15

STUDIES ON THE RECOVERY POTENTIALS OF A DISTURBED AQUATIC ECOSYSTEM: FOCUS ON PRE- AND POST-DREDGING ANALYSIS OF NWORIE RIVER, OWERRI, IMO STATE, NIGERIA.

By

JUSTINA U. UDENSI, MOSES O. E. IWUALA AND HARRIET C. NWIGWE
Department of Biotechnology,
Federal University of Technology,
Owerri, Imo State. Nigeria

And

NKECHI E. ONYEDINEKE
Department of Biological Sciences,
Federal University of Technology,
Owerri, Imo State, Nigeria.

And

JOSEPH N. OKEREKE and IFEYINWA C. MGBEMENA
Department of Biotechnology,
Federal University of Technology,
Owerri, Imo State, Nigeria.

ABSTRACT

A study was done to monitor the recovery potential of Nworie river system, in Imo State, Nigeria from July 2010 to January 2012. Water samples were collected from 5 Stations prior to, during and after dredging. Station 1 was the dredging point, Stations 2 and 3 were 250m and 500m upstream of the point, while Stations 4 and 5 were 250m and 500m downstream of the dredging point respectively. The physicochemical parameters of the water before dredging were assessed to be within acceptable limits of established water standards; pH 6.5-7.8, Temperature 27.6-29.9 ^{0}C, Conductivity 34-196µs/cm, Turbidity 0-76NTU, TDS 22.1-127.4 mg/l, TSS 9-51mg/l , Nitrate 1.2-33.6mg/l, Phosphate 0.2-3.7mg/l, Sulphate 0-33mg/l, DO 4.3-9.4mg/l and BOD_5 9.5- 10.9mg/l. During the dredging, the water physicochemistry changed noticeably with indices outside the permissible limits of the standards. The pH values decreased drastically to 4.6, DO to 1.3mg/l, Nitrate to 1.2mg/l, temperature increased to 30.2^{0}C, Turbidity 620NTU, TSS 349mg/l, Conductivity 498 µs/cm, TDS 298.8 mg/l, BOD_5 19.1mg/l, Sulphate 33mg/l and Phosphate 0.92mg/l. Three months after the dredging, the values for the parameters returned to their pre-dredging concentrations. However during the rainy season, as the leachates and silts from the spoils were washed into the river, the recovery of the river system was prolonged to about 9 months. This implies that the effects of dredging on the river are of short term, but improper disposal of dredge spoils compounded the impacts.

INTRODUCTION

Physical alteration of the ecosystem is one of the greatest threats to biological diversity both on land and in water bodies. One of such challenging activities is dredging (Aguwamba *et al.*, 2011).

Dredging is an excavation activity or operation usually carried out, at least partly, underwater, in shallow seas or freshwater areas for the purpose of gathering up bottom sediments and disposing of them at different locations. This technique is often used to keep waterways navigable. It is also used for fishing of certain species of edible clams and crabs. Irrespective of the benefits of dredging, the activity creates a lot of disturbance in aquatic ecosystems, often with adverse impacts (Ohimain *et al.*, 2008). The process of dredging creates spoils (excess materials) which include waterways sediments, river bank soils, vegetations, etc, which are carried away from the dredged area (Singh *et al.*, 1998). The process often dislodges chemicals residing in benthic substrates and injects them into the water column. The re-suspended sediments according to Delaune and Smith (1995) give rise to various adverse effects such as turbidity plumes, changes in physical and chemical equilibra of water with the potential to release contaminants into the water phase, plus the release of nutrients and increase in eutrophication, resulting in oxygen depletion and a host of other negative impacts.

It is believed that through dredging, Nworie River, as one of the major rivers in Owerri metropolis, in Imo State will gain substantial aesthetic and functional values. Also, it will serve as a reliable source of drinking water, fishing and other domestic uses for about 2 million inhabitants of Owerri (Ihejirika *et al.* 2011).

Expectedly, a number of challenges and problems are associated with river dredging activity, as have been recorded elsewhere in other parts of the country, especially in the South Eastern region of Nigeria. Ohimain *et al.*, (2008) have reported some of the consequences in the Niger Delta area during the dredging of a tributary of Warri River, to enable the drilling of an oil well. The impacts included algal bloom, impairment of benthic invertebrates and massive destruction of zooplankton.

