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Study on the Effects of Hydraulic Dredging and Disposal Operations on Water Quality of Nworie River, South-Eastern Nigeria

Justina Ugochi Udensi[1, *], Toochukwu Ekwutosi Ogbulie[1], Emeka-Nwabunnia Ijeoma[1], Nkeiruka Uche Chikezie[1], Ugochukwu Mmasi Godson[2], Awurum Ivy Nwaku[2], Ifeyinwa Celestina Mgbemena[1]

[1]Department of Biotechnology, Federal University of Technology, Owerri, Nigeria

[2]Biology Department, Alvan Ikoku Federal University of Education, Owerri, Nigeria

Email address:

udensiugochi@gmail.com (Justina U. U.), Ijeomaolaedo_k@yahoo.com (Emeka-Nwabunnia I.), uchikezie@yahoo.com (Nkeiruka U. C.), cudeeny@gmail.com (Ugochukwu M. G.), Ivymad86@yahoo.com (Awurum I. N.), drifeyinwa@gmail.com (Ifeyinwa C. M.)

[*]Corresponding author

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Abstract: A study was done to ascertain the effect of hydraulic dredging and spoils disposal on the physicochemical parameters of Nworie River. The study was carried out from July 2010 to January, 2012. Water samples were collected prior to, during and monitored several months after dredging. The samples were collected from 5 stations: station 1 was the dredging point, stations 2 and 3 were 250m and 500m upstream of the point, while and stations 4 and 5 were 250m and 500m downstream of it respectively. The physicochemical parameters of the water were analysed prior to dredging and most of the values obtained were within acceptable limit of established water standards. The pH was within the range of 6.5-7.8, Temperature 27.6-29.9°C, Conductivity 34-196µs/cm, Turbidity 0-76NTU, TDS 22.1-127.4 mg/l, TSS 9-51 mg/l, Nitrate 1.2-33.6mg/l, Phosphate 0.2-3.7mg/l, Sulphate 0- 33 mg/l, Dissolved Oxygen 4.3-9.4 mg/L and BOD_5 2.5 - 7.9 mg/l. During the dredging, the water physicochemistry changed: pH values decreased drastically to 4.6, DO to 1.3mg/l, Nitrate to 1.2 mg/l. Temperature increased to 30. 2°C, Turbidity 620NTU, TSS 349mg/L, Conductivity 498µs/cm, TDS 249 mg/l, BOD_5 19.1mg/l, Sulphate 33mg/l and Phosphate was 0.92mg/l. Three months after the dredging, the values for the parameters returned to their pre-dredging concentrations, however during rainy season, as the leachates and silts from the spoils were washed into the river, this prolonged the recovery of the river system to 9 months. This implies that the effect of dredging on the river is of short term but the disposal of the excavated materials at the river bank compounded and prolonged these impacts.

Keywords: Hydraulic, Dredging, Disposal Operations, Quality, Physiochemical, Nworie River

1. Introduction

Hydraulic dredging is a dredging technique which utilizes a cutterhead and pump system to suspend and suction the sediments into a slurry state, conveying the material via pipeline for discharge at different location. 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 [4] 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 water phase, release of nutrients, increase in eutrophication resulting in oxygen depletion and a host of other negative impacts. Though this technique is often used to keep water- ways navigable and for fishing of certain species of edible clams and crabs. Yet, the activity creates a lot of disturbance as well as threat to biological diversity in aquatic ecosystem [1]. The process of dredging creates spoils, that is, excess materials which include water- ways sediments, soil, river banks vegetation etc, which are carried away from the dredged area [19].

Through dredging, Nworie River being one of major rivers in Owerri metropolis in Imo State will regain its lost aesthetic and functional values. Another important reason for the dredging is that the river serves as a strategic water way capable of stimulating water transportation and tourism in Imo State [8]. It also serves as a source of drinking water, fishing and other domestic uses for about 2 million inhabitants of Owerri [7, 24, 25, 26].

