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Comparative Water Quality Assessment of Nembe, Bonny and Iwofe Ferry terminals in Port Harcourt, Nigeria

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Abstract: *The study was carried out to investigate the levels of some physicochemical parameters, nutrients and trace metals in water from Iwofe, Bonny and Nembe ferry terminals. The physicochemical parameter of water (temperature, pH, salinity, conductivity, TDS and DO) were checked in-situ while the trace metals (Pb, Fe, Cd and Cr) were analysed using Atomic Absorption Spectrophotometer (AAS) after acid digestion. The values of trace metals (mg/L) in Bonny were 0.41 (Cd); <0.001 (Cr); 0.012 (Ni) and 0.24 (Pb)]; Iwofe were 0.13 (Cd); <0.001 (Cr), <0.001 (Ni) and 0.31(Pb)] and Nembe, were 0.43 (Cd), <0.001 (Cr), <0.001(Ni) and 0.36 (Pb). The nutrients (mg/L) in water from Iwofe: Nitrate was 2.7, Phosphate was 0.2and Sulphate was 115.5. In Bonny, Nitrate was 4.6, Phosphate was 0.6 and Sulphate was 185.2. In Nembe, Nitrate was 3.3, Phosphate was 1.5 and Sulphate ion was 187.5. The levels of cadmium and lead were higher than the permissible limits recommended by World Health Organisation (WHO) and may probably be due to municipal waste, transportation and commercial activities. Therefore, the consumption of fish and water usage from such water body may pose threat to human health.*

***Keywords*:** *Inland waters, ferry terminals, nutrients, trace metals, permissible limits, and physicochemical parameters,*

I. Introduction

Water pollution in developing countries has reached an alarming situation and Nigeria is no exception. The water bodies have been subjected to various forms of degradation due to pollution arising from domestic waste, industrial activities; agricultural run offs and transport activities. In recent times, transport activities have been associated with growing levels of environmental impact [1, 2]. The use of Waterways for inland navigation may pose a threat to aquatic organisms and can have significant impacts on the water bodies.

The impact is seen to cause change in hydrological conditions; deterioration of water quality and as source of emission of pollutants. The demand for water transport is on the increase; with their resultant chemical substance (especially oil) spill by ships, nutrient overload release and species invasion representing important aspect of water quality. Wastes from water transport activities are: sewage, gray and bilge water, gas emissions, solid and hazardous waste, with metals, mineral oil and lubricants, and organic substances as major constituents [3].

Metals in the environment are due to natural sources as well as anthropogenic sources and they exist in different forms such as solid, solution, free ions, or absorbed to solid colloidal particles. Metals of most environmental concern in water are lead (Pb), Chromium(Cr), Arsenic(As), Cadmium(Cd), Copper(Cu) and Zinc(Zn) [4]. Naturally in aquatic ecosystems, metals occur in low concentration; some essential metals like copper (Cu) and zinc (Zn) have normal physiological functions in the bodies of organisms, but may be toxic at higher concentrations. The occurrence of metal contaminant in excess of natural loads has become a problem of increasing concern. Metals persist in the environment, bio-accumulate and bio-magnify through the food chains and increase the exposure to public health risks. Metals are released to the water column through sediment re-suspension, adsorption-desorption, reduction-oxidation, and the action of degrading organisms [5]. Accumulation of metals can be controlled by granular composition of the sediments and the physicochemical properties of the water.

Port Harcourt is located in the River Niger Delta Region of Nigeria and it is the economic base of Nigeria due to oil and gas production hence the development of Inland Waterways facilities and ports. Nembe, iwofe and bonny waterside are amongst the important ferry ports in Port Harcourt. Water transportation infrastructures are situated around the ports - at the edge of an ocean, sea, river, or lake - which receive passengers' boats / ships and transport cargo. The establishment of a Petrochemical industry, oil and gas servicing companies and other companies in the areas, has increase the activities and users of the terminals. At each terminal, there is a jetty and other over-water structures where massive transit of humans and goods occurs daily. This Inland navigation substitutes road transportation and contributes in making transportation more sustainable.

