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SEASONAL VARIATIONS IN SOME CHEMICAL PARAMETERS OF THE SOKOTO- RIMA RIVER SYSTEM IN NORTH WESTERN NIGERIA

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ABSTRACT

Some chemical parameters of water samples from Sokoto-Rima River at the fishing site for Argungu International Fishing and Cultural Festival (AIFCF) were assessed to determine the influence of water quality on the water productivity via titrations and instrumentation methods. Dissolved Oxygen was highest (18.67 ± 5.72 mg/L) in mid dry sub-season with overall mean of 13.68 ± 2.66 mg/L. Biological Oxygen Demand had annual mean of 4.34 ±1.56 mg/L. The annual mean pH value was 6.72 ±0.89. Conductivity was highest (128.80 ± 29.77 µS/cm) in early rainy sub-season with annual mean of 169.08 ±50.25 uS/Cm. The results provide baseline data for further limnological studies.

Keywords: Sokoto-Rima river system; Chemical characteristic of water; Pollution status

INTRODUCTION

Aquatic environment serves as habitat for many organisms (Boyd and Linchtkoppler, 1979). Fresh water bodies such as Rivers Niger, Benue, Kaduna and Sokoto-Rima river systems are important for urban water supply, irrigation and fish production (Abubakar *et al*., 2013). Estimate have shown that these water bodies have potential annual fish production of 511,703 metric tonne annually with good management (Ita and Sado, 1985). They are important natural habitats for biological activities, energy transfer and utilization. They provide food and oxygen for aquatic organisms and serve as media for wastes discharge and production of fish (Raji and Babatunde, 1998). Inland fresh water bodies are often subjected to intensive human and industrial activities which influence the quality of water. Good quality water supply relates to the web of physical, chemical and biological factors that constitute aquatic environment and influence the beneficial uses of water (Tchobanoglous and Schroeder, 1987). Water quality characteristics influence the principal and vital activities of survival, nutrient utilization and general performance of aquatic life, and regulate the suitability of water for living organisms. It has been estimated that the quality of water for human and livestock consumption, as well as for fish performance, depends on three major factors which interrelate to produce some specific quality parameters that make the water to have good or bad qualities (Beadle, 1974). These factors are physical, chemical and biological factors. Also, Delince (1992) reported that the quality of waters depend on the kind of soils they travel over. Amongst others, dissolved Oxygen, biological oxygen demand, pH and conductivity are the primary factors that determine the quality of water (Raji and Saidu, 2001). Water is said to be of good quality if its physical, chemical and biotic characteristics are within the recommended values.

Sokoto-Rima River is in the North Western part of Nigeria. Rima River developed as a result of amalgamation of River Bunsuru and River Gagare (Katsina State) at Shinkafi in Zamfara State. On reaching Goronyo via Sabon Birni, it was harnessed as Goronyo Reservoir; it then runs southwest and joins the Sokoto River near Sokoto to form the Sokoto-Rima river system. The river system pass through Argungu town (Kebbi State) and drains into River Niger at about 120km south of Birnin Kebbi. According to communities residing in the catchment areas of this River, the water is also use for drinking, washing and irrigation of crops in the dry season.

The study assessed some aspects of the limnology of Sokoto-Rima River at Argungu in Kebbi State where the Argungu lnternational Fishing and Cultural Festival (AIFCF) is hosted. Specifically the study determined some chemical properties in relation to seasons and assessed the pollution status of the river system.

Table 1: Physical and chemical parameters of water favourable to aquatic life

Parameter	Concentration
Total Solid (mg/L)	100
Biological Oxygen Demand (mg/L)	10
pH	6.5-8.0
Conductivity (uS/cm)	1500
Dissolved Oxygen (mg/L)	4

Source: vezeau, 1986

MATERIALS AND METHODS

Study Area

The study was conducted on the Sokoto-Rima River system at the traditional fishing site for Argungu International Fishing and Cultural Festival (AIFCF) in Kebbi State in North -Western Nigeria in Sudan Savanna Zone. AIFCF site is on longitude 12^{o} 44$^{'}$ 22$^{''}$ N and latitude 4^{o} 30$^{'}$ 35$^{''}$ E. The littoral margin of this site is lined with patches of aquatic vegetation mostly *Polygonum, Echinochloa* and *Nymphaea* species (Ita, 1993). The shore line is steeply sloping with limited breeding areas. The Rima River, at Argungu is located on flat river bed with the flow almost at ground level with extensive flood plains along the valley. Scattered across the plain are small natural flood ponds and pools such as *Mashe* pond near Argungu.