As a result of pollution, siltation and euthrophication, Imo State Government in collaboration with the Niger Delta Development Commission (NDDC) decided to embark on dredging to restore the environmental, health and economic values of the water. Some of the problems associated with dredging activities cannot be over emphasizes since it is not far from what is obtainable elsewhere in other parts of the country especially the South-eastern region of Nigeria. *Ohimain et al* [14] has reported some of these consequences in Niger Delta during the dredging of a tributary of Warri river to enable the drilling of an oil well. These impacts include algal bloom, impairment of benthic invertebrates and destruction of zooplanktons

In addition, the dumping of dredge spoils by the river bank has caused more severe environmental impacts than the operation itself. The disposal of the unconfined spoils by the river bank has led to the acidification and water contamination which have resulted in fish kills and vegetation damage, increased turbidity, reduction of primary productivity, bioavailability of sediment's trace metals [13, 9, 17]. This is typical of Nigerian situation. In Nigeria, 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 fight t against poverty and mal-nutrition [15, 7, 2].

Hence this study was aimed at ascertaining the effects of dredging on the water quality of Nworie River and the impacts of abandoning the excavated spoils by the river bank.

2. Materials and Methods

2.1. The Study Area

This work was carried out in Imo State which is situated between latitude 5° 4^1 and 6° 3^1 N; and longitude 6° 15^1 and 7° 34^1 E in South-east Nigeria. The area is dominated by plains 200m above sea level except for elevation associated with Okigwe upland. There are two major seasons: rainy season which starts from April to October, and dry season from November to March. The annual rainfall of about 1700mm to 2500mm is concentrated almost entirely between the months of March and October.

Temperature is similar all over the state, with maximum values ranging from 28°C to 35°C and minimum values from 19°C to 24°C [8].

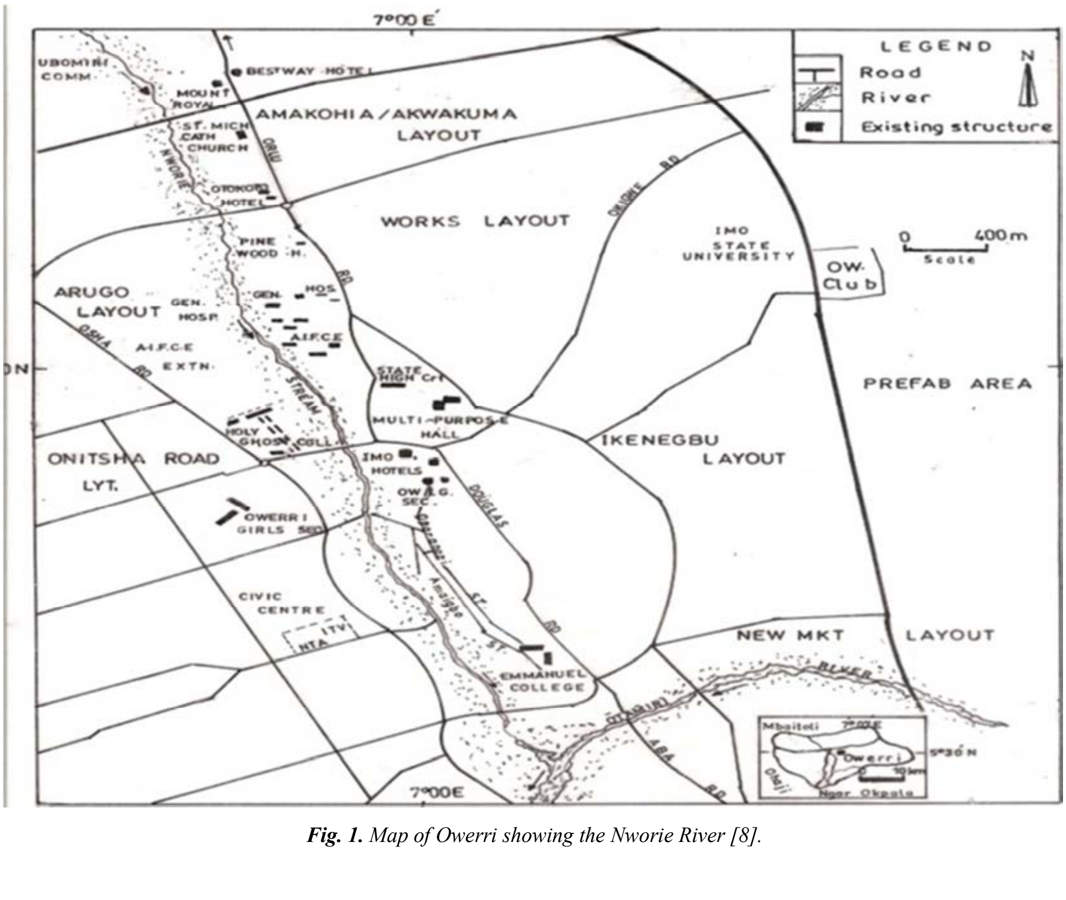

Fig. 1. Map of Owerri showing the Nworie River [8].

