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Preliminary Assessment of Some Physicochemical Parameters During Dredging of Nworie River, Owerri

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Abstract: The projected dredging of the Nworie River apart from its tourism potentials was hinged on the following factors: Eutrophication, sedimentation and pollutants. This investigation surveyed the following parameters for both surface and sediment samples: pH, Conductivity, Nitrate, Phosphate, Cl, Ca, Mg, Pb, Fe, Zn, Mn, Cu, Al, Cd, TOC; while Alkanity, TDS, TSS, Turbidity, DO, BOD were for water samples only. Three sampling locations were selected for comparative studies: Station 1, a partially dredged section of the river, station 2, dredged portion and station 3 the control section in Egbu axis of Otamiri River (non dredged). Apart from in situ measurement taken for pH and conductivity, the other variables were determined by data logging spectrophotometer. The mean pH value of 5.2 indicates the water is acidic and not fit for human consumption. Pb and Fe values in the sediment samples (0.4331 mg/l and 0.4867 mg/l respectively) exceeded the safe limits of WHO standard. The low levels of the nutrients, N and P and the mean DO value of 5.633 mg/l shows the dredging project will support aquatic biodiversity. There was significant difference between the surface and sediment samples of the parameters studied. The environmental and health implications of the variables were examined.

Key words: Dredging, water, sediments, Nworie river

INTRODUCTION

Nworie River is a first order stream that runs about a 5km course across Owerri metropolosis in Imo State before emptying into another river, the *Otamiri* River. It flows through the Federal Medical Centre (FMC) Owerri, Alvan Ikoku Federal College of Education (AIFCE), Owerri and Holy Ghost College Owerri. All these institutions discharge their untreated waste into Nworie River. The river acts as a source of drinking water, fishing and other domestic uses for the inhabitants. Its watershed is subject to intensive human and industrial activities resulting in the discharge of a wide range of pollutants. Dredging operations involve the removal of bed materials and associated vegetation from a river channel; or simply under water evacuations to establish a channel to improve navigation and commercial activities. The Imo State government decided to dredge the Nworie River in view of environmental, health and economic concerns hinged on such determinant factors as: Eutrophication, Sedimentation and Pollutants; which will help to reduce aquatic vegetation growth by lowering the river bed below photic zone. This in turn will help in dealing with nutrient loading, increase the habitat of fish and reduce the breeding ground for mosquitoes (Njoku and Acho, 2010). However the suspended sediment load and turbidity of a river are increased during the removal of bed or bank material and as a consequence other water quality characteristics such as temperature are affected (Ede and Williams, 2008). Also increased turbidity reduces high penetration and therefore primary productivity, which has a knock on effect throughout the food chain; and also most fishes, will have a reduced capacity to find and capture prey or food. Major modifications of the hydrological characteristics enhance pollutant re-routing capabilities of flood plains (Abam, 2008). But the effects of dredging on soft bottom organisms may be difficult to identity as the dredge may miss some areas entirely, leading to some sediment slumping (Jones, 1986).

Dredging may remove large amounts of sediments, change harbours features and modify the structure and dynamics of the soft bottom community (Kenny and Rees, 1996; Lewis *et al*., 2001). Studies on the assessment of the physiochemical variables of Nworie River are therefore necessary to understand its environmental and health effects. Nnaji and Duru (2006), working on Nworie River prior to the dredging activity analysed parameters such as pH, TDS, TSS, DO, Nitrate, Total hardness, phosphate, calcium and lead and found they exceeded safe limits. They concluded that Nworie River was polluted and posed a health threat to Owerri residents. Alinnor and Obiji (2010) working on the heavy metal content of fish samples from Nworie River, identified Fe, Cd, Mn, in fish specie *Tilapia guineesis* whereas Pb and Hg were below detection

