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Levels of Some Cations in Sokoto: Rima River System in North Western Nigeria

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Abstract:
The levels of some cations in Sokoto- Rima River system at the fishing site for Argungu International Fishing and Cultural Festival (AIFCF) were analyzed. Water samples were collected for twelve months and analyzed for cations. Statistical analysis was based on months, wet and dry seasons and five sub-seasons (early rainy, flood, early dry, mid dry and late dry seasons). NH_4 and Fe ions concentrations were higher than the recommended water quality standards while Na, Ca, Mg and K ions were within recommended standards for aquatic life. The water of this river is therefore safe as far as Na, Ca, Mg and K ions are concern, however, unsafe with regard to NH_4 and Fe ions.

Keywords*: Sokoto-Rima River, cations, pollution, water, River, water quality, AIFCF*

1. Introduction

Water bodies and their resources are abundant but their continuous usefulness depends on responsible usage (Adakole *et al.*, 2002). The quality of water can be influenced by both natural and artificial factors (Ismaila *et al*., 2007). 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 cations in these water bodies include domestic, agricultural and industrial activities. Lioyd (1992) noted that concentrations of these cations 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 cations pollution resulting from socio-economic activities (Manson, 1992).

Several works evaluated cations compositions of natural water bodies. These include those of Rivers of Zamfara Reserve in Zamfara (Ipinjolu and Argungu, 1998), Rivers Oadaji and Kantou in Nasarawa State of Nigeria (Gyar and Joseph, 2009), River, Okposi in River State, Niger Delta (Mannilla and Nwene, 2008), Kware Lake (Onaji *et al*., 2005), River Niger(Imerbore, 1970) and Kainji Lake (Adeniji, 1986). Sokoto-Rima River is a major source of domestic water supply, livestock watering, irrigation and fishing activities to the communities living around it. This therefore justified the need for investigation of the compositions and dynamic of some cations 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.

2. Materials and Methods

2.1. Study Area

The study was conducted in the Sokoto-Rima River system at fishing site for Argungu International Fishing and Cultural Festival (AIFCF) in Kebbi State in North -Western Nigeria .The site is situated in Sudan Savanna Zone on longitude $4^0\ 31^1\ 36^{11}$ E and latitude $12^0\ 45^1\ 26^{11}$ N. Five sampling points denoted as A, B, C, D and E were used. Sampling points B, C and D were in the main field area of AIFCF known in the local area as Matan Fada, while A and E were 500m each before and after the field area respectively.

2.2. Water Sampling

A total of fifteen 1 litre capacity plastic containers were used at each sampling. Water samples were collected from each of the sampling point monthly for twelve months. Each sample was replicated three times. The samples collected were analyzed in the Agriculture Chemical Laboratory of Usmanu Danfodiyo University, Sokoto, Nigeria for cations compositions using titration, Corning 400 flame Photometer and L. F. 2000 photometer.

3. 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.

4. Results

Concentrations in mg/L of studied cations in Sokoto-Rima River at the fishing site for Argungu International Fishing and Cultural Festival (AIFCF) are contained in Tables 1 and 2. Figures 1 to 6 showed mean monthly variations at the sampling points.

