



EFFECTS OF SAND DREDGING ON PHYTOPLANKTON DIVERSITY AND
TROPHIC STRUCTURE OF THE OBIKPOK NSIT RIVER, NIGER DELTA,
NIGERIA

*Obot, O. I. and Afia, O. E.

Department of Fisheries and Aquatic Environmental Management, University of Uyo, Nigeria

*Correspondance Email: ofonmbukobot@uniuyo.edu.ng

GSM: +234-7081554411

ABSTRACT

The study assessed the influence of sand dredging on phytoplankton diversity and water quality in the Obiokpok Nsit River, Akwa Ibom State, Nigeria. Monthly sampling was conducted from August 2023 to January 2024 across three stations representing different dredging intensities: upstream (undredged), midstream (moderately dredged), and downstream (intensively dredged). Physicochemical parameters were measured using standard methods, while phytoplankton samples were collected using plankton nets and identified microscopically. Significant spatial variations ($p < 0.05$) were observed in several environmental parameters, with dredged stations showing reduced transparency and dissolved oxygen but elevated turbidity, total suspended solids, and phosphate concentrations. A total of 1,684 phytoplankton individuals belonging to five taxonomic classes were recorded, with Cyanophyceae dominating the assemblage (83.14%). Taxonomic richness was highest at the upstream station (20 taxa) and lowest at the moderately dredged station (15 taxa). Canonical correspondence analysis indicated that nutrient enrichment and suspended solids were the major environmental drivers influencing phytoplankton distribution. The results demonstrate that sand dredging alters water quality conditions and shifts phytoplankton community structure toward disturbance tolerant taxa, potentially affecting the trophic integrity of the river ecosystem. These findings highlight the need for effective regulation and environmental monitoring of dredging activities in tropical freshwater systems.

Keywords: Sand-dredging, Phytoplankton diversity, Obiokpok-Nsit River, Niger-Delta

INTRODUCTION

Tropical freshwater rivers are vital ecosystems providing numerous services, including water supply, fisheries, and habitat for diverse biological communities. However, these systems are increasingly threatened by anthropogenic activities, among which sand dredging and mining are prominent in the Niger Delta region of Nigeria (Ogbuagu and Samuel, 2012; Abam and Oba, 2018). Sand dredging involves the excavation of riverbed sediments, a process that physically alters the aquatic environment and induces significant shifts in water quality and biological assemblages (Ogbeibu and Oribhabor, 2010), (Seiyaboh, 2013).

Phytoplankton, as primary producers, serve as critical indicators of water quality and ecological health due to their rapid response to environmental changes (Arimoro *et al.*, 2009; Ferreira *et al.*, 2012). Previous research in Nigerian rivers has demonstrated that sand-mining-induced perturbations often lead to reduced phytoplankton diversity and the selective loss of sensitive taxa (Ogbuagu and Samuel, 2012; Nwuyi *et al.*, 2023). For instance, studies in the Imo River and Buguma Creek have linked dredging to lower species richness and the dominance of tolerant groups such as diatoms and cyanobacteria (Ogbuagu and Samuel, 2012; Chris *et al.*, 2023).

In the Niger Delta and surrounding regions, the ecological consequences of dredging are often characterized by increased turbidity, resuspension of sediment-bound nutrients, and altered hydraulic patterns (Ogbeibu and Oribhabor, 2010; Akanwa, 2021). While several studies have examined these impacts in larger river systems, there is a need for site-specific assessments in smaller tropical rivers like the Obiokpok Nsit River, where local dredging

activities may have unique trophic implications. The study aim to evaluate the effects of sand dredging on phytoplankton diversity and trophic structure of the obiokpok nsit river, niger delta, Nigeria.

MATERIALS AND METHODS

The Study Area

The Obiokpok Nsit River is a freshwater system located within the Nsit Atai Local Government Area of Akwa Ibom State, southern Nigeria (Figure 1). It lies within the humid tropical rainforest zone, experiencing a bimodal rainfall pattern with a wet season from April to *October* and a dry season from November to March. Three sampling stations were established:

- Station 1 (4°48'57.66"N, 7°55'8.00"E) (Upstream): Located in an undredged area, serving as a reference site.
- Station 2 (4°48'59.21"N, 7°55'8.10"E) (Midstream): Characterized by moderate dredging activities.
- Station 3 (4°48'57.78"N, 7°55'9.39"E) (Downstream): *An area* of intensive dredging intensity. *This spatial* stratification aligns with standard ecological assessment protocols in the region (Ogbeibu and Oribhabor, 2010).