In addition, the dumping of dredge spoils by the river bank has been known to cause more severe environmental impacts than the operation itself. The disposal of the unconfined spoils by the river bank has often led to the following: acidification and water contamination, which soon result in fish kills and vegetation damage, increased turbidity, reduction of primary productivity and bioavailability of sediment's trace-metals (Ohimain and Andriesse, 2004, Lewis *et al.*, 2001, Perin *et al.*, 1997). In the typical Nigerian situation, especially the South-Eastern zone, the large scale pollution of surface water bodies is not only a major public health problem but also constitutes a principal obstacle to socio-economic advancement and the fight against poverty and malnutrition (Okpokwasili and Ogbulie, 1993; Ihejirika, *et al.*, 2011; Alinnor and Obiji, 2010).

The objective of this study therefore was to assess the water quality of Nworie River and its recovery potentials following Government-sponsored dredging operations, spanning about three years (2009 – 2012).

MATERIALS AND METHODS

The Study Area

The Nworie River is one of the major rivers in Owerri metropolis in Imo State, Nigeria. It runs through a distance of about 7.5 kilometers and cuts across Owerri geographical zone in South Eastern Nigeria (ISEPA/MPE, 2008).The river traverses four (4) Local Government Areas, namely: Mbaitoli, Owerri North, Owerri Municipality, and Owerri West LGAs. The River has its source at Egbeada village in Mbaitoli L.G.A. and flows through Akwakuma and Amakohia in Owerri North LGA, down to Owerri Municipality and finally empties itself into another river known as Otamiri River at Nekede village in Owerri West L.G.A. Along the route of the Nworie River are a number of private and public Institutions that discharge their wastes into the water body. Among these Institutions are the Federal Medical Centre (F.M.C.) Owerri; Alvan Ikoku Federal College of Education (A.I.F.C.E.); Holy Ghost College and a host of other Waste-generating Agencies.

Sample Collection: Water samples from the site of dredging were collected from five (5) stations within the study areas. Station 1 was at the dredging point, Stations 2 and 3 were 250m and 500m upstream of the dredging point and Stations 4 and 5 were 250m and 500mm downstream of the dredging point. Control Stations were Stations 3 and 5 which were used to determine if the effects of dredging were localized. Prior to dredging, water samples were collected twice from each Station in the months of July 2010 and January 2011 representing both rainy and dry seasons. During dredging, in March 2011 samples were collected from all the Stations. Post dredging samples were collected bimonthly after dredging as follows May, 2011, July 2011, September 2011, November 2011, and January 2012 covering a monitoring period of 9 months, to determine the duration of the effects of dredging. During sample collection, the following parameters were analyzed *in-situ*; pH, temperature, conductivity, total dissolved solids (TDS) and dissolved oxygen (DO) using digital pH meter/thermometer (HACH EC 20), Conductivity/ TDS meter (HACH CO 150) and Dissolved Oxygen meter respectively. Separate samples were collected for determining BOD_5 using 300ml BOD bottles with ground stopper.

Standard methods of (APHA, 1995) were used for the laboratory analysis. The portable datalogging spectrophotometer (HACH DR/ 2010) was used to determine turbidity, total suspended solids (TSS), nitrate, phosphate and sulphate content by selecting different wavelengths, program numbers and powder pillows where necessary.

RESULTS

Prior to dredging, the water quality was within the permissible limits of established water standards prescribed by FEPA (1991), WHO (2006) and NIS (2007). And the values of all the physicochemical parameters followed a particular trend (Table 1a). The pH values before the dredging were quite similar, ranging from 6.6 - 7.4. However, during the dredging in March 2011, the values declined to 4.6, at the dredging point of the Nworie River. The pH values of 6.2 and 6.5 were obtained at 250m and 500m upstream of the river from the dredging point. At 250m and 500m downstream of the dredging point 5.4 and 5.6 were recorded respectively. Several months after dredging, the pH values increased, with the highest value of 7.4 being recorded at the 250m downstream location. The temperature range remained relatively stable throughout the study period. The temperature ranged from 25.6 – 30.2^{0}C, and similar trends were recorded in all the stations. The lowest value of 25.6^{0}C was recorded in July 2010, and the highest value of 30.2^{0}C in November 2011. This was due largely to seasonal variations than to the dredging activity. The turbidity and TSS showed similar trends. The turbidity and TSS in all the stations were less than 45NTU and 25mg/l respectively. However, turbidity plumes were observed during the dredging activity, with the highest values of 620 NTU and 349 mg/l for turbidity and TSS respectively at the dredging point in the month of March, 2011. After dredging, the turbidity values reduced from 124 NTU in May, 2011 to 41NTU in January, 2012, and TSS from 120mg/l in May, 2011 to 10 mg/l in January 2012 at the dredging points. At the control stations, especially the upstream locations, lower values of 62NTU and 25mg/l were recorded for both turbidity and TSS respectively. After dredging, there was a sharp decrease to 30 NTU and 5 mg/l .

