ASSESSMENT OF THE ENVIRONMENTAL QUALITY OF ABA RIVER, ABIA STATE, NIGERIA

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ABSTRACT: As rivers still serve as a major source of water supply in Nigerian rural and urban communities; the assessment of their quality has become a growing concern. In this study the physicochemical properties of Aba River, in Abia State, South-East Nigeria were investigated, for a period of six months, at seven sampling points. Descriptive analysis, variation plots, analysis of variance (ANOVA), principal component analysis (PCA), Pearson Correlation (r) and Water Quality Index (WQI) were used to analyse data. Results show that turbidity, oil and grease (O&G), ammonia nitrogen, iron (Fe) and phosphates (PO_4^{-3}) exceeded the national permissible limits for aquatic life. There were significant spatial differences in levels of total suspended solids (TSS), total dissolved solids (TDS), electrical conductivity (EC), and O & G between the control and other locations at p<0.05. Five principal components (PCs) formed the extraction solution with a cumulative variability contribution of about 88.46%. PCs 1, 2, 3, 4 and 5 were highly correlated with Mg^{2+} (0.918), TSS (0.910), O & G (0.727), Nitrate (0.902) and temperature (0.791) respectively. The Water Quality Index revealed that the rating for the water quality across the sampling locations was between bad and average, with sampling point SLC having the least water quality. Proper treatment of industrial and domestic effluents before discharge into the river should be carried out, coupled with regular monitoring to prevent excessive buildings of pollutants in water body.

Key words: Aba River, anthropogenic factors, pollutants, multivariate analysis, water quality)

INTRODUCTION

Rivers and streams are major sources of water supply, especially in developing countries. This is very common in Sub-saharan Africa where there are deficiencies in the quality and quantity of water supply and sanitation. According to National Bureau of Statistics (2009), 27 percent of Nigerians depend absolutely on rivers as major sources of water supply. However, increasing human population, industrialization and intensive agricultural practice, and discharge of waste water into rivers and other surface water bodies have resulted in deterioration of water quality (Nouri *et al.*, 2011).

In Nigeria, increasing number of human activities along river banks in major towns such as Lagos, Ibadan, Kano, Benin and Aba have greatly impacted negatively on river water quality, thus interfering with the functioning of aquatic ecosystems (Adedeji and Adetunji, 2011; Johnson *et al.*, 2008). The consumption of water from these rivers has led to high prevalence of water borne diseases such as cholera, diarrhea, hepatitis, dysentery, etc. among Nigerians (Oguntoke *et al.*, 2009; Raji and Ibrahim, 2011). Information on river water quality is important for implementation of sustainable water use management strategies (Bu *et al.*, 2010). Basically, data on physical and chemical properties of river water from sampling in different locations provide reliable estimation of its quality. It will also help in identifying the possible sources of factors that affect water quality (Taiwo *et al.*, 2012; Chatteerjee, 2011).

MATERIALS AND METHODS

- **Study Area**

In this study, Aba River was chosen for water quality assessment due to its importance in the Sub-region. A tributary of the great Imo River, and the only river that passes through the commercial and industrial city of Aba, Aba River stretches down to Cross Rivers State where it empties into the Atlantic Ocean. The river recharges by precipitation and ground water; its watershed is the main source of water supply for Aba town, with an estimated population of 750,000 (NPC, 2006) within an area of 6320km^2 (Ezeronye and Ubalua, 2005).

