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SOIL PROPERTIES ASSOCIATED WITH THE INVASIVE *NYPA FRUTICANS* WURMB AND NATIVE MANGROVE PLANTS IN IBENO, AKWA IBOM STATE, NIGERIA

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ABSTRACT

The study examined the soil properties associated with the invasive *Nypafruticans* (INF) and native mangrove plants (NMP) in Ibeno LGA, AkwaIbom, Nigeria. Six 10m x 10m transect were laid randomly in the INF and NMP for the soil samples collection. Soil samples were collected at the depth of 0-15m (topsoil) and analysed using the standard methods. Results showed that the soils at both INF and NMP were alkaline (7.13 to 7.14). INF had higher concentration of hydrocarbon (1315.3 mg/kg) NO_3 (39.23 mg/kg) and available P (2.601 mg/kg) were higher under INF while K (694.23 mg/kg). Na (506.58 mg/kg), Mg (352.8 mg/kg), Mn (37.98 mg/kg) and Cl^- (11653 mg/kg), and conductivity (3228.33 µS/cm) were significantly higher in soils under NMP than the INF at $p<0.05$. Therefore, presence of invasive species (*Nypafruticans*) alters the soil properties of a mangrove ecosystem.

Keywords: Soil properties, Invasive, Nypafruticans, Mangrove, Ibeno LGA, Hydrocarbon

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INTRODUCTION

The impacts of alien invasive plants like *Nypafruticans* on ecosystem in the last decade are becoming worrisome and as well received growing attention. These species alter ecosystems because they differ from natives in eco-physiological traits, such as growth and allocation patterns (Liao *et al.*, 2008). Many alien invasive species have been shown to affect plant and animal communities (Alvarez and Cushman, 2002), ecosystem functioning (Belnap and Philips, 2001), soil properties and nutrient fluxes (Blank and Young, 2002) in the sites they invade.

Nypafruiticans Wurmb. is an invasive alien species to Nigeria from Singapore which was introduced in 1906 to check erosion. Widodo *et al.*, (2019) noted that *Nypafruticans* is a kind of estuarine plant distributed from Africa, South Asia, Indonesia, to the West Pacific which grows up to 10 m tall depending on the habitat fertility and produces many propagules which are dispersed with ocean currents. In the Niger Delta, it invades deforested and exposed mudflats and forms dense mono-specific stands which out-compete native mangrove species. The absence of stilt roots, lack of leaf litter and dense structure reduce estuarine habitat and may negatively affect native biodiversity. Biological invasions are considered most concerning threats to biodiversity, loss in terrestrial, fresh water and marine ecosystem (Dam-Roy *et al.*, 2017a). Furthermore, Nipa palm being a tropical plant, halophyte and has evolved mechanism for salt resistance, is found closer to oceans, creeks and estuaries. *Nypafruticans* is one of major mangrove species, whose habitat is distributed in tropical and subtropical coastal regions, provides important commodity materials to inhabitants from thatching materials, medicinal products (Hamilton and Murphy, 1988) to food sources and bio-ethanol feedstock (Matsui *et al.*, 2011; Matsui and Takahashi, 2016). Nipa palm became an invasive species in Nigeria because it has no natural enemies compared to native mangrove vegetation's which are cut down for firewood, fish stakes, fish traps, board, building, boat paddle, yam stake, fencing, curving etc.

Nigeria native mangrove consists of mostly tree and shrub with prop and pneumatophores roots e.g. Rhizophoreceae with prop (exposed supporting root) and Avicinniaceae with pneumatophores. Native mangrove plays key part in many fish, invertebrate, crustaceans and mollusk species life cycles; mangrove offer organisms a breeding ground (Orimoogunje and Ajibola-James, 2013). Recently, World Wildlife Fund for Nature (WWF) (2020) reported that mangrove forests are extremely productive ecosystem that provides numerous good and services both to the marine environment and people.

The current study was established upon the fact that soil is a life support system which performs multiple functions such as water and nutrient cycling; gas exchange with the atmosphere; supports all forms of terrestrial vegetation (tree, shrubs, grasses, algae, etc (Balestrini, *et al.*,

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2015). Jeffery *et al.*, (2010) described soil as a complete community within a given soil system. Soil condition has been recognized as an important factor for mangrove plantation and soil texture and topography have been the basis of species selection (Matsui and Takahashi, 2016). For example, *Rhizophora spp*. are chosen for muddy areas and *Sonneratia spp.* for sandy texture. Therefore, mangrove growth can better be explained when soil properties are taken into consideration with topography (Matsui *et al.*, 2008). However, changes in plant community structure may alter near-surface soil properties which could impact root growth, seedling emergence and growth, soil water and nutrient uptake (Hamblin, 1985), or heat capacity (Smith *et al.* 1987; Sperber *et al.*, 2003). Stubbs Creek Nigeria mangrove soil has been invaded by Nipa palm. Mangroves are considered as one of the major habitats in coastal ecosystem (Albert *et al.*, 2011). According to Jeffery *et al.* (2010) invasive plants have a multitude of impact on plant, community through their direct or indirect effect on soil chemistry and ecosystem function.

Several studies have focused on the ecology, distribution, and growth of *N. fruticans* (Teo *et al.*, 2010; Zakaria *et al.*, 2017). For instance, the effects of water properties and soil texture on the growth of a *Nypafruticans* was studied by Zakaria *et al.*, (2017); also, the effects of light, soil, salinity and disturbances on the growth of many palms have been studied (Tripler *et al.*, 2007). The location of the mangroves, between fresh water and the ocean, is a key site for the deposit of nutrients and other materials (Zakaria *et al.*, 2017). Other studies reported the growth responses of mangroves to salinity and nutrients (Alongi, 2011); and influence of nutrients in sediment with the composition of the mangrove flora (Clarke and Kerrigan, 2000) while Emoyoma *et al.* (2019) studied the impact of Nipa palm and mangroves forest on benthic macro invertebrate community; but there is limited knowledge on the impact of the species on soil properties. This study therefore, focuses on the effects of *N. fruticans* on soil properties in Ibeno LGA, AkwaIbom State, Nigeria.

