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E-mail:jfewr@yahoo.com

LEVELS OF SOME ANIONS IN SOKOTO-RIMA RIVER SYSTEM IN NORTH IN WESTERN NIGERIA

***Abubakar, M. and Ipinjolu, J.K.**

Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria.
***Corresponding author:** 07034898257

ABSTRACT

The level of some anions in Sokoto-Rima River system at the fishing site of the Argungu International Fishing and Cultural Festival (AIFCF) were analyzed. Water samples were collected for twelve months and analyzed for anions. Data generated was analyzed using ANOVA. Statistical analysis of the data was based on the months, wet and dry seasons and five sub-seasons namely early rainy (June and July), flood season (August and September), early dry season (October-December), mid dry Season (January and February) and late dry season (March-May). Chloride, nitrate, phosphorus, sulphate and nitrite ions were within the standard for aquatic life (Vezeau, 1989). Considering the concentrations of above ions obtained in this work, the river water is safe for the aquatic life therein.

Key words: Sokoto-Rima River, anions, water, pollution status, Nigeria, AIFCF

INTRODUCTION

Good quality water is one of the mankind's most precious gifts from nature. No other medical innovation comes close to having clean supply of water (Bunce, 1994). Africa was thought to be safe from pollution (FAO, 1991), however, in recent time due to rapid population growth, increase in industrial activities and high exploitation rate of natural resources, there has been steady increase in the quality and diversity of discharges that reach the aquatic environment (Adakole and Balogun, 2006). Water quality is a major economic and environmental issue in developing countries. The quality of the river system in these countries often fall below acceptable level for many uses (Pius and Happiness, 2012). Rivers are among the most vulnerable water bodies to pollution being a receptacle of industrial wastewater and run-off from agricultural lands (Adakole, 2000). It is difficult to find a river or other water bodies whose natural regime has not been altered by man's activities (Skjeikval *et al*., 2001). In Nigeria and other developing countries, several industries in urban areas have the unsanitary habits of disposing solids wastes at the dumps without adequate treatment. As a result, toxic and deleterious substances from these dumps are transported to inland water bodies (Adakole and Balogun, 2006).

Surface run-off and erosion are the sources of pollutants discharge into the rivers. Direct human discharges of waste, industrialization and agricultural activities at different segments of the rivers no doubt accentuate pollution stress on the aquatic environments and endanger the lives of fisheries resources (Pius and Happiness, 2001). The world Health Organization (WHO, 1997) estimated that up to 80% of all sickness and diseases in the world is cause by polluted water.

Nigeria is blessed with vast expanse of fresh water bodies constituting about 12.4% of its surface area and is dominated by two major river systems namely rivers Niger and Benue (Raji and Babatunde, 1998).The major sources of anions in these water bodies include domestic, agricultural and industrial activities. Lioyd (1992) noted that concentrations of these anions vary from one water body to another due to different levels of agricultural and industrial activities close to these water bodies. The quality of natural water bodies may be affected by anions pollution resulting from socio-economic activities (Manson, 1992). When the physical and chemical conditions of the ecosystem are changed from their normal ranges, similar changes are expected to occur in individual organism, populations and the communities of the ecosystem (Adakole, 2000). Knowledge of the chemical fluctuation of a body of water is important in the determination of its productivity and other characteristics. Sokoto-Rima River is a major source of domestic water supply, livestock watering and irrigation and fisheries resources to the communities living around it. This therefore justified the need for investigation on some anions in this important River in order to formulate management strategies for monitoring and control of the concentrations of these ions to enhance water quality of this River.

This paper presents the results of the study conducted for twelve months to access the status of some anions (Chloride, nitrate, phosphorus, sulphate and nitrite ions) at the fishing site for Argungu International Fishing and Cultural Festival along Sokoto-Rima river system which plays great roles to socio-economy of the people living around it.

MATERIALS AND METHODS.

Study Area

The study site along the Sokoto-Rima River system was at Argungu within fishing area for Argungu International Fishing and Cultural Festival (AIFCF) in Kebbi State in

North -Western Nigeria .The site is situated in Sudan Savanna Zone. Five sampling points denoted as A, B, C, D and E were used. Sampling points B, C and D were in the main water area of AIFCF known in the local area as matan fada, while A and E were 500m each upstream and downstream the fishing area.

