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INVESTIGATING THE QUALITY OF WATER STORED IN PLASTIC TANKS IN UMARU MUSA YAR'ADUA UNIVERSITY KATSINA, KATSINA STATE, NIGERIA

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ABSTRACT

Water is one of the most important natural resources which play an essential role in human life. Most of the Nigerian institutions stored water in either plastic or overhead tanks for different purposes. However, there has been a growing concern over the safety of the stored water for human consumption following reported cases of microbial occurrence in water stored in tanks. This study aimed at investigating the water quality stored in plastic tanks in Umaru Musa Yar'adua University Katsina. Water samples were collected from plastic tanks and analyzed for some physico-chemical and heavy metals parameters. The result of physico-chemical parameters obtained shows that only dissolved oxygen, biological oxygen demand and chemical oxygen demand were observed above the maximum permissible limit for drinking recommended by WHO and NSDWQ with the mean value of 55.18 mg/l, 38.86 mg/l and 38.08 mg/l respectively. While the remaining parameters such as pH, electrical conductivity, total dissolved solids, turbidity, total suspended solid, alkalinity, sulphate, nitrate, phosphate, chloride and total hardness were found within the acceptable limit. However, analyzed result of heavy metals parameters revealed that all parameters were observed within desirable limit by WHO and NSDWQ for drinking water and suggested that the quality of water stored in plastic tanks was very good. It is concluded that, the quality of water stored in plastic tanks is suitable for human consumption. It is therefore recommended that, continuous monitoring of the water should be maintain so as to ascertain the safety of the water.

Keywords: Physico-chemicals, Heavy metals, Water quality, Plastic tanks, UMYU Katsina

INTRODUCTION

The storage of water resources for different purposes in plastic tanks has become common in many developing countries particularly in areas where water is scarce. Water is a major factor in human beings since without it life cannot exist. Water is an essential nutrient that is involved in every function of the human body and two-thirds of the human body is made of water. It helps to transport nutrients and waste products in and out of the cells (Shivaraju, 2012). Water for human consumption should be safe and free from pathogenic agent, unwanted impurities and any harmful chemicals, pleasant to taste and usable for domestic purpose (Aduwo and Adeniyi, 2019). The need to ascertain the quality of water used by humans has become very intense in the past decade and it is difficult to imagine any programme for human development that does not require a readily available supply of water (Udom, *et al.,* 2018).

The contamination of water resources has important repercussions for the environment and human health (Muhammad *et al.,* 2011). Poor drinking water quality is significantly affecting the health of consumers. It was reported that at least 2 billion peoples worldwide used source contaminated water with feces for drinking purposes (WHO, 2018). Many developing nations suffer from either chronic shortages of fresh water or the readily accessible resources are heavily polluted. Accelerated population growth coupled with impoverished socioeconomic development with limited water resources and poor sanitation leads to an increase in diseases associated with poor living conditions among which water related and water borne diseases play a major role (Khan *et al.,* 2013). It is estimated that "each year 10 million people die because of drinking contaminated water or water of less quality globally (WHO, 2004; Abdullahi and Indabawa, 2012). WHO (1996) suggest that if sustainable safe drinking water and sanitation services were properly provided to all, each year there would be 200 million fewer diarrhoeal episodes, 2.1 million fewer deaths caused by diarrhoea, 76,000 fewer dracunculiasis cases, 150 million fewer schistosomiasis cases and 75 million fewer trachoma cases.

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Water quality deals with the physical, chemical, and biological characteristics in relation to all other hydrological properties (Hassan, *et al.,* 2017). Water is usually get contaminated through natural and anthropogenic sources. Among the pollutants which can affect water resources, the heavy metals paid serious attention due to their high toxicity in low concentration. Heavy metals in water may exist as colloidal, particulate, or dissolved phase modes (Adepoju-Bello and Alabi, 2005; Fallahzadeh, *et al.,* 2017). Water contaminated via heavy metals, various anions, cations and other elements, can have harmful effects on human health due to excessive intake of contaminated water by human beings (Muhammad, *et al.* 2010). Some of heavy metals like copper (Cu), cobalt (Co) and zinc (Zn) are essentially required for normal body growth and functions of living organisms, while the high concentrations of other metals like cadmium (Cd), chromium (Cr), manganese (Mn), and lead (Pb) are considered highly toxic for human and aquatic life. A specific amount of Cr is needed for normal body functions; while its high concentrations may cause toxicity, including liver and kidney problems and genotoxic carcinogen (Ouyang, *et al.,* 2002; Muhammad, *et al.,* 2011).

Therefore, water quality monitoring is an effective approach for water resources protection. Proper monitoring and reasonable assessment should be carried out in order to help the decision makers in making right decision and taking necessary measures. Growing concern on the safety of water stored in tanks were continuously increasing. Unfortunately, in the area under study, so far no research work have been conducted on the quality of water stored in plastic tanks for different purposes. Therefore, this study aim at investigating the quality of water stored in plastic tanks in Umaru Musa Yar'adua University Katsina.

