J. Trop. For. Res. Vol. 20(2004): 46-55

WATER AND SEDIMENT QUALITIES OF EKOLE RIVER, BAYELSA STATE, NIGERIA

OLAIFA, F.E. and LEILEI, K.E.
Department of Wildlife and Fisheries Management,
University of Ibadan, Ibadan, Nigeria
E-mail: floraolaifa@yahoo.com

ABSTRACT

A study was carried out to determine the physico-chemical characteristics and heavy metal contents of the water and sediments of Ekole River in Bayelsa State, Nigeria. Water and sediment samples were collected in the dry (December/January) and wet (June/July) seasons during 2003 and 2004. Surface water up to 15cm depth and sediments were sampled at nine locations: 100, 200,400, 500m upstream; 0, 100, 200, 300,400m downstream of an oil flow station. The samples were analyzed for total suspended solids (TSS), pH, chloride, dissolved oxygen, conductivity and heavy metals. These parameters were either measured *in-situ* using appropriate meters or analyzed in the laboratory using standard methods. The results obtained were compared with the Baseline Ecological Data for 'Gbaran Extended Field', upstream of the study area, World Health Organization and the Federal Environmental Protection Agency's standards for water quality.

The results showed increased TSS, pH and conductivity of the water over the baseline data. All heavy metals of interest: cadmium (Cd), lead (Pb), manganese (Mn), zinc (Zn), nickel (Ni), copper (Cu), iron (Fe) and chromium (Cr) were present in the water while Ni, Cd and Cr, absent in the baseline data were detected. Significant increases ($p < 0.05$) were recorded for iron, zinc, copper and manganese over baseline data. Higher concentrations ($p < 0.05$) of heavy metals were recorded in sediments than water and the dominant metal was iron.

It was concluded that changes in water quality had occurred in Ekole River near Obama flow station and the need to adhere to existing environmental laws and regular monitoring recommended.

INTRODUCTION

Water in Nigeria is subjected to stresses due to unplanned activities which lead to environmental degradation, (Mastaller, 1995). The major anthropogenic sources of water pollution in Nigeria are agriculture (fertilizer application, pesticide/biocide, and drugs), siltation due to the removal of vegetation, atmospheric deposition or disposal of solid wastes.

liquid effluents and oil pollution (both refined and crude oils). Increasing population and industrialization have promoted pressures on water (Clarke, 1994).

Attempts have been made through legislation to maintain good water quality (Federal Environmental Protection Agency 1991), but there is an urgent need to enforce laws and regulations. Water in the Niger Delta region of Nigeria supports several aquatic animals (Ashton-Jones, 1998), and birds (Ayeni *et al.* 1981). It is therefore very important to undertake detailed scientific studies and monitoring of major water bodies in the zone. The sediments at the bottom of water bodies form a continuum with terrestrial environments. It is rich in nutrients and serves as a sink for materials from the overlying water and watershed (Doresmus and Clesceri, 1982; Odiete 1999). The nature of the sediment can affect the primary productivity of the water especially with respect to the non-apatite minerals (iron and aluminium), pH, adequate dissolved oxygen and high level of microbial activity.

This study is aimed at assessing the water and sediment qualities of Ekole River in Bayelsa State, Nigeria with a view to ascertaining its wholesomeness for both man and animals.

MATERIALS AND METHODS

The Study site:

The Nun River System is a bifurcation of the River Niger after Aboh with the Forcados flowing westwards (Delta State) and the Nun River flowing southwards (Bayelsa State,Figure 1). It provides a good waterway towards the Brass River System and enters the Atlantic Ocean (Netherlands Engineering Consultants, 1961). A swampy plain interspersed with dry and seasonally dry plateau surrounds Ekole River. The soil is fine sandy and silty loam with low permeability. This region is an eco-zone between the freshwater and brackish water with a viable ecosystem of high biological productivity.

Ekole River flows from the Nun river through Otuegwe, Anyiama, Oloibiri,Okodi-Ogbia (in Ogbia Local Government Area); Dorgueowoama and Tereke villages (Okoroama-Tereke Local Government Area) all in Bayelsa State.

