Research Journal of

Environmental Sciences

ISSN 1819-3412

Academic Journals Inc.

www.academicjournals.com

Research Journal of Environmental Sciences 5 (1): 22-35, 2011
ISSN 1819-3412 / DOI: 10.3923/rjes.2011.22.35

Seasonal Assessment of Physico-chemical Concentration of Polluted Urban River: A Case of Ala River in Southwestern-Nigeria

A.O. Ayeni, I.I. Balogun and A.S.O. Soneye
Department of Geography, University of Lagos, Lagos, Nigeria

Corresponding Author: A.O. Ayeni, Department of Geography, University of Lagos, Lagos, Nigeria Tel: +234-08035894730

ABSTRACT

This study assessed the seasonal surface water quality of River Ala upstream Akure-Nigeria. This was necessitated by the peoples' consideration of water from rivers as substitute to the reigning incidence of water shortage in the downstream of the river. Six locations were chosen spatially within the urban built-up to reflect a consideration of all possible human activities that are capable of changing the quality of river water. Water samples were collected for a period of 12 months. The water samples collected were analyzed for physico-chemical parameters which include pH, total dissolved solids, dissolved oxygen, biochemical oxygen demand, total hardness, calcium, magnesium, chlorine, nitrate, iron and zinc using standard procedures. For spatial reference the location of sampling points were determined with GPS and interpolated on digitized topographical map sheets of the study area. The observed results of the laboratory analysis were then presented, described and compared descriptively with the international standards for drinking water. It was observed that variation exists in the quality of the sampled waters and impaired to different degrees using WHO drinking water standards for the selected parameters. The results of the correlation coefficient shows that inverse or direct relationship exist between some parameters for instance, there is inverse relationship between pH and DO at 95% confidence level during the rainy season while Ca^{+} has direct relationship with Mg and Cl^{-} 95%. Therefore, considering the level of impairments of Ala River in Akure-Nigeria, water is unsafe for domestic purposes and it continuous use prognosticate health danger to the residents.

Key words: Spatial, temporal, assessment, polluted, urban, surface water

INTRODUCTION

Water is a vital resource to man. Its quantity and quality as well its management contributes to its sustainability (Faniran, 1991; UNESCO-WWAP, 2003). Its usage constitutes a major criterion towards sustainable growth and development of a region and its economy (Katte *et al*., 2003; Gleitsmann *et al*., 2007). Water is one of the most important necessities of life that are required by man, animal and plant. Man uses water for domestic, industrial and agricultural purposes. As noted by researcher life on earth is impossible without water. Faniran (1991) argued that a man's most urgent need is drinking water. Stating that, man may survive several weeks without food but will die within few days if deprived of water. The past decade has seen remarkable impact of man on the environment due to unprecedented increase in population and rapid rate of urbanization as well as the intensification of the use of fragile and marginal ecosystems (Olorunfemi and Jimoh, 2000). This has led to progressive land and other vital resources degradation and continued desertification of marginal agricultural lands.

Understanding and monitoring surface water quality of a region remains a better tool towards promoting sustainable development of water resources within the societal economic and conservational contextual need (Ifabiyi, 2000). Also, of importance is the assessment of the human activities that are capable of changing the quality of river water within an urban area (Ayeni *et al.*, 2006). This is necessary, since per capita water demand is increasing while accessibility to available freshwater availability is on the decrease (Sullivan *et al.*, 2003; Watson and Lawrence, 2003). These have lead to usage of polluted and contaminated water source. Globally, about 80% of all diseases and deaths in developing countries are water-related as result of polluted water (Awake, 2001; Aderibigbe *et al.*, 2008).

This study therefore examined the quality of River Ala at the upstream and it possible implication on the people using the water for drinking and other domestic purposes in the downstream. Consequently, the continuous use of this water for domestic purposes in the downstream area portends grave danger to human health. The situation will be worse in nearest future if surface water pollution monitoring programme is not effectively addressed. Thus, the study calls for public enlightenment in order to create public awareness with respect to the need not to rely on water from this source for drinking purpose in the downstream. This is necessary in order to complement human development and sustainable surface water resources quality of River Ala.

MATERIALS AND METHODS

The study area: Akure is the capital city of Ondo State Nigeria and it is located in the central senatorial district of the state (Federal Office of Statistics, 1992). Akure falls between 739000 and 746000 Easting (i.e., between longitude 5°06'E and 5°38'E) and between 801500 and 807000 Northing (i.e., between latitude 7°07' N and 7°37'N) (Fig. 1).

Akure is bounded in the North by both Akure North and Ifedore local govt, in the west by Ile-Oluji/Oke-Igbo local govt, east by Owo local govt, in the South by Idanre local govt. the study area experience a frequent rainfall between April and July with a short break in August and continues between September and November, with the heaviest rainfall in July. The average daily temperature is ranging from 22°C during harmattan (December-February) to 32°C in March the peak temperature. The vegetation is tropical rainforest (Barbour *et al.*, 1982; Iloeje, 1977; Uluocha and Ekop, 2002). The population of the people residing in Akure is about 353,211 (Federal Bureau of Statistics, 2007).

Geography of river Ala: River Ala and tributaries is one of the main tributaries of River Ogbese, Southwestern, Nigeria. River Ala with total length of about 57 km has a length of about 14.8 km within Akure Township (Fig. 1). It took its source from northwestern part of Akure town and flow towards Southeastern part of the town. Akure Township dominated the upstream of River Ala while rural towns such as Ilado, Ehinala, Ajegunle, Owode Aiyetoro and Araromi are located in the downstream where the water is being used for drinking water and other domestic purposes.

Experimentation: The water samples were collected along River Ala during the rainy and dry seasons. Water samples were collected 3 times at 10 days interval for a period of 1 year between November, 2007 and October, 2008. These amounted to 18 samples in each season making a total of 36 for 1 year. The mean and SD of each parameter in all sampling points were calculated for each season samples and used for the analysis (Table 1). The measurements include simple (*In situ*) and basic to more complex parameters (Laboratory): Dissolved Oxygen (DO) and pH were determined in situ measured with a portable *in situ* pH meter and M90 Mettler Toledo AG DO meter, respectively (USGS, 2005). The water samples for laboratory analysis were collected using cleaned 1000 cm^3 new polythene bottles with hard plastic screw caps which was properly cleaned and rinsed with the water to be sampled were used in collecting samples taking to the laboratory. The samples were collected by dipping the covered plastic bottle at about 20-30 cm below the water surface at the midstream. The bottle was opened under water and fills up then, covered with the cap before taking it out from the water. The samples were coded immediately at the sampling point with names to avoid error of sampling replacement in the laboratory. Using standard methods for water samples examination of American Public Health Association in 1998, Total Dissolved Solid (TDS), Biochemical Oxygen Demand (BOD), Total Hardness (TH), Calcium (Ca^+), Magnesium (Mg^2), Chlorine (Cl^-), Calcium (Ca^+), Nitrate (NO_3^-), Zinc (Zn) and Iron (Fe) in water samples were kept in Cool box for preservation and conveyed to laboratory for appropriate analysis (Ayoade, 1988; WHO, 1993, 2006; USGS, 2005).

