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Assessment of Surface Water Quality in Zaria Metropolis: Implications for Environmental Health and Sustainable Management

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***Abstract**: Surface water bodies, including rivers, dams, and lakes, are integral to urban development and human life, supporting both urban residents and rural agricultural sectors. However, rapid population growth, urbanization, and industrialization have posed significant threats to water quality worldwide. Industrial discharges, in particular, contribute to water pollution, notably with toxic heavy metals. Assessing water quality involves monitoring various physicochemical parameters, which can be laborious and challenging. Therefore, this study employs statistical correlation analysis to understand the interrelationships among water quality parameters, aiming to simplify water quality assessment. Water samples were collected from Shika, Galma, and Ahmadu Bello University (ABU) dams in Zaria, Nigeria, and analysed for various parameters. Results showed that dissolved oxygen (DO) levels ranged from 1.37 to 3.67 mg/L, biochemical oxygen demand (BOD) ranged from 0.47 to 1.83 mg/L, and pH varied from 4.33 to 6.93 across different sampling points. Turbidity ranged from 65.27 to 152.20 NTU, total dissolved solids (TDS) ranged from 30.67 to 956.33 mg/L, and total suspended solids (TSS) ranged from 16.67 to 170.00 mg/L. Electrical conductivity (EC) varied from 62.97 to 1888.33 µs/cm, alkalinity (ALK) ranged from 14.00 to 28.00 mg/L, and chemical oxygen demand (COD) ranged from 93.30 to 123.30 mg/L. Sulphate (SO_4) concentrations ranged from 381.70 to 568.30 mg/L, nitrate (NO_3^-) ranged from 9.00 to 26.00 mg/L, and phosphate (PO_4) ranged from 0.12 to 0.61 mg/L. Statistical analysis revealed significant correlations among these parameters, indicating complex relationships within the aquatic ecosystem. Additionally, the analysis of variance (ANOVA) showed significant differences in water quality among sampling points, suggesting the influence of diverse pollution sources. Furthermore, the Water Quality Index (WQI) was calculated to assess the overall water quality status, indicating poor to unfit conditions for consumption across the studied locations. These findings underscore the urgent need for effective water management strategies to safeguard surface water quality for current and future generations.*

***Keywords:** Water quality index, physicochemical parameters, Analysis of variance, Correlation.*

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1.0 Introduction

Surface water bodies are mainly in the form of rivers, dams, and lakes (Aksoy, 2020). They play an irreplaceable role in urban development and human life (Gupta & Orbán, 2018). The quality of surface water is essential for human society, as surface water supports not only residents in the urban environment but also the agriculture sector in the rural environment (Khatri & Tyagi, 2014).
Water is the basic need of all living organisms and has been coined a national asset (Grey & Sadoff, 2007). Rapid growth in population, urbanization, and haphazard industrialization since the last decade has posed a serious threat to the water environment (Saha & Paul, 2018). Industrialization, despite its importance in terms of economic revenue, is said to be the worst water polluter (Ebenstein, 2012). The contamination of water bodies by the release of toxic heavy metals from urban and industrial discharges is a worldwide environmental problem in the present era (Singh *et al*., 2019).
Surface water quality is a critical aspect of environmental health and sustainability (Syeed *et al*., 2023). It refers to the chemical, physical, and biological characteristics of water bodies such as rivers, lakes, streams, and ponds (Carpenter *et al*., 2011). Surface water quality is indispensable for human well-being, ecological stability, economic prosperity, and environmental sustainability (Parkes, 2006). Ensuring clean and safe surface water is a shared responsibility, and effective management and protection of these resources are essential for current and future generations (Rossi, 2015).
The classification, modelling and interpretations of monitoring data are the most important steps in the assessment of water quality (Smith *et al*., 1997). Water quality parameters interact with each other (Saalidong *et al*., 2022). To define the resource water quality many researchers treated water quality parameters individually by describing the seasonal variability and their causes (Garizi *et al*., 2011). It is a very difficult and laborious task to regularly monitor all the parameters even if adequate manpower and laboratory facilities are available (Dinka, 2022). For this reason, in recent years an easier and simpler approach based on statistical correlation, has been developed using mathematical relationship for comparison of physicochemical parameters.
Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge (Singh *et al*., 2014). The study of correlation reduces the range of uncertainty associated with decision making (Schroeder & Benbasat, 1975). The significance of the observed correlation coefficients has been tested by using ANOVA.

