International Journal of Pharmaceutical and Medical Research
Volume – 2 Issue – 5 October 2014
Website: www.woarjournals.org/IJPMR *ISSN: 2348-0262*

Heavy Metals Concentration Dynamics Following the Dredging of Nworie River in Imo State, South-Eastern Nigeria.

J.U.Udensi[1*], H.C.Nwigwe[1], R.N.Okechi[1], C.E.Ihejirika[2], C.F. Johnson[3], A.A. Nwachukwu[1], and H.U. Anuforo[4], Corresponding Author: R.N.Okechi+2348035086155

1. Department of Biotechnology, Federal University of Technology, Owerri.
2. Department of Environmental Technology Federal University of Technology, Owerri.
3. Imo State Environmental Protection Agency/Ministry ofPetroleum and Environment.
4. Department of Biological Science, Federal University of Technology, Owerri

Abstract: ***The impacts of dredging on heavy metals concentrations of an urban surface water body was monitored. This study was carried out for a period of eighteen months, from July 2010 to January 2012. Water samples were collected from 5 stations prior to, during and after dredging. The heavy metal analysis was done using Atomic Absorption Spectrophotometer by Shimadzu (AAS- Model 6650). Prior to dredging, the values of the heavy metals were as follows: Iron, Fe(0.03-0.58)mg/l, Copper, Cu(0.01-0.25)mg/l, Zinc, Zn(0.09-0.64)mg/l , Manganese, Mn(0.08-0.94)mg/l, lead, Pb(0.01-0.09)mg/l, Cadmium, Cd(0.00-0.02)mg/l, Chromium, Cr(0.01-0.94)mg/l. During the dredging, the values of the various metals increased: Fe (6.55mg/l), Cu(5. 11 mg/l), Zn(5.82mg/l), Mn(4.01mg/l), Pb(3.02mg/l), Cd(0.91mg/l), Cr(2.00mg/l). Nine months after the dredging, the metals declined in this range: Fe (0.11mg/l), Cu(0.97mg/l), Zn (0.75mg/l), Mn(0.17mg/l), Pb(0.08mg/l), Cd(0.01mg/l), Cr(0.03mg/l). The result of the statistical analysis showed significant difference (P< 0.05) for the variations in the heavy metals values of the water samples. This implies that river-bed sediment has been the reservoir of these heavy metals, therefore the dredged materials once excavated from the river should be capped and confined in geotubes before disposal.***

Keywords: Heavy metals, Dredging, Dynamics, Atomic Spectrophotometry, Nworie River.

1. Introduction

When Nworie River is one of the major rivers in Owerri metropolis in Imo State, Nigeria. It covers a distance of about 7.5Km across Owerri Geopolitical Zone in South-eastern Nigeria (ISEPA/MPE 2008). The river transverses four Local Government Areas, namely: Mbaitoli, Owerri North, Owerri Municipality, and Owerri West L.G.As. Along the route of the river are both private and public institutions that discharge their wastes into the water body. There is incessant discharge of untreated wastes together with silts washed by erosion from the urban centres into the river (Nwigwe, 2011). This gave cause for urgent dredging of the river to entrench sustainable waste management strategies in order to protect the river as well as the flora and fauna from pollution and extermination.

The river serves as a source of drinking water, fishing and other domestic uses for the inhabitants of Owerri. As a result, the Imo State Government in collaboration with the Niger Delta Development commission (NDDC) decided to dredge the river in view of the environmental, health and economic concerns hinged on such determinant factors as eutrophication, sedimentation and pollution.

Dredging is an excavation activity usually carried out wholly or at least partly under water, in shallow seas or fresh water areas with the purpose of gathering up bottom sediment and disposing them at different locations. The dredging operation can create disturbances in aquatic ecosystem, often with adverse impacts (Smith and Rule, 2001; Nayar *et al.*, 2004; Dyekjaer, 2005). During dredging, water- way sediment, soil, river banks and vegetations along the right of way are typically removed and deposited as dredge spoils at the river bank (Ohimain *et al.*,2008). This has resulted to a number of environmental impacts including acidification and water contamination which have caused fish kills and vegetation damage (Ohimain and Andriesse, 2004). It has been reported that dredging causes re-suspension of sediments which may be linked to re-mobilization of contaminants, particularly heavy metals with increase in their bioavailability (Perin *et al.*, 1997). Heavy metals \gain access into the aquatic environment from both natural and anthropogenic sources and they become distributed in water bodies, suspended solids and sediments during the course of their transportation (Olajire and Imeopara, 2000; Okoye, 2011; Yadar, 2011). Heavy metal pollution of ecosystem is more in sediments and aquatic animals than in the pelagic region of the water (Olowu, 2010; Luinnik and Zubenko, 2000). The heavy metals can affect the aquatic biota, posing health hazards to fish consumers, such as humans and other wild life through food chain (Alinnor and Obiji, 2010; Singh and Kalamdhad, 2011; Dural *et al.*, 2007; Duruibe *et al.*, 2007; Bhunpander *et al.*, 2011; Obasohan and Eguaroen, 2008). It has also been report that sediments serve as reservoirs and sinks for heavy metals and dredging can cause the re-suspension of sediment-bound trace metals (Abida *et al.*,2009; Ouyang *et al.*, 2002; Stephens *et al.*,