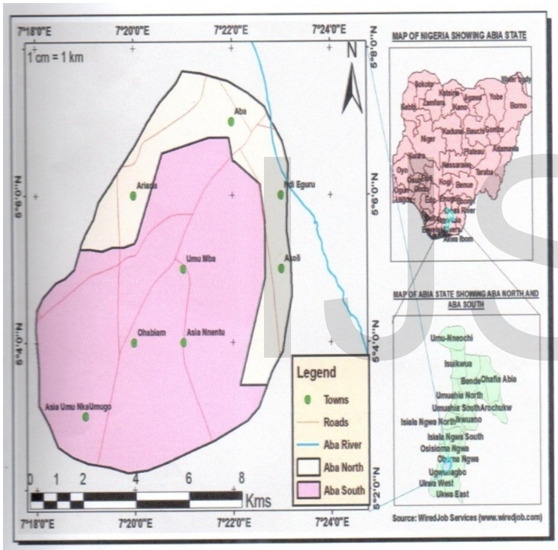

Fig. 1: Map of Nigeria showing Aba in Abia State

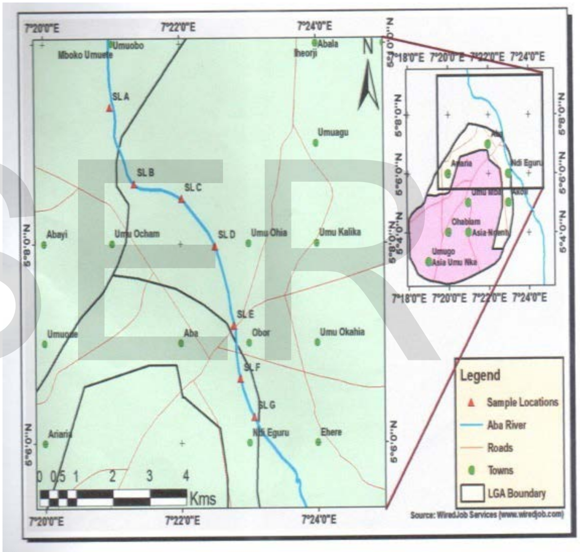

Fig. 2: Map of the study area showing sampling locations along Aba River

The main occupations of inhabitants of Aba include trading and manufacturing with few people engaged in subsistence farming and white collar jobs. Aba is located between Latitude $5^{0}2^{l}$N and $5^{0}8^{l}$ N and Longitude $7^{0}18^{l}$ E and $7^{0}24^{l}$ E (see Fig. 1) and is characterized by relatively low elevation and near flat topography which enhances its runoffs. Rainfall regime is bimodal and peaks between July and September, while the mean annual rainfall is between 2550mm and 2990mm which causes high discharges into the river.

The mean maximum air temperature of the area is 23^{0}C with the hottest months between January and March. Some patches of vegetation appear along the river banks due to intensive farming in the area.

The rapid growth of its population coupled with inadequate housing has led to the upsurge in slum settlements, with poor drainage systems. The banks of the river are currently used for various human activities including fishing, car washing, solid waste disposal, dyeing of clothes, washing of slaughtered animals, etc. A section of the river also receives effluents from two breweries and other cottage industries (tannery, textile, shoes, paper, etc.)

In recent times, the growing number of various activities along the river banks has generated a lot of concern among residents of the town and communities downstream who depend on the river as their major source of water supply. There is need to determine the quality of the river water, at least for the protection of health and safety of the local population.

- **Data Collection**

The study is an experimental research design involving sampling and laboratory analyses. Water samples were systematically collected for a period of six months (between March and September, 2016) covering the two seasons of the year (wet and dry seasons) at seven sampling points (SLA, SLB, SLC, SLD, SLE, SLF and SLG) along the river (see Fig. 2). One sample was collected at a time from each of these locations twice a month; sampling point SLA, located upstream, served as the reference point (control). Water samples were collected and analysed at Yemac Consulting and Analytical Services Limited, Aba using standard methods. Water quality parameters analysed include colour, temperature, electrical conductivity (EC), turbidity, pH, total suspended solids (TSS), total solids (TS), total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), Oil and grease (O&G), total hardness (TH), chloride (Cl^-) nitrate (NO_3^-), ammonia (NH_3), phosphate (PO_4^{3-}). Some trace metals including iron (Fe), magnesium (Mg) manganese (Mn), calcium (Ca) and zinc (Zn) were also determined with the help of Atomic Spectometry by using standard method of AOAC (2000). Also, the fecal coliform count of the river was determined. The Water Quality Index (WQI) for the seven sampling locations was calculated using the Online Calculator template of the United States National Sanitation Foundation Water Quality Index (NSFWQI). All these were analysed for drinking water quality since they may have adverse health effects (Judson *et al.*, 2009).