2.0 Methods and materials

2.1 Site description

Shika dam was constructed mainly for water supply, farming activities by people living around the dam, this has been substantial over the years. The dam is located on latitudes 11°07'45"E to 11°08'20"E and longitudes 07°46'N to 07°48'N (Tanko *et al*., 2012).
Galma dam is located on latitudes 11˚07'45"E to 11˚08'20"E and longitudes 07˚46'N to 07˚48'N (Mohammed *et al*., 2020).
River Kubanni dam, which is prevalently called Ahmadu Bello University (ABU) dam is located approximately within latitude 11°11'N and longitude 07°38'E, it is within the premises of the University main campus (Okon *et al*., 2020).

2.2 *Water Quality Index*

This study employed Water Quality Index (WQI), a standardized methodology to assess water quality across various sampling locations. This evaluation involves the utilization of which integrates established criteria outlined by both the World Health Organization (WHO) and the Nigerian Industrial Standards (NIS) for drinking water quality assessment. (Tang *et al.*, 2022).

The WQI for each sampling station is determined using the following equation:

$$WQI = \frac{\Sigma(qnWn)}{Wn} \qquad (1)$$

where *Wn*: Unit weight assigned to the nth parameter, calculated as:

$$Wn = \frac{K}{Sn} \qquad (2)$$

In equation 2, k is the proportionality constant ensuring the sum of all *W*n equals 1, Sn is the permissible limit for the nth parameter established by WHO and NIS standards and qn is the quality rating for the nth parameter, computed as:

$$qn = \frac{100(Vn - Vi)}{(Sn - Vi)}$$

In the above equation, Vn is the measured value of the nth parameter at the sampling station and Vi is Ideal value for the nth parameter, considered zero for most parameters except pH (7.0) and dissolved oxygen (14.6 mg/L).

The various inferences that can be deduced concerning the quality status of water based on the above parameters are shown in Table 1

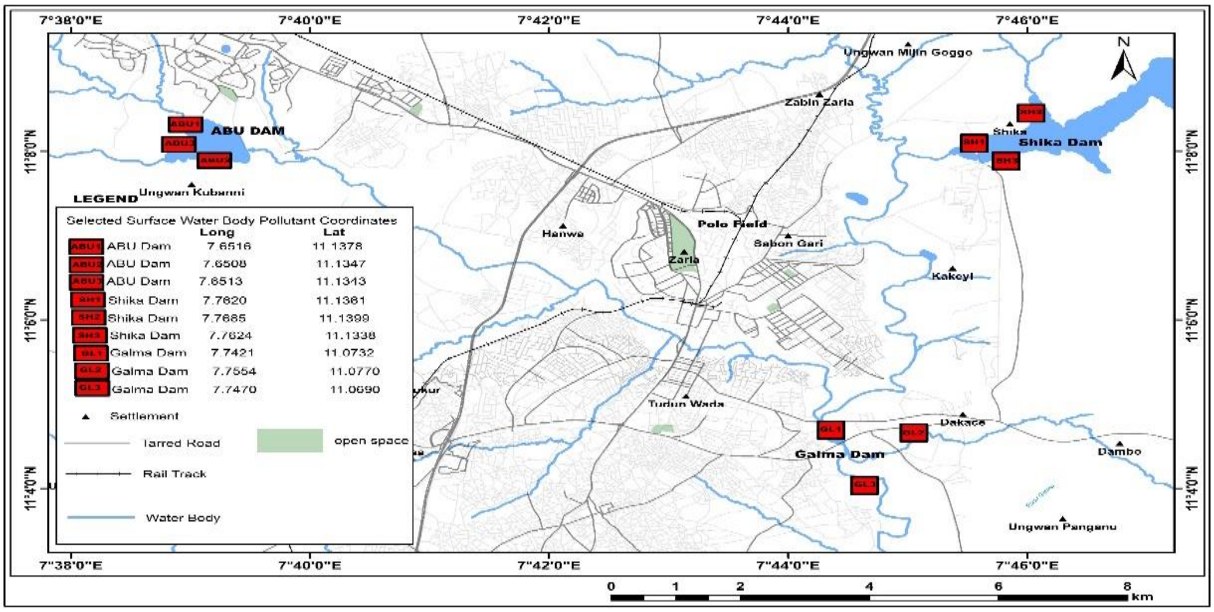

Fig 1: Map of Zaria Metropolis showing the points where the samples were collected