Previous research showed that over-water structures represent at least a partial obstacle to fish movement and may likely result in behavioral and physiological changes in these fishes [6]. Waste discharged

from watercrafts and cargos, which many believed are greatly diluted when emptied into water, may have effect on aquatic life, water quality, and the health of the ecosystem [3, 7].Water Pollution Control Measures have been put in place in many developed countries. However in developing countries like Nigeria; these laws are not stringent to avert discharge of wastes into the water bodies. This has necessitated the need to assess the quality of three major inland waterways in Port Harcourt.

II. Materials and Methods

2.1 Description of Study Area

The study site is shown in Fig. 1, Iwofe is located at about Lat 04^0 $45^0$24 N and 07^0 01 27.8 E. This site receives wastewater from its metropolis, effluents from various companies densely located at river bank such as Delta Marine (petrochemical Industry). Bonny waterside is located at about Lat 04^0 $45^0$25 N and 07^0 $01^0$27.7 E. This site receives wastewater from its metropolis, discharges from clinical, domestic and agricultural sectors and effluents from motor boats engines in the area. Nembe waterfront is located at about Lat 04^0 $45^0$25 N and 07^0 0127.7E. This site receives wastewater from its metropolis, market, dockyard of the Ibeto cement factory and from transportation of timber and other goods using speed boat.

Surface water samples were collected between 8.00am and 3.00pm in the month of October. The surface water temperature, pH, conductivity and TDS, salinity and DO were measured in the field using mercury in-glass thermometer; pH meter (Milwaukee model pH 600); Hand-held Conductivity/TDS/Salt/Temp Multimeter (model CTS-406) Hand-held refractometer (ATAGO, calibrated in 1000 millimicron) and Milwaukee Dissolved Oxygen meter (MW 600 Model). While biological oxygen demand (BOD) were measured in the laboratory after incubation for five days.

2.2 Collection and assessment of Water Samples

The water samples for metal analysis were collected using one liter glass container and 1ml of HNO3 added to it. Surface water samples for nutrients (SO4, NO4 and PO4) were collected with pre-cleaned plastic container. All the containers were kept in ice-chest box and taken to the laboratory for further analysis using APHA 4500 Method [8].

Metal analysis was carried out using Atomic Absorption Spectrophotometer (APHA D31100). Sample preparation was by acid digestion using 5ml concentrated nitric acid, followed by filtration through a 0.45 micron membrane filter. Then aliquots of the filtrate were made up to 50ml with deionized water and used to analyze for the various metals. A reagent blank was also incorporated and all regents used were of analytical grade. The heavy metals (Lead, Cadmium, Chromium, and Nickel) were determined using a flame Atomic Absorption Spectrophotometer (model: Agilent 55B SPECTRAA) with the appropriate hollow cathode lamp and resonance wavelength of the metals.

Figure 1. Map of study area.

III. Results

The result of various concentrations of physicochemical parameters of the water in Bonny, Iwofe, and Nembe waterfront is shown in Table 1.The mean values of parameters in Bonny creek were 7.7 (pH), 8.3mg/L (DO), 11.4ppt (salinity), 28.0^0c (temperature), 8.7 mg/L (BOD) 22.6 µs/cm (conductivity) and 14.9 mg/L (TDS). Iwofe has 7.5 (pH), 9.6 mg/l (DO), 4.37ppt (salinity), 27.6^0c (temperature), (BOD) 8.75µs/cm

(conductivity) and 5.79 mg/L (TDS). Nembe waterfront has mean concentration values of 7.6 (pH), 8.9mg/L (DO) 10.0ppt (salinity), 28.1^{0}C (temperature), 7.7 mg/L (BOD), 20.4 µs/cm (conductivity) and 13.1 (mg/L) (TDS). With exception of DO and BOD, the values of other physicochemical parameters were highest in Bonny while these values were lowest in Iwofe.

The concentration of mineral nutrient in Bonny, Iwofe and Nembe waterfronts is shown in Table 1. The levels of mineral nutrients varied among the various watersides. For Nitrate (mg/L) the values were 4.6, 2.7 and 3.3 for Bonny, Nembe and Iwofe waterfront respectively. For Phosphate (mg/L) the values were 0.6, 0.2, and 1.5 for Bonny, Nembe and Iwofe waterfront respectively and Sulphate (mg/L), the values were 185.2, 115.5, 187.5 for Bonny, Nembe and Iwofe waterfront respectively.

