Spatio-seasonal physico-chemistry of Aiba stream, Iwo, Nigeria.

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Abstract: Seasonal variation of some physico-chemical parameters of Aiba River at four locations has been assessed. Over the years, the river has been subjected to various human interferences and water quality was to be getting deteriorated gradually. Major anthropogenic activities practiced in and around the river are as follows: irrigation activities, car wash, artificial pond, washing cloths and utensils, spiritual bathing, discharge of domestic waste etc. All these constitute serious threat to the aquatic biota and thereby alter the physico-chemical and biological concentration of the river. The physico-chemical parameters were determined using standard methods and methods described by Ademoroti. The pH, water temperature, sulphate, phosphate, total alkalinity/bicarbonate levels indicate moderate quality of water. Electrical conductivity was above the maximum allowable limit in dry season. Dissolved oxygen and nitrate levels were slightly above maximum allowable limit for aquatic biota. BOD level indicates the absence of major organic pollution sources. The t-test calculated for seasonal variation shows that of all the parameters studied only temperature was significant at $P < 0.05$. One –way ANOVA for all the locations revealed that all the parameters studies were not significant at $P < 0.05$. The nutrient levels in the river system is a warning signal of eutrophication, hence the pollution level has to be checked. It is therefore recommended that periodical assessment of both physico-chemical and microbial analysis of the area should be carried out, as this would be helpful in early detection of any future degradation.

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1. Introduction

Worldwide pollution of rivers and streams has been one of the most crucial environmental problems since the 20th century (Dulo, 2008). The quality of the surface water is a very sensitive issue (Simeonov *et al.,* 2003). Anthropogenic influences (urban, industrial and agricultural activities, increasing consumption of water resources) as well as natural processes (changes in precipitation inputs, erosion, weathering of crustal materials) degrade surface waters and impair their use for drinking, industrial, agricultural, recreation or other purposes) (Carpenter *et al.,* 1998). Urban stream are common features of contemporary landscapes, and the effects of urban development on stream ecosystems are complex, with many physical, chemical and biological consequences (Hogg and Norris 1991, Suren 2000). Increased impervious surfaces due to development of roads and car parks, substantially effects urban stream flow regimes, reducing ground water recharge due to lack of precipitation infiltration, and leads to increasing runoff during rainfalls (Suren, 2000; Paul and Meyer, 2001). In addition, urban runoff can detrimentally alter stream chemistry, bringing with it suspended sediments such as nitrogen and phosphorous as well as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other pollutants that accumulate during times of low rainfall on roads and car parks (Garie and McIntosh 1986; Beasley and Kneale 2002). These are some of the ubiquitous consequences of urban development all of which can ultimately reduce stream "health" and biological diversity. Risks of water borne diseases are therefore a major public health concern in Iwo, a semi-urban area.

In 1997, the World Health organization (WHO) reported that 40 % of deaths in developing nations occur due to infections from water related diseases. Diseases contacted through drinking water kill about 5 million children annually and make one-sixth of the world population (WHO, 2004); and an estimated 500 million cases of diarrhoea, occur every year in children below 5 years in parts of Asia, Africa and Latin America (WHO, 2011).

Water is essential natural resources for sustaining life and environment that was always thought to be available in abundance and free gift of nature (Dikio, 2010). However, chemical composition of surface or sub-surface is one of the prime factors affecting the suitability of water for domestic, industrial and agricultural purposes. (Meenakshi, 2006).

With ever expanding population in Iwo, the water pollution has become a devastating issue as the agricultural, domestic and municipal sewage, containing bulk quantities of toxic heavy metals, are being continuously discharged in the stream, there is need for proper conservation and efficient utilization of fresh water bodies for sustainable development. As a result of these anthropogenic factors influences on Aiba stream, it becomes necessary that reliable physico-chemical properties and levels of inorganic pollution of Aiba stream investigated. In the light of this, the present study evaluates some physico-chemical parameters and levels of heavy metal pollution of Aiba stream.

2. Materials and Methods

2.1 Description of the Study Area

This study was conducted along the Aiba stream in the city of Iwo (N and E). Aiba stream drains through Kuti road, Bowen University road and Oke-Afo before discharging into the Oba River. Location 1 (Water Works) is the exit point or the spillway of the reservoir. This area is notable for refuse dump, spiritual birth and low traffic. Location 2 (Kuti area) runs through residential area and there is a car wash service; it was also observed that there was indiscriminate dumping of refuse into the stream; a local fish pond is also located in this area. Location 3 (Oweyo area) is along a major road leading to a private University, there is a filling station and car wash services around this area. Irrigation practices were also going on along this stream. Location 4 (Oke-Afo) is the area about 2 km from Aiba Reservoir. Agricultural activities and refuse dumping was observed as it runs through a residential area.

