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# Effect of Storage Conditions on Physicochemical Parameters of Rain Water

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***ABSTRACT:*** *The aim of this paper is to investigate the effect of storage conditions (time, containers and locations) on physicochemical parameters of rain water in Awka, Anambra state, Nigeria. Rain water sample were collected from roof drain at Nnamdi Azikiwe University, Awka. The water was stored in clay pots, white plastics, blue plastics, plain metal and black metal, indoor and outdoor laboratory. The water samples were stored for thirty-eight days within which analysis were carried out using the stored water in the containers at intervals of three days. The total suspended solids had a concentration range (before storage) of 60-10mg/l(during storage),total dissolved solids(before storage)50-0mg/l(during storage),total solids(before storage)110-10mg/l(during storage),total alkalinity(before storage)90-27mg/l(during storage),chlorine(before storage)59.48-23.49mg/l(during storage),turbidity(before storage)3.46-0ntu(during storage),temperature(before storage)25$^0$-29$^0$C(during storage),electrical conductivity(before storage)19µs/cm -139µs/cm (during storage), pH(before storage)5.8-6.6(during storage),total hardness(before storage)0.45-1.14mg/l(during storage) ,phosphate(before storage)7-11.44mg/l(during storage), sulphate(before storage)4.9-4.14mg/l(during storage)colour(before storage)5-25 tcu(during storage). The results indicated that all the physicochemical parameters analysed were within WHO standard except colour concentration for plain and black metals that deteriorated after ten days of storage. Statistically at 5% significant level, storage time affected all parameters except chloride and total hardness (indoor). Storage containers were not affected by Total Alkalinity, Total Hardness and Turbidity concentrations (outdoor). On locations, Total Suspended Solids (white plastic, blue plastic and plain metal), Total Solids (clay pot), Total Alkalinity (white plastic), Chloride (blue plastic and plain metal), Temperature (clay pot), Electrical Conductivity, pH, Sulphate and Colour (clay pot, white plastic, blue plastic, plain and black metal), Phosphate (clay pot) were significantly affected(indoor and outdoor). This study has shown that rain water should be stored in white plastic and blue plastic containers (indoor and outdoor) as time improves water quality during storage.*

***Keywords:*** *Rain water, Storage containers, Physicochemical parameters, Water quality*

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## I. INTRODUCTION

The global crisis of potable water shortage has sent man in search for new water resources and more intensively (Achadu *et al*., 2013). In Nigeria, it is commonly practice by individuals and households to keep or store water for domestic use especially where there is pressure on the water. Rainwater harvesting is necessary in places lacking rainfall, and it is an important source of fresh water especially for those who live in rural areas (Achadu *et al*., 2013). These areas of concern regarding the use of rainwater for either potable or non-potable applications, is the quality. Eniola *et al.*, (2007) opined that the quality of water may improve upon storage. With the growing popularity and use of rainwater harvesting system in Nigeria, more people are installing tanks, plastics, clay pots and rain barrels as a means of storage (Clayton, 2011). Rainwater harvesting system put the water users in charge of their supply and also responsible for water quality. Rainwater harvesting is an ancient practice of capturing rain runoff from roofs and other surfaces and storing it for a later or future use (Despins *et al*., 2015). However, during storage the quality parameters of water never remain constant as there are numerous reactions taking place in the stored water due to change in the environment, time, location (indoor or outdoor) and as well as the impacts from the material of construction used as storage containers or vessels (Ogbozige, 2015; Akubuenyi *et al*., 2013; Maggy *et al*., 2003; Agbede *et al*.,1995). Rainwater can be contaminated by

airborne pollutants during rainfall, on the roof drain surface, in the storage container, in the conveyance system, even within the distribution system and from the point of water user source (Clayton, 2011). However, contamination occurs primarily on the roof of a building system (Clayton, 2011). Once the water source is contaminated, the water quality remains poor and can even degrade over time as it remains in the storage and subsequently delivered to the point of use (Grayman *et al*., 2004). Some other factors, including mixing of water (Grayman *et al*., 2004), sunlight penetration (Clayton,2011), and Temperature of water (Spellman *et al*., 2000), determine the water quality during storage. Hence, it is important from a public health point of view to maintain the quality of drinking water during storage.

The aim of the present study is to investigate the effects of storage conditions of physicochemical parameters of rainwater in Awka, Anambra state, Nigeria.

## II. MATERIALS AND METHODS

### 2.1 Description of study area

Awka (Igbo: Oka) is the study area and state capital of Anambra State, Nigeria. The state lies between the co-ordinates of 6◦35' E to 7◦30'E and 5◦40'N to 6◦48N, with an estimated population of 301,657 thousand people according to the 2006 National population census of Nigeria. It has an approximate area of 199.1km (123.7m), by road, directed north of Port-Harcourt in the centre of the densely populated Igbo heartland in South East Nigeria. Awka is located between two major cities in Northern Igboland, Onitsha and Enugu. It has an average humidity of 80%, Mean Daily Temperature of 27˚C and Mean Annual Rainfall of 200cm.

### 2.2 Method of sampling and Collection of water samples

Rainwater sample was collected within Awka in Anambra state. The rainwater was collected from the roof drain of Nnamdi Azikiwe Universitiy Engineering Laboratoray, Awka, and the analysis was carried out in Civil Engineering Laboratoray at Nnamdi Azikiwe Universitiy, Awka. Prior to storage, all the containers were rinsed with distilled water and later with the water sample to be stored. The rainwater was stored in clay pots, white plastics, blue plastics, plain metals and black metals containers in the laboratory (indoor and outdoor). The water sample was stored for thirty eight days. Analyses were carried out using the water stored in these containers at intervals of three days.

### 2.3 Physicochemical parameters

The fresh rainwater as well as stored samples were analyzed for physico-chemical properties. Temperature and Electrical conductivity of the water samples were measured using HM digital EC meter aqua pro water tester. pH was done by electronic pH meter(JENWAY,2015). Turbidity was determined using Hanna turbidity meter. Total suspended solids, Total Dissolved Solids, Total Solids, Total Alkalinity, Total Hardness, Sulphate, Phosphate, Chloride and Colour were carried out as described by Standard Analytical Procedures for Analysis (1999).

**2.4 Statistical Analysis** All the data collected were analyzed statistically using analysis of variance (Two-factor without replication) Microsoft excel spread sheet 2007 version