Table 1: Definition of water quality status

Water-Quality Index (%)	Water-Quality Status
0- 25	Excellent
26- 50	Good
51- 75	Poor
76- 100	Very poor
> 100	Unfit for consumption

2.3 Statistical Treatment of Data

The statistical analysis was performed using SPSS version 20 software. Statistical studies were carried out by calculating correlation coefficients between different pairs of parameters and was used to test the significant differences in the levels of the physicochemical parameter studied (using ANOVA) across the sampling points at 95% ($p \leq 0.05$) confidence level.

Coefficient of correlation (r) defined according to equation 3

$$= \sqrt{\frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x-x)^2\Sigma(y-\bar{y})^2}} \qquad (3)$$

where, x = Individual reading of 1st parameter, $\bar{x}$ is the mean of Σ x ,y is the individual reading of 2nd parameter and $\bar{y}$ is the mean of Σ y

The correlation among the different parameters will be true when the value of correlation coefficient (r) is high and approaching to one. Correlation, the relationship between two variables, is closely related to prediction. The greater the association between variables, the more accurately we can predict the outcome of events (Schober et al., 2018).

2.4 Sample Collection

Water samples was collected using Composite sampling method from three different locations, Galma, Shika and ABU dam. At each location, the samples were collected from three sampling points. The sample at each point were collected using two litres plastic bottles that have been previously soaked in 10% nitric acid and rinsed with distilled water before sampling. During sampling, the sample bottles was pre cleaned three times with the water to be sampled before sampling and then the samples were collected by careful immersion of the sampling bottles into the water body. The samples were well- labelled and taken to the laboratory for analysis (Akan *et al.,* 2012).

2.5 Quality assurance

All reagents used are of analytical grade, distilled de-ionized water was used. All the glassware, polythene bags and sample bottles were washed with liquid soap, rinsed with distilled water, soaked in 10% HNO_3 for 24 hr and rinsed thoroughly with distilled deionized water and thereafter dried (Patra *et al.,* 2020).

2.6 Determination of physicochemical parameters

Parameters such as: pH, electrical conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) turbidity(TURB), alkalinity (ALK), total dissolved solid(TDS), total suspended solids (TSS), nitrate (NO_3^-), sulphate (SO_4^{2-}) phosphate (PO_4^{2-}) ions were determined using standard analytical methods described by APHA (2015).

3.0 Results and Discussion

3.1 Physicochemical parameters of water samples

Table 4 to 6 reveals a comprehensive overview of the concentrations of DO, BOD, TDS, TSS, ALK and COD which ranges from 1.23±0.06 (SH3) to 3.67±0.06 (ABU1), 0.47±0.06 (SH3) to 1.83±0.06 (ABU1), 30.67±1.22 (SH3) to 956.33±2.08 (SH2), 16.67±5.77 (SH3) to 170.00±10.00 (ABU2), 14.00±0.00 (SH2) to 28.00±1.00(ABU3), 93.30±5.77 (SH3, ABU2) to 123.30±5.77 (SH1) mg/L respectively in the water sample, measured (mg/L), at nine different sampling points. The DO levels across all nine samples fall significantly below the WHO's recommended standard of 5 mg/L. The highest DO level recorded in the samples is 3.67 mg/L (ABU 1), while the lowest is 1.37 mg/L (SH1). The reduced DO values detected in certain locations could stem from various factors, such as the breakdown of organic matter and vegetation decay (Ba, 2003). Rabiu *et al.,* (2018), in their water analysis of Watari Dam in Kano State, obtained a mean BOD value ranging from 2.6 to 3.9 mg/L, which aligns consistently with the findings of this study.

