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Research Article

Evaluation of Water Quality Index of River Musa for Drinking Purpose in Bida, Nigeria

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Abstract

River Musa in Bida, Nigeria is of great importance to the people of the town and its environs. Due to the indiscriminate disposal of domestic and industrial effluents into the river, there is a need to evaluate the river water quality for drinking purpose. The objective of this study was to evaluate some selected physicochemical parameters (Total dissolved solids (TDS), pH, ammonia (NH₄⁺), Sodium, Calcium, Magnesium and four heavy metals (Fe, Pb, Cu and Mn)) of water from River Musa to reveal the detailed water quality of the river for its suitability for drinking purpose. To achieve this objective, the Canadian Council Water Quality index (CCWQI) was applied to the analytical results of the selected parameters to obtain a single value that was used to rank the river at each of the sampling locations. The annual average water quality indexes (for both rainy and dry season) at five locations are (40.9, 42, 40, 39.1 and 37.5). The results showed that the water quality of the entire river is poor (39.9) and the river water is not suitable for drinking purposes.

Keywords: Bida, Drinking water, Quality index, Physiochemical properties, River Musa

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Introduction

The economic value of every water decreases due to the presence of pollutants which affects human health and other aquatic forms of life (James, 2008). Water pollution was investigated to be one of the major problems facing many countries of the world (Waruguru *et al.*, 2011). It is caused by direct or indirect disposal of the different pollutants. Nasir *et al.* (2012) reported that surface water as an important integral part of the environment is the major recipient of the pollutants originating from various sources from manmade and from naturally occurring activities within our environment. The authors reported that the high susceptibility of surface water to pollution was due to its easy accessibility of natural and anthropogenic activities from its surrounding.

Sources of water pollution have been classified into point and non-point sources. According to John (2017), a point source is a single identifiable localized source of water pollution, an example of point source are sewage treatment plants, factory effluents etc while non-point sources are identified as diffuse sources of pollution which cannot be traced back to a particular location due to pollution originating from a wide variety of human activities on the land and natural processes, an example use of fertilizer and pesticide in food production. Research has shown that the majority of the common freshwater sources in Nigeria are polluted, leading to serious outbreak diseases and sudden deaths. Research conducted by Umeh *et al.* (2004) cited by Aboyeji (2013) showed that 48% of the people in Katsina-Ala local government of Benue State, Nigeria were affected by urinary schistosomiasis,

because of an increase in water pollution index discharging into water bodies. Aboyeji (2013) noted that the causes of water pollution in some Nigeria communities are industrial based water pollution, agricultural water pollution, oil spill based water pollution and domestic water pollution.

Research has also shown that the quality of River Landzun in Bida, which is a tributary to the River Musa was not good for drinking purposes. Research conducted by Mohammed and John (2012) showed that River Landzun water pollution was generated by Bida abattoir effluent. River Musa being an important river for economic, agricultural and environmental significance in the town, there are various pollution activities taking place along the river bank. In view of this, the objective of the study was to evaluate the seasonal variation of some selected physicochemical properties of River Musa and determine its water quality for drinking purposes using the Canadian Council of Ministers of Environment (CCME) water quality Index.

Materials and Methods

Study location

River Musa in Bida town, Niger state is the longest river that flows across the town and its environs. The river water source is from Edokota station and empties at Bida Army Barrack Bridge. The river is geographically located between latitudes $9^{\circ}2'40''$ and $9^{\circ}8'0''$ N and longitudes $5^{\circ}58'40''$ and $6^{\circ}4'0''$ with a total length of (8.307) km. Bida has annual rainfall ranging from 1000mm to 1200mm with a marked rainy season from April to October. The average annual air temperature is 27°C . It is a major driver of economic, agricultural and environmental significance in the town. The river water is used by the people of Bida and its environs for different activities (irrigation, fishing and household usage).

Figure 1: Map of Bida Showing River Musa.