Water Sampling

Water samples were collected at five sampling stations denoted as A, B, C, D and E (Figure 1). Sampling stations B, C and D were within the main fishing area of AIFCF, known in the local area as matan fada, while A and E were 500m upstream and downstream of the fishing area, respectively.

Water samples were collected from each of the sampling station monthly for twelve months. Each sample was replicated three times. A total of fifteen 1 litre capacity plastic containers were used at each sampling. Also, thirty 250ml capacity sampling bottles were used, fifteen each for water sampling for Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD). The samples for D.O. analyses were collected at a depth of 10-15cm and then fixed immediately at the site by adding 2ml each of manganese sulphate and alkali-iodide-azide solutions to the water samples using 5ml syringe (Stirling, 1985). For BOD, the bottles were wrapped with black cellophane tape. In the laboratory, D.O. was analysed immediately, while BOD analysis took place after five days incubation period at room temperature following standard winkler's titration method (Udu and Ogunwale, 1986).

Water Analysis

The collected samples were analyzed for chemical properties in the Physical Laboratory, department of Forestry and Fisheries of the Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria. Dissolved Oxygen was determined by putting 2ml of Orthophosphoric acid into the sample which was titrated against sodium thiosulphate to the end point. Biological Oxygen Demand was determined by incubating collected water samples for 5 days at room temperature. Cleared liquid was decanted and 2ml of concentrated orthophosphoric acid (H_3PO_4) was added into it and some distilled water to dissolve the precipitate. Titration with 0.025M sodium thiosulphate was conducted until colour changed to original colour (milk) of the sample. The volume of sodium thiosulphate used was noted. BOD was calculated as the difference between initial DO and final D.O. (volume of sodiumthiosulphate used) (Udu and Ogunwale, 1986). Hydrogen ion concentration (pH) was determined using Jenway 3015 pH meter. The electrode of the pH meter was inserted into the water sample in the plastic rubber bottles and the hydrogen ion concentration was read from the screen of the pH meter. Conductivity was measured using a Windaus 3392 conductivity meter calibrated in microsiemen/centimeter (uS/cm). It was switched on, its probe was immersed into the water sample and the conductivity was read from the screen (Stirling, 1985).

Data Analysis

The data obtained were analysed on monthly bases, two seasons and five sub-seasons, namely: early rainy (June and July), flood (August and September), early dry (October, November and December), mid-dry (January and February) and late dry (March, April and May) sub-seasons (Mamman *et al.*, 2000). The parameters were analyzed following analysis of variance (ANOVA) (Steel and Torrie, 1980) and mean separation was by Duncan Multiple Range Test at 5% probability. The computer analysis was carried out using Statistical Package for Social Science (SPSS).

RESULTS

The results of sub-seasonal and seasonal variations in the chemical parameters are presented in Tables 2 and 3 respectively.

Dissolved Oxygen concentrations varied from a minimum of 3.60 ± 0.10 mg/L at sampling station D within the AIFCF area in September to a maximum of 24.43 ± 0.47 mg/L in February at sampling E at the downstream. The mean sub-seasonal DO concentration was lowest (8.48 ± 5.35 mg/L) in the flood sub-season and highest (18.67 ±

5.72 mg/L) in mid-dry sub-season, both at sampling station D (within AIFCF area) (Table 2). The mean values for rainy and dry seasons were 11.99 ± 2.02 mg/L and 14.08 ± 2.49 mg/L, respectively while annual mean was 13.68 ± 2.66 mg/L (Table 3). Dissolved oxygen at sampling station A, C, D both within AIFCF area and E in downstream, increased from June to July and remained low until November after which it increased to highest level in February. However, at sampling station B, dissolved oxygen decreased and increased from July to March, it peaked in April and May (Figure 1).

