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THE EFFECT OF CRUDE OIL POLLUTION ON MACROPHYTE ASSEMBLAGE IN KPORGHOR RIVER, SOUTHERN NIGERIA

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ABSTRACT

A study of the effects of crude oil pollution on macrophyte assemblage was carried out in Kporghor River, Rivers State. Standard procedures were used in data collection. Temperature, total dissolved solutes, dissolved oxygen, pH and electrical conductivity were taken in-situ using Extech multi-parameter equipment while biological oxygen demand was incubated in a BOD bottle and determined using standard methods. Aquatic macrophytes were sampled with 0.5m × 0.5m quadrant and estimates of the percentage cover of each species inside the 0.5 × 0.5 m quadrant was transformed onto a scale based on Braun-Blanquet. The diversity and abundance of the different species were higher in Station (2), followed by station (3) and Station (1) respectively. Bambus vulgaris having a percentage of (29.7%) being the most abundant with percentage abundance, Cyrtospermum senegalense (8.72%), Nymphaea lotus (5.81), Acanthophoenix crinite (4.65%), Pistia stratiotes and Eichornia grassippes (2.91%) respectively. Unidentified species of macrophyte collected from the sampling area accounted for 11.62% species abundance. The result of physico-chemical parameters: temperature (29±0.63°C to 29.15±0.72°C), pH (6.03±0.12 to 6.9±0.15), TDS (36.23±6.82mg/ to 40.05±5.30mg/L), conductivity (4430±792.42µS/cm to 4914.75±569.42µS/cm), DO (5.20±1.20mg/L to 5.50±0.49mg/L) and BOD (3.08±0.94mg/L to 3.40±0.61mg/L). Copper (0.015mg/L) level was below WHO, SON and DPR standards for Cu in water bodies. Cadmium (0.10mg/L), Lead (0.18mg/L) and Nickel (0.28mg/L) concentrations were above WHO permissible limits. The abundance of Bambusa vulgaris (an alien species) suggests its adaptation to the study area. However, mitigation actions are recommended to restore this polluted ecosystem.

Keywords: Oil spill, aquatic plants, Kporghor Tai, exotic species

INTRODUCTION

Environmental challenges in Nigeria especially in the Niger Delta have become worrisome. The Niger Delta region is known for its rich biodiversity which has served as a source of sustenance of traditional livelihoods of its local people for centuries (Vidal, 2010). However, the biodiversity is under severe threat as a result of oil and gas exploration activities (Baird, 2010). There is hardly any year without recorded incidences of oil pollution in the Niger Delta; as such crude oil spill is a common occurrence in the Niger delta region. Crude Oil Spill as used in this context can be defined as the introduction of crude oil or its derivatives with its associated gases into the environment (land, air and water) in quantities that is capable of causing immediate physical, chemical and biological damage to the affected ecosystem (Tanee and Anyanwu, 2008).

The behaviour of metals in natural waters is a function of the substrate sediment composition, suspended sediment composition and the water chemistry (Barakat *et al.*, 2012). Sedimentation is important in removing metals because these metals are adsorbed to organic and inorganic materials or forms chemical bonds with components of the sediment. Sediments act as the ultimate reservoir for the numerous potential chemical and biological contaminants that may be contained in effluents originating from these activities (Adeleye *et al.*, 2012).

However, in water, there is continuous exchange between sediments and the water column, which may cause the release of large proportion of dissolved metals adsorbed to particulate matter (Harikumar*et al.*, 2009). Ogoni-land has faced several incidences of Crude oil spill. This has caused huge negative impacts on the land and waters of the impacted community; little or no literature has report the impact of these oil spills on the macrophytes assemblage. Thus, this study was designed to examine the macrophyte composition of the study area.

