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Environmental Impact of Sand Dredging in Otamiri River, Chokocho-Etche Axis, Rivers State, Nigeria

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Abstract

This study was two seasons evaluation of the environmental impact of the sand dredging within the Chokocho-Etche axis of Otamiri River in Rivers State. Four strategic locations (A to D) were sampled for a comparative analyzes and location A served as control sampling point of the river. In-situ examinations were made for pH. temperature, velocity of flow, water dimensions, total dissolved solids (TDS), total suspended solids (TSS) and electrical conductivity (EC) while other water parameters such as heavy metals was analyzed with the aid of standard instrument such as Atomic Absorption Spectrophotometer. The field result showed an average pH of 5.70 which indicated slightly acidic water, above the WHO permissible limits of 6.5-8.5. TDS at sampling points A-D ranged between 1350.8 mg/l and 1780.9mg/l for wet season; and 1225.8mg/l and 1658.2mg/l in dry season respectively which exceeded the WHO 2011 limits of 1000 mg/l for drinking water. The mean concentration of Zinc (Zn) in water samples at A-D in both seasons were between 4.34±0.38mg/l and 5.33±0.48mg/l; Copper (Cu) were between 2.84±0.13mg/l and 3.67±0.40mg/l. Iron (Fe) were between 2.64±0.29mg/l and 3.19±0.24mg/l and Lead (Pb) were between 0.16±0.01mg/l and 1.04±0.63mg/l, respectively. The study established the order of metal enrichment as Zn>Cu> Fe>Pb which values exceeded the WHO safe threshold for zinc 3 mg/l, Copper 2 mg/l, Iron 0.3 mg/l and lead 0.01 mg/l respectively. The study advised that sand dredging should be restricted to an environment isolated from residential area permitted after an approved EIA report.

Keywords: *Biodiversity; Dredging; Enrichment; Permissible; Siltation; Environment*

1. Introduction

Sand dredging is a mining activity carried out at least partway underwater, in fresh water and shallow water areas with the target of putting together the sediments and disposing them for various uses. Environmental challenges occur when the rate of removal of gravel, sand and other sediments exceeding the rate of natural process (attenuation). The main objective is to make waterways easily navigable (Mmom and Chukwu, 2011; Adebimpe and Oladejo, 2012; Podila, 2017). Alternatively, sand dredging should attract some level of environmental impact assessment (EIA) in the concerned area and/or host community (Podila, 2017). This is to create excavation of sediments without influencing undue degradation and erosion at the site. The excavation of sand is a major problem to any riverbed considering the effect sustained sand dredging creates to any river habitat. Albeit sand removal disturbs the ecosystem and original habitat of an affected river, beaches, deltaic river bed regions and ocean beds. Some of these implications of sand excavation are dryness due to solar radiation that declines the water bodies, deepening of the estuaries and riverbeds. The widening of coastal inlets, river mouths, soil profile and vegetation are also adversely affected consequently leads to a major decline in fauna population (Uchenna and Nwaogazie, 2011). This study was for evaluation and characterization of the physicochemical properties in the dredged Otamiri River without proper environmental impact assessment (EIA) of the affected river, assess the threshold of trace elements concentration in the Otamiri River with a view of advising concerned bodies on the need for thorough evaluation of EIA and post EIA before and after dredging activities whether minor and/or major.

2. Materials and methods

2.1. Description of study area

Several studies have been carried out on Otamiri River along the Owerri Imo State axis; it originated from a spring in Egbu, an outskirt town of Owerri metropolis and runs across to Nekede and then to Chokocho in Etche local government area of Rivers State (Imo Geographic Information Service, 2009). The coordinates of the study area is $4^{0}59'27''$N and $7^{0}3'16''$E. The two-season study took place in early June and late December of 2017.