The coordinates of sampling points were taken using a Garmin 76 GPS portable Global Positioning System (GPS) for spatial reference and accurate interpolation on map. The coordinates was later overlaid as reference points on digitized and edited satellite imagery map that was processed in the Arcview 3.3 environment (Fig. 2).

From the accuracy viewpoint, the data values and associated error bars appearing in the model response figures were computed as the mean and standard deviation of the samples taken in the same transect on differing dates. Degree of association between the studied parameters was

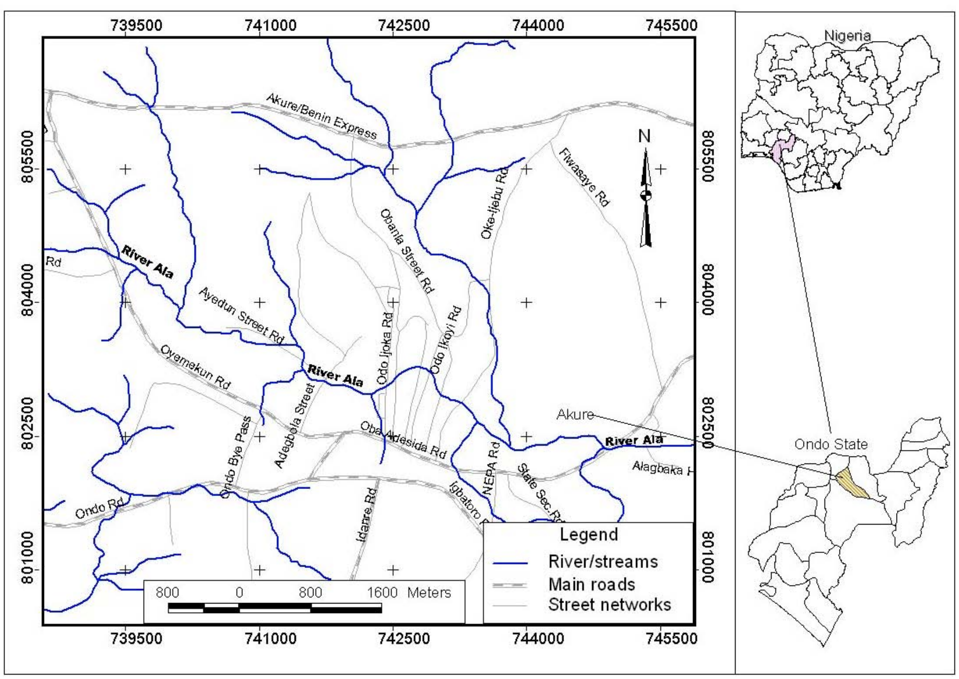

Fig. 1: Study area

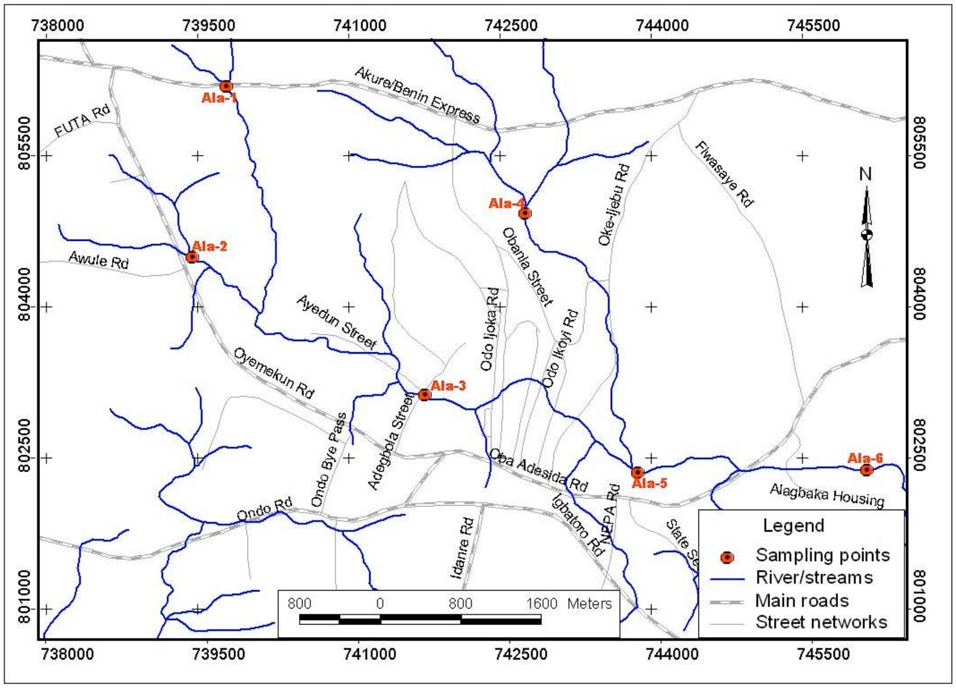

Fig. 2: Sampling points

determined using correlation coefficient while coefficient of variation was used to compare the spatial variability of the parameters along River Ala (Spiegel and Stephens, 1999). The analysis was done at the postgraduate analytical laboratory, Department of Chemistry, University of Lagos, Lagos in 2007/2008.

RESULTS AND DISCUSSION

Generally, pH mean values for each sampling points was lowest in Ala-5 and highest in Ala-6 with values of 6.1 and 8.1, respectively during the rainy season. During the dry season the lowest and highest values of 6.6 and 7.9 were observed at Ala-5 and 4, respectively (Table 1, Fig. 3). The overall mean value of pH of 7.2 and 7.3 for rainy and dry seasons falls within WHO (2006). Coefficient of Variation (CV) analysis on the data obtained showed that the concentrations of pH along River Ala are homogenous for the two seasons. Virtually all values are nearly neutral to alkalinity except sampling point Ala-5 in the rainy season as also observed on Ogun River (Martins, 1987; Jaji *et al*., 2007).

Dissolved Oxygen (DO) mean values for each sampling points was lowest in Ala-6 and highest Ala-5 with values of 5.52 and 7.53 mg L^{-1}, respectively during the rainy season (Table 1, Fig. 4). During the dry season the lowest and highest values of 3.2 and 6.03 mg L^{-1} were observed at Ala-2 and 5, respectively. The result of Coefficient of Variation (CV) analysis shows that the concentrations of DO were homogeneous for the two seasons. Ahonkhai and Chukwuogo (1996) argued that the variation of DO values in sampled water may be as a result of pollutant activities at the various land uses.