Descriptive statistics (means, ranges, minimum and maximum, standard error), bivariate and multivariate analyses were carried out with the aid of statistical packages of SPSS v.22.0 and MS Excel 2010. The minimum, maximum and mean values obtained from water quality parameters were used to compare with those of established regulatory standards of the National Environmental Standards and Regulations Enforcement Agency of Nigeria (NESREA, 2011) and those of the World Health Organisation (WHO, 2010). The Pearson correlation coefficient (r) was used to determine possible relationships between physical and chemical attributes of the river, while factor analysis and principal component analysis (PCA) were performed to discover the structure in the relationship between water quality parameters which affect the chemistry of the river and to investigate the possible sources of different pollutants (Zare Garizi *et al.*, 2011).

RESULTS AND DISCUSSION

- **Results**

Of all the parameters analysed EC (1364.00µ/cm), TS (2566.00mg/L); TDS (823.00mg/L), TSS (2850.00mg/L, O & G (1200.00mg/L) and chloride ions (129.00mg/L) recorded comparatively wide ranges with mean values exceeding regulatory standards in both seasons. Similar observations were recorded on NH_3, (19.88mg/L), PO_4^{3-} (5.27mg/L), Ca(3.5mg/L) and Mn (0.3mg/L). Also, the mean values of O & G, NO_3^-, Fe and colour exceeded permissible limits of NESREA (2011) for aquatic life. Other parameters recorded lower ranges and presented mean values lower than established standards (Table 1).

Table 1: Descriptive statistics of the Quality of Aba River

Parameters	Min	Max	Range	Mean	SE	NESREA (2011)	WHO (2010)
pH	5.39	7.06	1.67	6.09	0.51	6.5-8.5	6.5-9.5
Temperature (^{o}C)	26.00	29.00	3.00	27.65	0.14	-	10-15
Colour (TCU)	10.00	20.00	10.00	10.00	0.65	10	-
TH (mg/L)	3.48	195.00	191.52	191.52	9.45	-	300
EC (µS/cm)	5.00	1369.00	1364.00	1364.00	66.28	-	300
TS (mg/L)	65.00	2631.00	2566.00	2566.00	85.60	-	500
TDS (mg/L)	3.00	826.00	823.00	823.00	39.44	500	<1000
TSS (mg/L)	6.00	2856.00	2850.00	2850.00	77.65	-	500
O & G (mg/L)	0.00	1200.00	1200.00	1200.00	43.27	0.01	-
DO (mg/L)	3.04	8.30	5.26	6.66	0.22	≥ 6.00	6.00
BOD (mg/L)	0.64	3.30	2.66	1.78	0.11	≥ 3.00	
COD (mg/L)	1.40	5.75	4.35	3.06	1.78	30.00	
Turbidity (NTU)	5.00	53.00	48.00	15.72	2.25	10.00	
Cl^- (mg/L)	2.00	131.00	129.00	46.75	6.05	300.00	
NO_3^- (mg/L)	4.52	22.99	18.47	14.40	0.82	50	45
Na_3 (mg/L)	5.13	25.01	19.88	15.92	0.91	0.05	<1.50
PO_4^{3-} (mg/L)	0.14	5.41	5.27	2.00	0.24	3.50	-
Fe (mg/L)	0.17	0.43	6.26	1.98	0.27	0.30	0.30
Mg(mg/L)	0.11	0.46	0.35	0.22	0.02	0.20	0.20
Zn (mg/L)	0.21	0.45	0.24	0.35	0.01	-	5.0
Cu (mg/L)	0.00	0.15	0.15	0.06	0.01	1.00	-
Mn (mg/L)	0.00	0.13	0.13	0.04	0.01	-	0.05
Ca (mg/L)	3.00	38.00	35.00	14.76	1.08	-	75.00
Coliforms (MPN/100ml)	1.00	2.80	1.80	1.90	0.08		

SE=Standard Error, TH = Total Hardness, EC = Electrical Conductivity, TS = Total Solids, TDS=Total Dissolved Solids, TSS = Total Suspended Solids, O & G = Oil and Grease, DO = Dissolved Oxygen, BOD=Biological Oxygen Demand, COD = Chemical Oxygen Demand