Map of the Study Area

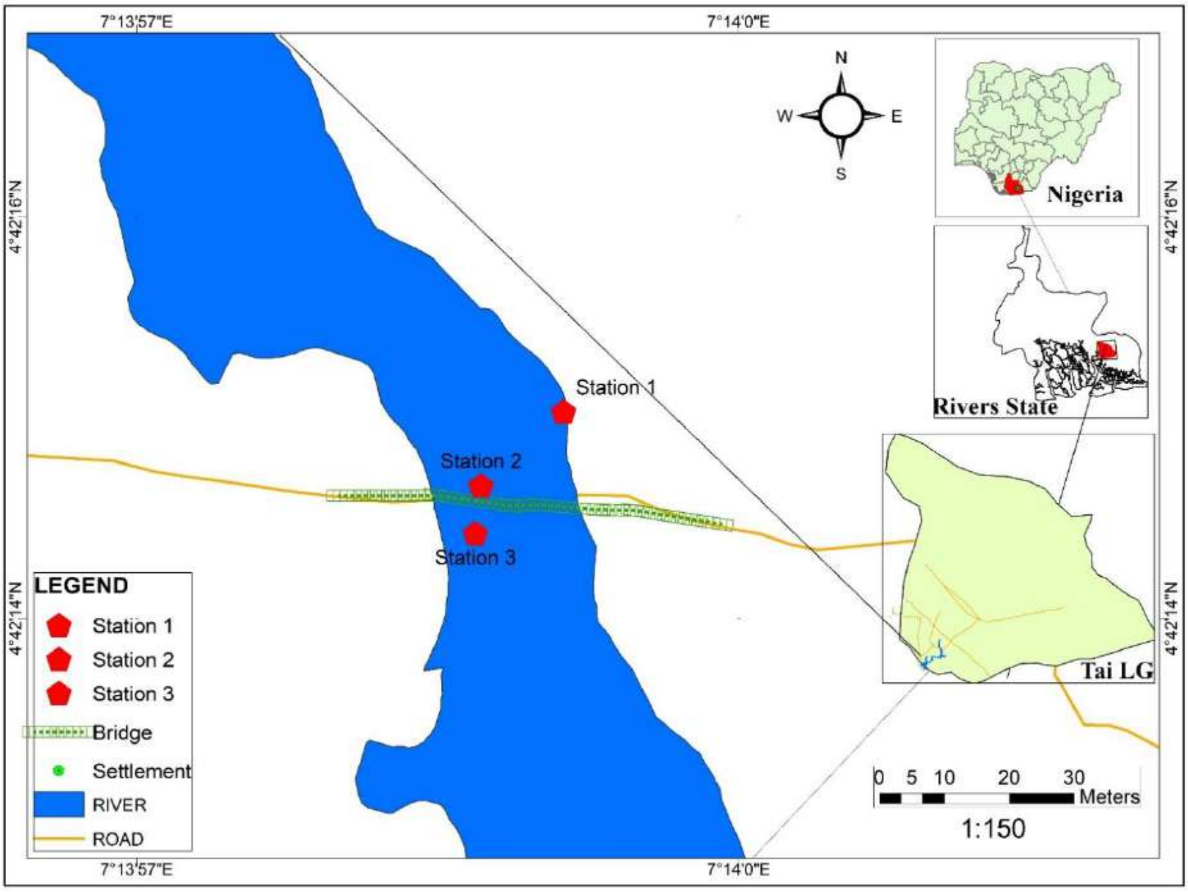

Figure 1.0: Map of the Study Area

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MATERIALS AND METHOD

The study was carried out at Kporghor Creek, Tai Local Government Area, Rivers State. Kporghor lies between N4° 42'.3257" and E7° 13'.7397". The Creek is a tidal brackish water ecosystem. The community and the Creek are surrounded by Gio, Wakama, Borobara and Gbam communities. Traditionally, Kporghor Creek serves as a strong livelihood support base for the people of the area and their neighborhoods. The Creek provides ready incentives for capture fisheries, transportation, cassava fermentation, fuel wood production and small-scale domestic waste disposal. The anthropogenic activities carried out around the Creek include illegal refining of crude oil (bunkering) and fishing. Its vegetation is dominated by red mangrove (*Rhizophora racemose*) with the presence of white mangrove (*Avicennia africana*), black mangrove (*Laguncularі racemosa*), mangrove sedge (*Paspalum vaginatum*), and Nypa palm (*Nypa fructicans*). The upper part of the Creek is vegetated by coconut (*Cocus nucifera*) and mango (*Mangifera indica*).

Sampling of Macrophytes

Sampling of macrophyte was carried out using a 0.5m x 0.5m quadrat. Macrophyte assemblages' abundance was assessed by visual estimates of the percentage cover of each species inside the 0.5 × 0.5 m quadrat which was transformed onto a scale based on Braun-Blanquet (1: < 5%; 2: 6-25%; 3: 26-50%; 4: 51-75; 5: 76-100%) (Roger *et al.,* 2013). In addition to the quadrats, macrophytes in the littoral region were also visually inspected from a boat. All macrophytes collected were identified at the Plant and Biotechnology Herbarium, University of Port Harcourt.

