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ASSESSMENT OF THE PHYSICOCHEMICAL AND MICROBIAL DIVERSITY OF ORASHI RIVER FLOOD PLAIN IN EGBEMA

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ABSTRACT

The physicochemical and microbial diversity of Orashi River flood plain in Egbema were assessed for agricultural use. Results showed high organic C and low N contents. The pH values of the four areas sampled ranged from 5.6 – 6.4. In the heavy metals assessed, Fe, Pb and Zn had significantly high values while values of Cr, Cd and Cu were very low. Higher heavy metal concentrations and acidic pH were observed in the oil producing sections of Ebocha and Mmahu than Okwuzi and Abacheke areas. Among the microbial groups determined, the total heterotrophic bacteria (THB) were the most prevalent followed by the total actinomyces (TA). The lipolytic, petroleum degrading and phosphate solubilizing bacteria were more prevalent in the oil impacted soil at Mmahu and Ebocha while the THB were more in the Okwuzi and Abacheke soil samples. More uniform results and *higher microbial counts were observed during the rainy season than the dry season. Observations indicated that the flood plains required amendment with nitrogen containing manure to improve the soil quality as the C/N ratio was generally poor. Results also showed negative impact on soil quality by oil producing activities.*

INTRODUCTION

Flood plains are mainly wetlands which serve as transitional ecosystems for both terrestrial and aquatic organisms. Such lands are endowed with extensive structural and functional attributes that enable them perform immense ecological roles in the biosphere. These flood plains have been credited with high organic nutrients turnover, alluvial deposits, high microbial nutrients source and breeding grounds for various aquatic organisms (1 and 2). Fishes arthropods and insects inclusive have been found there. These observations have also been reported (3 and 4). Following the high alluvial and microbial nutrients deposits, the rate of biogeochemical transformation taking place in such flood plains is very high.

Flood plains and wetlands occupy very vast amounts of lands available in Nigeria and they are often abandoned or untapped for various reasons ranging from lack of awareness of its potentials, misuse (some are used as sinks for industrial effluents) and other anthropogenic activities that reduce their qualities (2, 5 and 6). In Nigeria, the potential of available flood plains and wetlands have not been properly documented and exploited (7). Information concerning such areas outside mapping and identification remain very scanty. The fall in agricultural yields from conventional terrestrial farmlands calls for exploitation and extension to lands previously unused. Currently only paddy rice has been cultivated in some wetlands and floodplains, especially in Northern Nigeria and a few areas in southern Nigeria.

Following the potentials of wetlands as possible agricultural lands and lack of information concerning such lands, this study was aimed at assessing the quality of Orashi River floodplains to ascertain its characteristics. In doing this, the physicochemical and microbial diversity were adopted as indicators of soil quality for possible agricultural uses.

MATERIALS AND METHOD

The study area

The Orashi River floodplain is the study area. The river is a major tributary of River Nun. Orashi River traverses several communities in both Imo and Rivers States before joining the River Nun. Such communities as Egbema (in both Imo and Rivers States), Ogba and Ekpeye in River State have various sections of the Orashi River. The study area is therefore located at the Southern portion of Imo State and the Northern part of Niger Delta area of Nigeria. However, the portion studied lies in Egbema in both Rivers and Imo States. The area has a tropical climate and vegetation is the typical rainforest type. It has two distinct seasons - rainy and dry seasons. Following the presence of Orashi River, Nkissa River and Oloshi River in the area, the people are mainly fishermen. Others are farmers making use of the available lands. The discovery of large deposits of oil added another source of livelihood to the people. However, the adverse effects of oil production activities, with the resultant low agricultural yields have called for search for new areas for farming.

Sample collection

Soil samples were collected from the top soil (0-20cm) using soil augar from four different points of the study area. The points were Mmahu (where SPDC has an oil flow station), Abacheke, Okwuzi and Ebocha (near NAOC flow station). Each of the sampling sites lies at least 5km from the previous one.

At each sampling site, three different soil samples were collected and pooled together to give a composite sample for that particular site. The samples were put into clean sterile sample bottles (glass) and taken to the laboratory for analysis within 24-48hr for biological indices.

Samples collected for the months of December, January, February and March served for the dry season while those taken in May, June, July and September served as the rainy season samples. In each season, only the average results (means) were reported. Samples were collected between December, 2007-September, 2008.

Soil physicochemical properties analysis

Soil samples for physicochemical analysis were stored in the refrigerator at 4^0C till required for analysis which was between 24-48hr of collection. However, such parameters as pH and temperature were assessed *in situ* using HANNA 1910 multipurpose tester (Jenway). Soil organic carbon was determined according to AOAC (8).

The exchangeable acidity (EA)., electrical conductivity (EC) and effective cation exchange capacity (ECEC) were determined as outlined in UNEP manual (9). The available phosphorus (P) and total nitrogen (N) were determined (8).