MATERIALS AND METHODS

Study Area Description

Umaru Musa Yar'adua University Katsina is the study area. It is located in Batagarawa local government area, about 15 kilometers away from the capital city of Katsina state. It is geographically located between latitude $12^0$53'-$12^0$54'N and longitude $7^0$35'-$7^0$35'E. The total land area is about 4.894 square kilometers as illustrated in figure 1. The university has about 9,939 undergraduate students. The area is relatively flat with wet and dry climatic type. The average annual temperature is about 25^0C. The highest temperatures in the area is 38^0C usually recorded in the month of April and May and lowest temperature is about 14^0C recorded in December and January respectively. The mean annual rainfall ranges from 600mm to 750mm with highest rainfall in August and September. Humidity is higher during rainy season with the values ranging from 70% to 85% and falls down rapidly during the dry season to about 20%. The area falls within Sudan savanna vegetation belt, with scanty trees, shrubs and short grasses (Maiwada and Hassan, 2019).

Water Sampling Collection

Water samples were collected from the plastic tanks in four selected locations (Faculty of natural and applied sciences, main gate, male undergraduate student hostel and female undergraduate student hostel). These plastic tanks was selected on the basis of high number of water users in the area. The water samples were collected with clean polyethylene plastic container from the selected sampling tanks. Prior to water sampling, the bottles were thoroughly washed and rinsed with double - distilled water and nitric acid. Along with sampling, the water was allowed to flow for two to three minutes and then sampling bottles were slowly filled. Each water sample was filtered and a few drops of 5% HNO_3 were added to prevent further microbial growth. All water samples were labelled and stored at 4^0C. Samples were then transferred to laboratory for onward analysis. The concentrations of selected physico-chemical parameters include pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity (TA), chloride (Cl), turbidity, total hardness (TH), sulfate (SO_4), phosphate (PO_4), and nitrate (NO_2). Heavy metals concentration of lead, copper, chromium, iron and cadmium were also analyzed in the laboratory.

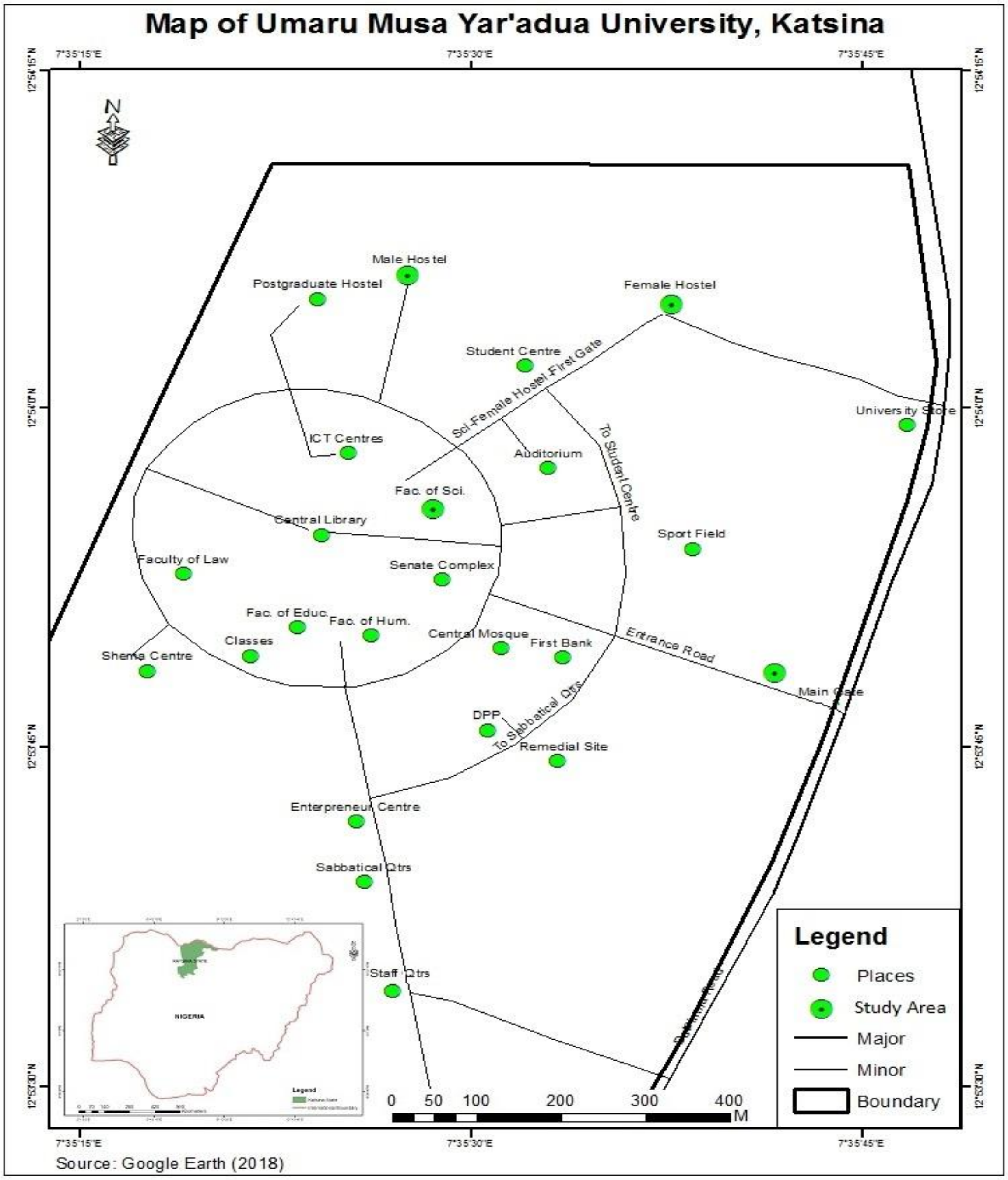

Fig. 1: Map of Umaru Musa Yar'adua University showing a study area.