Biological Oxygen Demand (BOD) is useful in evaluating the pollutional strength of water and it also gives a measure of the amount of oxygen required by microorganisms to decompose an

Table 1: Physico-chemical result of water samples

Results	Sampling points	Ala-1	Ala-2	Ala-3	Ala-4	Ala-5	Ala-6	Mean	SD	CV	WHO
pH	Rainy	6.80±0.3	7.20±0.4	7.10±0.3	7.90±1.6	6.10±0.3	8.10±0.4	7.2	0.7	10.2	6.5-8.5
	Dry	7.10±.3	7.80±0.8	6.80±0.7	7.90±0.6	6.60±1.0	7.40±1.1	7.3	0.6	8.0	
DO (mg L^{-1})	Rainy	6.40±1.0	5.93±2.2	5.77±0.2	6.13±1.9	7.53±2.1	5.52±0.6	6.2	0.7	11.5	-
	Dry	4.44±1.4	3.21±1.3	4.23±1.4	4.71±0.8	6.03±0.2	5.01±1.6	4.6	0.9	20.2	
BOD (mg L^{-1})	Rainy	21.00±1.9	15.00±1.5	6.00±0.4	35.00±2.1	33.00±0.5	35.00±1.8	24.2	12.1	50.2	10
	Dry	11.40±2.0	9.90±1.0	6.20±1.3	13.70±0.7	10.90±0.6	6.50±0.3	9.8	2.9	30.0	
TDS (mg L^{-1})	Rainy	192.00±61.1	256.00±49.8	357.00±140.2	432.00±88.7	230.00±14.2	176.00±36.5	273.8	100.4	36.7	500
	Dry	125.50±69.2	174.70±21.2	243.60±17.8	179.00±21.4	150.40±11.5	140.40±20.8	168.9	41.8	24.8	
Ca^{2+} (mg L^{-1})	Rainy	6.45±0.9	20.60±1.2	25.80±2.0	28.40±2.1	29.70±0.9	31.00±1.1	23.7	9.2	38.9	250
	Dry	24.10±1.0	33.00±1.1	34.10±0.9	41.20±2.2	28.00±1.5	24.00±2.7	30.7	6.7	21.7	
Mg (mg L^{-1})	Rainy	9.87±8.1	38.40±296.1	49.50±0.9	53.00±2.8	51.80±11.2	52.60±5.2	42.5	16.9	39.8	150
	Dry	46.00±2.1	31.00±1.9	8.00±3.0	40.00±6.7	20.00±4.5	8.80±3.3	25.6	16.0	62.3	
Cl (mg L^{-1})	Rainy	7.10±2.2	24.85±12.2	35.50±6.7	39.05±14.1	39.05±10.4	39.05±18.7	35.5	6.1	17.3	250
	Dry	8.00±3.4	12.00±2.1	16.00±1.5	12.00±12.6	12.20±1.7	20.80±3.5	13.5	4.4	32.5	
NO_3 (mg L^{-1})	Rainy	0.96±0.5	12.50±4.5	7.86±0.5	23.90±3.4	28.60±0.9	27.70±1.0	16.9	11.5	67.8	10
	Dry	1.01±0.2	2.21±0.4	3.61±1.1	4.12±0.2	4.07±0.8	7.57±0.7	3.8	2.2	59.1	
Zn (mg L^{-1})	Rainy	0.04±0.01	0.18±0.03	0.09±0.08	0.27±0.02	0.07±0.01	1.01±0.10	0.3	0.4	133.4	5
	Dry	0.02±0.02	0.12±0.03	0.29±0.02	0.09±0.02	0.66±0.09	0.08±0.02	0.2	0.2	113.6	
Fe (mg L^{-1})	Rainy	1.80±1.1	2.69±0.8	2.78±1.4	3.50±1.3	3.99±1.1	2.56±0.9	2.9	0.8	26.5	0.3
	Dry	1.30±0.7	1.30±1.4	1.50±1.9	1.60±1.0	2.1±1.2	1.7±0.9	1.6	0.3	18.9	

SD: Standard deviation, CV: Coefficient of variation, Source: Author field survey, 2007/2008

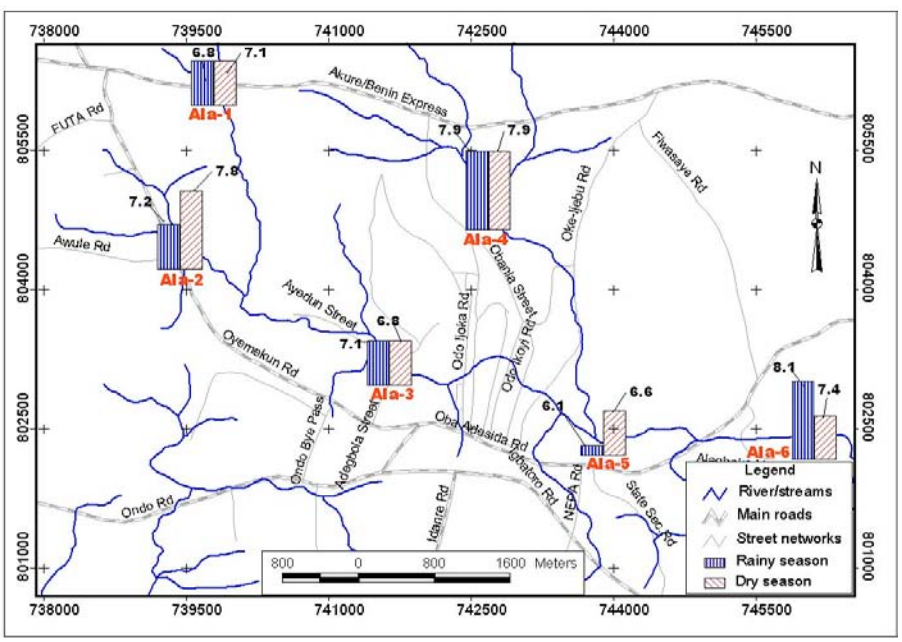

Fig. 3: pH seasonal concentration

organic matter in sampled water under specific set of condition (Akinwumi, 2000). BOD mean values for each sampling points was lowest in Ala-3 with value of 6.0 mg L^{-1} and highest in Ala-4