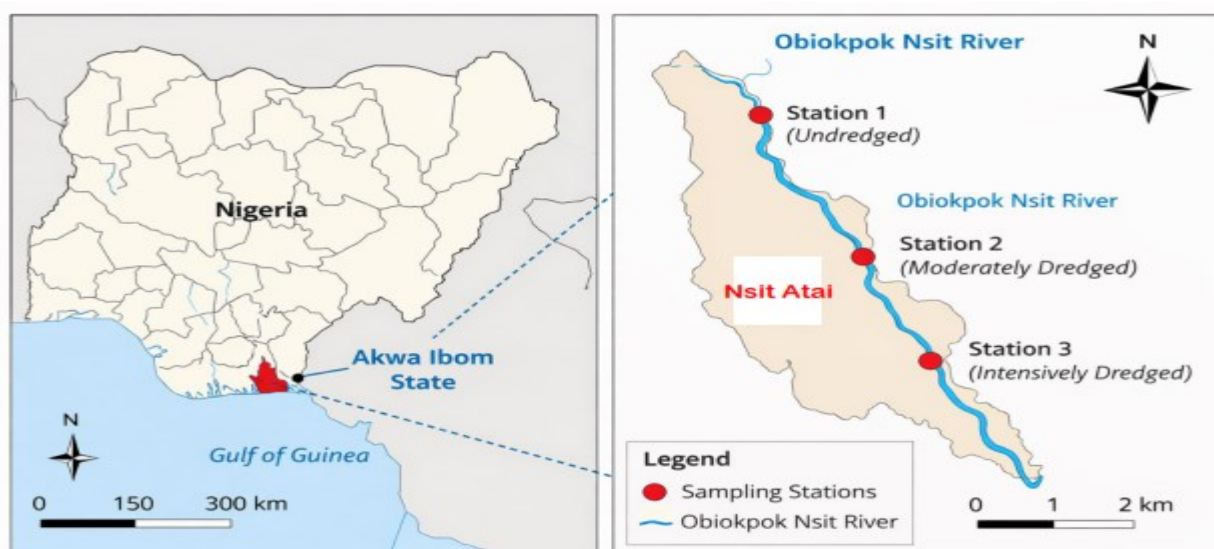


Figure 1. Map of the Obiokpok Nsit River study area showing sampling stations in Akwa Ibom State, South-South Nigeria

Sample Collection and Analysis

Monitoring was conducted monthly from August 2023 to January 2024. Surface water samples were collected using pre-cleaned polyethylene bottles for physicochemical analysis. In situ measurements included temperature, transparency (Secchi disc), pH, and dissolved oxygen (DO). Laboratory analyses for electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), and nutrients (nitrate, phosphate, sulphate) followed standard methods (APHA, 2017).

Phytoplankton samples were collected by filtering known volumes of river water through 55 µm mesh plankton nets and preserved in 4% formalin. Taxonomic identification was performed to the lowest possible level using standard keys (Arimoro *et al.*, 2009). Enumeration was conducted using a Sedgwick–Rafter counting chamber.

Statistical Analysis

Community structure was assessed using diversity indices, including the Shannon–Wiener index (H), Margalef richness index, and Pielou’s evenness. Spatial differences were tested using one-way analysis of variance (ANOVA) and Duncan’s multiple range test ($p < 0.05$). Canonical Correspondence Analysis (CCA) was employed to identify the environmental drivers of phytoplankton distribution.

RESULTS AND DISCUSSION

Physicochemical Characteristics

Spatial variation in the physicochemical parameters of the Obiokpok Nsit River showed significant responses to dredging intensity (Table 1). Transparency decreased significantly ($p < 0.05$) from the upstream station (55.17 ± 4.97 cm) to the intensively dredged station (29.92 ± 2.46 cm). Conversely, TSS increased from 0.01 mg/L at undredged sites to 0.03 mg/L at Station 3. Nutrient concentrations, particularly phosphate, were significantly higher at the intensively dredged station (2.43 ± 0.03 mg/L) compared to the undredged station (2.18 ± 0.07 mg/L).

