# Growth response of *Rhizophora racemosa G. Meyer* seedling in artisanal refining impacted mangrove vegetation, following the application of N.P.K 15:15:15 inorganic fertilizer

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***Abstract*: The growth response of *Rhizophora racemosa* seedlings was monitored in a designated artisanal refining-impacted mangrove vegetation in Delta State, Nigeria; following the application of different quantities of N.P.K 15:15:15 inorganic fertilizer. An area of 12.5 m x 6.25 m, was mapped out, demarcated into four treatment Plots-$A_1$ (1000g N.P.K), $A_2$ (1500g N.P.K), $A_3$ (Natural attenuation) and $A_4$ (2000g N.P.K), with a double control (non-polluted) Plot-B, sited 6km away. After treatment, the plots were left fallow for 30 days, after which propagules of *Rhizophora racemosa* were planted. Vegetative parameters such as leaf number, leaf length, leaf width, plant height, plant girth, leaf length/leaf width ratio, leaf area, plant dry weight, shoot dry weight and root dry weight were observed after 25, 50, 75 and 100 days of planting. Results showed that, the double control Plot-B, recorded the best performance in plant growth parameters among all the treatment options and was significant at $P < 0.05$. In the remediated plots, Plot- $A_4$, recording the overall best performance and Plot-$A_2$ recording the worst performance. The result indicates that, the application of appropriate quantities of N.P.K 15:15:15 inorganic fertilizer in artisanal refining-polluted mangrove vegetation, is capable of enhancing the growth performance of *Rhizophora racemosa* seedlings, hence N.P.K 15:15:15 inorganic fertilizer, can be used as remediation material in large scale mangrove remediation projects in the Niger.**

***Keywords*: Artisanal refining, *Rhizophora racemosa*, mangrove vegetation, remediation, N.P.K 15:15:15 inorganic fertilizer, propagules, vegetative parameters, natural attenuation**

## I. INTRODUCTION

Mangroves refers to stands of emergent salt tolerant plants that grow in coastal areas of tropical and subtropical regions of the world, especially at the intertidal region (Kraynak and Tetrault, 2003). Three major mangrove families are known in the Niger Delta region of Nigeria. These are Rhizophoraceae, Combretaceae and Aviceaniaceae. *Rhizophora racemosa* belongs to the Rhizophoraceae (red mangrove) family. Other species in this family include *Rhizophora mangle* and *Rhizophora harrisonni* (NDES, 1996). *Rhizophora racemosa* was first described in details by G. Meyer in 1818 (Newman, 2002) is the most common mangrove in West Africa (Nyananyo, 2006) but native to tropical regions East and West coast, South Western Pacific Islands and West Coasts of Africa, which includes the Niger Delta region of Nigeria. They are widely distributed across the East Atlantic regions of the world and they constitute 60% of the mangrove vegetation of the Niger Delta region (NDES, 1996, Newman, 2002).

The Niger Delta region is the crude oil and natural gas hub of Nigeria, with several networks of product pipelines occupying long stretches of the landscape and series of oil wells domiciled close to the local communities. The close proximity of theses oil facilities to the locals, has created a social problem of vandalization of oil wells and product pipelines for illegal bunkering and artisanal refining activities (UNEP, 2011, Yabrade and Tanee, 2016). The process of Artisanal refining brings about severe damages to the biotic and abiotic components of the ecosystem especially in many coastal communities across the Niger Delta (SDN, 2012; Yabrade and Tanee, 2016).

In order to mitigate and ameliorate the damages caused by artisanal refining activities in the Niger Delta, there is need to remediate such environment. Several methods of remediation such as physical, chemical and biological are available. Most of these methods have been found to be non- eco-friendly. Biological method (Bioremediation) which involves biostimulation (addition of nutrients) and bioaugmentation (addition of pollution degrading organisms) has been found to be most effective without any environmental side effects on the ecosystem.

NPK inorganic fertilizers are chemical compounds and a general purpose inorganic fertilizer comprising 15% each of Nitrogen (N), Phosphorus (P) and Potassium (K). Studies have shown that N.P.K 15:15:15 inorganic fertilizer, reduces the effect of crude oil on soil and enhances plant growth (Tanee and Kinako, 2008, Ngwu and Edeh, 2018). They aid plant growth, supplies essential plant nutrients, and serve as soil amendment and bioremediation agent (Ngwu and Edeh, 2018). N.P.K 15:15:15 inorganic fertilizers enhances soil productivity, increases soil organic content, enhances the activity of soil microorganisms which in turn facilitates bioremediation processes, increases the nutrient status of the soil and crop yield (Ngwu and Edeh, 2018).