MATERIALS AND METHODS

This study was carried out in Ibeno LGA, a riverine community in AkwaIbom State. It is bounded to the West by Eastern Obolo LGA, to the North by Onna, EsitEket and Eket LGAs and to the south by the Atlantic Ocean (Figure A). Ibeno LGA has latitudinal extent between 4° 30' N and 4° 45' N; and longitudinal extent between 7° 50' E and 8° 15' E. Ibeno occupies the largest coastline of more than 129 km in AkwaIbom State located in the mangrove swamp forest. Mean annual rainfall for this coastal region is high; from 2,000 mm to 2,500 mm. The mean minimum and maximum temperature are 26 °C and 30.5 °C respectively while the mean relative humidity of the area is about 83% (Werre, 2001).

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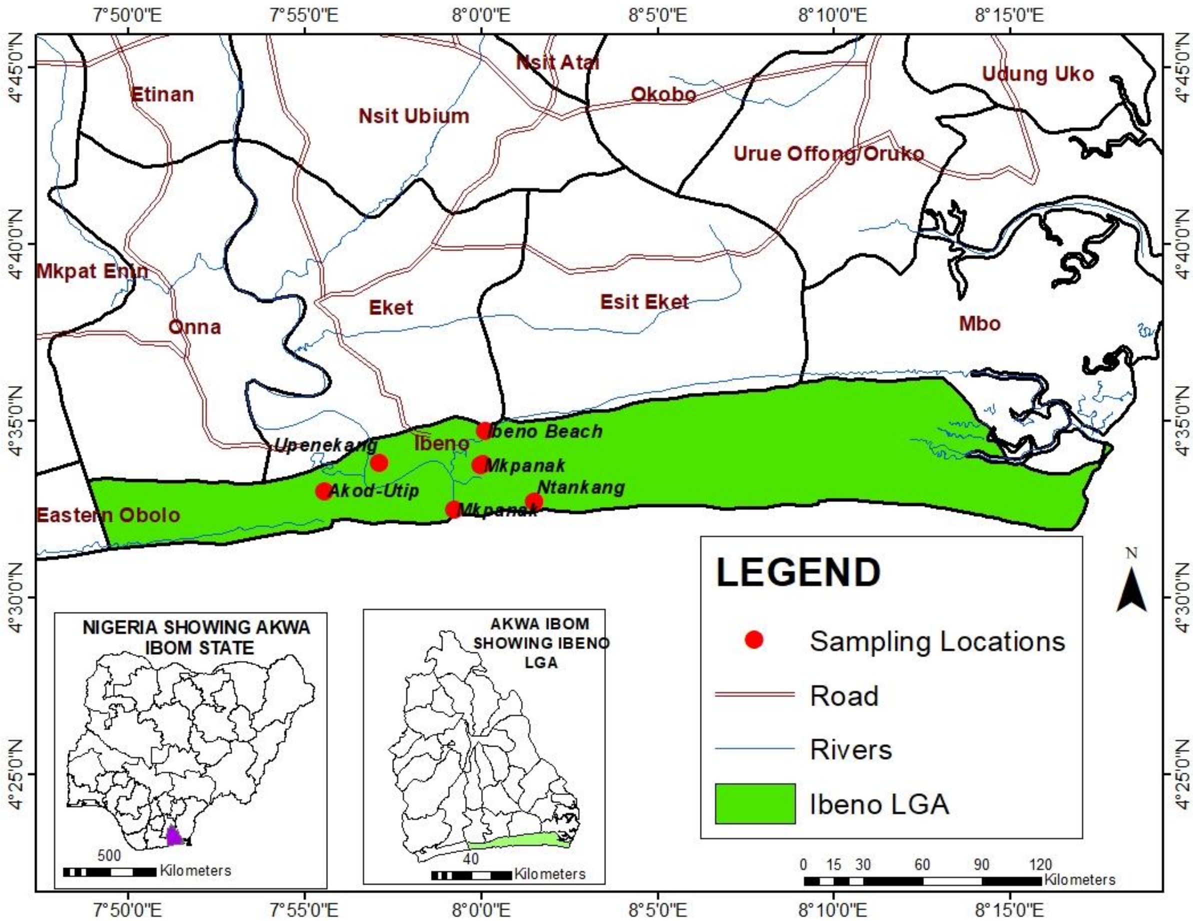

Figure A: Ibeno LGA showing Communities

Soil Samples Collection

Soil samples were collected from Nipa invasive soil and Nipa non-invasive soil along Akod, Utip River in Ibeno Community. Sampling points were collected from the six 10m x 10m transact that were randomly laid in the study area. Samples were collected into polythene sampling bags with soil auger at a depth of 0-15 cm. All samples were taken in triplicates and properly labeled and thereafter taken to the laboratory in a cooler for analysis of the following parameters; soil pH, conductivity, nitrate, phosphate, potassium, calcium, magnesium, sodium, chloride, total hydrocarbon and manganese. Exchangeable bases which included Calcium (Ca), Potassium (K), and Sodium (Na) were determined using flame photometry (Models PFP7 and PFP7/C), and Magnesium (Mg) using Atomic Absorption Spectrophotometer (Beckman Model DU). Total nitrogen (N) was determined using Kjeldahl steam distillation. Available phosphorus (P) was extracted with Bray and Kurtz solution (0.025M HCL to 0.03MN H_4F) using Murphy

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and Riley (1962) method. Soil pH was measured potentiometrically in 0.01M calcium chloride solution using 1:2 soil solution ratio while organic carbon was determined using the method of Walkey and Black (1934). Total hydrocarbon was determined by spectrophotometric method (Method). Descriptive statistics in form of mean and standard errors were used for the data analysis. T-test was employed to separate the means. Results were presented in tables and graphs.

