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Impact of Sand Mining on Water Quality and Bank Morphology of Ontamiri River in Owerri Nigeria

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ABSTRACT: Otamiri River is of great importance to the socio-economic well-being of Owerri Community. The banks help to protect and sustain the stability of the adjacent terrestrial ecosystem. Continued sand mining activities in the river is of serious concern to the inhabitants of the area. This study therefore investigated the impact of sand mining on the river water quality and the bank's morphology. Water samples were collected from three locations: upstream, midstream and downstream. The samples were analyzed in the laboratory using standard procedures. The impacted bank morphology was observed and the features compared with the un-impacted (control) area. The mean values of the parameters were temperature (29.50^{0}c). Ph(6.42), conductivity (69.60.µs/cm), total dissolved solids (44.62 mg/l) total suspended solids (34.00mg/l) and dissolved oxygen (7.70mg/l). The average concentrations of biological oxygen demand, chemical oxygen demand, silicon, sulphateand phosphate were 1.76mg/l, 2.8mg/l, 2.03mg/l, 3.20mg/l, and 1.45mg/l, respectively. The results further indicate that only the colour (191.60pcu), turbidity (61.56 NTU), nitrate (60.94 m/l), iron (1.29mg/l) and total coliform count (146/60 x 10^{2}cfu/ml) were higher than the World Health Organization's permissible limits. The mining activity caused bank erosion and collapse, widening of bank width and reduction of biodiversity and aesthetic quality.

KEYWORDS: Sand mining, Otamiri River, Water quality, Bank Morphology, Owerri.

I.INTRODUCTION

Otamiri River in Owerri, Imo State is a major source of water for the inhabitants of the community and its environs. The river is used for various purposes such as domestic activities, fishing, recreation and mining. It is also a habitat for many aquatic lives. The banks play supportive roles in the stability and sustenance of the contiguous terrestrial ecosystem. The vegetative cover on the banks help to increase water infiltration rate, provide mechanical support to the soil, thereby reducing bank. The river banks also provide habitat for aquatic lives such as microbes, earthworms and crustaceans.

In recent times, sand mining has become a lucrative business in the area because of its use in construction industry. According to [1]sand mining is the transfer of sand from its original disposition. It also involves the extraction of sand from open pit, dunes, beeches, and even dredged from river and ocean beds [2].

Although there are some economic benefits accruing from sand mining, past studies [3]; [4]; [5]; [6];[1]indicate that sand mining has adverse effects on the physical environment. It disrupts the natural dynamics of soil, water, vegetation and there interrelationships which in turn poses great threat to human and animal lives in the affected areas.

The recent increase in infrastructural expansion of roads and buildings in Owerri town and its surrounding village has put pressure on sand mining activity in Otamiri River Channel for the supply of sand resource. There is a need therefore to investigate the concomitant influence of this development on water quality and bank morphology of the river.

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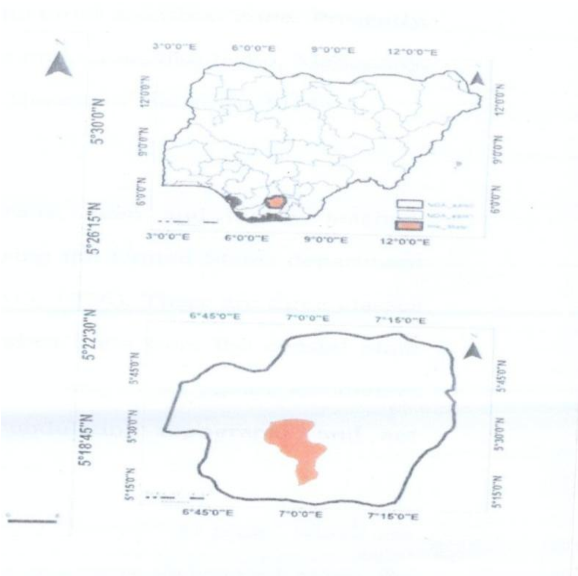
II.MATERIALS AND METHODS

The study area is Owerri in Imo State. It falls between latitudes $5^{o}25'$ and 5^{o} 23' N, and longitudes $7^{0}2'$ E and $14^{0}33'$ E [7](figure 1).The area is in the Niger Delta plain. It has horizontal structure with low relief that is undulating in some areas. Its elevation varies from 38m to 57m above sea level.