Crude oil artisanal refining has been known to cause serious havoc to the mangrove ecosystem leading the destruction of the mangrove species. It is therefore, expedient that viable remediation method is developed to salvage the destroyed ecosystem for mangrove restoration in the fragile Niger delta ecosystem. Such remediation method must be an eco-friendly method without much adverse effect on the ecosystem. Hence, the aim of this study, is to the viability of N.P.K 15:15:15 inorganic fertilizer as a remediation material on artisanal refining mangrove-impacted vegetation for the growth of *Rhizophora racemosa* seedlings, so as to boost the mangrove revegetation efforts in the Niger Delta.

## II. MATERIALS AND METHODS

*Description of Study Area*

The study was carried out, along Escravos River, Warri South-West LGA, Delta State, Nigeria at an abandoned artisanal refining (polluted) site in the mangrove forests of Ikpokpo community (Latitude 5.5933N, Longitude 5.2259E) and the non-polluted site was located some 6km away at the neighbouring Tebujor community (Latitude 5.5988N and Longitude 5.2350E). The area is a brackish water coastal environment, dominated by mangrove forest, which experiences unidirectional flooding due to tidal changes that alternate every 12 hours. The climate of the area is basically that of equatorial type characterized by heavy rainfall, high relative humidity and average temperature. The soil type is mainly peaty clay (chikoko).

*Sources of materials/ experimental design*

The NPK 15:15:15 inorganic fertilizer (remediation material) was obtained from Delta State Ministry of Agriculture referral, at Effurun, Delta state, Nigeria. The *Rhizophora racemosa* propagules were obtained from the wild of an unpolluted site.

An area devastated by artisanal refining was identified and a dimension of 12.5 m x 6.25 m was mapped out within the area. The mapped out area was then cleared of debris and dead standing trees and then partitioned into four Treatment Plots labelled as **$A_1$, $A_2$, $A_3$ and $A_4$** of 6.25 m x 3.13 m each, with stakes and water proof tarpaulin. The thick Polyethylene material (tarpaulin) was nailed to the stakes. The tarpaulins were dug deep to a depth of about 2 m below the soil surface and thoroughly arranged to minimize fluid movement from one treatment plot to another and from outside into the treatment plots. The double control Plot-**B** (the non-polluted site), also followed same process of preparation with only one plot (Okoro, 2009).

The fertilizer applied as the remediation material were applied to the different treatment plot by spreading the granules evenly the plots as follows: Plot-**$A_1$**, 1000g of N.P.K 15:15:15 (51.12 g/m$^2$); Plot-**$A_2$ -** 1500g (71.69 g/m$^2$); Plot-**$A_3$** untreated (natural attenuation); Plot-**$A_4$** - 2000g (102.25 g/m$^2$); and Plot-**B** served as the double control (non-polluted site) according to the procedure of Ayotamuno *et al*. (2006), and Chorom *et al*. (2010). The set up was allowed for 30 days before planting.

*Planting of Propagules of Rhizophora racemosa /Determination of Growth Parameters*

*Rhizophora racemosa* seedlings (propagules) were obtained from the wild close to the double control site. Care was taken to obtain fresh propagules without injuries to the roots and planted at the treatment plots. The propagules of equivalent sizes were planted with a spade one meter (1m) apart in each treatment plot, in a zig-zag form (Zabbey and Tanee, 2016).

Measurements of the vegetative growth parameters (plant heights, leaf length, leaf width, plant girth, leaf number and leaf area) were taken at every 25 day interval after planting. The fresh and dry weights were taken at the termination of the experiment. The leaf number was obtained by manual counting; plant girth (cm), measured with the aid of a vernier caliper at distance of 1 cm from the soil surface; plant height, leaf length and leaf width were measured in centimetres with the aid of measuring tape. The leaf length/leaf width ratio (cm) was obtained by dividing the leaf length by the leaf width while leaf area (cm$^2$) was obtained by multiplying the product of leaf length and leaf width with a constant (0.76). Plant total fresh weight were measured immediately after harvest to avoid loss of weight while plant dry weight and root dry weight were determined after drying to constant weight in grams using a casio digital scale model number SF-400.