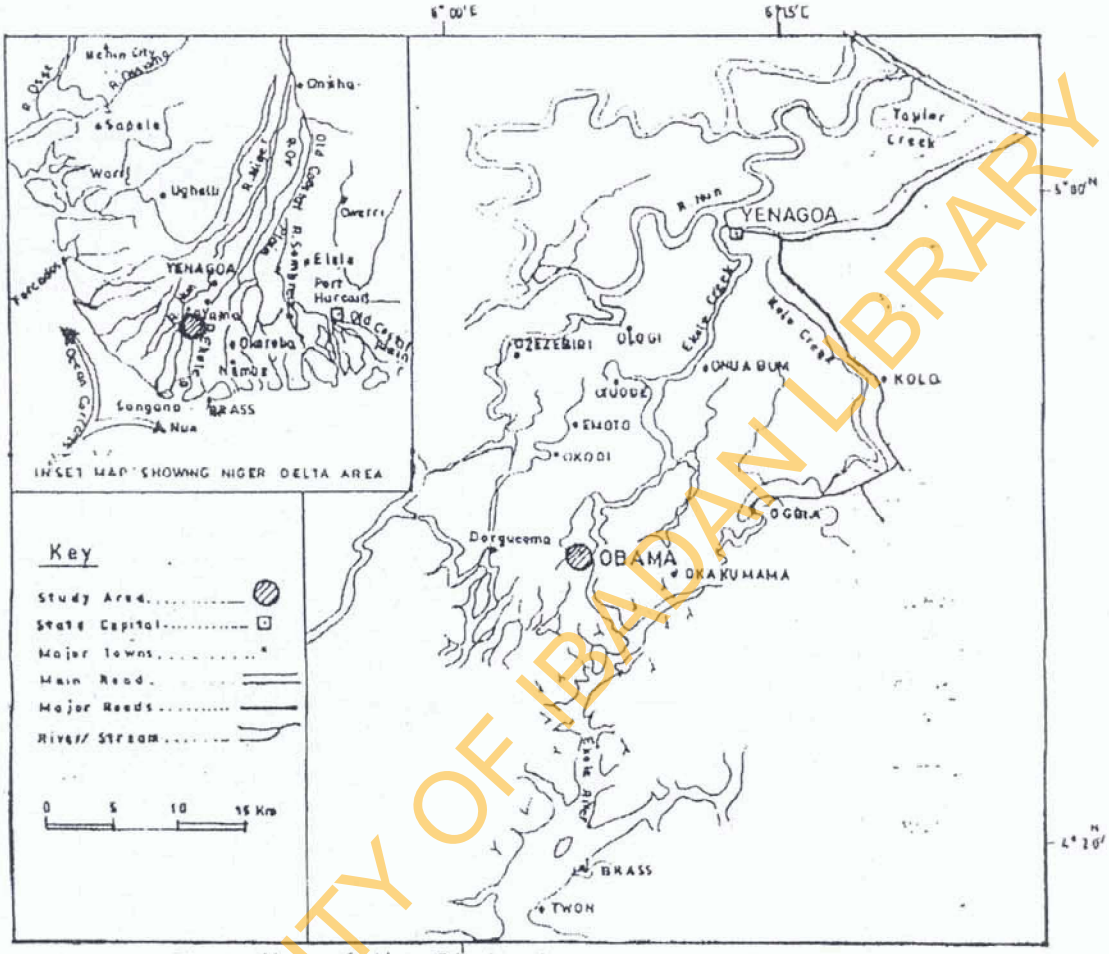

Fig. 1 : Map of the Study Area (ADAPTED FROM ASHTON-JONES 1988)

FIELD STUDIES

The study was carried out in the wet(June/July) and dry (December/January) seasons of 2003 and 2004 .Samples were collected at nine locations(Sampling depth 0-15 cm for surface water): 0 ,100, 200, 400, 500m upstream, 100, 200, 300 and 400m down stream of the oil flow-station at Obama along the course of the river .There was active gas faring and the effluents also contained metals and hydrocarbons . Sewage was also disposed into the river. This river was chosen because it is the major water body flowing through and linking the capital, Yenegoa. It serves as the main water source, boat route and the natives fish and use the water for agricultural purposes.Fast-changing parameters like pH, total suspended solids (TSS), Dissovled oxygen (DO), salinity and temperature were measured *in situ* using an Orion (Model 1260 pH/ISE) meter (A.S.T.M, 1992, APHA, 1992). Water for heavy metal analysis was collected in 1-litre plastic bottles, acidified with nitric acid (HNO_3) and iced on the field (5ml conc. HNO_3: 1L water sample). Sediment samples were collected with an Eckman grab sampler following the procedures outlined by Odiete (1999) and stored in polythene bags for analyses.