Water Sample Collection and analyses

Surface water samples for physical and chemical analysis were collected at 15-30 cm (0.49-0.98ft) depth (The depth of the sample location was determined using tape measurement procedure, as it was calibrated in feet of 1-100ft.), and it was determined by lowering the tape into the River and the measurement taken. The water samples were collected using niskin bottles. Samples collected were transferred into 70ml amber coloured reagent bottles for dissolved oxygen (DO) and biochemical oxygen demand (BOD) determination. Whereas, water collected for physical and chemical analysis was transferred into one-litre Plastic containers while, 120ml vial bottles were utilized for collection of water samples for trace heavy metals analysis. All sampling containers were properly washed with double distilled water, dried, corked with covers, well labelled and stored in cool box under laboratory condition 24 hours prior to samples collection.

All sample containers and niskin bottles were rinsed three times with the river water at each sampling point before samples collected collected with niskin bottles was transferred into them. Each sample was treated following standard APHA, 1998 procedure. Thereafter, all the samples were stored in the cool box and subsequently transported to the laboratory for treatment and analysis.

The physico chemical parameters of Kpoghor River determined are; temperature, hydrogen ion concentration (pH), electrical conductivity (EC), Total

Dissolved Solids (TDS), Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD).

The pH, temperature, conductivity, total dissolved solids (TDS) and dissolved oxygen (DO) were determined in-situ in the field using Extech, a multiple parameter digital meter (DO:700 model), after calibrating the instrument with the necessary standard solutions The units of measurement were temperature (^oC), conductivity (μS/cm), TDS (mg/l) and DO (mg/l), TDS (mg/l).

Determination of Heavy Metals

Water samples for heavy metals analysis was collected from each station with sterilized, well labelled amber coloured bottles and transported to the laboratory for analysis. Prior to analysis, water Samples were digested using a mixture of concentrated HNO_3: HCl (1:3). Thereafter, the sample was analysed for heavy metal using Atomic Absorption Spectrophotometry (Nwajei *et al.*, 2014).

RESULTS AND DISCUSSION

Physicochemical parameter

The mean values recorded are shown on table 1. The lowest (29±0.63^oC) mean temperature was reported in Station 2 while highest (29.15±0.72^oC) was reported in Station 1. The pH values recorded in this study, which ranged from 6.50±0.44 to 6.65±0.44, are within the range previously reported for freshwater bodies in the Niger Delta (Asonye *et al.*, 2008) and DPR (2002) limits of 6.0 to 9.0. TDS ranged between 36.83±6.82mg/L and 40.05±5.30mg/L in the study. Electrical conductance in this study, minimum, (4430.50±0796.42µS/cm) at Station 2 and maximum (4914.75±569.42µS/cm) at Station 1. This study at Kporghor River showed the range of dissolves oxygen from 5.20±1.20mg/L to 5.50±0.49mg/L which is around the tolerance range for fish. Detail is shown in table 1.

Macrophytes

The details about the abundance of macrophytes across study locations are shown in table 2. The study identified 11 taxa and 11 species of macrophytes in Kporghor River. The diversity and abundance of the different species were higher in Station (2), followed by station (3) and Station (1) respectively. *Bambus vulgaris* having a percentage of (29.7%) being the most abundant with percentage abundance, *Cyrtospermum senegalense (8.72%),Nymphaea lotus (5.81), Acanthophoenix crinite (4.65%), Pistia stratiotes* and *Eichornia grassippes (2.91%)* respectively. Unidentified species of macrophyte collected from the sampling area accounted for 11.62% species abundance

Heavy metals

Heavy metals associated with crude oil identified in the study are Copper, Nickel, Lead and Cadmium. Lead had the overall highest concentrations across sampling stations ranging from 0.1290±0.1219 to 0.2393±0. Nickel and Cadmium has same values of 0.001mg/l across sampling stations. This is within the safe limit for drinking water of 0.02mg/l and 0.005mg/l respectively.