*Statistical Evaluation*

Data generated from the study were analyzed using Statistical Package for Social Sciences (SPSS) version 2.0 by IBM Inc. Descriptive statistics such as mean and standard errors were done, while one-way analysis of variance (ANOVA) was used to check for the level of significance between the means at $P < 0.05$ probability level.

## III. RESULTS

Result in Fig. 1, showed that the double control Plot-**B** recorded the highest performance in foliage production with time as compared to other treatment options ($P < 0.05$) followed by Plot-**$A_4$** (2000g NPK) . Leaf production in Plots **$A_1$** (1000g NPK) and **$A_3$** (Natural Attenuation) were low. While Plot-**$A_2$** (1500g NPK) recorded zero leaf production.

Results in Figs. 2 and 3, showed the double control Plot-**B** and remediated Plot- **$A_4$** (2000g NPK) recorded significant progressive increase in leaf length and leaf width with time ($P < 0.05$) which were higher than that Plot-**$A_1$** (1000g NPK) and Plot-**$A_3$** (Natural Attenuation) especially at 100 days after planting. Zero values were obtained in Plot-**$A_2$** (1500g NPK) due to absence of leaf.

Results presented in Fig. 4 and 5 showed that, double control Plot-**B** recorded the highest increase in plant height and girth with time (p= 0.05). The least values were in recorded in Plot-**$A_3$**. Similar result was obtained for the length/width ratio (Fig. 6) and leaf area (Fig. 7).

The plant fresh weight, total dry weight, root dry weight and shoot dry weight are shown in Figs. 8, 9, 10 and 11 respectively. It was observed that the double control Plot-**B** recorded the highest plant biomass (fresh and dry weights) at the end of the experiment ($P < 0.05$). This was followed in descending order by Plots **$A_2$** (1500g NPK), **$A_3$** (No treatment), **$A_4$** (2000g NPK), and **$A_1$** (1000g NPK) with no significant difference at $P < 0.05$.

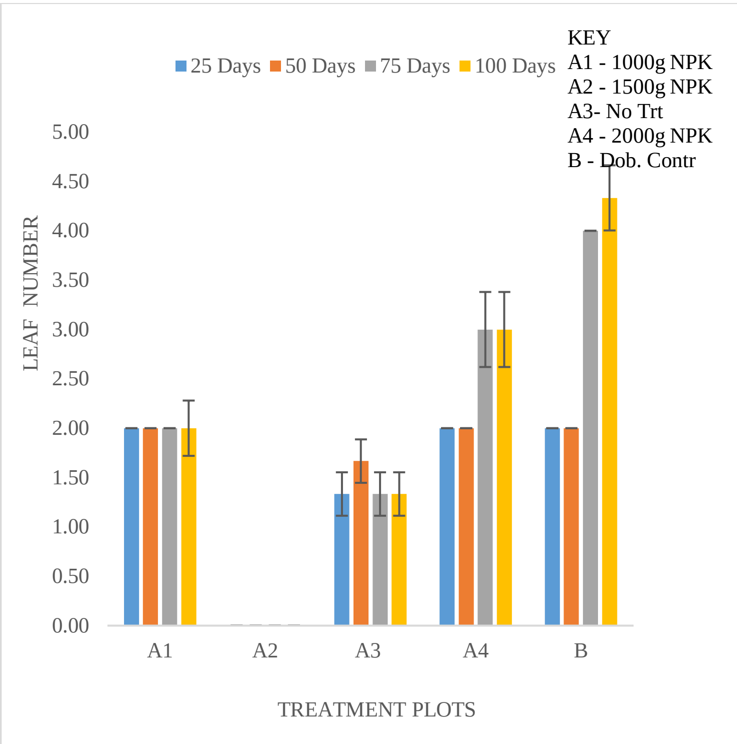


Fig. 1: Leaf number produced in each treatment plot.