## III. RESULTS AND DISCUSSION.

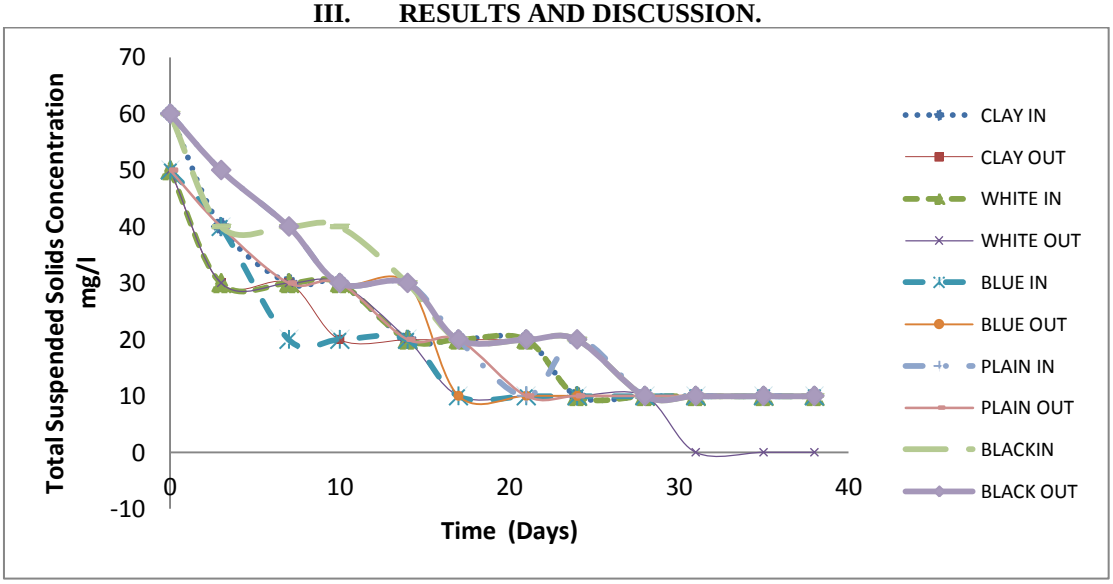


**Figure 1** Total Suspended Solids concentrations for rain water stored indoor and outdoor

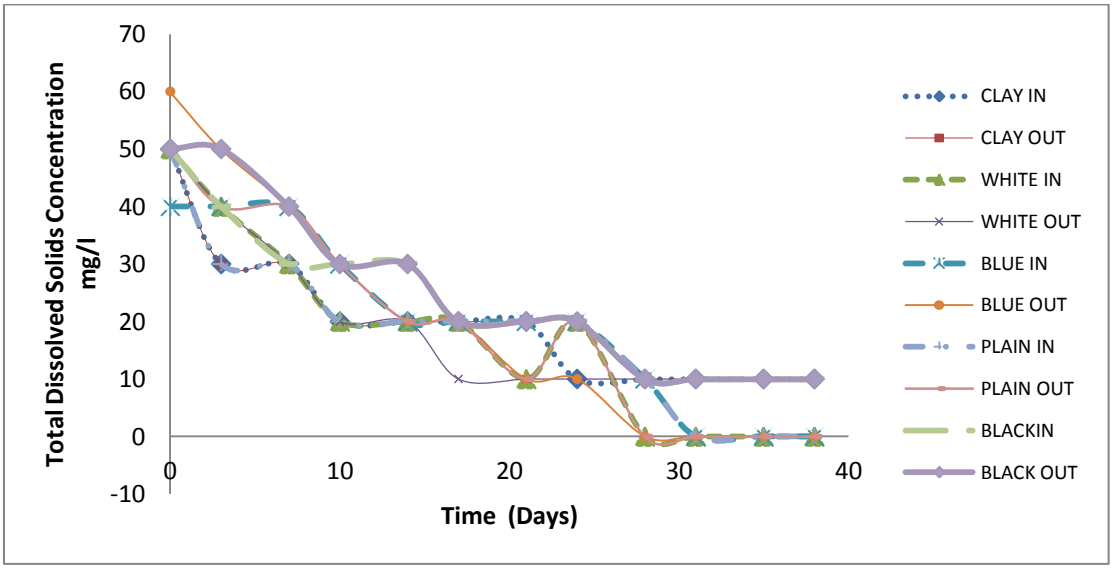


**Figure 2** Total Dissolved Solids concentrations for rain water stored indoor and outdoor

**KEY**: CLAY IN= Rainwater stored in clay pot stored indoor, CLAY OUT= Rainwater stored in clay pot stored outdoor, WHITE IN= Rainwater stored in white plastic indoor, BLUE IN= Rainwater stored in blue plastic indoor, BLUE OUT= Rainwater stored in blue plastic outdoor, PLAIN IN= Rainwater stored in plain metal indoor, PLAIN OUT= Rainwater stored in plain metal stored outdoor, BLACK IN= Rainwater stored in black metal indoor, BLACK OUT= Rainwater stored in black metal outdoor.