Source: Geography Department, UMYU 2020.

Analytical Procedures

Hydrogen ion concentration (pH) were measured using pH meter (pH 3505 Janway), electrical conductivity (EC) were measured by EC meter (EC 4510 Janway). Total dissolved solids (TDS), total suspended solids (TSS) were determined using equations. Total hardness (TH), Sulfate (SO_4), chloride (Cl) and nitrate (NO_2), chemical oxygen demand (COD) were measured using titrimetric method, phosphate (PO_4) using UV–visible spectrophotometer. DO and BOD were determined using HANNA HI 9143. Heavy metal concentrations were analyzed by an atomic absorption spectrophotometer (AAS Brand/Model Buck

Scientific/VGP210) due to its high sensitivity detection limit. Double-distilled water was used for experimental analysis. All chemicals used in this study were of analytical reagent grade (Muhangane, *et al.*, 2017).

Statistical Analysis

Data obtained were analyzed using mean and tabulated in Table 1 and 2. Furthermore, concentration of physico-chemical parameters were compared with the drinking water standards recommended by World Health Organization WHO, (2017) and heavy metals concentration with WHO, 2011 and Nigerian Standard for Drinking Water Quality NSDWQ, (2007).

RESULTS AND DISCUSSION

Physico-Chemical Parameters

The results obtained for physico-chemical parameters of all the water samples were presented in Table 1 along with standard guidelines for drinking purpose.

Table 1: Concentrations of physico-chemical parameters along with mean and standards guidelines. (All unit are in Mg/l except pH, EC & Turbidity in /, µS/cm & NTU)

Parameters	MGT	FHT	MHT	FST	Mean	Standards		
						WHO 2017		NSDWQ 2007
						HDL	MPL	
pH	6.6	6.8	6.8	6.9	6.75	7.0	8.5	6.5-8.5
EC	206	280	289	250	256.25	-	1500	1000
TDS	8.88	10.89	9.78	9.65	9.8	500	1500	500
Turbidity	0.33	0.51	0.48	0.38	0.43	-	5.0	5.0
TSS	0.98	1.56	1.38	1.10	1.25	500	500	500
DO	54.41	55.52	54.97	55.85	55.18	-	5.0	5.0
BOD	38.70	38.98	38.82	38.95	38.86	-	10	10
COD	35.75	38.78	38.82	38.95	38.08	-	10	10
TA	1.63	2.11	1.98	2.51	2.06	-	200	500
SO_4	3.60	4.82	3.88	3.93	4.06	200	400	100
NO_2	6.30	6.89	6.75	6.78	6.68	45	-	50
PO_4	0.05	0.08	0.06	0.06	0.06	0.05	>50	5.0
Cl	102.73	110.82	110.60	109.83	108.48	200	600	250
TH	120.63	122.72	120.89	120.85	121.225	100	500	150

MGT = Main Gate Tank, FHT = Female Hostel Tank, MHT = Male Hostel Tank, FST = Faculty of Science Tank

From the result obtained (Table 1), FST has the highest value of pH concentration 6.9 mg/l and MGT having the lowest value of 6.6 mg/l with the mean value of 6.75. The pH is a measure of the acidic or basic nature of a solution, pH usually does not have direct impact on consumers. Based on standards for drinking water, the mean value obtained is within the permissible limit recommended by WHO, (2017) and NSDWQ, (2007) for pH in water for human consumption. The water is of good quality. This result agreed with the similar findings of Muhangane, *et al.*, 2017.

Electrical conductivity is the measure of the capability of water to transmit electric current and is a useful tool for assessment of the purity of water. Conductivity does not directly affect human health (Muhangane, *et al.*, 2017). Maximum EC value of 289 was found in sample collected from MHT and minimum value of 206 in MGT with average value of 256.25 mg/l, this value is far below the maximum allowable limit set by WHO, (2017). This result collaborated with the findings of Abdullahi and Indabawa, 2012.

Regarding to total dissolved solids (TDS) concentration, 10.89 was observed in FHT as a highest concentration and 8.88 mg/l in MGT as lowest with a mean value of 9.8 mg/l. The value obtained falls within the acceptable limit recommended by WHO, (2017) and NSDWQ, (2007) guideline for drinking water. The low value of TDS obtained shows that there is absence of soluble and insoluble materials found in this water and indicate that the water is of high quality for drinking. This result is in conformity with the findings of Hassan *et al.,* 2017.