TABLE (1a): THE MEAN VALUES FOR THE PHYSICAL PARAMETERS

pH	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	7.2	6.8	6.5	6.9	7.1	7.4	6.6	6.5
250mUS	7.4	7.1	6	6.8	7.3	7.1	6.3	6.8
DREDGING POINT	7	6.6	4.6	5.6	7	6.6	6.5	6.7
250mDS	7.1	6.7	5.4	6.1	7.2	6.7	7.4	7.4
500mDS	7.4	6.8	5.6	6.3	7.4	7.2	7	7

TEMPERATURE	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	26	29.1	29.5	27	26.6	28.1	29.1	30
250mUS	26.4	28.5	28.2	27.2	26.5	27.5	28.8	28.9
DREDGING POINT	27.7	29.7	29.5	28	26.8	28.7	29.3	29.1
250mDS	27	28.2	29.7	26.7	27	28	30.2	30.1
500mDS	25.6	28.1	28.8	26.5	25.8	27.4	29.7	30

TURBIDITY	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	31	26	62	47	35	135	35	30
250mUS	44	29	84	50	46	146	51	45
DREDGING POINT	26	33	620	124	67	175	90	41
250mDS	36	21	512	52	44	108	42	36
500mDS	41	34	148	68	36	51	36	32

CONDUCTIVITY	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	78	81	84	78	60	51	75	78
250mUS	67	63	77	72	65	60	80	77
DREDGING POINT	66	90	498	254	87	66	99	89
250mDS	61	106	346	153	72	71	87	82
500mDS	93	87	103	86	71	61	71	69

TDS	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	39	40.5	42	39	30	25.5	37.5	39
250mUS	33.5	31.5	38.5	36	32.5	30	40	38.5
DREDGING POINT	33	45	249	127	43.5	33	49.5	44.5
250mDS	30.5	53	173	76.5	36	35.5	43.5	42
500mDS	46.5	43.5	51.5	43	35.5	30.5	35.5	30.5

TSS	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	0	0	52	33	12	20	5	0
250mUS	8	12	64	41	18	24	10	5
DREDGING POINT	16	10	349	120	24	21	13	10
250mDS	13	21	289	139	29	32	11	21
500mDS	0	8	131	88	36	23	18	16

(Key: US = Upstream, DS = Downstream)

TABLE (1b): MEAN VALUES FOR NUTRIENTS AND OXYGEN-RELATED PARAMETERS

PHOSPHATE	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	0.6	0.62	0.65	0.52	0.72	0.84	0.6	0.61
250mUS	0.52	0.7	0.61	0.56	0.68	0.63	0.51	0.62
DREDGING POINT	0.64	0.42	0.92	0.71	0.42	0.54	0.62	0.5
250mDS	0.62	0.38	0.59	0.5	0.52	0.82	0.4	0.36
500mDS	0.32	0.56	0.75	0.62	0.6	0.86	0.35	0.4

DO	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	7	5.7	4	8	7.1	8	5.8	5.1
250mUS	6.2	6	3.5	7.2	6.2	7.2	6.1	5.8
DREDGING POINT	5.2	4.4	1.3	3.4	4.5	5.8	6	5.9
250mDS	5.6	5.7	1.8	7	6.7	6.3	5.4	5.3
500mDS	7.1	7.3	2.7	6.5	6.8	6.5	7.2	6.8

BOD_5	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	3	2.1	10.6	8	5.8	2.8	1.9	2
250mUS	2.7	2.5	10.7	7.2	5.2	2.1	2.4	2.1
DREDGING POINT	2.7	4.3	19.1	12.3	7.5	5.5	3.6	2
250mDS	2.5	2	12.5	9.2	6.1	5	2.2	1.9
500mDS	2.3	1.8	11.9	7	4.8	4.1	2.5	2.1

