PHYSICO-CHEMICAL CONCENTRATION OF URBAN RIVER: A SEASONAL ASSESSMENT OF RIVER ALA IN AKURE, ONDO STATE, NIGERIA

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ABSTRACT

This study 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 in River Ala upstream 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. Coefficient of variation and Correlation coefficient were respectively used to test for homogeneity and significant relationship of paired parameters. Water samples were collected for a period of 12 months, and 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. It was observed that variation exists in the quality of the sampled waters and impaired to different degrees using WHO standards for the selected parameters.It was recommended among others that 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.

Keywords: *Physico-chemical, Seasonal assessment, surface water quality and urban centre*

INTRODUCTION

Water is a vital resource to man. Its quantity and quality as well as its management contributes to its sustainability. Its usage constitutes a major criterion towards sustainable growth and development of a region and its economy. Water is one of the most important necessities of life required by man, animal and plant. Man uses water for domestic, industrial and agricultural purposes. As noted by Willey (1987), 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. 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. Also, of importance is the assessment of the human activities that are capable of changing the quality of river water within an urban area. This is necessary, since per capita water demand is increasing while accessibility to available freshwater availability is on the decrease. These have lead to usage of polluted and contaminated water source. Globally, about 80 percent of all diseases and deaths in developing countries are water-related as a result of polluted water (Awake, 2001).

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 the nearest future if surface water pollution monitoring programme is not effectively addressed. Thus, the paper 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.

Akure is the capital city of Ondo State and it is located in the central senatorial district of the state. Akure falls within longitude. 5006'E to 5038'E and latitude 7007' N to 7037' N. Akure is bounded in the north by both Akure north and Ifedore local government, in the west by Ile-Oluji/Oke-Igbo local government, east by Owo local government, in the South by Idanre local government. 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 ranges from 22^0C during harmattan (December-February) to 32^0C in March the peak temperature. The vegetation is tropical rainforest (Barbour et al, 1982; Iloeje, 1978 and Uluocha and Ekop, 2002). The population of the people residing in Akure is about 353,211 (Federal Bureau of Statistics, 2007).

River Ala and tributaries is one of the main tributaries of River Ogbese, Southwestern, Nigeria. River Ala with total length of about 57km has a length of about 14.8km 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.

MATERIALS AND METHODS

The measurements include simple *(in situ)* and basic to more complex parameters (Laboratory): The pH, temperature and Dissolved Oxygen (DO) is measured with a portable in-situ pH meter, a mercury thermometer and M90 Mettler Toledo AG DO meter, respectively (USGS, 2006). The water samples for laboratory analysis were collected using cleaned 1000 cm^3 polythene bottles. The bottles were first rinsed with the water being sampled and then filled with sampled water. Biochemical Oxygen Demand (BOD), TSS, Total Dissolved Solid (TDS), Turbidity, Total Hardness (TH), Calcium ion (Ca^+), Magnesium ion (Ma^{2+}), Chlorine ion (Cl^-), Nitrate ($NO3^-$), $PO4^{3-}$ and Oil & grease in water were analyzed in the laboratory using standard methods for water samples examination (American Public Health Association, 1998).

The concentrations of the heavy metals [Iron (Fe) and Zinc (Zn)], in water samples are determined in accordance with WHO guidelines for drinking water quality (Ayoade, 1988; WHO 1993 and 2006, USGS 2005 and 2006). The sampling points were geo-referenced using a German 76 Global Position System (GPS) portable global positioning system. This was later overlaid on digitized satellite imagery map. The satellite imagery was processed, digitized and edited in the Arcview 3.3 environment. 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.

The water samples were collected along River Ala during the rainy and dry seasons. Water samples were collected three times at 10days interval for a period of one year between November, 2007 and October, 2008. These amounted to eighteen samples in each season making a total of thirty-six for one year. The mean and standard deviation (SD) of each parameter in all sampling points were calculated for each season samples and used for the analysis (Table 1).

New plastic 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 - 30cm 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. Dissolved oxygen (DO) and pH were determined in situ.

Using standard methods for water samples examination of American Public Health Association, (1998), Total Dissolved Solid (TDS), Biochemical Oxygen Demand (BOD), Total Hardness (TH), Calcium (Ca+), Magnesium (Mg2), Chlorine (Cl-), Calcium (Ca+), Nitrate (NO3-), Zinc (Zn), and Iron (Fe) in water samples were kept in Cool box for preservation and conveyed to laboratory for appropriate analysis. The analysis was done at the postgraduate analytical laboratory, Department of Chemistry, University of Lagos, Lagos. Degree of association between the studied parameters was determined using correlation coefficient while coefficient of variation was used to compare the spatial variability of the parameters along River Ala (Spiegel & Stephens, 1999).The observed results of the laboratory analysis were then presented, described and compared with the international standards for drinking water (WHO 2006).

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 "Ala-4", respectively. 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 (Table 1 and Fig. 3.1). 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 and Jaji et al, 2007).

DO mean values for each sampling points was lowest in "Ala-6" and highest "Ala-5" with values of 5.52mg/l and 7.53mg/l, respectively during the rainy season. During the dry season the lowest and highest values of 3.2mg/l and 6.03mg/l were observed at "Ala-5" and "Ala-5", respectively. The concentration of DO were homogeneous for the two seasons as revealed by its coefficient of variation (CV) analysis (Table 1 and Fig. 3.2). The variation in DO values in sampled water was as a result of pollutant activities at the various sampling points due to the various land uses.

