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Seasonal Limnological Variation and Nutrient Load of the River System in Ibadan Metropolis, Nigeria

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Abstract

Ibadan is a highly populated city, characterized by environmental problems arising from improper disposal of solid and liquid wastes, poor wastes collection and handling. We therefore investigated the seasonal limnology and nutrient load of the river system in Ibadan metropolis, Nigeria during the dry season (October 2003-March 2004) and rainy season (August-September 2004). The results revealed that colour, Total suspended solid (TSS), total solids (TS) ands total nitrogen were generally higher during the dry season. This suggests that the run-offs have only a diluting effect on these parameters. All the other physical parameters (pH, BOD, DO, COD, TDS, Total hardness) and Nutrient load based parameters (phosphate, sulphate, nitrate and nitrite) were generally higher during the rainy season. Also, in most of the sample points, BOD, TDS, TSS, colour and phosphate levels were relatively higher than the WHO standards for surface water during the two seasons. The poor water quality and nutrient loading observed in the study area has severe consequences on the in-dwelling aquatic flora and fauna. Proper treatment of effluent from industrial processes to acceptable levels, discouraging stagnation of domestic waste and sewage, availability of sewage treatment plants is necessary to curtail the health risk associated with the present level of pollution observed during this study.

Keywords: Ibadan, limnology, Nigeria, Nutrient, Physicochemical

Introduction

The major proportion of all water quality degradation worldwide is due to anthropogenic causes (Faniran *et al.*, 1994).). Urban runoff is a contributing factor to poor river water quality. The pollution of water bodies from pollutant transport through surface runoff and uncontrolled discharge of untreated

Mayer, 1982; Cotruvo, 1988; Kelter *et al*., 1997; Kempster *et al*., 1997). Domestic and industrial discharges into the river are probably responsible for the observed high concentration values of total hardness and total dissolved solids.

Given the present poor status of the waste management in the Ibadan metropolis, it is not surprising that enhancement of nutrient concentrations and BOD was simultaneously observed in each sampling site; reflecting the increased discharge of untreated waste water. However, none of the samples had values higher than recommended standards (Table 3) for sulphate (rainy season), nitrite and oil and grease.

Conclusion

- The poor water quality of the study area has severe consequences on the in-dwelling aquatic flora and fauna.
- Proper treatment of effluent from industrial processes to acceptable levels,
- Discouraging stagnation of domestic sewage,
- Availability of sewage treatment plant
- Along with thorough analysis and study of any water sources before being used for domestic applications is therefore recommended to minimize the health risk associated with the present level of pollution observed during this study.

References

[1] Adeyemo, O.K. (2003): Consequences of Pollution and Degradation of Nigerian Aquatic Environment on Fisheries Resources. - The Environmentalist 23: 297–306.

[2] Adeyemo, O.K., Agbede S.A. (2001): Environmental and Public Health Implications of Waste Disposal in Ibadan. - International Journal of Environmental Studies 58: 701-702.

[3] APHA, AWWA, WEF (1998) Standard methods for the examination of water and wastewater, 20th edition, L.S. Clesceri, A.E. Greenberg & A.D. Eaton (Eds.), American Public Health Association, American Water Work Association, Water Environment Federation, Washington DC.

[4] Bush, D., Mayer, M. (1982): A case of infantile methemoglobinemia in South Dakota. - Journal of Environmental Health 44 (6): 310-311.

[5] Cotruvo, J.A. (1988): Drinking water standards and risk assessment. -Regulatory Toxicology and Pharmacology 8(3): 288-292.

[6] DWAF (1986): Management of Water Resources of the Republic of South Africa. Technical report, Department of Water Affairs & Forestry, Pretoria South Africa.

[7] Faniran, J.A., Adeleke, B.B., Oderinde, R.A. (1994): Forcados Terminal Integrated Projects: Baseline Ecological Studies. Commissioned by Shell Petroleum Development Company of Nigeria.

[8] Hodges, L. (1973): Environmental Pollution: A survey of emphasising physical and chemical principles. Holt, Rhinehart and Winston, Inc. New York.

[9] Inanc, B., Kinaci, C., Ozturk, I., Sevimli, M.F., Arikan, O., Ozturk, M. (1998): Pollution Prevention and Restoration in the Golden Horn of Istanbul. -Water Science and Technology 37: 129-136.

[10] Inoue, T., Ebise, S. (1991): Runoff Characteristics of COD, BOD, C, N and P Loading from Rivers to enclosed Coastal Seas. -Marine Pollution Bulletin 23: 11-14.

[11] Kelter, P.B., Grundman, J., Hage, D.S., Carr, J.D. (1997): A discussion of water pollution in the US and Mexico with High School laboratory activities for analysis of lead, anthrazine and nitrate. -Chemical Education 74: 1413-1418.

[12] Kempster, P.L., Van Vliet, H.R., Kuhn, A. (1997): The need for guidelines to bridge the gap between ideal drinking-water quality and that quality which is practicably available and acceptable. -Water SA 23: 163-167.