2.2. Sample Collection

The river serves approximately two million inhabitants of Owerri. The study period covered from July 2010 to January 2012. For water samples collection, five stations were established within the water body. 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, stations 3 and 5 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 bi-monthly after dredging as follows: 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 0.75litres sterile plastic bottles for laboratory analysis. Standard methods of [3] were used for the analysis.

During sample collection, the following parameters were analysed in–situ; pH, temperature, conductivity, total dissolved solids (TDS), Dissolved Oxygen (DO) using digital pH meter/thermometer (HACHEC 20), Conductivity/ TDS meter (HACH CO 150) and Dissolved Oxygen meter respectively. Separate samples were collected for BOD using 300ml BOD bottles with ground stopper. The portable datalogging Spectrophotometer was (HACH DR/ 2010) was used to determine turbidity, total suspended solids (TSS), colour, nitrate, phosphate and sulphate by selecting different wavelengths, program numbers and powder pillows where necessary.

After laboratory analyses, the data analysis was carried out using minitab statistical package to determine the correlation between the heavy metals and the physicochemical parameters (Table 1).

Table 1. *Pearson's correlations coefficients of heavy metals with physicochemical parameters following the dredging of Nworie River.*

Parameters Metals	pH	Temperature	Turbidity	Conductivity	TDS	TSS	DO	BOD_5	Phosphate	Nitrate	Sulphate
Copper	-0.756	-0.131	0.752	0.764	0.764	0.765	-0.704	0.893	0.605	-0.922	0.709
Zinc	-0.893	0.092	0.949	0.944	0.944	0.965	-0.862	0.956	0.813	-0.842	0.915
Iron	-0.928	0.113	0.890	0.9397	0.939	0.945	-0.920	0.981	0.829	-0.809	0.922
Lead	-0.910	0.192	0.961	0.966	0.966	0.989	-0.927	0.953	0.810	-0.785	0.961
Manganese	-0.928	0.205	0.949	0.984	0.984	0.995	-0.927	0.954	0.822	-0.807	0.971
Cadmium	-0.837	-0.115	0.770	0.899	0.899	0.887	-0.924	0.967	0.689	-0.873	0.854
Chromium	-0.812	0.046	0.717	0.800	0.800	0.789	-0.880	0.925	0.537	-0.869	0.811

3. Results and Discussion

Prior to dredging, the water quality was within the permissible limits of established water standards of [5, 23, 11] Table 2. As such the pre-dredging values of all the physicochemical parameters followed a particular trend. 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 it 5.4 and 5.6 were recorded respectively. Several months after dredging, the pH, values increased with the highest value of 7.4 recorded at 250m downstream location (Fig. 2).

Table 2. *Comparison of the mean of the physicochemical parameters with established water standards.*

PARAMETERS SOURCES	Upstream	250m US	500m US	Dredging point	250m DS	500mDS	Nekede	Downstream	WHO	FEPA	NIS
Temperature (°C)	28.6	27.6	28.8	27.8	28.6	29.9	28.0	29.8	20-30		Ambient
pH	7.2	7.3	7.5	6.8	7.8	7.7	7.6	6.5	6.5-8.5		6.5-8.5
Colour (Ptc_0)	28	32	61	152	91	24	259	33	100	15	15
Conductivity (µs/cm)	34	60	69	196	80	87	113	129	100	100	1000
Turbidity (NTU)	0	10	38	76	08	19	20	11	50	50	5
Total Dissolved solids TDS (mg/L)	22.1	30	44.9	127.4	52	56.6	73.5	83.9	250	250	500
Total suspended solids TSS (mg/L)	12	18	1.3	51	19	09	34	11	50	50	N/A
Nitrate (NO_3^-)	25	27	25	4.5	1.2	16.7	33.6	8.9	40	40	50
Phosphate (PO_4^{3-})	1.6	2.8	0.2	0.3	0.8	1.4	3.7	0.6	5	5	N/A