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 organic matter in sampled water under specific set of condition (Akinwumi, 2000). BOD mean values for each sampling points was lowest in "Ala-3" and highest "Ala-4" & "Ala-5" with values of 6.2mg/l and 35mg/l, respectively during the rainy season while 11.4mg/l were observed at "Ala-1" as highest values during the dry season. The overall mean values of BOD of 22.6mg/l and 9.1mg/l for rainy and dry season was 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 (Table 1 and Fig. 3.3). The high value of "Ala-1", "Ala-2", and "Ala-3" to "Ala-6" in rainy season can 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 "Ala-4".

TDS mean values for each sampling points was lowest in "Ala-6" and highest "Ala-4" with values of 176mg/l and 432mg/l, respectively during the rainy season while 125mg/l and 243mg/l were observed at "Ala-1" and "Ala-3" as the lowest and highest values, respectively during the dry season. The overall mean values of TDS during rainy and dry season were 339.4mg/l and 201.1mg/l, respectively and fall below WHO (2006). The value of coefficient of variation (CV) analysis shows that the concentration of TDS along River Ala in Akure urban centre is homogeneous for the two seasons but weak in the dry season (Table 1 and Fig. 3.4). The high value of "Ala-1", "Ala-2" and "Ala-3" to "Ala-6" in rainy season can 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 "Ala-3". Since the concentration of TDS in all seasons are generally lower than WHO standard, turbidity content in the river will be relatively low which can lead to reduction in light penetration and therefore, limits photosynthesis. Such limitation might restrict plant growth and respiration in aquatic life, which will later have negative effects on man since low TDS might result in gastro-intestinal irritation (Akinwumi, 2000).

The result of Ca^{2+} shows that during the rainy season the concentration increases downstream from point "Ala-1" of 6.45mg/l to "Ala-6" of 33.6mg/l while the concentration increases from 24.1mg/l in "Ala-1" to 41.2mg/l in "Ala-3" and decreases downstream from 41.2mg/l in "Ala-3" to 23.4mg/l in "Ala-6". 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 (Table 1 and Fig. 3.5). The chemistry of this can also 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. Principally, soluble salts of Calcium will cause impair health precisely tooth disease, kidney and bladder disease.

As shown in Table 1 the Mg^{2+} mean values for each sampling points was lowest in "Ala-1" and highest "Ala-4" with values of 9.87mg/l and 53.0mg/l, respectively during the rainy season while 8.0mg/l and 46.0mg/l were observed at "Ala-3" and "Ala-1" as the lowest and highest values, respectively during the dry season. The overall mean values of Mg^{2+} during rainy and dry season were 44.2mg/l and 23.0mg/l, 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 (Table 1 and Fig. 3.6). The chemistry of this can also be attributed to the geological composition of the River bed-rock. The implication of this is that if the water is drank without treatment it might impair human health and lead to heart and kidney diseases.

The result of samples shows that, the Cl^- is generally low compared to the WHO, (2006) regulatory standard in both seasons. During the rainy season the lowest was recorded at sampled point "Ala-1" with 7.1mg/l while the lowest and highest recorded during the dry season are at sampled point "Ala-1" and "Ala-6" with 8.0mg/l and 20.8mg/l, respectively. The coefficient of variation (CV) analysis shows that the concentrations of Cl- along River Ala upstream are moderately homogeneous in both seasons (Table 1 and Fig. 3.7). The low content of Cl^- may arise as a result of various soluble salts and animal manure, which is a potential source of suphate. The implication of this in drinking water will lead to heart and kidney diseases and cause impair health.

The sampled water in points "Ala-1" and "Ala-5" has the highest values of $N0_3$. Point "Ala-1" recorded the lowest and highest values of 0.96mg/l and 28.6mg/l, respectively during the rainy season while the concentration of $N0_3$ increases from 1.01mg/l in "Ala-1" and 7.5mg/l in "Ala-6", respectively during the dry season. 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 "Ala-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 $N0_3$ along River Ala are moderately heterogeneous in both seasons (Table 1 and Fig. 3.8).

The high values in "Ala-4" to "Ala-6" during the rainy serason can be attributed to the contents of fertilizer load and natural watershed for agricultural activities since the region is generally agricultural land use area while the generally low of $N0_3$ in point "Ala-1" in both season can be attributed to the fact that the area is free from all sort of domestic/industrial and agricultural pollutional activities. The increasing output of nitrate (that is to say, dissolved nitrogenous compounds) in natural water is a serious problem, higher nitrogen increases the rate of eutrophication in water bodies and conflicts with health standards with occurrence of methemoglobinemia (an infant illness) and retard growth (Ifabiyi 1997; 2000).

The concentration of Zn in the sampled water ranges between 0.04mg/l and 1.01mg/l as the lowest and highest at point "Ala-1" and "Ala-6", respectively during rainy season. On the other hand, during the dry season, the concentration ranges between 0.02mg/l and 0.66mg/l as the lowest and highest at point "Ala-1" and "Ala-5", respectively. The overall mean value of both season falls below WHO (2006) regulatory standard. The value of coefficient of variation (CV) analysis shows that the concentrations of Zn along River Ala in Akure urban centre are highly heterogeneous in both seasons (Table 1 and Fig. 3.9). Zinc is commonly found in natural water which mainly result from deterioration of galvanized iron and leaching of brass (WHO 2006; Ojosipe, 2007).