Source: Maina and Yunusa (2020)

Note: SPI is sample point one, Edokota station, SP2 is sample point two, Musa mini bridge station, SP3 is sample point three, Bida/ Minna mini bridge station, SP4 is sample point four, Ciriko mini bridge station, SP5 is sample point five, Army Barrack station

Sampling and analytical technique

Water samples were taken from five locations (Edokota, Musa mini Bridge, Bida/Minna bridge, Ciriko and Army Barrack bridge) for pH, Magnesium, Calcium, Ammonia, total dissolved solids, Sodium and heavy metals (Iron, Lead, Manganese and Copper). The parameters were used to calculate water quality index. The pH was measured using a pH meter. Total dissolved solids, Ammonia, Calcium, Magnesium and Sodium were determined using standard methods recommended by the American Public Health Association (APHA, 1995). Heavy metals were determined using Atomic Absorption Spectrometer (AAS). The heavy metals of water samples were evaluated by digesting water samples using concentrated nitric acid HNO_3 and concentration of Iron (Fe), Copper (Cu), Lead (Pb) and Manganese (Mn) were measured with S series atomic absorption spectrophotometer

(AAS).

Method of samples collection

Sample collection was carried out with the use of plastic bottle containers which were washed before use. Bottles were properly rinsed with the river water at location points and were properly labelled. Samples were filtered with Whatmanpaper to remove particles before the analysis. Samples were collected at five (5) different locations. The detention time of samples was 45 minutes between the sample collection sites and the laboratory.

The five collection points are the main stations where various significant activities takeplace. These points are:

- i. Edokota mini bridge where major domestic and farming activities take place. The distance between this station and Musa station is 0.563 km.
- ii. Musa mini bridge where farming activities mostly occur. The distance between this station and Minna/Bida station is 2.940 km
- iii. Minna/Bida mini bridge where farming activities take place. The distance between this station and Ciriko station is 2.597 km.
- iv. Ciriko mini bridge where gardening, irrigation farming, abattoir and municipal (waste dump) take place. The distance between this station and Army Barrack station is 2.207 km.
- v. Army barrack mini bridge where farming activities occur.

Water quality index evaluation

Water Quality Indices make use of a 'single value' for the expression of the overall water quality of a particular source at a certain period of time on the basis of some water quality variables (Yogendra and Puttaiah, 2008). The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was used as a statistical technique for the work due to its simplicity and ability to simplify Drinking Water Quality (DWQ) data without compromising the technical integrity of the data (Haseenet *al.*, 2005). The results of these parameters were compared with the World Health Organisation standard (Table 1). The WQI determination using CCME consist of three factors; Scope F_1 , Frequency F_2 and Amplitude F_3 (John, 2006).

These factors were calculated for the five sample collection locations.

The Index compares the compliance of the observed data to a water quality standard or objective to give a score ranging from 0, (indicating the worst quality) to 100 (signifying the best quality) (Table 2). The Index is useful in monitoring water quality change at a particular location over a year and also in comparing directly among stations in which the same variables and objectives are employed. The index was used to quantify for the station or among the stations the number of parameters that exceed or fall below the standards.

The WQI determination using CCME,2005 consist of three factors; Scope F_1 , Frequency F_2 and Amplitude F_3 . These factors were calculated for the five locations as follows.

Scope (F_1) represents those water quality parameters with objectives that were tested during the time for the index calculation.

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}} \right) \times 100 \dots \dots \dots (1.1)$$

Frequency (F_2) represents the percentage of individual tests that do not meet the objectives ('failed tests'):

$$F_2 = \left(\frac{\text{Number of failed test}}{\text{Total number of test}} \right) \times 100 \dots \dots \dots (1.2)$$

Amplitude (F_3); This is a measure of amplitude. This was calculated in three steps:

Step 1a: Calculation of excursion in which failed tests greater than objective involves the use of the formula below

$$\text{Excursions} = \left(\frac{\text{Failed Test Value}}{\text{Objective}} \right) - 1 \dots \dots \dots (1.3a)$$

Step1b: Calculation of excursion in which failed tests less than objective was calculated as below

$$\text{Excursions} = \left(\frac{\text{Objective}}{\text{Failed Test Value}} \right) - 1 \dots \dots \dots (1.3b)$$

Step 2: Calculation of Normalized Sum of Excursions (nse)

$$\text{Nse} = \frac{\sum_{k=1}^n (\text{Excursions})}{\text{Total number of tests}} \dots \dots \dots (1.4)$$

Step 3: Calculation of Amplitude (F₃).

$$F_3 = \left(\frac{nse}{0.01nse + 0.01} \right) \dots\dots\dots (1.5)$$

The CWQI was finally evaluated as:

$$WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right) \dots\dots\dots (1.6)$$

Statistical analysis was done using SPSS (21.0 software) package.