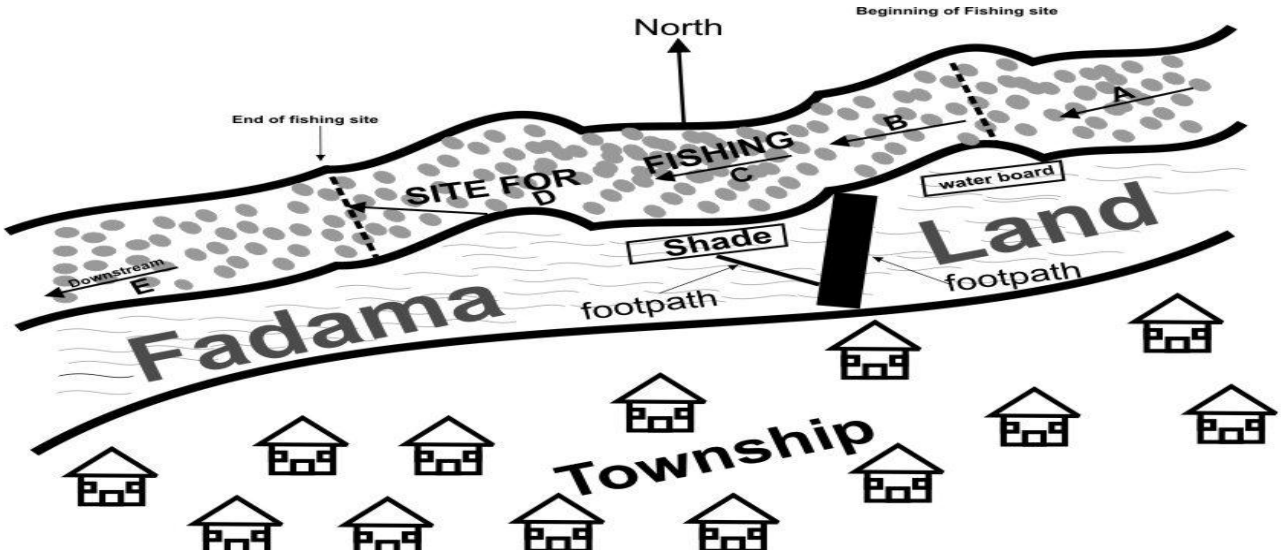

Figure 1: Map of Sokoto-Rima Rima system showing fishing site of AIFCF and the sampling points

Water Sampling.

A total of fifteen 1 litre capacity plastic containers were used, three containers for replicate samples at each point. Water samples were collected monthly for twelve months. The samples collected were analyzed in the physical Laboratory of the Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria for anions compositions using titration, Corning 400 Atomic Flame Photometry (Udo and Ogunwale, 1986) and Jenway 6100 Atomic Spectrophotometer (AOAC, 1990).

Data Analysis

The analyses were 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. Data generated were analyzed following analysis of variance

(ANOVA). The computer analysis was carried out using Statistical Package for Social Science (SPSS) software version 19. Mean separation was carried out following New Duncan Multiple Range Test and graphical presentations made.

RESULTS

The concentrations of anions analyzed are contained in table 1 and 2. Sub-seasonal analysis showed that the lowest bicarbonate ion of 0.72 ± 0.35 mg/L was recorded at sampling point B in the flood sub-season and highest (1.37 ± 0.55 mg/L) at sampling point C in early rainy sub-season both within AIFCF fishing area. The rainy season mean value was 1.03 ± 0.37 mg/L while dry season recorded 1.06 ± 0.14 mg/L and the annual mean was 1.05 ±0.20 mg/L (Table 2).

Monthly values in the bicarbonate ion levels showed similar trends during the study period. The concentrations decreased from June to January, peaked in February and decreased in April and May (Fig 2). The concentrations of chloride was lowest (1.09 ± 0.88 mg/L) at sampling point B within AIFCF fishing area in the late dry sub-season and peaked (3.22 ± 1.81 mg/l) in the mid dry sub-season at sampling point A in the upstream (Table 1). The mean values for rainy and dry seasons were 1.57 ± 0.47 mg/L and 1.98 ± 0.79 mg/L, respectively. The overall mean was 1.82 ± 0.70 mg/L (Table 2).

Except the concentration at the sampling point B within AIFCF fishing area which increased from June to July, the level at the other points decreased from June to January (Fig 3). The values at all the sampling points peaked in February. Sub-seasonal mean analysis showed lowest mean of 0.50 ± 0.11 mg/L at sampling point B in AIFCF area in the early rainy sub-season while highest mean of 1.33 ± 1.08 mg/L was obtained in the late dry sub-season at sampling point B in the fishing area (Table 1).

Seasonal analysis results showed the mean for the rainy season was 0.61±0.07 mg/L, that for the dry season was 0.78 ± 0.30 mg/L and the overall mean was 0.71 ± 0.25 mg/L (Table 2). The monthly trend in the nitrate ions concentrations in all the sampling points was similar with peak value in May (Figure 4). The lowest (0.20 ± 0.01 mg/L) mean sub-seasonal value in nitrite concentration was obtained at sampling point E in the Downstream in mid dry season while the highest value of 0.98 ± 0.02 mg/L was recorded in the flood sub-season at sampling point C in AIFCF fishing

area (Table 1). Rainy season recorded mean value of 0.91 ± 0.03 mg/L, dry season had 0.62 ± 0.27 mg/L and the overall mean was 0.74 ± 0.25 mg/L (Table 2).

From June to May, mean monthly variations of nitrite ions at the sampling points exhibited similar trends. The concentrations at A in the upstream, and B, D and C within AIFCF fishing area, decreased from June to August and peaked in September. The concentrations remained fairly constant till November and decreased gradually to January, and peaked in peak in March (Figure 5).