[13] Martin, J.C., Hoggart, C., Matissa, A. (1998): Improvement Priorities for Sewage Treatment in Latvian Small and Medium Sized Towns. -Water Science and Technology 37: 137-144.

[14] UNCHS, (Habitat)/UNEP (1997): City Experiences and International Support. 2: 67-70.

and partially treated sewage has been reported by Inoue *et al*, (1991); Inanc *et al*., (1998) & Martin *et al*, (1998).

There is an increasing need to protect the quality of Nigeria's water resources from degradation due to pollution, which interferes with the water uses at any scale. The characteristics of any water body usually indicate its level of pollution. Some of the identified effects of runoff water on such water bodies include nutrient enrichment, deterioration of the water quality, destruction of spawning grounds for aquatic life, general fish kill, etc.

Chemical and physical water quality indicators are important for assessing and/or protecting ecosystem integrity. Increasingly, monitoring efforts are focused on a holistic approach which examines the interaction of all media within a single watershed. This approach allows for the identification of changes in water quality, the discovery of emerging water quality problems, the assessment of pollution control measures, the effectiveness of compliance, and how to respond in an emergency response.

Diverse inputs of pollutants in Ibadan metropolitan area include domestic and industrial wastewaters, and rainwater, flow through the urban waterways primarily into the three main river systems (Ogunpa, Ona and Ogbere). Additionally, non-point source pollution from various urban features common in many watersheds continues to contribute appreciable levels of pollution.

The municipal and industrial wastewater discharge constitutes the constant polluting source, whereas, the surface run-off is a seasonal phenomenon, largely affected by climate in the basin. Seasonal variations in precipitation, surface run-off, ground water flow and water interception and abstraction have a strong effect on river discharge and subsequently on the concentration of pollutants in river water. It is imperative to prevent and control the rivers pollution and to have reliable information on the quality of water for effective management. In view of the spatial and temporal variations in the hydrochemistry of rivers, regular monitoring programs are required for reliable estimates of the water quality.

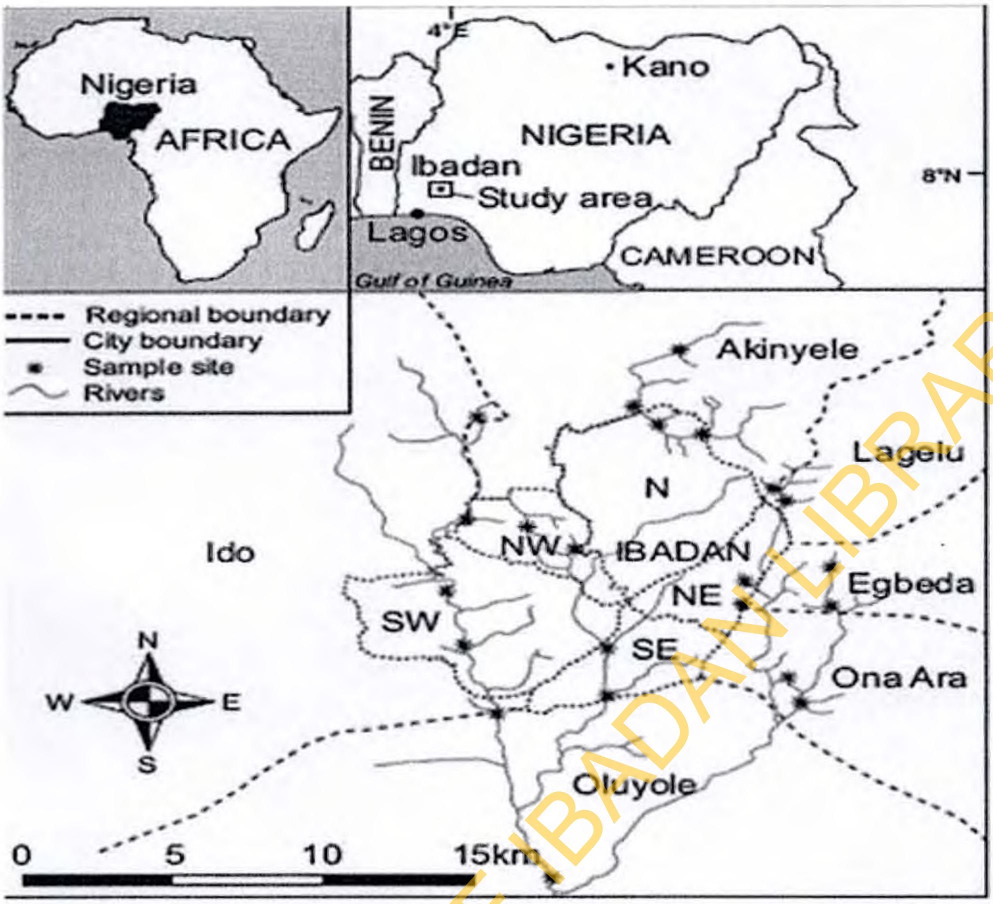
In this study, field investigations, which involved the collection and analyses of samples, were used to generate surface water quality data for Ibadan metropolis, which has severe potential pollution problems. This study also assessed the seasonal trend in the physical limnology and nutrient load of the river system in the eleven (11) local government areas in Ibadan metropolis.