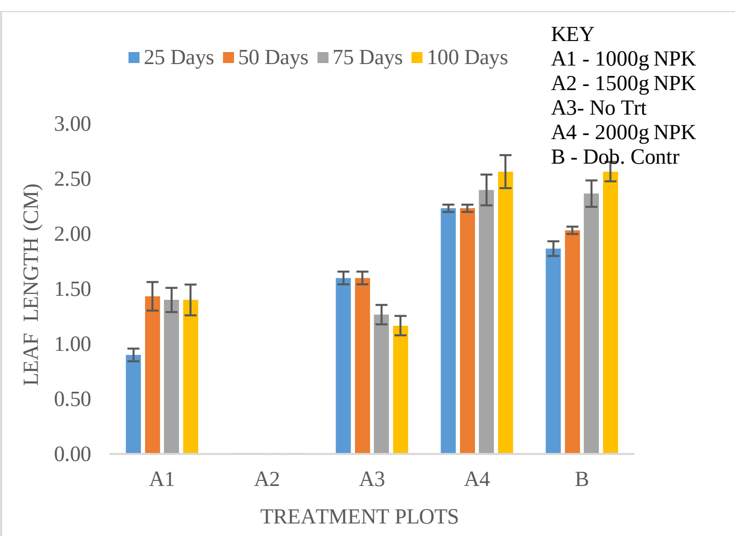


Fig. 2: Leaf length in the various treatment plots.

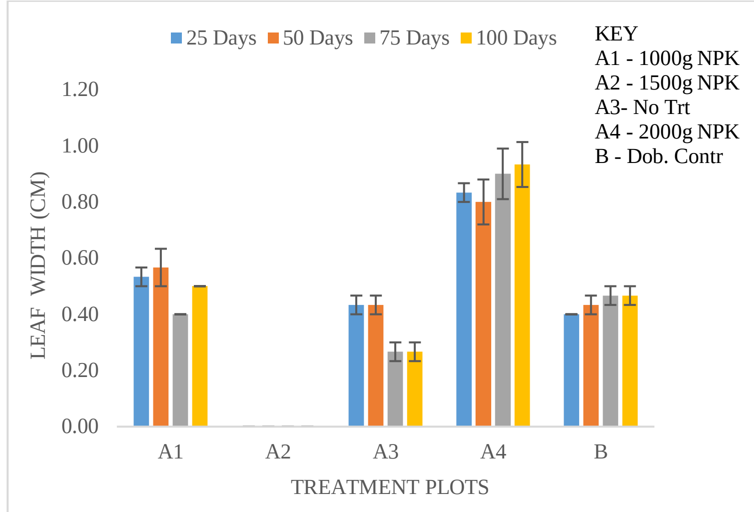


Fig. 3: Leaf width in the various treatment plots.

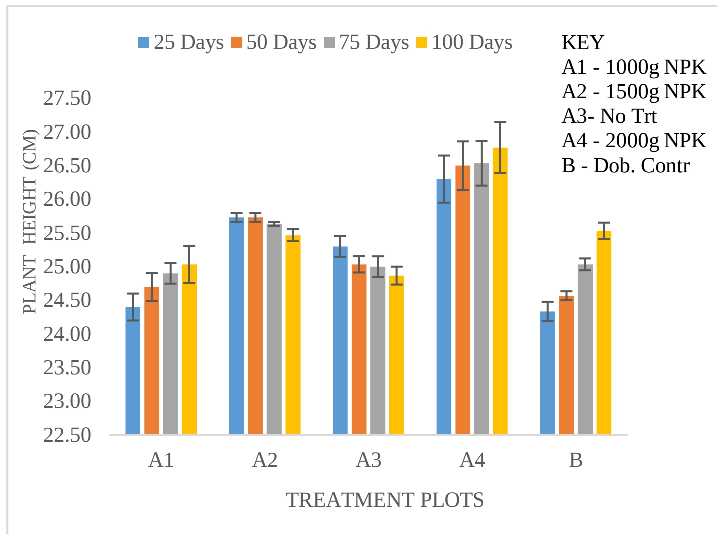


Fig. 4: Plant height in the various treatment plots.