The GPS coordinate of the sampling locations are shown below:

Location	N Coordinate	E Coordinate	Elevation
Water works	7º 38′ 10″	04º 11′ 50.7″	232 m
Kuti area	7º 38′ 09″	04º 11′ 36.7″	232 m
Oweyo Area	7º 37′ 41.0″	04º 11′ 0.75″	226 m
Oke-Afo area	7º 37′ 19.5″	04º 10′ 45.5″	227 m

2.2 Sample Collection

Samples were collected in September, 2009 for the wet season and March, 2010 for the dry season. Samples for water quality studies were collected in 2 L plastic bottles that had been previously soaked in 10 % nitric acid for 48 hrs, and rinsed with distilled water. The container was rinsed three times on site with river water before collecting the water sample for water quality analysis. All samples were filtered with cellulose acetate filters and before transporting to the laboratory and stored in the refrigerator prior analysis. Samples were stored immediately in a cooler, in order to ensure that the physical properties of the water samples were maintained, and transported to the laboratory for analysis.

2.3 Determination of Physico-chemical Parameters

All chemicals used were Anala R grade (BDH, England). Water temperature, and conductivity were determined using Testr II dual range meter (Eutech Instruments, Malaysia) after calibrating with standard buffer solutions while pH was measured using a pH Testr meter (Eutech Instruments, Malaysia). Sulphate was determined by turbidimetric method (Ademoroti, 1996); phosphate and was determined by colorimetric technique (APHA, 1998); nitrate was determined by ultraviolet screening method (APHA, 1998); total alkalinity/bicarbonate, Dissolved oxygen and BOD_5, was also determined by methods described by Ademoroti (1996).

3.0 Results and Discussion:

The pH of the stream water ranged from 6.90 to 8.80 with mean value of 7.45 ± 0.19 for dry season while in wet season, the pH ranged from 7.50 to 8.80 with mean value of 8.08 ± 0.34 (Table 1). It is evident that the pH was higher in wet season than dry season. In general, the Aiba stream water is said to be neutral. Atobatele and Ugwumba, (2008) earlier reported range vale of 5.53 – 9.48 with mean value of 7.98 ±0.11. The pH range was in conformity with pH range of 6.5 - 8.5 the stipulated value for drinking and domestic purposes by World Health Organization (WHO, 2006). The pH obtained was also within the range 6-9 set by EU for fisheries and aquatic life (Chapman, 1996). Therefore, the pH of the stream would not adversely affect its use for domestic and recreational purposes.

Temperature is one of the most important ecological features. It controls behavioural characteristics of organisms, solubility of gases and salt in water (Dixit and Tawari, 2007). Temperature ranged from 29.1^{o}C to 35.1^{o}C with mean value of 31.68 ± 1.25 ºC for dry season while in wet season, temperature ranged from 26.30 ºC to 29.30 ºC with mean value of 27.20 ± 0.70 ºC. The mean value of temperature in dry season was higher than wet season. The study area with surface temperatures of mean value of 30.40 ±1.10 ºC is typical of African rivers. The temperature of water from Aiba stream for both seasons were within the range of <40ºC recommended by Federal Environmental Protection Agency (FEPA, 2003). Trend in surface water temperature revealed no significant difference within the locations, the water samples were collected at a very close time interval.

Electrical conductivity values for dry season ranged from 210 to 620 μScm^{-1} with mean value of 412.51 ± 228.24 μScm^{-1} while wet season ranged from 110 to 180 μScm^{-1} with mean value of 147.50 ± 29.86 μScm^{-1} (Table 1). This result indicates that the mean values for dry season was higher than wet season. The results of EC for all the locations revealed that the EC increases from the source down stream (Table 2). This findings was in agreement with (Ferrar, 1989) that reported that the EC of a river is generally lowest at the source of its catchments and leaches ions from the soils and also picks organic material from biota and its detritus as it flows. The mean EC value of typically unpolluted river is approximately 350 μScm^{-1}(Koning and Ross, 1999). This suggests that the EC of the stream fall below the acceptable limit in the wet season while in the dry season, the EC was above the acceptable limit but the total mean value was below the acceptable limit. The effects of high electrical conductivity may include disturbances of salt and water balance and high salt concentrations in waste effluents; however it can increase the salinity of the receiving water, which may result in adverse ecological effects on aquatic biota (Fried, 1991).