The Biological oxygen demand (BOD) ranged from a minimum of 0.40 ± 0.20 mg/L at sampling station B in October to a maximum of 13.50 ± 0.30 mg/L) in September at sampling station D, both within the AIFCF area. The mean sub-seasonal value was lowest (1.79 ± 1.48 mg/L) in early dry sub-season at sampling station B and the highest (7.19 ± 6.92 mg/L) in the flood sub-season at sampling station D, both within AIFCF fishing site (Table 2). BOD was significantly ($p<0.05$) higher at sampling station C than the other four sampling stations during the early rainy sub-season while the values were not significantly different in the other four sub-seasons. The rainy season and dry season's values were 4.83 ± 1.86 mg/L and 4.01 ± 1.28 mg/L respectively, with annual mean of 4.34 ± 1.56 mg/L (Table 3). Biological oxygen demand at sampling stations A in upstream, D in AIFCF area and E in downstream increased from June to July while at B and C both within AIFCF fishing area, it decreased from June to August and peaked in September (Figure 2).

The minimum mean monthly pH value (1.00) was in June at sampling station D within AIFCF fishing site and the maximum (8.76 ± 0.01) was in April at sampling station A in the upstream. Sub-seasonal mean analysis revealed low value (3.57 ± 2.92) also at sampling station D in the early rainy sub-season and higher value (7.80 ±0.75) in late dry sub-season at sampling Station E at the downstream (Table 2). The value (3.57±2.92) at sampling station D within AIFCF area in early rainy sub-season was significantly ($P<0.05$) lower than the values for the other sampling stations (Table 2). The seasonal mean values for rainy and dry seasons were 6.15 ± 1.03 and 7.10 ± 0.54, respectively, while the annual mean was 6.72 ± 0.89 (Table 2). Hydrogen ion concentration increased from June to August, fluctuated from September to March and peaked in April (Figure 3).

Conductivity ranged from minimum of 89.67 ±1.53 µS/cm in August at sampling station C to a maximum of 268.00 µS/cm in April at sampling station D, both within the AIFCF area. The sub-seasonal value conductivity value was lowest (95.83 ± 6.85 µS/cm) in flood sub-season at sampling station C and highest (128.80 ± 29.77 uS/cm) was in the early rainy sub-season at sampling station D, both within AIFCF fishing site (Table 2). Seasonally, mean value of 111.05 ± 14. 76 uS/cm was obtained in rainy season while 207.77 ± 13.40 uS/cm was recorded in the dry season, the mean annual value was 169.08 ± 50.26 uS/cm (Table 3). The values decreased at all the sampling stations from June to August and subsequently increased to peak level in April (Figure 4).

Table 2: Sub-seasonal means of some chemical parameters in Sokoto-Rima River at the AIFCF fishing site

