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Evaluation of Physiochemical Loads in Different Water Storage Containers: Implications for Drinking Water Quality and Human Health

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Abstract- This study evaluated the physiochemical loads in different water storage containers its implications for drinking water quality and human health . Six samples from six different locations in Awka, Anambra State was used. The samples were labeled A to F. Sample A from crunches (Ezeokoye Chinonso) Awka, Sample B from Ezeinda Street Isuaniocha, Sample C Udoka Estate and Sample D from Ngozika Estate by Hon Boniface Okonkwo Road, Sample E from Amudo Awka (Okafor Street, Sample F from Umuzocha Awka (Enukorah Ilorah street) and stored in plastic containers, earthen pots, and concrete tanks for 7, 14, and 21 days. The evaluation focused on parameters including pH(6.03-6.96), electrical conductivity (68.3-116μs/cm)), temperature (18-28.5°C), hardness(116-200mg/L), turbidity(0.81-4.21NTU),chlorides(180-199mg/L),phosphates(8.00-9.725mg/L),fluoride(0.673-1.539mg/L), nitrogen (0.0632-1.552mg/L), copper (0.058-1.555mg/L), cadmium (0.213-1.418mg/L), lead (0.128-0.318mg/L), magnesium (0.004-0.018mg/L), manganese (0.203-0.301mg/L), selenium (0.023-0.145mg/L), nickel (0.001-0.027mg/L), chromium (0.011-0.042mg/L), and zinc (0.030-1.481mg/L). The findings reveal significant variations in parameter concentrations based on the storage material. Plastic containers exhibited the highest increases in parameter concentrations, suggesting possible leaching and higher chemical interaction rates. Earthegn pots showed moderate increases, indicating natural buffering and filtration properties. Concrete tanks provided the most stable conditions, with minimal changes in parameter concentrations, attributed to their inert and neutralizing nature. These results suggest that concrete tanks are optimal for long-term storage where stability is paramount. Earthen pots are suitable for applications benefiting from natural filtration and buffering. Plastic containers, while convenient for short-term storage, may not be ideal for extended periods due to potential leaching. This study underscores the importance of selecting appropriate storage materials to maintain the integrity of stored water samples, providing valuable insights for environmental monitoring, water quality management, and related fields. Further research is recommended to deepen understanding and refine storage strategies under various environmental conditions. Water storage containers are essential for providing access to safe and clean drinking water, particularly in regions with inadequate infrastructure. However, the materials used in these containers can impact the physiochemical quality of the stored water, potentially posing health risks such cancers,hormones distruption and reproductive issues over time to consumers.

Keywords: Physiochemical,storage, water.

I. INTRODUCTION

Water is abundantly found across the globe; however, only a limited portion is suitable for drinking or safe for human use. Consequently, it is essential to store potable water in containers to ensure a continuous supply in case of disruptions or emergencies. These storage vessels are commonly referred to as tanks or reservoirs. They are available in various shapes and sizes, constructed from materials such as fiberglass, concrete, clay, galvanized steel, and polyethylene. Furthermore, the design and dimensions of these reservoirs can vary significantly. While some researchers argue that water storage may lead to quality degradation, others present opposing viewpoints. A study indicated an increase in microbial contamination in water stored in steel, plastic, and clay containers over a month(Kulshreshtha,1998); however, this issue was attributed more to the inadequate hygiene practices of household users than to the type of storage container employed (Andrew, 2004).

As stated by Booker (2004), water is classified as potable when its physiochemical characteristics—such as temperature, pH, levels of dissolved oxygen (DO), chemical oxygen demand (COD), five-day biochemical oxygen demand (BOD5), electrical conductivity (EC), concentration of chloride ions (Cl^-), total alkalinity (TA), turbidity, total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), and bacteriological properties—are within the acceptable thresholds established by the World Health Organization (WHO).Due to insufficient pipe-borne water supplies throughout Africa, particularly in Nigeria, people are increasingly buying drinking water in the form of sachets or bottles. Systems that are used to distribute and store water are sensitive to degradation and pollution(Naveed,2019).