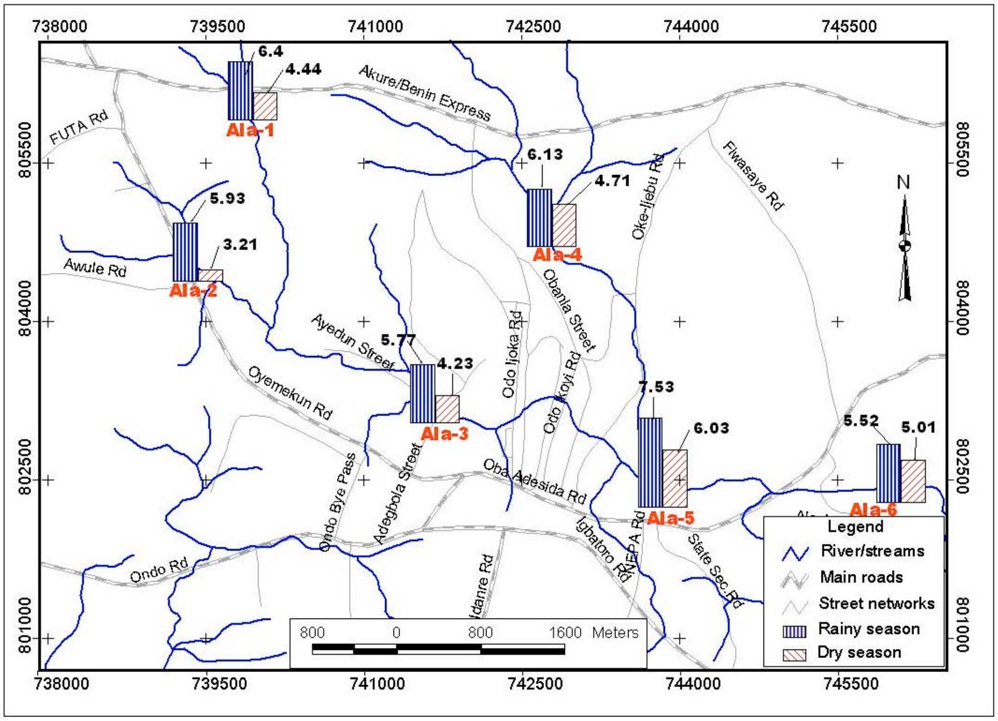

Fig. 4: Dissolved oxygen seasonal concentration

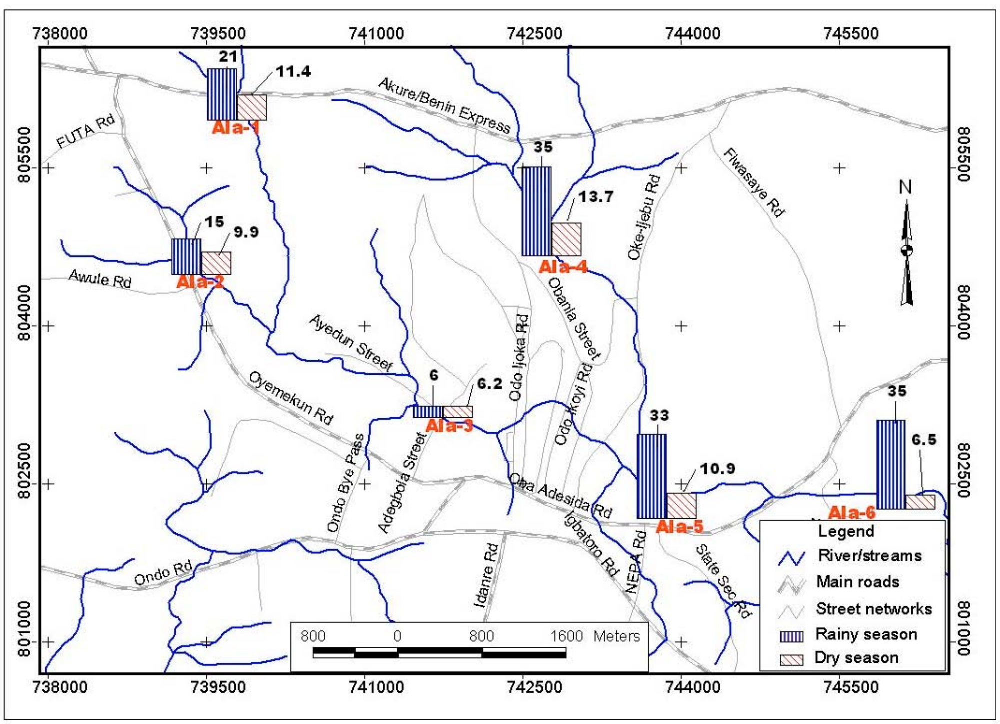

Fig. 5: Biological oxygen demand seasonal concentration

and 6 with values of and 35 mg L^{-1} each during the rainy season while 11.4 mg L^{-1} were observed at Ala-1 as highest values during the dry season (Table 1, Fig. 5). The overall mean values of BOD of 24.2 and 9.8 mg L^{-1} for rainy and dry seasons found above and within WHO (2006), respectively. The Coefficient of Variation (CV) analysis shows that the concentration of BOD along River Ala is moderately heterogeneous during the rainy season and slightly homogeneous during the dry season. As also observed by Martins (1987) and Jaji *et al.* (2007) on Ogun River the high value of Ala-1, 2 and 3 to Ala-6 in rainy season may be attributed to high percentage of transported loads of organic matter in the water. In dry season all points meet WHO standard except Ala-1 and Ala-4.

Total Dissolved Solid (TDS) mean values for each sampling points was lowest in Ala-6 and highest Ala-4 with values of 176 and 432 mg L^{-1}, respectively during the rainy season while 125 and 243 mg L^{-1} were observed at Ala-1 and 3 as the lowest and highest values, respectively during the dry season (Table 1, Fig. 6). The overall mean values of TDS during rainy and dry season were 339.4 and 201.1 mg L^{-1}, respectively and fall below (WHO, 2006). The value coefficient of variation analysis shows that the concentration of TDS along River Ala is homogeneous for the two seasons. The high value of Ala-1, 2 and 3 to Ala-6 in rainy season may be attributed to high percentage of transported loads of organic matter in the water. On the other hand, during the dry season all points meet WHO standard except point Ala-1 and 3. According to Akinwumi (2000) and Ahonkhai and Chukwuogo (1996) since the concentration of TDS in all seasons are generally lower than WHO standard, turbidity content in the river will be relatively low which may lead to reduction in light penetration and therefore, limits photosynthesis. Such limitation might restrict plant growth and respiration in aquatic life (Akinwumi, 2000).