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level. Dredging has been variously reported to cause changes in the physicochemical environment (Ohimain *et al*., 2008a, 2008b; Ohimain, 2006). For instance, as a result of dredging in Warri River, the pH of the dredged canal decreased from 7.2 to 4.0, Dissolved Oxygen (DO) decreased considerably from 6.0 mg/l to 0.4 mg/l, while BOD_5 increased from 1.0 mg/l to 18.0 mg/l. COD, Oil and grease, conductivity, TDS and sulphate values similarly increased, while Nitrate and alkalinity values decreased after dredging. At the dredged canal, turbidity and TSS increased rapidly after dredging, attaining a value of 11,398 NTU and 8200 mg/l respectively. Result of post dredging monitoring revealed that water quality improved significantly (after six months). pH and DO appreciated while COD, BOD_5, oil and grease depreciated to values close to pre-dredging concentrations (Ohimain *et al*., 2008a).

MATERIALS AND METHODS

Area of study: Nworie River watershed is subject to intensive human and industrial activities resulting in the discharge of a wide range of pollutants. The river is used for various domestic applications by inhabitants of Owerri. When the public water supply fails, the river further serves as a source of direct drinking water, especially for the poorer segment of the city. Occasionally children bath in the river. Nworie River started in Ohii in Mbatoli L.G.A Imo State and terminates into *Otamiri* river at Nekede (Fig. 1).

Nworie River is polluted by organic wastes as a result of inefficient waste management in Owerri.

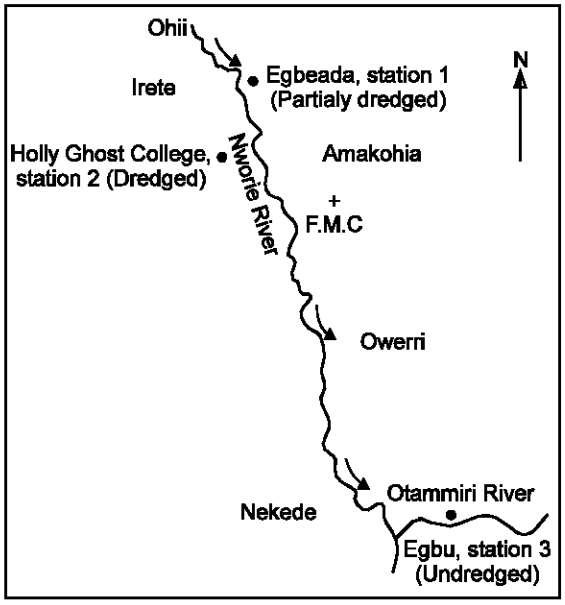

Fig. 1: Map showing sampling stations of Nworie River, July 2010. Source: Federal survey maps Owerri, Imo state, Nigeria 2010. Scale: 1,5000

Design of sample collection and procedure: Three sample stations were established after a reconnaissance visit to the river. The criteria for the choice of the sampling stations at the non-dredged station, partially dredged station and dredged station was for comparative studies. Station one is the partially dredged point at the *Egbeada* axis of the river. Station two is the dredged point close to Holy Ghost College Owerri. Station three is at *Egbu* end of the *Otamiri* River where no dredging activities took place. Samples were collected from four points and their mean recoded. Sampling was done during the rainy season in the month of July. Sediment and water samples were collected in 1 litre glass container respectively, labeled and transported to Ministry of petroleum and Environment (UNIDO/RAC) laboratory for analysis. Standard analytical methods were used for all the physicochemical and biological analysis (APHA, 1992).

Physicochemical and biological analyses: *In situ* measurement of pH and conductivity for water and sediments was taken in the field during sampling with pH meter (Suntex model TS-2). Other parameters were analysed in the laboratory with the use of spectrophotometer (Hach DR/2010), using their various specific methods.

Analysis of data: Statistical tools such as mean, standard deviation and variance were used to analyse the data obtained to ascertain how representative and close the data obtained were.

Two way analyses of variance were used to show significance difference between the samples and stations. Correlation analysis was carried out to show the relationship among the physicochemical and biological parameters.