Table 1: Physicochemical Parameters and nutrientsinIwofe, Nembe and Bonny waterfronts, Port Harcourt, Rivers state.

Parameters	Iwofe	Nembe	Bonny	FEPA/WHO	DPR
pH	7.5 ± 0.1	7.6± 0.1	7.7± 0.1	6.5 -8.5	6-9
Conductivity (µs/cm)	8.8± 3.0	20.4± 3.0	22.6± 3.0	200-1000/-	-
Temperature (^{0}C)	27.6± 0.5	28.1± 0.5	28.0± 0.5	27.8/30	30
TDS (mg/L)	5.8± 2.1	13.1± 2.1	14.9± 2.1	1000/2000	2000
Salinity (ppt)	4.4± 0.9	10.0± 0.9	11.4± 0.9	-/-	-
DO(mg/L)	9.6± 0.6	8.9± 0.6	8.3± 0.6	8-10/20	20
BOD(mg/L)	2.6± 0.5	2.8±0.5	2.50±0.5	10/10	10
N04(mg/L)	2.7	3.3	4.6	10/50	20
PO4(mg/L)	0.2	1.5	0.6	<5 / 5	5
SO4(mg/L)	115.5	187.5	185.2	200/ -	-

The concentration of metals in water samples from Bonny, Iwofe, Nembe creek is shown in Fig 2.The level of heavy metal concentration (mg/L) varied among water samples. The concentrations of Cadmium, in Bonny, Iwofe and Nembe waterfronts were 0.41, 0.13 and 0.43 respectively. For Chromium the value was <0.001for all the water fronts. The values of Lead were 0.24, 0.31, and 0.36 for Bonny, Iwofe and Nembe waterfront respectively. The values of Nickel were 0.012, <0.001, <0.001 for Bonny, Iwofe and Nembe waterfront respectively. Nembe has the highest concentrations of Cadmium and lead while chromium and Nickel were similar for the entire water front except Nickel in Bonny. However the differences in all the parameters observed in the water bodies were not significant at p<0.05. Except DO that had negative correlation with other parameters, all other physicochemical parameters had positive correlation with each other and nutrients. D0 had high significant negative correlation (r =-1) with pH while BOD had positive correlation with pH (r=+1).

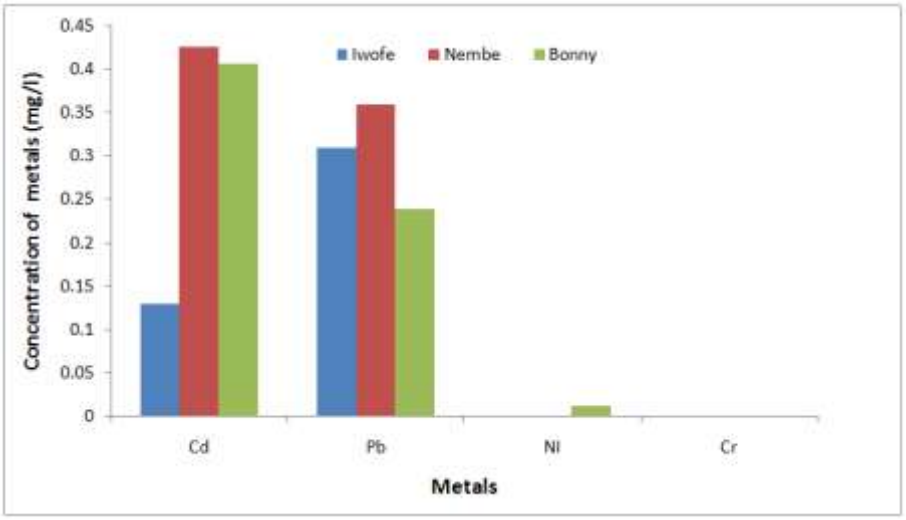

Figure 2 - Concentration of Heavy Metals in Bonny creek, Iwofe and Nembe waterfronts in Port Harcourt, Rivers state.

