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Comparison of Microbial, Nutrient and Heavy Metal Contents of Mangrove (*Rhyzophora Racemosa*) and Nypa Palm (*Nypa Fruticans*) Roots Collected From Selected Sitesin Rivers State.

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Abstract:

Mangroves are native species while Nypa palms are foreign species introduced into the Niger Delta. This study is aimed at determining the cause of the rapid encroachment of Nypa palm into mangrove forest. Root and soil samples were collected randomly in mangrove and Nypa palm forests at Asarama and Okrika. Heavy metal, nutrient and microbial analyses were carried out on the root samples. Results show that the bacterial content (4.85 ± 0.6 cfu/g $\times 10^6$) was more than fungal content (0.35 ± 0.01 cfu/g $\times 10^6$) in mangrove and Nypa palm roots. Mangrove roots had slightly higher microbial content (2.85 cfu/g $\times 10^6$) than Nypa palm roots (2.35 cfu/g $\times 10^6$) while Nypa palm roots had higher heavy metal content (7.7 ± 3.2 mg/kg) than mangrove roots (2.7 ± 1.2 mg/kg). Average nutrient content was more in mangrove roots (123.9 ± 121.1mg/kg) than in Nypa palm roots (44.9 ± 40.7 mg/kg). Furthermore, physical and microscopic observations indicate that Nypa palm roots were "straw-like" and hollow while the mangrove roots are thick and non-hollow. The morphology of the palm root predisposes them to absorbing more nutrients than mangrove roots. This implies that mangrove roots are slow transmitters of nutrients as compared to Nypa palm roots, which are quick transmitters of nutrient. Nypa palm thus have competitive advantage over mangroves in nutrient utilization despite the presence of heavy metals. These results provide some answers to why the palms are speedily colonizing many mangrove forest areas in the Niger Delta.

Keywords: *Rhizophora species, heavy metals, microbial contents, Nypa palm root, mangroves*

Introduction

Mangrove forest is rich in biodiversity, and serves as a habitat for numerous species ranging from microscopic to macroscopic organisms (NDES, 1997). Bacteria and fungi are responsible for the decomposition activity in mangrove forests (Numbere and Camilo, 2017). Decomposition is a major driver of nutrient turnover within the mangrove ecosystem. Mangrove litters at different stages of decomposition play significant role in sediment formation. The microbial count in mangrove swamp is high because of the presence of bacteria (Peter and Sivasothi, 2002). Bacteria are widely distributed and can live in extreme temperatures or harsh chemical environments. Their cell wall is made of peptidoglycan, which is formed from carbohydrates polymers linked together by peptide cross-bridges, which also include amino acids. They do not have membrane bound nuclei, nor their genetic material bound in a nuclear envelope. Bacteria do not contain chromosomes; instead they have a single circular molecule of DNA called plasmids, which contain the genetic material. Oxygen is a toxic molecule to most bacteria, which grow without it, but most strains require oxygen for growth and survival (Thiel, 1999). Bacterial population is high in mangrove swamps because most of them can live in moderately salty conditions, but will die in highly saline condition, growing best in optimum supply of nutrients (Thiel, 1999). The population is often higher than fungal population in mangrove swamps (EIA, 2001; Numbere, 2017) because of their method of reproductive ability through binary fission. Once in a favorable environment bacterial cells reproduce very quickly to form colonies. However, the presence of heavy metals can affect their population growth in mangrove and nypa palm forests.

Nypa palms is an invasive plant species introduced into the Niger Delta in 1906 (Keay, 1964). They have proliferated and colonized most mangrove areas (Wang *et al*. 2017). This study was thus embarked upon to find out why Nypa palms are rapidly taking over many mangrove forest areas. In other to achieve this aim, microbial count and heavy metal contents were determined in the roots of mangrove and Nypa palm plants,they are the main support system of the plant involved in absorption of inorganic nutrients and toxic materials from the soil. The roots also store food and carry out vegetative reproduction. Mangrove roots are adventitious, which ensure their survival in oxygen-deprived soil (Kathiresan and Bingham, 2001). Nypa palm roots are also entirely embedded in the soil and utilize nutrients. The objective of this study, therefore is to: determine; the microbial content of mangrove and Nypa palm roots: the heavy metal concentration in mangrove and Nypa palm roots and the nutrient content in mangrove and Nypa palm roots.

