



## Comparison of Physicochemical Parameters in Raw and Treated Borehole Sachet Water within Kaduna Metropolis

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### ABSTRACT

*This study examines the water quality parameters of pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Total Suspended Solids (TSS), temperature, and turbidity in raw and treated borehole water. The statistical analysis involved one-tailed and two-tailed t-tests to evaluate the significance of differences between these parameters. Regarding pH levels, both one-tailed and two-tailed p-values indicate a significant departure from the null hypothesis, revealing a substantial disparity in mean pH levels between raw and treated borehole water. The negative t-statistic suggests that treated water exhibits a higher pH than raw water. For TDS and EC levels, p-values greater than 0.05 signify a lack of strong evidence to reject the null hypothesis. Consequently, the disparities in mean TDS and EC levels between raw and treated borehole water may not be statistically significant. Although the positive t-statistics suggest higher values in raw water, these differences lack significance. The study also considers TSS levels, where a p-value exceeding 0.05 suggests no compelling basis to reject the null hypothesis. Consequently, the observed differences in mean TSS levels between raw and treated borehole water may not be statistically significant. A slightly lower TSS in raw water is implied by the negative t-statistic. For temperature, a p-value below 0.05 indicates a significant difference in mean temperature between raw and treated borehole water. The negative t-statistic proposes a lower mean temperature for raw water. Lastly, turbidity levels exhibit a p-value above 0.05, suggesting no substantial reason to reject the null hypothesis. Thus, the observed differences in mean turbidity levels between raw and treated borehole water may not be statistically significant. The negative t-statistic indicates slightly lower turbidity in raw water. This comprehensive analysis contributes to our understanding of water quality parameters in raw and treated borehole water. It underscores the significance of pH and temperature differences, while also highlighting the limited statistical significance in TDS, EC, TSS, and turbidity variations.*

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### INTRODUCTION

Water quality assessment is a critical aspect of ensuring public health and

environmental sustainability, especially in the context of sachet water sourced from boreholes [1]. The effectiveness of water treatment

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processes significantly impacts the safety of drinking water, and this is particularly crucial for sachet water, which is often sourced from boreholes [2].

Studies of water quality in Nigeria have shown that the major sources of water are creeks, rivers, shallow wells, and boreholes [3]. The appropriate acquisition and processing of water quality data are crucial for water resource management, and published articles on water quality monitoring and assessment are meant to convey essential and reliable information to water quality experts, decision-makers, researchers, students, and the public [4].

Water quality studies are among the most important ventures in the field of environmental studies in the 21st century [5]. This perception may be connected to the fact that water for various human endeavors such as industrial use, agriculture, construction, consumption, or other domestic applications demands a certain degree of quality to assure the suitability for the anticipated use [6].

The significance of water quality analysis in ensuring the safety of drinking water as well as their insights underscore the importance of understanding and managing water quality parameters to guarantee the provision of clean and safe sachet water, which plays a critical role in public health, particularly in areas with limited access to centralized water supply systems [7]. In most parts of Nigeria, access to portable water is strongly limited by cost, availability, nearness and other factors indicating that consumers are compelled to accept what they can afford or what is available [8]. In Nigeria, various contaminants have been detected in water samples from different part of the country. Contamination of borehole water has been reported for different parts of Nigeria [9, 10 and 11] arising from the possibility of having contaminants in sachet water and bore hole water. Since there is little information in the literature on the supply of water pollution mapping in Kaduna State, it is necessary to monitor many sachets and borehole water inside the state. As a result, the current research's objective is to evaluate and contrast the quality of

sachet and borehole water, which are the prevalent sources of drinking water within the study location [12, 13 and 14].

Hence, the study uses statistical analysis, specifically one-tailed and two-tailed t-test, to evaluate the significance of differences between these parameters.

### **Aim and Objectives**

The aim of this study was to evaluate the significance of differences between these parameters (pH, TDS, EC, TSS, temperature, and turbidity) of raw and treated borehole water. The specific objectives is to evaluate the hypothesis if there is no significant differences between the mean of raw and treated boreholes water parameters (pH, TDS, EC, TSS, temperature, and turbidity levels between the two groups.

