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EFFECT OF STORAGE CONTAINERS ON THE QUALITY OF DRINKING WATER.

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ABSTRACT

The essentials of water in sustaining life, and the need for it to be adequate, safe and accessible to human and animals cannot be over-emphasized. However, the deteriorating quality of such water after some period of storage is of great concern. Hence the need to investigate the cause of this quality deterioration with respect to the storage facility used. This study therefore is aimed at determining the quality of water during storage in different container materials for a period of four weeks. The container materials used were plastic container (PC), metallic container (MC) and Earthen pot (EP). Water quality parameters examined were Temperature, Color, Total suspended solids, Electrical Conductivity (EC), Chemical oxygen demand (COD), Biological Oxygen Demand (BOD), pH, Magnesium (Mg 2+) Calcium (Ca 2+), Turbidity, Total dissolved solids, Iron (Fe), Electrical conductivity, Hardness and Escherichia coli (E-coli). Samples were taken at 7days interval and the results obtained showed that earthen pot EP preserved water quality better than other containers. It was concluded that earthen pot EP better preserved water quality during storage compared to plastic container (PC), metallic container (MC). Results show that although there is no significant difference in physical and chemical water quality of plastic container (PC), metallic container (MC) and Earthen pot (EP) there is a difference in microbial contamination as measured by E. Coli counts.

Keywords; Quality, Contamination, Storage, Parameters, Significant**.**

INTRODUCTION

The storage of potable water is of great concern to most households. Water is essential to sustain life, and a satisfactory, adequate, safe and accessible supply must be available to all. Improving access to safe drinking water can result in tangible benefits to health (WHO 2006) The quality of drinking-water may be controlled through a combination of its treatment, storage and management. The type of storage vessel has a great impact on the quality of stored water with respect to time and other environmental conditions. This however has not been given much attention at household level and it may be responsible for most disease conditions affecting the populace (Sobsey, et al; 2003, Trevett, 2005).

Water has always been an essential and life-sustaining resource to humans as well as survival of all organisms. It is vital in metabolic processes and serves as a solvent for many bodily solutes. Though water makes a major fraction of the earth surface, a large amount of it is not available to humans in a form that can readily be used, as a source of drinking water or for other purposes. The human body is made up of over 70% of water. Where piped water supply to the home operates occasionally, storage facilities are frequently used to guarantee that there is enough water for the family needs all through the day (Akuffo et al 2013). Water age is a major factor in water quality drop within the distribution and storage systems. Most times the public are of the impression that piped water has a high quality, though it can be potentially deteriorated (biological and chemical) in distribution and storage systems (AWWA 2007). Many microbial and chemical constituents of drinking water can potentially cause adverse human health effects WHO (2006). Water storage vessel are critical component of distribution systems, yet can pose significant challenge for water utilities as they may have a negative impact on water quality. The presence of colonies in stored drinking water may show that the water either contaminated during distribution, storage, or the treatment process was not sufficient to eliminate microorganisms. This is a problem in developing countries where microbial contamination of protected drinking water is widespread. The term “protected water” made international estimates to greatly overstate access to safe drinking water and call for enhanced monitoring strategy combining indicators of sanitary protection with measures of water quality (Bain et al. 2014).

According to Booker (2014), water is said to be potable when the physiochemical and bacteriological properties fall within the limits specified by the World Health Organization (WHO). However, the percentage of the total available water in the world that is potable is very minute (Nala and Jagals, 2013). Developing countries are usually faced with the challenge of interrupted power supply (Kuma *et al.,* 2014). This affects the supply of water to consumers by Water Works Departments owned by governments or institutions. The effect is more in the rural communities where electricity is not even available for pumping of water. Hence, it has been a common practice to store rain water, borehole water, stream water and other sources of potable water in large containers so as to ensure continuity in supply during interruption or disaster (Ogbozige et al 2015).

Common water storage containers used in developing countries are made of steel, plastic and clay (Adeleke, 2012). These container materials are all sanctioned to be used for water storage by various standards such as the Standard Organization of Nigeria (SON). Nevertheless, water quality deteriorates with time in certain plastic container materials such as bottled water when exposed to sun. In addition, the maximum retention period for storing water in container materials is not usually stated by manufacturers. Hence, this research aimed at investigating the impact of storage container materials to water quality, as well as understanding the maximum retention period for storing water in any of them.