RESULTS AND DISCUSSIONS

Figures 1 shows the soil pH at invasive and non-invasive sites were 7.13 and 7.14 respectively. This shows that the pH in the entire study area was close to neutrality. The value recorded agrees with Komi and Sikoki (2013) and Emoyoma *et al.*, (2019). Studies have shown tropical mangrove forest worldwide and it has been observed that mangrove soils may either be acidic or alkaline. Some researchers found soil pH ranging from 2.87-6.40 (Ukpong, 1997; Moreno and Calderon 2011) while others reported soil pH above 7.0 ranging from 7.4-8.22 (Das *et al.*, 2012; Hossain *et al.*, 2012). Soil pH affect all the physical, biological and chemical soil properties (Brady and Weil, 2016) and the growth of specific organisms, soil microbial biomass and microbial activities. The conductivity of the invasive plot was lower compared to non-invasive plot (Figure 2). Too low EC level indicate low available nutrient and too high EC level indicate excess nutrient in the soil. This shows that non-invasive plants are associated with high EC level which indicates higher soil fertility.

Figure 3 showed that Nipa palm invasive soil has high concentration of hydrocarbon than non-invasive Nipa soil type. Stubbs Creek forest is rich in natural resources both biotic and abiotic. Exxon Mobil and other oil companies are located in Ibeno L.G.A of AkwaIbom State the soil is polluted with hydrocarbon. Hydrocarbon concentration from Nipa palm invasive soil plot was very high with mean concentration of 1315.3mg/kg compared to non-invasive plot which was 342.65 mg/kg. Hydrocarbon is the main component of crude oil, natural gases and most pesticides. Total hydrocarbon content is used to describe the quality of the measured hydrocarbon impurities present. Ekweozor et al. (2003) had reported 550-900 mg/kg, concentration range along Bonny Estuary. NOAC (2008) recorded 66.30-80.80 mg/kg concentration range along 18 Tebidaba-Brass pipelines at Igbomatoru.

It is also shown that nitrate (NO_3), and phosphorus (P) which are nutrients were higher in the invasive soil than the non-invasive while potassium (K) was higher in the non-invasive soil. Thus, the non-Nipa palm invasive site is rich in organic matter which improves the soil structure.

The cations namely Mg, Ca, and Na were higher in the non-invasive soils than the invasive soil (Figures 7-9). Mg, Ca and Na at invasive soil were 109.4 mg/kg, 0.00 mg/kg and 288.13 mg/kg

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respectively whereas in non-invasive soils, Mg, Ca and Na were 352.8 mg/kg, 18.45 mg/kg and 506.58 mg/kg. This shows that Ca at invasive plot was below detectable amount. Plant litter is an important source of organic matter which involves cation exchange capacity (CEC) which is a useful indicator of soil fertility because it shows the soil ability to supply three important nutrients; calcium, magnesium and potassium. Cations are held by negatively charged particles clay and humus called colloids. They act as a storehouse of nutrient for plant roots. On the other hand, Manganese and Chloride were higher in the non-invasive soils (Figures 10-11). The soil in nipa invasive site showed lower concentrations of micro nutrients which included Mn (13.03 mg/kg) and Cl (933.3 mg/kg), compared with non-invasive plot in which Mn was 37.98 mg/kg and Cl 11653 mg/kg. All soil properties were significantly varied between invasive and non-invasive soils except Ca at $p<0.05$.