Materials and Methods

The study was conducted between February─May, 2017 within two locations in the Niger Delta, namely: Asarama (4°44

N and 6°52 E) and Okrika (4°43 N and 7°05 E) (Fig. 1). Both study areas are dominated by mangrove and Nypa palm forests (Wang *et al*,. 2016). The Okrika station is close to a major oil refinery that has interconnecting pipelines passing through the mangrove forest to a jetty (EIA, 2001; Numbere, 2014). The area experiences constant rain fall all through the year except October, November and January. The peak rain fall occur in May─June, and averages 1,466.0 mm. Detailed description of the study area is given in Numbere (2014).

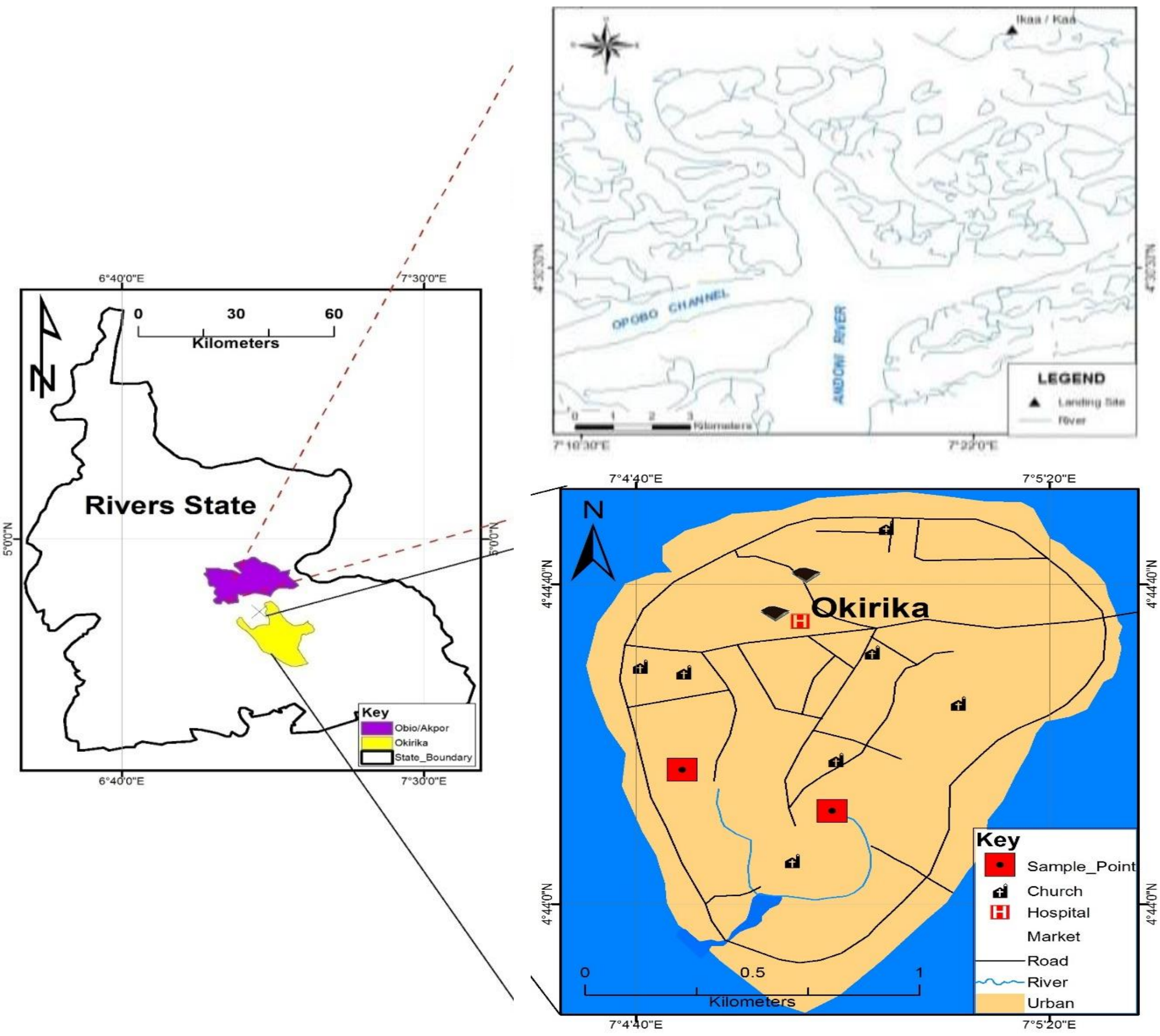

Figure 1. Map of study area indicating sites of root collection in two coastal communities in River State, Nigeria

Twenty root samples of both mangrove and Nypa palms were cut with a camp knife while some soil samples were collected from both locations at a depth of 5-10 m with a hand-held soil augur (Germany). Physicochemical analysis of some parameters from both stations were determined *in-situ* (Table 1) and in the laboratory.

Table 1. Physico-chemical parameters of soil tested in-situ in the mangrove forest of Asarama and Okrika in the Niger Delta, Nigeria

Locations	Coordinates	Salinity (ppt)	pH	Temperature C°	Moisture content
Asrarama	4°44 N and 6°52 E	20.6	6.02	27.1	10.02
Okrika	4°43 N and 7°05 E	26.3	7.5	30.3	10.12