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Table 1: Spatial variation of the physico-chemical parameters of Kporghor River

Stations	Temperature (ºC)	pH	TDS (mg/L)	EC (µS/cm)	DO (mg/L)	BOD (mg/L)
STN1	29.15±0.72	6.5±0.44	36.83±6.82	4914.75±569.42	5.38±0.84	3.08±0.94
STN 2	29±0.63	6.65±0.44	39.53±5.18	4430.5±796.42	5.2±1.20	3.4±0.61
STN 3	29.08±0.60	6.5±0.45	40.05±5.30	4432±828.42	5.5±0.49	3.35±0.66
MEAN	29.08	6.55	38.80	4592.42	5.36	3.28
DPR 2002	25-30	6.5-8.5	2,000-5,000	na	4.0-5.0	30-45

Key: DPR= Department of Petroleum Resources for regulation and compliance to petroleum laws. pH = Hydrogen ion concentration; TDS = Total Dissolved Oxygen; EC = Electric Conductivity; DO = Dissolved Oxygen; BOD = Biological Oxygen Demand, STN = Station; mg/L = milligram per liter, ºC= degree Celsius; µS/cm = microSiemens per centimetre; na = not available.

Table 2: Macrophytes Abundance across the three stations of Kpoghor River

S/N	Common Name	Scientific Name	STN 1	STN 2	STN 3	Total Number of species	Percentage Abundance (%)
1.	Water lily	*Nymphaea lotus*	2	6	4	10	5.81
2.	Water lettuce	*Pistia stratiotes*	-	3	2	5	2.91
3.	Water hyacinth	*Eichhornia crassipes*	1	2	2	5	2.91
4.	Arrow head weed	*Cyrtospermum senegalense*	4	8	3	15	8.72
5.	Bamboo	*Bambusa vulgaris*	13	29	8	50	29.07
6.	Palm tree	*Acanthophoenixcrinite*	1	2	5	8	4.65
7.	Sunflower	*Helianthus annuus*	2	3	3	8	4.65
8.	Cassava	*Manihot esculentum*	4	3	3	10	5.81
9.	Nypa palm	*Nypa fruticans*	6	5	1	12	6.98
10.	White mangrove	*Rhizophora racemosa*	2	6	2	10	5.81
11.	Red mangrove	*Avicenia africana*	11	5	3	19	11.05
12.	Unidentified species	-	4	12	4	20	11.62
		Total				**172**	

Table 3: Spatial variation of Heavy Metals In Kpoghor River

STATION	Cu (mg/L)	Ni (mg/L)	Pb (mg/L)	Cd (mg/L)
STATION 1	0.0013±0.0005	0.0010±0	0.1708±0.1999	0.0010±0
STATION 2	0.0015±0.0010	0.0010±0	0.1290±0.1219	0.0010±0.0005
STATION 3	0.0013±0.0005	0.0010±0	0.2393±0.1981	0.0010±0
MEAN	0.0014	0.0010	0.141	0.0010
WHO 2011	0.015	0.07	0.01	0.003
SON 2007	1.00	0.02	0.01	0.003
DPR 2002	1.5	Na	0.05	0.03

Key: Cu = Copper; NI = Nickel; Pb = Lead; Cd = Cadmium; mg/L = milligram per liter; na = not available; WHO = World Health Organization; SON = Standard Organization of Nigeria; DPR = Department of Petroleum Resources

The physico-chemistry of the River showed variations across study location. The lowest (29±0.63°C) mean temperature in Station 2 and the highest mean temperature (29.15±0.72°C) in Station 1 reflected an optimal condition for the survival of aquatic life, and are consistent with temperatures recorded in surface water bodies in the tropics and freshwater in the Niger Delta region (Ezekiel *et al.*, 2011, Agedah*et al.*, 2015).According to Talling (2010). The pH ranging from 6.50±0.44 to 6.65±0.44 in the study location , are within the range previously reported for freshwater bodies in the Niger Delta (Asonye *et al.*, 2008) and DPR (2002) limits of 6.0 to 9.0. The pH value reported in this present study may be attributed to the decomposition of substances with high organic content due to the effect of the pollution (Vincent-Apku *et al*., 2019). Consequently, drastic changes in pH will affect all other physico-chemical parameters of the water, including the aquatic organisms (Zhang *et al.*, 1995).

TDS which ranged between 36.83±6.82mg/L and 40.05±5.30mg/L in the study agrees with Vincent-Apku *et al*., (2019), who attributed it to the total dissolved solutes of a natural water body to salt intrusion of organic sources such as leaves, silt and planktons from the sea, as well as industrial wastes and sewages, while Essien-Ibok *et al*., (2010) in a similar study at Mbo River posited attributed to evapo-crystallization process and low precipitation in the Rivers.