The pH, turbidity (NTU) and EC (µs/cm) levels in the water samples ranges from 4.33±0.03 (SH2) to 6.93±0.47 (SH1), 152.20±7.80 (GL3) to 65.27±1.08 (ABU1), 62.97±3.09 (SH3) to 1888.33±14.19 (SH2) respectively. However, despite meeting the WHO standards, there are variabilities in pH levels among the water samples. The recorded pH ranges suggest a spectrum of acidity or alkalinity within the samples. The pH values are not consistence with the value reported by Garba *et al.,* (2014). The elevated turbidity levels in the water samples may be attributed to Seasonal Variations. Also, Sample SH2 stands out with very high conductivity of 1888.33±14.19 µs/cm, it significantly exceeds the WHO standard of 1000 µs/cm, indicating a high concentration of dissolved ions. Yunusa *et al.,* (2010) recorded slightly lower EC for Galma and ABU Dam.

The SO_4, NO_3^-, and PO_4^{3-} concentrations ranges from 381.70±7.64 (ABU1) to 568.30±2.89 (ABU2), 9.00±0.00 (SH1) to 26.00±0.00 (SH2) and 0.12±0.01 (ABU3) to

0.61±0.01 (GL3) Mg/L respectively. This ranges appears to be within the acceptable range All samples sulphate concentration is above the WHO standard of 250 mg/L. The major source of sulphate contamination in these water bodies may be attributed the use of fertilizers containing sulphates or animal waste and the runoff from agricultural lands into the water bodies.

3.2 Statistical Treatment of Data

Different pairs of water quality parameters with significant correlation coefficients are given in Table 2. In the present study B.O.D has strong significant positive correlation with D.O in Shika and ABU dams r= 0.988 and 0.866 respectively. This might be attributed to Spring runoff and increased agricultural activities during this season. The pH shows a negative correlation (r= -0.979, r= -0.971) in Shika Dam both D.O and B.O.D respectively.

Across all the sampling TDS has a positive correlation with DO (r=0.996, 0.882, 0.772) and BOD (r= 0.975,0.981,0.975); and strong negative correlation for pH (r= -0.997, -0.772) for Shika and Galma Dam repectively. Consistent positive correlation between TDS, DO, and BOD across all sampling instances suggests important relationships within the aquatic ecosystem, emphasising the influence of dissolved solids on oxygen dynamics and biological processes. The TSS was found to have a positive correlation with DO, BOD, TDS (r=0.952; r=0.914; r=0.945) for Shika Dam and a negative correlation with DO (r= -0.762, -0.789) for ABU and Galma, BOD (r=-0.942) for ABU, pH (r=-0.927) for Shika dam and TDS (r=-0.975: r=-0.782) for ABU and Galma dam. The positive correlation suggests that as TSS increases, DO also increases. This could be due to increased algae growth along with the suspended solids, which can sometimes produce oxygen through photosynthesis. The strong negative correlation indicates that higher TSS is associated with lower DO. The negative correlation of TSS/TDS might be attributed to the specific composition of suspended solids. Similarly, EC was found to have a positive correlation with DO, TDS (r= 0.996,0.878, 0.740; r=1,0.999,0.993) across all the sampling point, BOD (r=0.975,0.984) for Shika and ABU, TSS(r=0.9440) for Shika and negative correlation with pH (r=-0.977) for Shika dam, TSS (r=-0.974, -0.743) for ABU and Galma dam respectively. The correlation EC/DO may be due to Increased inorganic salts (which contribute to EC) might be linked to higher productivity of algae or aquatic plants that produce oxygen through photosynthesis. So, as the concentration of dissolved solids (TDS) increases, EC also increases.

Furthermore, NO_3^- was found to have a positive correlation with DO(r=0.969), BOD(r=0.937), TDS (r=0.985), TSS(r=0.909), EC(r=0.985), ALK(r=0.915) for Shika dam and a negative correlation with pH (-0.963), TSS(r=-0.743) for ABU dam, and ALK(r=-0.679, -0.813) for Shika and ABU dams respectively. This strong positive correlation suggests that higher nitrate concentrations are associated with higher dissolved oxygen (DO) in Shika Dam. This might be surprising, but it could be due to increased algae or aquatic plant growth stimulated by the nitrate (a nutrient). The NO_3^- /BOD strong positive correlation could be because nitrate can stimulate the growth of microorganisms that consume oxygen during organic matter decomposition, leading to higher BOD. Also Nitrate salts contribute to both Total Dissolved Solids (TDS) and Electrical Conductivity (EC). So, as nitrate concentration increases, both TDS and EC are likely to increase as well.