Radha and Susheela (2015) carried out a comparative microbiological analysis of water stored in different storage vessels. The impact of storage of lake water in various vessels like plastic, mud, copper and tempered steel was concentrated by looking at the quantity of coliforms present in the water when storage. Akuffo et al., (2013) did an evaluation of the nature of water when storage in the Nyankpala Community of the Tolo - Kumbungu District, Ghana. Colour, turbidity and total iron levels recorded in stored water in metallic holders were higher than W.H.O standard for consumable water. In spite of the fact that tap water recorded no coliform microscopic organisms during the examination time frame, stored water broke down from all storage offices recorded coliform microorganisms.

The presence of coliform microorganisms in stored water presumably came about because of unhygienic water handling practices. Water stored in PC recorded the most significant levels of coliform microscopic organisms during the investigation time frame. EP storage offices recorded lower coliform levels because they have narrow nozzles which make access to water more difficult compared to that of PC and MC which has wide openings at the top and that there was a huge contrast between the quantities of microorganisms at first present in the water and those present after storage for 15 days at encompassing temperature. There was a significant difference between chemical parameters initially measured in the water and those measured after storage for 15 days at ambient temperature.

Trevett et al., (2005) studied about "the significance of domestic water quality management with regards to fecal–oral infection transmission". It is shown that significant proof of infection transmission from once again debased drinking water exists. Specifically, the type of storage container and hand contact with stored drinking water has been related with expanded occurrence of diarrheal illness.

Temperature of the stored water is an important influence on the growth rate of bacteria that have survived treatment processes. Various field studies have shown that significant bacteria growth can occur in water of 15°C or higher (Fransolet et al., 1985; Smith et al., 1989; Donlan et al., 1994 from LeChevallier et al., 1996).

Microbial re-growth in potable water supplies is often a problem that is intensified by household water storage practices. A laboratory study found that factors such as long retention times of 4 to 7 days, low or no chlorine residual and temperatures above 15°C have all been shown to increase microbial re-growth in commonly used 1000litres fiberglass, polyethylene and cast-iron household storage tanks (Evison and Sunna,2001). This study also found that water temperature inside the tank and tank age were the parameters most important for bacterial growth and were responsible for 77.7% of the heterotrophic plate count values measured for water stored for 4 days (Evison and Sunna, 2001).

Furthermore, this study did not find significant variations in HPC counts or in physical and chemical parameters between the different tank types tested (polyethylene, fiberglass and cast iron). However, it did find that the bacteria within the different tanks did differ, most likely due to differences in water temperature and light penetration (Evison and Sunna, 2001).A separate laboratory study looking at the effects of cast iron and black polyethylene household storage tanks (1000L capacity) found that the stored water deteriorated significantly ($p = \leq 0.05$) microbiologically after 7 days of storage in both types of storage tanks, but did not find a significant difference in HPC counts between the two types of storage tanks. HPC counts varied seasonally, with the highest levels being measured during the summer months.

These containers were either made of plastic or clay and had either wide openings in which water was ladled or dipped out or narrow openings in which water was poured. Residence time was determined simply by asking the female head of household the last time water was collected; no specific times were reported. Due to the small size of the water storage containers (~25 L) this study's author believes the residence times to have been relatively short (< 1 day). This indicates that contamination was occurring between the point of supply and consumption and that the bacteria were able to grow within the household storage container. Clasen et al, (2003) noted that intervention studies that employ a 3-part intervention program involving a narrow mouth storage container with spigots that prevent hands from entering container; point-of-use disinfection; and community hygiene education have led to reductions in waterborne disease incidence. This agrees with the results from Trevett et al., (2005), CDC (2002). which found that the type of storage container that have contact of hands with the stored water were associated with increased diarrheal disease incidence.

MATERIAL AND METHODS

Sample Collection.

The water samples were collected from a tap point located at Abubakar Tafawa Balewa University of Technology Bauchi using a thoroughly washed jerry-can, it was then analyzed in accordance with APHA (2012) method to determined its physical, chemical and biological parameters. The analyzed sample was immediately stored in the storage vessels (Plastic PP, Earthen pot EP and metallic MC) vessels.