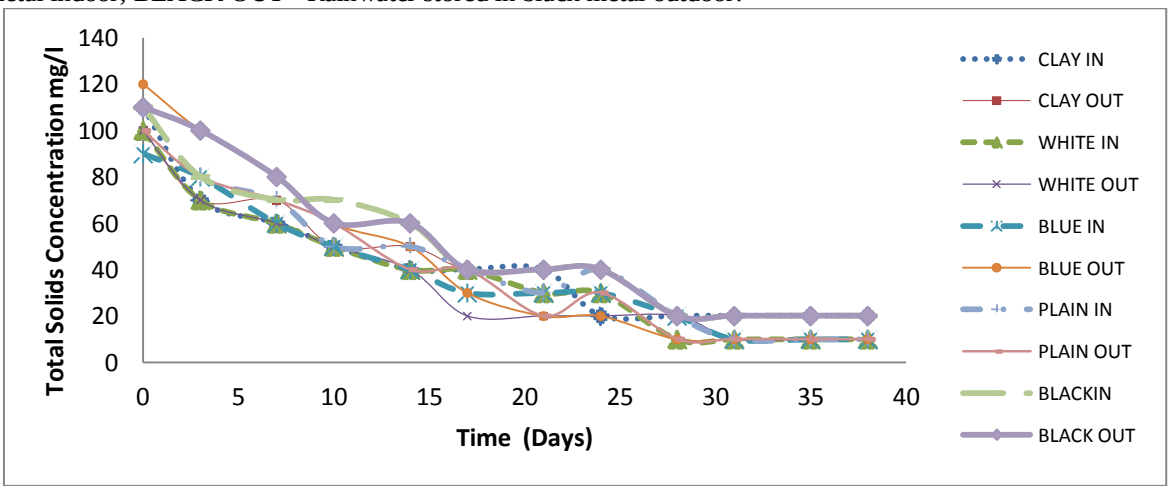


**Figure 3** Total Solids concentrations for rain water stored indoor and outdoor

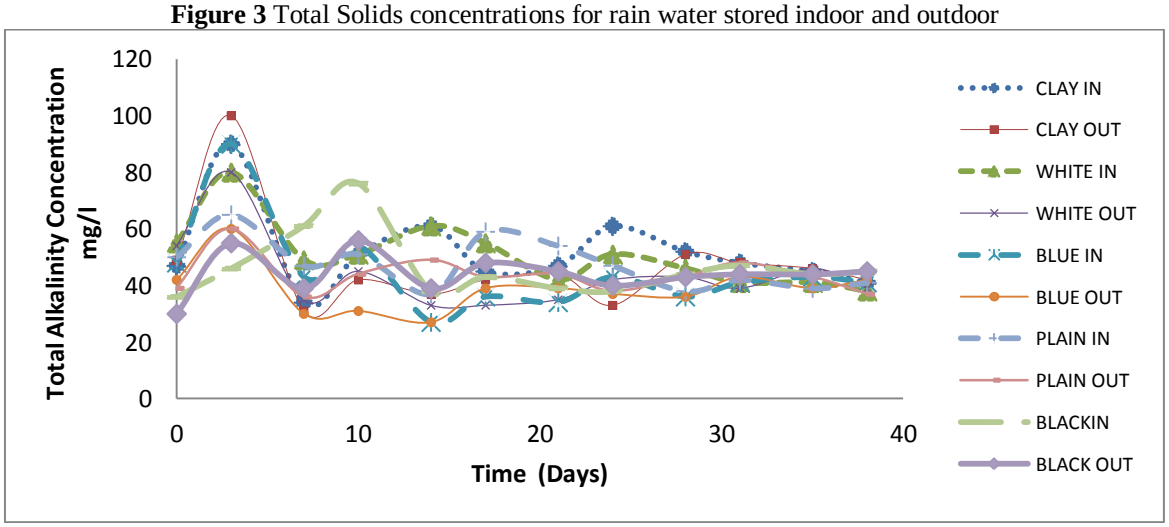


**Figure 4** Total Alkalinity concentrations for rain water stored indoor and outdoor

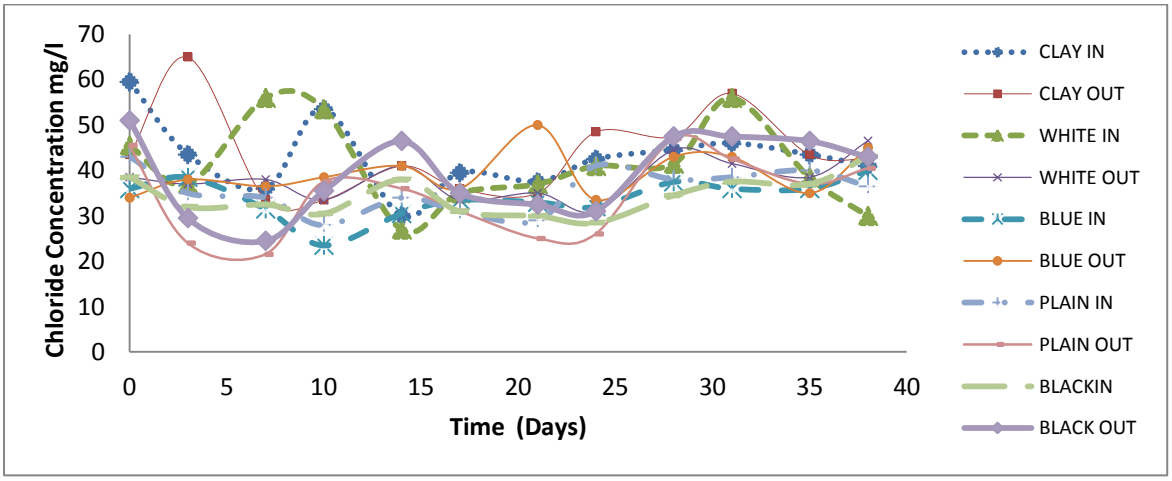


**Figure 5** Chloride concentrations for rain water stored indoor and outdoor

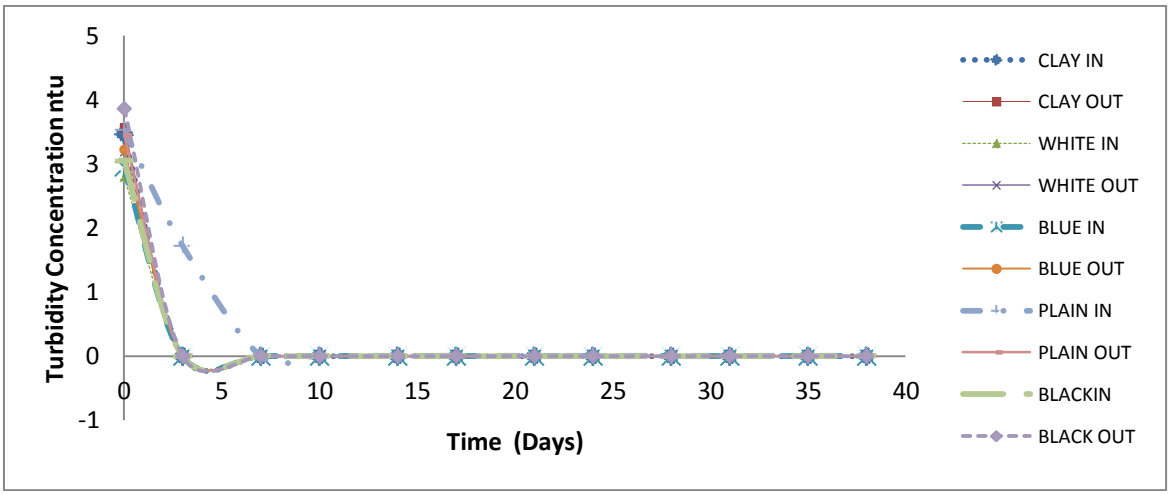


**Figure 6** Turbidity concentrations for rain water stored indoor and outdoor

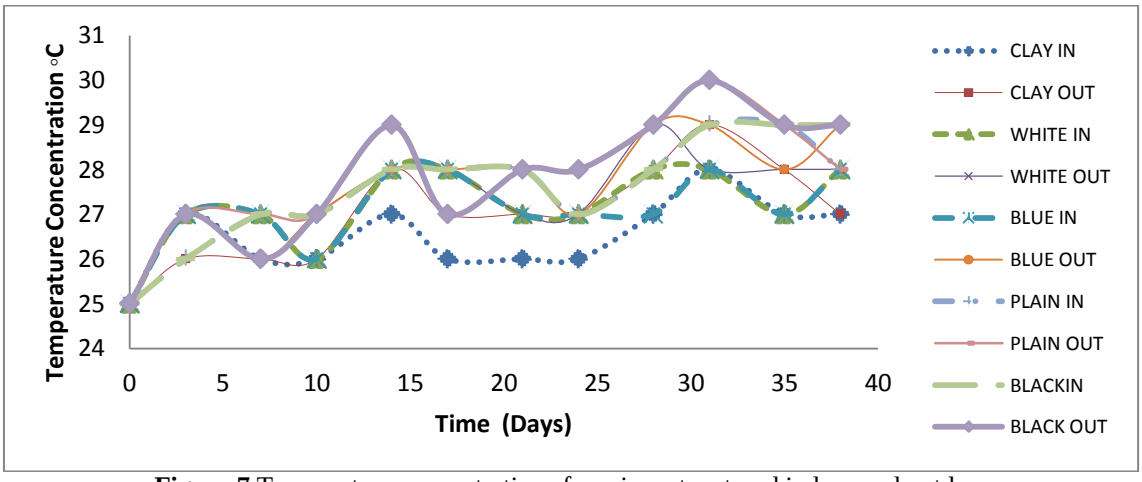


**Figure 7** Temperature concentrations for rain water stored indoor and outdoor

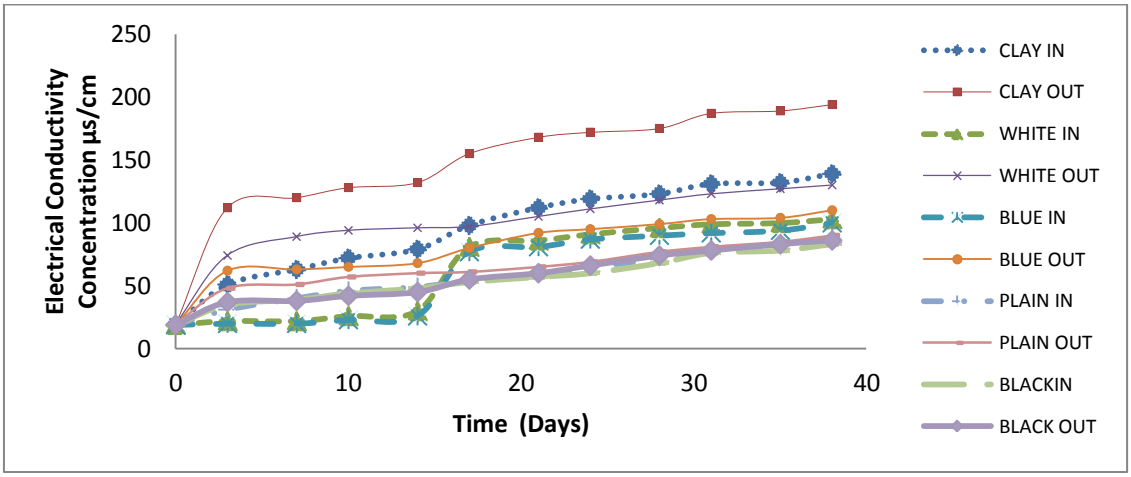


**Figure 8** Electrical Conductivity concentrations for rain water stored indoor and outdoor

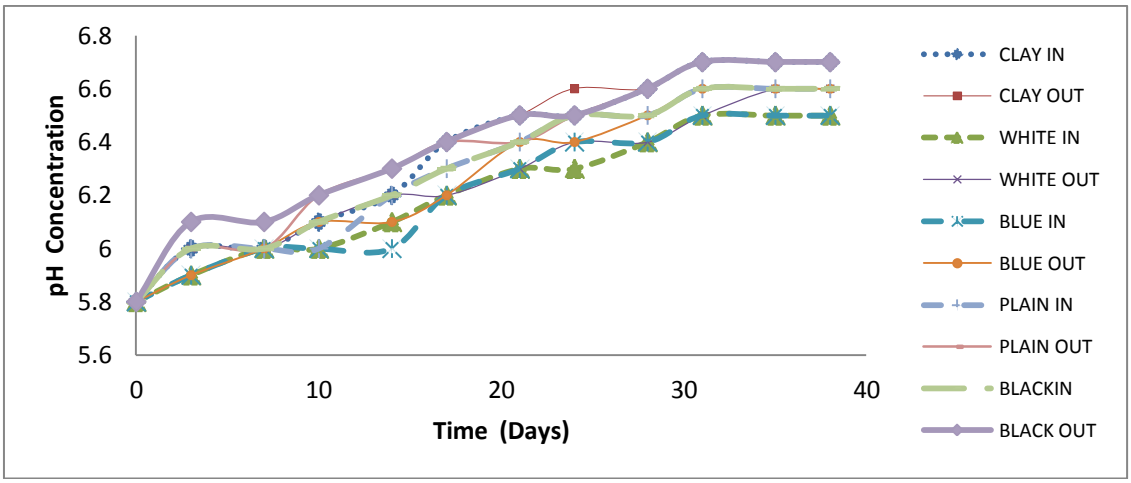


**Figure 9** pH concentrations for rain water stored indoor and outdoor

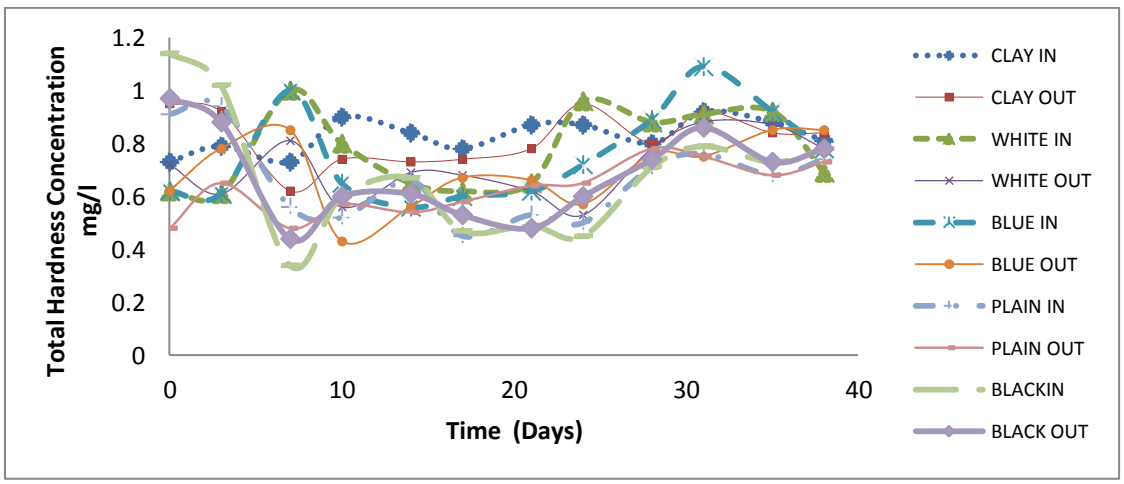


**Figure 10** Total Hardness concentrations for rain water stored indoor and outdoor

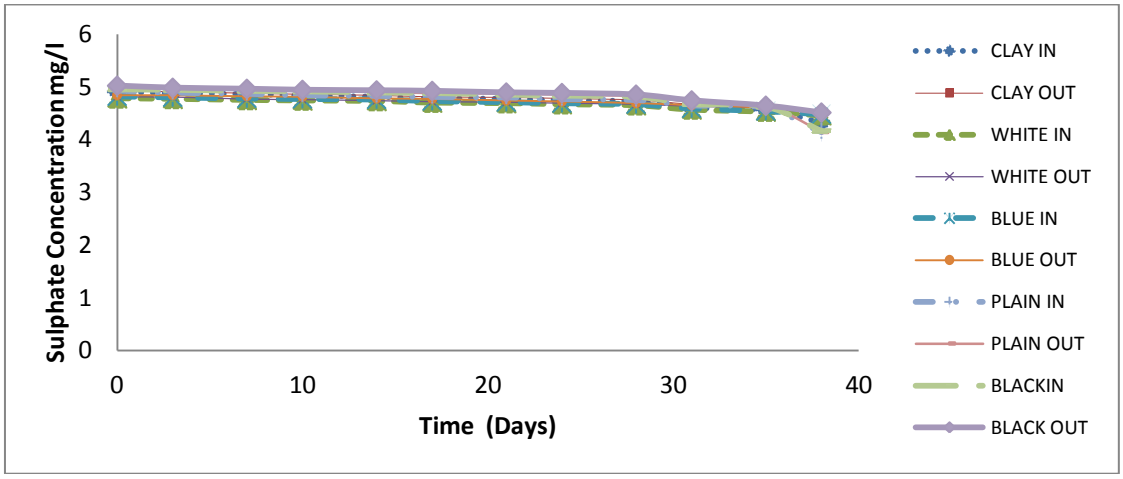


**Figure 11** Sulphate concentrations for rain water stored indoor and outdoor

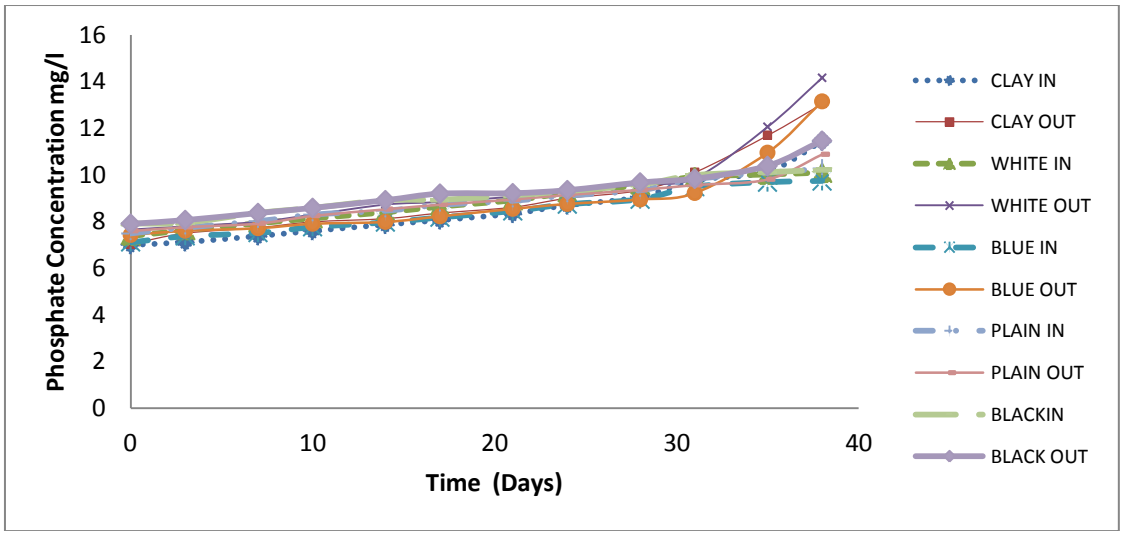


**Figure 12** Phosphate concentrations for rain water stored indoor and outdoor

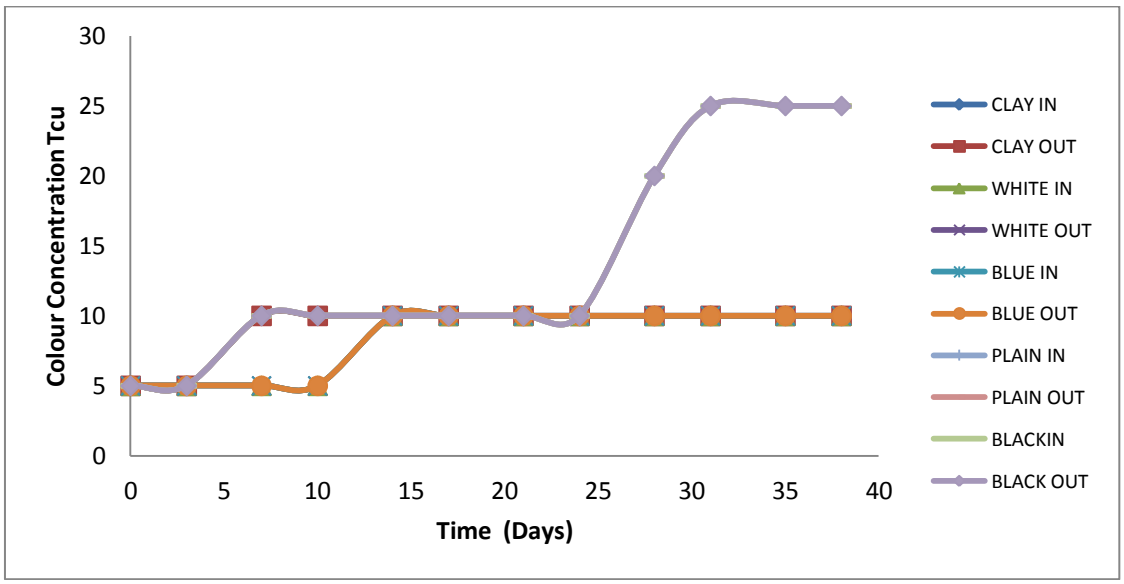


**Figure 13** Rainwater stored indoor and outdoor Colour concentrations

The rain water harvested and used for this research work was carefully collected from roof drain. The results shown in Figure 1 shows that there were improvement in Total Suspended Solids concentration with

respect to time for rainwater stored in each of the containers (indoors and outdoors). The results also indicated that there was reduction in total suspended solids concentration with time irrespective of the colour of containers or locations. The rain water stored in clay pot container (indoors) had a total suspended solids concentration range of 10mg/l to 60mg/l and had a total suspended solids concentration range of 10mg/l to 50mg/l (outdoors), it reduced from 60mg/l to 10mg/l after twenty one days of storage (indoors) and reduced from 50mg/l to 10mg/l after twenty four days of storage (outdoors), while the rainwater stored in white plastic container had a total suspended solids concentration range of 10mg/l to 50mg/l (indoors) and 0mg/l to 50mg/l (outdoors), it reduced from 50mg/l to 10mg/l after twenty four days of