Study area

Figure 1: Map of the study area

Owerri is drained mainly by Otamiri River, which is also one of the main rivers in Imo State.The area experiences tropical climate with two main regimes- a dry season and a rainy season. The most important vegetation in the area is tropical rainforest [8]Thesoil types consist of ferrealitic soils (ferralsols)and hydromorphic soils (gleysols)[8]

A. Survey of Sampling Location

A reconnaissance survey of the study area was conducted to determine specific places along the river subjected to sand mining activity. The river channel was then portioned according to the procedure described by [9]. This include the upstream with no mining activity and used as the control, the midstream which was the area of active mining, and the downstream with no mining operation but received the effects of the mining activity. An interval of kilometer was giving between each major sampling zone while the midstream with active sand mining activity was subdivided into intervals of 100 meters to enable more detailed study of the area to be carried out.

B. Water Sampling Technique

Water samples were collected during the day when mining operation was going on; from the upstream, midstream and downstream sections of the river. For each sampling location, three composite samples were combined to form a sample. These samples were properly labelled and taken to the laboratory for physco-chemical and microbiological analyses.

However, in-situ determination of some parameters such as Temperature, electrical conductivity, pH, and dissolved oxygen were carried out using a mercury thermometer, HANNA conductivity meter, electronic pH-meter and dissolved oxygen meter, respectively.

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C. Laboratory Analytical Procedure

The physical, chemical and microbiological properties of the water samples were analyzed using standard methods described by various authors and organizations.

The colour, total suspended solids (TSS), Total dissolved solids (TDS) and Turbidity were determined according to the procedures outlined by [10]and, [11]. Biological oxygen demand (BOD) and chemical oxygen demand (COD) were analysed by Winkler and Colorimetric methods, in that order.

The concentrations of Nitrate ($N0_3$), Sulphate($S0_4$) and phosphate ions were obtained using [12] analytical procedures. Silicon level was by colorimetric method while water hardness was by EDTA titration technique. The membrane filter procedure described by [13]was adopted in analyzing total coliforma count.

D. Statistical Analysis

Some descriptive statistics such as range, mean and standard error were used in analyzing the data. A pair-wise comparison in levels of the physicochemical parameters between the upstream and midstream, upstream and downstream and midstream and downstream were made using students –test.

III.RESULTS AND DISCUSSION

Water Quality

Presented in table 1 are the values of the physco-chemical and microbiological parameters of the water samples. The statistical variables and WHO standards are shown in table 2, while the pairwise comparisons of the data are given in table 3. Figures 2,3 and 4 depict the values in graphic forms.

Table1. Concentrations of physicochemical and microbiological parameters of the water samples

Parameters	**Upstream**	**Midstream**	**Midstream2**	**Midstream3**	Downstream
Temperature (^{0}C)	27.10	30.40	30.90	30.90	28.20
pH	5.50	6.80	6.60	6.80	6.40
Conductivity (µs/cm)	46.00	73.00	68.00	93.00	63.00
TDS (mg/L)	29.90	47.50	44.20	60.50	41.00
Turbidity (NTU)	7.31	72.10	69.60	97.70	61.10
TSS (mg/L)	4.00	40.00	38.00	54.00	34.00
Color (PCU)	38.00	176.00	283.00	291.00	170.00
DO (mg/L)	8.70	7.20	7.20	7.70	7.70
BOD (mg/L)	2.40	1.20	0.80	2.60	1.80
COD (mg/L)	3.84	1.92	1.28	4.16	2.88
Ca-Hardness (mg/L)	1.45	4.55	5.90	6.70	5.35
Nitrate (mg/L)	49.50	62.70	68.40	73.90	5.20
Sulphate (mg/L)	0.00	60.00	5.00	5.00	0.00
Phosphate (mg/L)	1.55	0.00	0.20	0.15	0.50
Phosphorus (mg/L)	0.50	0.00	0.10	0.00	0.20
Iron (mg/L)	0.15	0.61	3.98	0.35	1.11
Total chlorine (mg/L)	0.70	1.15	3.98	0.58	0.85
Silicon (mg/L)	0.37	2.36	3.24	3.50	0.63
Total coliform counts (mg/L)	$30x10^2$	$206x10^2$	$184x10^2$	$190x10^2$	$123x10^2$
Magnesium hardness (mg/L)	0.00	0.00	0.00	0.00	0

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Table2. The Minimum, Maximum, Range, Mean, SE and WHO standard