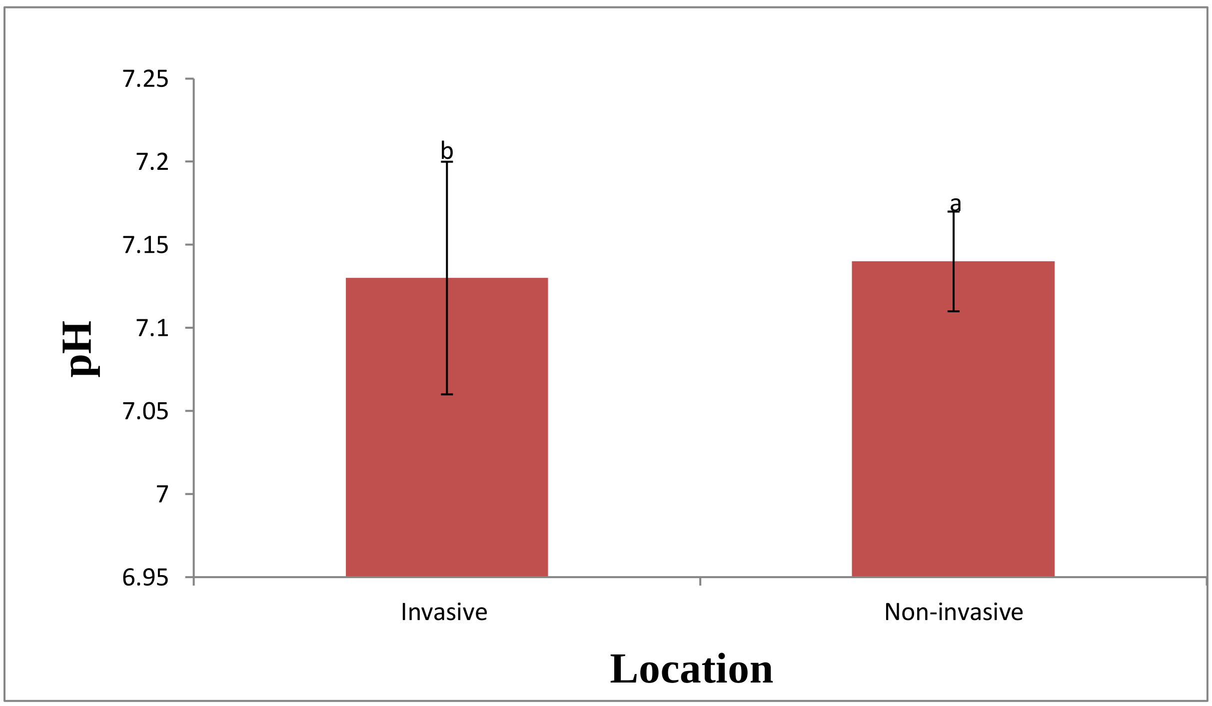

Figure 1: Mean pH in invasive and non-invasive plots with the standard error

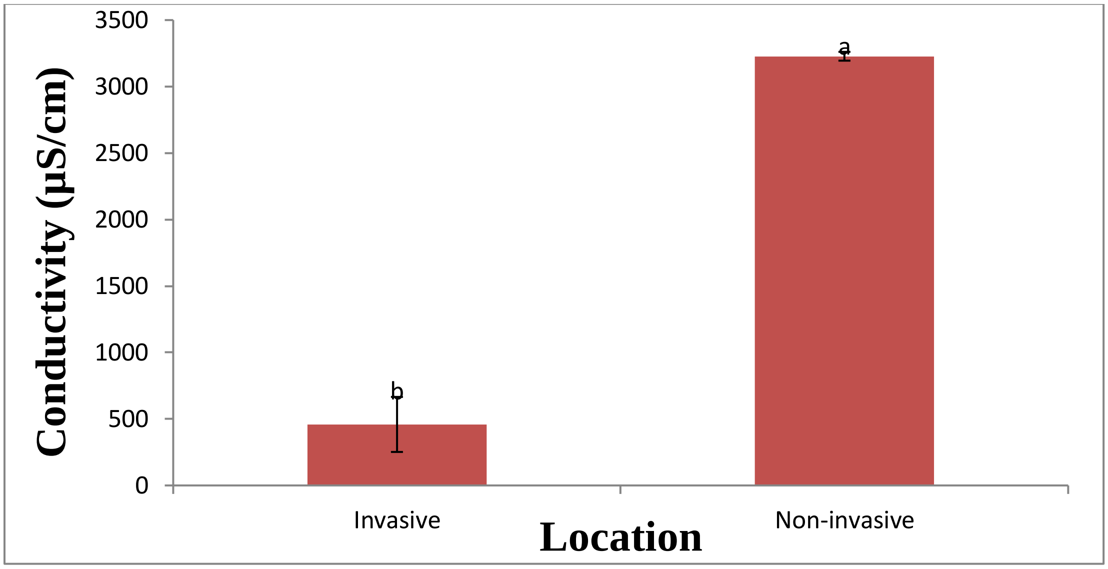

Figure 2: Mean conductivity in invasive and non-invasive plots with the standard error

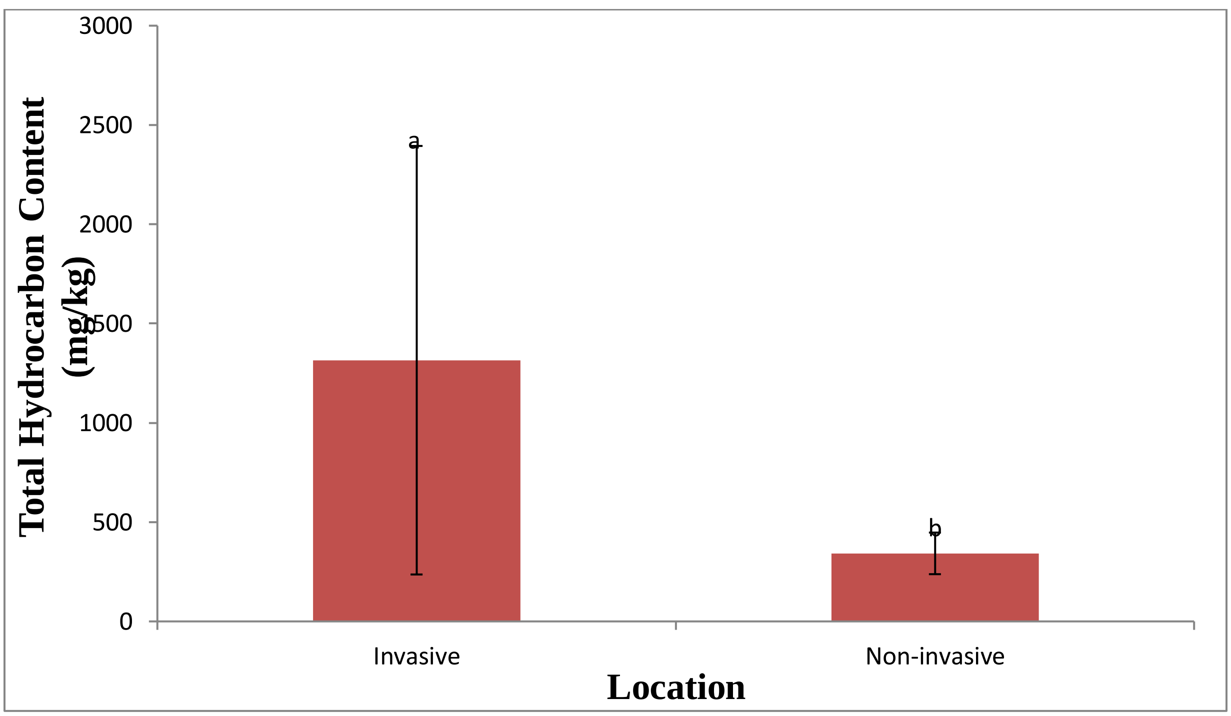

Figure 3: Mean total hydrocarbon in invasive and non-invasive plots with the standard error