NITRATE	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	33.6	28.2	20.3	17	15.9	23	12.1	12
250mUS	25	17.4	11.1	10.2	11.8	16.7	10.3	10
DREDGING POINT	16.2	10.4	1.2	4.5	6.7	8.9	9.8	10.2
250mDS	27	11.5	2.7	5.3	6.3	9.2	8.8	11.3
500mDS	25.1	12	4.5	6.2	8.9	11.9	7.7	9.4

SULPHATE	JULY'10	JAN'11	MARCH'11	MAY'11	JULY'11	SEPT'11	NOV'11	JAN'12
500mUS	0	0	1	3	5	0	0	1
250mUS	1	2	5	1	3	0	2	4
DREDGING POINT	0	5	33	13	0	2	0	3
250mDS	5	10		8	4	3	1	0
500mDS	0	2	13	5	2	0	3	2

***(Key:** US = Upstream ,DS = Downstream)*

DISCUSSION

Data obtained were in line with values for Warri River where the dredging of an oil well access canal led to increase in turbidity from 20 NTU to 11398 NTU and TSS from 20mg/l to 820mg/l (Ohimain *et al.,* 2008). Increased turbidity and TSS can lead to depletion of oxygen in a water body (Nwigwe, 2011) which will be of adverse effect to aquatic organisms. Similar studies reported that dredging could cause decrease in light penetrations by between 25 - 50% over a distance of 12km and that this effect was persistent for up to 18 months after dredging (Reavell, 1997). The reason for the prolonged effect was attributed to the washing of leachates and silts from the uncapped dredge spoils dumped by the river bank (USEPA/ USACE, 1998) Smith and Rule, 2001). However, instead of such improper disposal method, the spoils can be converted to wealth when used for construction purposes (Udensi and Opara, 2012). Udensi and Opara (2012) opined that such excavated materials can be converted to wealth by using them for land reclamation and/or other construction-related purposes. In July 2010 before the dredging , the values for conductivity and TDS were relativity low, however, during dredging the values increased sharply. In March, 2011 that is the period of the dredging operation, at the dredging point and 250m downstream, the conductivity and TDS values were high 498 µs/cm and 346µs/cm respectively for conductivity and 249 mg/l and 173mg/l respectively for TDS. These values decreased after dredging by September, 2011 to 66µs/cm and 71µs/cm for conductivity. The same trend was recorded in TDS values which decreased to 33mg/l and 35 5mg/l respectively in September, 2011. However, in November, 2011, the values obtained were relatively high; conductivity 99us/cm and TDS 49.5mg/l. Ohimain *et al.,* (2008) stated that increase in turbidity following dredging was related to the re-suspension of sediments and increased conductivity and TDS.

For the oxygen-related parameters and water nutrients (Table 1b), there was an inverse relationship between DO and BOD_5. The DO levels before dredging ranged from 4. 4mg/l to 7.3 mg/l while BOD values ranged from 2mg/l to 4.3mg/l. During dredging, the DO values decreased sharply at the dredging point and gradually at all other sampling Stations. After dredging, by May, 2011, the DO values had increased to its original values, although it tended to decrease slightly between the months of July and September, 2011. This could be as a result of rainfall carrying silts and spoils from the river bank back into the river. However, it was noted that as the dry season set in, from November, 2011 to January, 2012, the DO values increased to the original level. The factors responsible for DO depletions are probably linked to oxidation of re-suspended organic matter (Narayanan, 2011; Otuknedor and Obiukwu, 2005).

The nutrients in the water body, especially the phosphates did not seem to show much variation throughout the sampling period, the phosphate values obtained did not follow any particular trend. The nitrate concentrations decreased sharply at all the sampling points during the months of March, 2011. This equally agrees with the findings of Ohimain *et al.*, (2008). There were low sulphate concentrations at all the locations before the dredging. During the dredging, the sulphate contents increased to 33 mg/L However, between six to nine months after dredging, the values of these nutrients returned to their normal pre-dredging values.

CONCLUSION

This study has shown that the dredging of Nworie River actually caused physical as well as chemical alteration of the water quality. However, most of the changes were localized, and of short term, if not for the abandoned dredge spoils by the river bank; because the results of the 9 months post-dredging monitoring showed that there was considerable recovery few months after dredging; and this has obvious practical implications.