Parameter	Minimum	Maximum	Range	Mean	SE	WHO STD
Temperature (^{0}C)	27.10	30.90	3.80	29.50	0.78	20-30
pH	5.50	6.80	1.30	6.42	0.24	6.5-8.5
Conductivity (µs/cm)	46.00	93.00	47.00	69.60	7.48	100
TDS (mg/L)	29.90	60.50	30.60	44.62	4.95	250
Turbidity (NTU)	7.31	97.70	90.39	61.56	14.87	5
TSS (mg/L)	4.00	54.00	50.00	34.00	8.22	50
Color (PCU)	38.00	291.00	253.00	191.60	46.11	15
DO (mg/L)	7.20	8.70	1.50	7.70	0.27	>4
BOD (mg/L)	0.80	2.60	1.80	1.76	0.34	10
COD (mg/L)	1.28	4.16	2.88	2.81	0.54	40
Ca-Hardness (mg/L)	1.45	6.70	5.25	4.79	0.90	150
Nitrate (mg/L)	49.50	73.90	24.40	60.94	4.86	10
Sulphate (mg/L)	0.00	6.00	6.00	3.20	1.32	250
Phosphate (mg/L)	0.00	5.00	5.00	1.45	0.93	5.0
Phosphorus (mg/L)	0.00	0.50	0.50	0.16	0.93	5.0
Iron (mg/L)	0.15	3.98	3.83	1.29	0.69	0.33
Total chlorine (mg/L)	0.35	3.98	3.63	1.41	0.66	10
Silicon (mg/L)	0.37	3.50	3.13	2.03	0.65	-
Total coliform counts (mg/L)	$30.00x10^2$	$206.00 x10^2$	$176.00 x10^2$	$146.60 x10^2$	$32.38 x10^2$	Nil/100ml
Magnesium hardness (mg/L)	ND	ND	ND	ND	ND	150

Table3. Pairwise comparison of levels of the physicochemical parameters (T-test) ($p<0.05$)

Sampling Location	Mean	Standard Error	T	Sig.t
Upstream Midstream	13.53 43.79	3.92 15.87	-2.235	0.039
Upstream downstream	13.53 31.74	3.92 10.75	-2.165	0.044
Midstream Downstream	43.79 31.74	15.87 10.75	2.280	0.035

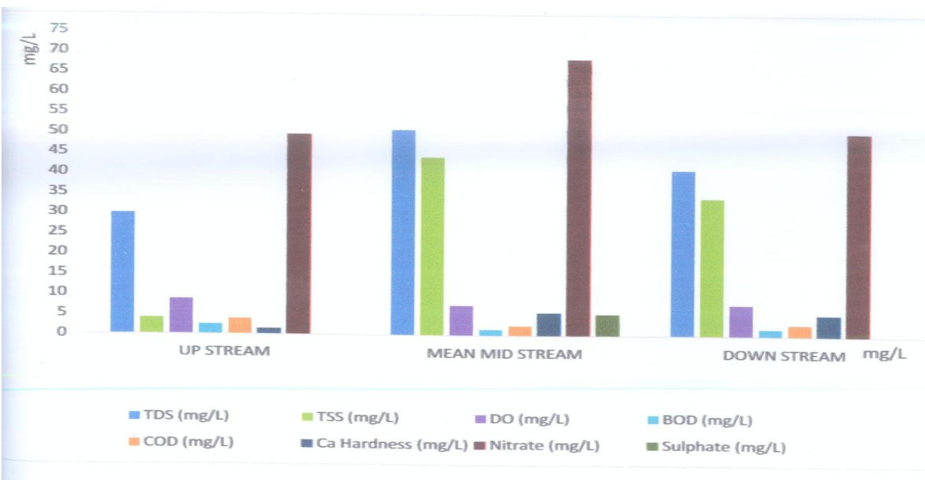

Fig 2 Graph showing concentrations of parameters at the upstream, midstream and downstream

