
COMPARATIVE ASSESSMENT OF CLAY POT AND PLASTIC CONTAINERS ON WATER QUALITY DURING 14-DAY HOUSEHOLD STORAGE IN ZARIA, KADUNA STATE

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ABSTRACT

Access to safe drinking water remains a critical challenge in many regions, especially in developing countries where improper storage can degrade water quality. This study examines the effect of storage container type and duration on the quality of water obtained from different sources: rain, well, and borehole. The investigation centers on how clay pots and plastic containers affect physicochemical parameters, including temperature, pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), and biochemical oxygen demand (BOD), over a 14-day storage period. Water samples were collected from selected sites in Zaria, Kaduna State, and subjected to laboratory analyses in accordance with standard procedures. Results revealed that both the type of container and the storage duration affect water quality. Prolonged storage led to a general decrease in dissolved oxygen (DO) and an increase in biochemical oxygen demand (BOD), turbidity, and total dissolved solids (TDS), reflecting increased organic load and oxygen demand alongside physicochemical interactions with container materials. Clay pots maintained better water quality than plastic containers due to their porous structure, which allowed limited aeration and temperature regulation - conditions generally less conducive to organic matter accumulation. Conversely, plastic containers exhibited greater chemical leaching and less favorable BOD/DO trends, consistent with conditions that may support microbial growth, resulting in faster overall deterioration of water quality. As no direct microbiological analysis (e.g., coliform counts) was conducted in this study, these microbial-related inferences should be regarded as indicative rather than confirmed, and are recommended for verification in future work.

Keywords: water storage; clay pots; plastic containers; physicochemical parameters; microbial activity; water quality deterioration; storage duration

1.0: INTRODUCTION

Water quality plays a critical role in public health, environmental stability, and socio-economic development. However, water stored in households - especially in plastic and clay containers - can undergo significant deterioration due to microbial proliferation, chemical leaching, and environmental interactions (WHO, 2022). The type of storage vessel and length of storage are known to influence both physicochemical and microbiological water characteristics (Obianyo, 2020).

Communities that rely on stored water, particularly in low-resource settings, remain vulnerable to quality degradation (Mwabi et al., 2012). This study, therefore, examines two widely used alternative sources - rainwater and groundwater from wells - and evaluates how storage conditions influence their quality over time. Rainwater harvesting is common in many rural communities, but harvested water may contain contaminants introduced from collection surfaces and container materials (Lade & Oloke, 2015).

Storage duration is a major determinant of water safety, with longer periods promoting microbial growth and shifts in physicochemical properties (Ikeokwu, 2021). Container type further contributes to these changes; for example, black plastic tanks have demonstrated better preservation capacity compared to other materials (Kr et al., 2025), an effect attributed in part to reduced light penetration and photodegradation in darker-coloured containers. The plastic containers used in the present study were blue rather than black (Plate 1); therefore, any preservation benefits associated

specifically with black pigmentation and light-blocking may not fully apply to the containers tested here. Over time, water stored in various vessels may experience chemical migration from container surfaces, microbial succession, parameter drift, and gas exchange, all of which alter its quality and pose potential health risks (Adesakin et al., 2022). Despite widespread reliance on stored water, however, limited attention has been given to how storage duration and container type jointly influence these changes in domestic settings, particularly for borehole, well, and rainwater sources. There is therefore a need to systematically assess how container type and storage duration affect the quality of water from commonly used domestic sources.

This research aims to provide insight into household water management by identifying safe storage durations, evaluating the influence of commonly used container materials, and proposing context-appropriate strategies for improving stored water safety. The findings are expected to inform public health guidelines, particularly in settings without centralized treatment systems. Emerging innovations, such as nanocoated containers and smart monitoring systems, may offer future pathways for improving water storage safety (Nishu & Kumar, 2023).

Maintaining the quality of potable water remains a persistent challenge, especially in rural communities where water is frequently stored before use. Even when collected water initially meets drinking standards, deterioration during storage is common. Clay pots and plastic containers are widely used, yet their impact on water quality over time remains inadequately understood (Nibret et al., 2025). This study is justified by the need to assess the effects of storage materials and duration on water quality, to reduce the risk of waterborne disease, and to recommend safe, suitable storage options for household use.