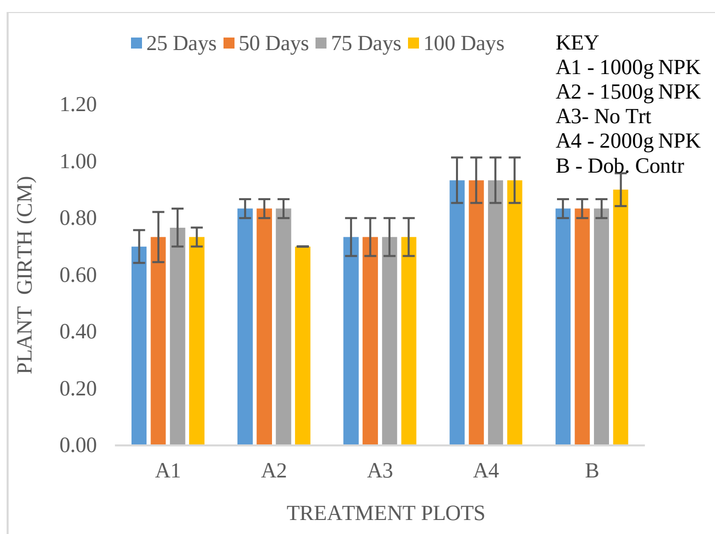


Fig. 5: Plant girth in the various treatment plots.

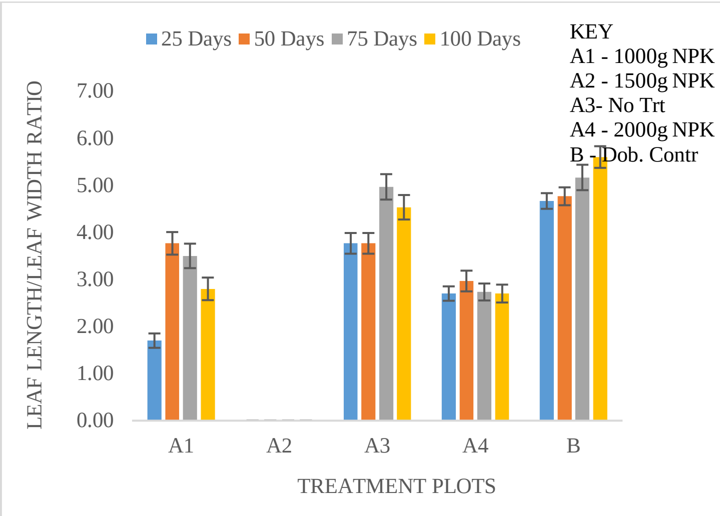


Fig. 6: Leaf length/width ratio in the various treatment plots.

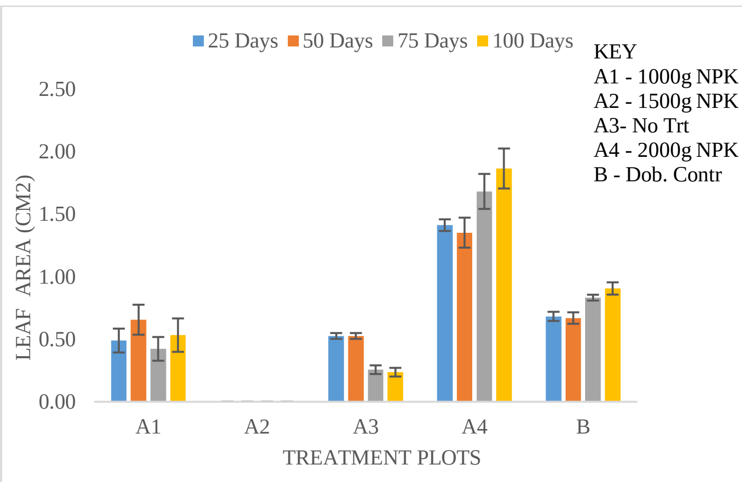


Fig. 7: Leaf area in the various treatment plots.

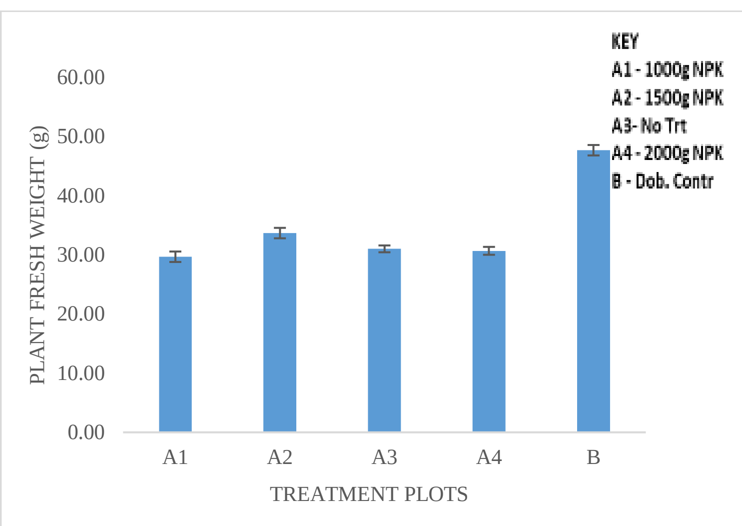


Fig. 8: Plant fresh weight in the various treatment plots.