Impact on Water Quality

The significant reduction in water transparency and increase in TSS and turbidity at dredged stations in the Obiokpok Nsit River are consistent with findings from other Nigerian rivers subjected to dredging (Sagala *et al.*, 2013; Ogbeibu and Oribhabor, 2010; Seiyaboh, 2013). Dredging activities disturb bottom sediments, leading to the resuspension of fine particles that reduce light penetration (Abam and Oba 2018; Akanwa, 2021). The elevated phosphate levels at the intensively dredged station (Station 3) suggest nutrient resuspension from the riverbed, a phenomenon also observed in the Eme River, where sand mining contributed to nutrient enrichment and signs of eutrophication (Anyanwu and Okeke, 2021).

Table 1: Spatial variation in physicochemical parameters (mean $\pm$ SD) across stations

Parameter	Station 1	Station 2	Station 3
Transparency (cm)	55.17 ± 4.97^a	51.17 ± 5.15^a	29.92 ± 2.46^b
Turbidity (NTU)	4.67 ± 0.35^a	4.93 ± 0.34^a	4.56 ± 0.85^a
Temperature ($^{\circ}\text{C}$)	30.17 ± 0.70^a	29.58 ± 0.64^{ab}	29.00 ± 0.86^b
pH	5.70 ± 0.19^a	5.68 ± 0.08^a	5.60 ± 0.19^a
Electrical conductivity ($\mu\text{S cm}^{-1}$)	94.83 ± 26.42^a	57.53 ± 10.15^b	61.63 ± 12.75^b
Total dissolved solids (mg L^{-1})	56.57 ± 11.09^a	32.67 ± 3.89^b	36.82 ± 5.85^b
Total suspended solids (mg L^{-1})	0.01 ± 0.002^b	0.01 ± 0.003^b	0.03 ± 0.002^a
Dissolved oxygen (mg L^{-1})	5.53 ± 0.51^a	5.30 ± 0.47^{ab}	5.12 ± 0.47^b
Biological oxygen demand (mg L^{-1})	2.95 ± 0.52^a	2.98 ± 0.57^a	2.72 ± 0.41^a
Total hardness (mg L^{-1})	127.50 ± 21.24^a	95.17 ± 11.97^a	105.50 ± 11.79^a
Alkalinity (mg L^{-1})	34.64 ± 5.09^a	26.63 ± 6.97^a	29.05 ± 5.06^a
Nitrate (mg L^{-1})	0.60 ± 0.26^a	0.14 ± 0.06^b	0.12 ± 0.05^b
Phosphate (mg L^{-1})	2.18 ± 0.07^b	1.67 ± 0.03^c	2.43 ± 0.03^a
Sulphate (mg L^{-1})	2.07 ± 0.17^a	1.41 ± 0.12^b	1.27 ± 0.06^b

Means with different superscripts along the same row are significantly different (Duncan’s test, $p < 0.05$).

Phytoplankton species

The phytoplankton species observed in this study are presentation in Table 2. The composition and abundance of the species differed spatially across the three stations investigated. *Aulacoseira granulata* was the most abundant (33.73) while *Bacillaria paxillifer* and *Closterium gracile* were the least abundant species.

Table 2: Phytoplankton species spatial variations in Obiokpok Nsit River

Phytoplankton Species	Station 1	Station 2	Station 3	Sum	%
<i>Bacillaria paxillifer</i>	1	0	0	1	0.06
<i>Fragilaria sp.</i>	6	2	17	25	1.48
<i>Melosira migrans</i>	1	0	0	1	0.06
<i>Navicula sp.</i>	2	3	2	7	0.42
<i>Nitzschia paradoxa</i>	2	0	0	2	0.12
<i>Pinnularia major</i>	4	4	2	10	0.59
<i>Synedra ulna</i>	1	7	4	12	0.71
<i>Tabellaria fenestra</i>	2	7	3	12	0.71
<i>Thalassiosira sp.</i>	2	2	11	15	0.89
<i>Thalassiothrix nitzschoides</i>	11	3	9	23	1.37
<i>Audouinella sp.</i>	0	4	0	4	0.24
<i>Closterium gracile</i>	1	0	0	1	0.06
<i>Closterium venus</i>	4	2	8	14	0.83
<i>Cosmarium quadrum</i>	7	5	7	19	1.13
<i>Gyrosigma kuetzingii</i>	5	2	4	11	0.65
<i>Pleurosigma sp</i>	2	1	0	3	0.18
<i>Spirogyra sp.</i>	47	0	32	79	4.69
<i>Ulothrix sp.</i>	14	0	28	42	2.49
<i>Aulacoseira granulata</i>	290	68	210	568	33.73
<i>Mougeotia sp.</i>	204	222	122	548	32.54
<i>Oscillatoria planctonica</i>	0	0	85	85	5.05
<i>Oscillatoria sancta</i>	46	70	83	199	11.82
<i>Euglena variabilis</i>	0	0	1	1	0.06
<i>Tribonema viride</i>	0	0	2	2	0.12
Total	652	402	630	1684	100.00