Materials and Methods

Study Area

Ibadan (Oyo state, Nigeria) is the largest city in West Africa and the second largest in Africa, with land size covering an area of $240km^2$. The city is located on geographic grid reference longitude 3° 5E, latitude 7° 20N (Filani, 1994). Ibadan is situated at an average height of 200m above sea level, drained by three major river basins (Ogunpa, Ona and Ogbere) and surrounded by secondary rainforest as well as a savanna. Spatially, it sprawls over a radius of 12-15 km and experiences a mainly tropical climate with an estimated annual rainfall of about 1250 mm (UNCHS/UNEP, 1997). The study area comprise of 11 local government areas. The study area (Ibadan) and sampling points are shown in Figure 1.

Figure 1: A map of Nigeria showing Ibadan and the study area.



Sampling

Water samples were collected from Rivers in twenty-two sites comprising of one upstream and one downstream sample per each of the eleven local government areas in Ibadan metropolis between October 2003 and March 2004 during the dry season. This was repeated in between August and September, 2004 during the rainy season. Mid-stream water samples were collected from the rivers at each sample point and stored in pre-cleaned 500ml plastic containers. Once collected, the samples were immediately stored on ice in a dark cooler box and transported to the laboratory. The samples were stored at 4°C and analysed within six hours of collection.

Physical and Nutrient load analysis

The following physical parameters were assessed using standard methods for examination of water and wastewater (APHA, 1998): pH, colour, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), oil and grease, total hardness, biochemical oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD). Nutrient Load was assessed using the

Statistical analysis

The data thus obtained were computed and subjected to statistical analysis. Descriptive statistics for each parameter are mean and standard error of means. Mean values of samples from each local government areas for various parameters were compared. The significance of differences between seasons and locations were compared, using analysis of variance (ANOVA) and Duncan's multiple range tests. Microsoft Excel and SPSS packages were used for the analysis and graphing. The mean values were also compared with water quality standards of W.H.O, EEC, FEPA (Nigeria) and some other countries.

Results

Results of the assessment of physical parameters during the dry and rainy seasons are presented in tables 1 and 2 respectively. Values are presented as means of the up-gradient and down-gradient values plus/minus the standard error of mean (SEM). The standard values recommended by WHO, Nigeria and other countries is presented in Table 3. The results of the nutrient loads in the rivers are presented in figures 3-7. During the dry season (table 1), the pH values of the rivers sampled varied between 7.61 at ISE/LGA and 4.00 at INW/LGA, O/LGA had pH value of 5.8. I/LGA had the highest colour value at 22.97 TCU although there was no significant difference between the LGAs. BOD was significantly lower 31.4mg/l at IN/LGA and significantly higher at INE/LGA. DO was significantly higher at IN/LGA, 8.2mg/l and lower at ISE/LGA, however COD did not vary significantly between the LGAs during the dry season. TSS values was significantly different at only 2 of the LGAs, lower at IN/LGA, 6.35 mg/l and higher at I/LGA 530mg/l.

Table 1: Physicochemical parameters of rivers in the eleven local government areas in Ibadan during the dry season (October 2003-March 2004) are presented as means ± standard error of mean (SEM)