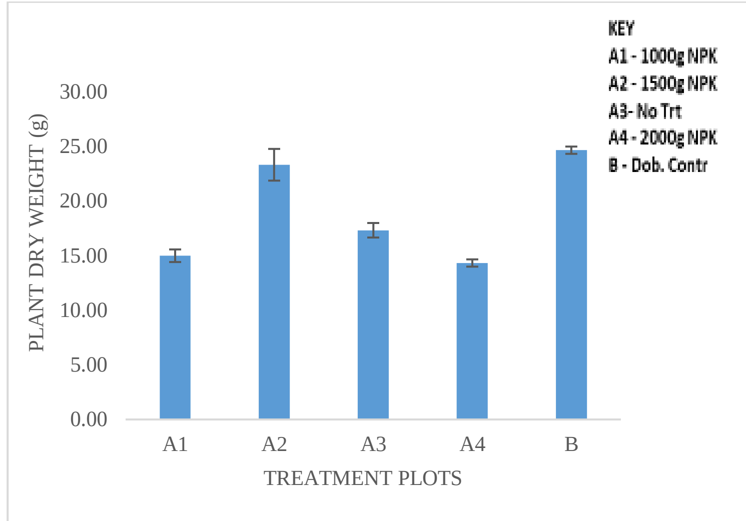


Fig. 9: Plant total dry weight in the various treatment plots.

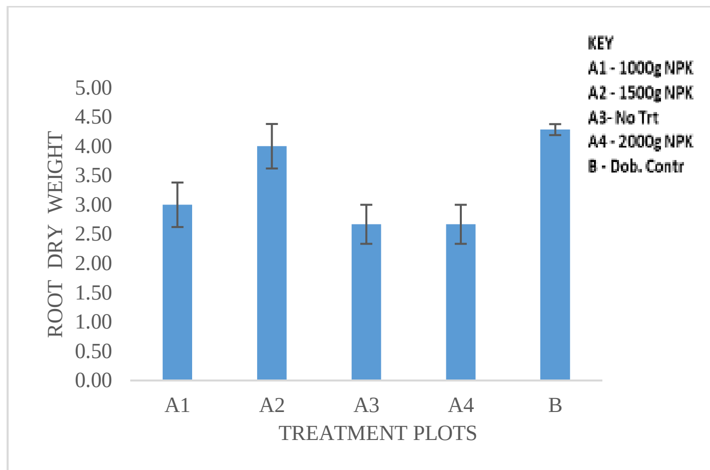


Fig. 10: Root dry weight in the various treatment plots.

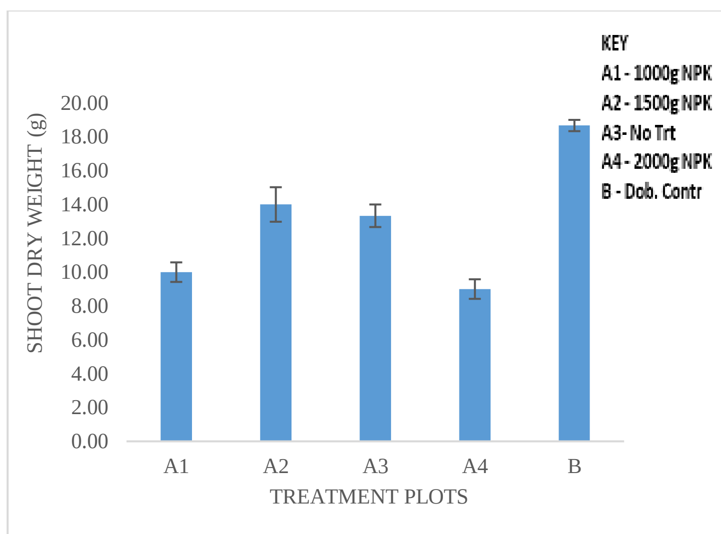


Fig. 11: Shoot dry weight in the various treatment plots.