storage (indoors) and reduced from 50mg/l to 0mg/l after thirty days of storage (outdoors). Similarly, the rain water stored in blue plastic container had a concentration range of 10mg/l to 50mg/l (indoors) and 10mg/l to 60mg/l (outdoors), it reduced from 50mg/l to 10mg/l after eighteen days of storage (indoors) and reduced from 60mg/l to 10mg/l after twenty four days of storage (outdoors). The rainwater stored in plain metal container had a total suspended solids concentration range of 10mg/l to 60mg/l (indoors) and 10mg/l to 50mg/l (outdoors), it reduced from 60mg/l to 10mg/l after twenty days of storage (indoor) and reduced from 50mg/l to 10mg/l after twenty one days of storage (outdoors). The rainwater stored in black metal container had a total suspended solids concentration range of 10mg/l to 60mg/l (indoors and outdoors), it reduced from 60mg/l to 10mg/l after days of storage (indoors) and reduced from 60mg/l to 10mg/l after twenty four days of storage (outdoors). This is in agreement with the result obtained in similar study by Moses *et al*., (2016). The reduction observed in total suspended solids concentration each day of this study is due to the fact that, upon storage, big suspended or flocculated particles as well as other impurities settled down at the bottom of the storage containers thus reducing the total suspended solids (Ogbozige, 2015). In the same vein, the water quality showed improvement in terms of Total Dissolved Solids concentration with respect to time for rainwater stored (indoors and outdoors) in each of the containers. The results also indicated that there is reduction of total dissolved solids with time irrespective of the colour of containers or locations. The rainwater stored in clay pot and black metal had a total dissolved solids concentration range of 10mg/l to 50mg/l (indoors and outdoors), it reduced from 50mg/l to 10mg/l after twenty eight days of storage (indoors and outdoors), while the rainwater stored in white plastic had a total dissolved solids concentration range of 0mg/l to 50mg/l (indoors) and 10mg/l to 50mg/l (outdoors), it reduced from 50mg/l to 0mg/l after twenty seven days of storage (indoors) and it reduced from 50mg/l to 10mg/l (outdoors). The blue plastic container had a total dissolved solids concentration range of 0mg/l to 40mg/l (inside) and 0mg/l to 60mg/l (outside), it reduced from 40mg/l to 0mg/l after twenty seven