There were spatial variations in the level of water quality parameters. While mean minimum values of all the parameters analysed were recorded at SLA (control), maximum values were recorded at SLC, SLD and SLE especially on TDS, DO, BOD, chlorides and O & G in both seasons of the year. The levels of TS, TDS, EC and O & G were most significantly different across the sampling locations (Figs 1-6). Positive correlations were recorded between EC and TDS (0.995); TH and TSS (0.890); EC and TH (0.835), NH_3 and NO_3^- (0.858) while high negative correlation was observed between DO and COD (-0.824) (see Appendix 1). The five principal component formed a cumulative variability of 81.33%.

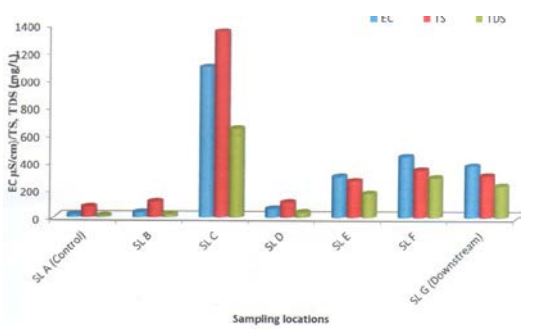

Fig. 1: Spatial variations in mean electrical conductivity, total solids and total dissolved solids of the Aba River

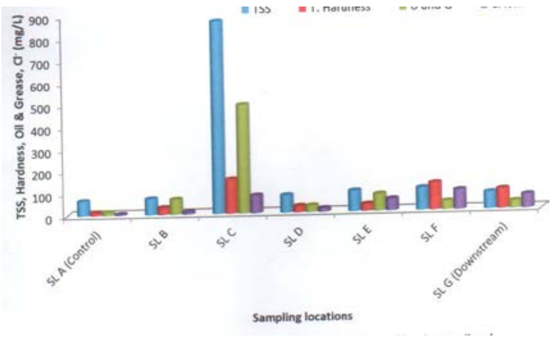

Fig. 2: Spatial variations in mean total suspended solids, total hardness, oil and grease and chloride ions concentrations of the Aba River

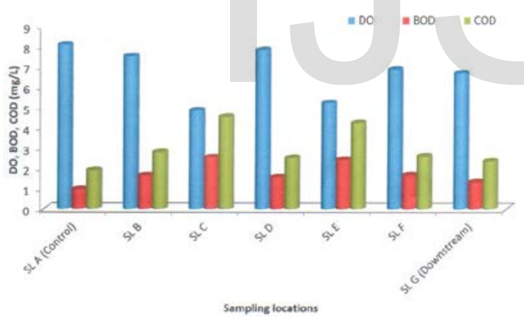

Fig. 3: Spatial variations in mean dissolved oxygen, BOD and COD of the Aba River

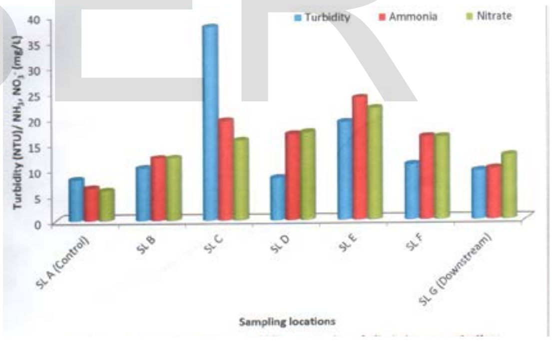

Fig. 4: Spatial variations in mean turbidity, ammonia and nitrate ion concentrations of the Aba River

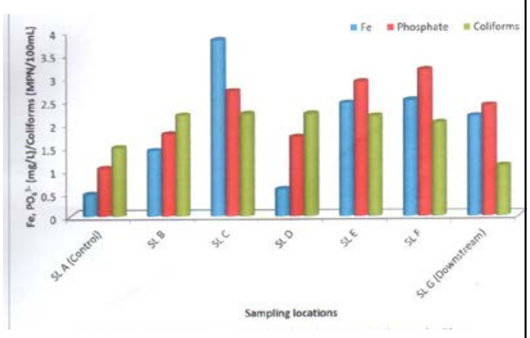

Fig. 5: Spatial variations in mean Fe, phosphate ion concentrations and coliform counts of the Aba River