Parameter	Location		Sub-season			
		Early Rainy	Flood	Early Dry	Mid Dry	Late Dry
Ammonium (NH_4^+)	A(Upstream)	3.08 ± 0.53	1.53 ± 1.32	1.31 ± 0.90 [a]	2.40 ± 0.22 [b]	1.31 ± 1.14
	B (AIFCF)	2.93 ± 0.47	1.43 ± 1.29	1.27 ± 0.95	2.57 ± 0.29	1.22 ± 0.95
	C (AIFCF)	2.83 ± 0.43	1.37 ± 1.14	1.80 ± 1.18	2.83 ± 0.23	1.20 ± 1.06
	D (AIFCF)	2.53 ± 0.30	1.30 ± 1.06	1.27 ± 0.90	2.60 ± 0.42	1.03 ± 0.99
	E(Downstream)	2.83 ± 0.57	1.43 ± 1.29	1.33 ± 1.10	2.60 ± 0.28	1.10 ± 1.09
Sodium (Na+)	A (Upstream)	0.82 ± 0.04 [b]	0.80 ± 0.15	1.16 ± 0.30	1.40 ± 0.19	1.30 ± 0.16
	B (AIFCF)	1.06 ± 0.11 [a]	0.80 ± 0.13	1.08 ± 0.35	1.33 ± 0.10	1.32 ± 0.23
	C (AIFCF)	0.86 ± 0.04 [b]	0.90 ± 0.06	1.14 ± 0.31	1.35 ± 0.22	1.31 ± 0.20
	D (AIFCF)	0.86 ± 0.08 [b]	0.85 ± 0.14	1.12 ± 0.37	1.28 ± 0.22	1.30 ± 0.15
	E(Downstream)	0.84 ± 0.05 [b]	0.92 ± 0.10	1.10 ± 0.33	1.52 ± 0.17	1.34 ± 0.18
Calcium (Ca^2)	A (Upstream)	1.00 ± 0.31	0.28 ± 0.04	0.42 ± 0.21	0.78 ± 0.20	0.50 ± 0.06
	B (AIFCF)	0.88 ± 0.28	0.30 ± 0.11	0.42 ± 0.24	0.89 ± 0.25	0.49 ± 0.10
	C (AIFCF)	0.73 ± 0.17	0.30 ± 0.05	0.42 ± 0.18	0.86 ± 0.16	0.44 ± 0.10
	D (AIFCF)	0.71 ± 0.15	0.28 ± 0.05	0.41 ± 0.20	0.90 ± 0.20	0.61 ± 0.10
	E (Downstream)	0.80 ± 0.24	0.29 ± 0.06	0.45 ± 0.41	0.89 ± 0.22	0.57 ± 0.16
Magnesium (Mg^2)	A (Upstream)	0.27 ± 0.24	0.36 ± 0.02	0.42 ± 0.18	0.52 ± 0.11 [ab]	0.59 ± 0.14 [a]
	B ((AIFCF)	0.23 ± 0.20	0.31 ±0.14	0.39 ± 0.11	0.55 ± 0.10 [ab]	0.31 ± 0.11 [c]
	C (AIFCF)	0.34 ± 0.16	0.36 ± 0.14	0.37 ± 0.18	0.48 ± 0.16 [ab]	0.47 ± 0.05 [ab]
	D (AIFCF)	0.43 ± 0.17	0.32 ± 0.11	0.50 ± 0.25	0.43 ± 0.09 [b]	0.36 ± 0.13 [bc]
	E(Downstream)	0.32 ± 0.18	0.31 ± 0.15	0.37 ± 0.23	0.59 ± 0.14 [a]	0.27 ± 0.22 [c]
Potassium (K^+)	A (Upstream)	2.78 ± 0.31 [a]	1.75 ± 0.14	1.71 ± 0.36	2.25 ± 0.25	2.58 ± 0.07 [ab]
	B(AIFCF)\\	1.73 ± 0.25 [c]	1.83 ±0.25	1.63 ± 0.34	2.30 ± 0.29	2.62 ± 0.15 [a]
	C(AIFCF)	1.49 ± 0.11 [c]	1.77 ± 0.14	1.60 ± 0.25	2.08 ± 0.33	2.52 ± 0.04 [ab]
	D (AIFCF)	1.52 ± 0.15 [c]	1.85 ± 0.16	1.61 ± 0.18	2.18 ± 0.20	2.57 ± 0.17 [ab]
	E (Downstream)	2.14 ± 0.34 [b]	1.80 ± 0.19	1.68 ± 0.25	2.28 ± 0.26	2.50 ± 0.05 [b]
Iron (Fe^2)	A (Upstream)	4.28 ± 1.63[a]	2.60 ±0.30	1.80 ± 0.74	1.80 ± 0.74	4.12 ±2.19[a]
	B (AIFCF	3.28 ±1.92[ab]	2.55 ± 0.43 [a]	1.69 ± 0.45	1.53 ± 0.84	2.73 ± 0.91 [b]
	C (AIFCF)	3.80 ± 1.46 [ab]	1.77 ± 0.15 [b]	2.51 ± 1.31	2.02 ± 1.44	2.50 ± 1.02 [b]
	D (AIFCF)	2.47 ± 0.25 [b]	2.53 ± 0.28 [a]	2.77 ± 1.75	1.12 ± 0.64	3.79 ± 0.29
	E (Downstream)	3.43 ± 0.99 [ab]	2.00 ± 0.17 [b]	1.63 ± 1.23	2.10 ± 1.79	2.60 ± 1.33 [b]