PARAMETERS	ALG	INLG	ILG	ISWLG	INWLG	ISELG	OALG	ELG	LLG	INELG	OLG
pH	7.09 ± 0.2^{ab}	7.39 ± 0.47^{a}	6.83 ± 0.06^{ab}	6.93 ± 0.05^{ab}	4.00±0.04c	7.61 ± 0.81^{a}	7.33 ± 0.1^{a}	7.02 ± 0.22^{ab}	6.95 ± 0.15^{ab}	6.75 ± 0.05^{ab}	5.8 ± 0.9^{b}
Colour	5.8 ± 0.0^{a}	4.65 ± 0.15^{a}	22.97 ± 15.72^{a}	7.67 ± 0.42^{a}	4.23 ± 0.76^{a}	9.84 ± 7.66^{a}	9.31 ± 1.48^{a}	10.4 ± 4.6^{a}	16.7 ± 1.6^{a}	19.46 ± 0.71^{a}	19.9 ± 1.5^{a}
B.O.D	53.4 ± 0.65^{ab}	31.4 ± 9^{b}	63.9 ± 2.5^{ab}	51.2 ± 22.8^{ab}	54.1 ± 1.3^{ab}	66.9 ± 35.45^{ab}	79.15 ± 3.4^{ab}	87.9 ± 33.8^{ab}	91.45 ± 21.3^{ab}	126.6 ± 44^{a}	93.6 ± 25^{ab}
D.O	7.05 ± 0.05^{ab}	8.2 ± 0.7^{a}	7.2 ± 0.1^{ab}	6.9 ± 1.2^{ab}	6.35 ± 0.25^{ab}	4.0 ± 3.0^{b}	6.65 ± 0.6^{ab}	7.05 ± 0.25^{ab}	6.65 ± 0.55^{ab}	6.15 ± 1.05^{ab}	7.6 ± 0.3^{ab}
C.O.D	20.1 ± 0.07^{a}	28.7 ± 1.4^{a}	23.2 ± 5.15^{a}	16.2 ± 0.45^{a}	17.25 ± 1.45^{a}	21.05 ± 1.05^{a}	24.2 ± 5.8^{a}	30.1 ± 5^{a}	25.7 ± 7.65^{a}	31.25 ± 9.85^{a}	29 ± 10^{a}
T.S.S	36 ± 29.9^{ab}	6.35 ± 0.25^{b}	530 ± 469.9^{a}	67.4 ± 0.73^{ab}	88.57 ± 11.4^{ab}	66.1 ± 0.01^{ab}	99.5 ± 0.4^{ab}	83.4 ± 16.7^{ab}	66.35 ± 0.35^{ab}	54.0 ± 4.0^{ab}	63 ± 3^{ab}
T.D.S	31 ± 4^{a}	2.00 ± 0^{a}	550 ± 529.9^{a}	26.3 ± 5.13^{a}	51.6 ± 1.5^{a}	58.6 ± 30.2^{a}	84.8 ± 36.2^{a}	69.7 ± 30.3^{a}	100.2 ± 0.2^{a}	110.4 ± 10^{a}	78.1 ± 0^{a}
T.S.	200 ± 0.0^{a}	200 ± 0^{a}	825 ± 675^{a}	190.0 ± 10^{a}	950 ± 750^{a}	1337 ± 1162^{a}	147 ± 27^{a}	200 ± 0^{a}	175 ± 5^{a}	180 ± 0^{a}	165 ± 15^{a}
T. hardness	148 ± 22.5^{a}	163.2 ± 37.5^{a}	175.7 ± 25^{a}	201 ± 25^{a}	201 ± 25^{a}	511 ± 491^{a}	270 ± 120^{a}	114 ± 14^{a}	163 ± 12^{a}	136 ± 15^{a}	426 ± 75^{a}
Oil & Grease	0.11 ± 0.01^{a}	0.12 ± 0.02^{a}	1.17 ± 0.96^{a}	0.15 ± 0.02^{a}	0.16 ± 0.04^{a}	1.63 ± 1.51^{a}	0.16 ± 0.04^{a}	0.19 ± 0.01^{a}	1.19 ± 0.99^{a}	0.19 ± 0.02^{a}	0.19 ± 0.01^{a}

*Parameters in the same row with different superscripts are significantly different ($p<0.05$)

Table 2: Physicochemical parameters of rivers in the eleven local government areas in Ibadan during the rainy season (August-September 2004) are presented as means ± standard error of mean (SEM)

PARAMETERS	ALG	INLG	ILG	ISWLG	INWLG	ISELG	OALG	ELG	LLG	INELG	OLG
pH	7.2 ± 0.1^{ab}	7.8 ± 0.8^{a}	6.85 ± 0.05^{ab}	5.3 ± 1.55^{b}	6.6 ± 0.6^{ab}	7 ± 0.1^{ab}	6.35 ± 0.15^{ab}	6.2 ± 0.2^{ab}	6.85 ± 0.05^{ab}	6.6 ± 0.1^{ab}	7.45 ± 0.05^{a}
Colour	1.95 ± 0.05^{a}	2.8 ± 1.35^{a}	1.95 ± 0.25^{a}	1.55 ± 0.05^{a}	2 ± 0.01^{a}	3.4 ± 1.6^{a}	1.7 ± 0.1^{a}	1.8 ± 0.15^{a}	1.4 ± 0.00^{a}	1.6 ± 0.01^{a}	2.25 ± 0.45^{a}
B.O.D	$32\pm10^{bc}d$	$20.14\pm7.96^{c}d$	46.6 ± 6.55^{abc}	50.7 ± 3.4^{ab}	$31\pm18.8^{bc}d$	50.4 ± 0.01^{ab}	50.7 ± 3.4^{ab}	56 ± 5^{ab}	7.75±0.65d	60.8 ± 0.4^{a}	11.4±1d
D.O	31 ± 1.2^{a}	17.9 ± 10.8^{a}	17.6 ± 8.9^{a}	11.4 ± 1.05^{a}	18.7 ± 11.4^{a}	17.8 ± 0.3^{a}	8.55 ± 0.65^{a}	15 ± 2.5^{a}	28.6 ± 16.5^{a}	13.7 ± 1.6^{a}	26.2 ± 6.15^{a}
C.O.D	28 ± 1.9^{b}	25.8 ± 5.35^{bc}	18.7 ± 2.03^{bc}	17.8 ± 0.65^{bc}	13.9 ± 7.2^{c}	39.2 ± 0.96^{a}	21.6 ± 3.5^{bc}	18.6 ± 0.1^{bc}	25.7 ± 4.35^{bc}	41 ± 1.1^{a}	21.1 ± 3.9^{bc}
T.S.S	7.6 ± 0.9^{a}	8.3 ± 0.8^{a}	7.15 ± 0.65^{a}	6.98 ± 0.82^{a}	54 ± 45^{a}	8.4 ± 0.33^{a}	9.3 ± 1.4^{a}	13 ± 0.5^{a}	7.65 ± 0.5^{a}	8.9 ± 0.8^{a}	12.5 ± 0.34^{a}
T.D.S	95 ± 5^{c}	119 ± 31^{bc}	95 ± 5^{c}	98.5 ± 1.5^{c}	105 ± 5^{bc}	165 ± 15^{abc}	190 ± 10^{ab}	98.5 ± 1.5^{c}	190 ± 10^{ab}	240 ± 60^{a}	138.5 ± 41^{bc}
T.S.	105 ± 5^{a}	149 ± 51^{a}	125 ± 25^{a}	105 ± 5^{a}	275.8 ± 125.8^{a}	190 ± 10^{a}	210 ± 10^{a}	105 ± 5^{a}	210 ± 10^{a}	275 ± 75^{a}	150 ± 50^{a}
T. hardness	426.7 ± 25^{b}	664.8 ± 189^{a}	401.7 ± 0.15^{b}	338.8 ± 37.6^{b}	318 ± 83.5^{b}	326 ± 25^{b}	301.2 ± 50.2^{b}	351 ± 0.01^{b}	276 ± 25^{b}	313.8 ± 12.6^{b}	439 ± 87.5^{b}
Oil & Grease	0.64 ± 0.4^{a}	0.97 ± 0.14^{a}	0.83 ± 0.02^{a}	0.78 ± 0.03^{a}	0.8 ± 0.02^{a}	0.94 ± 0.09^{a}	0.83 ± 0.02^{a}	0.95 ± 0.1^{a}	1 ± 0.00^{a}	0.65 ± 0.4^{a}	1.14 ± 0.06^{a}