The concentration of Fe in the sampled water ranges between 1.8mg/l and 3.99mg/l as the lowest and highest at point "Ala-1" and "Ala-5", respectively during rainy season. On the other hand, during the dry season, the concentration ranges between 1.3mg/l and 2.1mg/l as the lowest and highest at point "Ala-1" & "Ala-2" and, "Ala-5", respectively. The overall mean value of both season were above the WHO (2006) regulatory standard. The value of coefficient of variation (CV) analysis shows that the concentrations of Fe along River Ala upstream are slightly homogeneous in both seasons (Table 1 and Fig. 3.10). 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 and Jaji et al, 2007).

The variation in the concentration of DO, BOD, TDS, Ca^{2+}, Mg^{2+} and Cl^- could result from debris particles and organic acids of decaying plant along the river course. Although, the downstream reduction in values of some points can be attributed to self-purification of the river as it flows downstream. Apart, from the extent of some pollutants such as synthetic detergent chemicals, heavy metals, oil and salt, which are discharged into the river by Global soap and detergent industry in Ilorin metropolis also contributed to the variation of parameters concentration downstream. Also, the low values of NO_3, Zn and Fe in both seasons at point "Ala-1" can be attributed to pollution free activities in the area.

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^{2+}, Mg and Cl^- at 99% confidence level. It was also discovered that, during the same rainy season Ca^{2+} has strong direct relationship with Mg^{2+} and Cl^- and, $N0_3$ 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 & Mg^{2+} and, Cl^- at 95% confidence level. The analysis also reveals that during the same dry season strong direct relationship exist between Cl^- and $N0_3$ and, $N0_3$ and Fe, respectively at 95% while the relationships between BOD and Mg^{2+} 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 appropriate 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.