Table 1: Sub-seasonal means in mg/L of some cations in Sokoto-Rima River at the AIFCF area
Values are means ± standard deviation
Means in acolumn with the same letter are not significantly different ($p<0.05$)
AIFCF means Argungu International Fishing and Cuitural Festival
B, C and D are sampling points within the AIFCF area

Parameter	Location	Rainy season	Dry season	Annual mean
Ammonia (NH_4^+)	A (upstream)	2.31 ± 1.09	1.67 ± 0.63	1.93 ±0.79
	B (AIFCF)	2.18 ± 1.06	1.69 ± 0.77	1.88 ± 0.80
	C (AIFCF)	2.10 ± 1.03	1.94 ± 0.82	2.00 ± 0.78
	D (AIFCF)	1.92 ± 0.87	1.63 ±0.85	1.75 ± 0.76
	E (Downstream)	2.13 ± 0.99	1.68 ± 0.80	1.86 ± 80
	Mean	**2.13 ±0.77**	**1.72 ± 0.67**	**1.88 ±0.72**
Sodium (Na^+)	A (upstream)	0.81 ± 0.01	1.29 ± 0.12	1.10 ± 0.27
	B (AIFCF)	0.93 ± 0.18	1.24 ±0.14	1.12 ± 0.22
	C (AIFCF)	0.88 ± 0.03	1.27 ± 0.11	1.11 ± 0.23
	D (AIFCF)	0.86 ±0.00	1.23 ± 0.09	1.08 ±0.22
	E (Downstream)	0.88 ±0.06	1.32 ± 0.21	1.14 ±0.28
	Mean	**0.87 ±0.08**	**1.27 ± 0.12**	**1.11 ±0.23**
Calcium (Ca^2)	A (upstream)	0.64 ±0.51	0. 57 ± 0.19	0.60 ± 29
	B (AIFCF)	0.59 ±0.41	0.60 ± 0.25	0.60 ± 0.27
	C (AIFCF)	0.52 ± 0.30	0.57 ± .0.25	0.55 ± 023
	D (AIFCF)	0.50 ±0.30	0.64 ± 0.25	0.58 ± 0.24
	E (Downstream)	0.55 ± 0.36	0.64 ± 0.23	0.60 ± 0.25
	Mean	**0.56 ±0.29**	**0.60 ± 0.20**	**0.58 ± 0.24**
Magnesium (Mg^2)	A (upstream)	0.32 ± 0.06	0.51 ± 0.09	0.43 ± 13
	B (AIFCF)	0.27 ± 0.06	0.42 ± 0.12	0.36 ±0.12
	C (AIFCF)	0.35 ± 0.01	0.44 ±0.06	0.40 ± 0.07
	D (AIFCF)	0.38 ± 0.08	0.41 ± 0.10	0.40 ± 0.08
	E (Downstream)	0.32 ± 0.00	0.41 ± 0.16	0.37 ± 0.13
	Mean	**0.33 ± 0.05**	**0.44 ±0.10**	**0.39 ± 0.10**
Potassium (K^+)	A (upstream)	2.26 ± 0.73	2.18 ±0.44	2.21 ± 0.48
	B (AIFCF)	1.78 ±0.70	2.18 ±0.51	2.02 ± 0.42
	C (AIFCF)	1.63 ± 0.19	2.06 ±0.46	1.90 ± 0.42
	D (AIFCF)	1.68 ± 0.23	2.12 ± 0.48	1.95 ± 0.43
	E (Downstream)	1.97 ± 0.24	2.15 ± 0.42	2.08 ± 0.34
	Mean	**1.87 ± 0.37**	**2.14 ± 0.39**	**2.03 ± 0.40**
Iron (Fe^2)	A (upstream)	3.44 ± 1.19	2.51 ±1.40	2.88 ±1.26
	B (AIFCF)	2.92 ± 0.52	1.98 ±0.65	2.36 ± 0.73
	C (AIFCF)	2.79 ±1.43	2.34 ±0.28	2.52 ± 0.78
	D (AIFCF)	2.50 ± 0.04	2.56 ± 1.35	2.54 ± 0.95
	E (Downstream)	2.72 ± 1.01	2.11 ±0.49	2.35 ± 0.70
	Mean	**2.87 ± 0.80**	**2.30 ±0.84**	**2.53 ±0.85**