The water quality of the residential storage tanks may be impacted by the indirect exposure of these tanks to external factors as wind, dust, and others. If there is obvious corrosion in the tanks, there may be a high concentration of heavy metals.Method of preservation of potable water impacts not only on its quality, but also its safety(Deborah,2000). This study when completed will proper solutions on the best suited water storage material which will minimize deterioration in physiochemical properties of stored water and its accompanying health implication

II. MATERIALS AND METHODS

Study Location

The state capital of Anambra State, Awka, served as the study's location. The region is 63.4 sq mi (164.2 km2) in total, with coordinates of 6°10′N 7°04′E. The wet and dry seasons are the two separate seasons of Awka, which is located in a tropical rainforest. The dry season begins in November and lasts until March each year, whereas the wet season runs from April through October, peaking between June and September. According to Omoja et al. (2021), the area has 1639.40 to 3863.40 mm of rainfall annually, with a mean temperature of 27 °C and a relative humidity of around 70-80%. The Nnamdi Azikiwe University is located in the city, which has an estimated population of 301,657 according to the 2006 Nigerian census. The Onitsha-Enugu expressway also passes through the city.

Sourse: Nzoiwu et al(2017)

Sample Collection

The representative samples of groundwater to be stored was collected directly from the boreholes during pumping using clean, sterile containers to prevent contamination. The samples were marked and part of each tested in its initial state at Springboard Research Laboratory Udoka Estate Awka to determine the Physiochemical properties before being stored.

Six water samples were collected from different boreholes in Awka metropolis, each underwent physical and chemical analysis. The sample was labeled A to F.Sample A from crunches (Ezeokoye Chinonso) Awka.

Sample B from Ezeinda Street Isuaniocha, Sample C Udoka Estate and Sample D from Ngozika Estate by

Hon Boniface Okonkwo Road, Sample E from Amudo Awka (Okafor Street,Sample F from Umuzocha Awka (Enukorah Ilorah street).The water was allowed to run for three minutes before collection to avoid collecting rust from the pipe walls. Before collecting the water, the plastic bottles were rinsed three times with the borehole water. The representatives sample containers were filled to the brim and lids immediately covered. The other samples containers were then stored in the plastic containers, concrete mould an earthen pots and tests conducted for six weeks at intervals of seven (7), fourteen (14) and twenty one (21) days.

MATERIALS AND METHOD

pH

A laboratory pH meter was used to measure pH using the electrometric method, and the APHA standard procedure (APHA, 1998) was followed for analysis.

The electrodes were wiped dry and washed with distilled water. A portion of the sample was then used to rinse the pH electrode in a tiny beaker. The electrodes were positioned at least one centimeter away from the edge and bottom of the tiny beaker, and enough sample was added to the beaker to submerge the tips of the electrodes to a depth of about 2 cm. This was reflected in the temperature adjusting dial. I turned on the pH meter and took a sample's pH reading.

Electrical conductivity (EC)

EC was analyzed according to APHA 210B guideline and according to APHA standard method (APHA;1998).

Procedure

The conductivity cell was thoroughly rinsed with a minimum of three aliquots of the sample. Subsequently, the sample's temperature was adjusted to 20°C. The conductivity cell, equipped with the electrodes, was then submerged in an adequate volume of the sample. The conductivity meter was activated, and the conductivity of the sample was documented.

Temperature

Temperature was determined with the use of thermometer. 50ml of the water sample was measured into 100ml volumetric flask. Thermometer was inserted into water and allowed to stand for 10minutes before its value was recorded.

Total hardness using titration method

A volume of 50 ml of the water sample was transferred into a beaker. Subsequently, a 50% buffer solution of NH_3 was introduced. Additionally, three drops of solocrome black tea indicator were incorporated and the mixture was thoroughly swirled. The solution was then titrated with a 0.01 EDTA solution until the color transitioned from wine red to a clear blue, devoid of any bluish tinge.

$$\text{Total Hardness} = \frac{\text{Volume of Tirate} \times 100}{\text{Volume of sample}}$$

Chloride

A volume of 100 ml of the sample was transferred into an Erlenmeyer flask, and the pH was adjusted to a range of 7 to 10 using either H_2SO_4 or NaOH solution. Subsequently, 1 ml of K_2CrO_4 indicator solution was introduced, and the mixture was titrated with a standard 0.01M Silver Nitrate solution until a reddish-brown coloration was achieved.

Turbidity

The turbidity curvette was rinsed with distilled water and the instrument adjusted to zero. The water sample was poured into the curvette and the instrument adjusted to read result. The obtained result is measured in NTU unit.