*Parameters in the same row with different superscripts are significantly different ($p<0.05$)

The highest TDS was obtained at I/LGA, 550mg/l, though there was no significant difference between the LGAs. TS were not statistically significantly different in all the LGAs, the highest value being 1337mg/l at ISE/LGA and the lowest 147 mg/l at OA/LGA. Total hardness as well as oil and grease values did not vary significantly in all the rivers sampled. The results obtained during the rainy season (table 2), revealed that pH values were significantly different at IN/LGA, 7.8, O/LGA, 7.45 and ISW/LGA, 5.3. Water colour values were not statistically significantly different between the LGAs. Significant variations were however recorded in the values of BOD between the LGAs. Values as low as 7.75mg/l were obtained at L/LGA, 11.4mg/l at O/LGA, while as high as 50.0mg/l was recorded at ISW and OA LGAs. DO did not vary significantly between the LGAs. COD varied significantly between the LGAs especially A/LGA, 28 mg/l, INW/LGA, 13.9 mg/l, ISE/LGA, 39.2 mg/l and INE/LGA, 41.1 mg/l. No significant variation in TSS was recorded and the values ranged from 54 mg/l at INW/LGA to 6.98 mg/l at ISW/LGA.TDS varied significantly between the LGAs with values ranging from 240 mg/l at INE/LGA to 95 mg/l at A/LGA and I/LGA. Variation in TS values was not statistically significant between the LGAs during the rainy season while the only significantly different value for total hardness 664.8 mg/l was recorded at IN/LGA. Oil and grease values were not significantly different in all the LGAs. Study of the nutrient loads revealed a generally higher phosphate levels in all the LGAs during the rainy season (fig 2). Sulphate levels were higher during the rainy season in all the LGAs with the exception of ALGA that had a much higher value during the dry season (fig 3). Nitrate values during the two seasons varied considerably between the LGAs. Levels were higher generally during the dry season; however at ALG and LLG, the values for rainy season were higher (fig 4). Nitrite levels in the rivers were appre4ciably higher during the rainy season in all the LGAs (fig 5); however total Nitrogen values were generally higher during the dry season in all the LGAs