Microbial content was determined using Sabouraud Destrose, and nutrient Agar for fungi and bacteria respectively. The following heavy metals in root samples were tested in the laboratory, namely Lead (Pb), Cadmium (Cd) and Chromium (Cr) using spectrophotometric method while the following nutrient contents were also tested, namely Nitrogen (N), Phosphorous (P), Potassium (K) and Nitrate (NO_3) using macro-kjeldahl method followed by colorimetric test. For structural analysis, root samples were cut into thin sections and viewed under an electron microscope while external attributes were studied physically.

Statistical Analysis

A t-test was conducted to test if there was any significance difference in heavy metal, nutrient and microbial contents between mangrove and nypa palm.as there were only two treatments Bar charts were plotted to illustrate the differences in concentration.

Results

Microbial content

There was no significant difference in microbial content between the roots of mangrove and Nypa palm ($P = 0.89$). But there was a significant difference between fungal and bacterial counts in roots of mangrove and Nypa palm ($P = 0.015$). The total heterotrophic bacteria (THB) was greater than the total heterotrophic fungi (TBF) (Fig. 2).

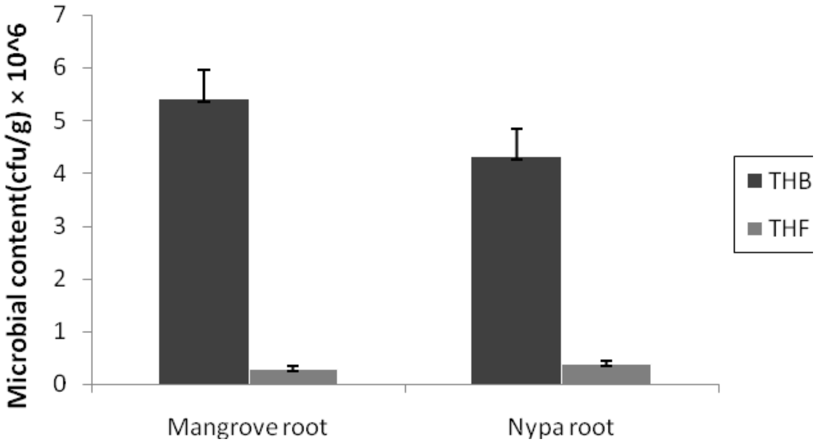

Figure 2. Microbial content in mangrove and nypa palm root samples collected from Asarama and Okrika Jetty in the Niger Delta, Nigeria.