Heavy mental analysis

This was conducted using Varian AA240 Atomic Absorption Spectrometer according to the method of APHA(2017)(American Public Health Association)
Working principle:Atomic absorption spectrometers working principle is based on the sample being aspirated into the flame,atomized when the AAS's light beam is directed through the flame into the monochromator and into the detector that measures the amount of light absorbed by the atomized element in the flame.since metals have their own characteristic absorption wavelength,a source lamp composed of that element is used making the method relatively free from spectral or radiational

interferences.The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample

III. RESULTS AND DISCUSSION

Experimental Results and Presentation
The results obtained from the physiochemical analysis on the samples were presented in a tabular form

Table 1: Physical analysis of samples in their initial state i.e. before storage

Physical	SAMPLES							Acceptable Standards		
Parameter		A	B	C	D	E	F	WHO	APHA	NSDWQ
pH	Unit	6.87	6.84	6.71	6.03	6.60	6.20	6.5-8.5	6.5-8.5	6.5-8.5
Hardness	(mg/l)	174	192	116	146	122	118	100-300	100-300	150
Turbidity	(NTU)	1.70	1.90	1.68	0.81	1.32	4.03	5 NTU	5 NTU	5 NTU
Colour		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Taste		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Temperature	(^{0}C)	24^0	26^0	25^0	28^0	25^0	27^0	20^0-50^0C	20^0-50^0C	20^0-50^0C
Electricity Productivity	(µs/cm)	74.20	82.10	10.2	114	68.3	79.2	400	1000	1000

Table 2: Chemical parameters Analysis of sample in their initial state (before storage)

Chemical	SAMPLES						Acceptable Standards		
Parameter	A	B	C	D	E	F	WHO	APHA	NSDWQ
Chloride(mg/l)	191	196	182	194	188	199	250	250	250
Phosphate(mg/l)	10.237	8.314	8.112	8.018	8.512	9.234	10	100-30	150
Fluoride (mg/l)	0.673	1.538	0.865	1.394	1.280	0.744	0.5-1.0	1.5	1.50
Nitrogen(mg/l)	0.0986	0.0605	0.0862	0.071	0.0632	0.081	50	10	10
Copper (mg/l)	1.555	0.429	0.161	0.058	0.314	0.406	1.0	2.0	1.0
Cadmium (mg/l)	1.418	0.501	0.385	0.216	0.213	0.422	0.003	0.003	0.003
Lead (mg/l)	0.129	0.317	0.251	0.105	0.112	0.203	0.01	0.01	0.01
Magnessium (mg/l)	0.008	0.017	0.005	0.013	0.004	0.015	0.01	0.01	0.01
Manganese (mg/l)	0.250	0.203	0.215	0.125	0.210	0.231	0.01	0.01	0.01
Selenium (mg/l)	0.113	0.023	0.162	0.076	0.141	0.089	0.01	0.01	0.01
Nickel (mg/1)	0.002	0.001	0.108	0.027	0.011	0.005	0.01	0.01	0.01
Chromium (mg/l)	0.011	0.014	0.042	0.033	0.034	0.026	0.01	0.01	0.01
Zinc (mg/l)	1.481	0.097	0.234	0.030	0.086	0.048	5.0	3.0	3.0

Chloride (Cl)

The WHO(2017) and NSDWQ guidelines state that a maximum of 250 mg/l of chloride (Cl^-) is allowed. The maximum amount of APHA that is allowed is 100 mg/l. As seen in Table 2, all the samples of water from different locations of Awka metropolis have high values of chloride ranges from 182mg/l to 196mg/l which is within the permissible range for drinking.

Fluoride

In compliance with WHO and NSDWQ guidelines, the permissible value for fluoride is 0.5-1.5mg/l. the permissible value of APHA is 0.01mg/l. as shown in the table 2, the current analysis result reveals that all the samples of water from different locations of Awka metropolis have high values of chloride ranges from 0.673mg/l to 1.5mg/l which is within the permissible range for drinking.

Nitrogen
Nitrogen is important in detecting the contamination of borehole water. The borehole water in Awka metropolis was analyzed for their Fluoride content and other related parameters.

Copper
Concentration of copper above 2 mg/L depicts in water unwanted bitter taste, and at greater concentrations, it also affects the color of the water. As can be seen in table 2 copper (Cu), the WHO and NSDWQ suggest limits of 1.0 mg/L for copper content in drinking water, whereas APHA recommends 2.0 mg/L.

Cadmium (Cd)
The concentration of copper in each of the water samples ranged from 0.161 to 1.555, as can be seen in table 2 above. Within the safe allowable limits, Samples B and C are both below the threshold value.