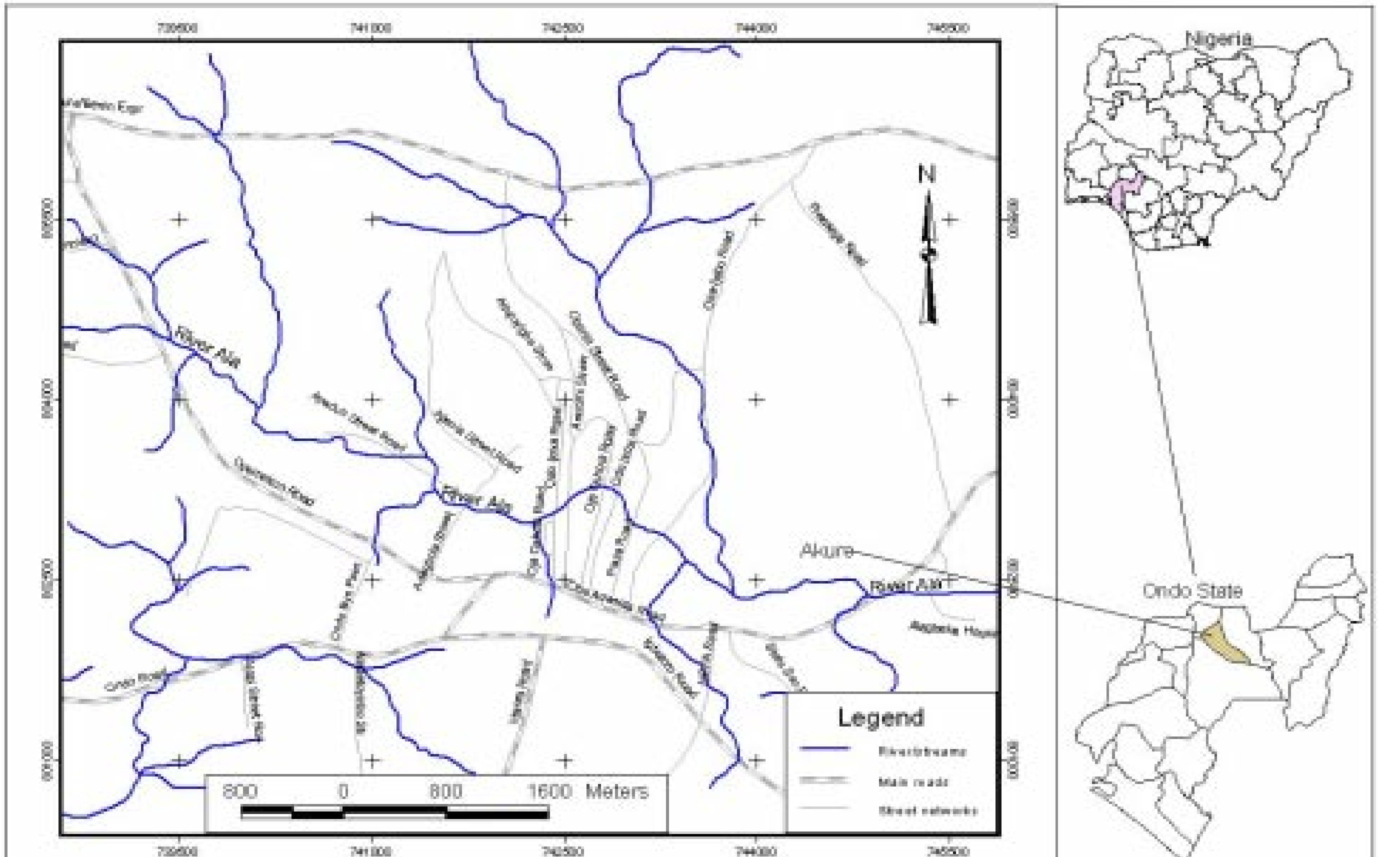

Fig. 1: Study area

Table 1: Physico-chemical result of water samples

	pH		DO (Mg/l)		BOD (Mg/l)		TDS (Mg/l)		Ca^{2+} (Mg/l)	
SP	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Ala-1	6.8±0.3	7..1± .3	6.4± 1.0	4.44±1.4	21±1.9	11.4±2.0	192±61.1	125.5±69.2	6.45±0.9	24.1±1.0
Ala-2	7.2±0.4	7.8±0.8	5.93±2.2	3.21±1.3	15±1.5	9.9±1.0	256±49.8	174.7±21.2	20.6±1.2	33.0±1.1
Ala-3	7.1±0.3	6.8±0.7	5.77±0.2	4.23±1.4	6.0±0.4	6.2±1.3	357±140.2	243.6±17.8	25.8±2.0	34.1±0.9
Ala-4	7.9±1.6	7.9± 0.6	6.13±1.9	4.71±0.8	35±2.1	13.7±0.7	432±88.7	179±21.4	28.4±2.1	41.2±2.2
Ala-5	6.1±0.3	6.6±1.0	7.53±2.1	6.03±0.2	33±0.5	10.9±0.6	230±14.2	150.4±11.5	29.7±0.9	28.0±1.5
Ala-6	8.1±0.4	7.4±1.1	5.52±0.6	5.01±1.6	35±1.8	6.5±0.3	176±36.5	140.4±20.8	31.0±1.1	24.0±2.7
Mean	7.2	7.3	6.2	4.6	24.2	9.8	273.8	168.9	23.7	30.7
SD	0.7	0.6	0.7	0.9	12.1	2.9	100.4	41.8	9.2	6.7
CV	10.2	8.0	11.5	20.2	50.2	30.0	36.7	24.8	38.9	21.7
*	6.5 – 8.5		-		10		500		250	

Table 1 (Continued)

	Mg (Mg/l)		*Cl (Mg/l)*		*NO3 (Mg/l)*		*Zn (Mg/l)*		*Fe (Mg/l)*	
SP	*Rainy*	*Dry*	*Rainy*	*Dry*	*Rainy*	*Dry*	*Rainy*	*Dry*	*Rainy*	*Dry*
Ala-1	*9.87±8.1*	*46.0±2.1*	*7.1.0±2.2*	*8.0±3.4*	*0.96±0.5*	*1.01±0.2*	*0.04±0.01*	*0.02±0.02*	*1.8±1.1*	*1.3±0.7*
Ala-2	*38.4±296.1*	*31.0±1.9*	*24.85±12.2*	*12.0±2.1*	*12.5±4.5*	*2.21±0.4*	*0.18±0.03*	*0.12±0.03*	*2.69±0.8*	*1.3±1.4*
Ala-3	*49.5±0.9*	*8.0±3.0*	*35.5±6.7*	*16.0±1.5*	*7.86±0.5*	*3.61±1.1*	*0.09±0.08*	*0.29±0.02*	*2.78±1.4*	*1.5±1.9*
Ala-4	*53.0±2.8*	*40.0±6.7*	*39.05±14.1*	*12.0±12.6*	*23.9±3.4*	*4.12±0.2*	*0.27±0.02*	*0.09±0.02*	*3.5±1.3*	*1.6±1.0*
Ala-5	*51.8±11.2*	*20.0±4.5*	*39.05±10.4*	*12.2±1.7*	*28.6±0.9*	*4.07±0.8*	*0.07±0.01*	*0.66±0.09*	*3.99±1.1*	*2.1±1.2*
Ala-6	*52.6±5.2*	*8.8±3.3*	*39.05±18.7*	*20.8±3.5*	*27.7±1.0*	*7.57±0.7*	*1.01±0.10*	*0.08±0.02*	*2.56±0.9*	*1.7±0.9*
Mean	*42.5*	*25.6*	*35.5*	*13.5*	*16.9*	*3.8*	*0.3*	*0.2*	*2.9*	*1.6*
SD	*16.9*	*16.0*	*6.1*	*4.4*	*11.5*	*2.2*	*0.4*	*0.2*	*0.8*	*0.3*
CV	*39.8*	*62.3*	*17.3*	*32.5*	*67.8*	*59.1*	*133.4*	*113.6*	*26.5*	*18.9*
*	*150*		*250*		*10*		*5*		*0.3*	

Note: SD: Standard deviation, CV: Coefficient of variation, * WHO Standard, SP: Sampling Point