The PO_4^{3-} was found to have a positive correlation with TURB(r=0.799,0.860) in shika and Galma dam respectively, TSS(r=0.686) in galma dam, DO(r=0.759) in ABU Dam and S04(r=0.737,0.674,0.739) across all the sampling points and a negative correlation with ALK (r=-0.679, -0.813) in shika and ABU dam, TDS(r=-0.924) in galma dam, EC(r=-0.925) in galma dam, DO(r=-0.799) in galma dam, TURB(r=-0.690) in ABU dam and COD(r=-0.691) in shika dam. A PO_4^{3-}/TURB positive correlation could be

Table 2: Correlation between different pairs of parameters

Parameter	SHIKA	ABU	GALMA
BOD/DO	0.988	0.866	-
pH/DO	-0.979	-	-
pH/BOD	-0.971	-	-
TDS/DO	0.996	0.882	0.772
TDS/BOD	0.975	0.981	0.975
TDS/ pH	-0.997		-0.772
TSS/DO	0.952	-0.762	-0.789
TSS/BOD	0.914	-0.942	-
TSS/pH	-0.927	-	-
TSS/TDS	0.945	-0.975	-0.782
EC/DO	0.996	0.878	0.74
EC/BOD	0.975	0.984	-
EC/pH	-0.977	-	-
EC/TDS	1	0.999	0.993
EC/TSS	0.944	-0.974	-0.743
COD/TURB	-0.915	-	-
NO_3^-/DO	0.969	-	-
NO_3^-/BOD	0.937	-	-
NO_3^-/EC	0.985	-	-
NO_3^-/ALK	-0.679	-0.813	0.915
PO_4^{3-}/TURB	0.799	-0.69	0.86
PO_4^{3-}/ALK	-0.708	-0.874	
PO_4^{3-}/COD	-0.691		
PO_4^{3-}/SO4	0.737	0.674	0.739
TURB/DO	-	-0.973	-0.92
TSS/TURB	-	0.811	0,815
EC/TURB	-	-0.908	-
NO_3^-/ SO_4	-	-0.967	0.756
PO_4^{3-}/DO	-	0.759	-0.779
ALK/EC	-	-	-0.685
COD/ALK	-	-	0.81
PO_4^{3-}/TDS	-	-	-0.924
PO_4^{3-}/TSS	-	-	0.686
PO_4^{3-}/EC	-	-	-0.925

attributed a common source, such as runoff from agricultural land that carries both fertilizers (phosphate) and soil particles (increasing turbidity).

The data obtained from the analysis of physico-chemical parameters of surface water samples was subjected to ANOVA as shown in Table 5. The results of this analysis showed that there was a statistically significant difference at a confidence level of 95% ($p \leq 0.05$). This suggests that the water quality varies significantly between these points. The presence of a significant difference across all sampling points strongly indicates the influence of additional pollution sources.

3.3 Water Quality Index of Analysed surface water samples

In this study, the index for some surface water bodies in Zaria namely Shika, Galma, and ABU dams was measured. In the course of this study, the WQI values for these locations was determined. The WQI recorded in this study was found to be 137.2. 97.88 and 100.12 in Shika, Galma and ABU dams respectively These values provide an indication of the water quality at these sites.In this study, the WQI value of 137.2 and 100.12 falls into this category, signifying that the water quality is unfit for consumption. Although, the value of 97.88 is lower, indicating very poor water quality. This study's findings are consistent with those reported by Ramakrish in 2009 in a groundwater study conducted in India.

Table 3: Water Quality Index(WQI) of Analysed Water Samples

Samples	Index Values	WQI Status
SH	137.2	Unfit
GL	97.88	Very Poor
ABU	100	Unfit

The comparison of water quality analysis (Table 3). results from the three different sampling sites, namely SH, ABU, and GL, reveals significant variations in physicochemical parameters and water quality index (WQI) status. The WQT for the samples are 137.2 (SH), 100 (ABU), and 97.88 (GL). These values indicate that the water quality in SH is unfit while ABU and GL exhibit unfit and very poor statuses, respectively. These findings suggest varying degrees of pollution and degradation in the sampled water bodies, with SH showing the poorest water quality.