Parameter	Location	Sub-season				
		Early Rainy	Flood	Early Dry	Mid Dry	Late Dry
DO(mg/L)	A(Upstream)	14.68 ± 1.81	10.42 ± 3.78 [a]	13.22 ± 5.74 [a]	17.62 ± 5.06 [c]	14.86 ± 4.09 [a]
	B (AIFCF)	14.54 ± 1.62	12.83 ± 2.86	11.26 ± 1.15	12.75 ± 2.83	15.37 4.65
	C (AIFCF)	13.78± 2.48	11.28 ± 2.91	13.19 ± 3.21	16.40 ± 2.42	15.32±1.48
	D (AIFCF)	12.43 ± 4.08	8.48 ± 5.35	11.82 ± 5.62	18.67 ± 5.72	15.46 ± 2.70
	E(Downstrem)	11.00 ± 2.85	10.48 ± 3.67	11.13 ± 2.93	18.33 ± 6.70	16.66 ± 4.66
BOD (mg/L)	A (Upstream)	2 ± 1.10 [b]	6.02 ± 6.09	4.33 ± 4.12	3.95 ± 2.20 [ab]	5.03 ± 1.05
	B (AIFCF)	2.52 ± 1.10 [b]	5.70 ± 3.44	1.79 ± 1.48	2.48 ± 0.97 [b]	5.50 ± 3.76
	C(AIFCF)	6.98 ± 2.06 [a]	5.48 ± 5.54	1.82 ± 0.85	5.88 ± 1.91 [ab]	3.81 ± 3.17
	D(AIFCF)	3.08 ± 1.84 [b]	7.19 ± 6.92	3.90 ± 2.79	4.15 ± 1.67 [ab]	4.65 ± 1.34
	E(Downstream)	3.07 ± 1.55 [b]	5.93 ± 5.92	4.56 ± 4.05	5.38 ± 3.92 [a]	2.88 ± 2.18
pH	A(Upstream)	6.16 ± 0.18[a]	6.88 ± 0.39	7.26 ± 0.28	6.27 ± 0.32	7.73 ± 0.78
	B (AIFCF)	5.74 ± 0.37[a]	6.86 ± 0.38	7.14 ± 0.33	6.31 ± 0.12	7.40 ± 1.00
	C (AIFCF)	5.85 ± 0.38	6.83 ± 0.37	7.21 ± 0.29	6.56 ± 0.23	7.62 ± 0.85
	D (AIFCF)	3.57 ± 2.92 [b]	6.87 ± 0.37	7.29 ± 0.33	6.38 ± 0.22	7.68 ± 0.80
	E(Downstream)	5.82 ± 0.35[a]	6.91 ± 0.39	7.27 ± 0.26	6.54 ± 0.34	7.80 ± 0.75
Conductivity	A (Upstream)	124.50 ± 25.75	97.00 ± 4.82	189.56 ± 40.68	219.33 ± 4.46	213.11±50.78
(uS/Cm)	B (AIFCF)	128.80 ± 29.77	99.17 ± 5.04	192.00 ± 41.90	223.00 ± 5.02	214.22± 49.96
	C (AIFCF)	124.33 ± 27.02	95.83 ± 6.85	189.56 ± 41.58	219.17 ± 7.52	213.00 ±51.33
	D (AIFCF)	123.00 ± 27.39	97.17 ± 5.31	189.00 ± 40.78	217.67 ± 5.85	213.89±52.16
	E(Downstream)	124.17 ± 26.13	96.50 ± 6.47	189.33 ± 40.22	219.67 ± 4.50	214.3 ±51.97

Values are mean ± standard deviation; Means of sampling station in a season with the same letter are not significantly different ($P>0.05$); AIFCF means Argungu International Fishing and Cultural Festival

Table 3: Mean values of some chemical parameters in Sokoto-Rima River at the AIFCF fishing site

Parameter	Location	Rainy season	Dry season	Annual mean
DO(mg/L)	A (upstream)	12.55 ± 3.01	15.23 ± 2.22	14.16 ± 2.62
	B (AIFCF)	13.69 ± 1.21	13.13 ±2.o8	13.35 ± 1.62
	C (AIFCF)	12.53 ± 1.77	14.97 ±1.63	13.99 ± 1.98
	D (AIFCF)	10.46 ± 2.79	15.32 ± 3.43	13.37 ± 3.86
	E (Downstream)	10.74±0.37	15.37 ± 3.77	13.52 ± 3.68
	Mean	11.99 ±2.01	14.80 ±2.49	13.68 ±2.66
BOD (mg/L)	A (upstream)	4.22 ± 2.55	4.44 ± 0.55	4.35 ± 1.33
	B (AIFCF)	4.11 ± 2.25	3.26 ± 1.97	3.60 ± 1.85
	C (AIFCF)	6.23 ± 1.06	8.84 ± 2.03	4.79 ± 2.02
	D (AIFCF)	5.14 ± 2.91	4.23 ± 0.38	4.60 ± 1.56
	E (Downstream)	4.5 ± 2.02	4.27 ± 1.27	4.36 ± 1.36
	Mean	4.83 ±1.86	4.01 ± 1.28	4.34 ± 1.56
pH	A (upstream)	6.52 ± 0.51	7.09 ± 0.75	6.86 ± 0.66
	B (AIFCF)	6.30 ± 0.79	6.95 ±0.57	6.69 ± 0.67
	C (AIFCF)	6.34 ± 0.69	7.13 ± 0.53	6.81 ± 0.67
	D (AIFCF)	5.22 ± 2.33	7.12 ± 0.67	6.36 ± 1.63
	E (Downstream)	6.37 ± 0.77	7.20 ± 0.63	6.87 ± 0.75
	Mean	6.15 ± 1.03	7.10 ± 0.54	6.72 ±0.89
Conductivi(mg/L)	A (upstream)	110.75 ± 19.45	207.33 ± 15.70	168.70 ± 54.92
	B (AIFCF)	113.99 ± 20.95	209.67 ±15.95	171.40 ± 54.62
	C (AIFCF)	110 .08 ± 20.15	207.24 ± 15.62	168.38 ± 55.28
	D (AIFCF)	110 ± 0.09 ± 18.26	206.85 ±15.58	168.15 ± 54.90
	E (Downstream)	110.34 ± 19.57	207.78 ± 16.19	168.80 ± 55.46
	Mean	111.05 ± 14.76	207.77 ± 13.40	169.08 ±50.26