Table 3: Physiochemical analysis of samples stored in plastic containers for 21 days

Parameter	Units	A	B	C	D	E	F
Ph		6.98	6.90	6.79	6.12	6.69	6.25
Hardness	Mg/l	175	193	116	147	123	118
Turbidity	NTU	1.85	2.02	1.76	1.25	1.88	4.21
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Taste	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Temperature	^{O}C	25	27.5	26.3	28.7	26.2	28.3
Electrical conductivity	(µs/cm)	76	86	105.2	115.8	67.9	81
Chloride	Mg/l	191	195	183	193	188	197
Phosphate	Mg/l	10.236	8.31	8.02	8.01	8.342	9.511
Fluoride	Mg/l	0.652	1.531	0.822	1.332	1.104	0.054
Nitrogen	Mg/l	0.113	0.249	1.167	0.154	0.127	0.116
Copper	Mg/l	0.516	0.425	0.162	0.054	0.313	0.401
Cadmium	Mg/l	1.411	0.501	0.356	0.203	0.21	0.421
Lead	Mg/l	0.130	0.318	0.252	0.106	0.113	0.204
Magnesium	Mg/l	0.009	0.018	0.007	0.015	0.005	0.018
Manganese	Mg/l	0.256	0.214	0.219	0.127	0.213	0.236
Selenium	Mg/l	0.115	0.026	0.166	0.164	0.145	0.091
Nickel	Mg/l	0.002	0.003	0.109	0.026	0.012	0.006
Chromium	Mg/l	0.012	0.015	0.043	0.043	0.034	0.026
Zinc	Mg/l	1.479	0.097	0.235	0.032	0.088	0.050

Table 4: Physiochemical analysis of samples stored in concrete reservoirs for 21 days

Parameter	Units	A	B	C	D	E	F
Ph		7.00	6.89	6.80	6.28	6.74	6.36
Hardness	Mg/l	178	200	119	150		
Turbidity	NTU	1.56	1.77	1.54	0.69	0.98	2.97
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Taste	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Temperature	^{O}C	26	26.4	27.3	28.5	26.2	28.4
Electrical conductivity	(µs/cm)	76	83.4	103	113.5	69.6	80.7
Chloride	Mg/l	193	198	184	196	190	181
Phosphate	Mg/l	10.242	8.323	8.123	8.053	8.552	9.722
Fluoride	Mg/l	0.671	1.531	0.864	1.393	1.280	0.752
Nitrogen	Mg/l	0.212	0.126	0.148	0.131	0.118	0.86
Copper	Mg/l	1.554	0.429	0.162	0.059	0.330	0.413
Cadmium	Mg/l	0.420	0.509	0.387	0.218	0.205	0.424
Lead	Mg/l	0.128	0.316	0.251	0.105	0.113	0.204
Magnesium	Mg/l	0.009	0.018	0.006	0.014	0.005	0.016

Manganese	Mg/l	0.252	0.301	0.217	0.128	0.284	0.272
Selenium	Mg/l	0.113	0.023	0.162	0.076	0.140	0.088
Nickel	Mg/l	0.001	0.001	0.115	0.019	0.011	0.004
Chromium	Mg/l	0.011	0.040	0.041	0.032	0.032	0.025
Zinc	Mg/l	1.478	0.096	0.233	0.031	0.086	0.047

Table 5: Physiochemical analysis of samples stored in earthen pots for 21 days

Parameter	units	A	B	C	D	E	F
pH		6.70	6.59	6.53	6.3	6.78	6.45
Hardness	Mg/l	170	189	114	142	120	116
Turbidity	NTU	1.58	1.79	1.63	0.72	1.27	3.95
Colour		NIL	NIL	NIL	NIL	NIL	NIL
Taste		NIL	NIL	NIL	NIL	NIL	NIL
Temperature	^{O}C	18	20	19	22	19	20
Electrical conductivity	(µs/cm)	74	80	101	113	66	77
Chloride	Mg/l	190	192	179	190	184	196
Phosphate	Mg/l	10.238	8.320	8.150	8.110	8.590	9.720
Fluoride	Mg/l	0.670	1.538	0.862	1.390	1.278	0.752
Nitrogen	Mg/l	1.550	0.426	0.157	0.053	0.334	0.452
Copper	Mg/l	0.125	0.316	0.250	0.105	0.110	0.201
Cadmium	Mg/l	0.417	0.500	0.384	0.215	0.201	0.420
Lead	Mg/l	0.107	0.315	0.204	0.011	0.103	0.059
Magnesium	Mg/l	0.005	0.016	0.004	0.013	0.003	0.013
Manganese	Mg/l	0.258	0.239	0.230	0.158	0.236	0.248
Selenium	Mg/l	0.113	0.023	0.162	0.076	0.141	0.089
Nickel	Mg/l	0.002	0.001	0.105	0.024	0.010	0.005
Chromium	Mg/l	0.011	0.014	0.042	0.033	0.034	0.025
Zinc	Mg/l	1.480	0.096	0.232	0.029	0.084	0.045