Variations in the water physicochemistry, following the dredging, seemed to be responsible for reduction of zooplankton, fish kills and vegetation damage, etc.

Furthermore, apart from the adverse impacts of the dumped dredge spoils on the aquatic ecosystem, the terrestrial environment, plants and other associated, biota on land are adversely affected, especially when such spoils are of toxic nature.

REFERENCES

Agunwamba, J. C, Onuoha, K. C and Okoye, A. C (2011) Potential effects on the marine Environment of Dredging of the Bonny channel in Niger Delta. *Environmental Monitoring Assessment*. Springer Science 10 (7): 61-65.

Alinnor, I. J and Obiji, I. A (2010). Assessment of trace metal composition in fish samples from Nworie River . *Pakistan Journal of Nutrition* 9: 81-85.

APHA (American Public Health Association) (1995) *Standard methods for the Examination of water and waste water.* 5th ed APHA/ AWWA/ WPCF. Washington, D. C 946p.

Delaune, R. D and Smith C. J (1995) Release of Nutrients and Heavy metals following oxidation of freshwater and saline sediments. *Journal of Environment Quality* 14:167-168

HACH (1997). *HACH DR/2010 Spectrophotometric Handbook* Hach Company, USA pp 147- 303.

Ihejirika, E. I. Nwachukwu. M. I, Udensi. J. U, Ihejirika, O. C and Agbaegbu, M. C. (2011) Management Consequences and Disease Transmission Potentials of Dredge sediments from Nworie River, Owerri, Eastern Nigeria.

Journal of Biodiversity and Environmental Science 1 (5): 32-38

ISEPA / MPE (2008). *Environment Impact Assessment of Nworie River* Imo State Environmental Protection Agency / Ministry of Petroleum and Environment Draft Report pp 7-48.

Lewis, M. A Wiber, D.E., Stanley, R. S and Moore, J. C (2001) Dredging impact on Urbanized Florida Bayou: Effects on Benthos and Algal Periphyton *Environ. Pollution* 115:81-85.

Narayanan, P. (2011) *Environmental Pollution: Principles, Analysis and Control.* Satish Kumar Jain, New Delhi India pp. 127- 183.

Nwigwe, H. C (2011) *Aquatic Resource Management: A tool for food security in Nigeria.* 19[Th] Inaugural Lecture of Federal University of Technology, Owerri, Nigeria 72p

Ohimain, E. I and Andriesse, W. (2004) Environmental impacts of Abandoned dredge spoils and sediments. Available options for their handling, restoration and rehabilitation. *Journal of soil and sediment* 4:59-65.

Ohimain, E. I., Imoobe, T.O.I and Bawo, D.D.S. (2008). Changes in water physico-chemical properties following the dredging of an oil well Access Canal in the Niger Delta. *World Journal of Agric Sci.* 4(6) :752- 758.

Okpokwasili, G. C. and Ogbulie, J. N (1993) Bacterial and metal quality of Tilapia (*Oreochromis nilotica*) Aquaculture systems. *International Journal of Environmental Health Research 3:190-202.*

Otuknedor T. V and Obiukwu. C (2005) Impacts of Refinery effluent on the physico-chemical properties of water body in the Niger Delta. *Applied Ecology and Environmental Research* 3 (1): 61- 72.

Perin, G., Fabris, R. Robello-Wagener, C. H. and Scotto, C. (1997) A five year study on the heavy metal pollution of Guanabara Bay sediment and Evaluation of metal Bioavailability by means of Geological speciation. *Water Research.* 31 (12) 3017- 3028.

Reavell, P. E. (1997) The effects of dredging on light penetration in the Boro River, Okarango Delta, *Water Resources* 23. 109-114.

Singh, S.P., Tack, F.M.G and Verloo M. G (1998) Land Disposal of heavy metal contaminated dredged sediments. A Review of Environmental Aspects. *Land Contamination and Reclamation* 6 (3):1-19

Smith, S. D, K and Rule M.J (2001) The effects of Dredge spoil dumping on a shallow water soft, sediment community in the solitary island marine Park, NSN, Australia, *Marine Pollution Bulletin* 42 (11). 104-104.

Udensi, J. U and Opara. F. N (2011) Waste to wealth: An Approach to Environmental management. *International Journal of Environmental Health and Human Development.* 12 (2) 66-70.