Dissolved oxygen (DO) is one of the most important factors in stream health (Vankatesharaju *et al*., 2010). The deficiency of DO directly affects the ecosystem of a river due to bioaccumulation and bio magnification (Vankatesharaju *et al.,* 2010). The seasonal variation shows that dry season (9.32±0.94 mg/L) with range value of 8.06 -12.09 is higher than wet season (5.60 ± 1.59 mg/L with range value of 2.02 – 12.09 (Table 1). Total average varied between 2.02 – 12.09 with mean value of 7.46 ± 1.11 mg/L and show decreasing trend along the stream (Table 2). Atobatele and Ugwumba (2008) earlier reported range value of 1.75 -11.20 mg/L with mean value of 7.23 ± 0.20 mg/L. The standard for sustaining aquatic biological life is stipulated at 5 mg/L a concentration below this value adversely affect biological life, while concentration below 2 mg/L may lead to death for most fishes (Chapman, 1997).

Phosphate and nitrate estimation are important in evaluating the potential biological productivity of surface water (Vankatesharaju *et al.,* 2010). Phosphate comes from fertilizers, pesticides, industry and cleaning compounds. Natural sources include phosphate containing rocks and solid or liquid wastes. These are classified as orthophosphate, condensed phosphates and originally bound phosphates (Jayalakshmi *et al.,* 2011). Any increase in the levels of any of these two nutrients will increase the risk of experiencing Eutrophication. Seasonal variation shows that the value of phosphate was very high in wet season (10.46 ± 10.45 mg/L) than dry season (0.55 ± 0.07 mg/L) while the total mean value was 5.50 ± 5.19 mg/L (Table 1). Phosphate levels in location 3 (Oweyo) was unusually high (21.22 ± 20.63 mg/L) compared with other locations (Table 2). This might be due to irrigation practices going on along this area.

Nitrate is a form of nitrogen and a vital nutrient for growth, reproduction, and the survival of organisms (Adeyemo *et al.,* 2008) Nitrate was not detected in wet season while the dry season had a mean value of 2.28 ± 1.54 mg/L ranging from Nd – 6.76 mg/L (Table 1). The total means value for nitrate was1.14 ± 0.83 mg/L with range of Nd – 6.76 mg/L (Table 1). High nitrate levels (> 1 mg/L) are not good for aquatic life (Johnson *et al.,*2000). The high levels of nitrate observed in this study is in agreement with Wolfhard and Reinhard, (1998); and Adeyemo *et al.,* (2008). Wolfhard and Reinhard, (1998) reported that nitrate are usually built up during the dry season and that high levels of nitrate are only observed during early rainy season. This is because initial rain flush out deposited nitrate from near-surface soil and nitrate levels reduces drastically as rainy season progresses.

The sulphate content of natural waters is an important consideration in determining their suitability for public and industrial supplies (Vankatesharaju *et al.,* 2010). Sulphate was not detected in the wet season while the mean value for dry season was 6.85 ± 3.20 mg/L. The total mean value was 3.43 ± 1.97 ranging from 1.21 - 14.24 mg/L. The mean value obtained for this study was below the WHO (2004) limit of 250 mg/L for drinking water. Based on the results, the sulphate are not likely to cause health hazard and can be said to be potable. The presence of sulphate in drinking water can cause noticeable taste, and very high levels might cause a laxative effecting unaccustomed consumers (WHO, 2011).

The result of the seasonal variation of Total alkalinity was presented in Table 1. The determined phenolphthalein alkalinity for this study was zero; as a result, the values for total alkalinity and bicarbonate were the same. The mean value for wet season was higher that dry season while the total mean value was 83.12 ± 8.66 mg/L. WHO (2004) guideline recommended TA mg $CaCO_3$/L of 200 mg/L. The total alkalinity obtained in this study was below the recommended limit; hence this may not pose any threat in terms of the safety of the water for drinking purpose.

BOD. The levels of BOD_5 in Aiba stream revealed that dry season was slightly higher than wet season with mean value of 3.56 ± 1.33 mg/L while the wet season was 3.0 ± 0.51 mg/L. The total mean value was 3.28 ± 0.67 mg/L ranging from 1.75 – 7.50 mg/L.