2001, Olowu *et al.,* 2010). Re-suspension of sediments causes the oxidation of sediment leading to the mobilization of metals into the water body (Saulnier and Mucci, 2000).
Hence, this study is aimed at assessing and monitoring the variations in the heavy metals concentrations of the river following the dredging.

2. Study Area

This study was carried out in Imo State, situated in the South-eastern rainforest vegetational belt of Nigeria. It lies between latitude $5^0 4^1$ and 6^0 3^1 N and longitude $6^0 15^1$ and 7^0 34^1 E. The area is dominated by plains 200m above sea level except for elevation associated with Okigwe upland (ISEPA/MPE, 2008). There are two major seasons: wet season which last from April to October and dry season from November to March. The study area has an annual rainfall of about 1700mm to 2500m which is concentrated almost entirely between the months of March and October. Average humidity of 80%-85% occurs during the rainy season. Temperature is similar all over the state, with maximum values ranging from 28^0C to 35^0C and minimum values from 19^0C to 24^0C (ISEPA/MPE, 2008).

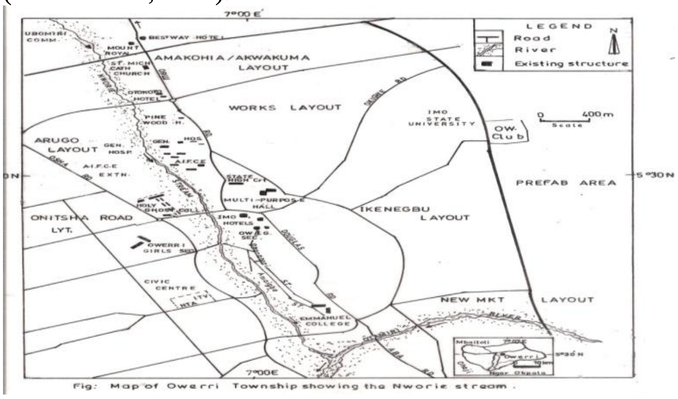

Fig. 1 map of Owerri township showing the Nworie River

3. Mateials and Methods

The urban surface water body that serves approximately two million inhabitants of Owerri was studied from July 2010 to January 2012. 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 500m 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, on March 2011, samples were collected from all the stations. Post dredging samples were collected after dredging as follow: May, 2011, July 2011, September 2011, November 2011, and January 2012 covering a monitoring period of 9 months to determine if the effects of dredging is of long-term. The water samples were collected in 75cl (0.75litres) sterile plastic bottles for the heavy metals analysis. During sampling, some parameters such as pH, temperature, conductivity, total dissolved solids (TDS) and Dissolved Oxygen (DO) were determine in- situ using pH meter/thermometer (HACH EC 20), conductivity/ TDS meter (HACH Co 150) and dissolved oxygen meter respectively. Separate samples were collected for Biochemical Oxygen Demand using 300ml BOD bottles. According to the standard methods of (APHA, 1995), Atomic Absorption Spectrophotometers by Shimadzu (AAS- Model 6650) was used for the heavy metal analysis. Other physicochemical parameters such as total suspended solids (TSS), turbidity, nitrate, sulphate, phosphate were analyzed using portable data-logging spectrophotometer (HACH DR 2010). In order to determine the origin of the elevated heavy metals, a correlation analysis of the heavy metal values with the results of physicochemical parameters was carried out.