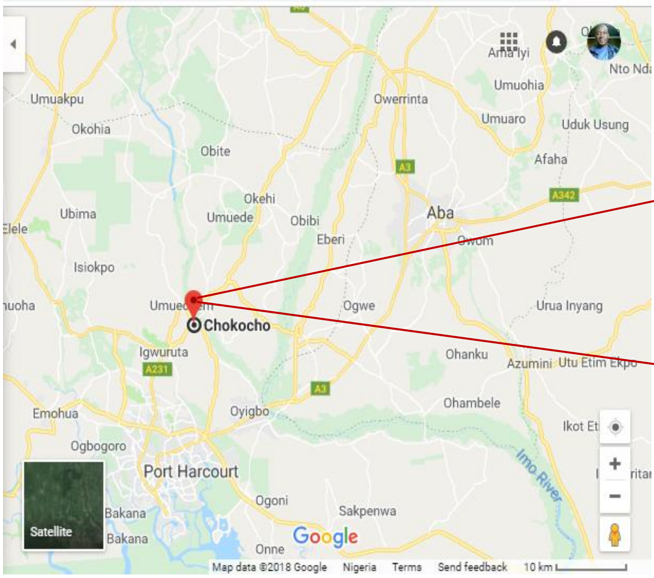

Fig. 1: Chokocho-Etche Community in Rivers State.

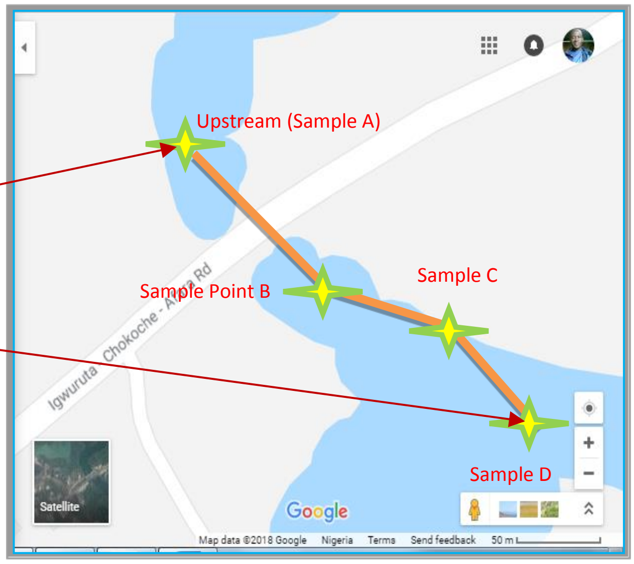

Fig. 2: Sampling points on Otamiri River

2.2. Sample collection

The study considered the Otamiri river of Chokocho axis where serious dredging and abattoir impact currently laden the river (Fig. 1). The first three sampling locations were regarded as direct impact zone (downstream-samples B - D); the fourth sampling location was the upstream taken as control (sample A) respectively. Instruments like the surveyor tape, 2m long marine rope of 4 mm diameter, metal poles staked at the marked sampling stations, wading gear and hand paddled boats were used for sample collection. Each sample was collected against the direction of water flow at a depth of 20-50cm below water surface. Also used was a 60ml centrifuge tubes capped with a polytetrafluoro-ethylene (PTFE) tape and samples were immediately transferred to the standard laboratory for proper analyses in a cooler containing ice cubes. A total of twelve (12) physicochemical parameters were determined during the wet and dry seasons; flow velocity was achieved using a current meter (Aqua flow Probe-6900) which established the mean velocity (0.38m/s) of the river within the two seasons.

2.3. On-site instrument

On-site analyses of hydraulic depth, width, cross-sectional area, turbidity, flow rate of the river and temperature were measured with the wedge gear, turbidiometer, velocity meter and thermometer. The conductivity was measured using an Aqua probe AP-5000 following standard procedures of the American Society for Testing and Materials (ASTM,2007) and American Public Health Organization (APHA, 2013) (DcZuane, 1997),

2.4. Laboratory analysis

TDS and TSS measurements were carried out in accordance to APHA (2013) and Sawyer *et al.* (1994) by the filtration procedure. TDS was evaluated by gravimetric method. The analysis of four heavy metals including Pb, Fe, Cu and Zn were carried out in accordance to ASTM (2007) standard protocols using the atomic absorption spectrophotometer (AAS). The obtained results were documented automatically on a computer linked with the AAS system (Onyeike and Osuji, 2003; Onyekuru *et al.*, 2017). The pollutants concentrations found in each aquatic media were compared to WHO standard limits for drinking water (WHO, 2011). The Microsoft Excel, 2010 served as an instrument employed for computation of mean and standard deviation of analyzed field data.

3. Results

The physicochemical properties of water samples for both wet and dry season sampling locations are shown in Tables 1-5.