Table 2: Mean values in mg/L of some cations in Sokoto-Rima River at the AIFCF fishing area
Values are mean ± standard deviation; AIFCF: Argungu International Fishing and Cultural Festival
B, C and D are sampling points within the AIFCC fishing area

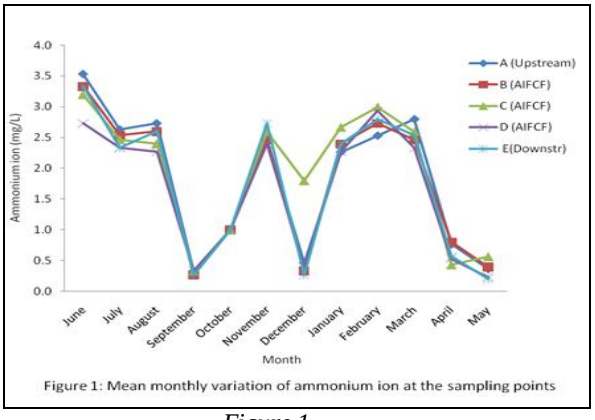

Figure 1

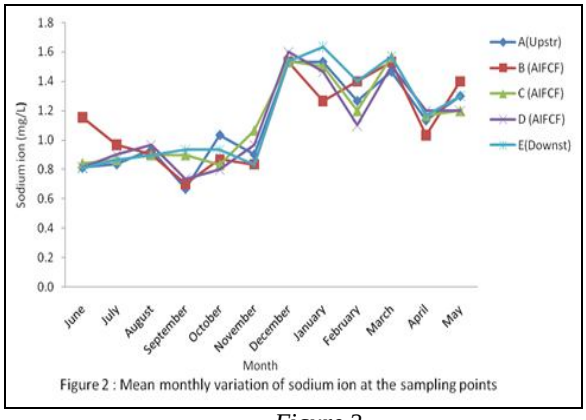

Figure 2

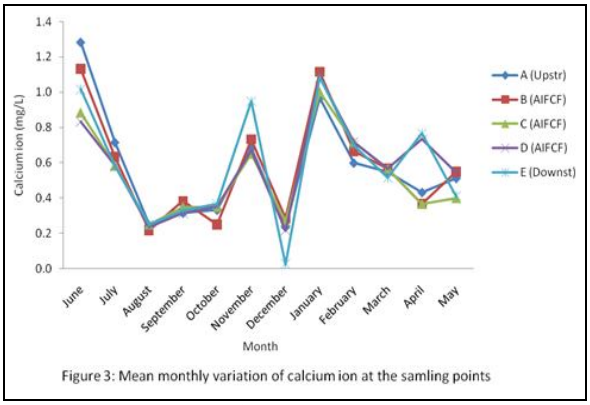

Figure 3: Mean monthly variation of calcium ion at the samling points

Figure 3

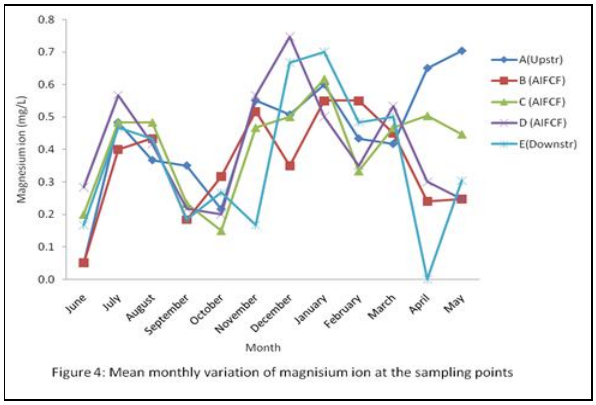

Figure 4: Mean monthly variation of magnisium ion at the sampling points

Figure 4

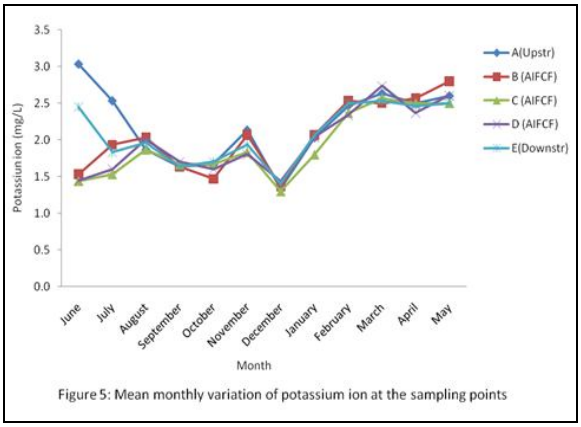

Figure 5: Mean monthly variation of potassium ion at the sampling points

Figure 5

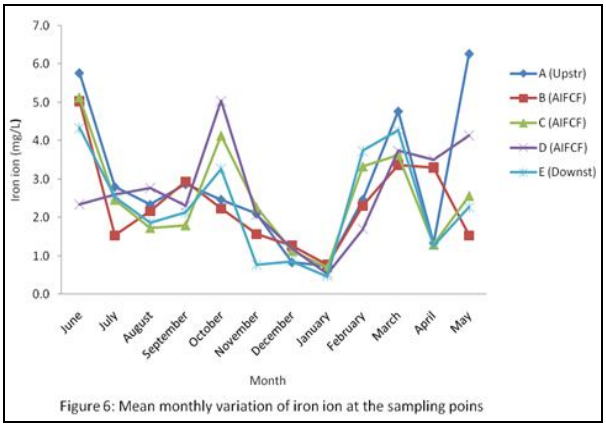

Figure 6: Mean monthly variation of iron ion at the sampling poins

Figure 6

5. Discussion

The ammonium ion concentrations in all sampling points were higher in early rainy sub-season (Table 1). This could be attributed to the influx of exogenous materials such as drainage of metabolic wastes by livestock and fertilizers from nearby farms (Argungu and Ipinjolu, 1998). This is in line with the finding of Onaji *et al*. (2005) in Kware Lake in North Western Nigeria. Both seasonal and overall means (Table 2) are higher than standard recommended (0.02mg/L) for aquatic life and portable water (0.5mg/L) FEPA (1991).

The sub-seasonal means (Table 1), seasonal and the annual means (Table 2) are lower than values of 6.27 ± 2.22 mg/L obtained during flood at Rivers and Dams in Zamfara reserve (Ipinjolu and Argungu 1988) and higher than mean value of 0.01mg/L for Kware Lake (Onaji, 2005), both in north western Nigeria.

The concentration in the sampling point B was significantly higher than the other sampling points during the early sub-season. Sodium ions concentrations at sampling points in early dry, mid dry and late dry sub-seasons were higher. These were due to higher concentrations of dissolved sodium ion during low water. These sodium ions concentrations and the seasonal as well as overall means are within the standard (200 mg/L) recommended for portable water (FEPA, 1991).

The sub-seasonal means of sodium ions in early dry, mid dry and late dry sub-seasons agreed with the range of 1.00 to 1.80 mg/L for Kware Lake in Sokoto State Nigeria (Onaji *et al.*, 2005). However, they were less than the value of 9.32mg/L found in Ravi River in Parkistan (Tariq *et al.*, 1994) but greater than the values of 0.08 ± 0.08mg/L obtained by Gyar and Joseph (2009) for rivers Oadaji and 0.03 ± 0.09 for river Kantou in Nasarawa State Nigeria.