Results and Discussion

Water Quality Index for the five locations along the river was calculated for rainy and dry seasons in a year (2019) using selected physicochemical parameters listed in Table 3 and 4. The values of the various scopes (F₁), frequencies (F₂), and amplitudes (F₃), with their water quality index are presented in Table 5. During the rainy season, the water quality index values of the river at all stations i.e Edokota location, Musa bridge station, Bida/Minna station, Cirriko station and Army Barrack station were 43, 46.3, 46.1, 43.9 and 37.7 respectively. The values showed that the water was ranked poor at Edokota, Cirriko and Army barrack stations, but marginal at Musa and Bida/Minna stations. During the dry season, the water quality index values were relatively lower than in the rainy season, however, ranked poor for all the stations. The average annual index values (Table 6) of the River Musa (which range from 37.5 to 42.0) show that the water quality for drinking purposes at the all locations were ranked poor. The poor ranking of the river could be attributed to different types of pollutants entering the river due to various anthropogenic activities at those stations. Pollutants such as domestic sewage, runoff water from agricultural lands and abattoir wastes near the banks of the river may be responsible for the poor water quality of the river. In a similar study conducted on the Asa river in Ilorin Nigeria, it was reported that runoff water from agricultural land and domestic sewage wereresponsible for the poor water quality of river Asa in Ilorin (Ahaneku and Animanshaun, 2013). The poor water quality rating observed was determined by the analytical results of the physiochemical parameters (Table 3 and Table 4) chosen for WQI calculation. The pH average values of five stations during the rainy season

range from 5.00-5.97. These values were below the WHO standard (6.5-8.4).

Similarly, research conducted in Owerri Nigeria Amadi *et al.* (2010b) reported a mean pH value of 5.02 for Otamiririver. This could be attributed to agricultural runoff from lands within the locations. During the dry season, average values ranged from (5.3-7.57) were observed in the five stations compared to rainy season data. The pH value of the river at the Edokota station has the highest average value of (7.57) and slightly alkaline compared to other stations.

Ahaneku and Animanshaun (2013) reported a (weak) alkaline pH mean value of 8.11 during dry season for river Asa, Ilorin. A higher value of pH obtained from River Musa during dry the season could be attributed to the hardness of water as a result of the concentration of calcium carbonates during dry season which are mostly CaCO₃ from rocks, sulphate and nitrite of calcium and magnesium. The variations of pH between Edokota Bridge and other sampling stations during rainy and dry seasons were statistically insignificant at 5% (between upstream and downstream). During the rainy season, the TDS average values ranged from 9.35 to 148.74 mg/l with the highest value recorded at Cirriko station (148.74 mg/l) and are within the WHO standard (0-500 mg/l). In contrary to this study, Animanshaun *et al.* (2016) reported that during the rainy season, high TDS mean value (290mg/l) for Asa river in Ilorin. The observed value indicates that the river is been compromised by anthropogenic activities during the rainy season. During the dry season, the TDS average values of the river musa at the five stations ranges from 11.10 -104.34 mg/l. Ahaneku and Animanshaun (2013) reported that during the dry season the TDS mean value of 418 mg/l for river Asa. The variations of total dissolved solids between Edokota and other sampling stations during both seasons were statistically significant at a 5% level.