IV. Discussion

Physicochemical features of water in Bonny, Iwofe and Nembe waterfronts were within WHO permissible limits[9]. The Temperature range in the water is apparently suitable for aquatic life in the tropical region of Nigeria. The pH of the water is alkaline and within the normal range of WHO. The other physicochemical parameters showed a wide range of values which were low when compared with World Health

Organisation (WHO) and Department of Petroleum Resources (DPR) limits for substances discharge into water for domestic use in Nigeria[10, 11]. The amount of DO in water is a good indicator of water quality. Water with DO above 6ppm will support fish and other desirable forms of aquatic biota whereas water with less than 2ppm oxygen will support mainly decomposers. There is negative correlation between the DO and BOD; this implies that the DO decreases with increase in BOD which is the oxygen needed for organic decomposition.

Despite human activities and waste discharges, nutrients values were generally low in all the waterfronts and within permissible limits of 200mg/l for SO4, 50mg/L for NO4, and 5mg/L for PO4 in water. WHO[9] stated that Sulphate occurred in drinking water at a level that is of no health concern while PO4 is generally low in water. According to the specified requirement and standard prescribe by ECE system for classifying the quality of surface freshwaters for maintenance of aquatic life, the inland water of Nembe, Bonny and Iwofe fall under class 1[12].

The heavy metals distribution and concentration in the water samples is in the order Cd>Pb>Ni>Cr. The concentrations of the heavy metals studied were generally higher than standard set for marine environment except for Nickel and Chromium. Cadmium occurs in water as a result of human activities. The concentration of Cadmium was highest ranging from 0.425mg/L in Nembe waterfront, 0.406mg/L in Bonny waterfront and 0.130mg/L in Iwofe waterfront. These values were higher than WHO recommended value of 0.003mg/l [9]. However, low levels of Cd have been obtained in previous findings in Nigerdelta [13, 14, 15]. Lead concentrations were high when compared to WHO permissible limit of 0.01mg/L; this is due to the fact that lead is closely related with crude oil and municipal waste disposal [16]. The levels of lead recorded in this study(0.240mg/L-0.360mg/L) are consistent with previous result in Niger Delta [15, 17].Nickel concentrations were generally low in the three waterfronts as compared to WHO permissible limit of 0.2mg/L in water. Nickel concentration being the lowest shows much variation when compared with other rivers in the Niger Delta[18, 17]). Chromium is a low mobility element which could explain the low value of <0.001mg/L and is low when compared to WHO permissible limit of 0.1mg/L in water body.

The study of activities in the three waterfronts shows that Nembe waterfront has a jetty for local transport and journeys outside Port Harcourt. Transportation using diesel and petro engine boats and the dockyard of the Ibeto cement factory were the major activity there. In addition, there is an area for fishing and human settlements. Nembe waterside witnesses a lot of activities as a result of a large number of people that patronize a popular market, the Creek road market, situated close to this ferry port, where a lot of buying and selling of food stuff and other products. Bonny waterfront in Port Harcourt is subject to human-induced pressures resulting from urbanisation, industrialization, and intensive navigation. It links Port Harcourt city with Bonny Island where most of all oil installations in Rivers State are situated. It also links the Island directly with the Atlantic ocean through which crude oil is exported by massive oil tankers. The activities in Bonny waterfront could explain for the extremity in values in some physicochemical parameters, mineral nutrients and heavy metals in Bonny waterfront. In addition to transportation on Iwofe waterfront, municipal wastes (sewage) and industrial effluents from the city are directly discharged into the river. Sometimes, the concentrations of metals measured in water do not reflect the relative contributions of pollution from the activities in the waterfronts. This has been attributed to the action of some physicochemical process such as precipitation, trapping, settling and storage of pollutants in sediments and aquatic organisms [19]. [20] reported that the discharge of industrial effluents and civic pollution of various kinds would deteriorate the water quality making it unsuitable for both aquatic and human life.

V. Conclusion

Transport activities and waste generated by the operations of vessels at ports have negative impact on water quality and could cause serious environmental problems. Cadmium and lead in the three waterfronts were higher than the proposed maximum permissible limits by World Health Organisation (WHO) may probably be due to municipal waste, transportation and commercial activities. The higher the levels of trace metal in water body, the greater the consequences on biodiversity and toxicity on human health. In addition, the consumption of fish and water usage from such water body may pose threat to human. Therefore, periodic monitoring of metals contents and quality of inland water used for transportation is important to ensure safety and continuous sustainable use of aquatic resources.

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