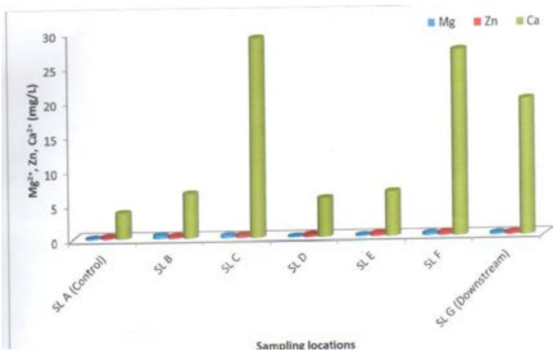

Fig. 6: Spatial variations in mean Mg, Zn and Ca ion concentrations of the Aba River

The first PC was most highly correlated with Mg^{2+} ion concentration (0.918) and also had high positive loadings for Ca^{2+} ions (0.855), TH (0.835), colour (0.798), Cl^- ions (0.776) and Mn^{2+} ions (0.758). PC2 was most highly correlated with TSS (0.910) and also presented high positive loadings for TS (0.846), turbidity (0.588) with high negative loading for DO (-0.627). PC 3 was most highly correlated with O & G (0.727) with high positive loadings for turbidity (0.64), BOD (0.622) and coliforms (0.557). PC 4 was most highly correlated with NO_3^- (0.902) while PC 5 was highly correlated with water temperature (0.791). The component plot in rotated space revealed that the water quality parameters were not evenly distributed in space, as COD, O & G and coliforms appeared to be more closely related than the other parameters.

Table 2: Extraction Sums of Squared Loadings of the Water Quality Parameters

Components	Total	% of Variance	Cumulative%
1	12.416	51.735	51.735
2	2.462	10.259	61.994
3	2.117	8.819	70.813
4	1.447	6.031	76.844
5	1.197	4.986	81.830

Water Quality Index showed that sampling locations SLC (43), SLE (46) and SLF (49) along the river were highly polluted while the rest were moderately polluted. Sampling point SLA presented a higher WQI of 85 which was good (Nibedita, 2015).

- **Discussion**

Results obtained on the physical and chemical parameters of Aba River clearly indicate the level of impact of anthropogenic factors on river water quality; and in line with those obtained on other surface water bodies in Nigeria (Okoye *et al*, 2011; Andem *et al.*, 2012). The observed variations in the levels of O & G, TSS, EC and TDS across sampling locations are reflections of different human activities that take place along the river banks. High temperature recorded at SLE compared with the control point might be as a result of run-offs from abattoir located nearby. Elevated temperature can affect the rate of photosynthesis, decrease dissolved oxygen in water thereby harming aquatic animals. The recorded low pH values at all the sampling locations (except SLA) was attributed to effluent discharges from industries, waste dumps and run-offs at the river banks. Low pH of water may not only affect reproductive functions of aquatic animals but may also increase solubility of metals which increases water toxicity levels affecting fish and rendering water unsuitable for other uses (Amadi *et al.*, 2010). High values of EC and TDS recorded at SLC in particular, can be attributed to the nature of effluents discharged from nearby breweries. There was high correlationship between these two parameters: as EC increased, TDS also increased. The high mean colour recorded at SLF could be associated with the dyeing in textile industry in proximity with the sampling point. Water from this location may cause foaming in boilers, hinder precipitation methods such as iron removal or water softening (Kumar and Prabhabar, 2012). The high levels of DO, O & G, turbidity, BOD and COD mostly recorded at SLC in both seasons of the year were attributable to intense motor maintenance and industrial activities around this sampling location.