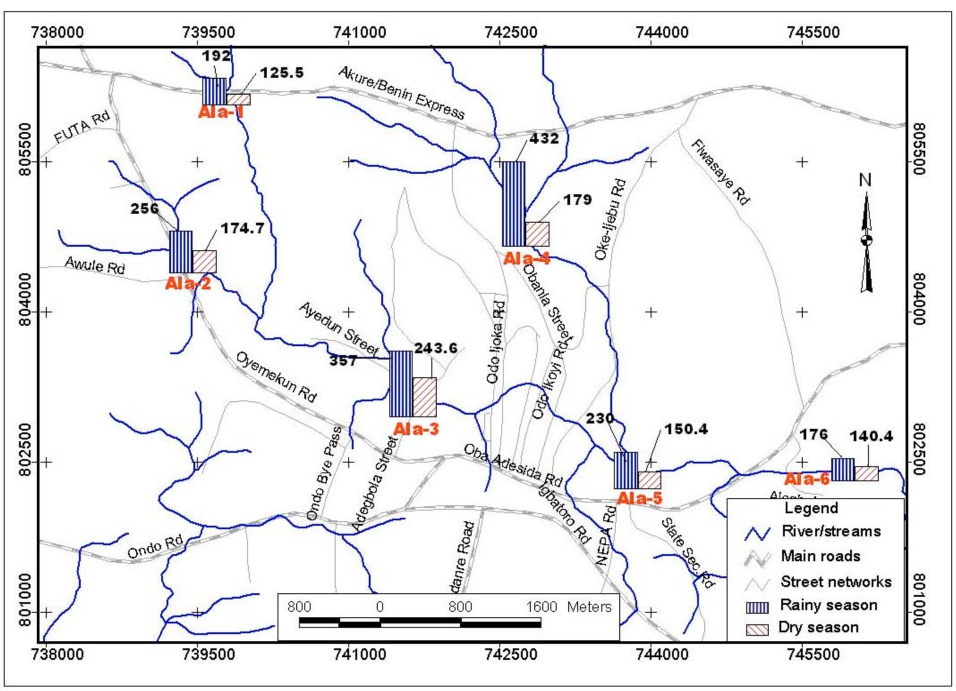

Fig. 6: Total dissolved solid seasonal concentration

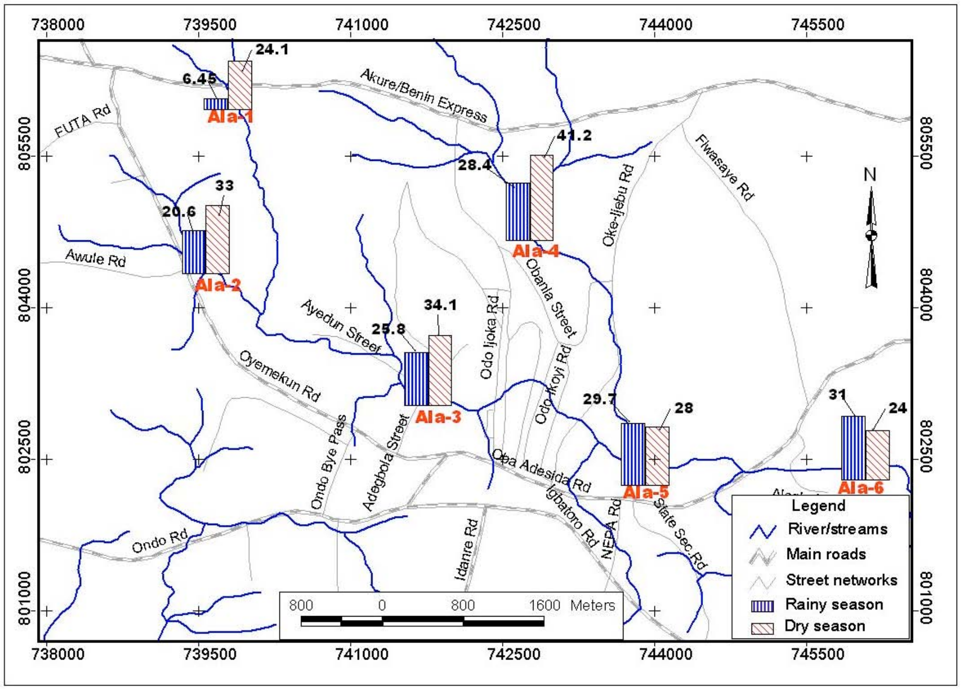

Fig. 7: Calcium hardness seasonal concentration

The result of Calcium hardness (Ca^{2+}) shows that during the rainy season the concentration increases downstream from point Ala-1 of 6.45 mg L^{-1} to Ala-6 of 33.6 mg L^{-1} while the concentration increases from 24.1 mg L^{-1} in Ala-1 to 41.2 mg L^{-1} in Ala-3 and decrease downstream from 41.2 mg L^{-1} in Ala-3 to 23.4 mg L^{-1} in Ala-6 (Table 1, Fig. 7). The Ca^{2+} of the sampled water at the all points was generally lower than that of WHO (2006) standard and moderately homogeneous in their level of concentration in both seasons. This can be attributed to the geological composition of the rock on which the river flows and self-purifications process, which normally include complex physico-chemical and biological processes such as sedimentation of suspended matter, coagulation of colloid and absorption of dissolved substances (Ahonkhai and Chukwuogo, 1996; Ifabiyi, 1997). Principally, soluble salts of Calcium will cause impair health precisely tooth disease, kidney and bladder disease.

Magnesium Hardness (Mg^{2+}) mean values for each sampling points was lowest in Ala-1 and highest Ala-4 with values of 9.87 and 53.0 mg L^{-1}, respectively during the rainy season while 8.0 and 46.0 mg L^{-1} were observed at Ala-3 and 1 as the lowest and highest values, respectively during the dry season (Table 1, Fig. 8). The overall mean values of Mg^{2+} during rainy and dry season were 44.2 and 23.0 mg L^{-1}, respectively and also fall below (WHO, 2006). The Coefficient of Variation (CV) analysis shows that the concentration of Mg^{2+} along River Ala upstream is slightly homogeneous during the rainy season and moderately heterogeneous during the dry season. Ojosipe (2007) and Ifabiyi (1997) attributed the chemistry of this to the geological composition of the River bed-rock. The implication of this is that if the water is drinking without treatment it might impair human health and lead to heart and kidney diseases (Ojosipe, 2007).

The result of samples shows that, the Chloride (Cl^{-}) is generally low while compared to the WHO (2006) regulatory standard in both seasons. During the rainy season the lowest was recorded