## **METHODOLOGY**

### **Study Area**

Igabi, situated in Kaduna state, is a significant local government area (LGA) within Nigeria's administrative system. Established in 1989, it emerged from the former Zaria local government and is one of the four that constitute the Kaduna metropolitan city. Its administrative center is Turunku, and it encompasses three districts: Igabi, Rigachikun, and Rigasa [12]. Positioned at a latitude of 10°47'0" north and a longitude of 7°46'0" east, Igabi is strategically located. The 2006 census reported a population of 430,753 [13]. The region experiences an annual rainfall ranging from 250mm to 1000mm, with the rainy season lasting from May to October and a dry period from October to April [14]. The average wind speed is 11 km/h. With an average temperature of 32 °C and humidity around 48%, Igabi's subtropical climate influences its environment. The population has grown due to its appeal as a habitation destination. Igabi's role in Kaduna state showcases its significance as an LGA, influenced by its climate, population, and geographic features, making it an evolving and vibrant locality.

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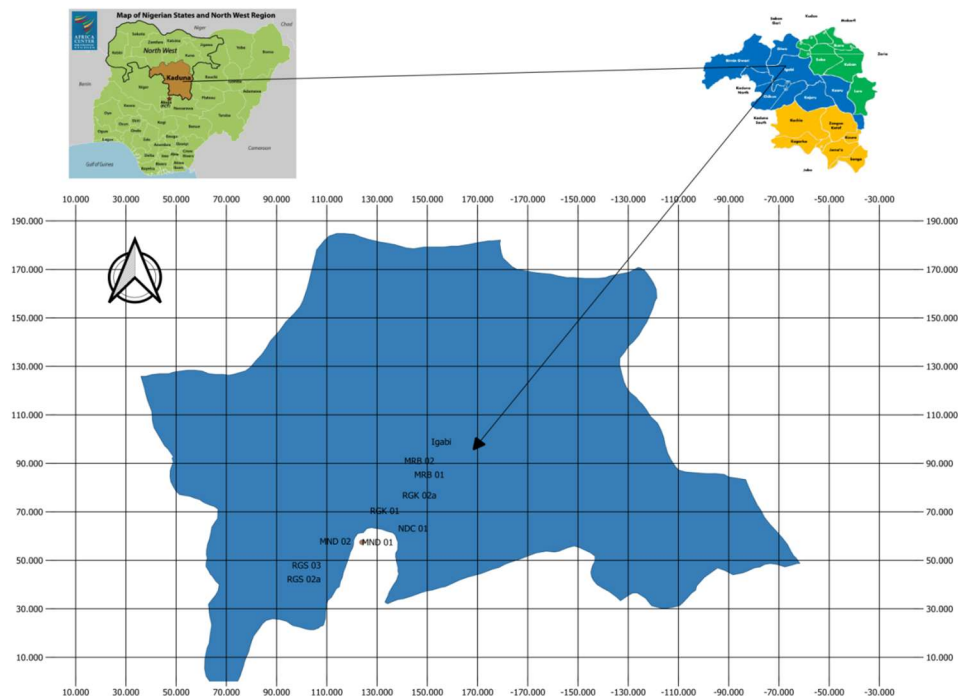
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### Collection of Water Sample

The study adhered to the standard methods for water and wastewater analysis [15] during sample collection. A preliminary survey was conducted to identify suitable sampling locations and obtain permission from sachet water factories. Sampling sites were selected based on the availability of sachet water factories, including Unguwan Kaji (NDC),

Rigachukun, Maraban Jos, Mando, and Rigasa, all in Kaduna town. A total of 20 samples were collected, 16 on the first day and the remaining 4 the following day, comprising both raw (borehole water) and treated (sachet water) samples. All samples were meticulously stored in refrigerated conditions to ensure preservation. The study location and the sampling points is presented in Figure 1.



**Figure 1:** Location of the water boreholes (Field work)

Data Collection and Preparation: Raw water (borehole water) and treated water (sachet water) samples were collected from various sachet water factories at selected locations within Kaduna Metropolis. A total of 20 samples were collected, with 16 on the first day and 4 on the subsequent day.

Procedure:

1. Three sets of sample bottles (100ml x2 and 50ml) for each site were sterilized a day to the sample collection.
2. Raw water (borehole) tap was cleaned with ethanol using cotton wool, opened

and allowed to run for a waste for at least five minutes.

3. A 1,000ml sample bottle was filled with the raw water to brew for physicochemical analyses.

Data Entry: The collected data, including the measured values of different physicochemical parameters (pH, TDS, EC, TSS, temperature, and turbidity), were entered into an Excel spreadsheet.