The analysed physicochemical parameters (Table 4) indicated that the dissolved Oxygen (DO) in the sampling sites are below the WHO standard of 5 mg/L, indicating poor oxygenation in the water bodies. The biochemical oxygen demand (BOD) levels exceeded the WHO standard of 5 mg/L in all samples, indicating high organic pollution and oxygen demand. Also, the pH values generally fall within the WHO-recommended range of 6.5-8.5, except for sample SH2, which shows acidic pH, potentially indicating acidification due to pollution or natural factors. The turbidity (TURB) values are significantly elevated across all samples compared to the WHO standard of 25 NTU, indicating high levels of suspended particles and reduced water clarity.

Total Dissolved Solids (TDS) and Total Suspended Solids (TSS): TDS and TSS levels vary widely across samples, but were within WHO standards, indicating the mineral content and suspended particle loads in the water. On the other hand, the electrical conductivity (EC) value in sample SH2 was exceptionally high, indicating elevated ion concentrations and potential contamination from industrial or agricultural sources. Other analytical parameters were alkalinity (ALK), chemical oxygen demand (COD), sulfate (SO4), nitrate (NO3-), and phosphate (PO4) levels show variations across samples, reflecting diverse sources of pollution and environmental conditions.

The ANOVA results as shown in Table 7 demonstrate significant variations ($p < 0.05$) in physicochemical parameters among the sampling sites, indicating spatial heterogeneity in water quality within the study area.

Table 4: Physicochemical parameters of selected surface water Zaria and its environment

Parameter	SH1	SH2	SH3	WHO
DO (Mg/L)	1.37±0.06	2.97±0.06	1.23±0.06	5
BOD (Mg/L)	0.57±0.06	1.23±0.06	0.47±0.12	5
pH	6.93±0.47	4.33±0.03	6.88±0.30	6.5-8.5
TURB (NTU)	97.23±2.37	114.37±1.27	144.73±2.34	25
TDS (Mg/L)	36.20±1.91	956.33±2.08	30.67±1.22	500
TSS (Mg/L)	23.33±5.77	53.33±5.77	16.67±5.77	200
EC (µs/cm)	70.60±3.84	1888.33±14.19	62.97±3.09	1000
ALK (Mg/L)	16.67±0.58	14.00±0.00	14.33±0.58	500
COD (Mg/L)	123.30±5.77	113.30±5.29	93.30±5.77	20
SO_4 (Mg/L)	466.70±5.77	486.70±11.55	485.00±13.23	250
NO_3^- (Mg/L)	9.00±0.00	26.00±0.00	12.00±0.50	50

PO_4 (Mg/L)	0.37±0.03	0.52±0.13	0.59±0.01	10

Table 5: Physicochemical parameters of ABU Dam

Parameter	ABU1	ABU2	ABU3	WHO
DO (Mg/L)	3.67±0.06	2.97±0.06	2.13±0.06	5
BOD (Mg/L)	1.83±0.06	1.10±0.10	1.03±0.12	5
pH	6.36±0.24	6.78±0.17	6.74±0.13	6.5-8.5
TURB (NTU)	65.27±1.08	70.93±1.07	75.40±1.22	25
TDS (Mg/L)	46.07±0.12	42.27±0.06	41.87±0.12	500
TSS (Mg/L)	40.00±0.00	170.00±10.00	153.33±5.77	200
EC (µs/cm)	91.90±0.30	84.63±0.15	83.93±0.15	1000
ALK (Mg/L)	23.33±0.58	28.00±1.00	20.33±0.58	500
COD (Mg/L)	120.00±0.00	93.30±5.77	100.00±10.00	20
SO_4 (Mg/L)	381.70±7.64	568.30±2.89	370.00±0.00	250
NO_3^- (Mg/L)	15.90±0.12	11.50±0.00	15.00±0.00	50
PO_4 (Mg/L)	0.20±0.02	0.22±0.00	0.12±0.01	10