Source: Author field survey, 2006/2007

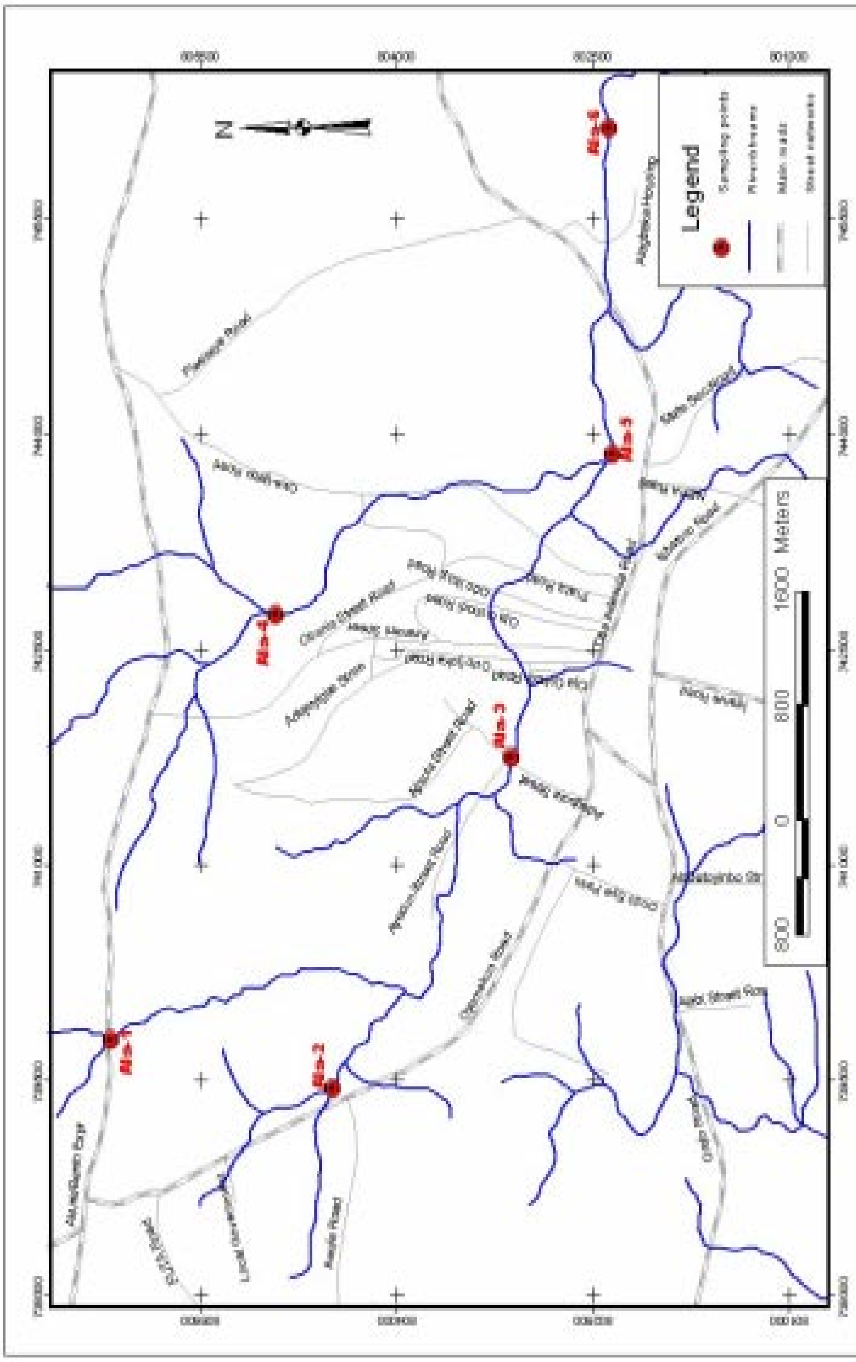

Fig. 2: Sampling points

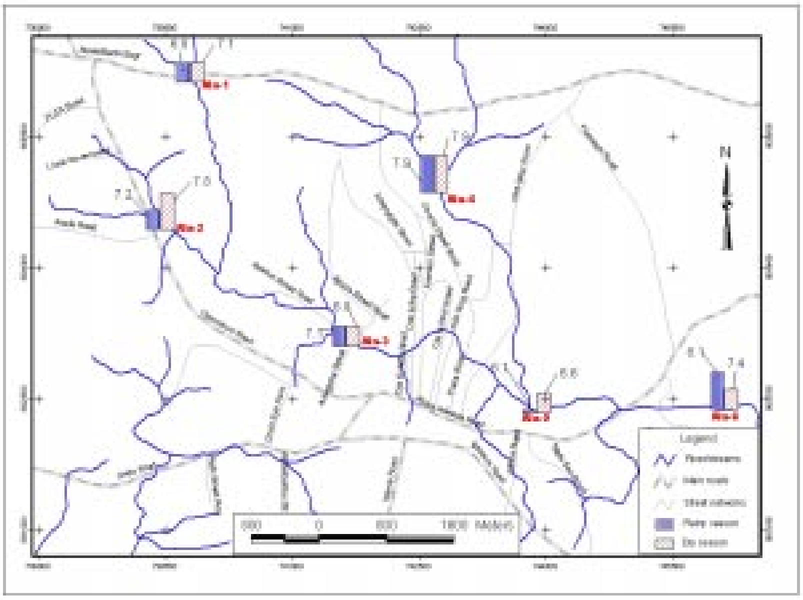

Fig. 3.1: pH Seasonal concentration

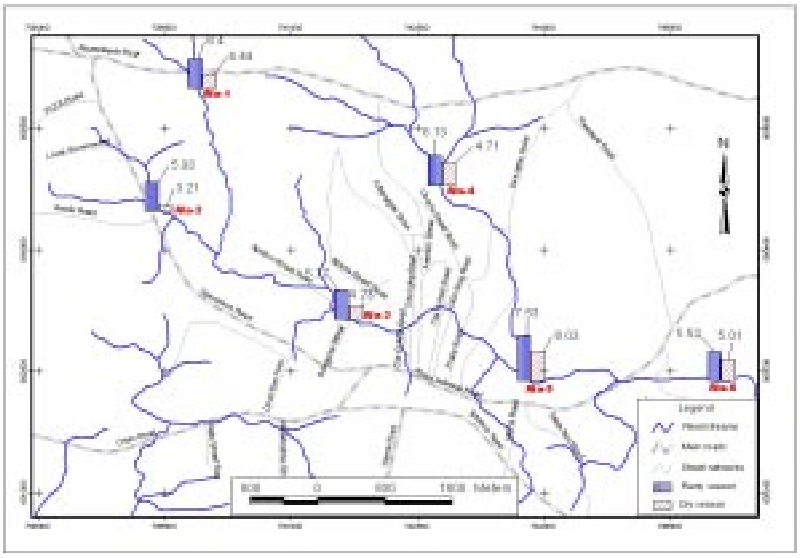