Data Analysis Tool: The Excel Data Analysis Tool was utilized to perform paired two-sample t-tests, assuming equal variances, for each of the physicochemical parameters. This

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analysis aimed to determine whether there were statistically significant differences between the mean values of raw and treated borehole water.

Setting up the Analysis Tool: In Excel, the Data Analysis Tool was accessed through the "Data" tab. The "t-Test: Two-Sample Assuming Equal Variances" option was selected, and the appropriate input range for the two groups (raw and treated borehole water) was specified.

Parameters and Hypotheses: The analysis tool required inputs such as the hypothesized mean difference (typically set to 0) and significance level (often 0.05). The null hypothesis assumes

no difference between the means, while the alternative hypothesis posits a difference.

### RESULT AND DISCUSSION

Upon executing the analysis, the tool provided results including t-statistic values, p-values (both one-tailed and two-tailed), degrees of freedom (df), and critical t-values. Interpreting Significance: The obtained p-values were compared with the chosen significance level. If the p-value was less than the significance level, it indicated a statistically significant difference between the mean values of raw and treated borehole water for that specific parameter. The results are presented in Tables 1.

**Table 1:** Results of analysed samples

	PH		TDS		EC	
	RAW	TREATED	RAW	TREATED	RAW	TREATED
MRB 01	6.15	7.25	43.69	47.97	83.67	91.49
MRB 02	5.66	6.72	191.5	200.5	366	383.6
RGK 01	6.14	6.65	89.7	26.44	172.2	50.06
RGK 02	6.15	6.66	83.08	61	159.3	116.7
NDC 01	6.66	7.07	139.2	32.49	265.8	56.04
MND 01	6.52	7.04	67.73	15.07	129.4	28.91
MND 02	6.16	6.54	44.76	70.26	85.68	134.4
RGS 01	6.49	6.62	50.49	53.42	96.56	102.1
RGS 02	6.67	6.94	67.03	49.94	12.83	94.22
RGS 03	6.9	7.5	97.84	7.23	187.2	13.73

	TSS		TEMPERATURE		TURBIDITY	
	RAW	TREATED	RAW	TREATED	RAW	TREATED
MRB 01	5.76	9.24	24.7	25.2	0.96	1.54
MRB 02	1.92	3	24.6	25.2	0.32	0.5
RGK 01	0.84	2.4	24	24.6	0.14	0.4
RGK 02	1.08	1.44	23.8	24.4	0.18	0.29
NDC 01	4.38	8.1	24.7	25.1	0.73	1.35
MND 01	3.72	4.98	24.7	25	0.62	0.83
MND 02	2.64	1.14	25.2	24.8	0.44	0.19
RGS 01	6.12	2.76	23.5	24.3	1.02	0.46
RGS 02	0.18	0.78	24.8	25.3	0.03	0.13
RGS 03	5.34	0.06	24.7	26	0.89	0.01

The statistical analysis of the result obtained in Table 1 is presented in Tables 2a and 2b.

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**Table 2a:** t-Test: Two-Sample Assuming Equal Variances for pH, TDS and EC

t-Test: Two-Sample Assuming Equal Variances

	pH		TDS		EC	
	Variable 1	Variable 2	Variable 1	Variable 2	Variable 1	Variable 2
Mean	6.35	6.899	87.502	56.432	155.864	107.125
Variance	0.131756	0.099232	2171.758	2966.098	10257.5	10935.18
Observations	10	10	10	10	10	10
Pooled Variance	0.115494		2568.928		10596.34	
Hypothesized Mean Difference	0		0		0	
Df	18		18		18	
t Stat	-3.61225		1.370725		1.058726	
P(T<=t) one-tail	0.000996		0.093656		0.151863	
t Critical one-tail	1.734064		1.734064		1.734064	
P(T<=t) two-tail	0.001992		0.187312		0.303726	
t Critical two-tail	2.100922		2.100922		2.100922	

**Table 2b:** t-Test: Two-Sample Assuming Equal Variances for TSS, Temperature and Turbidity

t-Test: Two-Sample Assuming Equal Variances

	TSS		Temperature		TURBIDITY	
	Variable 1	Variable 2	Variable 1	Variable 2	Variable 1	Variable 2
Mean	3.198	3.39	24.47	24.99	0.533	0.57
Variance	4.71764	9.6922	0.275667	0.247667	0.131046	0.265867
Observations	10	10	10	10	10	10
Pooled Variance	7.20492		0.261667		0.198456	
Hypothesized Mean Difference	0		0		0	
Df	18		18		18	
t Stat	-0.15995		-2.27308		-0.18572	
P(T<=t) one-tail	0.437353		0.017754		0.427371	
t Critical one-tail	1.734064		1.734064		1.734064	
P(T<=t) two-tail	0.874705		0.035507		0.854743	
t Critical two-tail	2.100922		2.100922		2.100922	