days of storage (indoors) and it reduced from 60mg/l to 0mg/l after twenty four days of storage (outdoor), while the rain water stored in plain metal container had a total dissolved solids concentration range of 0mg/l to 50mg/l (indoors and outdoors), it reduced from 50mg/l to 0mg/l after twenty seven days of storage (indoors and outdoors). The total dissolved solids for the rain water stored in all the containers falls within WHO permissible limit of 600mg/l, which is in agreement with the result obtained in similar study by (Ubuoh *et al*., 2016). Moses *et al*., (2016), opined that dissolved solids can settle and deposit at bottom of container upon storage thereby reducing the levels of impurities present in water.

The results in Figure 3 show that there is improvement in water quality in terms of Total Solids concentration with respect to time for rainwater stored (indoors and outdoors) in each of the containers. The results also indicated that there is reduction of total solids with time irrespective of the colour of containers or locations. The rain water stored in clay pot and black metal container had a total solids concentration range of 20mg/l to 110mg/l (indoors and outdoors), it reduced from 110mg/l to 20mg/l after twenty four days of storage (indoors and outdoors), while white plastic container stored with rainwater had a concentration range of 10mg/l to 100mg/l (indoors and outdoors), it reduced from 100mg/l to 10mg/l after twenty one days of storage (indoors) and reduced from100mg/l to 10mg/l after eighteen days of storage (outdoors). The rainwater stored in blue plastic container had a total solids concentration range of 10mg/l to 90mg/l (indoors) and 10mg/l to 120mg/l (outdoors), it reduced from 90mg/l to 10mg/l after fifteen days of storage (indoors) and reduced from 120mg/l to 10mg/l after twenty days of storage (outdoors), while the rainwater stored in plain metal container had a concentration of 10mg/l to 110mg/l (indoors) and 10mg/l to 100mg/l (outdoors), it reduced from 110mg/l to 10mg/l after twenty days of storage (indoors) and reduced from 100mg/l to 10mg/l after twenty four days of storage (outdoor). The total solids reduced each day of this study as a result impurities that settled down at the bottom of the storage containers thus reducing the total solids as observed in total suspended solids and total dissolved solids in Figure 1 and 2.