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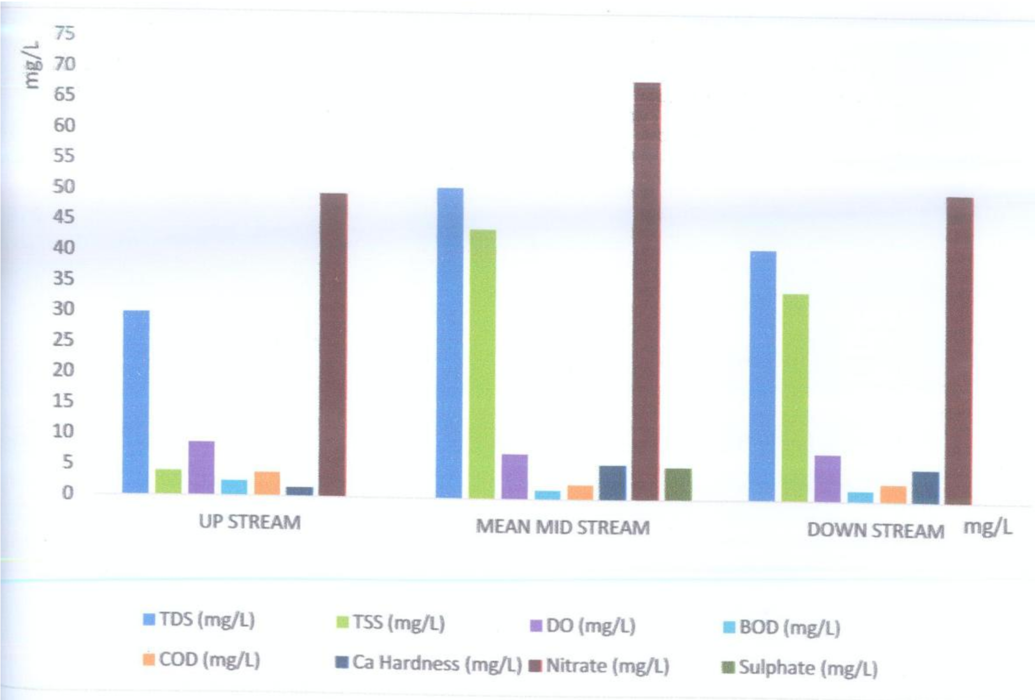

Fig 3 Graph showing levels of physicochemical properties at the upstream, midstream and downstream

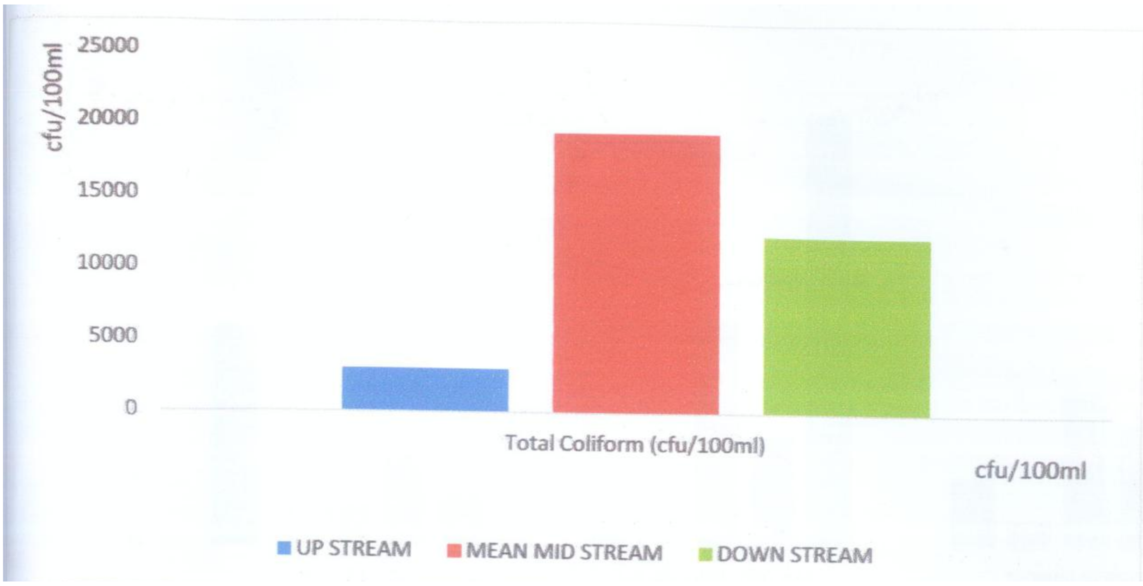

Fig 4 Graph showing Total Coliform count at the upstream, midstream and downstream

From tables 1 and 2, the temperature varied from 27.10 to 30.90^{0}C with a mean value of 29.50$\pm$ 0.78. The upstream and downstream values were within WHO stand while the midstream was above the limit. The higher values recorded in the midstream could be attributed to sand mining activity which removed the vegetation at the bank thereby exposing the river water to direct impact of sunlight. This is conformity with the report by [14] that the temperature

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difference experienced at any marine environment was influenced by the weather and degree of shade from sunlight. Water temperature, according to [15] was the most important ecological factor because it regulates the physco-chemical processes and distribution of organisms.

Table I also shows that the pH values for the upstream and downstream were 5.5 and 6.4, respectively and were below the WHO permissible limit. The midstream values (6.6 – 6.8) where within the limits. The low pH observed at the upstream and downstream was probably due to organic matter input from vegetation. These areas were not affected by sand mining and had their vegetation intact, unlike the midstream were mining activity destroyed the vegetative cover.

The decomposition of organic matter releases carbon dioxide which combines with water to form weak acid.