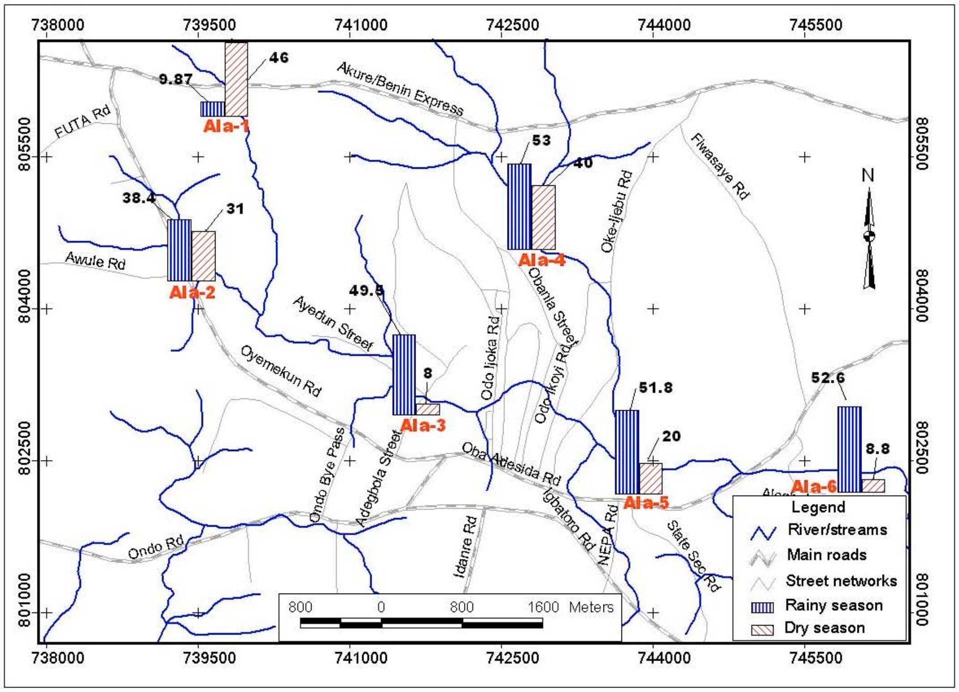

Fig. 8: Magnesium hardness seasonal concentration

at sampled point Ala-1 with 7.1 mg L^{-1} while the lowest and highest recorded during the dry season are at sampled point Ala-1 and 6 with 8.0 and 20.8 mg L^{-1}, respectively (Table 1, Fig. 9). The Coefficient of Variation (CV) analysis shows that the concentrations of Cl^- along River Ala upstream are moderately homogeneous in both seasons. The low content of Cl^- may arise as a result of various soluble salts and animal manure, which is a potential source of sulphate (Ojosipe, 2007). The implication of this in drinking water will lead to heart and kidney diseases and cause impair health (Ojosipe, 2007).

The sampled water in Ala-1 and Ala-5 has the highest values of Nitrate (NO_3). Point Ala-1 recorded the lowest and highest values of 0.96 and 28.6 mg L^{-1}, respectively during the rainy season while the concentration of NO_3 increases from 1.01 mg L^{-1} in Ala-1 and 7.5 mg L^{-1} in Ala-6, respectively during the dry season (Table 1, Fig. 10). The overall mean value of rainy season fall above WHO (2006) regulatory standard while that of dry season meet the regulatory standard. Only points Ala-1 and 3 meet the WHO (2006) standard during the rainy season while all the sampling points in dry season meet the standard. The Coefficient of Variation (CV) analysis shows that the concentrations of NO_3 along River Ala are moderately heterogeneous in both seasons. The high values in Ala-4 to 6 during the rainy may attributed to the watershed from agricultural activities while the generally low of NO_3 in point Ala-1 in both season may be attributed to the fact that the area is free from all sort of domestic/industrial and agricultural pollutional activities (Ahonkhai and Chukwuogo, 1996; Ifabiyi, 1997). The increasing output of nitrate may leads to methemoglobinemia and retard growth (Ifabiyi, 1997, 2000).

The concentration of Zinc (Zn) in the sampled water ranges between 0.04 and 1.01 mg L^{-1} as the lowest and highest at point Ala-1 and 6, respectively during rainy season. On the hand, during the dry season, the concentration ranges between 0.02 and 0.66 mg L^{-1} as the lowest and highest