Calcium ion recorded the least concentrations in all the sampling points except the A of the early rainy sub-season. Early rainy sub-season recorded highest value (1.00 ± 0.31 mg/L) which could be due to increased in the water level that resulted to leaching of calcium ion into the water bodies (Golterman, 1975). These values, the seasonal and annual means (Table 2) are within the recommended water quality criteria (75 mg/L) (FEPA, 1991) for portable water and aquatic life (100 mg/L) (Vezeau, 1989).

The sub-seasonal means (Table 1), seasonal and annual means (Table 2) concentrations of calcium were lower than the values of 23.7 ±9.2 mg/L and 30.7 ± 6.7 mg/L recorded in the rainy and dry seasons, respectively, for River Ala in Akure State Nigeria (Ayeni *et al*., 2010) and 63.10 mg/L for River Okposi in Rivers State, Nigeria (Manilla and Nwene. 2008). They were however high than 0.03 ± 0.09 mg/L reported for Kantou River (Gyar and Joseph, 2009) but close to the mean value of 0.46 ± 0.06 mg/L recorded at Kware lake (Wapdiyel, 2002).

The magnesium ion concentrations, the highest sub-seasonal mean value was recorded in the mid-dry sub-season which could be due to increased concentrations as a result of evaporation of surface water during dry season and influx of weathered rock from the catchment area during rainfall. However, the seasonal and the annual means values are less than the standard (100mg/L) (Vezeau, 1989) for aquatic life and drinking water (SON, 2007). It was lower than 2.30 and 5.33mg/L,from August 1996 to April 1997 for reservoir and streams/rivers, respectively in Zamfara State of Nigeria (Ipinjolu and Argungu, 1998), 223mg/L and 264

mg/L for river and dam, respectively, in December (1997) in Kebbi State of Nigeria (Singh, 1998) and 38.98mg/L for Okposi River in River State of Nigeria (Manilla and Nwene, 2008) and higher than the values of 0.07 ± 0.12 mg/L obtained in Rivers Oadaji and Kantou, respectively, in Nasarawa State of Nigeria (Gyar and Joseph, 2009) However, the means are in line with 0.29 ± 0.23, 3.02 ± 0.92 and 2.04 ± 0.57 mg/l for Goronyo, Lugu Dam and Kware Lake, respectively , between April and July 2001 (Wapdiyel, 2002).

The potassium ions, the significant ($P<0.05$) difference in the concentrations occurred in early rainy sub-season. The sub-seasonal means values are higher in late dry sub-season which could be due to evaporation of water during the late dry sub-season. The sub-seasonal (Table 1), seasonal and overall means (Table 2) recorded in this study are in line with 2.41 mg/L for River Niger (Imerbore, 1970) and 2.3 to 2.5 mg/L for River Kaduna (Ita, 1993).

Iron in the early rainy sub-season was the highest in most of the sampling points (Table 2). This may be attributed to weathering of rocks and erosion of clay soils (Pierce, 1997) during the sub-season. Rainy season obtained the mean value of 2.87 ± 0.80 mg/L while dry season recorded 2.30 ± 0.84 mg/L and the annual mean was 2.53 ± 0.85 mg/L. The concentrations are greater than the standards (0.3 mg/L) recommended for aquatic life and drinking water (1mg/L) (FEPA, 1991).

6. Conclusion

Sodium, calcium and magnesium were within their respective recommended drinking standards of 200 mg/L, 75 mg/L and 30/150 mg/L for drinking water (FEPA, 1991) respectively. However, ammonium ion was above the maximum permissible level of 0.02 mg/L for aquatic life (Roberts, 1971) and 0.5 mg/L for drinking water (FEPA, 1991). Iron ion was also above 0.3 mg/L Nigerian standard for drinking water and for aquatic life, they should therefore be brought to standards for aquatic life and drinking purposes through the monitoring of their sources.

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