## IV. DISCUSSION

*Rhizophora racemosa* plants grow in the lower stretches of the coast line and come in contact easily with floating crude oil from pollution sources in the marine ecosystem of the Niger Delta, such as equipment failure, illegal bunkering and artisanal refining activities, hence they are sensitive to and severely affected by oil spill (Phillips, 2003, UNEP, 2011, Yabrade and Tanee, 2016), which may leads to loss of leaves, stunted growth and eventual death (Sandilyan and Kathiresan, 2012, Mensah *et al*, 2013).

Results from this study showed that, the double control (non-polluted) Plot-**B**, recorded the highest growth performance in vegetative parameters with time among all the treatment options as there was significant increase in leaf production, leaf length, leaf width, plant height, plant girth, leaf length/width ratio and leaf area with time. The plant fresh weight, plant dry weight, shoot dry weight and root dry weight figures of the double control plot, were also better than those recorded in all the remediated plots and the natural attenuation plot. The healthy plant development and increased growth of vegetative parameters experienced in the double control plot, could be as a result of the absence of crude oil pollutants which is capable of inhibiting plant growth (Chindah *et al.*, 2007) and the availability of nutrients and other environmental and climatic conditions required for plant growth and development (Tanee and Kinako, 2008, Koul and Taak, 2018). The slow growth in vegetative parameters experienced in the polluted site could be attributed to the presence of crude oil pollutants in the research site, which may slow down plant growth. Also the poor performance in growth experienced in the natural attenuation plot may be due to the inhibitory effects of the artisanal refining waste product from the crude oil (Chindah *et al*, 2007, Mensah *et al*, 2013).

The results obtained from this research as shown in Figs 1-11, showed that there was improvement in vegetative parameters in all the plots treated with remediation material (N.P.K 15:15:15 inorganic fertilizer), except for Plot-**A2** treated with 1500g of N.P.K 15:15:15 inorganic fertilizer, which could not produce leaves after 100 days of planting, hence leaf parameters (number of leaves, leaf length, leaf width, leaf length/leaf width ratios and leaf area) were zero, while the other vegetative parameters experienced moderate growth, this is in line with studies carried out by Mensah *et al*, 2013, which shows that acute concentration of crude oil inhibits leaf production. The results also showed poor performance recorded in the natural attenuation plots when compared with the other remediated plots (Plots **A1,** and **A4**) and the double control Plot-B. However, the Plot treated with 2000g of N.P.K 15:15:15 inorganic fertilizer (Plot- **A4**), recorded the overall best performance in vegetative parameters, among the remediated plots and the natural attenuation plot The improved growth performance of *Rhizophora racemosa* seeedlings in remediated Plot- **A4**, could be as a result of the fact that the quantity of remediation materials (102.25g/m2 of N.P.K. 15:15:15) applied was moderate enough to have directly facilitated plant growth (Tanee and Kinako, 2008) and/or enough to have stimulated crude oil degrading bacteria to breakdown the crude oil pollutants generated from artisanal refining activities, into particles and nutrients that may have been utilized by *Rhizophora racemosa* seedlings, for growth and development (Koul and Taak, 2018). This is in line with other studies which establish the fact that, N.P.K supply nutrients to plants, aides microorganisms responsible for crude oil biodegradation (Ngwu and Edeh, 2018); and generally supports plant growth when appropriate quantity is applied to soil (Ngwu and Edeh, 2018). Results from this study is also in line with other studies which showed that N.P.K. 15:15:15 inorganic fertilizer is an effective remediation material, as it aides plant growth and development (Tanee and Kinako, 2008, Ngwu and Edeh, 2018), supply nutrients such as Nitrogen which encourage root development in plants, helps soil fixation to reduce leaching of important nutrients required for plant development (Iqbal, 2019) and also supports microorganisms responsible for crude oil biodegradation, which facilitates development of vegetative parameters in plants (Ngwu and Edeh, 2018).

## V. CONCLUSION

Appropriate quantities of N.P.K 15:15:15 inorganic fertilizer (102.25 $g/m^2$), applied on artisanal refining impacted-mangrove vegetation, is capable of increasing soil nutrients and facilitating bioremediation processes, which enhances the growth and development of *Rhizophora racemosa* seedlings. Hence N.P.K 15:15:15 inorganic fertilizer, being a low cost remediation agent which is readily available, is recommended for bioremediation of artisanal refining-polluted site for mangrove revegetation in the Niger Delta.