Table 1: Concentration of heavy metals in mg/l from Otamiri River for wet season

Samples	Pb (mg/l)	Fe (mg/l)	Cu (mg/l)	Zinc (mg/l)
Control A	0.11	2.49	2.79	4.42
Point B	0.31	2.63	2.75	3.89
Point C	0.28	2.79	3.13	4.56
Point D	0.25	2.63	2.18	4.67
Mean±STD	0.24±0.09	2.64±0.12	2.71±0.40	4.39±0.35

Table 2: Concentration of heavy metals in mg/l from Otamiri River for dry season

Samples	Pb (mg/l)	Fe (mg/l)	Cu (mg/l)	Zinc (mg/l)
Control A	0.17	2.51	2.84	4.75
Point B	0.42	2.73	2.85	4.30
Point C	0.35	2.85	3.83	4.98
Point D	0.27	3.23	2.86	4.97
Mean±STD	0.30±0.11	2.83±0.30	3.10±0.49	4.75±0.32

Table 3: Physicochemical concentrations of wet seasons at sampling stations

Parameters	Control A	Point B	Point C	Point D	WHO, 2011
pH	5.85	5.03	5.78	5.39	6.5-8.5
Temp (°C)	27.4	29.1	28.4	28.7	30
Velocity (m/s)	0.3	0.6	0.7	0.6	NA
Hyd. Cond.(m/s)	2.64×10^{-5}	3.84×10^{-5}	5.95×10^{-5}	2.45×10^{-5}	NA
EC (µs/cm)	75	185	187	201	NA
Turbidity (NTU)	8.5	9.3	10.6	9.6	5
TSS (mg/L)	82.6	152.6	100.63	251.2	NA
Lead (mg/L)	0.16	0.42	1.48	1.45	0.01
Iron (mg/L)	2.84	3.08	3.36	3.26	0.3
Copper (mg/L)	2.93	3.12	3.95	3.83	2
Zinc (mg/L)	5.56	4.62	5.38	5.67	3
TDS (mg/L)	1350.8	1780.9	1482.1	1683.5	1000

Hyd. Cond.= Hydraulic conductivity; Temp= Temperature; EC= Electrical conductivity; TSS= Total suspended solid; TDS= Total dissolved solids

Table 4: Physicochemical concentrations of dry seasons at sampling stations

Parameters	Control A	Point B	Point C	Point D	WHO, 2011
pH	6.01	5.82	5.84	5.46	6.5-8.5
Temp (°C)	26.8	25.8	27.3	27.8	30
Velocity (m/s)	0.25	0.4	0.5	0.4	NA
Hyd. Cond.(m/s)	3.84×10^{-5}	4.74×10^{-5}	5.95×10^{-5}	1.87×10^{-5}	NA
EC (µs/cm)	65	169	177	192	NA
Turbidity (NTU)	7.4	8.4	9.7	8.9	5
TSS (mg/L)	70.3	143.8	80.86	230.7	NA
Lead (mg/L)	0.15	0.39	0.59	0.35	0.01
Iron (mg/L)	2.43	2.75	3.02	2.84	0.3
Copper (mg/L)	2.75	2.94	3.38	2.81	2
Zinc (mg/L)	4.52	4.08	4.96	4.99	3
TDS (mg/L)	1225.8	1658.2	1392.1	1461.6	1000

Hyd. Cond.= Hydraulic conductivity; Temp= Temperature; EC= Electrical conductivity; TSS= Total suspended solid; TDS= Total dissolved solids

Table 5: Mean±SD concentrations of both wet and dry seasons at sampling stations

Parameters	Control A	Point B	Point C	Point D	WHO, 2011
pH	5.93±0.11	5.43±0.56	5.81±0.04	5.43±0.05	6.5-8.5
Temp(ºC)	27.1±0.42	27.45±2.33	27.85±0.78	28.25±0.64	30
Velocity (m/s)	0.28±0.04	0.5±0.14	0.6±0.14	0.5±0.14	NA
Hyd. Cond.(m/s)	$3.24x10^{-5}$±$8.49x10^{-6}$	$4.29x10^{-5}$±$6.36x10^{-6}$	$5.95x10^{-5}$±0	$2.16x10^{-5}$±$4.10\ x10^{-6}$	NA
EC (µs/cm)	70±7.07	177±11.31	182±7.07	196.5±6.36	NA
Turbidity (NTU)	7.95±0.78	8.85±0.64	10.15±0.64	9.25±0.49	5
TSS (mg/L)	76.45±8.70	148.2±6.22	90.75±13.98	240.95±14.50	NA
Lead (mg/L)	0.16±0.01	0.41±0.02	1.04±0.63	0.9±0.78	0.01
Iron (mg/L)	2.64±0.29	2.92±0.23	3.19±0.24	3.05±0.30	0.3
Copper (mg/L)	2.84±0.13	3.03±0.13	3.67±0.40	3.32±0.72	2
Zinc (mg/L)	5.04±0.74	4.34±0.38	5.17±0.30	5.33±0.48	3
TDS (mg/L)	1288.3±88.39	11719.55±86.76	1437.1±63.64	1572.55±156.91	1000