Figure 2: Phosphate level in Rivers in Ibadan, Nigeria during the two seasons

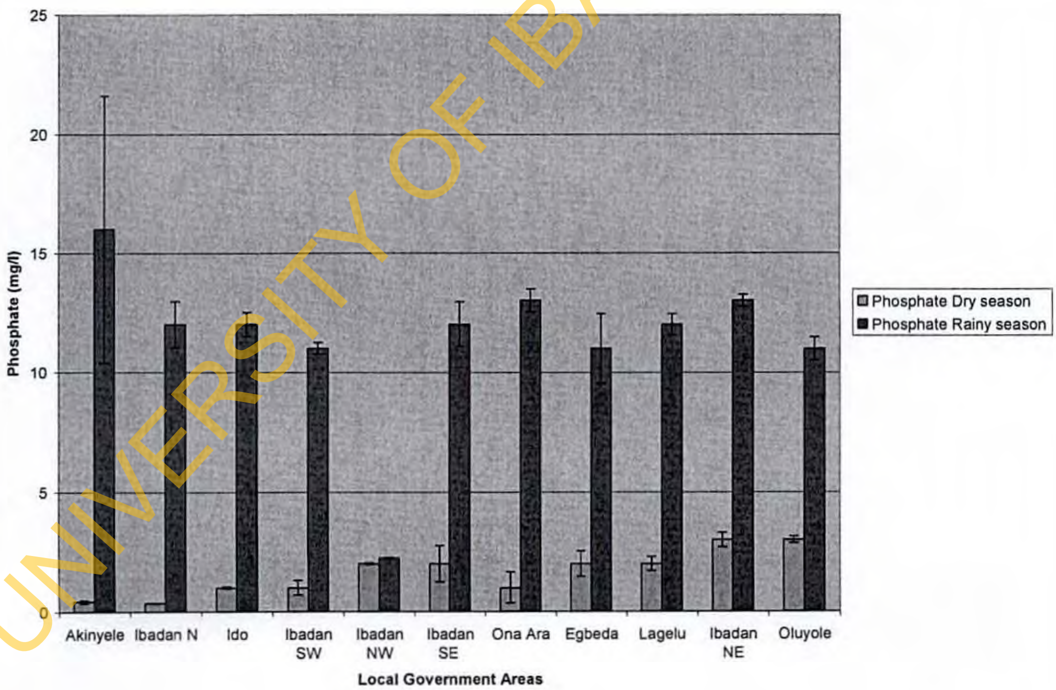


Figure 3: Sulphate level in Rivers in Ibadan, Nigeria during the two seasons

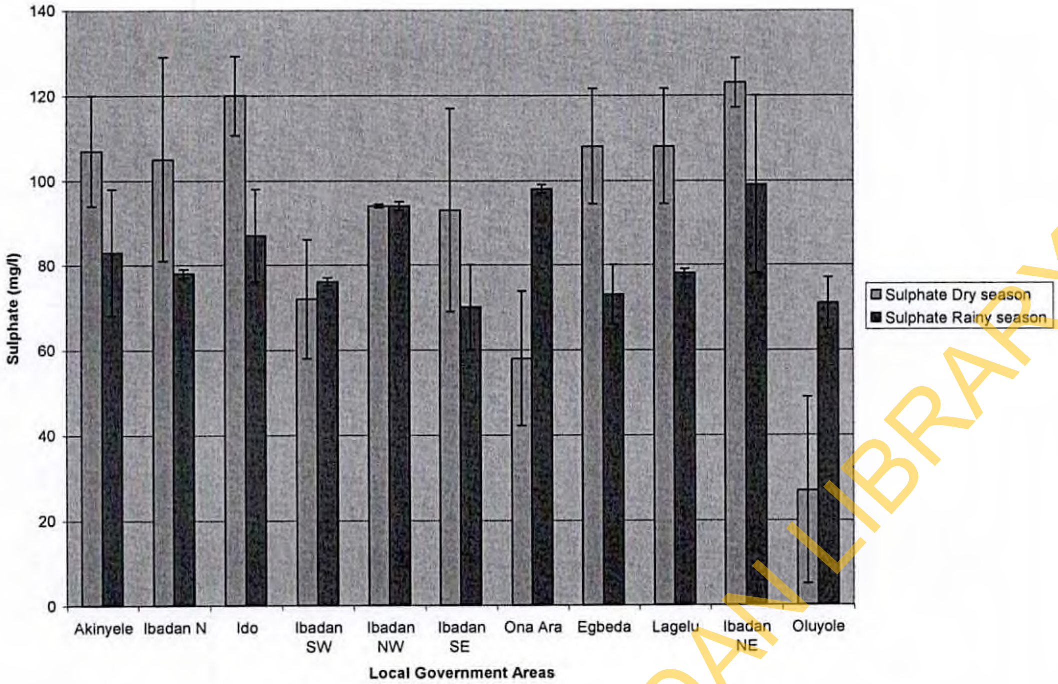