RESULTS AND DISCUSSION

Tables 1 and 2 show the levels of the physiochemical and biological variables of Nworie River from water and sediment samples.

The mean concentration of pH for both water and sediment are low showing acidity with the lowest pH at the dredged station (5.24) for sediments and 5.82 for water samples. A mean pH of 5.6 was reported in a previous study conducted on Nworie River (Nnaji and Duru, 2006), which shows the water body was still acidic with the dredging project. There was a decrease from 6.22 to 5.82 for water samples from non-dredged station; and from 5.67 to 5.24 for sediments. A similar decrease of pH was reported in dredging of Warri River from 7.2 to 4.2 (Ohimain *et al*., 2008a). The pyrites when undisturbed under water cover are innocuous, but their disturbance often results in severe acidification, heavy metal pollution and ecosystem damage. The exposure of these pyrites through dredging and spoil disposal

Table 1: Mean of the measured physicochemical and biological parameters of the surface water samples of Nworie River for the month of July, 2010

Parameter	WHO's STD	Mean	Range	Partially dredged	Dredged	Undredged	Standard deviation
pH	6.5-8.5	5.897	5.65-6.22	5.65	5.82	6.22	0.293
Conductivitys (µS/cm)	100	113.000	84-155	100	84	155	37.242
TDS (mg/l)	250	56	47-76	50	42	76	17.776
TSS (mg/l)	50	18.333	13-26	26	16	13	6.806
Turbidity NTU	50	42.333	2-73	73	52	2	36.474
Nitrate (mg/l)	40	9.033	4.7-12.4	12.4	4.7	10	3.939
Phosphate (mg/l)	5	2.427	0.35-1.72	1.72	0.56	0.35	2.303
Sulphate (mg/l)	250	8.4000	2-13.1	13.1	10.1	2	5.742
Alkalinity (mg/l)	200	24.933	14.9-37.4	37.4	14.9	22.5	11.446
Chloride (mg/l)	200	12.533	8.5-16.2	16.2	12.8	8.5	3.807
DO (mg/l)	4.0	5.633	4.6-7.0	5.3	4.6	7.0	1.234
BOD (mg/l)							
Calcium (Ca mg/l)	70	0.727	0.08-1.9	1.9	0.2	0.08	1.018
Magnessium (Mg mg/l)	0.5	0.217	0.01-0.6	0.6	0.04	0.01	0.332
Lead (Pb mg/l)	0.05	0.0433	0.02-0.08	0.08	0.03	0.02	0.032
Iron (Fe mg/l)	0.3	0.4100	0.27-0.62	0.34	0.62	0.27	0.1852
Zinc (Zn mg/l)	<1.0	0.567	0.4-0.7	0.6	0.4	0.7	0.153
Manganese (Mn mg/l)	0.4	0.733	0.05-0.07	0.07	0.05	0.1	0.0252
Chromium (Cr mg/l)	0.1		BDL	BDL	BDL	BDL	
Copper (Cu mg/l)	0.3	0.8110	0.19-1.24	1.24	1.003	0.19	0.551
TOC (%)		BDL	BDL	BDL	BDL	BDL	
Aluminium (Al mg/l)		0.91	0.69-0.91	0.91	0.72	0.69	0.110
Cadmium (Cd mg/l)		0.046	0.02-0.052	0.046	0.052	0.02	0.173

Table 2: Mean of the measured physicochemical and biological parameters of the sediments samples of Nworie River for the month of July, 2010