The results in Figure 4 show the concentrations of Total Alkalinity present in the water samples stored in all the containers (indoors and outdoors). The total alkalinity concentrations reduced gradually each day of this study, which may be as a result of resistant to change in pH (Raymond, *et al*., 2013). The rainwater stored in clay pot, white plastic and blue plastic container had a total alkalinity concentration range of 27mg/l to 100mg/l (inside and outside), while the rainwater stored in plain metal and black metal container had a total alkalinity concentration range of 30mg/l to 76mg/l (indoors and outdoors) showing that the rain water has good buffering capacity (Ezekiel *et al*., 2010). This result also collaborates with the study of Moses *et al*.,(2016). The result in

Figure 5 shows the concentrations of Chloride present in the rainwater samples stored in all the containers (indoors and outdoors). The rainwater stored in clay pot, white and blue plastic container had a chloride concentration range of 26.99mg/l to 64.97mg/l (indoors and outdoors), while the rainwater stored in plain metal and black metal container had a concentration range of 21.49mg/l to 50.98mg/l (indoors and outdoors) and still falls within WHO permissible limit of 300mg/l. The result in Figure 6 shows that there is reduction in the Turbidity of rainwater samples stored in all containers (indoors and outdoors). The turbidity concentration for the rainwater stored in clay pot had a range 0NTU to 3.46NTU (indoors) and 0NTU to 3.56NTU (outdoors), it reduced from 3.46NTU (indoors) and 3.56NTU (outdoors) to 0NTU after three days of storage. The rainwater stored in white plastic had a concentration range of 0NTU to 2.79NTU (indoors) and 0NTU to 3.18NTU (outdoors), it reduced from 2.79 NTU to 0NTU (indoors) after three days of storage, and reduced from 3.18NTU to 0NTU after eight of storage (outdoors), while the rain water stored in blue plastic had a concentration range of 0NTU to 2.95NTU (indoors) and 0NTU to 3.22NTU (outdoors), it reduced from 2.95NTU (indoors) and 3.22NTU (outdoors) to 0NTU after eight days of storage. The rainwater stored in plain metal had a concentration of 0NTU to 3.53NTU (indoors) and 0NTU to 3.44NTU (outdoors), it reduced from 3.53NTU (indoors), and 3.44NTU (outdoors) to 0NTU after eight days of storage. The rainwater stored in black metal containers had a concentration range of 0NTU to 3.05NTU (indoors) and 0NTU to 3.86NTU (outdoors), it reduced from 3.05NTU (indoors), and 3.86NTU (outdoors) after eight days of storage. This result is in agreement with what was reported in similar study by Moses *et al*.,(2016) and Achadu *et al*.,(2013). The reduction observed is a result of the cloudiness or flocculated particles settle down in the container (Ogbozige, 2015). The Turbidity concentrations for the stored rainwater, falls within WHO permissible limit of 5NTU.

The result in Figure 7 shows the Temperature difference in the stored rainwater samples. The increase in temperature concentration for the rainwater stored (outdoors) is as a result of sunlight radiation, while the decrease observed (indoors) is as a result of cold Temperature during storage. However, the rainwater stored in clay pot, white plastic, blue plastic, plain and black metal containers had a Temperature concentration range of 25$^{o}$C to 30$^{o}$C, which is in agreement with the result reported in similar study by (Achadu *et al*., 2013). The Temperature reading was taking in between the hours of 10am to 12am each day of this study.

The result in Figure 8 shows that the Electrical Conductivity of the water samples stored in the containers (indoors and outdoors) increased each day of this study. This could be attributed to some electron fluctuation upon storage (Ravichandran *et al*., 2016; Maxwell *et al*.,2014; Ogbozige, 2015; Ezeribe *et al*., 2012).

The rainwater stored in clay pot container had Electrical Conductivity concentration range of 19µs/cm to 139µs/cm (indoors) and 19µs/cm to 194µs/cm (outdoors), while the rainwater stored in white and blue plastic containers had electrical conductivity concentration range 19µs/cm to 103µs/cm (indoors and outdoors), plain and black metal containers had electrical conductivity concentration range of 19µs/cm to 88µs/cm (indoors) and 19µs/cm to 88µs/cm (outdoors), which falls within WHO permissible limit of 1000µs/cm.

The rainwater stored in clay pot, white plastic, blue plastic, plain metal and black metal container had a pH range of 5.8 to 6.7 (indoors and outdoors) showing that the rain water is slightly acidic. This result is in agreement with what was reported by other researchers in similar study (Achadu *et al*., 2013; Emerole *et al*., 2015; Ubuoh *et al*., 2016). The slight increase in pH values might be due to some electron fluctuation upon storage (Ravichandran *et al*., 2016) as shown in Figure 9.

The results in Figure 10 suggest that storage of water in containers (indoors and outdoors) does not guaranty the improvement or deterioration of it total hardness quality. This is because the variation (increase or decrease) in the concentration in each of the storage container during the storage period were not chronological (Ogbozige, 2015). However, the rainwater stored in clay pot, white plastic, blue plastic plain and black metal containers had a total hardness concentration range of 0.44mg/l to 1.14mg/l (indoors and outdoors). This falls within WHO permissible limit 300mg/l. Sulphate for the rainwater stored in clay pot, white and blue plastic containers had a concentration range of 4.6mg/l to 4.84mg/l (indoors and outdoors) while plain and black metal containers had a Sulphate concentration range of 4.6mg/l to 5.02mg/l (indoors and outdoors) as shown in Figure 11. This falls within WHO permissible limit of 1000mg/l. This result are consistent with the findings of Achadu *et al*.,(2013) and Ubuoh *et al*.,(2016). In addition, the rainwater stored in clay pot, white plastic, blue plastic, plain and black metal container had a Phosphate had concentration range of 7.00mg/l to 14.15mg/l (indoors and outdoors), as shown in Figure 12.

The results in Figure 13 suggest that the Colour of the rainwater sample stored in all the containers (indoors and outdoors) maintained his quality apart from plain and black metal containers. However, the rainwater stored in clay pot, white plastic and blue plastic containers had a concentration range of 5TCU to 10TCU (inside and outside) which falls within WHO permissible limit of 15TCU, while the rainwater stored in plain and black metal containers had a concentration range of 5TCU to 20TCU (indoors and outdoors). The increase in colour after twenty-eight days of storage in plain and black metal containers can be attributed to the

rusting which might have resulted from reaction of iron in the container and oxygen present in the stored water (Ogbozige, 2015).

**Table1: Statistical evaluation of storage conditions on rain water physicochemical parameters at 5% significant level**

| Parameters | Source of variance | Type of storage container | F_Cal | F Critical | P_Value |
|---|---|---|---|---|---|
| Total Suspended Solids (Mg/l) | Time | Clay pot | 21.454 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | White plastic | 28.885 | 2.817 | 0.000 |
| | Location | | 7.857 | 4.844 | 0.017 |
| | Time | Blue Plastic | 21.533 | 2.817 | 0.000 |
| | Location | | 6.600 | 4.844 | 0.026 |
| | Time | Plain Metal | 35.971 | 2.817 | 0.000 |
| | Location | | 7.857 | 4.844 | 0.017 |
| | Time | Black Metal | 58.833 | 2.817 | 0.000 |
| | Location | | 0.000 | 4.844 | 1.000 |
| Total Dissolved Solids (Mg/l) | | | | | |
| | Time | Clay pot | 66.454 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | White plastic | 17.058 | 2.817 | 0.000 |
| | Location | | 0.647 | 4.844 | 0.438 |
| | Time | Blue Plastic | 17.500 | 2.817 | 0.000 |
| | Location | | 0.000 | 4.844 | 1.000 |
| | Time | Plain Metal | 22.830 | 2.817 | 0.000 |
| | Location | | 0.186 | 4.844 | 0.674 |
| | Time | Black Metal | 51.400 | 2.817 | 0.000 |
| Total Solids (Mg/l) | Location | | 2.200 | 4.844 | 0.166 |
| | Time | Clay pot | 1.120 | 2.817 | 0.392 |
| | Location | | 5.024 | 4.844 | 0.015 |
| | Time | White plastic | 56.146 | 2.817 | 0.000 |
| | Location | | 1.320 | 4.844 | 0.274 |
| | Time | Blue Plastic | 24.719 | 2.817 | 0.000 |
| | Location | | 1.736 | 4.844 | 0.214 |
| | Time | Plain Metal | 90.14 | 2.817 | 0.000 |
| | Location | | 3.142 | 4.844 | 0.103 |
| | Time | Black Metal | 70.941 | 2.817 | 2.817 |
| Total Alkalinity (Mg/l) | Location | | 0.647 | 4.844 | 4.844 |
| | Time | Clay pot | 7.713 | 2.817 | 0.001 |
| | Location | | 2.283 | 4.844 | 0.158 |
| | Time | White plastic | 5.283 | 2.817 | 0.005 |
| | Location | | 6.434 | 4.844 | 0.020 |
| | Time | Blue Plastic | 4.427 | 2.817 | 0.010 |
| | Location | | 3.541 | 4.844 | 0.086 |
| | Time | Plain Metal | 2.238 | 2.817 | 0.098 |
| | Location | | 2.383 | 4.844 | 0.150 |
| | Time | Black Metal | 2.902 | 2.817 | 0.045 |
| Chloride (Mg/l) | Location | | 0.765 | 4.844 | 0.400 |
| | Time | Clay pot | 1.356 | 2.817 | 0.310 |
| | Location | | 0.057 | 4.844 | 0.814 |
| | Time | White plastic | 0.740 | 2.817 | 0.686 |
| | Location | | 0.996 | 4.844 | 0.339 |
| | Time | Blue Plastic | 1.404 | 2.817 | 0.291 |
| | Location | | 9.591 | 4.844 | 0.010 |
| | Time | Plain Metal | 2.027 | 2.817 | 0.128 |
| | Location | | 0.265 | 4.844 | 0.616 |
| | Time | Black Metal | 3.816 | 2.817 | 0.017 |
| Turbidity (Ntu) | Location | | 6.757 | 4.844 | 0.024 |
| | Time | Clay pot | 4928.040 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | White plastic | 234.325 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | Blue Plastic | 522.207 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | Plain Metal | 16.798 | 2.817 | 0.000 |
| | Location | | 1.114 | 4.844 | 0.313 |
| | Time | Black Metal | 72.775 | 2.817 | 0.000 |

