as THPC, TFC and TCC exceeded WHO limits.

## Discussions

### *Physical Parameters*

The pH of the water samples ranged from 6.2 – 7.6 with an average value of 6.675. This shows that harvested rain water within Owerri is not acidic in comparison to research work by Igwo-Ezikpe and Awodele (2010), which showed that the pH of four industrial areas of Lagos state namely: Ilupeju, Costain, Ikeja and Ikorodu were 4.94, 4.20, 4.22 and 4.30 respectively. This was attributed to vehicular activities and old practice of bush burning by farmers and hunters.

The mean value of total suspended solid for all the locations is 126 mg/l while the range is from 1.72 – 68.05

this is higher than the value of 5.25 ± 1.2 mg/l reported by Okoye *et al* (2011) in physicochemical and trace metal levels of rain water for Ile-Ife, South-western Nigeria. Total dissolved solid (TDS) of 3.02 ± 1.0 mg/l was reported by the same authors, while the mean value of the present study is 24.49 mg/l, which also is higher than the reported value of Okoye *et al* (2011). This value indicates high pollution level. 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 unsafe at TDS levels greater than about 250 mg/l (WHO, 2011). The total suspended solids and total dissolved solids (TDS) in the present study are within the permissible limit.

Drinking water should ideally have no visible colour. Colour in drinking water is usually due to the presence of coloured organic matter, iron and other metals either as natural impurities or as corrosion products. The concentration of colour in the present study ranged from 37 – 69 PCU and mean value of 56.25PCU. While this may be considered high, no health – based guideline value is proposed for colour in drinking water (WHO, 2011)

*Chemical Parameters*

The levels of ions such as Sulphate (484.81 ± 115.03), phosphorus (8 ± 6.59) and phosphate (25.03 ± 20.32) were all above the recommended limits. Nitrate (42.3 ± 27.85) was within limits. 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 low levels of essential trace elements like Calcium and Magnesium 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 (Chuukwuma *et al*, 2012; WHO, 2011).

The results further shows that heavy metals – aluminium (1.70mg/l), lead (0.44mg/l) and iron (2.12mg/l) were present in the water samples at levels above the WHO standards, except for Zinc (0.81mg/l) and copper (0.23mg/l). Zinc impacts an undesirable taste to water at a taste threshold concentration of about 4 mg/l (as zinc sulphate). 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).

*Microbiological Indicators*

The microbiological indicators assessed showed no detection for E. coli (0 cfu/ml). The total heterotrophic plate count (38.25cfu/100ml), total coliform count (1cfu/100ml) and total fungal count (20.5cfu/100ml) in the harvested rainwater in Owerri, Imo state exceeded WHO Standards (WHO, 2011). Therefore it is not safe for drinking or portable usage. The presence of fungal flora in rainwater was studied by Nishihara *et al*. (1989) who detected 29 fungal genera, while Czeczuga and Orłowska (1997) identified 33 fungus species in the rainwater falling from six different roof types.

**Conclusion**

This study provided reference information on the quality of harvested rainwater in Owerri, Imo state, Nigeria. The result of the analysis of the quality of harvested rainwater in Owerri, Imo state showed that the harvested rainwater within the study area is not safe for portable use without proper treatment. Available treatments for harvested rainwater are: the application of settling tanks, disinfection combined with membrane filtration, reverse osmosis, heat treatment, solar disinfection-SODIS and slow sand filtration followed by chlorination. Further research in this area should be on the impact of different roofing materials, storage systems, sanitary measures etc. on the quality of harvested rainwater.

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