Sample analysis

To measure TSS, the water sample was filtered through a pre weighed filter. The residue retained on the filter was air dried for 24 hours until the weight of the filter no longer changes. The increase in the weight of the filter represents the total suspended solids. A colorimeter was used based on APHA standard to measure color and turbidity. A sample cell (the blank) is filled with 25ml of de-ionized water. The apparatus (colorimeter) was set to a program number for APHA color and another sample cell (the prepared sample) was also filled with a 25ml of the sample. The blank was place into the cell holder and tightly covered with the instrument cap and the instrument Zeroed. The prepared sample was afterwards placed into the cell holder, tightly covered and the read button pressed to give the color value of the sample.

A sample cell (the blank) was filled with 10ml of de-ionized water. The apparatus (colorimeter) was set to a program number for APHA turbidity and another sample cell (the prepared sample) was also filled with a 10ml of the sample. The blank was place into the cell holder and tightly covered with the instrument cap and the instrument Zeroed. The prepared sample was afterwards placed into the cell holder, tightly covered and the read button pressed to give the turbidity value of the sample.

Volumetric analysis method was used in determining total hardness ($CaCO_3$) and chemical oxygen demand (COD).

Total Hardness ($CaCO_3$) was then examined Reagents were prepared then 100ml of water sample was pipette into a 250ml conical flask. 1ml of buffer solution was added, swirled and 3 drops of indicator added. Titrate against 0.02N EDTA solution until change of color odor occurs. Standardize the EDTA solution against the standard calcium solution using 10ml portion to check EDTA titre. Dilute the 10ml to 50ml in water.

Chemical Oxygen Demand was determined from titration factor of $KMnO_4$ solution by boiling 100ml distilled water after adding anti-bump granules and 5ml sulfuric acid. After which $KMnO_4$ solution was added until weakly pink color appears. Add 20ml oxalic acid from pipette again with $KMnO_4$ until weakly pink.

100ml of sample in an Erlenmeyer flask was taken and a, 5ml sulfuric acid was added to it, and boiled for 5minutes. 20ml of $KMnO_4$ solution from a pipette and allowed to simmer for 10 minutes. 20ml of oxalic acid was added and the mixture heated until the color completely disappears. The solution was then titrated with $KMnO_4$ until colour turned pink.

Biological Oxygen Demand (bod) was determined by preparing water at the rate of 1000 to 1200ml per dilution. with water temperature at 20^0C. The dilution resulted in a sample with residue DO_5

Ph, EC, TDS and temperature were determined by dipping the Ph probe into the sample tested; The sample was briefly stirred and after a couple of minutes their values were displayed respectively and recorded.

To determine the E-coli, a media was prepared by measuring 100ml of distilled water and then add 4.8grams of Mac-conkey Agar into the water and shaken. After incubation period of 24 hours, the bacteria count was taken.

Atomic Absorption Spectrophotometer (AAS) was used to determine the ion content such as iron (fe), calcium (ca), and magnesium (mg) concentration after digesting upon the introduction of HNO_3 (Nitric acid) in other to expose the metals therein.

RESULT AND DISCUSSIONS.

Results

For each of the water quality parameter examined, the results obtained after the storage period elapsed at 28days are presented in figure 1, 2 and 3 below. Analysis of variance ANOVA was used to determined levels of significance in using the respective storage containers. The changes that occurred during storage are discussed accordingly.