Most of the trace metals of Aba River, apart from Mg and Zn ions, were found to be within the permissible limits of NESREA (2011). These two exceptions may have originated from leaching and run-offs from fertilizer application in nearby farmland, and laundry activities along the river banks. The Water Quality Index of Aba River ranged between bad to average, suggesting heavy impact of anthropogenic activities on the water body. Sampling points SLC, SLE and SLF had extremely bad water quality resulting from high concentration of human activities around these locations; although higher in the dry than in the wet season due to increase in its volume coupled with increased dispersion and dilution of water pollution load (Sinha, 2006).

CONCLUSION

The study has tried to analyse the water quality parameters of Aba River. Results show that the most probable sources of water pollution are the major human activities taking place along the river banks. The constant discharge of raw industrial effluents, and run-offs from abattoirs, textile industry, farmlands and car maintenance activities constitute the major sources of pollution of the river. The overall water quality indicates that the river water is not potable but may be used for other purposes. It is therefore recommended that the Federal and State Environmental Regulatory Agencies should ensure the enforcement of prescribed standards and regulations for industries, abattoirs and other activities that discharge their effluents into the rivers, coupled with regular monitoring to ensure compliance. Residents along the river banks should find alternative methods of waste disposal instead of throwing them into the river to avoid further deterioration of its quality. They should be advised to adopt cost-effective water treatment methods before consuming the water to avoid the building up of some pollutants in their body. Further studies should be carried out on microbial and heavy metals concentration as well as sediment chemistry for improved understanding on the current quality status of the river.

REFERENCES

Adedeji, O.B. and Adetunji, V.E. (2011) Aquatic pollution in Nigeria. The Way Forward. *Journal of Application of Sci and Environ Sanitation* 6 (2): 115-121.

Amadi, A.N., Olaselinde, P.I., Okosun, E.A. and Yis, J. (2010). Assessment of Water Quality Index Otamiri and oramiriukwa rivers. *Phy. Int J.,* 1(2); 116 -123.

Andem, A.B., Udofia, U., Okoroafor, K.A. *et al.* (2012). A study on some physical and chemical characteristics of Ona River, Apata, Ibadan, Oyo State Nigeria. *European Journal of Zoological Research*, 1 (2): 37-46.

AOAC (2000). Official methods of analysis of Association of Official Analytical Chemists, Arlington, Va. USA, 17th Ed, Chap. 17.

Bu, H., Tan, X., Li, S., Zhang, Q. (2010). Temporal and spatial variations of water quality in the Jinshui River of the South Qinling Mts, China. *Ecotox. Environ Safe,* 73(5):907-913.

Chatteerjee, A.K. (2011). Water supply, waste disposal and environmental engineering. Khanna Pub, Delhi.

Ekubo, A.T. and Abowei, J.F. (2011). Aspects of aquatic pollution in Nigeria. *Research Journal of Environmental and Earth Sciences*, 3 (6): 673-693

Ezeronye, O.U. and Ubalua, A.O. (2005). Studies on the effects of abattoir and industrial effluents on the heavy metals and microbial quality of Aba River, in Nigeria. *African Journal of Biotechnology*, 4 (3): 266-272.

Johnson, A., Abbaspour, K., Amini, M., Bade, H. P. *et al.* (2008). Geogenic contaminants. *Swiss Federal Inst. of Aquatic Sci and Tech*, 65:16-19 .

Judson, R., Richard, A., Dix, D.J., Houck, K. *et al.* (2009). The toxicity data landscape for environmental chemicals; *Environ Health Respect*, 117 (5), 685-695

Kumar, P.M. and Prabhabar, S.O. (2012) Physicochemical parameters of river water: *A Review Int. J of Pharmac Bio Archieves*, 3(6): 1304-1312.

National Bureau of Statistics (NBS) (2009) Social Statistics in Nigeria: Abuja.

National Population Commission, Abuja. Census 2006.

National Environmental Standards and Regulations Enforcement Agency, NESREA (2011), Accessed 13th Oct. 2016

Nibeta, P. (2015) Water Quality Assessment of Brahmani River Basin in Odisha using NSFWQI, *Int. J. of Energy, Sustain and Environ Engr;* 2(1):28-31

Nouri, J., Lorestani, B., Yousefi, N., Khorasani, N. *et al*. (2011). Phytoremediation potential of native plants growin in vicinity of Ahangaran lead-zinc mine, Iran, Environ. *Earth Sci*, 62 (3):639-644.