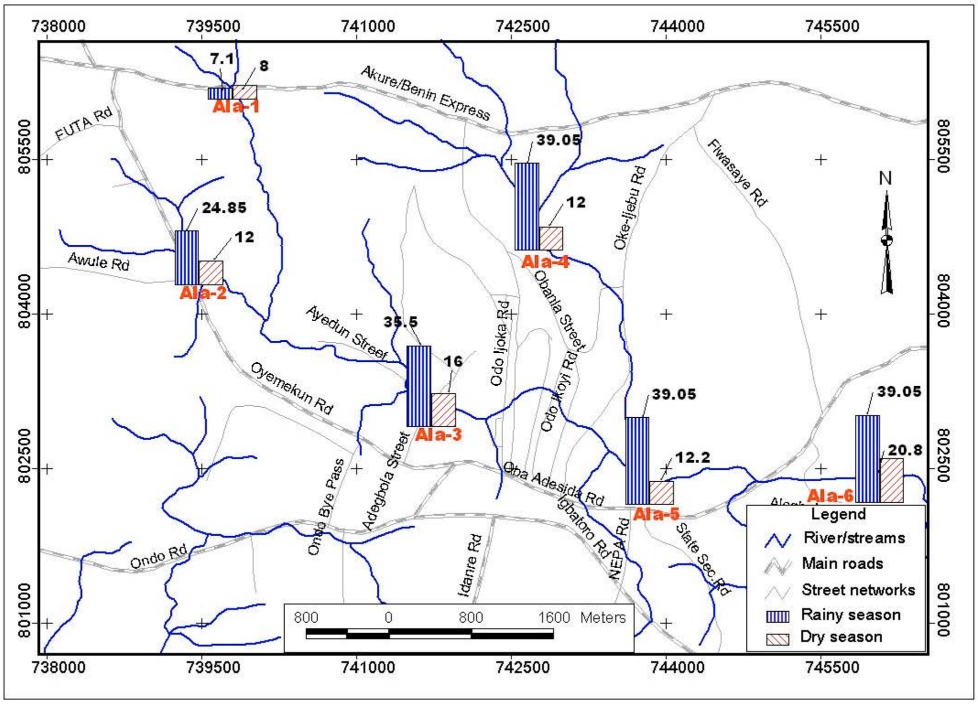

Fig. 9: Chloride seasonal concentration

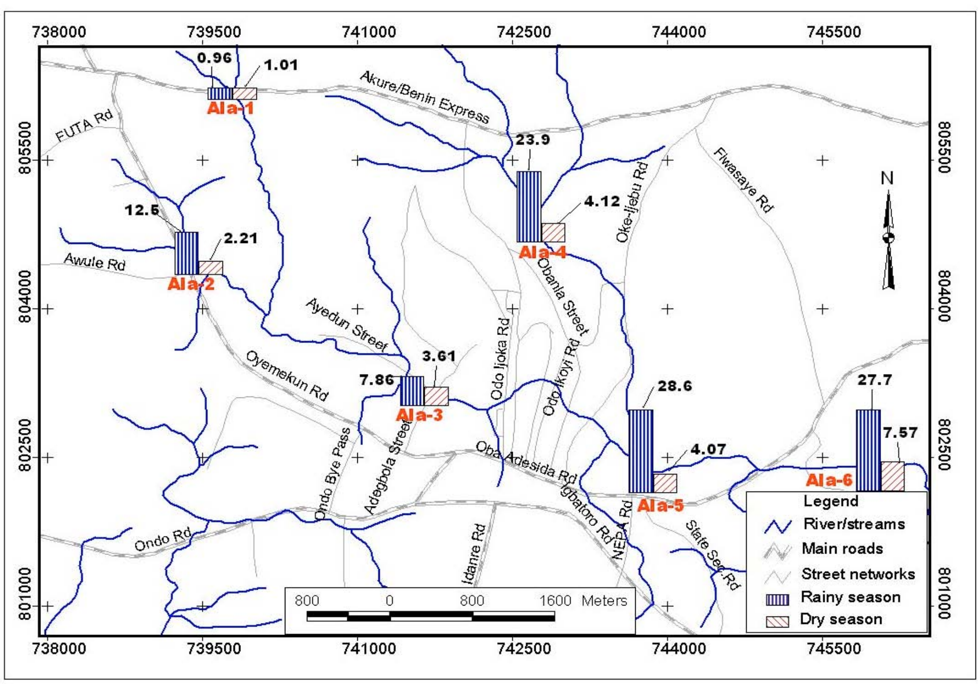

Fig. 10: Nitrate seasonal concentration

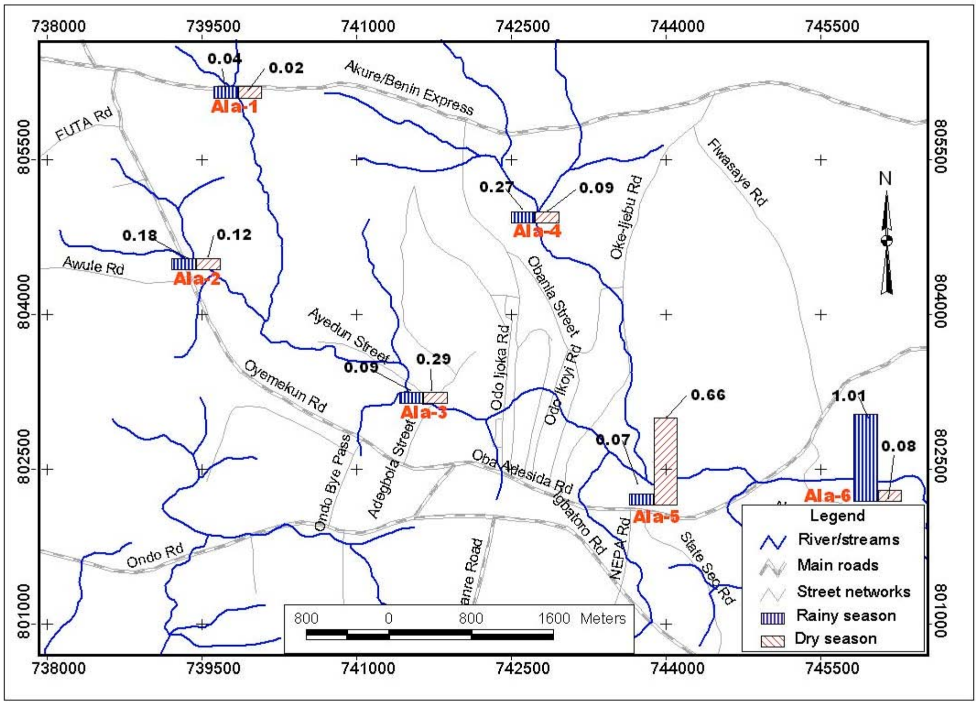

Fig. 11: Zinc seasonal concentration

at point Ala-1 and 5, respectively (Table 1, Fig. 11). The overall mean value of both season falls below WHO (2006) regulatory standard. The value Coefficient of Variation (CV) analysis shows that the concentrations of Zn along River Ala in Akure urban centre are highly heterogeneous in both seasons. Zinc is commonly found in natural water which is mainly result from deterioration of galvanized iron and leaching of brass (WHO, 2006; Ojosipe, 2007).

The concentration of Iron (Fe) in the sampled water ranges between 1.8 and 3.99 mg L^{-1} as the lowest and highest at point Ala-1 and 5, respectively during rainy season. On the hand, during the dry season, the concentration ranges between 1.3 and 2.1 mg L^{-1} as the lowest and highest at point Ala-1, 2 and 5, respectively (Table 1, Fig. 12). The overall mean value of both season were above the WHO (2006) regulatory standard. The value Coefficient of Variation (CV) analysis shows that the concentrations of Fe along River Ala upstream are slightly homogeneous in both seasons. The source of Fe in water may be from dissolved rock and soil and anthropogenic sources of iron such as leached corrosive iron material in the urban environment and rural settlement (WHO, 2006; Jaji *et al*., 2007).

The variation in the concentration of DO, BOD, TDS, Ca^{2+}, Mg^{2+} and Cl^- could resulted from debris particles and organic acids of decaying plant along the river course (Martins, 1987; WHO, 2006; Jaji *et al.*, 2007). Although, the downstream reduction in values of some points can be attributed to self-purification of the river as it flows downstream (Ifabiyi, 1997, 2000; WHO, 2006; Ojosipe, 2007). Apart, from the extent of some pollutants such as household waste, heavy metals and waste oil from automobile mechanics which are discharge into the river may also contribute to the variation of parameters concentration. Also, the low values of NO_3, Zn and Fe in both seasons at point Ala-1 may be attributed to pollution free activities in the area.

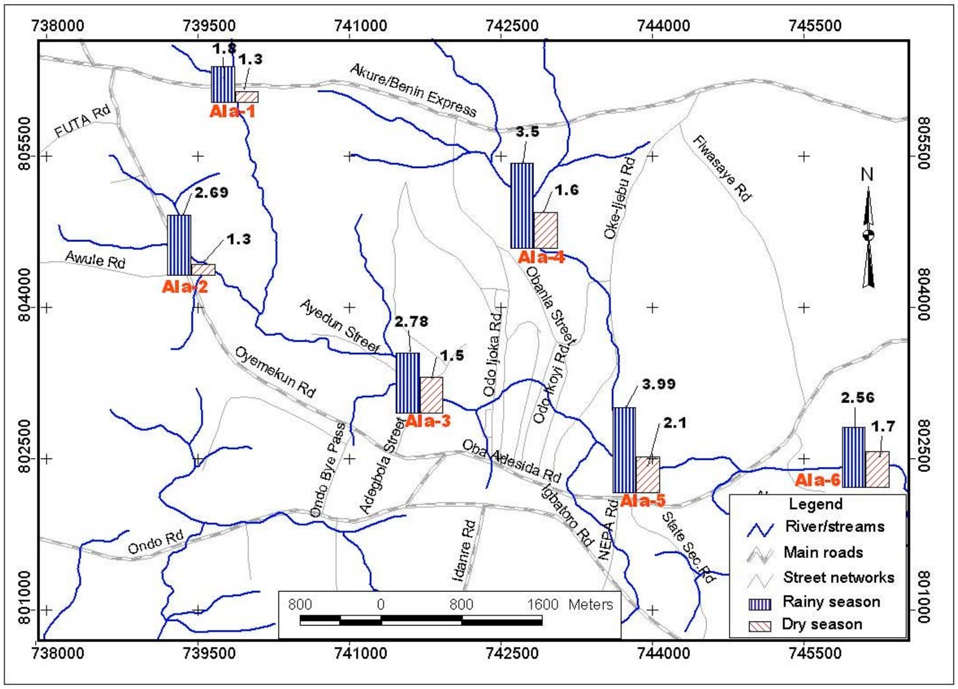

Fig. 12: Iron seasonal concentration

The result of the degree of relationship between the water parameters downstream shows that strong inverse relationship between ph and DO at 95% confidence level during the rainy season while TDS also have strong inverse relationship with Ca^{+}, Mg and Cl^{-} at 99% confidence level. It was also discovered that, during the same rainy season Ca^{+} has strong direct relationship with Mg and Cl^{-} and NO_3 and Fe at 95 and 99% confidence levels, respectively. On the other hand, the result of the degree of relationship between the water parameters downstream during the dry season shows that strong inverse correlation between BOD and Mg and Cl^{-} at 95% confidence level. The analysis also reveals that during the same dry season strong direct relationship exist between Cl and NO_3 and NO_3 and Fe, respectively at 95% while the relationships between BOD and Mg and Zn and Fe, were respectively strong at 99%.