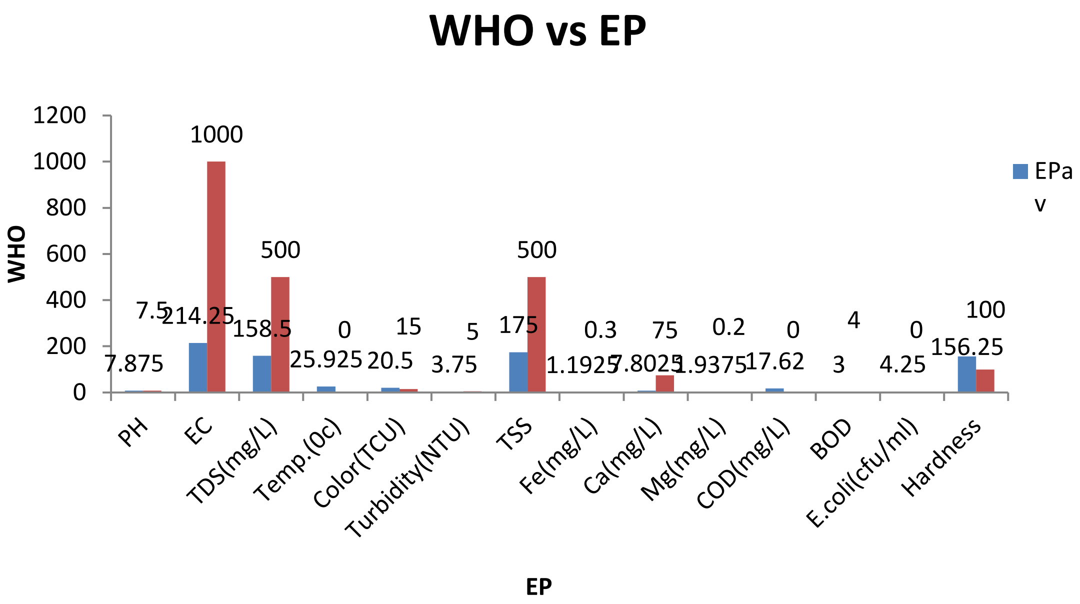

Fig. 1: EP parameters vs WHO

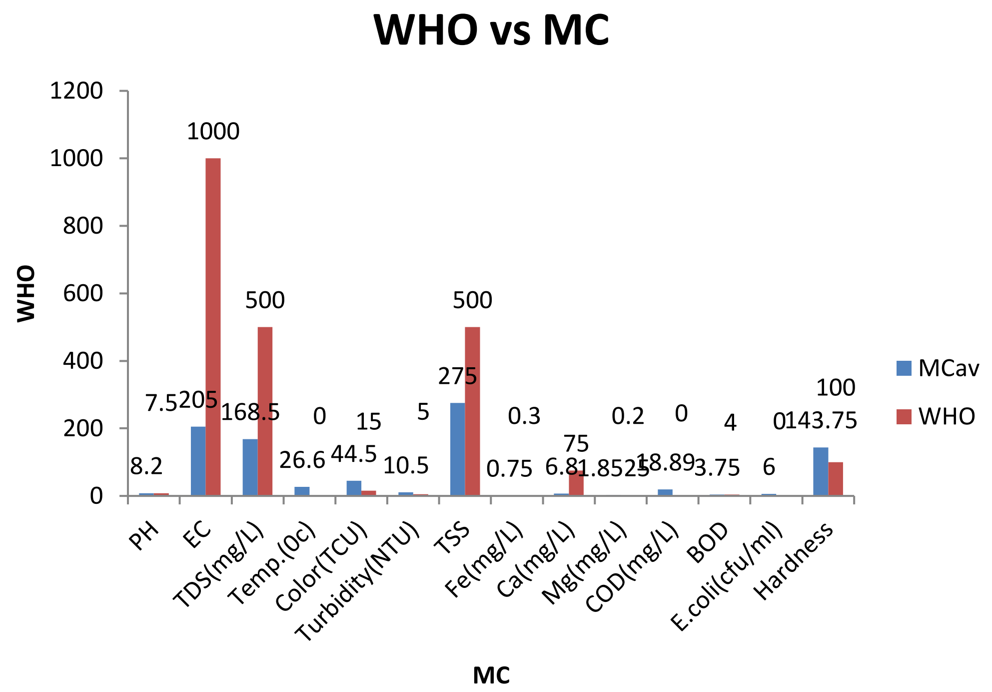

fig.2: MC parameters vs WHO

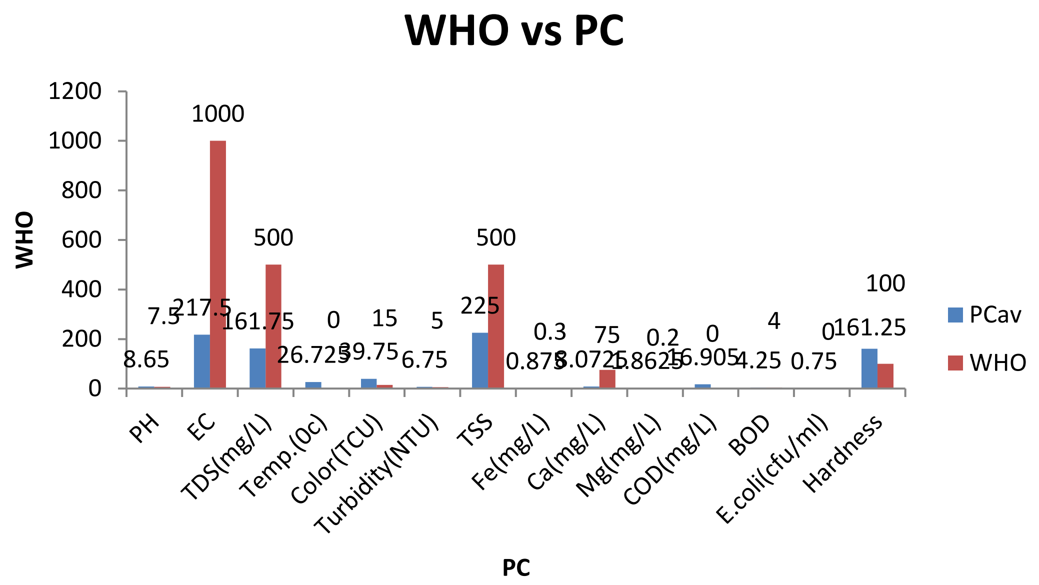

Fig 3: PC parameters vs WHO

Result Discussion.

The initial pH value prior to storage for the control was 8.4 which are within the acceptable limit as approved by W.H.O standard. Nevertheless, during the storage period, there were instances in which the pH values recorded were outside the range of the permissible limits set by WHO (6.5-8.5). This variation in pH from the permissible limits were more noticeable in water stored in Metallic vessel (MC) and Plastic Vessel (PC) as can be observed in figure 1 that, there was a significant rise in the pH during the seventh (7th) day of retention. This might be as a result of the pollutants or unwanted chemicals are present from the type of material used to store the water for the first time.

A statistically insignificant association was observed in comparing the mean PH values of water samples from EP, MC and PC with the control ($p>0.05$).

Before storage, the initial electrical conductivity (EC) value of the control was 230µs/cm, this revealed that the EC concentrations for all the water stored irrespective of the vessel used were within WHO standard (1000 µS/cm).

A statistically insignificant association was observed in comparing the mean EC values of water samples from EP, MC and PC with the control ($p>0.05$).

Prior to storage the value of TDS for the control was 167mg/l. Table 3 showed that TDS at some point increase above the value of the control which could be as a result of the material shedding some particles into the water stored in them. Nevertheless, the values for the TDS for all the Storage vessels fell within the standard given by WHO (500mg/l).

A statistically insignificant association ($p>0.05$) was observed in comparing the mean TDS values of water samples from EP, MC and PC.

Temperature measurements were taken at about 1pm on each day of the analysis. The temperature of the control was 27^0C.figure 1 shows some variations in the values which will may be as a result of the ambient temperature of the environment. While EP gave the lowest temperature of 25.6^oC. Clay pots work on the process of vaporization. When you pour water into an earthen pot, the clay of the vessel absorbs the heat of the water and it evaporates, thereby keeping it cool.

A statistically insignificant association was observed in comparing the mean Temperature values of water samples from EP, MC and PC with the control ($p>0.05$).

The color of the control was 23TCU before storage which exceeds the acceptable limit by W.H.O Standard. The three storage containers show that the water color in all the reservoirs increased on the first week. Also, the maximum value recorded in these reservoirs was 89 TCU, which is much larger than the permissible limit set by W.H.O Standard (15 TCU), indicating that the water stored in these vessels are not okay in terms of coloration.