During the rainy season sodium (Na) average values from all locations range from 7.00–23.49 mg/l and all were within the WHO standard (0-200 mg/l)) with the highest value obtained at Edokota station. Amadi *et al.* (2010b) also reported a mean Na value of 54.3 mg/l for Otamiri

river. During the dry season the recorded Na average values for the studied sites ranged from 1.13-15.83 mg/l, with the highest value recorded at Ciriko station. Similarly, in a research conducted in Anambra Nigeria, Chukwuma *et al.* (2016) reported a mean Na value of 7.72 mg/l in Ele River during the dry season. The high value of Na of River Musa during the rainy season could be attributed to agricultural runoff from farm lands within the locations. The variations of Sodium between Edokota and other sampling stations for both rainy and dry seasons were statistically significant at a 5% level. During the rainy season the average values of Ca at all sampling points ranged from 1.27-6.55 mg/l and are were all within the permissible limit recommended by WHO (0-200 mg/l). In contrary to this study (Amadi *et al.* 2010b) reported that during the rainy season high Ca mean value of (84.2 mg/l) of Otamiri river in Owerri was observed. The hardness of water occurred as a result of the presence of dissolve calcium and magnesium (Amadi *et al.*, 2010b).

During the dry season, the average calcium concentration at all sampling points ranged from 10.95-24.32 mg/l with the highest value recorded at Cirriko station (24.32 mg/l). Chukwuma *et al.* (2016) also reported a Ca value of 20.52 mg/l from Ele River. The variations of Calcium between Edokota and other sampling stations for both seasons were statistically insignificant at a 5% level. The average magnesium values at all sampling points during the rainy season range from 1.13-8.23 mg/l and are within the WHO threshold (0-150 mg/l). During the dry season, average magnesium values at all sampling points ranged from 14.92-30.82 mg/l which were within the threshold. Chukwuma *et al.* (2016) also reported that the mean Mg values of (17.85 mg/l) of Ele River was observed. During the dry season average values of Mg were higher than the rainy season values because of the high level of concentration of water hardness. The variations of magnesium between Edokota and other sampling stations for both seasons were statistically insignificant at a 5% level.

During the rainy season, the average values of manganese at all sampling points ranged from 0.25-0.68 mg/l. The Mn average values of the

River Musa at the five stations were above the permissible limit recommended by WHO (0-0.1). During the dry season, the average Manganese values at all sampling points ranged from 0.34-0.45 mg/l. Contrarily Cosmas *et al.* (2015) also reported the annual average value of (0.08 mg/l) of Mn of Bunza ground water in Kebbi, Nigeria. In a similar study (Amadi *et al.*, 2010b) also reported an annual average value of (0.35 mg/l) of Mn for the Otamiri river in Owerri. The high values of manganese at all stations for both rainy and dry seasons could be attributed to the disposing of industrial waste into the river from mechanic villages near the stations. The variations of Mn within Edokota and other sampling stations were statistically insignificant at a 5% level for the two seasons. During the rainy season the average iron values at all sampling points ranged between 0.534-0.99 mg/l with the highest value recorded at Army barrack station (0.99) which was above the WHO standard (0-0.3 mg/l).

During the dry season, the iron average values of the River Musa at the five stations were above the permissible limit. The values ranged between 0.34-0.46 mg/l. The variations of Iron within Edokota and other sampling stations during the rainy season were statistically significant at a 5% level. During the dry season the variations of iron within Edokota and other sampling stations were statistically insignificant at a 5% level. During the rainy season, the average values of lead at all sampling points ranged between 0.15-0.38 mg/l and all are above the permissible limit recommended by WHO (0-0.01mg/l). During the dry season, the average Pb concentration at all sampling points range between 0.42-0.51 mg/l. The high level of the lead during the both seasons at all stations could be attributed to disposing of industrial waste into the river from mechanic villages near the stations and as well as dissolved lead metal products inside the river. The variations of lead between Edokota and other sampling stations during both seasons were statistically insignificant at a 5% level.