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|---|---|---|---|---|---|
| Temperature (°C) | Location | | 1.000 | 4.844 | 0.338 |
| | Time | Clay pot | 7.400 | 2.817 | 0.001 |
| | Location | | 6.600 | 4.844 | 0.026 |
| | Time | White plastic | 11.181 | 2.817 | 0.000 |
| | Location | | 1.000 | 4.844 | 0.338 |
| | Time | Blue Plastic | 6.380 | 2.817 | 0.002 |
| | Location | | 4.714 | 4.844 | 0.052 |
| | Time | Plain Metal | 13.857 | 2.817 | 0.000 |
| | Location | | 3.142 | 4.844 | 0.103 |
| | Time | Black Metal | 11.986 | 2.817 | 0.000 |
| Electrical Conductivity (µs/cm) | Location | | 1.320 | 4.844 | 0.274 |
| | Time | Clay pot | 27.998 | 2.817 | 0.000 |
| | Location | | 118.413 | 4.844 | 0.017 |
| | Time | White plastic | 7.478 | 2.817 | 0.000 |
| | Location | | 26.146 | 4.844 | 0.006 |
| | Time | Blue Plastic | 11.750 | 2.817 | 0.000 |
| | Location | | 14.866 | 4.844 | 0.002 |
| | Time | Plain Metal | 68.602 | 2.817 | 0.000 |
| | Location | | 23.921 | 4.844 | 0.004 |
| | Time | Black Metal | 184.580 | 2.817 | 0.000 |
| pH | Location | | 5.003 | 4.844 | 0.000 |
| | Time | Clay pot | 140.200 | 2.817 | 0.000 |
| | Location | | 7.857 | 4.844 | 0.017 |
| | Time | White plastic | 90.888 | 2.817 | 0.000 |
| | Location | | 11.000 | 4.844 | 0.006 |
| | Time | Blue Plastic | 111.171 | 2.817 | 0.000 |
| | Location | | 15.400 | 4.844 | 0.002 |
| | Time | Plain Metal | 81.214 | 2.817 | 0.000 |
| | Location | | 12.571 | 4.844 | 0.004 |
| | Time | Black Metal | 209.800 | 2.817 | 0.000 |
| Total Hardness (Mg/l) | Location | | 55.00 | 4.844 | 0.000 |
| | Time | Clay pot | 1.428 | 2.817 | 0.281 |
| | Location | | 0.055 | 4.844 | 0.817 |
| | Time | White plastic | 1.999 | 2.817 | 0.132 |
| | Location | | 2.100 | 4.844 | 0.175 |
| | Time | Blue Plastic | 3.785 | 2.817 | 0.018 |
| | Location | | 2.017 | 4.844 | 0.183 |
| | Time | Plain Metal | 1.313 | 2.817 | 0.329 |
| | Location | | 0.508 | 4.844 | 0.490 |
| | Time | Black Metal | 18.525 | 2.817 | 0.000 |
| Sulphate (Mg/l) | Location | | 0.008 | 4.844 | 0.927 |
| | Time | Clay pot | 335.055 | 2.817 | 0.000 |
| | Location | | 61.516 | 4.844 | 0.000 |
| | Time | White plastic | 142.977 | 2.817 | 0.000 |
| | Location | | 35.719 | 4.844 | 0.000 |
| | Time | Blue Plastic | 231.725 | 2.817 | 0.000 |
| | Location | | 81.031 | 4.844 | 0.000 |
| | Time | Plain Metal | 455.285 | 2.817 | 0.000 |
| | Location | | 113.457 | 4.844 | 0.000 |
| | Time | Black Metal | 16.994 | 2.817 | 0.000 |
| Phosphate (Mg/l) | Location | | 7.152 | 4.844 | 0.000 |
| | Time | Clay pot | 36.945 | 2.817 | 0.000 |
| | Location | | 11.085 | 4.844 | 0.006 |
| | Time | White plastic | 5.065 | 2.817 | 0.000 |
| | Location | | 3.271 | 4.844 | 0.090 |
| | Time | Blue Plastic | 6.030 | 2.817 | 0.002 |
| | Location | | 2.396 | 4.844 | 0.149 |
| | Time | Plain Metal | 68.923 | 2.817 | 0.000 |
| | Location | | 0.160 | 4.844 | 0.695 |
| | Time | Black Metal | 24.412 | 2.817 | 0.000 |
| Colour(Tcu) | Location | | 2.422 | 4.844 | 0.147 |
| | Time | Clay pot | 6553 | 2.817 | 0.000 |
| | Location | | 6553 | 4.844 | 0.000 |
| | Time | White plastic | 15.117 | 2.817 | 0.000 |
| | Location | | 11.000 | 4.844 | 0.000 |
| | Time | Blue Plastic | 15.117 | 2.817 | 0.000 |
| | Location | | 11.000 | 4.844 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| | Time | Plain Metal | 6553 | 2.817 | 0.000 |
| | Location | | 6553 | 4.844 | 0.000 |
| | Time | Black Metal | 6553 | 2.817 | 0.000 |
| | Location | | 6553 | 4.844 | 0.000 |

The Total Suspended Solids concentration for the rainwater stored in clay pot and black metal containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location, while the total suspended solids concentration for the rain water stored in white plastic, blue plastic and plain metal containers was significantly (P<0.05) affected by storage time and location as shown in table 1. However, the Total Dissolved Solids concentration for the rain water stored in all the containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location. Total Solids concentration for the rain water stored in clay pot container was not significantly (P>0.05) affected by storage time but was significantly (P<0.05) affected by storage location, while the total solids concentration for the rain water stored in white plastic, blue plastic, plain metal and black metal containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location. Total Alkalinity concentration for the rain water stored in clay pot, blue plastic and black metal was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location, while the rain water stored in white plastic storage container was significantly (P<0.05) affected by storage time and location in terms of total alkalinity concentration. Total Alkalinity concentration for the rain water stored in plain metal container was not significantly (P>0.05) affected by storage time and location as shown in table 1. Chloride concentration for the rain water stored in clay pot, white plastic and plain metal container was not significantly (P>0.05) affected by storage time and location, while the rain water stored in blue plastic container was not significantly (P>0.05) affected by storage time but was significantly (P<0.05) affected by storage location in terms of chloride concentration. However, the rain water stored in black metal container was significantly (P<0.05) affected by storage time and location in terms of chloride concentration. Turbidity concentration for the rain water stored in all the containers was significantly (P>0.05) affected by storage time but was not significantly (P>0.05) affected by storage location. The Temperature of the rain water stored in clay pot container was significantly (P<0.05) affected by storage time and location, while the temperature of the rain water stored in white plastic, blue plastic, plain and black metal containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location. Electrical Conductivity and pH concentrations of the rain water stored in all storage containers were significantly (P<0.05) affected by storage time and location as shown in table 1. Total Hardness concentration for the rain water stored in clay pot, white plastic and plain metal containers was not significantly (P>0.05) affected by storage time and location, while the rain water stored in blue plastic and black metal containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location. Additionally, the concentration of Sulphate and Colour for the rain water stored in all the storage containers was significantly (P<0.05) affected by storage time and location. Furthermore, the concentration of phosphate for rain water stored in clay pot container was significantly (P<0.05) affected by storage time and location, while the rain water stored in white plastic, blue plastic, plain metal and black metal containers was significantly (P<0.05) affected by storage time but was not significantly (P>0.05) affected by storage location as shown in table 1.