The minimum Electrical Conductance in this study was (4430.50±0796.42µS/cm) at Station 2 and maximum (4914.75±569.42µS/cm) at Station 1. This was quite higher than (195 ± 74[b] 2870 ± 234[a]) that was reported by Vincent-Akpu *et al.*, (2015) at Bodo Creek. They postulated that conductivity is strongly influenced by the concentrations of dissolved constituents, temperature, BOD, pH and DO, as these parameters are negatively correlated with EC.

According to Jingxi *et al.*, (2020), dissolved oxygen is a measure of the degree of pollution by organic matter and the destruction of organic substances, as well as the self-purification capacity of the water body. They also indicated that the maximum tolerance for fish is 5mg/L. This study at Kporghor River showed the range of dissolves oxygen from 5.20±1.20mg/L to 5.50±0.49mg/L which is around the tolerance range for fish.

Biological oxygen demand is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. Values for biological oxygen demand ranged between 3.08±0.94mg/L and 3.35±0.66mg/L.

Macrophytes

The research identified 11 taxa and 11 species of macrophytes in Kporghor River, the depletion in macrophytes availability in the Kporghor River is an indication that pollution has occurred in the river which has led to only 11 species of macrophytes. Oil spill pollution in Kporghor River has negative impacts on the first (station 1) and

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last sampling station (station 3 - located at the extreme of the river, hence making station (2) more abundant in macrophytes assemblage than stations (1) and (3) respectively. This is attributed to the impact of the crude oil spillage on the surrounding land and Kporghor River which affects the macrophytes vegetation negatively.

Macrophytes grow in different water bodies and in different forms either as emergent, submerged, or free floating. Most of these macrophytes need the services of sediments to grow effectively (John and Michael, 1986) but are been hampered by oil spill pollution which affect their productivity and relative abundance. Macrophytes provide food, shelter and cover against predators as well as generating oxygen as by-product of photosynthesis (Lesiv, Polishchuk and Antonyak, 2020). These essential services are lost through oil spill pollution in rivers and lakes where macrophytes are destroyed. This in turn, negatively affects the productivity of the river. Hence, Kporghor River is in jeopardy.

Heavy metals

The high concentrations of lead in the study area could be the attributed to hydrocarbons pollution in the river. Lead, which is carcinogenic, interferes with vitamin D metabolism, and affects mental development in infants, due to its toxicity to the central and peripheral nervous systems (SON, 2007). The overall concentration (0.1290±0.1219 to 0.2393±0) of lead across sampling stations falls within the permissible limit in WHO (2011) and SON (2007).The metal concentration trend recorded in this study was such that metal concentrations decreased as distance from the source of spill increased. This is similar to the trend reported by Zhang *et al.*(2015), where the concentration of heavy metal of a lake in Louisiana gradually declined with distance from the source of oil pollution.

Nickel and Cadmium has same values of 0.001mg/l across sampling stations. This is within the safe limit for drinking water of 0.02mg/l and 0.005mg/l respectively, as approved by the United Nations Environmental Protection Agency (EPA, 2013) but are in contrast to the findings of Ifelebuegu *et al*., (2017) at an oil polluted freshwater site in Nun River where heavy metal values, including Nickel and Cadmium exceeded the regulatory limits of the Department of Petroleum Resources (DPR, 2002). Copper ranged between 0.0013±0.0005 at Stations 1 and 3 and 0.0015±0.0010 at Station 2. This range does not compromise the quality of drinking water (EPA, 2013) and as such does not pose threats to health (Government of Western Australia, Department of Health, 2016).

CONCLUSION

Kporghor River is one of the rivers that have suffered from the impact of oil spill and pollution of several kinds. The elements which are present in these spills affect the productivity of water bodies and as such, the plants and animal species found in them suffer the same effects. Macrophytes grow and have high productivity when the water bodies are healthy and functioning at optimal levels, but are impacted negatively when oil spills and pollutions occur. The Macrophytes assemblage of the Kporghor River has been greatly affected with the heavy metals which also in turn affect the physico-chemical parameters of the water hence reducing the abundance and percentage composition of the different species that are present in the water. The impacts of oil spill on the water bodies and on macrophytes assemblage led to the spatial and less distribution of macrophytes in the water. The lesser and relative abundance of macrophytes as seen in the different stations is an indication that oil spills affect macrophytes assemblage drastically and hence subsequent spills should be stopped to allow for macrophytes abundance and more distribution in Kporghor River.

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