Ahaneku and Animanshaun (2013) reported that the concentration of the heavy metals of river Asa, Ilorin (lead and iron) exceeded the permissible level recommended by WHO for drinking purpose at the two seasons (0.09 and 1.40 for the rainy

season, 0.11 and 1.90 mg/l for dry season respectively). During the rainy season the average values of ammonia at all sampling points ranged between 0.96-1.21 mg/l and all were above the permissible limit recommended by WHO (0-0.2 mg/l). contrarily, Ahaneku and Animanshaun (2013) reported low ammonia mean value (0.09 mg/l) for Asa river in Ilorin during rainy season. During the dry season, the average ammonia concentration at all sampling points ranged between 4.40-6.97 mg/l with the highest value recorded at Army barracack station (6.97 mg/l). Ahaneku and Animanshaun (2013) also reported during the dry season low ammonia mean value (0.2 mg/l) for Asa river in Ilorin. The higher concentration of ammonia during both seasons could be attributed to the discharge of domestic and abattoir wastes into the river along the river banks. The variations of ammonia within Edokota and other sampling stations for both seasons were statistically insignificant at a 5% level. During the rainy season the average values of Cu at all sampling points ranged between 0.30-0.58 mg/l and all were within the permissible limit recommended by WHO (0-1.0 mg/l). During the dry season, the average Cu concentration at all sampling points ranged between 0.33-0.78 mg/l. In a similar study, Animanshaun *et al.* (2016) reported during rainy and dry seasons low mean values of Cu (0.7 and 0.8 mg/l) were observed for Asa river in Ilorin. The variations of Cu between Edokota and other sampling stations during the rainy season was statistically insignificant at a 5% level and during the dry season the variation of Cu within all sampled points was statistically significant at all points.

Conclusion

The concentrations of selected physicochemical properties of River Musa were assessed and the annual river water quality index was determined using the CCME water quality Index. The result of the study showed that the river is not recommended for drinking purposes. More so, the study revealed that the application of Water Quality Index is a useful statistical technique in assessing the quality of river for drinking purposes in the study area. Periodic monitoring of the river and evaluation of

water parameters should be adopted.

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Table 1: WHO set of established Standard

Parameters	WHO
Ph	6.5-8.5
Lead	0.01
Manganese	0.1
Sodium	200
Copper	1.0
Iron	0.3
Ammonia	0.2
Magnesium	150
Total Dissolve solid	500
Calcium	200

Source: WHO water drinking standard (2019)

Table 2: Canadian water quality index ranking, values and description

Ranking	CWQI Values	Description of the Ranks
Excellent	95-100	Water quality satisfies with all criteria for drinking purpose
Good	80-94.4	Water quality rarely disagree with all criteria for drinking purpose
Fair	65-79.9	Water quality sometimes disagree with all criteria for drinking purpose
Marginal	45-64.9	Water quality often violates with all criteria for drinking purpose
Poor	0-44	Water quality does not satisfy any criteria for drinking purpose

Source: CCME (2005)

Table 3.: Descriptive statistics of water quality parameters of the river during rainy season

LOCATION	Ca(mg/l)	Mg (mg/l)	Na (mg/)	N- NH ₃ mg/l	Fe(mg/l)	Mn (mg/l)	Cu mg/L	pH	Pb mg/L	TDS (Mg/l)
EDOKOTA										
Mean	1.38	2.47	23.49	0.98	0.54	0.26	0.30	5.97	0.23	16.92
Minimum	0.64	2.30	22.90	0.88	0.48	0.04	0.20	4.90	0.15	13.32
Max	2.08	2.70	23.86	1.11	0.59	0.47	0.35	8.00	0.40	19.98
SD	0.72	0.21	0.51	0.12	0.08	0.30	0.09	1.76	0.14	3.36
MUSA BRIDGE										
Mean	6.55	1.13	20.95	1.15	0.59	0.41	0.32	5.63	0.15	9.35
Minimum	1.76	0.30	18.76	0.90	0.59	0.33	0.05	5.10	0.15	6.66
Max	16.03	1.70	23.30	1.65	0.59	0.49	0.45	6.60	0.16	13.32
SD	8.21	0.74	2.27	0.43	0.01	0.12	0.23	0.84	0.00	3.51
BIDA/MINNA										
Mean	1.27	3.43	20.20	1.21	0.65	0.48	0.43	5.50	0.15	12.99
Minimum	0.96	2.50	17.80	0.95	0.59	0.47	0.40	5.00	0.15	6.66
Max	1.64	4.40	24.10	1.69	0.70	0.49	0.45	6.50	0.15	18.98
SD	0.35	0.95	3.41	0.42	0.08	0.02	0.03	0.87	0.00	6.17
CIRIKO										
Mean	1.92	8.23	17.87	1.06	0.70	0.69	0.58	5.07	0.15	148.74
Minimum	1.68	6.90	9.90	1.00	0.70	0.471	0.50	4.80	0.15	113.22
Max	2.31	10.20	22.90	1.16	0.70	0.90	0.75	5.50	0.15	179.82
SD	0.33	1.74	6.98	0.09	0.00	0.30	0.14	0.38	0.00	33.52
ARMY BARRACK										
Mean	1.72	4.23	7.00	0.96	0.99	0.45	0.41	5.00	0.38	42.18
Minimum	0.80	2.90	2.20	0.91	0.59	0.43	0.35	4.70	0.15	13.32
Max	2.20	6.20	9.90	1.04	1.40	0.47	0.44	5.20	0.50	59.94
SD	0.80	1.74	4.19	0.07	0.57	0.03	0.05	0.26	0.20	25.21
WHO standard	0-200	0-150	0-200	0-0.2	0-0.3	0-0.1	0-1.0	6-8.5	0.01	0-500