**Table2: Statistical variation of storage time and container type for physicochemical parameters of stored rain water (indoors) at 5% significant level**

| Parameters | Source of variation | F_Cal | F Critical | P-Value |
|---|---|---|---|---|
| Total Suspended Solids (Mg/l) | Time | 59.164 | 2.014 | 0.000 |
| | Containers | 6.265 | 2.583 | 0.000 |
| Total Dissolved Solids (Mg/l) | Time | 50.563 | 2.014 | 0.000 |
| | Containers | 3.142 | 2.582 | 0.000 |
| Total Solids (Mg/l) | Time | 150.441 | 20.014 | 0.000 |
| | Containers | 9.045 | 2.583 | 0.000 |
| Total Alkalinity (Mg/l) | Time | 4.424 | 2.014 | 0.000 |
| | Containers | 1.159 | 2.583 | 0.341 |
| Chloride (Mg/l) | Time | 1.769 | 2.014 | 0.089 |
| | Containers | 5.849 | 2.583 | 0.000 |
| Turbidity (Mg/l) | Time | 74.025 | 2.014 | 0.000 |
| | Containers | 1.525 | 2.583 | 0.211 |

| | | | | |
|---|---|---|---|---|
| Temperature(°C) | Time | 16.597 | 2.014 | 0.000 |
| | Containers | 8.700 | 2.583 | 0.000 |
| Electrical Conductivity(Mg/l) | Time | 32.839 | 2.014 | 0.000 |
| | Containers | 24.488 | 2.583 | 0.000 |
| pH | Time | 232.511 | 2.614 | 0.000 |
| | Containers | 28.293 | 2.583 | 0.000 |
| Total Hardness (Mg/l) | Time | 1.560 | 2.014 | 0.143 |
| | Containers | 2.187 | 2.583 | 0.085 |
| Sulphate (Mg/l) | Time | 30.250 | 2.014 | 0.000 |
| | Containers | 5.652 | 2.583 | 0.000 |
| Phosphate (Mg/l) | Time | 67.811 | 2.014 | 0.000 |
| | Containers | 11.805 | 2.583 | 0.000 |
| Colour(Tcu) | Time | 5.848 | 2.014 | 0.000 |
| | Containers | 7.024 | 2.583 | 0.000 |

The Total Suspended Solids, Total Dissolved Solids and Total Solids concentration for the rain water stored in all the storage containers indoors were significantly ($p<0.05$) affected by storage time and containers type as shown in table 2. However, Total Alkalinity concentration for the rain water stored in all the storage containers indoors was significantly ($p<0.05$) affected by storage time but was not significantly ($P>0.05$) affected by storage container type. Chloride concentration for the rain water stored in the entire storage container indoors was not significantly ($p>0.05$) affected by storage time but was significant ($p<0.05$) by storage container type as shown in table 2. Turbidity concentration for the rain water stored in the entire storage containers indoors was significantly ($P<0.05$) affected by the storage time but was not significantly ($P>0.05$) affected by storage container type. Temperature, Electrical Conductivity and pH concentrations for the rain water stored in the storage containers indoors were significantly ($p<0.05$) affected by storage time and container type. Furthermore, Sulphate, Phosphate and Colour concentration for the rain water stored in all the storage containers were significantly ($p<0.05$) affected by storage time and container type. Total Hardness was not significantly ($P>0.05$) affected by storage time and container type for the rain water stored in all containers as shown in table 2.

**Table3: Statistical variation of storage time and container type for physicochemical parameters of stored rain water (outdoors)**

| Parameters | Source variation | F-cal | F critical | P-value |
|---|---|---|---|---|
| Total Suspended Solids (Mg/l) | Time | 54.905 | 2.014 | 0.000 |
| | Containers | 6.932 | 2.583 | 0.000 |
| Total Dissolved Solids (Mg/l) | Time | 63.303 | 2.014 | 0.000 |
| | Containers | 4.820 | 2.583 | 0.000 |
| Total Solids(Mg/l) | Time | 99.636 | 2.014 | 0.000 |
| | Containers | 7.947 | 2.583 | 0.000 |
| Total Alkalinity(Mg/l) | Time | 7.611 | 2.014 | 0.000 |
| | Containers | 1.920 | 2.583 | 0.123 |
| Chloride (Mg/l) | Time | 2.988 | 2.014 | 0.004 |
| | Containers | 3.225 | 2.583 | 0.020 |
| Turbidity(Ntu) | Time | 778.639 | 2.014 | 0.000 |
| | Containers | 1.000 | 2.583 | 0.417 |
| Temperature(°C) | Time | 35.809 | 2.014 | 0.000 |
| | Containers | 7.641 | 2.583 | 0.000 |
| Electrical Conductivity(Mg/l) | Time | 24.672 | 2.014 | 0.000 |
| | Containers | 91.008 | 2.583 | 0.000 |
| pH | Time | 230.329 | 2.014 | 0.000 |
| | Containers | 28.428 | 2.583 | 0.000 |
| Total Hardness(Mg/l) | Time | 3.281 | 2.014 | 0.002 |
| | Containers | 5.307 | 2.583 | 0.001 |

| | | | | |
|---|---|---|---|---|
| Sulphate(Mg/l) | Time<br>Containers | 29.514<br>12.827 | 2.014<br>2.583 | 0.000<br>0.000 |
| Phosphate(Mg/l) | Time<br>Containers | 40.444<br>2.947 | 2.014<br>2.583 | 0.000<br>0.030 |
| Colour(Tcu) | Time<br>Containers | 5.163<br>5.302 | 2.014<br>2.583 | 0.000<br>0.001 |

The Total Suspended Solids, Total Dissolved Solids and Total Solids concentration for the rain water stored in the entire storage containers (outside) were significantly ($P<0.05$) affected by storage time and container type as shown in table 3. However, Total Alkalinity, Chloride and Turbidity concentration for rain water stored in all the storage containers (outside) was significantly ($p<0.05$) affected by storage time but was not significantly ($P>0.05$) affected by storage container type as shown in table 3. Furthermore, Temperature, Electrical Conductivity, pH, Total Hardness, Sulphate, Phosphate and Colour concentration for rain water stored in all the storage containers (outside) was significantly ($P<0.05$) affected by storage time container type.

## IV. CONCLUSION

The present study focused on the effects of storage conditions on physicochemical parameters of rain water in Awka, Anambra state, Nigeria. Storing of rain water was found desirable as it improved the water quality upon storage with respect to time. All physiochemical parameters were significantly affected by storage time (inside and outside), except Chloride and Turbidity, while Total Alkalinity, Total Hardness (inside and outside) and Turbidity (outside) were significantly affected by storage containers. Storage location had a significant effect on Total Suspended Solids (white plastic, blue plastic and plain metal), Total Solids (clay pot), Total Alkalinity (white plastic), Chloride (blue plastic and plain metal), Temperature (clay pot), Electrical Conductivity, pH, Sulphate and Colour (clay pot, white plastic, blue plastic, plain and black metal), Phosphate (clay pot). Consequently it is being recommended that rain water should be stored in white plastic and blue plastic containers (indoors and outdoors).

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