CONCLUSION

Based on the analysis of water parameters using the various analytical techniques, it can be concluded that, River Ala upstream water quality has degraded beyond reasonable doubt. This may have resulted from domestic and possibly industrial wastes that are disposed directly to the river at various locations without treatment due to poor implementation of environmental regulations. However, there is the need for routine checks to ascertain the suitability or otherwise of these water sources so as to forestall outbreak of water borne diseases in downstream environment of the river. This could be achieved through proper monitoring and effective public enlightenment and environmental awareness campaign programmes such as Environmental education, Seminars and Workshop among others. The treatment of runoff including urban waste water being generated from all land use along the river channels should be enforced by law enforcement agency. The relevant water agency/ stakeholders should be implored to treat water from the river to conform to the International Standards and improve the context of the supply of adequate drinkable water to the people in the downstream. Also, the residents along River Ala in the upstream environment should embrace the culture of using waste incinerator and disposing management instead of discharging their waste to River Ala.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Department of Geography, University of Lagos, Nigeria for the use of their Remote Sensing and GIS laboratory.

REFERENCES

Aderibigbe, S.A., A.O. Awoyemi and G.K. Osagbemi, 2008. Availability, adequacy and quality of water supply in ilorin metropolis, Nigeria. Eur. J. Scientific Res., 23: 528-536.

Ahonkhai, S.I. and E.I. Chukwuogo, 1996. Effects of industrial activities in warri area on the surface water quality. Environ. Monitor. Assess., 16: 259-264.

Akinwumi, F.O., 2000. Aquatic Lives and the Environmental Changes. In: Contemporary Issue in Environmental Studies, Jimoh, H.I. and I.P. Ifabiyi (Eds.). Haytee Press and Publishing, Ilorin.

Awake, 2001. Water, will there be enough?. Watch Tower Bible and Tract Society, Pennsylvania, June 22, pp: 4-13.

Ayeni, A.O., I. Balogun and O. Adeaga, 2006. Impact of selected land-use types on surface water quality downstream of Asa dam in Kwara State, Nigeria. Proceedings of International Conference on Infrastructure Development and the Environment (ICIDEN, 2006), Sept. 10-15, Abuja, Nigeria.

Ayoade, J.O., 1988. Tropical Hydrology and Water Resources. Macmillian Publishing Company, London.

Barbour, K., J.S. Oguntoyinbo, J.O.C. Onyemelukwe and J.C. Nwafor, 1982. Nigeria in Maps. Nigerian Publishers, Ibadan.

Faniran, A., 1991. Water Resources Development in Nigeria. University of Ibadan, Ibadan, pp: 95.

Federal Office of Statistics, 1992. Federal Republic of Nigeria Official Gazette. Federal Government Printer, Lagos, Nigeria.

Federal Bureau of Statistics, 2007. Federal Republic of Nigeria Official Gazette. Vol. 94, Federal Government Printer, Lagos, Nigeria.

Gleitsmann, B.A., M.M. Kroma and T. Steenhuis, 2007. Analysis of a rural water supply project in three communities in Mali: Participation and sustainability. Nat. Resour. Forum, 31: 142-150.

Ifabiyi, I.P., 1997. Variation in water gravity with rainfall incidences: A case study of Ogbe Stream Ile-Ife. Res. Publ. Geography, 6: 139-144.4

Ifabiyi, I.P., 2000. Water Resources Utilization: Implication on Environmental Setting. In: Contemporary Issues in Environmental Studies, Jimoh, H.I. and I.P. Ifabiyi (Eds.). Haytee Press and Publishing Co. Ltd., Ilorin, Nigeria.

Iloeje, N.P., 1977. A New Geography of Nigeria. Longman Nigeria Ltd., Ibadan, pp: 260.

Jaji, M., O.O. Bamgbose, O.O. Odukoya and T.A. Arowolo, 2007. Water quality assessment of Ogun river, South West Nigeria. Environ. Monit. Assess., 133: 473-482.

Katte, V.Y., M.F. Fonteh and G.N. Guemuh, 2003. Domestic water quality in urban centres in cameroon: A case study of dschang in the West Province. Afr. Water J., 25: 45-56.

Martins, O., 1987. The Ogun River: Geochemical characteristics of a small drainage basin. Hydrol. Process., 64: 475-482.

Ojosipe, B.A., 2007. Water and waste water analysis. Proceedings of the Mandatory Training Workshop on Water. June, 2007 Institute of Public Analysist of Nigeria (IPAN).

Olorunfemi, J.F. and H.I. Jimoh, 2000. Anthropogenic Activities and the Environment. In: Contemporary Issues in Environmental Studies, Jimoh, H.I. and I.P. Ifabiyi (Eds.). Haytee Press, Ilorin.

Spiegel, M.R. and L.J. Stephens, 1999. Theory and Problems of Statistics. 3rd Edn., McGraw-Hill, New York, pp: 285-351.

Sullivan, C.A., J.R. Meigh, A.M. Giacomello, T. Fediw and P. Lawrence *et al.*, 2003. The water poverty index: Development and application at the community scale. Nat. Resour. Forum, 27: 189-199.

Uluocha, N.O. and G. Ekop, 2002. Nigeria: Geography. In: History and Cultures of Nigeria up to AD 2000, Osuntokun, A., D. Aworawo and F. Masajuwa (Eds.). Frankad Publishers, Lagos, Nigeria.

UNESCO-WWAP, 2003. Water for people, water for life WHO/UNICEF (2002). The United NationWorld Water Development Report (UNESCOWWAP).

USGS, 2005. The strategy for improving water quality monitoring in the United States. Final Report of the Intergovernmental Task Force on Monitering Water Quality. http://acwi.gov/lopez.main.html.

Watson, S.B. and J. Lawrence, 2003. Drinking water quality and sustainability. Water Qual. Res. J. Canada, 38: 3-13.

WHO, 1993. Guidelines for Drinking-Water Quality. 2nd Edn., Vol. 1, World Health Organization, Geneva.

WHO, 2006. Guidelines for Drinking-Water Quality. 3rd Edn., World Health Organization, Geneva.