Turbidity is the measure of the clarity or cloudiness of water. Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms (Muhangane, *et al.*, 2017). Turbidity highest concentration of 0.51 NTU fall in FHT and lowest value of 0.33 NTU in MGT with the average value of 0.43 NTU. Across the studied tanks, turbidity values falls within the desirable limit for human consumption established by WHO, (2017). A similar result reported by Shuaibu, *et al.,* 2015 revealed values near permissible limit in domestic water from Katsina metropolis.

Total suspended solids is an important parameter in water quality assessment. The high concentration of 1.56 mg/l was observed in FHT and lowest concentration of 0.98 mg/l in MGT. An average value of 1.25 mg/l was obtained across all samples. This value is found within stipulated value for drinking by WHO, (2017) and NSDWQ, (2007). The low value of TSS across all samples indicates that no suspended materials was found in the water and suggest that the stored water in plastic tanks is of good quality for different uses. This result is similar with the findings of Reda, 2016.

Dissolved oxygen DO is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. DO value indicates the degrees of pollution in water bodies (Obeta and Ocheje, 2013). FST has the maximum concentration of DO 55.85 mg/l and MGT having the minimum value of 54.41 mg/l with a mean value of 55.18 mg/l. From the result, DO concentration shows very little variation in all samples. This value was regarded as above the acceptable limit recommended value of 5.0 mg/l by WHO (2017) standards for drinking water. This high DO concentration could be due to the high of dissolution from atmosphere and photosynthesis. This disagreed with the findings of Abdullahi and Indabawa, 2012.

For BOD, FHT appeared with the highest concentration of 38.98 mg/l and MGT having the lowest with 38.70 mg/l. The mean value of 38.86 mg/l was obtained. By looking at the result carefully, it shows very little variation of BOD concentrations in all samples. The mean value obtained exceeded the threshold limit set by WHO (2017) and NSDWQ, (2007) for drinking water. This might be as a result of the presence of high organic and inorganic materials and is an indication of pollutants and shows that the water is not good for consumption. This result agreed with the findings of Edwin, *et al.,* 2015.

Chemical oxygen demand COD is an important parameter in water quality assessment. According to NSDWQ, (2007) COD standards for drinking is within 10 mg/l. The value obtained for COD in this study is higher in sample collected from FST with the concentration of 38.98 mg/l and lower value was observed in MGT with 35.75 mg/l. The mean value of 38.08 mg/l. This is above stipulated limit value by NSDWQ, (2007) for drinking water. This might be due to the fact that the water samples contained high quantity of pollution with any of oxidazable organic and inorganic pollutants. This result is in agreement with the study carried out by Edwin, *et al.,* 2015.

Total alkalinity TA concentration as observed in the study is higher in FST with the value of 2.51 mg/l and lower in MGT with a value of 1.63 mg/l. The average value of 2.06 mg/l was obtained. The mean value was found below the acceptable limit set by WHO (2017) and NSDWQ, (2007) for drinking water. A very low value of TA present in the study samples indicates that no or very less of alkaline minerals was found. This result is in line with the findings of Hassan, *et al.,* 2017.

Maximum sulphate SO_4 concentration in this study was found in sample collected from FHT having the value of 4.82 mg/l and minimum value of 3.60 mg/l was observed in MGT. The average value of 4.06 mg/l was obtained which is within the permissible level recommended by WHO (2017) and NSDWQ, (2007). The low value of SO_4 was due to the absence of inputs of fertilizers, manure, sewage and wastewater of livestock. As observed, the low concentration of SO_4 in drinking water has no effect on consumers. But intake of elevated concentrations of SO_4 through drinking water may cause heath effect such as laxative action

Nitrate NO_2 concentration in this study is higher in FHT with the value of 6.89 mg/l and MGT has the lowest value of 6.30 mg/l. The NO_2 average value of 6.68 mg/l was observed. The mean concentration of nitrate is found below the limit established by WHO (2017) and NSDWQ, (2007) for human consumption. The low value of nitrate indicates absence of organic residues (e.g. decay of plants, manure, fertilizers and detergents) in the studied water. High concentration of nitrate in drinking water cause serious effect on human health particularly women and infants. This result is collaborated with the findings of Khan *et al.,* 2013.

For phosphate, FHT appeared with the highest concentration value of 0.08 mg/l and MGT having the lowest concentration value of 0.05 mg/l. across the studied tanks water, PO_4 has the average value of 0.06 mg/l which is within the acceptable limit for drinking recommended by WHO, (2017) and NSDWQ, (2007). This is in line with the findings of Kokkinos *et al.* 2019.

The maximum concentration of chloride was observed in FHT 110.82 mg/l and minimum concentration of 102.73 mg/l in MGT, and an average value of 108.48 mg/l across all plastics tanks water. Chloride is well within the permitted level for human consumption by WHO, (2017) and NSDWQ, (2007). The low concentration of chloride in drinking water has less effect on human health. This findings is similar with the result of Shuaibu, *et al.,* 2015.

Hardness of water is attributed to mainly the bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium (Reda, 2016). Total hardness has the highest concentration of 122.72 mg/l in FHT and lowest concentration was observed in MGT with 120.63 mg/l and an average value of 121.23 mg/l was obtained across all samples. This value is found within permissible limit for drinking by WHO, (2017). This is in line with the findings of Abdullahi and Indabawa, 2012.