The variation was as a result of increased dilution and influx of fresh water during the raining season and sedimentation process during the dry season. Higher content of organic load as well as the high proliferation of micro-organism are the causative factors for maximum BOD levels (Shukla *et al.,* 1989).

The t-test calculated for seasonal variation shows that of all the parameters studied only temperature was significant at P < 0.05. One –way ANOVA for all the locations revealed that all the parameters studies were not significant at P < 0.05.

4.0 Conclusion

This study summarizes the seasonal variation in physico-chemical parameters of the Aiba stream. The result shows that the physico-chemical properties indicate moderate quality of water. Electrical conductivity was above the maximum allowable limit in dry season. Dissolved oxygen and nitrate levels were slightly above maximum allowable limit for aquatic biota. BOD level indicates the absence of major organic pollution sources. The t-test calculated for seasonal variation shows that of all the parameters studied only temperature was significant at P < 0.05. One –way ANOVA for all the locations revealed that all the parameters studies were not significant at P < 0.05. The nutrient levels in the river system is a warning signal of eutrophication, hence the pollution level has to be checked.

Table 1: Mean (± standard error) and range of measured physico-chemical parameters for Aiba stream for wet and dry seasons.

Season	pH	Temperature (ºC)	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	Total alkalinity (mg/L)	BOD (mg/L)
Dry									
Mean±SE	7.45 ± 0.19	31.68 ± 1.25*	412.50 ± 114.10	9.32 ± 0.94	0.55±0.07	6.85 ± 3.20	2.28 ± 1.54	75.00±14.29	3.56±1.33
Range	6.90 – 7.70	29.10–35.10	210.00 – 620.00	8.06 – 12.09	0.37 -0.70	1.21– 14.24	0.00-6.76	40.00 – 110.00	1.75–7.50
Wet									
Mean±SE	8.08± 0.34	27.20 ± 0.70	147.50 ± 14.93	5.60 ±1.59	10.46±10.45	Nd	Nd	91.25 ± 10.08	3.0±0.51
Range	7.50–8.80	26.30–29.30	110.00–180.00	2.02-8.67	0.00-41.85			75.00 – 120.00	2.25–4.50
Total									
Mean±SE	7.80±0.21	29.44±1.08	280.00±73.10	7.46±1.11	5.50±5.19	3.43±1.97	1.14±0.83	83.12±8.66	3.28±0.67
Range	6.90 -8.80	26.30-35.1	110.00 -620.00	2.02-12.09	0.00-41.85	0.00-14.24	0.00-6.76	40.00-120.00	1.75-7.50

*= significantly different at P<0.05

Table 2: Mean value of measured physico-chemical parameters of Aiba stream for each locations

	pH	Temperature (ºC)	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	Total alkalinity (mg/L)	BOD (mg/L)
Water works									
Mean±SE	8.20±0.60	27.70±1.40	165.00±55.00	10.38±1.71	0.18±0.18	7.12±7.12	3.38±3.38	75.00±0.00	2.50±0.25
Range	7.60 -8.80	26.30-29.10	110.00-220.00	8.67-12.09	0.00 -0.37	0.00-14.24	0.00-6.76	-	2.25-2.75
Kuti									
Mean±SE	8.05±0.45	30.80±4.30	175.00±35.00	8.37±0.51	0.35±0.35	5.08±5.08	0.94±0.94	77.50±2.50	5.12±2.38
Range	7.60-8.50	26.50-35.10	140.00-210.00	7.86-8.87	0.00-0.70	0.00-10.17	0..00-1.87	75.00-80.00	2.75-7.50
Oweyo									
Mean±SE	7.20±0.30	28.85±2.15	390.00±230.00	6.04±2.21	21.22±20.63	0.60±0.60	0.00	65.00±25.00	2.38±0.13
Range	6.90-7.500	26.70-31.00	160.00-620.00	3.83-8.25	0.59-41.85	0.00-1.21	0.00	40.00-90.00	2.25-2.50
Oke-Afo									
Mean±SE	7.60±0.10	30.40±1.10	390.00±210.00	5.04±3.02	0.26±0.26	0.9±0.90	0.24±0.24	115.00±5.00	3.12±1.38
Range	7.50-7.70	29.30-31.50	180.00-600.00	2.02-8.06	0.00-0.52	0.00-1.79	0.00-0.49	110.00-120.00	1.75-4.50

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