A statistically significant association was observed in comparing the mean EC values of water samples from EP,

MC and PC

The turbidity of the control was 5 NTU as shown in table 6 which met the turbidity level set by W.H.O standard (5 NTU). As seen in fig.1, the turbidity of water stored in MC and PC increased excessively during the 14th and 21st day of the storage period with values higher than the permissible limit set by W.H.O Standard. On the other hand, turbidity values recorded in the EP fell within the required limit. The high values of turbidity recorded in MC are as a result of the high coloration of the water, which might have impeded the passage of light through the samples when analyzed through a turbidimeter.

A statistically insignificant level of $p>0.05$ association was observed in comparing the mean Turbidity values of water samples from EP, MC and PC.

The value of TSS for the control was 300 which were well below the limit set by the WHO. MC show to have highest TSS value after the 14days of storage of the water sample but thereafter reduced to about same constant values as the other storage vessels. A statistically insignificant association was observed in comparing the mean TSS values of water samples from EP, MC and PC.

The iron content of the two controls before storage was 0mg/L. This signifies that sample did not meet the requirement set by W.H.O and Nigerian Standard for drinking water (0.3mg/L) as at the time it was collected. Nevertheless, fig. 1 showed that the concentrations of iron in the stored water improved during the first 7days of retention. The increase in concentration of the iron content in water stored in EP could as a result of iron trace elements found in the clay used for making the container.

A statistically insignificant association was observed in comparing the mean Iron values of water samples from EP, MC and PC with the control (p>0.05).

The calcium content of the control was 16.50mg/l which is within the WHO standard. Although, there was a significant increase in all the containers after the 7 days retention period after which there was as constant decrease also for the remaining 3 weeks.

A statistically insignificant association was observed in comparing the mean calcium values of water samples from EP, MC and PC with the control (p>0.05).

The magnesium content of the control was 13.81mg/l which exceeded limit given by the WHO standard. The values fell significantly after the first week of storage and for the remaining period of retention it maintains almost a constant value for all containers as seen in fig. 1,2 and 3 respectively which were all within the WHO standard.

A statistically insignificant association was observed in comparing the mean magnesium values of water samples from EP, MC and PC with the control (p>0.05).

The initial value from the control was 8mg/l. But subsequently there was significant increase in the values for all containers. The standard value for COD is not specified by WHO.

A statistically insignificant association was observed in comparing the mean COD values of water samples from EP, MC and PC with the control (p>0.05).

The initial value from the control was 6mg/l which was above the standard set by WHO. But subsequently there was significant decreased in the values for all containers and a little fluctuation in the values at some point probably due to how the test was carried.

A statistically insignificant association was observed in comparing the mean BOD values of water samples from EP, MC and PC with the control (p>0.05).

Before storage the value of E-coli was 40cfu/ml which was extremely high compared with the laid down standard by W.H.O. This signifies that the sources where these water samples were collected, did not meet the W.H.O Standard for Drinking water Quality in terms of E-coli count (0 CFU/100mL) as at the time the water samples were collected. The growth of bacteria in the storage vessels suggests that either; the few bacteria present in the water samples prior to storage were spore-forming bacteria that might have shield themselves against the un-conducive environment, or bacteria from the surrounding environment might have found their way into the stored water in the vessels.

Based on the information displayed in the 3 containers, it can be concluded that; fecal bacteria growth rate was higher in water stored in MC is higher than water stored in other storage vessels.

A statistically significant association was observed in the mean Escherichia coli values of water samples from EP, MC and PC respectively.

The PC container in fig.3 has shown to have the highest level of hardness. This may be as a result of high calcium ion (Ca^{2+}) present in the water stored in PC container as compared to the other containers. The control had a value of 203 in terms of $CaCo_3$ which exceeded the WHO standard value of 100 but there was a significant decrease in hardness in the vessels over time.

A statistically insignificant association was observed in comparing the mean hardness values of water samples from EP, MC and PC with the control ($p>0.05$).

CONCLUSION.

This study concludes that the material of storage containers significantly affects the quality of the water with time. All parameters of stored water are changed in the MC, PC, and EC. Even though stored water available in the household storage vessels could generally be considered potable, the presences of contaminants in the water were of concern. The study revealed that EC, TDS, calcium and temperature of stored water in all storage vessels were within the WHO maximum permissible limit of drinking water. From the comparison EP has shown to have a better ability to preserve quality of stored water.

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