2.0: MATERIALS AND METHODS

2.1 MATERIALS

The list of equipment used is shown in Table 1

Table 1: List of Materials and Equipment Used

Glassware	Apparatus	Reagent
BOD Bottles	pH meter (H183200)	Manganous sulphate solution
Pipette pump	TDS-EC-Temperature Combo Meter	Alkaline iodine
Burette	Pipette Turbidity meter	Concentrated sulphuric acid
Beaker	Retort stand and clamp	Starch solution
Glass funnel		
Conical Flask		
Measuring cylinder		

2.2 SAMPLE COLLECTION PROCEDURE

Borehole and rainwater samples were collected from Orbit Apartment in Zango, while a well water sample was collected from Hayin Dogo, Samaru, Sabon Gari Local Government, Zaria. Before sampling, each container was rinsed three times with the respective source water to minimize contamination. Samples were taken, and containers were filled carefully. All relevant data, including date, time, and sampling locations, were recorded on-site. In-situ measurements of temperature, pH, EC, and TDS were conducted using calibrated portable meters. The remaining portions of the samples were sealed and placed carefully in storage. Thereafter, samples were either analyzed immediately or refrigerated at 4 °C pending analysis.

2.3 EXPERIMENTAL SETUP

The experiments were conducted using two types of containers: clay pots and plastic containers as shown in Plate 1. Each container had a capacity of at least 5 litres and was filled to about 80–90% of its volume to mimic typical household storage conditions. For each of the three water sources (borehole, well, and rainwater), one clay pot and one plastic container were used, giving a total of six containers. Each container was filled to 80-90% of its 5-litre capacity to mimic typical household storage conditions. They were then stored out of direct sunlight and opened only during sampling. Sampling was conducted at predetermined intervals on Days 1, 3, 7, and 14.



Plate 1: Clay and plastic storage containers.

2.4 LABORATORY ANALYSIS

All parameters were analyzed following standard laboratory procedures. Dissolved Oxygen (DO) was measured using high-quality reagents and standard procedures. Biochemical Oxygen Demand (BOD) was determined using the 5-day BOD test, with samples incubated at 20 ± 1 °C for five days. Each of the samples' storage times -1, 3, 7 and 14 days were incubated for five days to enable the measurement of 5-day BOD. The pH was measured with a calibrated pH meter, and turbidity was assessed with a Nephelometric turbidity meter. Temperature, Electrical Conductivity (EC), and Total Dissolved Solids (TDS) were measured with a TDS-EC-Temperature combo meter, respectively as shown in Plate 2.

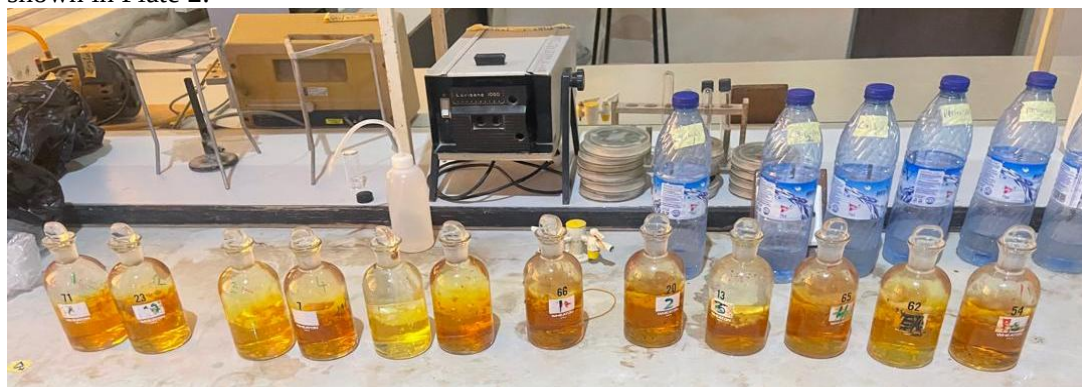


Plate 2: BOD/DO samples of various storage to be analysed.

2.5 SAMPLE HANDLING AND PRESERVATION

Field-sensitive parameters such as DO, temperature, pH, and turbidity were analysed immediately at the sampling point. BOD samples were filled without headspace and placed in an incubator at 20 ± 1 °C immediately after sampling. EC and TDS measurements were performed within 24 hours of collection. Samples that could not be analysed immediately were stored at 4 °C to prevent deterioration. All samples were handled according to standard procedures to ensure quality and reproducibility.