Values are mean ± standard deviation; AIFCF: Argungu International Fishing and Cultural Festival

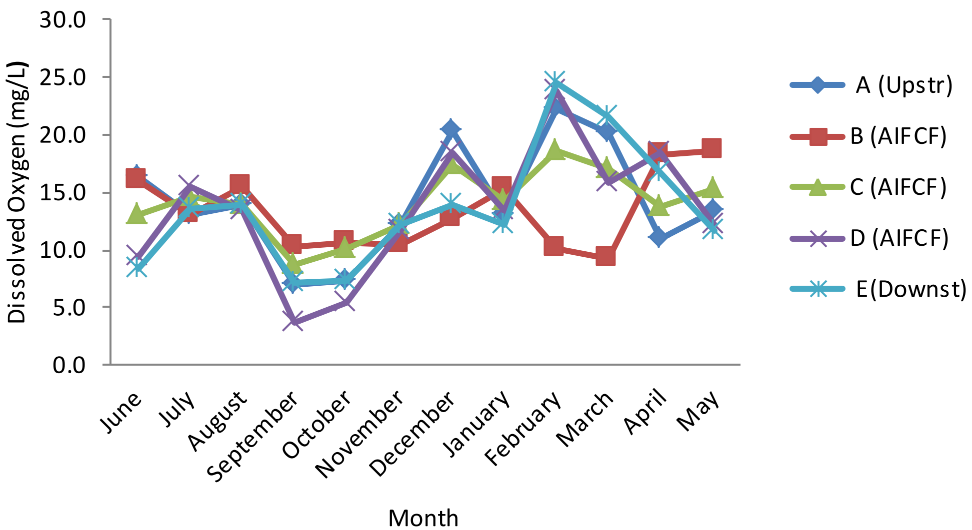

Figure 1: Mean monthly variation of Dissolved Oxygen at sampling points

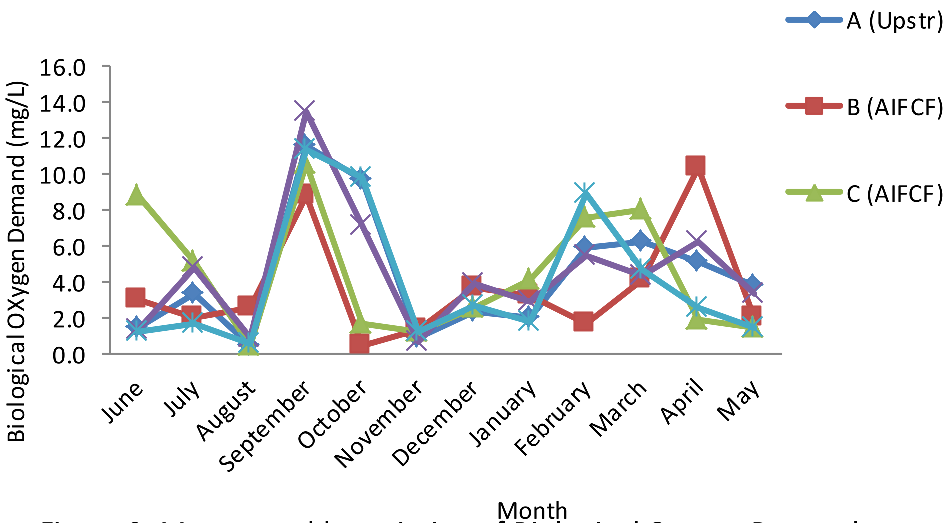

Figure 2: Mean monthly variation of Biological Oxygen Demand at the sampling points