PARAMETERS SOURCES	Upstream	250m US	500m US	Dredging point	250m DS	500mDS	Nekede	Downstream	WHO	FEPA	NIS
Sulphate (SO_4^{2-})	33	1	30	0	0	13	13	5	250	250	100
Zinc (Zn)	0.16	0.64	1.52	0.44	0.22	1.04	0.65	0.08	<1.0		3
Iron (Fe)	0.53	0.88	0.90	0.73	0.87	1.26	1.04	0.91	0.3	0.3	0.3
Copper (Cu)	0.30	1.2	2.14	0.44	0.16	0.72	0.20	0.32	0.3		1.0
Chromium (Cr)	0.01	0.09	0.08	0.09	0.08	0.08	0.09	0.10	0.1	0.05	0.05
Cadmium (Cd)	0.01	0.03	0.02	0.02	0.02	0.04	0.06	0.02	N/A	0.01	0.003
Lead (Pb)	0.35	0.12	0.18	0.37	0.23	0.43	0.30	0.35	0.05	0.05	0.01
Manganese (Mn)	0.05	0.07	0.06	0.05	0.06	0.10	0.20	0.05	0.4		0.2
Dissolved oxygen (DO)	5.6	5.2	4.3	5.9	8.2	9.4	6.5	8.1	4.0	6-10	N/A
Biochemical oxygen demand (BOD_5)	2.7	2.9	2.5	4.3	6.1	7.9	4.8	5.5		10	

Fig. 3 also shows that temperature range remained relatively stable throughout the study period. The temperature ranged from 25.6°C – 30.2°C, and similar trends were recorded in all the stations. The lowest value of 25.6°C was recorded in July 2010, and highest value of 30.2°C in November, 2011. This was more of seasonal variations than as a result of the dredging activity. The turbidity (Fig. 5) and TSS (Fig. 7) in all the stations were less than 45NTU and 25mg/l respectively. However, turbidity plumes was 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 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 5mg/l. Data obtained were in line with values for Warri River where the dredging of any oil well access canal led to increase in turbidity form 20 NTU to 11398 NTU and TSS from 20mg/l to 8200mg/l [14]. Increased turbidity and TSS can lead to depletion of oxygen in a water body which will be of adverse effect to aquatic organisms [12]. Similar studies reported that dredging could cause decrease in light penetrations by between 25- 50% for over a distance of 12km and that this effect was persistent 18 months after dredging [18]. 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 [20, 22]. However, instead of such disposal operation for the excavated materials or spoils, they can be converted from waste to wealth [21]. Udensi and Opara [21] opined that such excavated materials can be coverted to wealth by using them for land reclamation and other construction related purposes instead of such improper disposal operation methods.