Note: TDS = Total Dissolved Solids

Table 4. Descriptive statistics of water quality parameters of the river during dry season

Location	pH	TDS (mg/L)	N- NH4mg/L	Ca (mg/l)	Mg (mg/L)	Na (mg/l)	CU mg/l	Pb (mg/l)	Mn (mg/l)	Fe (mg/l)
Edokota										
Mean	7.57	11.10	4.43	10.95	24.16	1.45	0.33	0.44	0.34	0.42
Minimum	6.1	6.66	4.17	8.02	8.76	0.96	0.11	0.35	0.26	0.33
Max	8.8	13.32	4.89	13.22	34.29	2.00	0.61	0.49	0.39	0.52
SD	1.37	3.85	0.41	2.66	13.56	0.52	0.26	0.07	0.06	0.09
Musa										
Mean	6.9	11.1	4.41	14.16	14.92	1.12	0.63	0.42	0.37	0.35
Minimum	5.5	6.66	4.32	6.41	7.05	0.79	0.33	0.28	0.28	0.28
Max	8	19.98	4.51	26.05	28.69	1.3	1.11	0.55	0.46	0.42
SD	1.28	7.69	0.09	10.45	11.97	0.29	0.42	0.13	0.08	0.07
Minna										
Mean	5.6	17.69	4.40	14.16	20.11	2.09	0.78	0.46	0.41	0.42
Minimum	5.5	13.32	4.16	5.61	4.86	1.29	0.28	0.35	0.30	0.33
Max	5.7	19.98	4.71	20.84	37.45	3.5	1.17	0.55	0.50	0.52
SD	0.1	3.79	0.28	7.79	16.39	1.23	0.46	0.10	0.09	0.09
Ciriko										
Mean	5.53	104.34	5.76	24.32	17.92	15.83	0.76	0.51	0.45	0.46
Minimum	5.5	86.58	5.34	23.25	16.54	11.2	0.5	0.35	0.33	0.32
Max	5.6	119.88	6.59	25.65	19.94	21.90	1.00	0.62	0.56	0.52
SD	0.06	16.76	0.71	1.23	1.79	5.49	0.25	0.14	0.12	0.11
Army Barak										
Mean	6.63	46.62	6.97	15.09	30.08	6.50	0.65	0.49	0.45	0.44
Minimum	5.6	39.96	5.37	6.41	11.19	6.20	0.27	0.35	0.37	0.33
Max	8.3	53.28	8.05	21.24	47.67	6.90	0.83	0.62	0.54	0.57
SD	1.46	6.66	1.42	7.73	18.28	0.36	0.32	0.13	0.09	0.12
WHO Standard	6.5- 8.5	0-500	0-0.2	0-200	0-150	0-200	0-1.0	0-0.1	0-0.1	0-0.3