Heavy Metals Concentration

The result of analyzed water samples for heavy metals concentration along with WHO and NSDWQ were presented in Table 2.

Parameters	**MGT**	**FHT**	**MHT**	**FST**	**Mean**	**Standards**	
						WHO 2011	**NSDWQ 2007**
Lead	0.001	0.003	0.003	0.002	0.0022	0.01	0.1
Copper	0.002	0.004	0.003	0.003	0.003	2.0	1.0
Chromium	0.001	0.002	0.002	0.001	0.0015	0.05	0.05
Iron	0.003	0.004	0.004	0.003	0.0028	0.3	0.5
Cadmium	0.001	0.003	0.002	0.002	0.002	0.03	0.03

MGT = Main Gate Tank, FHT = Female Hostel Tank, MHT = Male Hostel Tank, FST = Faculty sof Science Tank

Lead was detected in all samples, with maximum concentration found in FHT and MHT (0.003 mg/l). A minimum concentration of 0.001mg/l was found in MGT with average value of 0.0022 mg/l. All samples were below the permissible limit of drinking water set by WHO 2011 and NSDWQ, 2007. This might be true because no contact of emission of lead into the plastic tanks water from any sources. This is contrary to a study by Abdulrashid and Abdurrahman, (2020) where lead was detected in some water samples.

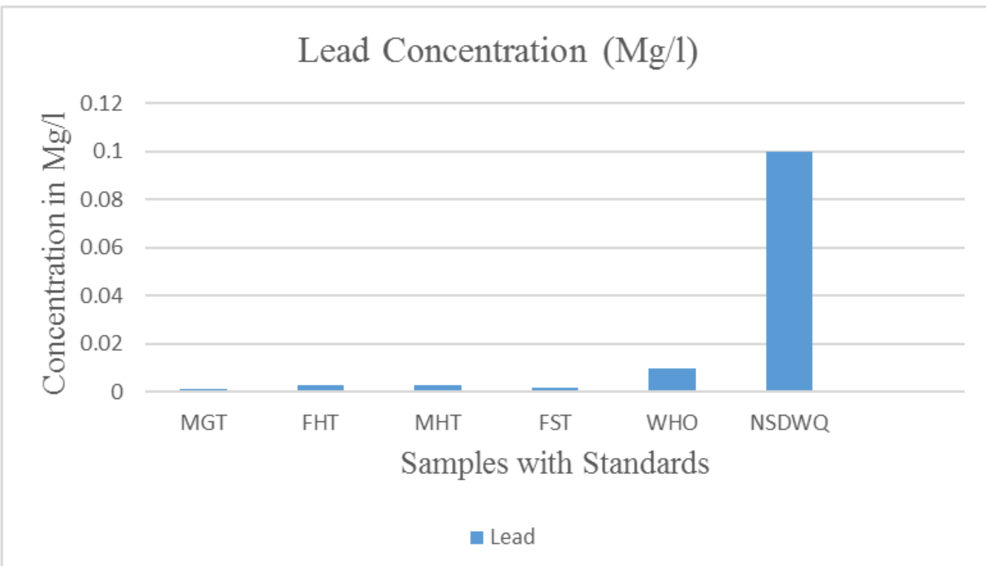

Figure 2: Lead concentration in Mg/l

Highest copper concentration was detected in FHT and lowest concentration in MGT. A mean value of 0.003 mg/l was obtained. Copper was present in all water samples but found below the limit for drinking water recommended by WHO, 2011 and NSDWQ, 2007. This implies that the water may be safe for human consumption. Desirable amount of copper is essential for normal organism growth and metabolism but excess intake may lead to severe health problem. This result agreed with the findings of Kantoma, *et al.*, 2017.