Parameter	WHO's STD	Mean	Range	Partially dredged	Dredged	Undredged	Standard deviation
pH	6.5-8.5	5.243	5.24-5.67	5.36	5.24	5.67	0.222
Conductivity (µS/cm)	100	111.8000	104.00-118.80	112.6	104.0	118.8	7.432
Nitrate (mg/l)	40	0.3400	0.16-0.59	0.59	0.27	0.16	0.223
Phosphate (mg/l)	5	1.8500	1.65-2.08	2.08	1.65	1.82	0.217
Sulphate (mg/l)	250	1.8733	1.03-2.36	2.23	2.36	1.03	0.7332
Chloride (mg/l)	200	1.5300	1.30-1.82	1.82	1.47	1.30	0.2651
Calcium (Ca mg/l)	70	0.377	0.14-0.62	0.37	0.62	0.14	0.24007
Magnessium (Mg mg/l)	0.5	0.0403	0.03-0.05	0.04	0.051	0.03	0.01050
Lead (Pb mg/l)	0.05	0.4343	0.26-0.61	0.61	0.433	0.26	0.17500
Iron (Fe mg/l)	0.3	0.7967	0.29-1.62	1.62	0.48	0.29	0.7193
Zinc (Zn mg/l)	<1.0	0.3567	0.003-0.75	0.75	0.32	0.003	0.3763
Manganese (Mn mg/l)	0.4	0.0467	0.00-0.08	0.081	0.062	BDL	0.04163
Copper (Cu mg/l)	0.3	0.9867	0.02-1.52	1.42	1.52	0.021	0.8387
TOC (%)		0.5467	0.34-0.68	0.62	0.34	0.68	0.18148
Aluminium (Al mg/l)		0.8433	0.24-1.26	1.03	1.26	0.24	0.53501
Cadmium (Cd mg/l)		0.0467	0.03-0.06	0.061	0.049	0.026	0.01528

BDL = Below Detection Limit

results in pyrite oxidation leading to acidification and heavy metal pollution. Abandoned dredged machines and materials can also lead to low pH (Ohimain, 2006). The discharge of untreated organic waste into the Nworie River also lowers the pH (Umunnakwe *et al*., 2009). Acidification resulting from the oxidation of the pyritic spoils results in vegetation damage and fish kills (Ohimain, 2006).

Dissolved oxygen, DO decreased from 7.0 at the non-dredged station to 4.6 at the dredged station. However they are within safe limits set by WHO standard for aquatic biodiversity survival. But the FEPA standard for DO is 6-8 mg/l to sustain aquatic life including fish (FEPA, 1991). The DO values before dredging on Nworie River ranged between 1.05-20.34 mg/l (Nnaji and Duru, 2006). Turbidity, TSS increased from the non-dredged station to dredged station (Table 1). A rapid increase in turbidity and TSS attaining a value of 11,398 NTU and 8,200 mg/l respectively was reported after dredging of Warri River (Ohimain, 2006). Increased sediment load adversely affect the biodiversity of most rivers and lakes (Njoku and Acho, 2010). Though the turbidity mean value reported for Nworie River at the dredged site (52 NTU) slightly exceeded the limit of WHO standard, this

phenomenon reduces the depth of the river thus endangering those aquatic species requiring specific depth for survival. Invariably, sediment loaded rivers are murky or clouded and thus reduces light penetration. The partially dredged station at *Egbeada* axis of Nworie River recorded the highest level of turbidity (73 NTU). This could be as a result of combined effect of the discharge of untreated effluent into that axis as a result of abandoned dredged materials causing alteration of topography. Stagnant rivers or water bodies are breeding ground for mosquitoes, which are vectors of malaria parasites.

The two main nutrients investigated in this study were nitrogen (nitrates) and phosphorus (phosphate). Nitrate values decreased from 10 mg/l at the non-dredged station to 4.7 mg/l after dredging from the water samples and also decreased from 0.59 mg/l at the partially dredged to 0.27 mg/l at the dredged station. However the levels are within the acceptable limits. Alkalinity also decreased from 22.5 mg/l at the dredged station to 14.9 mg/l for the water samples. This decrease in nitrate level has been previously reported after dredging of the Warri River (Ohimain *et al*., 2008a). Phosphate increased after dredging of the river from 0.35 mg/l at the non-dredged to 0.56 mg/l at the dredged station. However they are within acceptable limits set by WHO standard. If Nworie River continues to receive excessive nutrients, it will stimulate excessive plant growth. This enhanced plant growth (alga bloom) reduces dissolved oxygen in the water. This particularly affects the ecosystem and in most cases may change it totally. Consequently, there is reduction in oxygen because of the decomposition of large masses of algae. In this situation, there will be death of aquatic animals such as fish. The net effect could be a reduced aquatic biodiversity. At the partially dredged station during the investigation, the phosphate value was highest, 1.72 mg/l.