4. Results and Discussion

Heavy metals concentrations in the river occurred in traces prior to the dredging. However, following the dredging, the concentrations of the heavy metals increased in several folds. The heavy metals values decreased drastically 3 to 9 months after the dredging activities. The concentration of Iron in the surface water sample of Nworie River before dredging was within the range of 0.3-0.58mg/l , the concentration of Copper was 0.01- 0.25mg/l, Zinc, 0.09- 0.64mg/l, Manganese, 0.08-0.94,g/l, Lead, 0.01-0.09mg/l, Cadmium, 0.00-0.02mg/l, and Chromium, 0.01-0.94 mg/l. However, following the dredging, the concentrations of various heavy metals increased as follow: Fe (6.55mg/l), Cu (5.11mg/l), Zn (5.82mg/l), Mn (4.01mg/l), Pb (3.02mg/l), Cd (0.91mg/l), Cr (2.00mg/l). Several months after dredging, the metals decreased in this range: Fe (0.9-0.ll mg/l), Cu (2.82-0.97mg/l), Zn (1.52- 0.75mg/l), Mn (1.4-0.17mg/l), Pb (0.12-0.08mg/l), Cd (0.02-0.01mg/l), and Cr (0.92-0.03mg/l).
The reduction in heavy metals concentration could be due to dilution as the river water moves from upstream, the undisturbed area to downstream. However, the presence of uncapped and unconfined contaminated excavated dredged materials dumped by the river bank has led to prolonged effects of dredging. Similar cases of washing of leachates into water body have been reported by many researchers (Ohimain *et al.*, 2008; USEPA/ USACE, 1998; and Turner, 1997). A correlation study was carried out between the heavy metals and the physicochemical parameters. This was done in order to understand the source of the elevated heavy metals. From the correlation analysis all the 11 physicochemical parameters exhibited relationship with the heavy metals as shown in Table (1**).** There was strong negative correlation (-0.756 to -0.928) between the pH and all the metals. This implies that acidity plays major role in the elevation of the water heavy metals concentrations. The relationship between the temperature and the heavy metals was relatively low ranging from -0.115 to 0.192. Then other parameters such as turbidity, conductivity, TDS, TSS, phosphate, sulphate correlated positively with the heavy metals. Their high values encouraged the deposition of the heavy metals. For instance, sulphate concentrations had a strong positive correlation with all the metals with correlation coefficients 0.709 to 0.971. It has been previously reported that sediments of aquatic ecosystem are high in non-biovailable forms of heavy metals that are bound to the sediment as metal sulphides (Ohimain and Andriesse, 2004; Horsfall and Spiff, 2002). So the dredging activity may have caused re-suspension of anoxic sediments, leading to their oxidation, which resulted in the formation of sulphuric acid causing the lowering of the pH and the release of the heavy metals.
Conductivity and total dissolved solids (TDS) showed similar strong positive relationship with all the metals, this may be due to the fact that the acidification following the oxidation of the sediments has caused the mobilization of the sediment-bound-

metals into the water column. Turbidity and total suspended solid (TSS) had strong positive relationship with the heavy metals. This could be due to increased water turbidity, suspended solids as well as the concentrations of the heavy metals associated with the sediment phase. Dissolved Oxygen (DO) correlated negatively with the metals while BOD had a strong positive correlation with them. Probably, the suspension of sediment has exerted an oxygen demand causing the depletion of oxygen which is utilized for the oxidation of metal sulphides to their sulphate forms thus leaching the metals back into water body.

5. Conclusion

In monitoring the variations of the heavy metals concentrations following the dredging of Nworie river, it was discovered that the dredging activities caused a change in the water quality, especially increase in heavy metal values. The result of 9 months post-dredging analysis showed that these effects were short-lived, and were only prolonged because the contaminated dredge spoils were dumped unconfined at the river bank. Also changes in the other physicochemical parameters influenced the dynamics of the heavy metal concentrations.

References

[1] Abida B, Harikrishna S, and Irfanulla K. 2009. Analysis of Heavy Metals in Water, Sediment and Fish Samples of Madwala Lakes of Bangalore Kamataka. International Journal of Chem. Tech. Research ***1*** **(2):** 245-249.

[2] Alinnor I.J, and Obiji I.A**.** 2010 Assessment of Trace Metal Composition in Fish Samples from Nworie River. Parkistan Journal of Nutrition **9**:81-85.

[3] American Public Health Association. 1995. Standards for the Examination of Water and Wastewater (APHA/ AWWA /WPCF), Washington D.C. p.946.

[4] Bhupander K, Mukherjee D.P, Kumar S, Mishra M, Praksh D, Singh S.K.M, and Sharina CS. 2011. Bioaccumulation of Heavy metals in Muscle tissue of fishes from selected aquaculture ponds in East Kolkata wetlands. Annals of Biological Research **2 (5):** 125-134.

[5] Dural M, Goksu L.M, and Ozak A..A. 2007. Investgation of heavy metal levels in economically important fish species captured from Tusla Lagoom. Food Chemistry. **102:** 415-421.