Fig. 3.2: DO Seasonal concentration

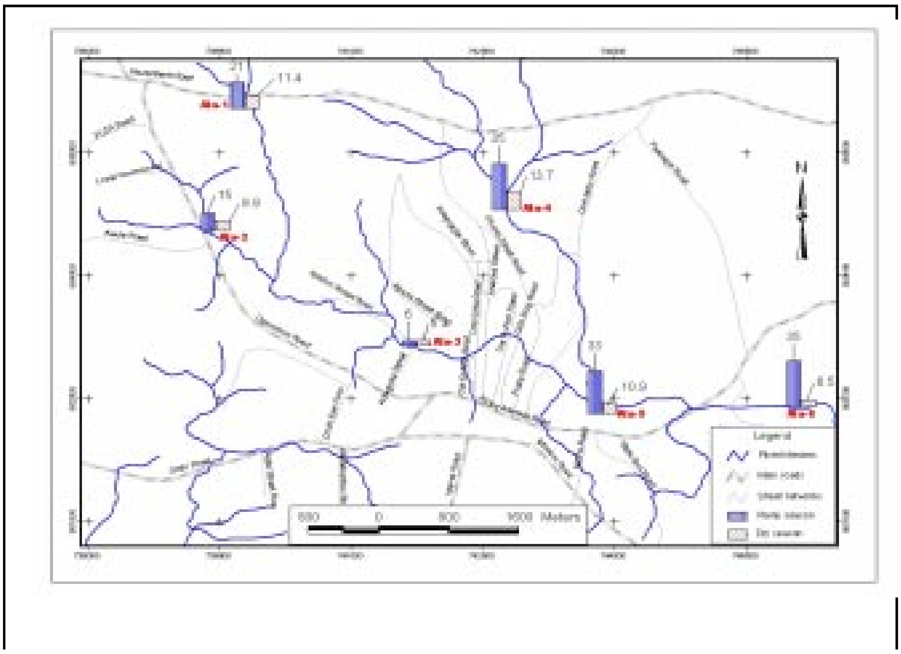

Fig. 3.3: BOD Seasonal concentration

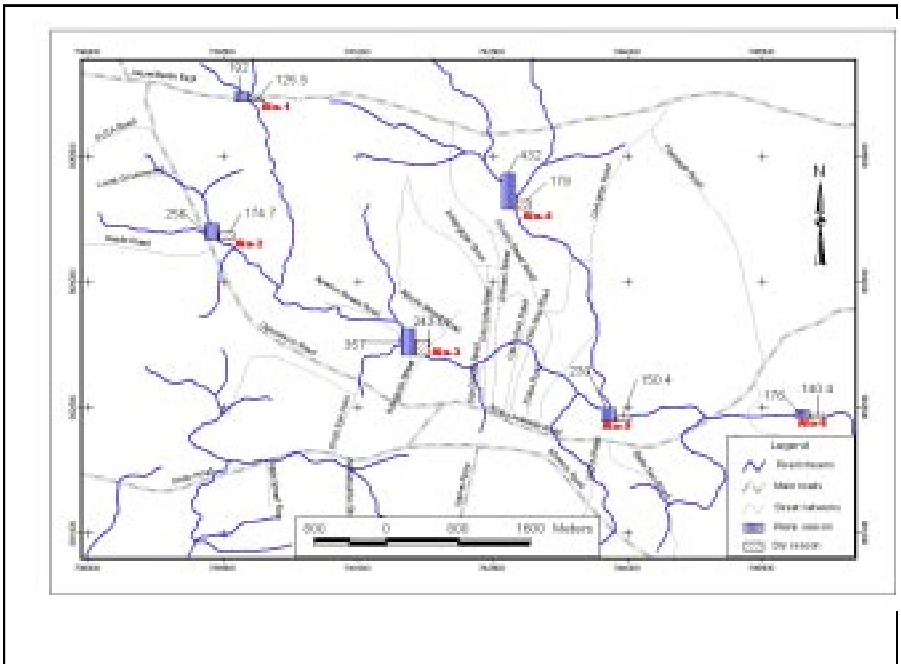

Fig. 3.4: TDS Seasonal concentration

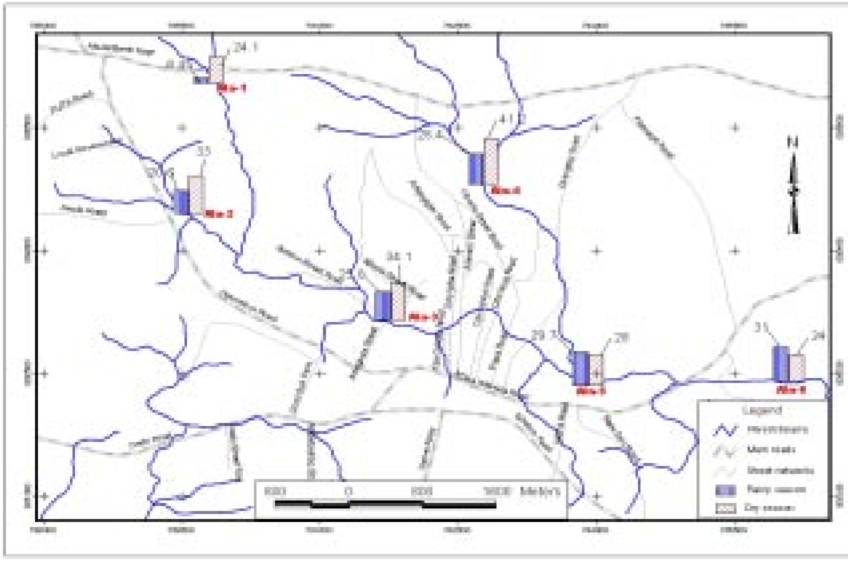