Table 5 Quality index for wet and dry season

	Wet season				Dry season			
	Scope (F ₁)	Frequency (F ₂)	Amplitude (F ₃)	Water Quality Index (WQI)	Scope (F ₁)	Frequency (F ₂)	Amplitude (F ₃)	Water Quality Index (WQI)
Station								
Edokota	50	40	74.1	43.4	50	42.5	84.1	38.4
Musa	50	40	67.3	46.3	60	37.5	81.0	37.8
Bida/Minna	50	40	67.8	46.1	60	47.5	85.0	33.9
Ciriko	50	42.5	71.5	43.9	50	47.5	90.0	34.3
Army Barrack	50	45	84.3	37.7	50	40	87.4	37.4

Table 6: Average annual WQI and the ranking

Station	Average Annual WQI	Ranking
Edokota	40.9	Poor
Musa	42	Poor
Bida/Minna	40	Poor
Cirriko	39.1	Poor
Army Barrack	37.5	Poor

Table 7: Rainy season ANOVA between parameters and locations

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	1.953	4	0.488	0.512	0.729
	Within Groups	9.540	10	0.954		
	Total	11.493	14			
Cu	Between Groups	.133	4	0.033	1.697	0.227
	Within Groups	.196	10	0.020		
	Total	.329	14			
TDSmg/L	Between Groups	41547.111	4	10386.778	28.518	0.000
	Within Groups	3642.175	10	364.218		
	Total	45189.286	14			
Ca mg/l	Between Groups	60.176	4	15.044	1.092	0.412
	Within Groups	137.774	10	13.777		
	Total	197.950	14			
Mg mg/L	Between Groups	86.447	4	21.612	14.338	0.000
	Within Groups	15.073	10	1.507		
	Total	101.520	14			
Namg/L	Between Groups	493.904	4	123.476	7.413	0.005
	Within Groups	166.557	10	16.656		
	Total	660.461	14			
Pbmg/L	Between Groups	0.064	4	0.016	1.358	0.315
	Within Groups	0.117	10	0.012		
	Total	0.181	14			
Fe mg/L	Between Groups	0.662	4	0.166	3.639	0.044
	Within Groups	0.455	10	0.045		
	Total	1.117	14			
Mn mg/L	Between Groups	0.307	4	0.077	2.903	0.078
	Within Groups	0.264	10	0.026		
	Total	0.571	14			
N-NH ³ Mg/l	Between Groups	0.134	4	0.034	0.431	0.784
	Within Groups	0.779	10	0.078		
	Total	0.913	14			

Table 8: Dry season ANOVA between parameters and locations

		Sum of Squares	Df	Mean Square	F	Sig.
pH	Between Groups	9.137	4	2.284	2.029	0.166
	Within Groups	11.260	10	1.126		
	Total	20.397	14			
Cu	Between Groups	.120	4	0.030	11.396	0.001
	Within Groups	.026	10	0.003		
	Total	.146	14			
TDSmg/L	Between Groups	19004.205	4	4751.051	57.442	0.000
	Within Groups	827.110	10	82.711		
	Total	19831.315	14			
Ca mg/l	Between Groups	305.498	4	76.374	1.602	0.248
	Within Groups	476.655	10	47.666		
	Total	782.153	14			
Mg mg/L	Between Groups	416.181	4	104.045	0.557	0.699
	Within Groups	1866.531	10	186.653		
	Total	2282.711	14			
Na mg/L	Between Groups	464.799	4	116.200	18.067	0.000
	Within Groups	64.317	10	6.432		
	Total	529.115	14			
Pb mg/L	Between Groups	0.616	4	0.154	1.551	0.261
	Within Groups	0.994	10	0.099		
	Total	1.610	14			
Fe mg/L	Between Groups	0.022	4	0.006	0.554	0.701
	Within Groups	0.099	10	0.010		
	Total	0.122	14			
Mn mg/L	Between Groups	0.026	4	0.006	0.751	0.580
	Within Groups	0.085	10	0.009		
	Total	0.111	14			
N-NH ³ Mg/l	Between Groups	2.739	4	0.685	0.365	0.828
	Within Groups	18.766	10	1.877		
	Total	21.505	14			