Soil metallic contents were determined using the atomic absorption spectrophotometer (AAS) method after acid digestion using HACH D2/02/2010 Spectrophotometer (8).

Microbiological analysis

The prevalence of various groups of soil microorganisms was determined using the culture techniques (10). The various soil samples were inoculated on various culture media using the spread plate inoculation technique after ten-fold serial dilution (10). Tryptone soil agar was used for total hecterotropic bacteria (THB), McConkey agar for coliform bacteria (CB) Tributryrin agar for lipolytic bacteria (LB) and modified mineral salt agar for nitrifying bacteria (NB). The vapour phase technique was used to determine prevalence of petroleum degrading bacteria (PDB) (11). The phosphate solubilizing bacterial count was determined using the phosphate solubilizing media according to US Patent (12).

The actinomyces prevalence was determined using the starch nitrate agar (13). The results of each culture was expressed as colony forming units per gram (cfu/g).

RESULTS

Results obtained for the physicochemical parameters measured are shown (Table I). The temperature values ranged between 28.2-29. 6^0C in dry season and 28.8-32. 4^0C in rainy season. pH range in the dry season (5.2-6.8) was lower than the rainy season (6.3-7.2). Organic carbon and other parameters had higher values in the rainy season than in the dry season. Values obtained at Mmahu were similar to those at Ebocha while those from Okwuzi were quite similar to those from Abacheke. This was the trend in both seasons.

For the heavy metals analyzed, only Pb Fe, and Zn had significantly important values in both seasons. Pb. had a value range of 42.46-92.33 my/g in the rainy season and 37.61-87.32 mg/g in dry season. Though the values of Cr, Cd and Cu were significantly low, they followed the same trend earlier reported according to the sampling sites and seasons.

Results obtained in the microbiological analyses showed that the most prevalent organisms were the THB which had the highest counts in each soil sample and season too. While counts of THB ranged from 6.3-7.1x10^6 cfu/g in the rainy season, i' increased to 6.8-7.6x10^6 cfu/g in the rainy season The leas prevalent group of organisms were the NB which had a range o 1.4-2.1x10^3 cfu/g in the dry season and 2.1.3.6x10^3 cfu/g in th rainy season. LB and PDB were higher in Mmahu and Ebocha so samples but lower in the Okwuzi ad Abacheke soil samples. PS and TAC followed the same old trend of being higher in Okwu and Abacheke soil samples though it was the least affected grou Again values in rainy season were equally higher than those of t dry season (Table II).

DISCUSSION AND CONCLUSIONS

The analysis of the soil conditions in the Orashi River floodplains revealed extensive modifications of the soil quality by the oil production activities. Nwaugo *et al*. (14) had reported a pH range of 5.3-5.6 in soil close to flare jets in Egbema. Findings in this study agreed with that observation as Mmahu and Ebocha which are very close to oil flow stations, had lower pH range in both seasons. Temperature ranges in this area (Ebocha and Mmahu) was equally higher than those at Okwuzi and Abacheke has been reported (14). Researchers had attributed the high temperature to persistent gas flaring in the area (14 and 15). N and P were equally observed to be lower in the Ebocha and Mmahu soil samples, which could have been caused by the high temperature and acidic pH. N and P are vapourizable. High temperature could result in low N and P soil content which agreed with the present finding (1 and 2).

Organic carbon, EA, EC and ECEC were higher in the Ebocha and Mmahu soil than the other two soil sources. This again could be attributed to anthropogenic activities including the oil production activities. The establishment of the flow stations attracted several human activities which increased and complicated the type and quality of wastes generated in the area. Chemical substances from the materials used by the companies might have affected the soil properties. The soil samples from Okwuzi and Abacheke could be taken as controls in assessing the effects of these activities. This was further buttressed by the C/N ratio. Crude oil and chemicals used in its production were said to be high in C content which invariably impinged on the C/N ratio. This was in consonance with Johnston (16) and Spieles and Mitsch (17).

Observations in the metal concentrations did not differ from the earlier established trend observed in the physicochemical properties. Pb Fe and Zn had quite significant values. Soil irrigated with oily wastewater had high concentrations of these metals (6). Nwaugo *et al.* (14) working on the effects of petroleum produced water in Egbema also observed higher soil Pb, Fe and Zn. This study therefore agreed that oil production activities could increase Fe, Pb and Zn concentrations in the soil. This becomes more glaring as the production equipment in the oil industries are made from the alloys of these metals. The possibility of corrosion or rusting could release such metals into the soil which agree with Kiikkila (18).

Analysis of the microbial diversity showed that soil from Abacheke and Okwuzi generally had high microbial counts. However, LB and PDB were higher in Ebocha and Mmahu soil. This could be attributed to substrate induction as Ebocha and Mmahu have oil flow stations suggesting that such areas could easily experience oil contamination. It was reported that PDB are ubiquitous but more available in oil contaminated soil (19). The low prevalence of NB could be attributed to environmental changes. It was stated that NB are very sensitive to environmental changes and will decrease in prevalence as soon as conditions become adverse (20 and 21). The changes in pH, temperature and metal concentrations could have affected the NB adversely.