Fig. 3.5: Ca2+ Seasonal concentration

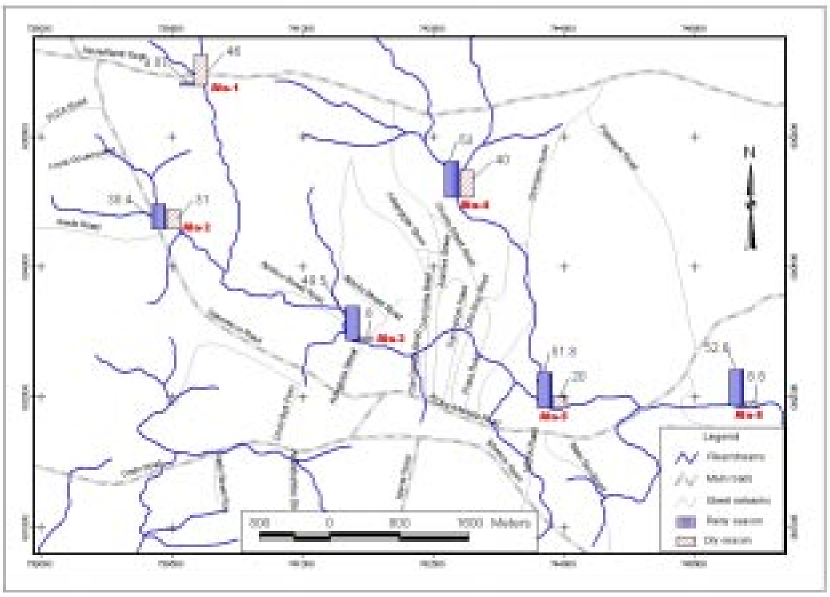

Fig. 3.6: Mg2+ Seasonal concentration

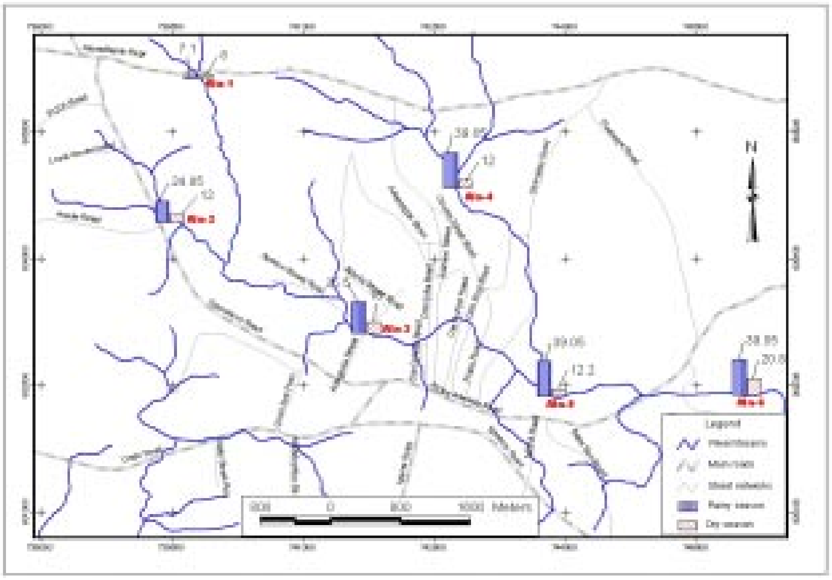

Fig. 3.7: Cl- Seasonal concentration

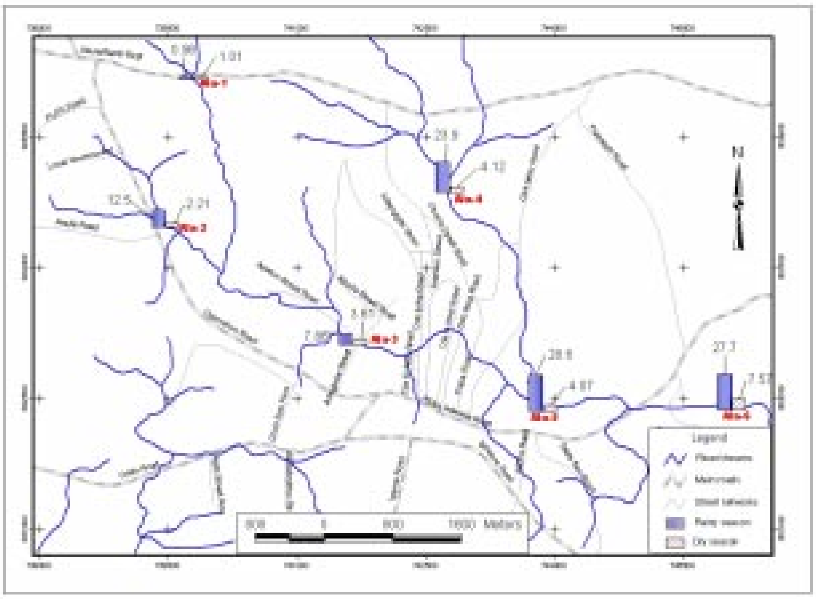