Heavy Metal Content

There was significant difference in heavy metal content between Nypa palm and mangrove roots (*P* = 0.02) (Fig. 3). Furthermore, Nypa palm roots had higher heavy metal content than mangrove roots.

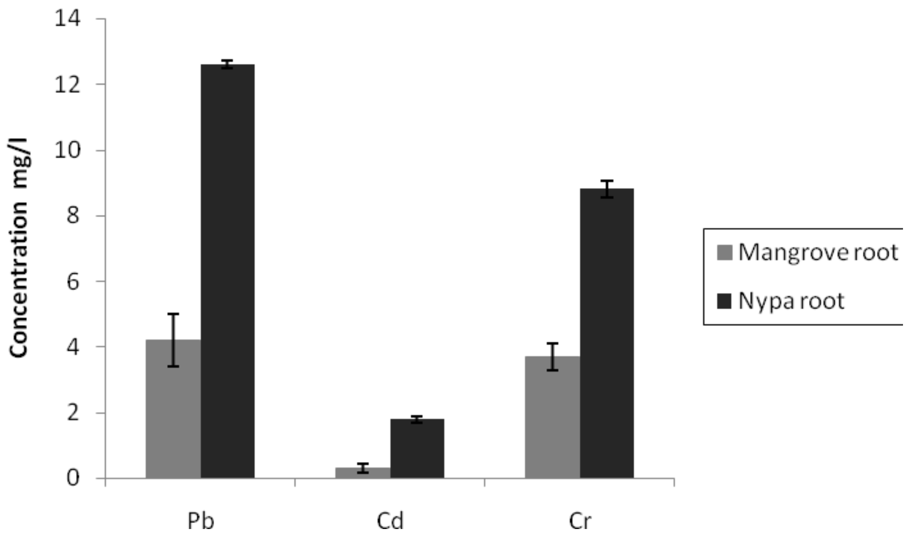

Figure 3. Heavy metal content in mangrove and nypa palm root samples collected from Asarama and Okrika Jetty in the Niger Delta, Nigeria.

Nutrient Content

There is no significant difference (*P* = 0.55) in nutrient content in the roots of Nypa palm and mangrove. But Potassium (K) concentrations varied between mangrove and Nypa palm roots (Fig. 4). The Nitrate content for both roots were negligible while Nitrogen and Phosphorous had no significant concentration.

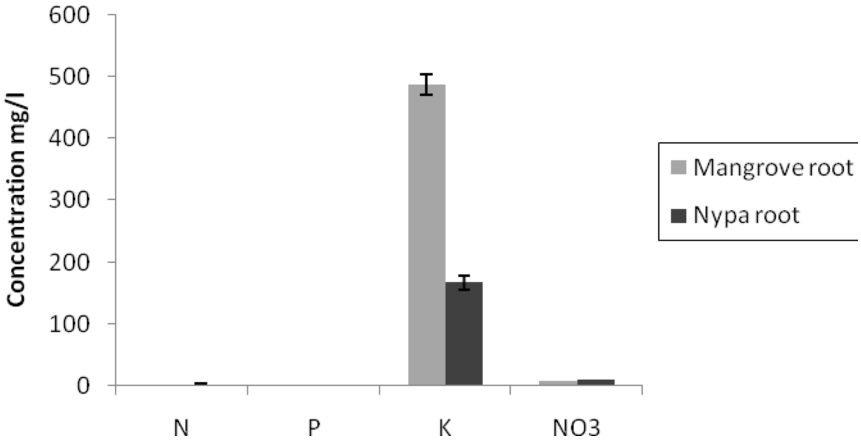

Figure 4. Nutrient content in mangrove and nypa palm root samples collected from Asarama and Okrika Jetty in the Niger Delta, Nigeria.

Structural Differences

Physical and microscopic examination of the roots indicates that mangrove roots are tougher and thicker whereas Nypa palm roots are lighter, feebler and straw-like (Fig. 5).