Hyd. Cond. = Hydraulic conductivity; Temp= Temperature; EC= Electrical conductivity; TSS= Total suspended solid;TDS= Total dissolved solids

4. Discussion

The result of the analyses indicated in milligram per litre (mg/l) showed that the mean concentration of zinc (Zn) was the highest, followed by copper (Cu), iron (Fe) and lead (Pb) in that order tending toward zero in all the samples (Zn>Cu> Fe>Pb). Of the four (4) sampling locations, wet season heavy metal results indicated that Zn in water samples at point A to D were 4.42mg/l, 3.89mg/l, 4.56mg/l and 4.67mg/l; Cu were 2.79mg/l, 2.75mg/l, 3.13mg/l and 2.18mg/l; Fe were 2.49mg/l, 2.63mg/l, 2.79mg/l and 2.63mg/l and Pb were 0.11mg/l, 0.31mg/l, 0.28mg/l and 0.25mg/l, respectively. The dry season heavy metals sampling results at point A to D also indicated that Zn were 4.75mg/l, 4.30 mg/l, 4.98mg/l and 4.97mg/l; Cu were 2.84 mg/l,2.85 mg/l,3.83 mg/l and 2.86 mg/l; Fe were 2.51 mg/l, 2.73 mg/l, 2.85mg/l and 3.23mg/l and Pb were 0.17 mg/l, 0.42mg/l, 0.35mg/l and 0.27mg/l, respectively. Tables 1 to 2 indicated that the order of metal enrichment was Zn>Cu> Fe>Pb for the heavy metal concentration. These were above the permissible concentration limits of WHO (2011) which are Zinc 3 mg/l, Copper 2 mg/l, Iron 0.3 mg/l and Lead 0.01mg/l (shown in Table 1-2). The high concentrations of heavy metals in this stretch of the river may be due to the pipes used for the several dredging platforms; and poured spent engine oil (SEO) in the water body after carrying out the repairs. The other environmental factors may be attributed to the influence of soil type, leaching, erosion of natural deposits from within and around Chokocho-Etche community. The mean concentration of total dissolved solids (TDS) for wet and dry seasons (see Table 5) recorded in sampling points A to D were 1288.3±88.39mg/l, 11719.55±86.76mg/l, 1437.11±63.64mg/l and 1572.55±156.91mg/l, respectively which exceeded the WHO (2011) limits of 1000mg/l for drinking water. The increase in both organic and inorganic matter may have been connected to the several abattoirs and sand dredging points located at the river banks. Table 5 showed that mean concentration of turbidity of the water samples A to D were 7.95±0.78mg/l, 8.85±0.64mg/l, 10.15±0.64mg/l and 9.25±0.49mg/l, respectively with the highest indicated at point C which exceeded WHO (2011) standard of 5mg/l.

5. Conclusions

Analyses of several physicochemical properties were carried out to ascertain the water quality of the Otamiri River of Chococho Etche extraction aptness for domestic use. The study also examined the concentration of heavy metals such as zinc (Zn) which was the highest, followed by copper (Cu), iron (Fe) and lead (Pb). The other measured water parameters in the four sample stations A to D include pH (5.93, 5.43, 5.81, and 5.43), turbidity (7.95±0.78mg/l, 8.85±0.64mg/l, 10.15±0.64mg/l, and 9.25±0.49mg/l) and TDS (1288.3±88.39mg/l, 11719.55±86.76mg/l, 1437.11±63.64mg/l and 1572.55±156.91mg/l), respectively for the 2 seasons. These were found to exceed the permissible limits of WHO (2011) standards pH-6.5-8.5; Turbidity-5mg/l, and TDS-1000mg/l. Due to the lack of awareness and ignorance of the polluters and the general public, there is need for consistent monitoring of the studied River. The study advised that sand dredging should be restricted to an environment isolated from residential area permitted after an approved Environmental Impact

Assessment (EIA) report. The dredging sites should be regularly monitored by custodian government agency to control flood, erosion, water siltation and biodiversity devastation in the area.

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