The lowest (6.37 ± 2.45 mg/L) sulphate ion concentration was at sampling point A (Table 1). Seasonally, 19.90 ± 7.01 mg/L and 15.54 ± 8.28 mg/L were the mean values for rainy and dry seasons, respectively, and the annual mean was 17.28 ± 7.95 mg/L (Table 2). There were similar trends in sulphate ions concentrations in all the sampling points except from June to July during which concentrations at sampling point D increased and concentration at B decreased from April to May both within the AIFCF fishing area (Figure 6)

The mean sub-seasonal concentrations of phosphorus was lowest (0.03 mg/L) at sampling points A in the upstream, and B and D within AIFCF fishing site, in the flood sub-season while the highest (0.10 ± 0.11 mg/L) was obtained in late dry sub-season at sampling points C in the AIFCF fishing area (Table 1). The rainy and dry seasons values were 0.04 ± 0.01 mg/L and 0.06 ± 0.03 mg/L, respectively, while the overall mean was 0.05 ± 0.03 mg/L (Table 2).

The trends in the mean monthly variations of phosphorus concentrations in the sampling points revealed increased level from May to June, slight variations from June to March and sudden increased to the peak in April (Figure 7).

Table 1: Sub-seasonal means (mg/L) of some anions in Sokoto-Rima River at the AIFCF fishing site

Parameter	Location	Sub-season				
		Early Rainy	**Flood**	**Early Dry**	**Mid Dry**	**Late Dry**
Bicarbonate (HCO_3^-)	A (Upstream)	1.27 ± 0.37	0.87 ± 0.20	0.92 ± 0.19 [ab]	1.13 ± 0.34	1.03 ± 0.47
	B (AIFCF)	1.10 ± 0.30	0.72 ± 0.35	0.76 ± 0.22 [b]	1.12 ± 0.43	0.99 ± 0.35
	C (AIFCF)	1.37 ± 0.55	0.75 ± 0.14	1.04 ± 0.26 [a]	1.23 ± 0.55	1.07 ± 0.38
	D (AIFCF)	1.32 ± 0.64	0.73 ± 0.20	1.01 ± 0.36 [a]	1.28 ± 0.50	1.13 ± 0.48
	E (Downstream)	1.32 ± 0.64	0.87 ± 0.12	0.86 ± 0.15 [ab]	1.13 ± 0.55	1.14 ± 0.33
Chloride (Cl^-)	A (Upstream)	2.03 ± 0.37 [b]	1.43 ± 0.25 [b]	1.63 ± 0.14	3.22 ± 1.81	1.46 ± 0.93
	B (AIFCF)	1.15 ± 0.76 [c]	1.43± 0.16 [ab]	1.59 ± 0.27	2.88 ± 1.74	1.09 ± 0.88
	C (AIFCF)	1.38 ± 0.16 [c]	1.68 ± 0.53 [a]	1.43 ± 0.11	2.97 ± 1.83	1.47 ± 0.98
	D (AIFCF)	1.50 ± 0.18 [bc]	1.15 ± 0.37 [b]	1.59 ± 0.18	3.02 ± 1.92	1.32 ± 0.89
	E (Downstream)	2.67 ± 0.70 [a]	1.25± 0.23 [ab]	1.49 ± 0.35	3.15 ± 1.85	1.42 ± 0.99
Nitrate (NO_3)	A (Upstream)	0.63 ± 0.15 [ab]	0.57 ± 0.08	0.67 ± 0.17	0.53 ± 0.16	1.19 ± 0.71
	B (AIFCF)	0.50 ± 0.11 [b]	0.60 ± 0.13	0.60 ± 0.17	0.60 ± 0.18	1.06 ± 0.59
	C (AIFCF)	0.65 ± 0.15 [ab]	0.63 ± 0.08	0.60 ± 0.10	0.53 ± 0.16	1.33 ± 1.08
	D (AIFCF)	0.63 ± 0.08 [ab]	0.57 ± 0.15	0.60 ± 0.14	0.53 ± 0.16	1.09 ± 0.96
	E (Downstream)	0.77 ± 0.08 [a]	0.53 ± 0.10	0.62 ± 0.12	0.58 ± 0.16	1.21 ± 0.85