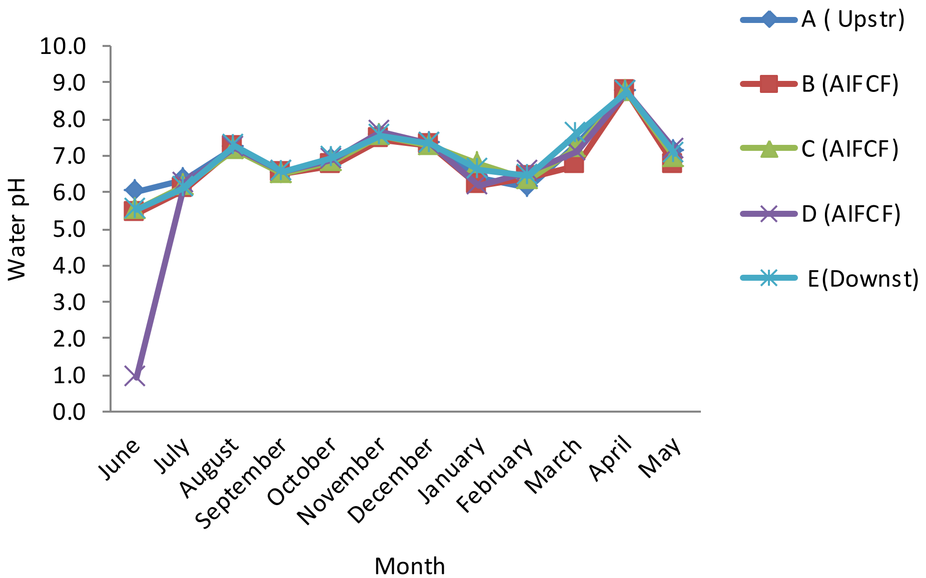

Figure 3: Mean monthly variation of water pH at the sampling points

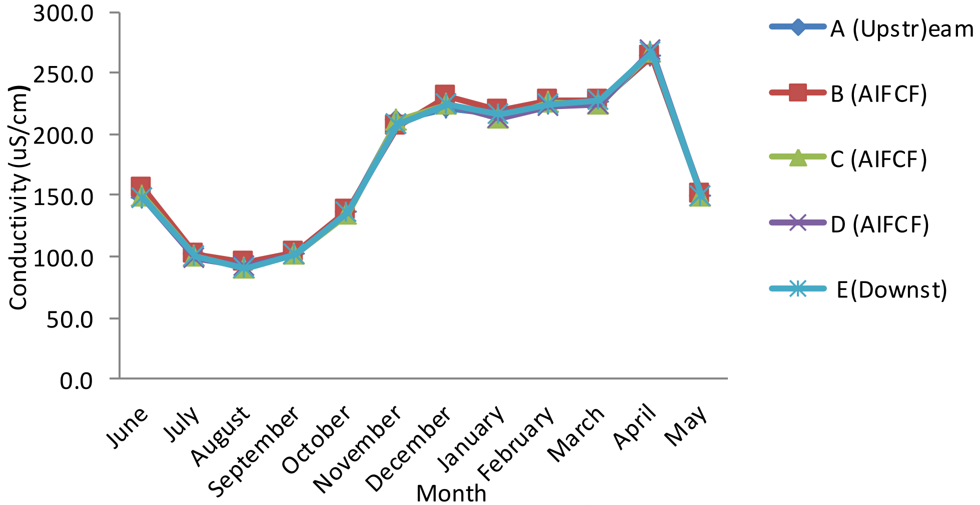

Figure 4: Mean monthly variation of conductivity at sampling points

DISCUSSION

The dissolved oxygen concentrations in all the sampling station were higher in the mid- dry sub-season which could be due to low water temperatures (24.50 ±4.93) because oxygen dissolved faster at low temperature and slowly when the temperature is high (Tchobanoglous and Shroeder, 1987; Panday *et al.*, 2005). The Dissolved oxygen values obtained in the mid- dry sub-season, except at sampling station B, were above the minimum concentration recommended (15mg/L) for portable water but highly favourable for aquatic life (Vezeau, 1989). Decrease in dissolved oxygen concentrations in the flood sub-season, could be attributed to higher biological oxygen demand. Lioyd (1992) reported that increase in biological oxygen demand in natural water bodies results in decrease in dissolved oxygen concentration because of physiological activities by aquatic organisms and microbial decomposition of organic matter. Dissolved oxygen was generally higher than the biological oxygen demand throughout the study period. The sub-seasonal, seasonal and the annual mean values of dissolved oxygen concentrations in AIFCF were higher than the values of 6 mg/L obtained in Kainji Lake (Mbagwu and Adeniji, 1994), 6.8mg/L in River Benue (Okayi *et al.*, 2001), 6.2mg/L and 4.6 mg/L as the mean concentrations for rainy and dry seasons, respectively for river Ala in Ondo State of Nigeria (Ayeni *et al.*, 2010).

In the early dry sub-season, there was decrease in BOD at sampling station B and C within AIFCF fishing area probably due to decrease in biochemical reactions by organisms in the water. The BOD was higher in the flood season and could be due to influx of organic inputs and higher rate of decomposition. The BOD of 1.79 ± 1.48 mg/L to 7.19 ± 6.92 mg/L recorded in this study were less than the critical value (10 mg/L) for aquatic life (Vezeau, 1989) but in line with recommended water quality standard (6.5 to 9.2 mg/L) meant for drinking (FEPA, 1991). The values obtained in this study are in line with the values of 2.2mg/L minimum and 4.9mg/L maximum in some fresh water bodies in Akwa Ibom State, Nigeria (Unaman and Edokpayi, 2006) but below 9.3 mg/L and 24.2 mg/L found during the dry and rainy seasons respectively in River Ala (Ajayi *et al.*, 2010)