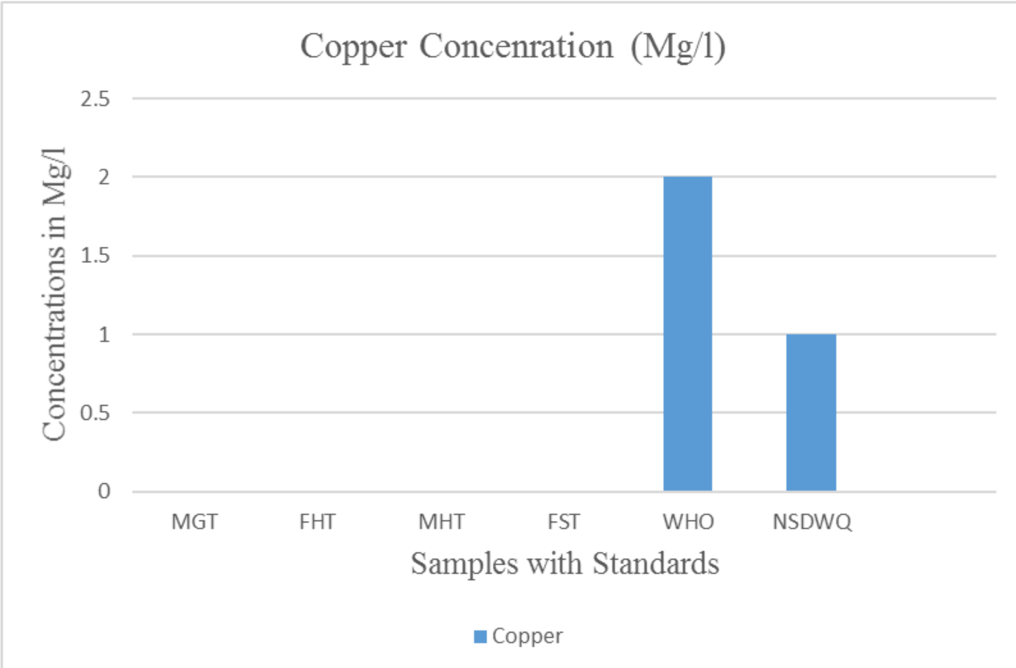

Figure 3: Copper concentration in Mg/l

Chromium was detected in samples with the maximum concentration found in FHT and MHT (0.002 mg/l and minimum concentration were detected in MGT and FST. An average value of 0.0015 mg/l was obtained. All chromium concentration were below the permissible limit set by WHO and NSDWQ for drinking water. Similar findings in related studies by Shivaraju, (2012) have been reported in Mysore city India that indicated significantly lower concentrations of chromium in overhead tanks water. This implies that human health is not threatened by water stored from plastic tanks.

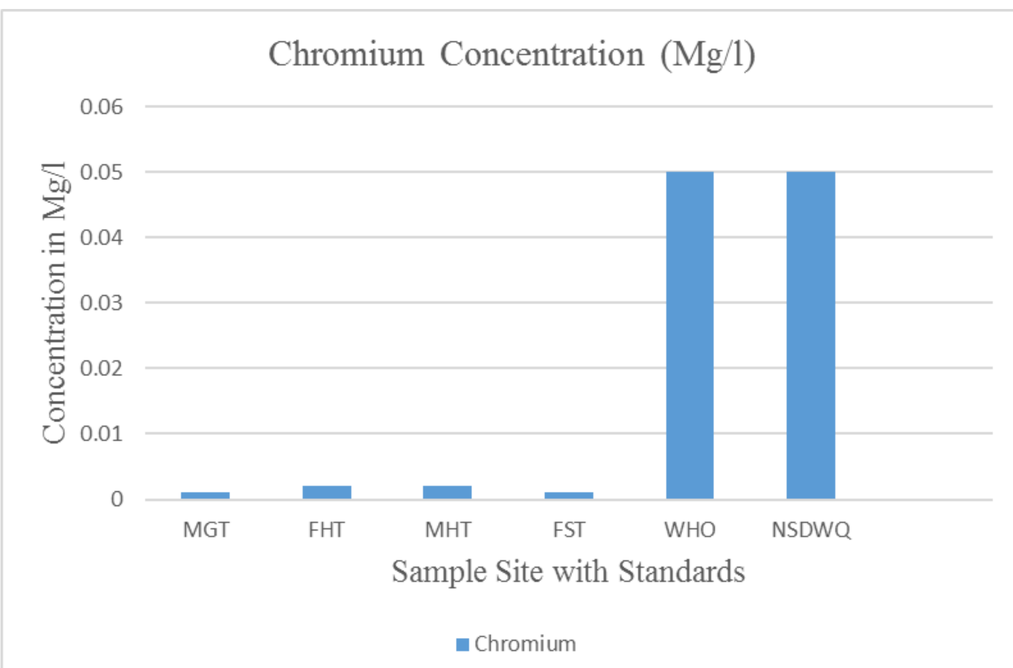

Figure 4: Chromium concentration in Mg/l

Iron ions may be present in drinking water as a result of the use of iron coagulants or corrosion of steel and iron cast in pipes during water distribution. Iron is an essential element in human nutrition (WHO, 2008). Iron concentration in all samples was found within the limit for drinking water set by WHO standards having the maximum concentration of 0.004 mg/l in FHT and MHT and minimum concentration of 0.003 mg/l was detected in MGT and FST. The result disagreed with the findings of Shuaibu, *et al.*, (2015) in which iron level in domestic water of Katsina metropolis were observed higher.