3.0 RESULTS AND DISCUSSION

These are the results of the physicochemical and biological analyses of borehole, rain, and well water stored in both clay and plastic containers over 14 days. The parameters analyzed include Turbidity, Temperature, Electrical Conductivity (EC), Total Dissolved Solids (TDS), pH, Dissolved Oxygen (DO), and Biochemical Oxygen Demand (BOD). The findings are summarized in Tables 2 – 8

Table 2: Turbidity (NTU) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	4.0	3.6	4.0	4.2	3.3	4.8
3	3.8	3.1	3.9	3.4	2.9	4.5
7	2.1	3.0	3.7	1.5	2.7	4.3
14	3.1	5.3	1.5	0.4	5.0	2.0

Table 3: Temperature (°C) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	25.6	24.5	24.0	23.8	23.8	23.8
3	26.4	25.6	26.0	26.3	26.1	26.2
7	23.5	24.3	23.7	23.9	23.4	23.4
14	25.6	24.9	23.6	24.9	24.8	24.7

Table 4: Electrical Conductivity (µS/cm) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	217.0	22.9	550.0	240.0	14.83	592.0
3	310.0	69.9	669.0	264.0	21.5	693.0
7	363.0	108.4	716.0	291.0	13.09	728.0
14	292.0	90.1	630.0	260.0	15.7	669.0

Table 5: Total Dissolved Solids (mg/L) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	109.8	11.4	276.0	120.1	7.38	296.0
3	153.5	34.8	334.0	132.5	10.63	347.0
7	182.6	54.0	357.0	146.0	6.37	365.0
14	147.4	45.0	315.0	130.1	7.67	335.0

Table 6: pH by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	8.5	7.86	7.52	7.86	7.53	7.64
3	8.83	6.58	6.32	7.92	7.69	8.49
7	7.92	8.76	7.75	7.1	7.53	8.82
14	8.76	6.27	6.44	6.36	6.33	6.57

Table 7: Dissolved Oxygen (mg/L) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	2.6	2.9	2.5	2.4	2.6	2.3
3	2.9	2.60	2.20	2.5	2.5	1.8
7	2.5	2.5	1.7	2.7	2.7	1.6
14	2.5	2.4	2.7	2.5	2.5	2.2

Table 8: Biochemical Oxygen Demand (mg/L) by Storage Day and Sample Type

Day	Borehole	Clay pot		Borehole	Plastic	
		Rain	Well		Rain	Well
1	1.7	0.1	0.6	0.3	0.8	0.2
3	1.0	0.5	0.9	0.5	0.2	1.1
7	0.8	1.0	0.7	0.7	0.5	0.6
14	0.6	0.5	0.7	0.8	0.7	0.9

As seen in Table 2, Turbidity generally decreased between days 1–7 in both containers, particularly in borehole water (4.0 - 2.1 NTU in clay), suggesting sedimentation of suspended particles. However, increases by day 14, for instance, rainwater (3.0 - 5.3 NTU in clay) signify microbial regrowth or resuspension of particles, a known phenomenon during prolonged storage. The slightly higher turbidity variability in clay may reflect interaction with porous surfaces, which can both trap and later release particulates. Overall, plastic containers yielded more stable turbidity readings than clay pots, likely due to their smooth, non-porous surfaces that minimize particle interactions. The final turbidity values, mostly below 5 NTU, conform with WHO (2017) limits for potable water except in rainwater for day 14, where a higher value was recorded, most likely attributed to measurement error. This result aligns with findings of earlier studies which reported a gradual reduction in turbidity during water storage, followed by slight fluctuations linked to container properties and biological activity (Binibor et al., 2025; Olawade et al., 2021)

Temperature fluctuations were modest across both containers, as seen in Table 3; however, clay-stored water occasionally showed slight cooling, as on day 7. This supports the evaporative cooling effect of porous earthenware, where water loss through micropores reduces internal temperature. Evaporative cooling in clay materials is well documented as a mechanism that lowers water temperature through latent heat loss via evaporation. Plastic, being non-porous, lacks this effect and maintains ambient temperatures. These results obtained are largely consistent with trends reported by previous researchers whose works corroborated the findings that water stored in clay pots tends to remain cooler than that stored in plastic containers, owing to evaporative cooling through the porous clay walls (Saagoto & Chowdhury, 2025)

Both EC and TDS increased initially (days 1–7) and declined by day 14, especially in clay pot. For instance, the EC and TDS of the borehole water increased from 217 - 363 $\mu\text{S}/\text{cm}$ before dropping to 292 $\mu\text{S}/\text{cm}$ and 109.8 – 182.6 mg/L before dropping to 147.4 mg/ L as contained in Tables 4 and 5 respectively. This trend implies Initial leaching of minerals due to evaporation followed by adsorption onto container walls. Clay-induced reductions in TDS are consistent with studies showing ion exchange and pollutant trapping in porous matrices. In contrast, plastic tends to retain dissolved ions, resulting in more stable but higher residual values. These observations agree with findings from related studies (Inchaurrondo & Font, 2022).