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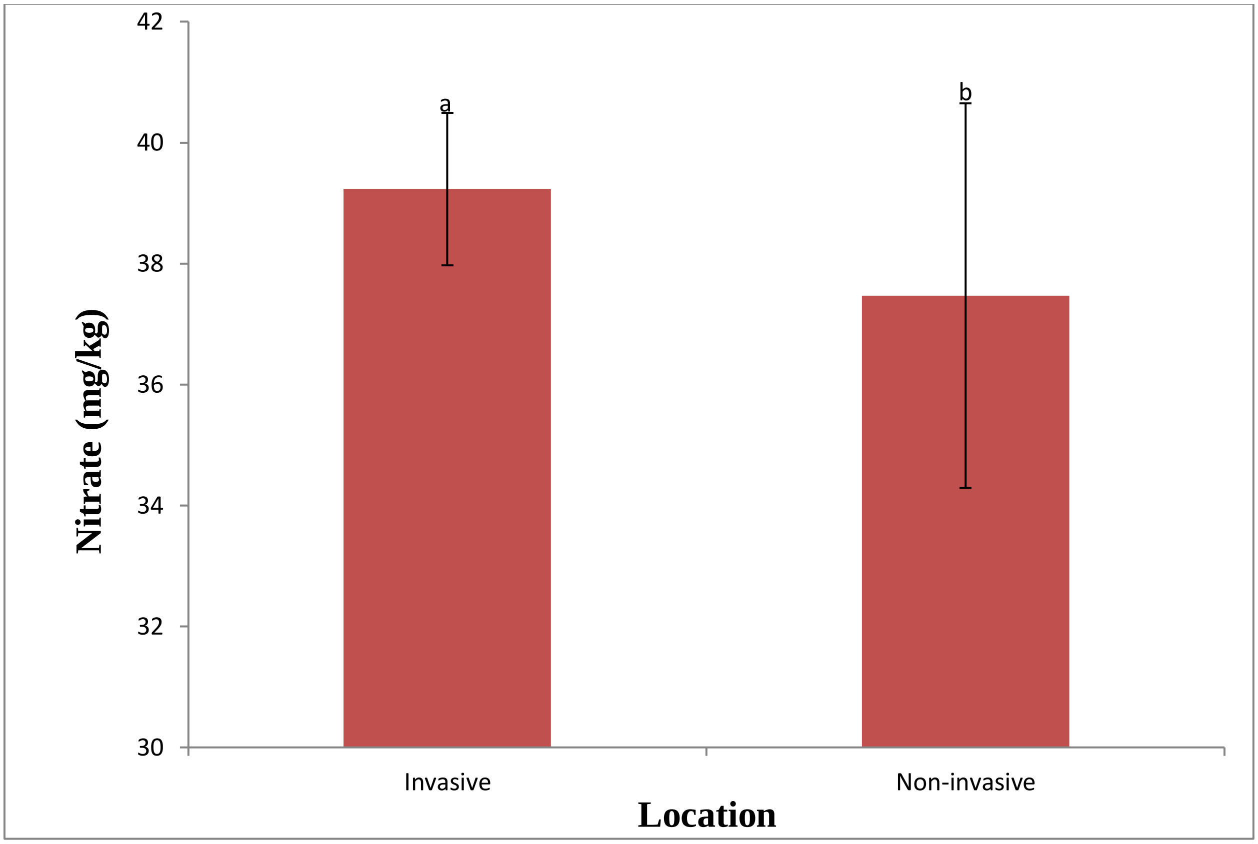

Figure 4: Mean nitrate in invasive and non-invasive plots with the standard error

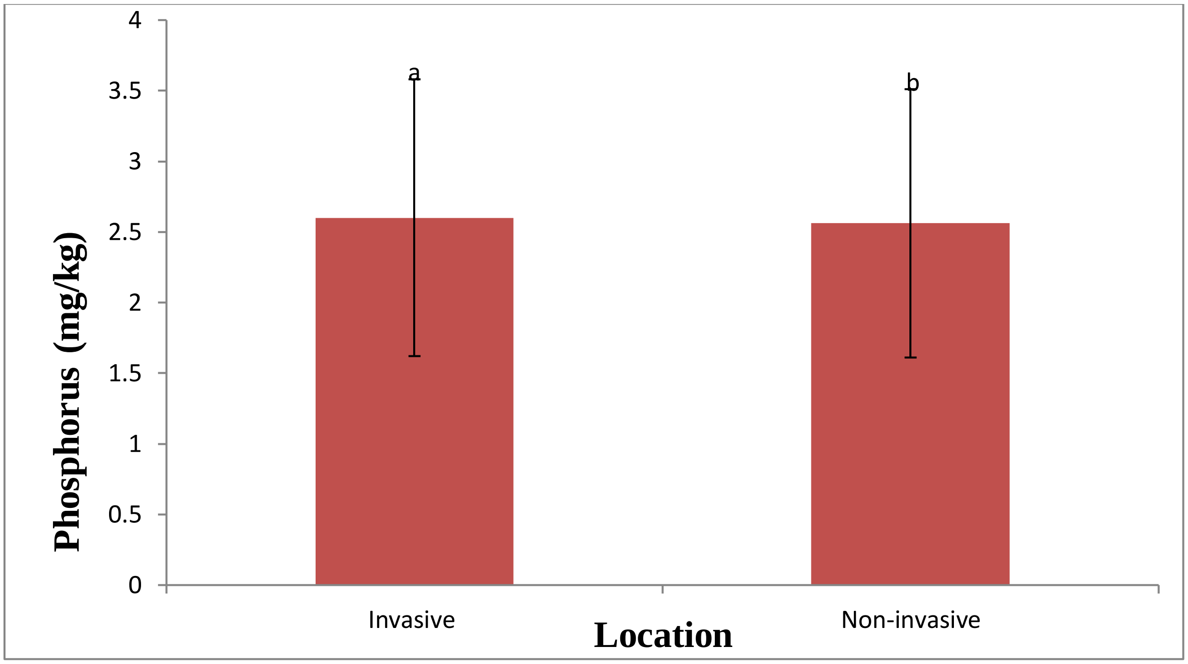

Figure 5: Mean phosphorus in invasive and non-invasive plots with the standard error