In this case, both the one-tailed and two-tailed p-values are much smaller than 0.05, indicating that there's strong evidence to reject the null hypothesis. This suggests that there's a

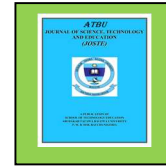
significant difference in the mean pH levels between the raw and treated borehole water groups. The negative t-statistic indicates that the

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mean pH of the treated borehole water is higher than that of the raw borehole water.

In this case, the two-tailed p-value is larger than 0.05, indicating that there's not strong evidence to reject the null hypothesis. This suggests that the observed difference in mean TDS levels between raw and treated borehole water may not be statistically significant. The positive t-statistic suggests that the mean TDS level of raw borehole water is higher than that of treated borehole water, but this difference is not statistically significant at the chosen significance level.

In this case, the two-tailed p-value is larger than 0.05, indicating that there's not strong evidence to reject the null hypothesis. This suggests that the observed difference in mean EC levels between raw and treated borehole water may not be statistically significant. The positive t-statistic suggests that the mean EC level of raw borehole water is higher than that of treated borehole water, but this difference is not statistically significant at the chosen significance level.

In this case, the two-tailed p-value is larger than 0.05, indicating that there's no strong evidence to reject the null hypothesis. This suggests that the observed difference in mean TSS levels between raw and treated borehole water may not be statistically significant. The negative t-statistic suggests that the mean TSS level of raw borehole water is slightly lower than that of treated borehole water, but this difference is not statistically significant at the chosen significance level.

In this case, the two-tailed p-value is smaller than 0.05, indicating that there's evidence to reject the null hypothesis. This suggests that the observed difference in mean temperature between raw and treated borehole water is statistically significant. The negative t-statistic suggests that the mean temperature of raw borehole water is lower than that of treated borehole water. Given the p-value and the chosen significance level, you may conclude that there is a statistically significant difference between the two groups' mean temperatures.

In this case, the two-tailed p-value is larger than 0.05, indicating that there's no strong evidence to reject the null hypothesis. This suggests that the observed difference in mean turbidity levels between raw and treated borehole water may not be statistically significant. The negative t-statistic suggests that the mean turbidity of raw borehole water is slightly lower than that of treated borehole water, but this difference is not statistically significant at the chosen significance level.

## CONCLUSION

**PH Levels:** The significant difference in both one-tailed and two-tailed p-values indicates a substantial reason to reject the null hypothesis. This implies a significant difference in the mean pH levels between raw and treated borehole water. The negative t-statistic suggests treated water has a higher pH than raw water.

**TDS Levels:** The two-tailed p-value greater than 0.05 indicates no strong evidence to reject the null hypothesis. This suggests the observed difference in mean Total Dissolved Solids (TDS) levels between raw and treated borehole water may not be statistically significant. The positive t-statistic implies a higher mean TDS in raw water, but this is not significant.

**EC Levels:** Similar to TDS, the two-tailed p-value is greater than 0.05, indicating no strong evidence to reject the null hypothesis. The observed difference in mean Electrical Conductivity (EC) levels between raw and treated borehole water may not be statistically significant. The positive t-statistic suggests higher EC in raw water, but this isn't significant.

**TSS Levels:** The two-tailed p-value above 0.05 indicates no strong evidence to reject the null hypothesis. This implies the observed difference in mean Total Suspended Solids (TSS) levels between raw and treated borehole water may not be statistically significant. The negative t-statistic suggests slightly lower TSS in raw water, but it's not significant.

**Temperature:** The two-tailed p-value is below 0.05, indicating evidence to reject the null hypothesis. This implies a statistically significant difference in mean temperature between raw and

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treated borehole water. The negative t-statistic suggests the mean temperature of raw water is lower.

Turbidity: The two-tailed p-value above 0.05 indicates no strong evidence to reject the null hypothesis. This suggests the observed difference in mean turbidity levels between raw and treated borehole water may not be statistically significant. The negative t-statistic suggests slightly lower turbidity in raw water, but it's not significant.