Water stored in clay pots exhibited greater pH variability, mostly alkaline; for instance, the borehole recorded values of 8.5, 8.83, 7.92, and 8.76 on Days 1, 3, 7, and 14, respectively, as shown in Table 6, while plastic samples showed a gradual decline by Day 14, as low as 6.33. The alkalinity in clay can be attributed to mineral dissolution and the buffering capacity of earthen materials, which has been reported to increase pH in stored water. Conversely, the decreasing pH in plastic may reflect microbial respiration and organic matter degradation, producing acidic by-products over time. These findings align with earlier reports (Shan et al., 2023; WHO, 2017) that prolonged storage generally leads to a reduction in pH as a result of biological and chemical interactions within the water and container.

The clay-borehole series, however, did not decline monotonically but fluctuated, suggesting that short-term measurement variability may be superimposed on the underlying alkaline trend. Because only a single pH reading was taken per container per sampling day, rather than a replicate mean, it is not possible to fully separate genuine short-term chemical fluctuation (e.g., transient CO₂ exchange at the water surface following container handling, or intermittent mineral dissolution from the clay matrix) from procedural sources of variability, such as electrode calibration drift over the 14-day monitoring period or minor differences in sample temperature at the time of reading, given that pH is inherently temperature-dependent. This pattern is noted as a limitation of the single-measurement design; future work should calibrate the pH meter immediately before each reading, record sample temperature alongside pH, and take replicate readings per sampling event to confirm whether such swings reflect real short-term variability in the clay-borehole system or measurement noise.

DO levels remained relatively low but were slightly more stable in clay storage (2.4–2.9 mg/L) compared to plastic storage, as seen in Table 7. The porous nature of clay can facilitate limited oxygen diffusion, helping maintain DO relative to plastic. Previous research confirms that clay storage can enhance oxygenation due to gas exchange across porous walls, whereas plastic containers form closed systems that limit aeration and may promote oxygen depletion through both chemical and biological oxygen-consuming processes. The overall DO levels across all container-source combinations ranged between 1.6 and 2.9 mg/L, consistent with previously reported values for stored water (Ibrahim et al., 2024; Maury Njoya et al., 2024). The observed pattern generally conforms to the established trend of gradual oxygen depletion followed by stabilization as physicochemical processes approach equilibrium during storage.

BOD generally decreased over time in clay storage, as demonstrated in the borehole source (1.7–0.6 mg/L, Table 8), indicating a reduction in biodegradable organic matter - potentially through organic matter stabilization, adsorption onto the porous clay surface, or a combination of both. Plastic samples showed greater variability and occasional increases; for instance, well water in plastic containers reached a BOD as high as 1.1 mg/L on Day 3, suggesting a possible rise in organic load or oxygen-demanding activity, which may be associated with microbial processes, although this was not directly measured in this study. These findings align with earlier studies confirming that prolonged storage in both container types generally led to water stabilization with minimal residual organic pollution potential (Bigohe et al., 2025; Muhammad et al., 2026; Wielen, 2025). Meanwhile, clay containers appeared to reach this stabilized state more consistently than plastic in the present study.

CONCLUSION

This study assessed the effect of storage container type (clay pot and plastic) and storage duration on the quality of water obtained from rain, well, and borehole sources. The analysis focused on physicochemical and biochemical parameters, including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, turbidity, temperature, Electrical Conductivity (EC), and Total Dissolved Solids (TDS). The study confirms that container material plays a critical role in mediating physicochemical transformations during storage, with associated implications for organic load and oxygen demand that may reflect underlying microbial activity, though this was not directly measured. Clay exhibited beneficial interactions - including evaporative cooling, adsorption, and comparatively more stable DO/BOD trends - whereas plastic containers, while providing greater structural stability, showed physicochemical trends (declining DO, variable BOD) that may indicate a greater potential for microbial-related deterioration over time. Overall, clay pots appear preferable for short-to-medium-term household water storage based on the physicochemical parameters assessed in this study. These findings should be interpreted with the caveat that no direct microbiological analysis (e.g., total coliform or *E. coli* enumeration) was conducted; future work incorporating such analysis is recommended to confirm whether the observed physicochemical trends correspond to actual microbial risk. Beyond clay and plastic containers, future studies could also include metallic, glass, or calabash containers to compare a wider range of storage options and their influence on water quality. A further limitation of this study is that single containers (rather than replicated containers) were used for each source-container combination, with one physicochemical measurement recorded per sampling day. Additionally, each water source was drawn from a single sampling site (Orbit Apartment, Zango, for borehole and rainwater; Hayin Dogo for well water), which may not capture the hydrogeological and