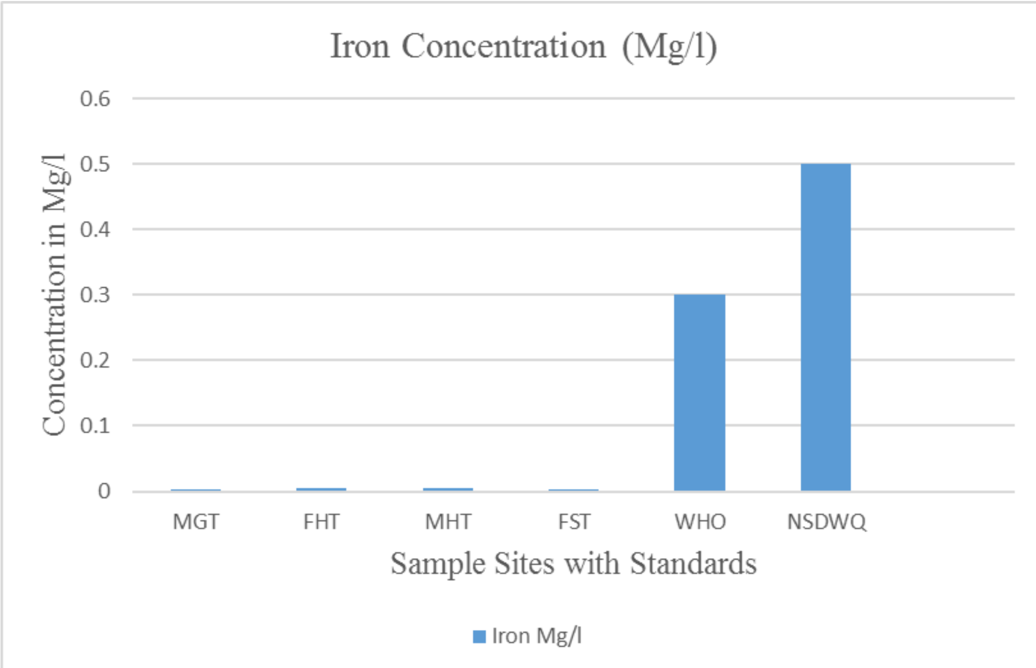

Figure 5: Iron concentration in Mg/l

Cadmium is naturally present in water in small quantity. Highest concentration of cadmium was detected in FST (0.003 mg/l and lowest concentration of 0.001 mg/l was detected in MGT with the mean value of 0.002 mg/l. This is within acceptable limits set by WHO, 2011 for drinking. Excessive cadmium exposure may weaken the body immune system and cause a serious human health damage such as renal dysfunction, obstructive lung disease, renal effect and pulmonary effect. This is contrary to a study by Edwin, *et al.,* (2015) where cadmium was observed higher in one drinking water sample in two communities in south-east, Nigeria.

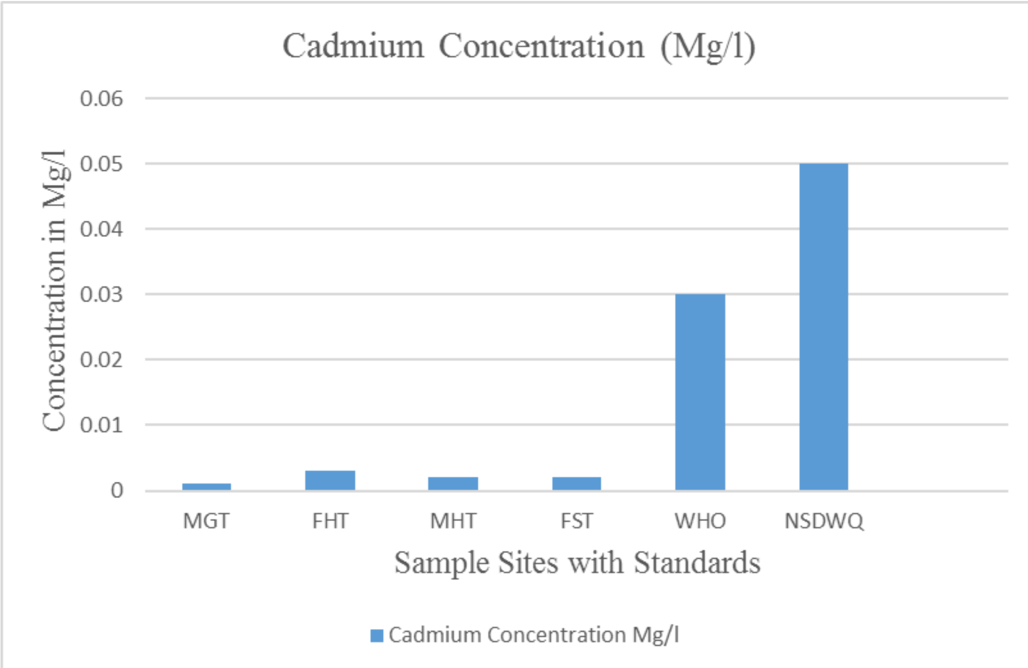

Fig. 6: Cadmium concentration in Mg/l

CONCLUSION

This study investigated the quality of water stored in plastic tanks in Umaru Musa Yar'adua University Katsina, water samples obtained from the plastic tanks were analyzed for some physic=chemical and heavy metals parameters. Result observed for physico-chemical parameters indicated that all parameters were found below the limit set by WHO, 2017 and NSDWQ, 2007 for drinking except DO, BOD and COD which were found above the limit. All heavy metals analyzed were found below the maximum permissible limit by WHO, 2011 and NSDWQ, 2007. Therefore, the water is good for human consumption and other purposes. It is therefore recommended that, further monitoring need to be maintain.

REFERENCES

Abdullahi, U.A., and Indabawa I.I (2012) Study on physicochemical and heavy metals (Pb, Fe, Mn) concentrations of tap water in Dutse, Jigawa state, Nigeria. *Bayero Journal of Pure and Applied Sciences,* 5(2):89 – 92.