Generally, the microbiological analysis showed that the soil has various types of micro-organisms involved in biogeochemical transformations. The presence of the PSB and TAC suggest such high biogeochemical activities. This agreed with the findings of other workers (7 and 18). These groups of microorganisms were not extensively affected. Actinomycetes are often used in bioremediation activities, hence can survive in harsh environmental conditions (22 and 23). THB could even contain members of the other microbial groups hence its high prevalence (24 and 25).

Generally, seasonal influence was significant. The rains diluted the harsh environmental pollutants and even spread them out to reduce their effects on a particular area (14 and 17). The dilution and spreading effects of the run off water or flooding during the rainy season could have re-distributed the soil contaminants and physicochemical factors in addition to the nutrients which changed the soil parameters and microbiological growth.

In conclusion, observations indicated low C/N ratio in Mmahu and Ebocha soil samples in addition to low microbial counts and enzyme activities and is suggestive of soil contamination. On the other hand, better soil conditions were observed in Okwuzi and Abacheke sections of the Orashi floodplains suitable for agricultural purpose. However, the soil conditions in the floodplains could be improved by application of organic or compost manure since the C/N ratio of the entire soil sample was generally low.

Table I. Physicochemical properties of Orashi River floodplain - according to seasons.

Rainy Season

Parameters	Ebocha	Okwuzi	Abacheke	Mmahu
Temp oC	30.4	29.1	28.8	31.6
pH	5.6	6.2	6.4	5.8
N%	0.15	0.18	0.19	0.16
P	12.11	11.19	11.82	12.02
Org. Carbon	8.23	6.90	7.25	8.06
EC. ds/m	0.36	0.31	0.33	0.35
EA	1.69	1.63	1.66	1.72
ECEC	5.42	5.12	5.16	5.40
C.N ratio	54.86	38.33	38.15	50.37
Pb mg/g	92.33	55.21	42.46	78.43
Cu mg/g	0.06	0.04	0.04	0.06
Zn mg/g	3.2	2.9	3.0	3.6
Fe mg/g	20.4	14.1	15,3	17.6
Cd mg/g	0.03	0.02	0.05	0.10
Cr mg/g	0.04	0.02	0.06	0.14
	Dry Season			
Temp. ^{0}C	29.4	28.6	28.2	29.6
pH	5.2	5.8	6.2	5.8
N	0.11	0.14	0.16	0.13

Table I. Contd.

P	10.41	11.21	10.92	10.24
Org. Carbon	6.31	5.11	5.03	6.12
EC ds/m	0/3	0.4	0.4	0.3
EA	1.42	1.32	1.72	1.54
ECEC	5.77	5.41	5.63	5.24
C/N ratio	57.36	36.50	31.43	47.07
Pb	87.32	50.31	47.61	66.40
Cu mg/g	0.06	0.04	0/04	0.06
Zn mg/g	3.7	3.3	3.2	3.9
Fe mg/g	19.6	12.6	12.4	18.2
Cd mg/g	0.02	0.01	0:2	0.8
Cr mg/g	0.002	0.01	0.1	0.9

Table II. Microbial diversity of Orashi flood plain according to seasons (cfu/g)

Dry season

Microbial Diversity	Ebocha	Okwuzi	Abacheke	Mmahu
THB	6.3×10^6	6.8×10^6	7.11×10^6	$.1 \times 10^6$
PSB	2.4×10^3	3.4×10^3	3.4×10^3	2.6×10^3
LP	2.6×10^3	2.4×10^3	2.2×10^3	2.4×10^3
NB	1.4×10^3	1.8×10^4	1.210^4	1.6×10^3
PDB	1.4×10^5	2.4×10^4	2.1×10^4	$2.6.\times 10^4$
TA	2.4×10^4	2.3×10^5	$2.3 \times 10\ 10^5$	2.4×10^5
	Rainy	season		
THB	6.8×10^6	7.2×10^6	7.6×10^6	6.9×10^6
PSB	39×10^4	3.4×10^4	3.8×10^4	3.4×10^4
LP	3.1×10^4	2.8×10^4	2.6×10^4	3.3×10^4
NB	2.1×10^3	3.6×10^3	3.3×10^3	2.3×10^3
PDB	1.6×10^5	3.1×10^4	3.6×10^4	1.7×10^5
TA	2.6×10^5	2.4×10^5	2.4×10^5	2.6×10^5

Values are means of the results obtained in the months of the reason.

THB - Total heterotrophic bacteria
PSB - Phosphate solubilizing bacteria
LP - Lipolytic bacteria
NB - Nitrifying bacteria

PDB - Petroleum degrading bacteria
TA - Total actinomyces

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