Table 6: Physicochemical parameters of Galma Dam

Parameter	GL1	GL2	GL3	WHO
DO (Mg/L)	2.47±0.06	2.33±0.06	2.00±0.10	5
BOD (Mg/L)	0.67±0.12	0.73±0.06	0.93±0.150	5
pH	6.64±0.13	6.62±0.09	6.61±0.05	6.5-8.5
TURB (NTU)	135.07±3.44	118.73±1.08	152.20±7.80	25
TDS (Mg/L)	36.90±0.26	39.53±0.06	36.60±0.30	500
TSS (Mg/L)	46.67±5.77	36.67±5.77	53.33±5.77	200
EC (µs/cm)	73.43±0.21	79.30±0.44	73.10±0.26	1000
ALK (Mg/L)	17.67±0.58	16.00±0.00	16.67±0.58	500
COD (Mg/L)	116.70±5.77	103.30±5.77	113.30±5.77	20
SO_4 (Mg/L)	515.00±8.66	488.30±7.64	513.30±7.64	250
NO_3^- (Mg/L)	14.00±1.73	10.70±0.58	11.50±0.90	50
PO_4 (Mg/L)	0.58±0.03	0.48±0.03	0.61±0.01	10

Table 7: Analysis of Variance for the physicochemical parameters across the sampling points

		Sum of Squares	df	Mean Square	F	Sig.
DO	Between Groups	14.941	8	1.868	458.409	.000
	Within Groups	.073	18	.004		
	Total	15.014	26			
BOD	Between Groups	4.194	8	.524	54.442	.000
	Within Groups	.173	18	.010		
	Total	4.367	26			
pH	Between Groups	16.459	8	2.057	41.177	.000
	Within Groups	.899	18	.050		
	Total	17.358	26			

Turbidity	Between Groups	25708.987	8	3213.623	320.177	.000
	Within Groups	180.667	18	10.037		
	Total	25889.654	26			
TDS	Between Groups	2245631.634	8	280703.954	261796.434	.000
	Within Groups	19.300	18	1.072		
	Total	2245650.934	26			
TSS	Between Groups	74785.185	8	9348.148	252.400	.000
	Within Groups	666.667	18	37.037		
	Total	75451.852	26			
EC	Between Groups	8640352.847	8	1080044.106	43005.532	.000
	Within Groups	452.053	18	25.114		
	Total	8640804.900	26			
Alkalinity	Between Groups	504.667	8	63.083	189.250	.000
	Within Groups	6.000	18	.333		
	Total	510.667	26			
COD	Between Groups	3094.519	8	386.815	10.614	.000
	Within Groups	656.000	18	36.444		
	Total	3750.519	26			
SO_4^{-2}	Between Groups	96000.000	8	12000.000	180.000	.000
	Within Groups	1200.000	18	66.667		
	Total	97200.000	26			
NO_3^-	Between Groups	604.487	8	75.561	154.556	.000
	Within Groups	8.800	18	.489		
	Total	613.287	26			
PO_4^{-3}	Between Groups	.839	8	.105	50.375	.000
	Within Groups	.037	18	.002		
	Total	.876	26			

4.0 Conclusion

The study underscores the critical importance of assessing and monitoring surface water quality in the context of rapid urbanization and industrialization. Results demonstrate significant variations in physicochemical parameters across different sampling points, indicating potential sources of pollution and environmental degradation. The observed correlations among water quality parameters highlight the complex interrelationships within aquatic ecosystems, emphasizing the need for holistic approaches to water quality management.

Moreover, the Water Quality Index (WQI) analysis reveals poor to unfit conditions for consumption in the studied locations, underscoring the urgency of implementing effective remediation measures. The findings underscore the pressing need for comprehensive water management strategies to mitigate pollution and ensure the sustainability of surface water resources.

Based on the findings of this study, the following recommendations are proposed:

i. Implementation of regular and comprehensive monitoring programs to continually assess surface water quality across various sampling points.
ii. Pollution Control Measures: Enforce stringent regulations and pollution control measures to curb industrial discharges, agricultural runoff, and other sources of contamination.
iii. The lunching of public awareness campaigns to educate communities about the importance of preserving water quality and the adverse effects of pollution.
iv. The integration of sound approach to water management that considers the interconnectedness of surface water bodies with surrounding ecosystems.

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Uba Sani conducted the research

Abdulkadir Ibrahim contributed to the conceptual framework

Akande, Esther Oluwatoyosi wrote the manuscript

John, Oghenetega Mercy provided data analysis

Murtala, Mohammed Rumah assisted in reading through the manuscript