It was observed that after twenty one days storage (from table 3) after that there was slight increase in concentrations of parameters in samples stored in plastic containers as it were before storage with the exception of magnesium, Nickel and zinc that remained unchanged. Also, same pattern was observed in table 4 at the end of twenty one days storage as against the initial concentrations before storage in concrete reservoirs though turbidity slightly decreased while Lead, nickel, chromium and zinc concentrations did not change. In table 5, there was slight decrease in concentrations of parameters with the exception of copper, cadmium, lead, magnesium, selenium, nickel, chromium and zinc which did not change. The decrease in concentrations can be attributed to the absorption by the materials of the pot which can lead to microbial growth if not effectively monitored.

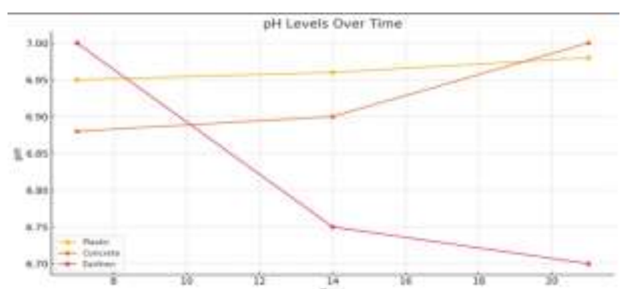

Figure 1: Plot of pH against time under the three storage conditions

From the curves it is evident that the pH of the samples became lower with storage in the earthen pot and this can be attributed to the high porosity of the materials of the pot and this can pose a great risk of contamination and growth of bacteria.This can be reduced by frequent cleaning of the earthen pot.There is also increase in pH in both plastic and concrete storage containers between 6.90 and 7.00

though still within permissible limit and these changes can be from storage and environmental conditions.

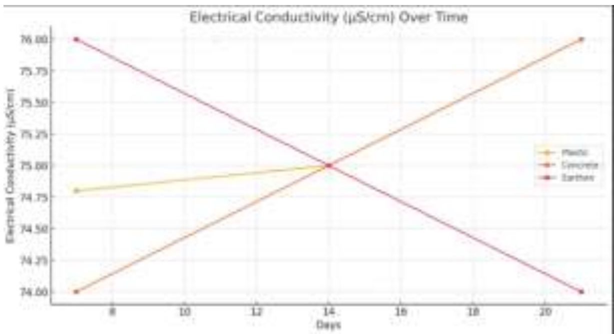

Figure 2: Plot of electrical conductivity over time for the three storage conditions

IV. CONCLUSION AND RECOMMENDATIONS

Generally, plastic containers showed higher increases in concentrations of parameters, indicating possible leaching of chemicals or higher rates of interaction with the stored samples and this can pose serious health risk such as carcinogenic effects, oxidative stress, endocrine, disruption, cardiovascular diseases and developmental effects when consumed over time Earthen pots exhibited moderate increases in concentrations, suggesting a natural buffering and filtering effect, leading to more stable conditions over time.

The most stable in terms of parameter concentration changes, likely due to the neutralizing and inert nature of concrete, which minimizes interactions with the stored samples. Concrete tanks showed the least change in parameter concentrations, making them ideal for storing samples where minimal chemical interaction is desired.

Earthen pots can be useful if a moderate level of natural filtration and buffering is beneficial. They offer a balance between stability and natural interaction with the environment.
Plastic containers can be used for short-term storage where quick access and ease of use are prioritized. However, for long-term storage, they may not be ideal due to potential leaching and higher rates of chemical interaction. Regularly monitor the storage conditions, including temperature, pH, and other relevant parameters, to ensure the integrity of the stored samples and to prevent any undesirable changes over time.

Further research and empirical data collection are recommended to refine these observations and to better understand the interactions between storage materials and specific sample types under various conditions. By considering these recommendations, the most appropriate storage method can be chosen for your samples based on their specific needs and the desired stability of the parameters over time.

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