Figure 4: Nitrate level in Rivers in Ibadan, Nigeria during the two seasons

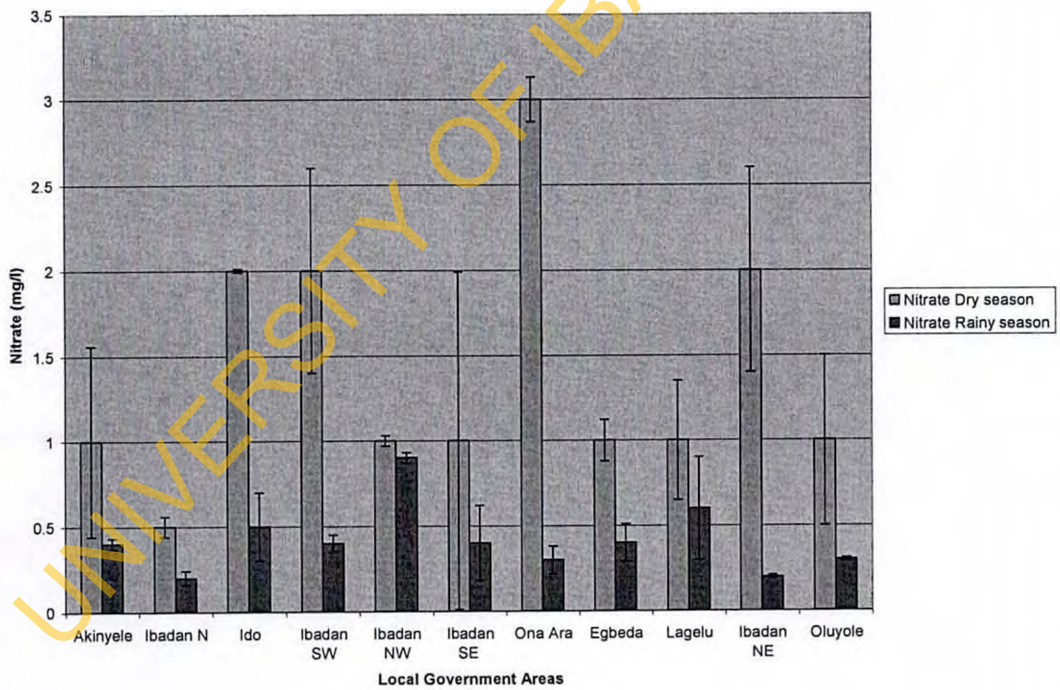


Figure 5: Nitrite level in Rivers in Ibadan, Nigeria during the two seasons

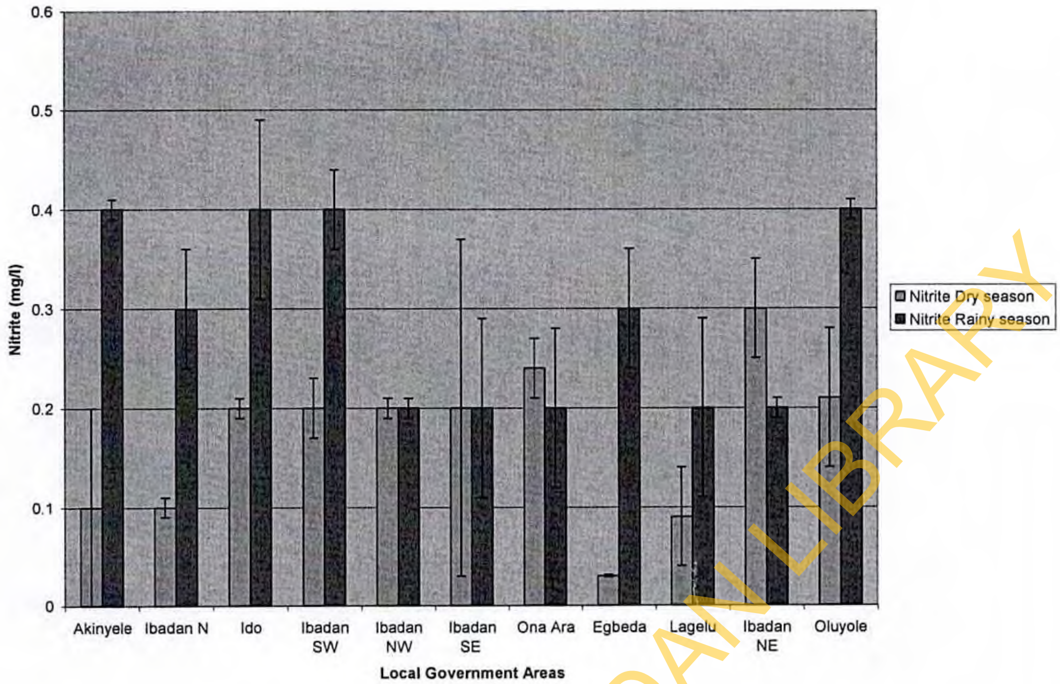
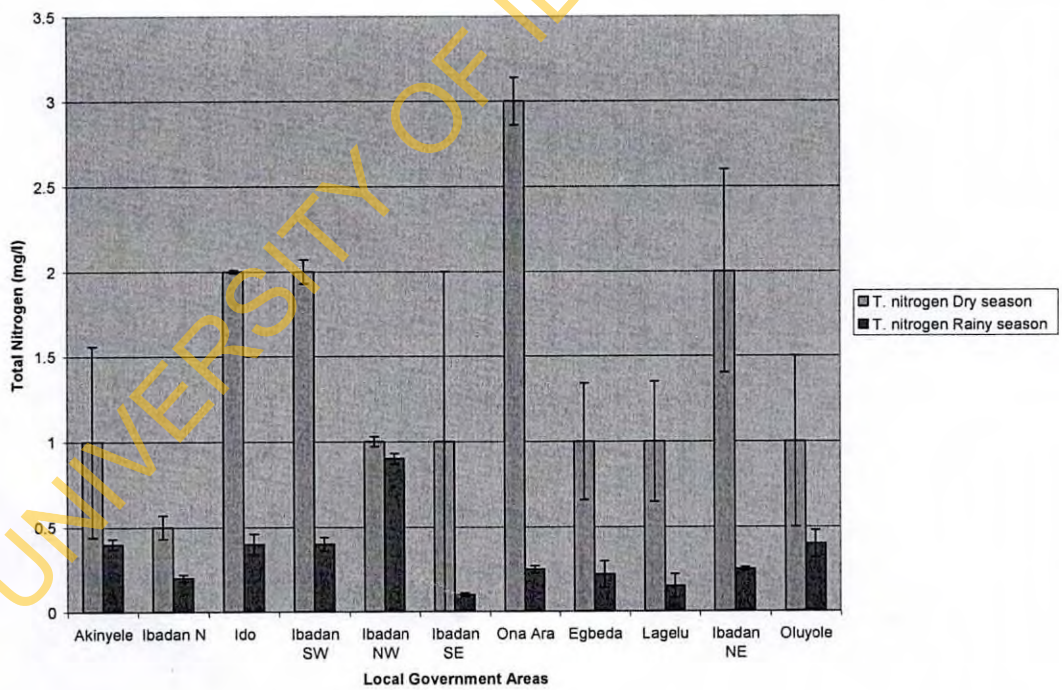