Phytoplankton Class Composition

Five phytoplankton classes were recorded during the study period (Table 3). *Cyanophyceae* was the dominant group across all stations.

Table 3: Phytoplankton class spatial variations in Obiokpok Nsit River

Phytoplankton Family	Station 1	Station 2	Station 3	Sum	%
<i>Baccillariophyceae</i>	32	28	48	108	6.41
<i>Chlorophyceae</i>	80	14	79	173	10.27
<i>Cyanophyceae</i>	540	360	500	1400	83.14
<i>Euglenophyceae</i>	0	0	1	1	0.06
<i>Xanthophyceae</i>	0	0	2	2	0.12
Total	652	402	630	1684	100.00

Spatial Variation in Phytoplankton Diversity

Phytoplankton diversity indices varied spatially, revealing that Station 1 had the highest taxonomic richness (20 taxa), while Station 2 had the lowest (15 taxa). Interestingly, Station 3 recorded the highest *Shannon diversity* ($H = 2.014$) and evenness (0.4162), despite the intensive dredging (Table 4).

Table 4: Spatial variation in Phytoplankton diversity indices

Diversity Indices	Station 1	Station 2	Station 3
Taxa_S	20	15	18
Individuals	652	402	630
Dominance_D	0.306	0.3635	0.1891
Shannon_H	1.587	1.431	2.014
Evenness_e^H/S	0.2444	0.2789	0.4162
Margalef	2.932	2.335	2.637
Equitability_J	0.5296	0.5285	0.6967

Ecological and Trophic Implications

The dominance of Cyanophyceae (83.14%) across all stations, particularly at impacted sites, indicates a shift toward nutrient-tolerant and stress-resistant taxa (Ihejirika *et al.*, 2013; Anyanwu and Okeke, 2021). Blue-green algae such as *Oscillatoria species* often thrive in perturbed environments with high organic enrichment (Chris *et al.*, 2023; Arimoro *et al.*, 2009). The result shows that, *Oscillatoria planctonica* and *Oscillatoria sancta* were prominent at Station 3, reflecting the influence of dredging-induced sediment disturbance on community composition.

The reduction in taxonomic richness from 20 taxa (Station 1) to 15 taxa (Station 2) suggests that moderate dredging intensity may exert a selective pressure that eliminates sensitive phytoplankton species, as documented by Ogbuagu and Samuel, (2012) and Chris *et al.* (2023). However, the higher diversity index recorded at Station 3 compared to Station 2 suggests a complex spatial response, potentially due to the colonization of opportunistic species or downstream transport of taxa from less disturbed upstream reaches, a pattern mirrored in some other tropical river assessments (Ihejirika *et al.*, 2013).

Diatoms (Bacillariophyceae), though less abundant than Cyanophyceae in this study, remained a significant component of the assemblage. *Diatoms* are widely used as bioindicators of water quality due to their sensitivity to changes in turbidity and nutrient regimes (Ogbuagu and Samuel, 2012; Ferreira *et al.*, 2012). The presence of *Aulacoseira granulata* as a dominant species indicates its tolerance to the increased suspended load and altered light environment associated with dredging (Ferreira *et al.*, 2012).

Relationship Between Physico-Chemical Parameters and Phytoplankton Family

Canonical correspondence analysis (CCA) was used to examine the relationships between phytoplankton assemblages and environmental variables across the sampling stations (Figure 2). The ordination diagram illustrates how physicochemical parameters influence the distribution of phytoplankton groups within the study area.

The first canonical axis explained 68.33% of the total variation in species–environment relationships, indicating that it represents the major environmental gradient influencing phytoplankton distribution. The second axis accounted for 27.93% of the variation, suggesting that together the first two axes explained the majority of the ecological patterns observed.