Fig. 3.8: N03 Seasonal concentration

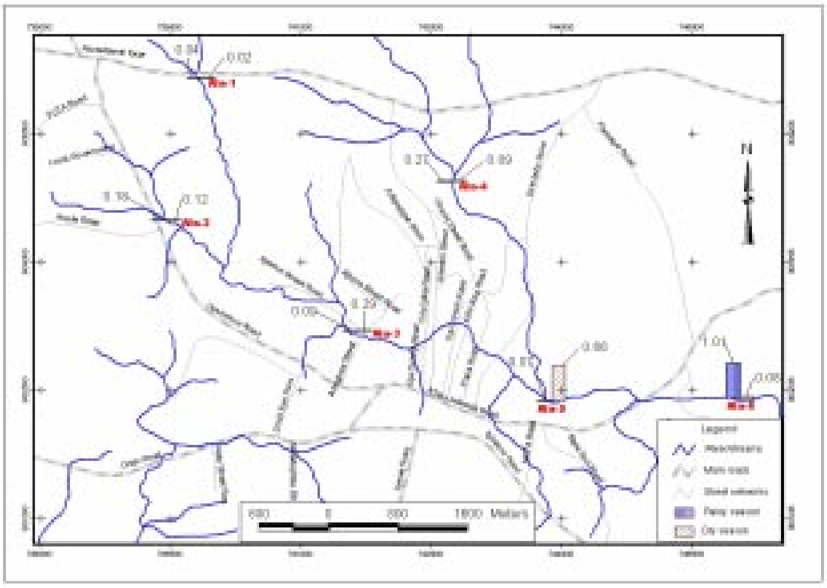

Fig. 3.9: Zn Seasonal concentration

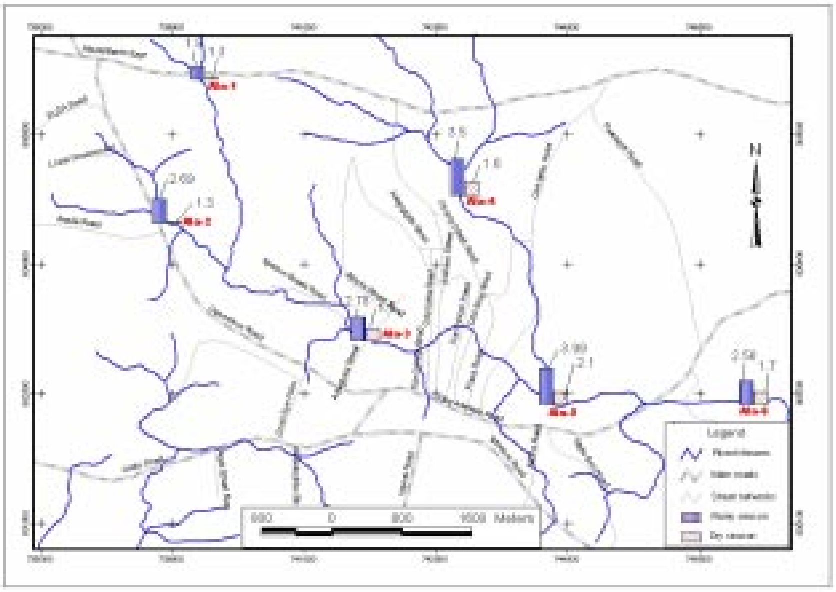

Fig. 3.10: Fe Seasonal concentration

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