The laboratory analyses of the water and sediments were carried out according to the guidelines of A.S.T.M, (1992) and A.P.H.A, (1992). The heavy metals in the water and sediments were quantified using an atomic absorption spectrophotometer (AAS). The data obtained from both field and laboratory studies were subjected to Analysis of Variance, Fisher's Least Significant Difference (LSD) and correlation analyses.

RESULTS:

The physico-chemical characteristics of Ekole River compared with the Baseline Ecological Data for 'Gbaran Extended field (Environmental Pollution Monitoring Project, 1991/92), World Health Organization standards for domestic water, (WHO, 1991) and FEPA standards for effluent discharges to water bodies (FEPA, 1991) are presented on Tables 1-3.

Table 1: Physico-chemical Characteristics of the Ekole river Water (a) Dry Season

Sample Station	pH	TSS Mg/l	Cr mg/l	Do mg/l	Cond Is/cm	Cd mg/l	Pb mg/l	Mn mg/l	Zn mg/l	Ni mg/l	Cu mg/l	Fe mg/l	Cr mg/l
1	6.30	130.0	20.0	10.83	69.0	<0.001	0.04	0.13	0.05	<0.001	0.015	7.76	0.01
2	6.70	110.0	21.65	7.02	81.3	<0.001	0.05	0.15	0.06	<0.001	0.01	5.43	0.02
3	6.50	150.0	27.20	8.64	72.3	<0.001	0.05	0.23	0.08	0.01	0.01	6.54	0.34
4	7.26	133.0	27.45	4.11	79.3	<0.001	0.17	0.23	0.06	0.02	0.03	5.39	0.543
5	6.65	206.0	39.60	4.81	80.1	<0.001	0.06	2.60	0.08	0.03	0.03	9.64	0.46
6	7.5	200	30.0	5.24	83.5	<0.001	0.08	1.10	0.08	0.01	0.02	6.71	0.51
7	7.20	263.0	25.80	6.25	79.6	<0.001	0.13	0.26	0.07	0.01	0.02	5.94	0.49
8	7.15	270.0	24.05	7.16	72.8	<0.001	0.10	0.21	0.06	<0.001	0.02	6.8	0.29
9	7.30	235.0	21.06	8.90	75.3	<0.001	0.9	0.19	0.08	<0.001	0.01	6.12	0.26

(b) Wet Season

Station	pH	TSS	CL	DO	Cond	Cd	Pb	Mn	Zn	Ni	Cu	Fe	Cr
1	6.60	125.0	15.40	8.92	73.4	ND	0.02	0.15	0.04	ND	0.01	7.54	<0.001
2	6.90	122.0	17.05	8.56	84.5	ND	0.02	0.11	0.03	ND	ND	5.56	0.01
3	6.40	168.0	24..50	7.52	70.1	ND	0.03	0.19	0.07	ND	ND	6.04	0.01
4	7.40	142.2	26.60	8.82	64.5	ND	0.10	0.24	0.08	ND	0.01	5.12	0.2
5	6.60	230.5	30.51	4.12	70.8	ND	0.03	2.25	0.09	ND	0.02	9.66	0.24
6	7.40	203.3	27.52	4.99	80.3	ND	0.06	1.91	0.06	ND	0.01	5.82	0.21
7	7.50	250.8	21.34	6.70	74.1	ND	0.10	0.14	0.07	ND	ND	5.63	0.30
8	7.00	282.0	19.45	7.23	73.1	ND	0.10	0.11	0.06	ND	ND	6.11	0.30
9	7.45	245.0	21.28	8.82	70.5	ND	0.05	0.20	0.06	ND	ND	5.99	0.26

ND – Not Detected (>0.001)

Table 2 Heavy Metals in Sediments of Ekole River

Table 3: Physico-chemical characteristics of Ekole River water and sediments during dry and wet seasons compared with BEDA 1991/92, WHO and FEPA Standards.