Abdulrashid, Y. and Abdurrahman, N. (2020) Assessment of selected heavy metals in drinking water consumed within Katsina metropolis. *FUDMA Journal of Sciences*, 4(3), 531-537.

Adepoju-Bello A, Alabi O (2005) Heavy metals: a review. *The Nig. J. Pharm* 37:41–45.

Aduwo, A.I. and Adeniyi, I.F. (2019) The Physico-Chemical Water Quality of the Obafemi Awolowo University Teaching and Research Farm Lake, O.A.U. Campus, Ile-Ife, Southwest, Nigeria. *Journal of Environmental Protection*, 10, 881-899.

Edwin, N., Ibiam, U.A., Igwenyi, I.O., Ude, V.C. and Eko, S.N. (2015) Evaluation of Physicochemical properties, mineral and heavy metal content of drinking water samples in two communities in South-East, Nigeria: A public health implication. *Journal of Environment and Earth Science,* Vol.5, No.9, 89-95.

Fallahzadeh, R.A., Ghaneian, M.T., Miri, M., Dashti, M.M. (2017) Spatial analysis and health risk assessment of heavy metals concentration in drinking water resources. *Environ Sci Pollut Res,* 24 (32), 24790-24802.

Hassan A.S., Abubakar I.B., Musa A., and Limanchi M.J. (2017) Water quality investigation by physic-chemical parameters of drinking water of selected areas of Kureken, Kumbotso local government area of Kano. International Journal of Mineral Processing and Extractive Metallurgy, 2, (5), 83-86. doi: 10.11648/j.ijmpem.20170205.14.

Khan, S., Shahnaz, M., Jehan, N., Rehman, S., Shah, M.T. and Din, I. (2013) Drinking water quality and human health risk in Charsadda district, Pakistan. *Journal of Cleaner Production*, 60: 93-101.

Kokkinos, K., Lakioti, E., Samaras, P., Karayannis, V. (2019) Evaluation of public perception on key sustainability indicators for drinking water quality by fuzzy logic methodologies. *Desal. Wat. Treat.* 170: 378–393.

Maiwada, A.S. and Hassan M. (2019) People's perception on changing climate and human influence in Katsina state, Northwestern Nigeria. FUDMA Journal of Sciences, 3 (2), 245-249.

Muhammad S, Shah MT, and Khan S. (2010). Arsenic health risk assessment in drinking water and source apportionment using multivariate statistical techniques in Kohistan region, northern Pakistan. *Food ChemToxicol* 48:2855–2864.

Muhammad, S., Shah, M.T., Khan, S., (2011). Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan region, northern Pakistan. *Microchem. J.* 98, 334-343.

Muhangane, L., Nkurunungi, J.B., Yatuha, J. and Andama, M. (2017) Suitability of Drinking Water Sources from Nyaruzinga Wetland for Domestic Use in Bushenyi Municipality, Uganda. *Journal of Water Resource and Protection*, 9, 1587-1611.

NSDQW. Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria, 2007, pp: 30.

Obeta, M.C. and Ocheje, F.J. (2013) Assessment of groundwater quality in Ankpa urban Kogi state, Nigeria. *Environmental Research Journal*, 7 (3): 37-47.

Ouyang, Y., Higman, J., Thompson, J., Toole, O.T., and Campbell, D. (2002) Characterization and spatial distribution of heavy metals in sediment from Cedar and Ortega Rivers sub-basin, *J. Contam. Hydrol*. 54: 19– 35.

Reda, A.H. (2016) Physico-Chemical Analysis of Drinking Water Quality of Arbaminch Town. *Journal of Environmental & Analytical Toxicology*, 6, 356. doi:10.4172/21610525.1000356

Shivaraju, H.P. (2012) Assessment of physico-chemical and bacteriological parameters of drinking water in Mysore city India. *International Journal of Research in Chemistry and Environment*, 2(1), 44-53.

Shuaibu, L., Dutsinma, B.A., Yar'adua, A.Y. (2015) Determination of physico-chemical parameters, zinc and iron levels in domestic waters of Katsina Metropolis, Nigeria. *International Research Journal of Pure & Applied Chemistry* 5(3): 263-272.

Udom, G.J., Nwankwoala, H.O. and Daniel T.E. (2018) Physico-chemical evaluation of groundwater in Ogbia, Bayelsa State, Nigeria. *International Journal of Weather, Climate Change and Conservation Research,* Vol.4, No.1, pp.19-32.

World Health Organization. (1996) World Health Report – Fighting Disease, Fostering Development, World Health Organization, Geneva,

World Health Organization. (2004). Physical and Chemical Standard. Standards for Drinking water Quality.

World Health Organization. (2008), Guidelines for drinking water quality in the World. Geneva Recommendation.

World Health Organization. (2017). Guidelines for drinking-water quality. In: Incorporating 1st Addendum, fourth ed. World Health Organization, Geneva.

World Health Organization. (2018) Drinking-water. World Health Organization fact sheets, https://www.who.int/en/news-room/fact-sheets/detail/drinkingwater,