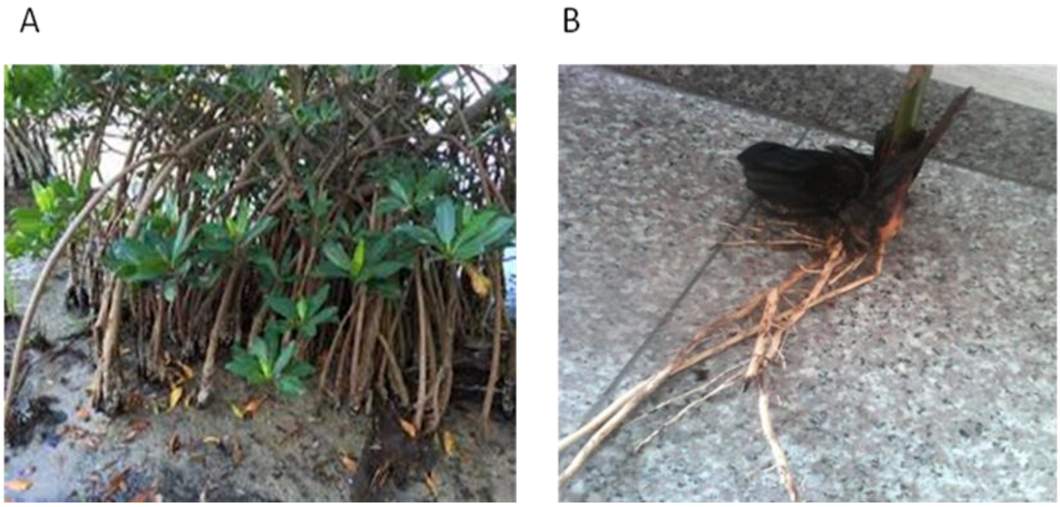

Figure 5. (A). Mangrove and (B). Nypa palm roots. The roots of nypa palm are more fibrous, lighter and completely buried in the soil whereas the mangrove roots are adventitious, harder and protrude from the soil surface. The nypa roots are hollow and "straw-like" while the mangrove roots are non-hollow and have tightly packed cells

Discussion

Previous studies had shown that bacteria population always out-numbered fungal population in mangrove ecosystem (Feller *et al*., 2010; Numbere, 2017). These earlier observations are in line with the results of this study that showed higher population of bacteria than fungi. This can be attributed to a higher multiplicative and replicative ability of bacteria compared to fungi, which had made them to be present in almost every facet of the mangrove environment.

Some parts of mangrove roots are embedded in the soil while other parts protrude from the soil to absorb atmospheric oxygen (e.g. pneumatophores). This condition makes the mangrove roots to harbor both aerobic and anaerobic bacteria (Alongi, 2005). In contrast, Nypa palm roots are completely embedded in the soil and quickly absorb heavy metals and nutrients, which they distribute to their parts of the plants. However, high heavy metal concentration seems not to affect the growth of the Nypa palms, as indicated by their robust growth within mangrove stands.

Root structure of mangrove and Nypa palm also play key role in nutrient and heavy metal absorption and redistribution. The hollow nature of Nypa palm root makes them to act as siphon, which leads to the quick absorption of soil nutrients when compared to mangrove root that is thick and non-hollow. This is because the tightly packed cells of mangrove roots make them to distribute the nutrient much slower compared to the hollowed roots of Nypa palm. Field observations indicate that when mangroves are in the same environment with the palms, the palms grow better, faster and proliferate to colonize the entire area. This condition is accelerated by human activities such as oil and gas exploration (Numbere, 2018), which conta,imates the environment with crude oil, and this inhibits the growth and development of mangroves. The results of this study had indicated some reasons why the Nypa palms are outgrowing the mangroves and colonizing the mangrove forests in the Niger Delta. More studies are however still needed to investigate the transmission of nutrients, heavy metals and microbes to the parts of other mangroves species such as *Avicennia germinas* and *Laguncularia racemosa*.

In conclusion, mangrove roots had higher microbial population, which led to higher nutrient concentration as compared to Nypa palm roots that had lesser nutrient content but higher heavy metal concentrations. In addition, the physical assessment of the root samples indicates that Nypa palm roots are straw-like, which could predispose them to better nutrient absorption and utilization.

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