Physico-chemical parameter	Mean values for study area				BEDA 1991/92		WHO Guidelines For water	FEPA standard for water
	Dry Season		Wet Season					
	Surface Water	Sediment	Surface Water	Sediment	Surface Water	Sediment	(WHO 1991)	(FEPA 1991)
pH	6.92	-	7.03	-	6.2	-	6.5-9.2	6- 9
TSS(mg/l)	188.59	-	197.1	-	NS	-	25	30
Chloride(mg/l)	26.32	-	22.63	-	33	-	600	600
D.O(mg/l)	7.0	-	7.3	-	NS	-	>4.0	NS
Conductivity(µ/cm)	77.02	-	73.48	-	73.68	-	NS	NS
Cadmium (mg/l)	<0.00	<0.00	ND	ND	ND	ND	<0.00 – 2	<1.0
Lead	0.085	1.64	0.06	1.4	0.03	2.06	<0.03	<1.0
Manganese (mg/l)	0.567	54.45	0.48	51.98	0.08	45.86	0.5	5
Zinc (mg/l)	0.069	22.94	0.062	20.93	0.28	2.16	15	<1.0
Nickel (mg/l)	0.018	0.6	0.004	0.54	ND	ND	<0.02 -5	<1.0
Copper (mg/l)	0.018	2.19	0.006	1.99	0.08	3.02	1.5	<1.0
Iron (mg/l)	6.7	95.38	6.39	94.04	2.3	80.9	1	2
Chromium (mg/l)	0.33	0.49	0.17	0.42	ND	ND	NS	<1.0

Note: ND = Not Detected

NS = Not specified

There were significant differences ($P < 0.05$) between surface water and sediment heavy metal contents. Correlations ($P<0.05$) were observed between TSS and pH (+0.55), D.O and pH (+0.54), D.O. and chloride (-0.69) D.O and conductivity (+0.82) in the dry season and only between D.O and Chloride (-0.65) in the rainy season.

In surface water during the dry season, Zn was positively correlated ($p<0.05$) with Mn (0.99), Ni with Pb (0.96), Cu with Pb and Ni (0.92, 0.87respectively). Iron correlated with Mn (0.96), Zn (0.87) and Cu (0.69), while Cr showed a positive correlation with Pb (0.82), Ni (0.83) and Cu (0.78). In the wet season, Zn correlated with Mn (0.99); Ni with Pb (0.98); Cu with Pb (0.74) and Ni (0.82), while Fe correlated with Pb (0.74), Mn (0.97); and Zn (0.94) correlated positively with Pb(0.87), Ni (0.90), and Cu (0.86).
In sediments during the dry season Mn correlated with Pb (0.86); Zn with Pb (0.73), and Mn (0.83); Ni with Pb (0.96), Mn (0.84), and Zn (0.79); Cu with Pb (0.90), and Ni (0.83);Fe with Pb (0.83), Ni (0.78),Mn (0.76),and Cu (0.73);and Cr correlated with Pb (0.93), Mn (0.73) , Zn (0.74) , Ni (0.95), Cu (0.89) .In the wet season, Ni correlated with Mn (0.78), Cu (0.80) and Cr(0.70); Fe and Mn (0.80), Cr and Cu (0.86).Cadmium showed little variation with depth and season.

DISCUSSION

This study was undertaken to assess the physico-chemical characteristics and heavy metal contents of Ekole River water. The presence of heavy metals in the water and sediments was similar to the findings of other workers in the Cross River Estuary (Ntekim, 1987; Etim and Akpan, 1999). The results showed that sediments contained significantly higher ($P < 0.05$) concentrations of heavy metals than water. Similar observations of higher concentrations of heavy metals in sediments than water have been made for River Niger. This is attributed to the discharge of industrial and domestic effluents into the river systems. Iron was the dominant metal and differed significantly between surface water and sediments ($p < 0.05$).