Nitrite (NO_2)	A (Upstream)	0.91 ± 0.05	0.90 ± 0.07	0.76 ± 0.31	0.25 ± 0.01 [c]	0.82 ± 0.18 [ab]
	B (AIFCF)	0.90 ± 0.05	0.89 ± 0.05	0.84 ± 0.13	0.31 ± 0.02 [a]	0.87 ± 0.05 [ab]
	C (AIFCF)	0.92 ± 0.05	0.98 ± 0.02	0.82 ± 0.23	0.32 ± 0.01 [a]	0.76 ± 0.23 [ab]
	D (AIFCF)	0.90 ± 0.03	0.90 ± 0.08	0.86 ± 0.17	0.27 ± 0.01 [b]	0.91 ± 0.06 [a]
	E (Downstream)	0.92 ± 0.04	0.91 ± 0.07	0.66 ± 0.24	0.20 ± 0.01 [d]	0.71 ± 0.22 [b]
Sulphate (SO_4^{2-})	A (Upstream)	32.82 ± 9.01	16.25 ± 2.29 [a]	12.71 ± 5.73	6.37 ± 2.45	38.96 ± 25.99 [a]
	B (AIFCF)	25.13 ± 12.17	15.85 ± 3.58 [a]	11.92 ± 3.50	8.73 ± 3.87	15.44 ± 5.26 [b]
	C (AIFCF)	26.37 ± 9.53	11.25 ± 1.16 [b]	16.89 ± 9.56	7.13 ± 2.89	18.16 ± 10.89 [b]
	D (AIFCF)	16.90 ± 5.05	16.20 ± 3.21 [a]	21.0[a] ±4.85	6.95 ± 3.74	23.53 ± 8.52 [b]
	E (Downstream)	25.37 ± 4.53	12.87 ± 0.82 [b]	12.4[a] ± 8.08	17.47 ± 14.10 [a]	15.41 ± 9.73 [b]
Phosphorus (P)	A (Upstream)	0.04 ± 0.00	0.03 ± 0.00 [a]	0.04 ± 0.01 [a]	0.04 ± 0.01 [a]	0.09[a] ± 0.09
	B (AIFCF)	0.04[b] ± 0.00	0.03 ± 0.00 [ab]	0.04 ± 0.01	0.04 ± 0.01	0.10 ± 0.10
	C (AIFCF)	0.04 ± 0.00	0.03 ± 0.01 [b]	0.04 ± 0.01	0.04 ± 0.01	0.10 ± 0.11
	D (AIFCF)	0.04 ± 0.00	0.03 ± 0.00 [ab]	0.04 ± 0.01	0.04 ± 0.01	0.10 ± 0.10
	E (Downstream)	0.04 ± 0.00	0.04 ± 0.00 [a]	0.04 ± 0.01	0.03 ± 0.01	0.09 ± 0.09

Values are mean ± standard deviation
Means in a column of parameter with same letter are not significantly different (P > 0.05)
AIFCF: Argungu International Fishing and Cultural Festival.

Table 2: Mean values (mg/L) of some anions in Sokoto-Rima River at the AIFCF fishing site

Parameter	Location	Rainy season	Dry season	Annual mean
Bicarbonate (HCO_3^-)	A (upstream)	1.07 ± 0.28	1.03 ±0.10	1.04 ± 0.16
	B (AIFCF)	0.91 ± 0.27	0.96 ± 0.18	0.94 ± 0.19
	C (AIFCF)	1.06 ± 0.43	1.11 ± 0.10	1.09 ± 0.23
	D (AIFCF)	1.03 ± 0.42	1.14 ± 0.14	1.09 ± 0.24
	E (Downstream)	1.09 ±0.32	1.04 ± 0.16	1.06 ± 0.20
	Mean	**1.03 ±0.27**	**1.06 ±0.14**	**1.05 ±20**
Chloride (Cl^-)	A (upstream)	1.73 ± 0.42	2.10 ± 0.97	1.95 ± 0.75
	B (AIFCF)	1.29 ± 0.19	1.85 ± 0.92	1.63 ± 0.73
	C (AIFCF)	1.53 ± 0.21	1.95 ± 0.88	1.79 ± 0.67
	D (AIFCF)	1.32 ± 0.25	1.98 ± 0.091	1.72 ± 0.75
	E (Downstream)	1.96 ± 1.00	2.02 ± 0.98	1.99 ± 0.86
	Mean	**1.57 ± 0.47**	**1.98 ±0.79**	**1.82 ± 0.70**
Nitrate (NO_3)	A (upstream)	0. 60 ± 0.04	0.80 ± 0.35	0.72 ± 0.27
	B (AIFCF)	0.55 ± 0.70	0.75 ±0.27	0.68 ± 0.22
	C (AIFCF)	0.64 ± 0.01	0.82 ± 0.44	0.75 ± 0.33
	D (AIFCF)	0.60 ± 0.04	0.74 ± 0.31	0.68 ± 0.23
	E (Downstream)	0.65 ± 0.17	0.80 ± 0.35	0.74 ± 0.28
	Mean	**0.61 ±0.07**	**0.78 ±0.30**	**0.71 ±0.25**
Nitrite (NO_2)	A (upstream)	0.91 ± 0.01	0.61 ± 0.31	0.73 ± 027