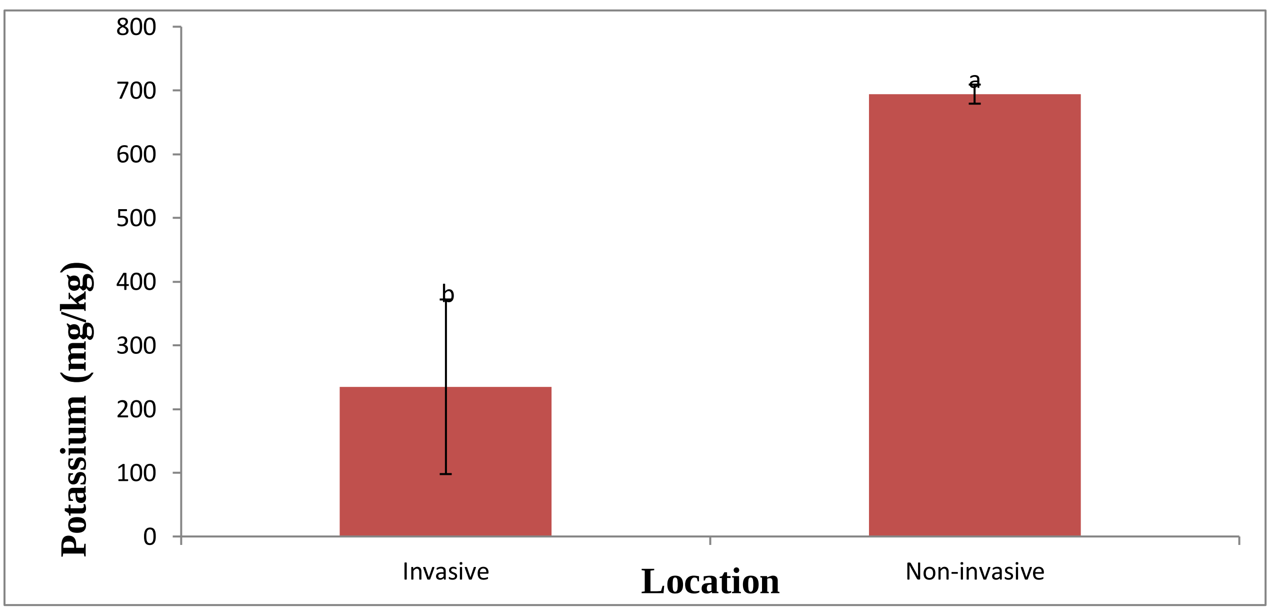

Figure 6: Mean potassium in invasive and non-invasive plots with the standard error

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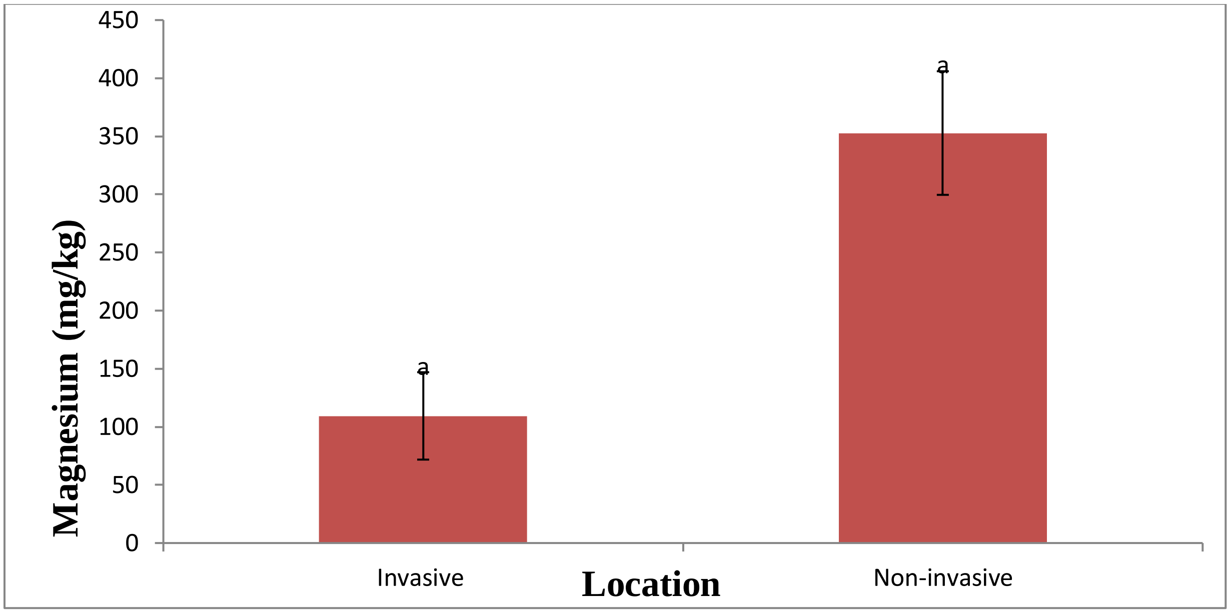