## REFERENCES


[1] Ayotamuno, M.J. and Kogbara R.B., (2005). Bioremediation of Crude Oil Polluted Agricultural Soil at Port Harcourt, Nigeria, Using Different Levels of Nutrient Application. Proc. NIAE, 2005. 27(2), 352-360.

[2] Chindah, A.C., Braide, S.A., Amakiri, J. and Onohurhefe J. (2007). Effect of Crude oil on the Development of Mangrove (Rhizophora mangle L.) Seedling from the Niger Delta, Nigeria. Revista UDO Agricula 7(1): 181-194.

[3] Chorom, M., Sharifi, H.S., Motamedi, H. (2010). Bioremediation of a crude oil-polluted soil by application of fertilizers. Iranian Journal of Environmental Health, Science and Engineering. 7(4), 319 - 326.

[4] Iqbal, S.A. (2019). Pollution: The Ugly Face of Environment. Discovery Publishing House PVT Limited, New Delhi, second edition. Pp 4-19.

[5] Koul, B. and Taak, P. (2018). Biotechnology Strategies for Effective Remediation of Polluted Sites. Springer Nature Singapore Plc. Ltd. Pp 77-115.

[6] Kraynak, J. and Tetrault, K.W. (2003). The complete idiot's guide to the oceans. Penguin group Inc., USA. Pp 12-19.

[7] Mensah, S.I., Okonwu, K. and Yabrade, M. (2013). Effects of crude oil application on the growth of mangrove seedlings of Rhizophora racemosa G. Meyer. Asian Journal of Biological Sciences. 10(3):9-23.

[8] NDES, (1996). Niger Delta Environmental Survey: Preliminary Report, First Phase. 1: 1-96.

[9] Newman, A. (2002). Tropical Rain Forest. New York, NY: Checks Books. Pp 6-8.

[10] Ngwu, O. E., & Edeh, V. N. (2018). Effect of varying rates of NPK 15: 15: 15 fertiliser on the physicochemical properties of the soil,

growth and yield of cucumber (Cucumis sativus L.). International Journal of Plant & Soil Science. 28(4), 1-7.

[11] Nyananyo, B.L. (2006). Plants from the Niger Delta. Onyoma Research Publications. Pp 307-308.

[12] Okoro, C. C. (2009). Biosurfactant-enhanced remediation of hydrocarbon contaminated mangrove swamp. International Journal of Biological and Chemical Sciences. 3(1): 63-74.

[13] Phillips, R.C. (2003). The Seagrasses of the Arabian Gulf and Arabian Region. In: Green, E.P. and Short, F.T. (eds.). World Atlas of sea grasses. Berkeley, CA: UNEP World Conservation Monitoring Centre, University of California Press. Pp 74-81.

[14] Sandilyan, S. and Kathiresan, K. (2012). Mangrove conservation: A global perspective. Journal of Biodiversity and Conservation. 21: 3523–3542.

[15] SDN, (2012). Communities not Criminals:Illegal oil refining in the Niger Delta: trying to understand an informal Economic. Stakeholders Democratic Network Publications, 22 Okoriji, D/line, Portharcourt, 2012. Pp 5-42.

[16] Tanee, F. B. G., & Kinako, P. D. S. (2008). Comparative studies of biostimulation and phytoremediation in the mitigation of crude oil toxicity in tropical soil. Journal of Applied Sciences and Environmental Management, 12(2), 88-104.

[17] UNEP., (2011). Environmental Assessment of Ogoni Land. United Nations Environmental Programme, USA. Pp 262-263.

[18] Yabrade, M., & Tanee, F. B. G. (2016). Impact of Artisanal Petroleum Refining on Vegetation and Soil Quality: A Case Study of Warri South West Salt Wetland of Delta State, Nigeria. Research Journal on Environment and Toxicology. 8(4), 2-10.

[19] Zabbey, N. and Tanee, F.B.G. (2016). Assessment of asymmetric mangrove restoration trials in Ogoniland, Niger Delta, Nigeria: lessons for the future. Ecological Restoration. 34(3), 245-257.