Figure 6: Total nitrogen level in Rivers in Ibadan, Nigeria during the two seasons



Discussion

Surface water quality is a matter of serious concern today due to their role in carrying off the municipal and industrial wastewater and run-off from agricultural land in their vast drainage basins. The surface water quality in a region is largely determined both by the natural processes (precipitation rate, weathering processes, soil erosion) and the anthropogenic influences viz. urban, industrial and agricultural activities and increasing exploitation of water resources. Since rivers constitute the main inland water resources for domestic, industrial and irrigation purposes; they are therefore among the most vulnerable water bodies to pollution.

Since Nigeria is entirely within the tropics and subject to heavy rains and because most of the landfills and dumpsites are usually unlined, toxic waste constituents, solvents, and leachates leak or leach from them into the soil, where they contaminate underground and surface water (Adeyemo & Agbede, 2001). The results from this study reveal that colour, Total suspended solid (TSS), total solids (TS) ands total nitrogen were generally higher during the dry season. This suggests that the run-offs have only a diluting effect on these parameters. All the other physical parameters (pH, BOD, DO, COD, TDS, Total hardness) and Nutrient load based parameters (phosphate, sulphate, nitrate and nitrite) were generally higher during the rainy season; this also suggests that runoff water contributes a significant proportion of these constituents into the river systems. The results relative to recommended standards (Table 3) shows that all (100%) the samples recorded higher values for TDS, BOD and colour (during dry season) and phosphate (during rainy season); 60-99% had higher values for phosphate and BOD (dry season) and TSS; 20-59% had higher values for pH, TDS (rainy season) and total hardness (dry season); while 10-19% had higher values for total hardness and colour (rainy season), nitrate, sulphate and pH (dry season).

Table 3: Water quality standards of W.H.O, EEC, FEPA (Nigeria) and some other countries

PARAMETERS	FEPA (Nigeria)-Effluent disposal limits (1991)	WHO (1993)	USEPA (1996)	UGANDA	MALAWI
pH	6-9	6.5-9.5	6.5-8.5	6.5-8.5	-
Colour (TCU)	7	15	15	10	<15
B.O.D (mg/l)	30	-	-	-	-
D.O (mg/l)	-	5-8*	-	-	-
C.O.D (mg/l)	-	-	-	100	-
T.S.S (mg/l)	30	-	-	Nil-50	-
T.D.S (mg/l)	2000	1000	500	1000	500
T.S. (mg/l)	-	-	-	-	
T. hardness (mg/l)	-	500	-	500	100
Oil and Grease (mg/l)	10	-	-	10	-
Phosphate (mg/l)	5	0.5	-	-	-
Sulphate (mg/l)	500	250	250	200	200
Nitrate (mg/l)	20	3	1	45	45
Nitrite (mg/l)	-	3	1	3	<1

In Nigeria, leachates from refuse dumping, as shown by high values of BOD, COD, total solids, suspended solids in the receiving surface water bodies, indicate the high potential cause of gross organic pollution (Adeyemo, 2003). Phosphates are equally undesirable anions in water; they are the limiting factor in eutrophication and result in adverse ecological effects that could render the water unsuitable for aquatic life (DWAF, 1986). The high phosphate ion content of Ibadan river system might be due to leaching of agricultural wastes into the river and/or the use of phosphate additives in detergent formulations, which get leached into water bodies through wastewaters generated industrially, domestically or municipally and/or from cloth dyeing and garment industries operating in the study area

Significant nitrate contamination of surface water is found in areas of high population pressure and agricultural development. Nitrates result as the end product of biochemical oxidation of ammonia which results by breaking up of protein. The increase of nitrates indicates fecal pollution (Bush &