environmental variability present across other borehole, well, or rainwater sources within Zaria/Kaduna State. While this design allowed comparison across three water sources, two container types, and four storage durations within available resources, it does not permit statistical testing (e.g., ANOVA) of the significance of observed differences, and single measurements and single-site sampling cannot rule out the influence of measurement, sampling, or site-specific variability. Future studies should therefore incorporate replicate containers per condition, multiple sampling sites per source type, and direct microbiological assays, to enable formal statistical validation of both the physicochemical and microbial effects of container type and water source on stored water quality.

REFERENCES

- Adesakin, T. A., Oyewale, A. T., Mohammed, N. A., Bayero, U., Adediji, A. A., Aduwo, I. A., Bolade, A. C., & Adam, M. (2022). Effects of prolonged storage condition on the physicochemical and microbiological quality of sachet water and its health implications: a case study of selected water brands sold within Samaru Community, northwest Nigeria. *Microbiology Research*, 13(4), 706–720.
- Binibor, P. I., Nwachukwu, N. A., Ndulue, G. U., Ndukwe, D. U., Obumneme, A., Ngwu, V., & Usman, O. H. (2025). *Investigating the effect of storage materials on the quality of potable water*. 9(3).
- Ikeokwu, O. M. (2021). *Effect of storage container on the bacteriological quality of water from different sources*. 9(2), 47–53. <https://doi.org/10.15406/jmen.2021.09.00323>
- Inchaurredo, N. S., & Font, J. (2022). *Clay, Zeolite and Oxide Minerals: Natural Catalytic Materials*. 1–53.
- Lade, O., & Oloke, D. (2015). *Rainwater harvesting in Nigeria: Socioeconomic survey and common water supply practices*.
- Maury Njoya, I. Q., Lecomte-Nana, G. L., Barry, K., Njoya, D., El Hafiane, Y., & Peyratout, C. (2024). An Overview on the Manufacture and Properties of Clay-Based Porous Ceramics for Water Filtration. *Ceramics*, 8(1), 3.
- Mwabi, J. K., Mamba, B. B., & Momba, M. N. B. (2012). *Removal of Escherichia coli and Faecal Coliforms from Surface Water and Groundwater by Household Water Treatment Devices / Systems: A Sustainable Solution for Improving Water Quality in Rural Communities of the Southern African Development Community Region*. 10, 139–170. <https://doi.org/10.3390/ijerph9010139>
- Nibret, E., Cherie, F., & Yime, A. (2025). Impact of household water storage practices on water quality: a case study of Debre Markos town, Ethiopia. *Journal of Water, Sanitation and Hygiene for Development*, 15, 1007–1022. <https://doi.org/10.2166/washdev.2025.023>
- Nishu, & Kumar, S. (2023). Smart and innovative nanotechnology applications for water purification. *Hybrid Advances*, 3, 100044. <https://doi.org/https://doi.org/10.1016/j.hybadv.2023.100044>
- Obianyo, J. I. (2020). *Effect of storage containers on water quality*. 1(1), 66–73.
- Olawade, D. B., Wada, O. Z., Asogbon, O., Owojori, G. O., & Adewole, A. O. (2021). *Assessment of Household Water Quality from Selected Storage Vessels used in a South-Western Rural Community, Nigeria*. 15(2), 31–44. <https://doi.org/10.9734/AJEE/2021/v15i230224>
- Saagoto, M. S., & Chowdhury, N. (2025). Traditional clay pot coolers as drinking water cooling technology for urban heat adaptation in Bangladesh. *Sustainable Energy Technologies and Assessments*, 83, 104575. <https://doi.org/https://doi.org/10.1016/j.seta.2025.104575>
- Shan, Y., Cai, G., Zhang, C., Wang, X., Shi, Y., & Li, J. (2023). *Effects of Acidic / Alkaline Contamination on the Physical and Mechanical Properties of Silty Clay*. 1–16.
- WHO. (2017). *Potable reuse: Guidance for producing safe drinking-water*. World Health Organization.