Figure 7: Mean magnesium in invasive and non-invasive plots with the standard error

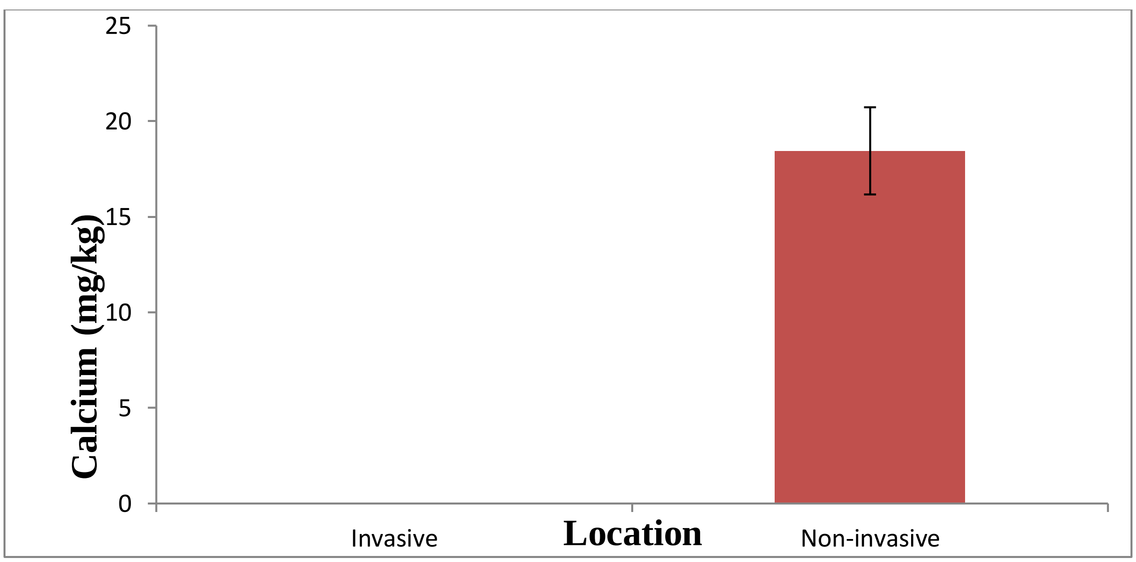

Figure 8: Mean calcium in invasive and non-invasive plots with the standard error

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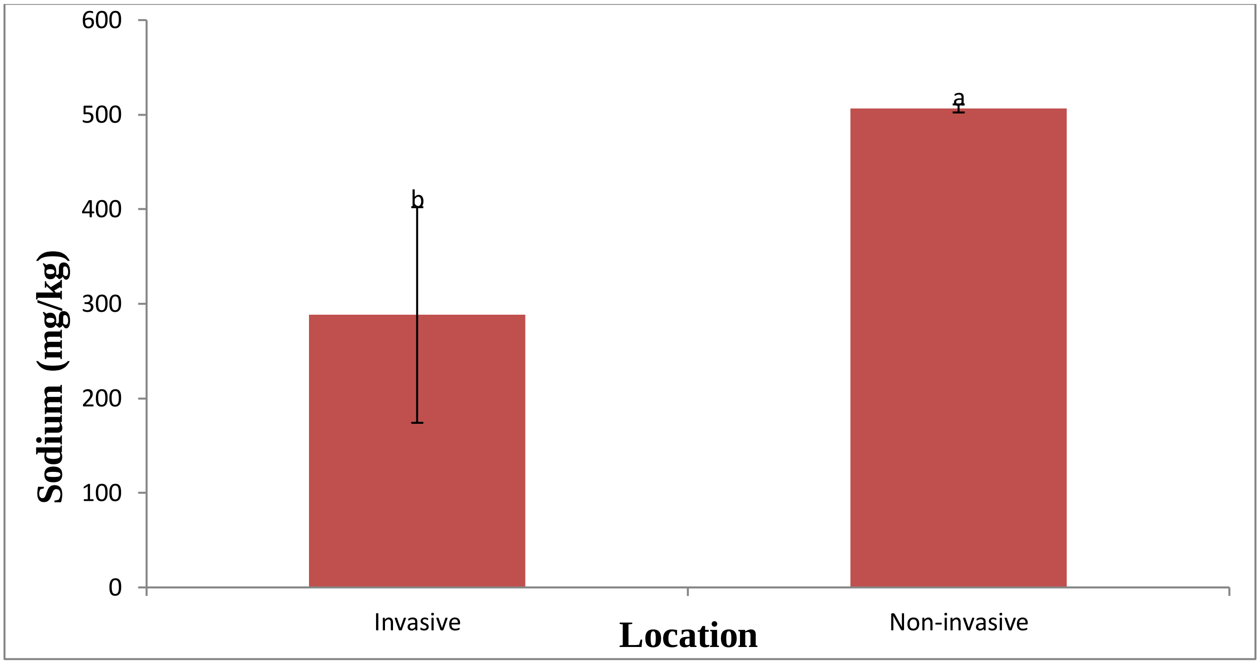