	B (AIFCF)	0.90 ± 0.01	0.67 ± 0.32	0.76 ± 0.25
	C (AIFCF)	0.95 ± 0.04	0.63 ± 0.27	0.76 ± 0.26
	D (AIFCF)	0.90 ± 0.00	0.68 ± 0.36	0.77 ± 0.28
	E (Downstream)	0.92 ± 0.01	0.52 ± 0.28	0.68 ± 0.29
	Mean	**0.91 ± 0.03**	**0.62 ±0.27**	**0.74 ±0.25**
Sulphate (SO_4^{2-})	A (upstream)	24.54 ± 11.72	19.35 ± 17.28	21.42 ± 13.84
	B (AIFCF)	20.49 ± 6.56	12.03 ± 3.36	15.41 ± 6.15
	C (AIFCF)	18.81 ± 1o.69	14.06 ± 6.04	15.96 ± 7.32
	D (AIFCF)	16.55 ±0.49	17.16 ± 8.93	16.92 ± 6.32
	E (Downstream)	19.12 ± 8.84	15.09 ± 2.55	16.70 ± 5.26
	Mean	**19.90 ±7.01**	**15.54 ±8.28**	**17.28 ±7.95**
Phosphorus (P)	A (upstream)	0.03 ± 0.00	0.06 ± 0.03	0.05 ± 0.02
	B (AIFCF)	0.03 ± 0.00	0.06 ± 0.04	0.05 ± 0.03
	C (AIFCF)	0.03 ± 0.00	0.06 ± 0.03	0.05 ± 0.03
	D (AIFCF)	0.03 ± 0.00	0.06 ± 0.034	0.05 ± 0.03
	E (Downstream)	0.03 ± 0.00	0.05 ± 0.03	0.05 ± 0.03
	Mean	**0.04 ± 0.01**	**0.06 ±0.03**	**0.05 ± 0.03**

Values are mean ± standard deviation; AIFCF: Argungu International Fishing and Cultural Festival
B, C and D are sampling points within the AIFCC fishing area