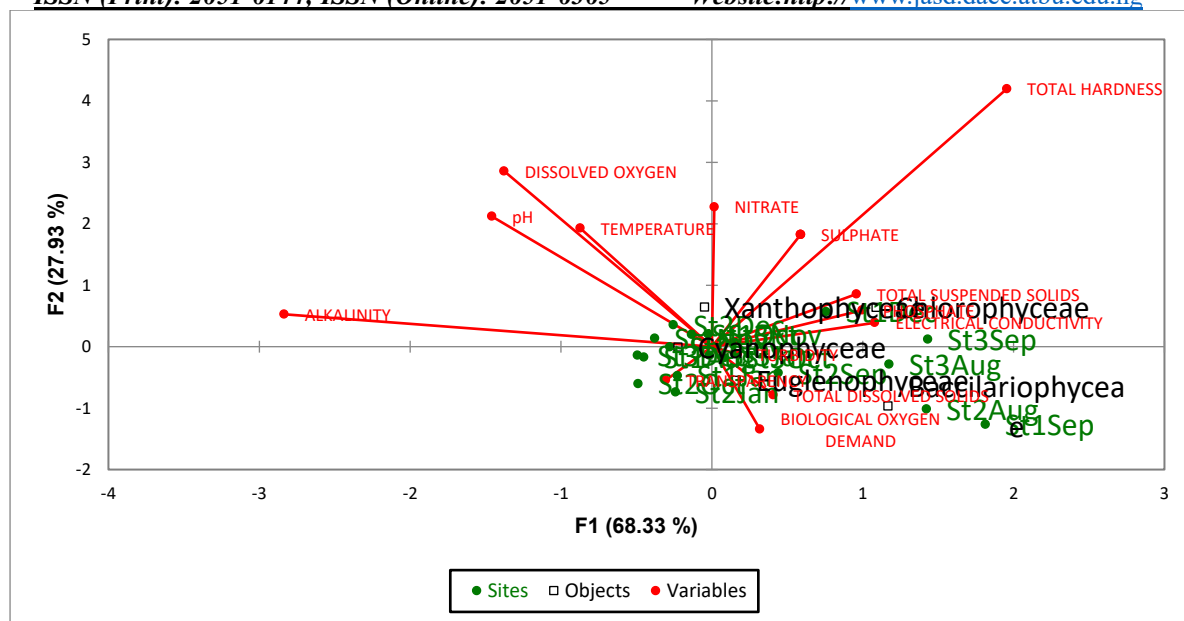


Figure 2: Canonical correspondence analysis showing relationships between phytoplankton assemblages, environmental variables, and sampling stations in the Obiokpok Nsit River.

Comparative Analysis

The observed patterns in the Obiokpok Nsit River align with the general ecological footprint of sand dredging in tropical regions. The loss of sensitive taxa and the dominance of tolerant species are predictable outcomes of habitat alteration (Ogbeibu and Oribhabor, 2010; Iloba et al., 2019). For instance, dredging in the Ikpoba River led to the elimination of sensitive macroinvertebrates and the dominance of stress-resistant organisms (Ogbeibu & Oribhabor, 2010). Similarly, studies in southeastern Nigeria have reported that sand mining activities alter physicochemical characteristics and lead to ecological imbalances (Ihejirika *et al.*, 2013; Nwuyi *et al.*, 2023).

CONCLUSION AND RECOMMENDATIONS

The study demonstrates that sand dredging significantly influences both the physicochemical conditions and phytoplankton community structure of the Obiokpok Nsit River. Increased turbidity, suspended solids, and nutrient concentrations were associated with dredging activities and contributed to shifts in phytoplankton composition toward tolerant taxa, particularly Cyanophyceae. Such ecological changes may have cascading effects on trophic interactions and overall ecosystem functioning. Sustainable management of riverine resources therefore requires stricter regulation of dredging operations, routine ecological monitoring, and environmental impact assessments prior to dredging activities in tropical freshwater systems.

The prevalence of indicator taxa such as *Oscillatoria* species underscores the perturbed state of the river. It is recommended that environmental management policies be enforced to regulate sand dredging activities, including the implementation of pre-operation impact assessments and the monitoring of water quality to ensure the long-term sustainability of tropical riverine ecosystems.

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