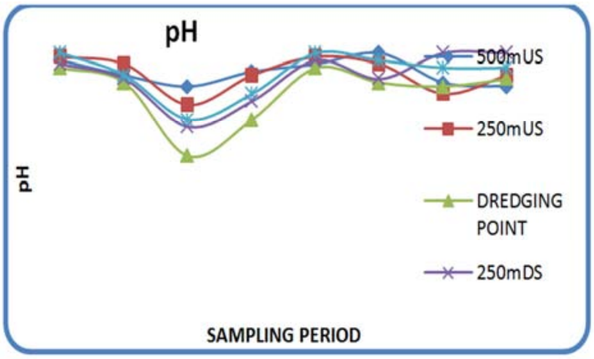

Fig. 2. *Changes in pH values.*

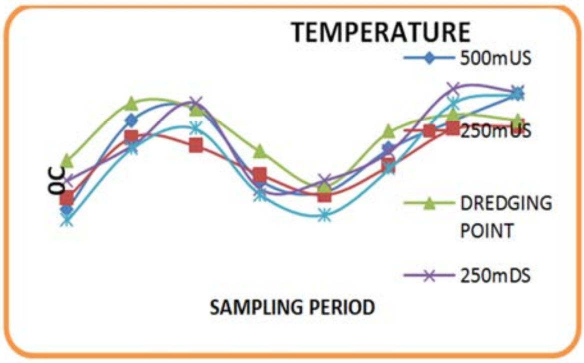

Fig. 3. *Changes in temperature values.*

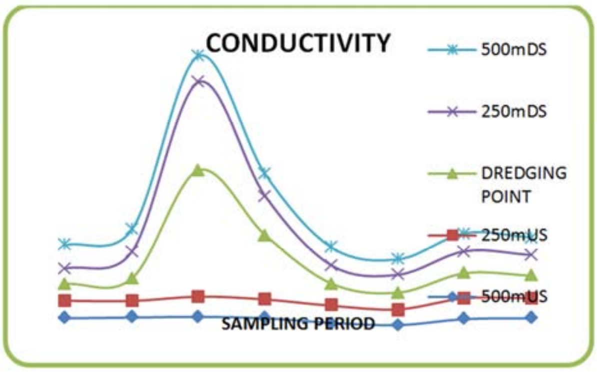

Fig. 4. *Changes in conductivity values.*

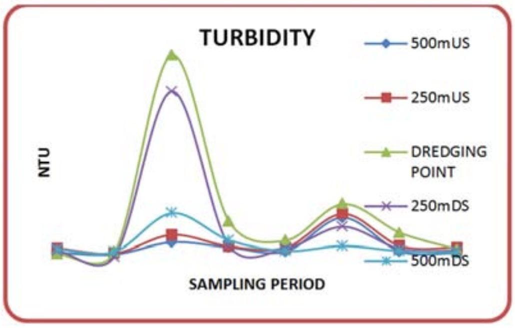

Fig. 5. *Changes in turbidity values.*

Conductivity and total dissolved solids (TDS) were also shown in Figs 4&6 respectively. 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 498µs/cm and 346µs/ cm respectively for conductivity and 249 mg/l and 173mg/l respectively for TDS. These values decreased six months after dredging in September, 2011 to 66µs/cm and 71µs/ cm for conductivity. Some trends were 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 99µs/cm and TDS 49.5mg/l. Ohimain *et al.,*[14] stated that increase in turbidity following dredging was related to the re-suspension of sediments and increased conductivity which in turn leads to changes in Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5) can be seen in Figs 8&9. 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_5 values ranged from 2mg/l to 4.3mg/l. During dredging the DO values decreased sharply at the dredging point and gradually at other sampling stations. After dredging, by the second month, 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 back into the river silts and spoils from the river bank. It was noted that as dry season set in, from November, 2011 to January, 2012, the DO values increased to its pre-dredging values. The factors responsible for DO depletions are probably linked to oxidation of re-suspended organic matter [10, 16].