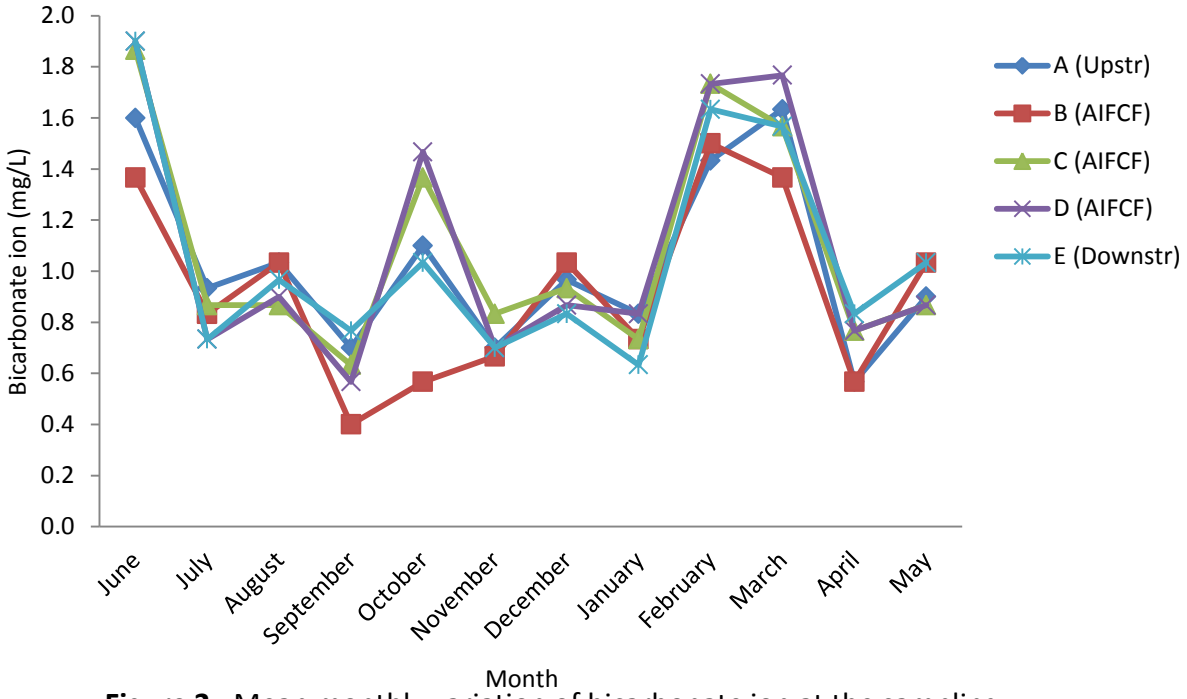

Figure 2 : Mean monthly variation of bicarbonate ion at the sampling points

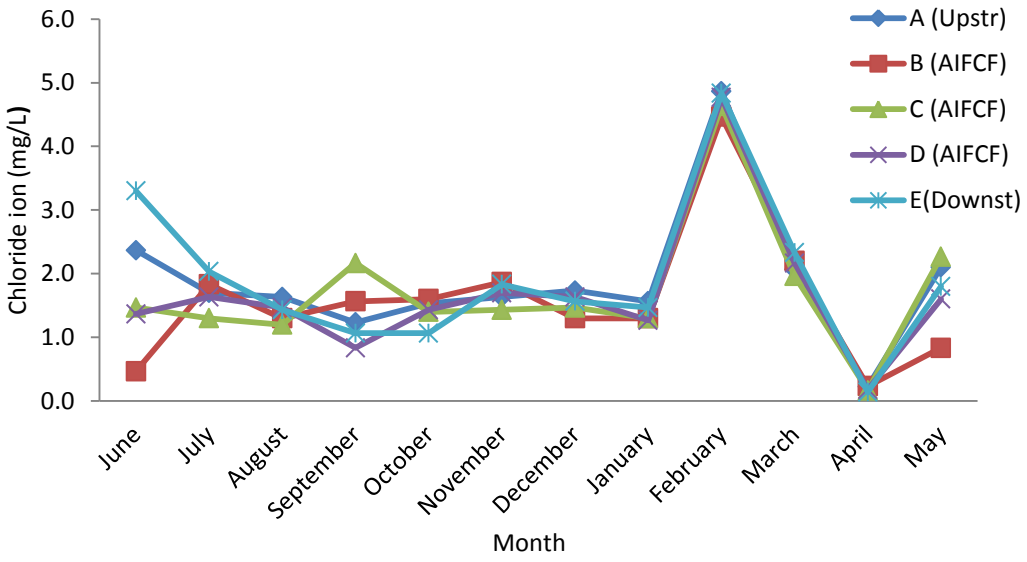

Figure 3: Mean monthly variation of chloride ion at the sampling points

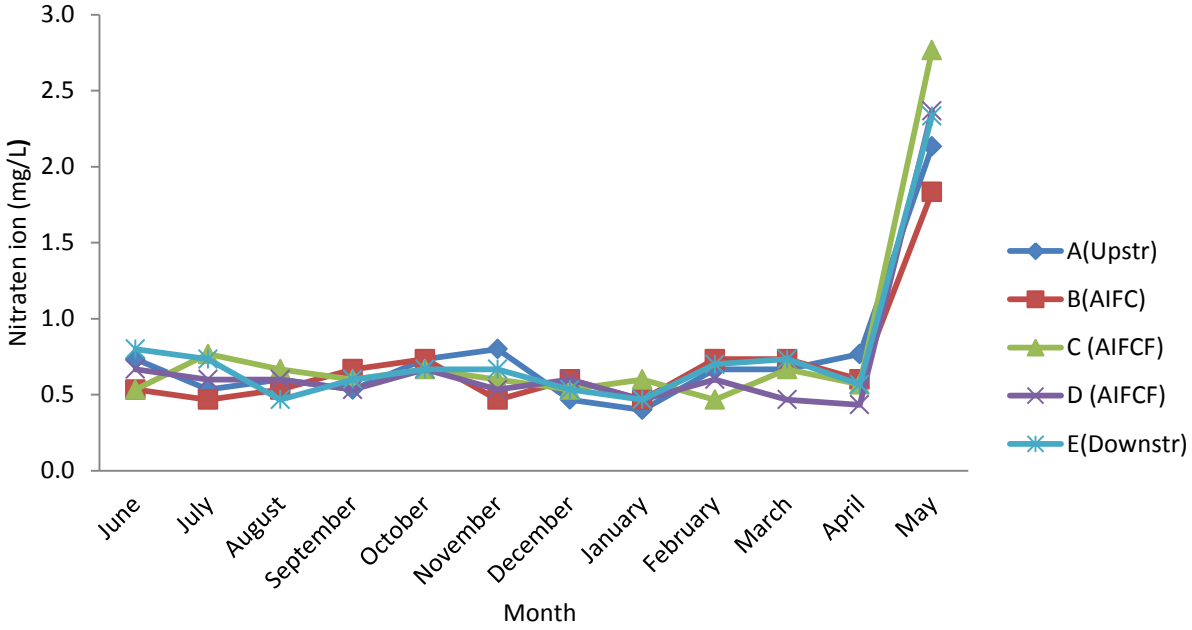

Figure 4: Mean monthly variation of nitrate ion at the sampling points

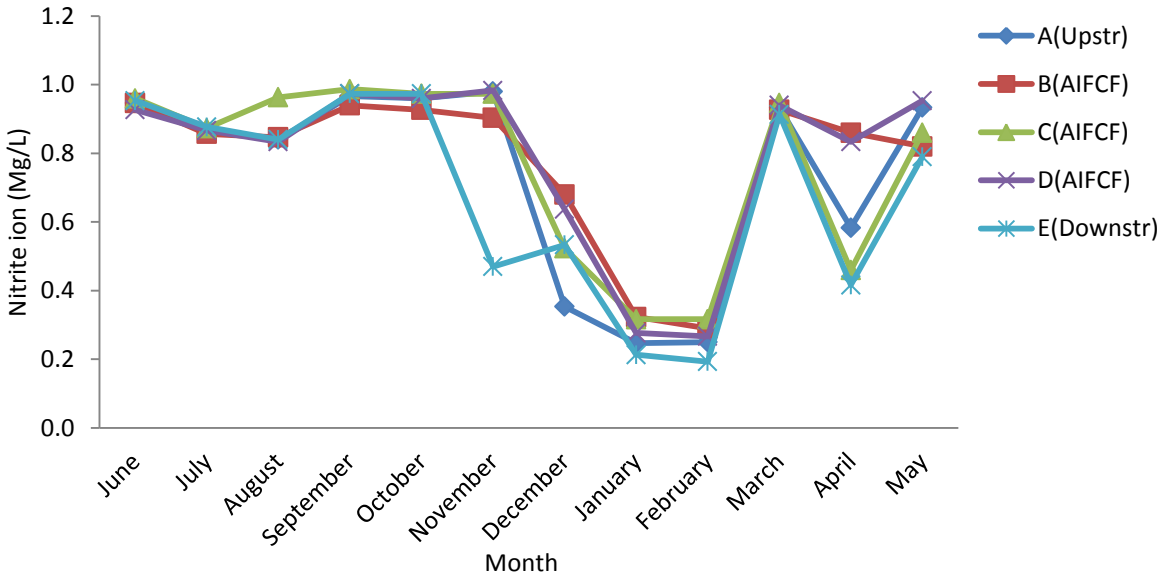

Figure 5: Mean monthly variation of nitrite ion at the sampling points

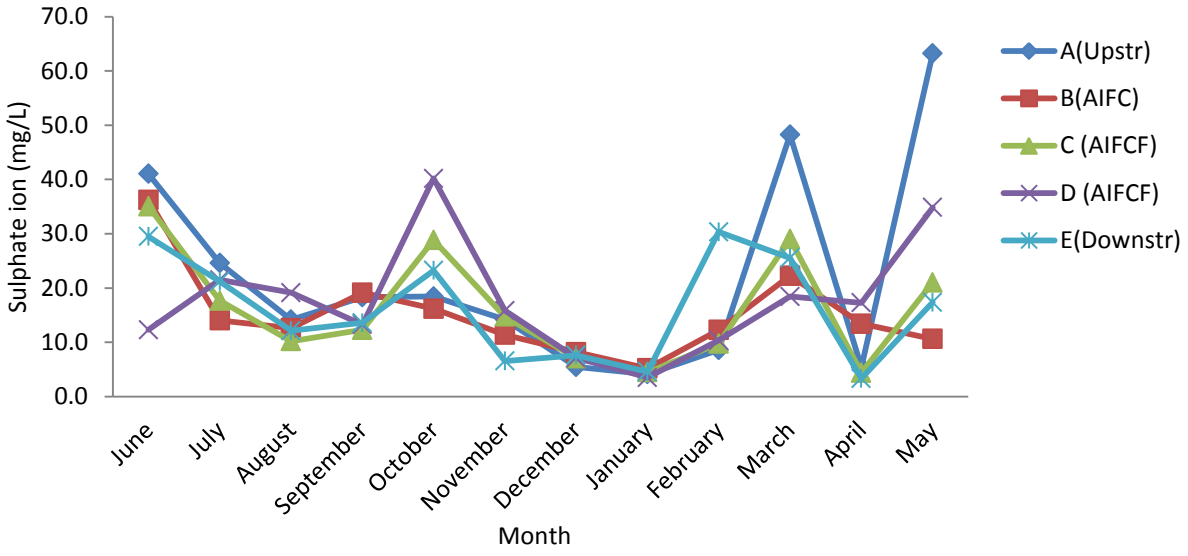

Figure 6: Mean monthly variation of sulphate ion at the sampling points

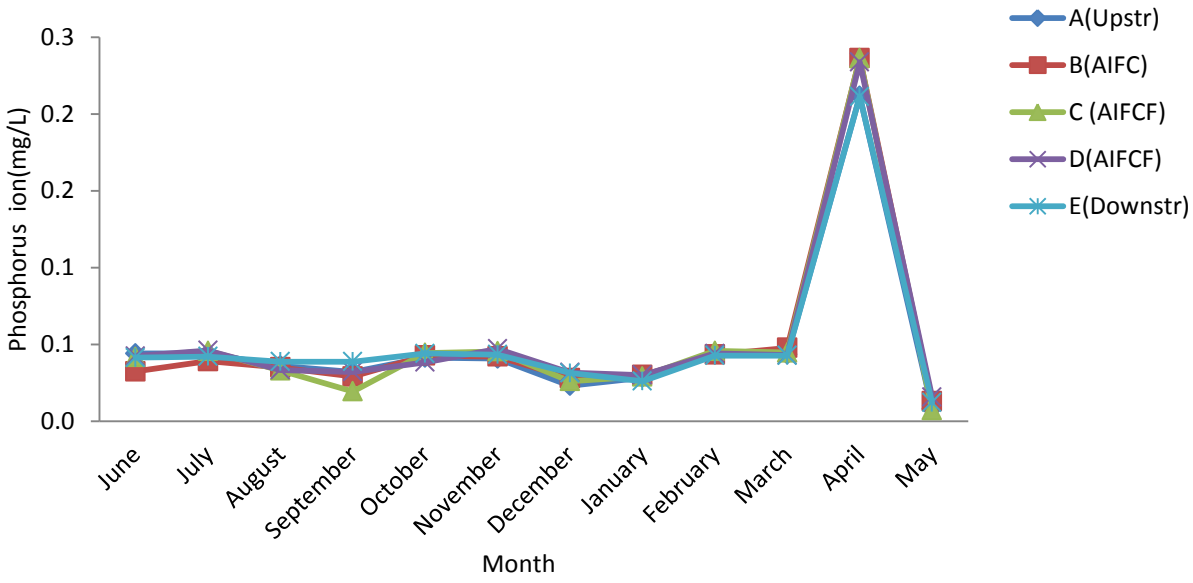

Figure 7 : Mean monthly variation of phosphorus ion at the sampling points

DISCUSSION

The significant variations recorded in some of the elements in some sub-seasons do not revealed clear pattern between the sampling points. The bicarbonate varied significantly between some points in the early dry sub-season and was highest (1.37 ± 0.55 mg/L) in early rainy sub-season (Table 1) probably due to weathering of calcarious rocks from the catchment area which could introduce into this water body the CO_3^{2-} that reacted with H^+ producing more $HC0_3^-$ (Golterman, 1975).