### RECOMMENDATIONS

1. Ensure that the pH levels of treated water are consistently maintained within safe limits for consumption. Regularly monitor and adjust the treatment processes to maintain the desired pH level.
2. Focus on understanding other factors affecting TDS levels, such as geological characteristics or local contamination sources, to ensure water quality.
3. Investigate other water quality indicators that might provide insight into differences between raw and treated water.
4. Continue monitoring TSS levels to ensure treatment processes effectively reduce suspended solids and maintain water quality standards.
5. Ensure temperature measurement accuracy and consider how variations might impact water treatment processes and consumer preferences.
6. Focus on maintaining efficient treatment processes to consistently reduce turbidity levels, even though the difference observed might not be statistically significant.

### REFERENCE

1. Ighalo, J. O., & Adeniyi, A. G. (2020). A comprehensive review of water quality monitoring and assessment in Nigeria. *Chemosphere*, 260, 127569.

2. Afolabi, A. S., & Raimi, M. O. (2021). When Water Turns Deadly: Investigating Source Identification and Quality of Drinking Water in Piwoyi Community of Federal Capital Territory, Abuja Nigeria.
3. Segun, AA, & Raimi, MO (2021). When Water Turns Deadly: Investigating Source Identification and Quality of Drinking Water in Piwoyi Community of Federal Capital Territory, Abuja Nigeria. *Online Journal of Chemistry*, 1(1).
4. Eyankware, M. O., & Ephraim, B. E. (2021). A comprehensive review of water quality monitoring and assessment in Delta State, Southern Part of Nigeria. *Journal of Environmental & Earth Sciences*, 3(1), 16-28.
5. Brankov, J., Pešić, A. M., Joksimović, D. M., Radovanović, M. M., & Petrović, M. D. (2020). Water Quality Estimation and Population's Attitudes: A Multi-Disciplinary Perspective of Environmental Implications in Tara National Park (Serbia). *Sustainability*, 13(1), 241.
6. Cosgrove, W. J., & Loucks, D. P. (2015). Water management: Current and future challenges and research directions. *Water Resources Research*, 51(6), 4823-4839.
7. Liu, J. (2023). A Synthetic Data-driven Solution for Urban Drinking Water Source Management (Master's thesis, NTNU).
8. Nathaniel Atamas Bahago, Gideon Wyasu and Vincent Chijioke Ugboaja. Quality Assessment of Borehole and Sachet Water Samples in Kaduna South Metropolis, *Communication in Physical Sciences* 2019, 4(2):167-173
9. Ibe, F. C., Enyoh, C. E., Opara, A. I., & Ibe, B. O. (2020). Evaluation of pollution status of groundwater resources of parts of Owerri metropolis and environs, Southeastern Nigeria,

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- using health risk and contamination models. *International Journal of Energy and Water Resources*, 4, 357-374.
10. Ukah, B. U., Ameh, P. D., Egbueri, J. C., Unigwe, C. O., & Ubido, O. E. (2020). Impact of effluent-derived heavy metals on the groundwater quality in Ajao industrial area, Nigeria: an assessment using entropy water quality index (EWQI). *International Journal of Energy and Water Resources*, 4(3), 231-244.
  11. gbasi, J. C., Chukwu, C. N., Nweke, N. D., Uwajingba, H. C., Khan, M. Y. A., & Egbueri, J. C. (2023). Water pollution indexing and health risk assessment due to PTE ingestion and dermal absorption for nine human populations in Southeast Nigeria. *Groundwater for Sustainable Development*, 21, 100921.
  12. Muhammed, A. Y., Salahudeen, H., Saliu, A. M., Suleiman, S., Maliki, J. A., Kawai, J. M., ... & Linus, O. F. (2021). Analysis of borehole water accessibility in Samaru Community, Zaria Metropolis, Kaduna State, Nigeria. *Journal of Social, Humanity, and Education*, 2(1), 67-84.
  13. Sridhar, M. K. C., Okareh, O. T., & Mustapha, M. (2020). Assessment of knowledge, attitudes, and practices on water, sanitation, and hygiene in some selected LGAs in Kaduna State, Northwestern Nigeria. *Journal of environmental and public health*, 2020.
  14. Yohanna, P., Apeh, O. V., & Lawuyi, T. (2021). Analyzing the quality of ground water in kaduna south local government area, Kaduna State, Nigeria. *FUDMA Journal of Sciences*, 5(2), 413-418.

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