Figure 9: Mean sodium in invasive and non-invasive plots with the standard error

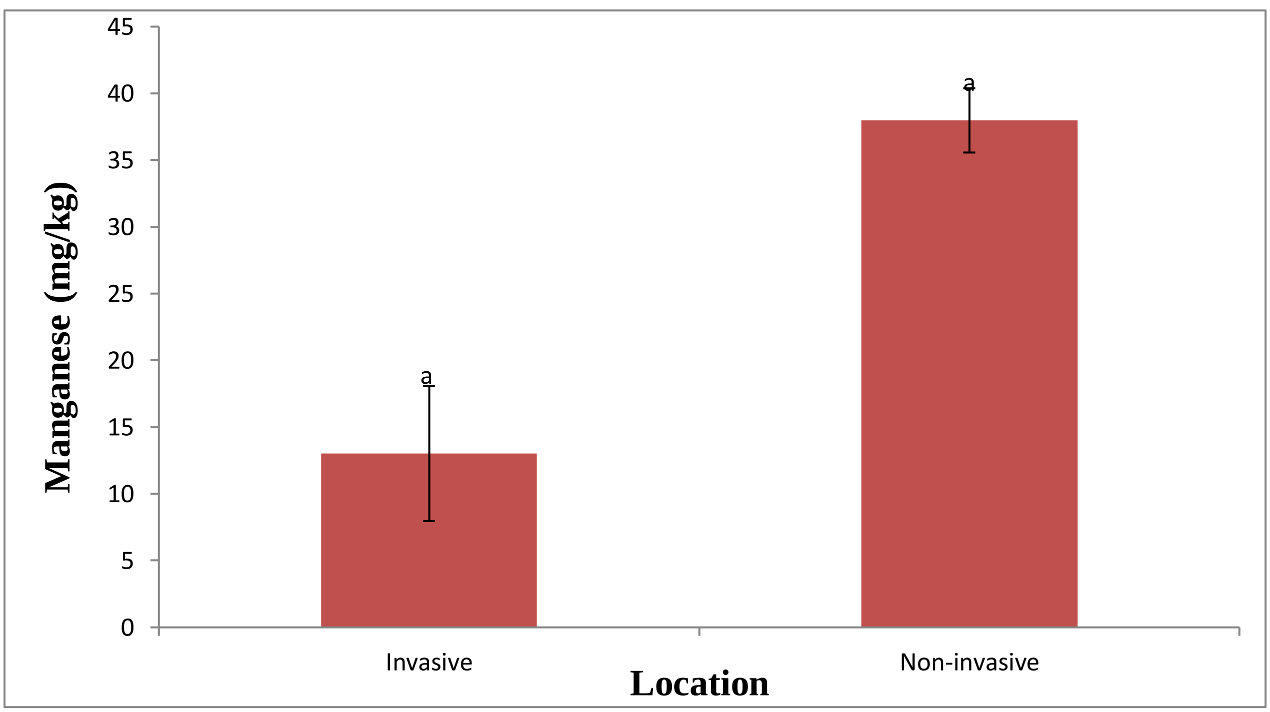

Figure 10: Mean manganese in invasive and non-invasive plots with the standard error

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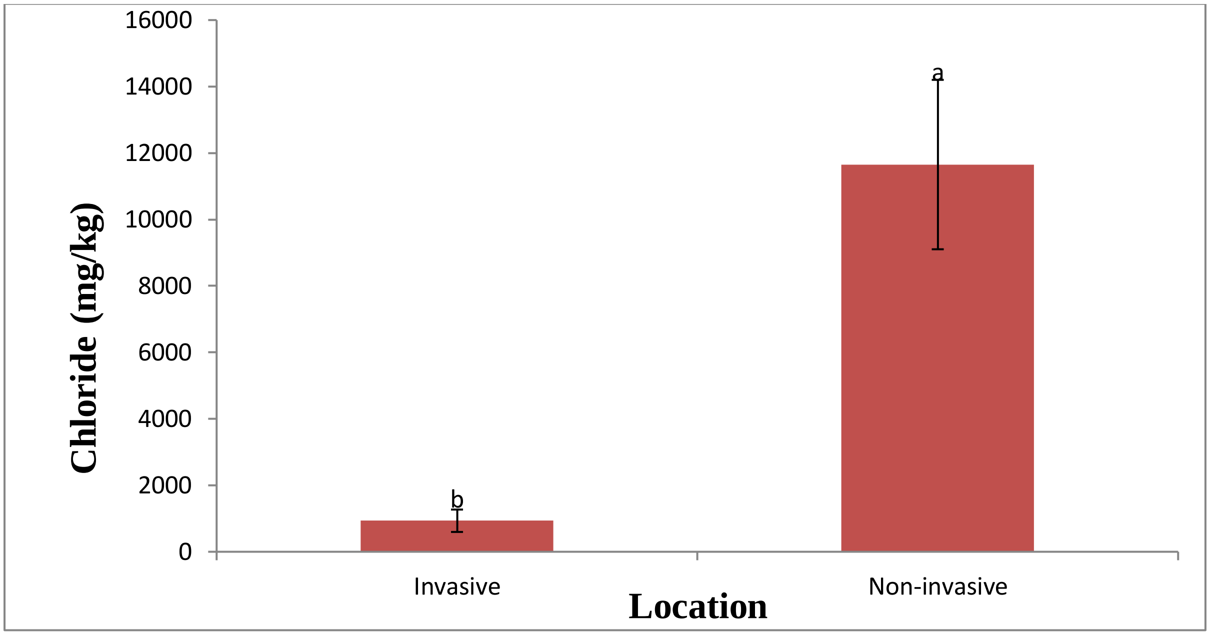

Figure 11: Mean chloride in invasive and non-invasive plots with the standard error

CONCLUSION

It can be concluded that the conductivity, K, Mg and Na were extremely higher in the non-invasive soils than the Nipa palm invasive plot. In addition, total hydrocarbon was extremely higher under the Nipa palm invasive soils than the non-invasive plot. However, nitrate and P which build the nutrient level of soils were slightly higher in the invasive soils whereas the micronutrients (Mn, Cl) were lower in the invasive soil. It therefore showed that invasive *Nypafruticans* has the potential to alter the soil chemical properties of a mangrove soil, hence control measures of the invasion of *Nypafruticans* should be put in place as to restore the original nature of the mangrove soil.

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