Physico-chemical Characteristics of Water

The mean pH value of 6.95 was higher than the 6.2 observed by Environmental Pollution Monitoring Project (1991/92) but was within the acceptable FEPA and WHO limits. The mean value of TSS of 188.59mg/l was higher than the BEDA 1991/92, WHO and FEPA limits. There was a decrease in chloride content of the water than the BEDA 1991/92 and it was also lower than FEPA limit.. There was a marked increase in conductivity than BEDA 1991/92.The appearance of cadmium, nickel and chromium in the water and sediments that were not observed before could be due to the influence of increased oil related activities in the area (Ntekim, 1987, Etim and Akpan, 1991).Manganese, zinc, iron and copper increased during this study than the BEDA 1991/92. Their values were greater than WHO guidelines except where not specified. There was an increase of lead in surface water than the BEDA 1991/92. This observed value was higher than WHO (1991) guidelines. This study showed changes in the water and sediment qualities across sampling stations, depths (surface water

and sediments) and seasons compared with BEDA 1991/92. Heavy metal concentrations were higher in the dry than rainy seasons.

CONCLUSION AND RECOMMENDATIONS

Water quality changes occur due to differences in the activities along the water course and the water shed surrounding the water body .Anthropogenic activities on land and water affect water quality at an increasing rate. . There is therefore a need for sustainable use of water with consideration for its quality. There is a need to enforce the Environmental Impact Assessment laws already established in the country. There should be regular monitoring to assess regularly the water quality and this should have a multi-disciplinary approach to consider various aspects of water pollution and offer workable solutions. Environmental education and awareness are important to make everyone maintain a clean environment.

REFERENCES

American Public Health Association (1992) *Standard Methods for Examination of Water and Wastewater*. 18th Edition.American Public Health Association, Washington, D.C.

American Society for Testing and Materials (1992). *Standard Guide for Collection, Storage, Characterization and Manipulation for Toxicological Testing*. Method E 1391 – 90. Annual Book of A.S.T.M Standards, water and environmental Toxicology ,Vol. 11(04). American Society for Testing and Materials .Philadelphia Pa.

Ashton – Jones, N. (1998). *The Human Ecosystems of the Niger Delta*. An Environmental Rights Action (ERA) Handbook. Kraft Books Limited, Ibadan

Ayeni, J.S.O. Afolayan, T.A. and Ajayi, S.S. (1981). *Introductory Handbook on Nigerian Wildlife*. Kainji Lake Research Institute, New Bussa, Nigeria. Pp 67 – 80.

Clarke, R. (1994). *The Pollution of Lakes and Reservoirs*. United Nations Environmental Programme, Environmental Library, No. 12. Nairobi, Kenya.

Doresmus, C. and Clesceri, L.S. (1982). Microbial Metabolism in Surface Sediments and its Role in the immobilization) of phosphorus in Oligotrophic Lake Sediments. *Hydrobiologia*, Vol. 191 pp 261 – 268.

Environmental Pollution Monitoring Project, (1991/92). Ecological Baseline Study of 'Gbaran Extended Field'. A Final Report by EPMP of Anambra State University of Technology, for Shell Petroleum Development Company.

Etim, L. and Akpan, E.R. (1991). Seasonal Variations of Metals (Hg, Pb, As) in the body Tissue of *Egreria radiata* (Lam). Bravaivia: Tellinacea: Donoadae) from the Cross River Nigeria. *Journal of African Zoology*, vol. 105 pp 465 – 472.

Federal Environmental Protection Agency (1991). *National Interim Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Wastes Management in Nigeria*. 238pp.

Mastaller, M. (1995). Utilization of Mangrove Forests. A Challenge for Development Policy. *Natural Resources and Development*. Vol. 42 pp 7 – 24.

Netherlands Engineering Consultants.(1961).The Waters of the Niger Delta. Report of an Investigation by Netherlands Engineering Consultants (NEDECO), The Hague. Second Revised Edition, March, 1961.

Ntekim, E.U. (1987). Heavy Metal Concentration in the Sediments from Calabar River and Qua Iboe River Estuary. M.Sc Thesis, University of Calabar 11pp.

Odiete, W.O. (1999). Environmental Physiology of Animals and Pollution Diversified Resources Limited, Lagos 261pp.

World Health Organization (1991). *Guidelines and Standards for Domestic and Aquatic life* Geneva, 1991.