Some of the heavy metals identified in Nworie River were lead, Pb; Iron, Fe; Zinc, Zn; manganese, Mn; Chromium, Cr; Copper, Cu and cadmium, Cd. From Table 1 and 2 the mean values of lead and and iron exceeded the allowable limits in the sediments samples (0.4343 mg/l and 0.7967 mg/l) and also the levels were higher than water samples. There was significant difference between the two ($p<0.05$).

Reports have shown that heavy metal pollution of ecosystems occurs more in sediments and aquatic animals than in water samples (Luinnik and Zubenko, 2000). There was increase in Pb levels from 0.26 mg/l at the non-dredged station to 0.433 mg/l after dredging. During dredging, vegetation, soil, sediment within the right of way of the proposed development are removed and typically dumped and their disturbance often results in heavy metal pollution (Ohimain, 2008). Besides wastes from illegal dumping, pollutants enter rivers through storm water and sediment run-off. These pollutants can lower reproductive success, prevent proper growth and development and even cause death in both humans and aquatic habitat. In humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing foetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problem in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tracks, joints and reproductive system and acute or chronic damage to the nervous system. Alinnor and Obiji (2010) working on Nworie River identified Fe, Cd and Mn from fresh fish specie *Tilapia guineensis* with mean values 3.275, 0.048 and 0.103 ppm whereas Pb was below detection limit. The analysis also shows Cu and Zn level of mean values 1.247 and 3.241 ppm in *Tilapia guineensis* respectively. Heavy metals gain access into the aquatic environment from natural and anthropogenic sources and distributed in the water bodies, suspended solids and sediments from the course of their transportation (Olajire and Imeo Kparia, 2000). Obodo (2004) working on Anambra River in Nigeria reported heavy metal contamination of fish samples such as Pb, Cu, Zn, Mn and Fe. These heavy metals may be ingested directly by eating the fish contaminated with elemental toxicants.

The cations Ca, Mg and Al are all within acceptable limits for both water and sediments samples. This indicates that the cationic exchange capability of the Nworie River is functional. The mean conductivity for water and sediments (113.000^{-} and 118.800^{-} are relatively slightly higher than the acceptable limits though the lowest values were recorded at the dredged station (84^{-} for water and 104.00 for sediments respectively).

Conclusion: The results of the analysis if the physiochemical variables investigated from water and sediment samples of Nworie River indicated that most of the parameters did not exceed the safe limits set by WHO standards. The mean pH of the river was still acidic even with the ongoing dredging project. Consequently, the water is not fit for human consumption. The TDS, TSS values were within safe limits of the WHO standard, while turbidity was slightly high at the dredged point. Turbidity increase might enhance the reduction of depth of the river thus endangering those aquatic species requiring specific depth for survival thereby setting the stage for their migration elsewhere. However, the suspended sediment load was not adversely affected as a result of the dredging. The low values of the mean concentration of the nutrients (N and P) indicate that eutrophication might not occur hence the dredging activity would still support aquatic biodiversity.

Though some heavy metals were identified both in the water and sediment samples, the mean concentration of lead and iron in the sediment samples exceeded the safe limits. This shows the water is polluted even with the dredging of the river. This could be proved as a result of observed reduction in quantity and size of some fish species caught by the local fishermen during field study such as *tilapia guineesis*, cat fish, electric fish. This could be as a result of combined effect of drastic reduction in organic wastes the fish population feed on (indicated by low N and P) and the concentration of the trace metals. In view of these findings, remediation methods should be adopted to ensure the safety of the environment and safeguard the aquatic life in the river as the project progresses.

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