The chloride in the three sampling points (B, C and D) within the AIFCF area was lower than the upstream (A) and downstream (E) values in the early rainy sub-season and higher levels were recorded in all the sampling points in the mid-dry sub-season. Mid dry sub-season recorded the highest values of chloride ions concentration in all the sampling points probably due to decreased in the water level which might increase the concentration during this sub-season (Baijot *et al.,* 1997). The sub-seasonal, seasonal and overall means were lower than the values of 32.20 ± 30.83 mg/L in dry season (April) and 11.31 ± 6.54mg/L in wet season (August) in Rivers/dams of Zamfara reserve in Zamfara State of Nigeria (Ipinjolu and Argungu, 1998), 15.5 ± 0.03 mg/l and 15.6 ± 0.12 mg/l, for Oadaji and Kantou Rivers, respectively, in Nasarawa State of Nigeria (Gyar and Joseph, 2009), 60.62 ± 9.95 mg/l for Okposi River in Rivers State of Nigeria (Manilla and Nwene, 2008) and 35.5 ± 6.1 mg/L and 13.5 ± 4.4 mg/L for rainy and dry seasons, respectively, for River Ala in Akure, Ondo State of Nigeria (Vandi *et al.,* 2010).

Nitrate varied significantly between some points in the early rainy sub-season. The concentrations decreased from early rainy season to lowest values in mid dry sub-season (Table 1) and was highest (1.33 ± 1.08 mg/L) in late dry sub-season which could be due to precipitates in the water body, bush fire and clearing of vegetation for farming activities (Goldman and Horne, 1983). This highest concentration and the seasonal and the annual mean values (Table 2) were within the standard recommended for aquatic life (5mg/L) (Vizeau, 1989).

The sub-seasonal, seasonal and the annual means were lower than the values 17.33 ± 0.09 mg/l and 4.78 ± 0.09 mg/l for Oadaji and Kantou Rivers, respectively, in Nasarawa State of Nigeria (Gyar and Joseph, 2009), 16.9 ± 11.3 mg/l and 3.8 ± 2.2 mg/l as mean concentrations for rainy

and dry seasons, respectively, for river Ala in Akure, Ondo State Nigeria (Ayeni *et al*., 2010). They are however close to 0.5 ± 0.4 mg/l reported for Kainji reservoir in the middle belt zone of Nigeria (Adeniji, 1986) and 1.33 mg/l for River Okposi (Manilla and Nwene, 2008).

The sulphate ions concentrations in the sub-seasons except in early dry sub-season recorded significant ($P<0.05$) difference. A in upstream of late dry season obtained the highest sulphate ion concentration. This highest value reported in late dry season is in line with the report of Goldman and Horne (1983) that sulphate ion concentration in natural water bodies increases from lower level in rainy season to high level in dry season. The sub-seasonal, seasonal and the overall means were lower than the values of 27.60 ± 0.84 mg/L in February to 14.33 ± 30.01mg/L in April for Rivers in Zamfara reserve in north –western Nigeria (Ipinjolu and Argungu, 1998) and 6.00 ± 0.21 mg/L and 11.75 ± 0.012 mg/L, for Oadaji and Kantou Rivers, respectively, in Keffi, Nasarawa State of Nigeria (Gyar and Joseph, 2009). Of all the anions studied, sulphate had the highest concentration.

The phosphorus ion concentrations was highest in the late dry sub-season in all the sampling points (Table 1) and could be attributed to low level of water, precipitation, low humidity and intense solar radiation, which could cause increased concentration of phosphorus. However, the values were within the water quality standard (0.1mg/L) (vizeau, 1989) favourable for aquatic life. The sub-seasonal, seasonal and the annual means of phosphorus ions were lower than the values of 1.9 ± 1.3mg/L in Kainji reservoir in Nigeria (Adeniji, 1986) but in line with the mean concentrations of 0.13 mg/L recorded for River Niger in Savanna zone of Niger (Imerbore, 1970) and 0.6 ± 0.36 mg/l in Dadin Kowo reservoir (Ovie and Adeniji, 1990).

The flood sub-season obtained the highest value of nitrite ions concentration (Table 1). This could be due to human activity, influx of fertilizers and livestock faeces into the water body. The sub-seasonal, seasonal and overall means of nitrite levels are higher than the recommended water quality standard (0.1mg/L) for aquatic life. The sub-seasonal, seasonal and the annual mean concentrations of nitrite ions were higher than the values of 0.47 ± 0.40 mg/L obtained for Kware Lake (Onaji, 2005).

CONCLUSION

Chloride, nitrate, phosphorus, sulphate and nitrite ions were within the standard for drinking (SON, 2007) and for aquatic life (Vezeau, 1989).

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