There was decrease in pH below neutrality in the early rainy and flood sub-seasons and could be due to run-off containing substances that may lower the pH of the water body. The neutral pH in early and late dry sub-seasons is probably due to higher concentration of potassium and sodium ions left behind as a result of high evaporation of surface water during these hot sub-seasons (early and late dry sub-seasons). The seasonal and overall means were within the recommended water quality standard (6.0 to 9.0) for aquatic life (Roberts, 1978) and portable water (6.5 to 8.5) (SON, 2007). The sub-seasonal pH of the sampling stations are in line with 7.1 obtained in River Asa in Kwara State, Nigeria (Abubakar and Oyebode, 2001), 6.8 ±0.12 for Ikot Eback stream Essien in Udim Local Government Area of Akwa Ibom State, Nigeria (Unaman and Edokpayi, 2006). There was an increase in conductivity from flood sub-season to early rainy sub-season. The lowest sub-seasonal mean values recorded in the flood sub-season could be attributed to increase in water level as a result of flood and rainfall which decreased the concentration of dissolved ions through dilution process (Delince 1992). The highest mean conductivity (128 ± 29.77 uS/Cm) was obtained in early rainy sub-season because of the early run-off that carried dissolved ions into the river system. The seasonal and overall means are lower than the recommended water quality standard (1500 uS/cm) for aquatic life (Vizeau, 1989). Values recorded in the present study are higher than 62.2 for River Niger (Imevbore, 1971).

CONCLUSION

In this study conducted from June 2010 to May 2011, the mean values of the chemical parameters (dissolved oxygen, biological oxygen demand, hydrogen ion concentration and conductivity) studied indicated that the water of the Sokoto-Rima River at the fishing site for AIFCF was limnologically stable and to the fisheries therein, domestic and irrigational uses, it is safe. However, in early rainy sub-season (June and July) at sampling station D (Figure 1) the water was acidic, therefore its usages should be minimized during this period to avoid hazardous effects associated with low acidity.

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