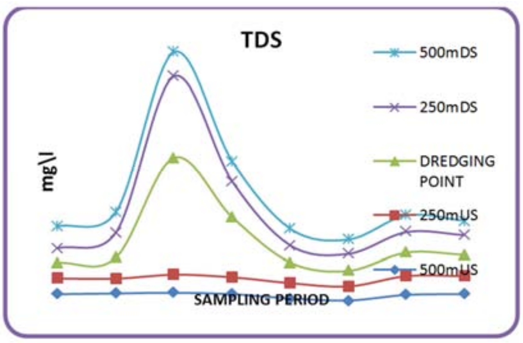

Fig. 6. *Changes in TDS values.*

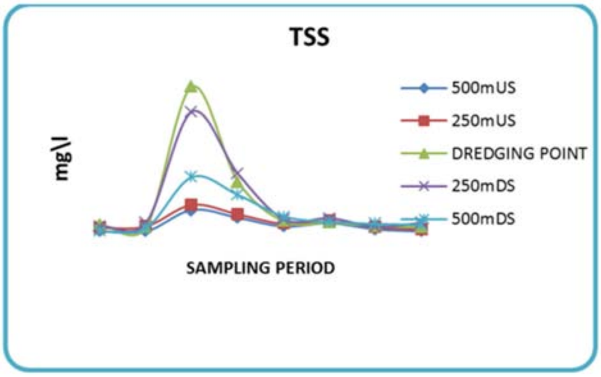

Fig. 7. *changes in TSS values.*

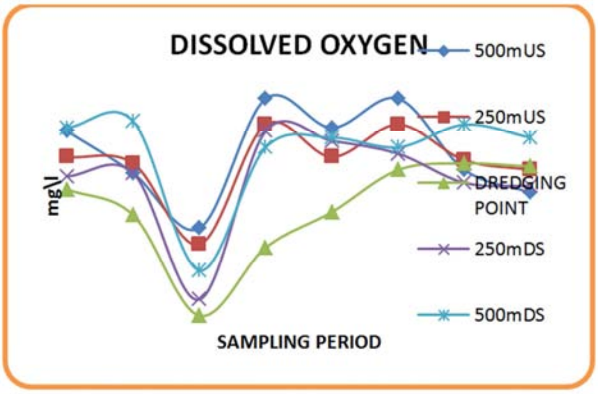

Fig. 8. *Changes in DO concentrations.*

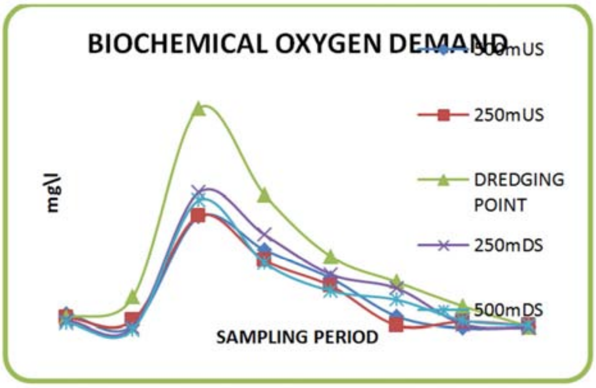

Fig. 9. *Changes in BOD_5 concentrations.*

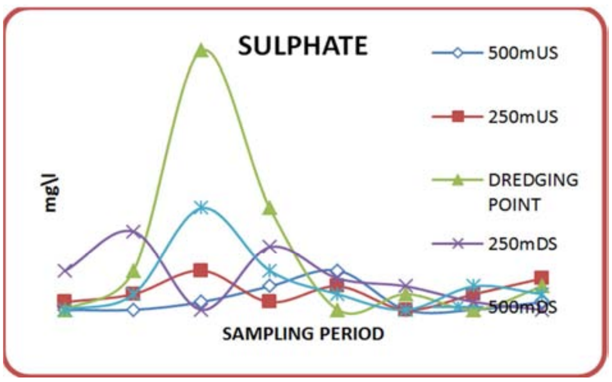

Fig. 10. *Changes in sulphate concentrations.*

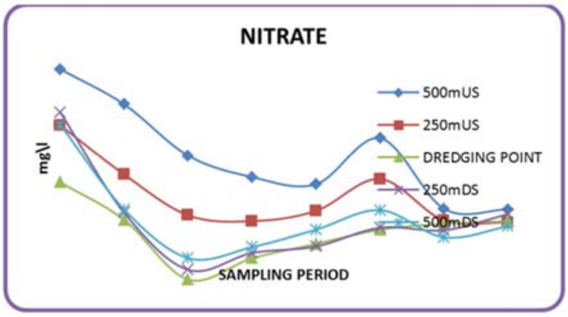

Fig. 11. *Changes in nitrate concentrations.*

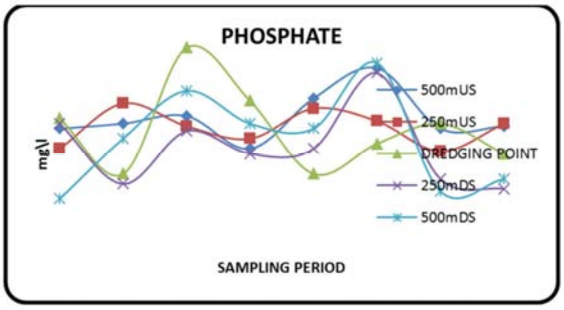

Fig. 12. *Changes in phosphate concentrations.*

The nutrients (nitrates, phosphates, sulphates) in the water body did not seem to show much variations throughout the sampling period, especially in phosphate, the values obtained did not follow any particular trend. The nitrate concentrations decreased sharpy at all the sampling points during the month of March, 2011. This corroborates with the findings of Ohimain *et al.*, [14]. There were low sulphate concentration 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.

4. Conclusion

The study has shown that the dredging of Nworie River actually caused physical as well chemical alteration of the water body. However, most of the changes were localized and of short term, if not for the abandoned dredge spoils by the river bank. The results of the 9 months post-dredging monitoring showed that there was considerable recovering after few months of dredging. For any dredging operation to be carried out, a well articulated Environmental Impact Assessment should be done. And this will contain the appropriate strategies for handling and/or disposing the spoils and other wastes that will arise thereafter.

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