The mean values of conductivity, TDS, and TSS were 69.60 µs/cm, 4.62mg/l and 34.00mg/l, in that order. These were below WHO STD. However, the midstream had relatively higher values than the other sections and this could be linked to the influence of sand mining. No serious threat was then posed to water quality from these parameters.

The average turbidity value was 61.56mg/l and was higher than the WHO permissible limit. The values significantly p<0.05) varied from upstream to downstream. The highest values (69.60-97.70mg/l) recorded in the midstream were probably because of the impact of sand mining which introduce solid particles into the water column. These turbidity values had reduced the water quality for domestic purpose but could be used for cooling of machines in industries [16].

The colour values were upstream (38.00pcu), midstream (176.00 – 291.00pcu), and downstream (170.00pcu). These were higher than the WHO STD and also significantly (p<0.05) differed along the river course. Colour changes following sand mining was also reported by [17]The mean DO was 7.70mg/l, and fell within STD. This indicated that there was enough DO to support marine lives.

Nitrate concentrations varied from 49.50 to 73.90mg/l with average concentration of 60.94mg/l. There was a significant (p<0.05) increase in the values from downstream to upstream. The probable sources of the high nitrate values could be from runoff or seepage water from the soil exposed by sand mining, or from agricultural activities in the catchment area [18]. High nitrate concentration adversely affects water quality by causing eutrophication[19].The lowest value obtained from downstream was probably because of self purification of the river water.

Mean iron level was 1.29mg/l and was higher than WHO STD (0.33mg/l). There was a significant (P<0.05) increase in the concentrations along the sampling zones. Higher concentrations of the metal could be from sources outside sand mining activity such as the nearby mechanic workshops.

Total coliform count was higher than the permissible limit and significantly (p<0.05) varied between the sampling points. It ranged from 30.00×10^2 to 206.00×10^2. This positive result indicated a pollution problem in the river water. Parameters such as BOD, COD, Hardness, sulphate, phosphate were below WHO permissible limit. Others include chlorine, silicon and magnesium. The levels therefore had no adverse effects on the water quality.

E. River Bank Morphology

Observation of the impact of sand mining activity on bankmorphology showed that the vegetation was destroyed where sand was excavated. This exposed the soil to raindrop impact and runoff, that cased bank erosion and collapse (figure 5).

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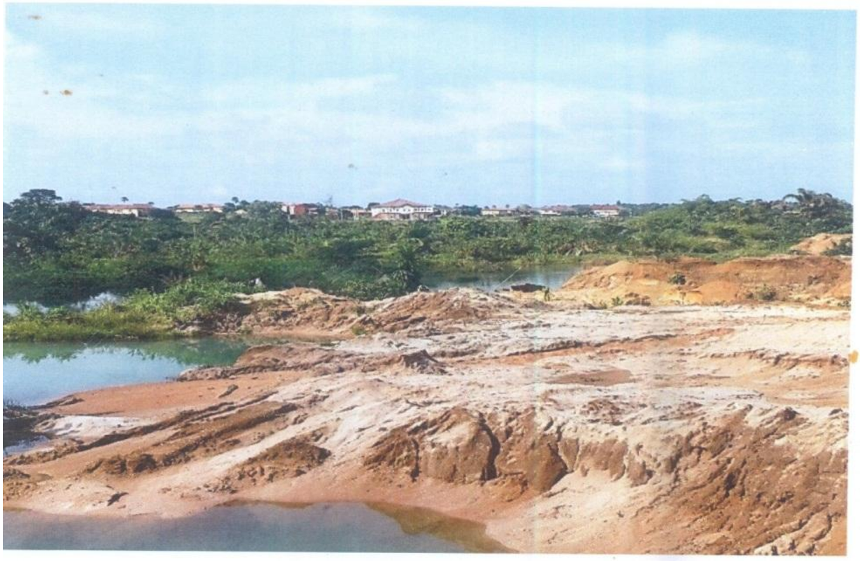

Figure 5: A section of the altered Bank morphology of Otamiri River

In addition, the river banks widened with no definitemorphology.The entire impact caused intrusion of soil particles, organic debris and nutrients into the river water. Biodiversity and aesthetic quality of the area were also destroyed.

IV.CONCLUSION

The findings of this study have to a large extent corroborated with some of the results obtained by previous workers on similar research. The mining activity in Otamiri River increased some physicochemical parameters above WHO permissible limits thereby polluting the river water.

The activity also destroyed the vegetation, soil structure and stability leading to bank erosion and collapse. Biodiversity and adjacent arable lands were in addition, adversely affected. Sand mining in Otamiri River should be prohibited as is the practice in many countries where in stream mining was being done.

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