Okoye, N.H., Obidike, G.E. and Nduka, J.K.C (2011). Analysis of untreated effluents from soap factories in Aba, Abia State, Nigeria. *Journal of Basic Physical Research,* 2 (2): 21-25.

Oguntoke, O., Aboderin, O.J. and Bankole, A.M. (2009). Association of waterborne disease mortality pattern and water quality in parts of Ibadan city, Nigeria. *Tanzania Journal of Health Research*, 11 (4): 189-195.

Raji, M.I. and Ibrahim, Y.K. (2011). Prevalence of water-borne infections in Northwest, Nigeria: A Retrospective study. *Journal of Public Health and Epidemiology;* 3(8)382-385.

Sinha, Y.K. (2006). *Environmental Chemistry and Toxicology* 1st Edition, Foludese Press Ltd. Ibadan, pp215.

Taiwo, A.M., Olujimi, O.O., Bamgbose, O. and Arowolo, T.A. (2012). Surface water monitoring in Nigeria: Situational analysis and future management strategy. *Journal of water Resources and Protection,* 4:500-504.

WHO, World Health Organisation (2010). *Guidelines for Drinking Water Quality*. 4th Ed. NCF Classification WA 675, World Health Org; Geneva Switzerland, 307 -433.

Zare-Garizi, A., Sheikh, V. and Sadoddin, A. (2011) Assessment of seasonal variations of chemical characteristics in surface water using multivariate statistical methods. *Int J Environ. Sci Tech,* 8(3):581-592.

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Appendix 1

Correlation Matrix (r) between the Water Quality Parameters of Aba River

Temp	pH	Col.	Cond.	T.H	TS	TDS	TSS	O &G	DO	BOD	COD	Turb	Cl^-	NO^-_3	NH_3	
pH	-0.002															
Col.	0.126	0.419**														
Cond.	0.127	0.365	0.595**													
TH	0.056	0.522**	0.621**	0.835**												
TS	0.067	0.318*	0.411*	0.805**	0.622**											
TDS	0.132	0.378**	0.618**	0.955**	0.852**	0.788**										
TSS	0.058	0.194	0.173	0.491**	0.326*	0.890**	0.463**									
O & G	0.025	0.208	0.208	0.757**	0.630**	0.429**	0.757**	0.105								
DO	-0.233	-0.467**	-0.533**	-0.737**	-0.600**	-0.688**	-0.734**	-0.508**	-0.465**							
BOD	0.151	0.375*	0.335*	0.653**	0.423**	0.470**	0.646**	0.216	0.604**	-0.666*						
COD	0.079	0.462**	0.365*	0.688**	0.478**	0.640**	0.676**	0.462**	0.588**	-0824**	0.794**					
Turb	0.105	0.206	0.296	0.791**	0.562**	0.757**	0.775**	0.553**	0.759**	-0.641**	0.681**	0.745**				
Cl^-	0.159	0.230	0.709**	0.747**	0.715**	0.568**	0.769**	0.316*	0.516**	-0589**	0.507**	0.524**	0.617**			
NO^-_3	0.075	0.464**	0.249	0.188	0.205	0.104	0.202	0.018	0.140	-0.486**	0.529**	0.506**	0.249	0.413**		
NH_3	0.076	0.488**	0.324*	0.381*	0.312*	0.273	0.382**	0.135	0.328**	-0.589**	0.682**	0.717**	0.435**	0.429**	0.858**	
PO_3^{4-}	0.208	0.196	0.452**	0.420**	0.335**	0.136	0.455**	-0.123	0.330*	-0.174**	0.378*	0.216	0.324*	0.545**	0.370*	0.367*

***Significant at p<0.05, ** = significant at p<0.01, Temp = Temperature, cond = Conductivity, TH= Total Hardness, TS = Total Solids, TDS= Total Dissolved Solids, TSS= Total Suspended Solids, O & G = Oil and Grease , Do = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand, Turb = Turbidity**