[6] Duruibe J.O, Ogwuegbu M.D.C, and Egwurugwu J.N. 2002. Hevy metals pollution and Human bio-toxic effects. International journal of physical science **2 (5***):112-m8.*

[7] Horsfall M, and Spiff,I A. 2002. Distribution and partitioning of Trace metals in sediments of the lower reaches of the New Calabar River, Port – Harcourt, Nigeria. Environmental monitoring and Assessments. **78**:309-326.

[8] ISEPA/ MPE 2008. Environmental Impact Assessment of Nworie River. Imo State Environmental protection Agency/ Ministry of Petroleum and Environment Draft Report. 7-48 .

[9] Luinnik P.M, and Zubenko I.B. 2000. Role of bottom sediments in the secondary pollution of Aquatic Environment by Heavy metals compounds. Lakes and Reservoirs: manage **5**:11-12.

[10] Nayar S, Goh B.P.L, and Chon L.M. 2004. Environment Impact of Heavy Metals from Dredged and Resuspended Sediment on Phytoplankton and Bacteria . Assessed in– Situ Mesocosms. Ecotoxicology and Environmental Safety, **59(3)** 349-309.

[11] Obasohan E.I, and Eguaroen I.O. 2008. seasonal variations of Bioaccumulation of heavy metals in a fresh water fish (*Erpetoichythy calabaricus*) from Ogba river Benin city , Nigeria. African Journal of general Agriculture. **4 (3):** 153-156.

[12] Ohimain E.I, Jonathan G, and Aboh S.O. 2008. Variations in Heavy metals concentrations following the dredging of an oil well canal in Niger Delta. Advances in Biological Research **2 (5-6):** 97-103.

[13] Ohimain E.I, and Andriesse W. 2004. Environmental impacts of Abandoned Dredged soil and sediments:Available option for their Handling, Restoration and Rehabilitation . Journal of soil and sediment **4**:59-65.

[14] Okoye C, Ibeto N, and Ihedioha J.N. 2011. Assessment of heavy metals in chicken feeds sold in south eastern Nigeria. Advances in Applied Science Research **2(3):** 63-68.

[15] Olajire A.A, and Imeopara, C . (2000) A study of the water quality of the Osun River. Metal monitoring and geochemistry. ***Bull. Chem.. soc. Ethopia .*** **14:1-8**

[16] Olowu A.R, Yejugo O.O, Adeniyi,O A.I, Denloye B.A, Babatunde O.A, and Ogundayo L.A. 2010. Determination of Heavy metals in fish tissues , water, and sediment from Epe and Badagry Lagoons, Lagos Nigeria. Environmental Journal of chemistry **7(1):** 215-134.

[17] Ouyang Y, Higmann J, Thompson J, O'. Tool T, and Campbell D. 2002. Characterization and spatial distribution of heavy metals in sediments from Cedar and Ortega Rivers. Journal of Contamination Hydrology. **54**:19-35.

[18] Perin G, Fabris R, Manente S, Robello W, Hamacher C, 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

[19] Saulnier I, and Mucci A. 2000. Trace Metal Remobilization Following the Re-suspension of Estuarine Sediments Sagueney Fjord, Canada. Applied Geochem. 1**5**:203-222.

[20] Singh J, and Kalamdhad, A.S. 2011. Effects of Heavy Metals on Soils, Plants, Human Health and Aquatic Life. International Journal of Research in Chemistry and Environment, **1**:15-21.

[21] Smith S.D.K, and Rule M.J. 2001. The Effects of Dredge Spoil Dumping on a Shallow soft Sediment Community in the Solitary Island Marine Park, NSN, Australia. Marine Pollution Bulletin **42 (11):**104-1048.

[22] Stephens R.S, Alloway B.J, Parker A, Carter J.E, and Hodson M.E. 2001. Changes in the Leachability of Metals from Dredge Canals Sediments During Drying and Oxidation. Environmental Pollution. **114**: 407- 413.

[23] Turner R.E. 1997. Wetland Loss in the Northern Gulf of Mexico Multiple Working Hypothesis . Estuaries. **20** : 1-3.

[24] USEPA/ USACE. 1998. Evaluation of Dredged Material Proposed for Discharge in Water of the US. Inland Testing Manual Report No . EPA- 823-398-398-004. 391P-

[25] Yadar S.S, and Kumar R. (2011) Monitoring water quality of Kosi River district Uttar Pradesh, India. Advances in Applied Science Research **2 (3) :** 50-53