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Soil Nutrients Stability in Cultivated Oil-Spill-Impacted Soils in Niger Delta

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Abstract: This study investigated the impact of oil spillage on soil nutrient compositions and agronomical/growth parameters of waterleaf (*Talinum triangulare*), maize (*Zea mays*), and okra (*Abelmoschus esculentus*) in the Niger Delta region of Nigeria under controlled greenhouse conditions. A randomized complete block design was used, with polluted and unpolluted soil matrices, and a control treatment. Soil matrices and plant growth parameters, including seed germination, leaf height, fresh leaf count, fruit/flower count, dead leaf/stem number, and plant height, were analyzed at four time points: Day 0, Day 30, Day 60, and Day 90. The soil matrices were analyzed via atomization of the metals using flame atomic absorption spectrophotometer for the nutrient elements including potassium (K), sodium (Na), calcium (Ca), and magnesium (Mg). The results showed significant variations in nutrient concentrations and agronomical/growth parameters across different soil matrices, crops, and time points. Specifically, K concentrations decreased by 40% and Ca concentrations decreased by 50% in polluted soils over the 90-day period, while Na concentrations increased by 200%. Waterleaf (*Talinum triangulare*) showed resilience to oil spillage, maintaining relatively stable growth and nutrient uptake patterns, whereas maize and okra exhibited significant declines in growth and nutrient concentrations. These findings underscore the detrimental effects of oil spillage on soil nutrients stability, plant growth, and environmental sustainability, emphasizing the need for effective remediation strategies and the potential use of waterleaf as a bioindicator for oil spillage impacts.

Keywords: *Soil Nutrients; Niger Delta; Polluted Matrices; Environmental Sustainability; Agronomical Parameters; Plant Growth.*

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I. INTRODUCTION

Environmental pollution by petroleum is a pervasive issue associated with oil exploration and production, causing devastating damage to ecosystems and human health [1]; [2]. The Niger Delta region of Nigeria is particularly vulnerable to oil spillage due to its rich oil reserves and lack of effective environmental regulations [3]. Oil spillage has been linked to various environmental problems, including destruction of wildlife, loss of fertile soil, pollution of air and water, and damage to ecosystems [4]; [5]. Agronomical/growth analysis is a crucial aspect of assessing the impact of oil spillage on plant growth and productivity. This type of analysis provides valuable insights into the effects of oil spillage on plant morphology, physiology, and yield. By examining agronomical/growth parameters such as seed germination, leaf height, fresh leaf count, fruit/flower count, dead leaf/stem number, and plant height, researchers can gain a better understanding of the mechanisms by which oil spillage affects plant growth and development. Studies have investigated the impact of oil spillage on soil physicochemical properties, including pH, organic matter, and nutrient concentrations [5]; [2]. On one hand, Eke et al. (2019) [3] found that oil spillage significantly reduced potassium concentrations in soil, leading to reduced plant growth and productivity. In another development, Nnaji & Egwu (2018) [6] reported a significant decrease in calcium concentrations in oil-polluted soils, which can lead to reduced plant growth and productivity. Despite these findings, there is a need for further and careful examination of the impact of oil spillage on soil nutrient concentrations and crop growth in the Niger Delta region. More so, there is a gap in knowledge on the impact of oil spillage on magnesium and sodium concentrations in soil, as well as the effects on indicator crops such as *Talinum triangulare*, *Zea mays* and *Abelmoschus esculentus*. Studies have focused on the impact of oil spillage

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on soil physicochemical properties, but few have investigated the effects on plant growth and productivity under controlled greenhouse conditions [5]; [3]. This study aims to address these knowledge gaps by investigating the impact of oil spillage on soil nutrient concentrations (potassium, calcium, magnesium, and sodium) and crop growth under greenhouse conditions. The specific objectives of this study are, therefore, to determine the nutrient elements of oil-spill-impacted soil samples and to evaluate the effects of oil spillage on the growth and productivity of indicator crops.

II. METHODOLOGY

This study was conducted to assess the effects of crude oil contamination on soil nutrient stability and the growth performance of three staple crops namely, *Talinum triangulare* (waterleaf), *Zea mays* (maize), and *Abelmoschus esculentus* (okra)—under controlled conditions. A Randomized Complete Block Design (RCBD) was employed, given its efficacy in minimizing experimental error and improving the precision of treatment comparisons [7]; [8]. The experimental setup comprised eight distinct treatment groups, including unpolluted and polluted soil matrices, each with and without the selected crop species. These included two control groups (unpolluted-unplanted and polluted-unplanted) and six treatment groups in which each crop was cultivated in both soil conditions.

Each treatment was replicated four times, yielding 32 experimental units distributed uniformly across blocks to reduce spatial variability. Soils were portioned into 20 kg per experimental unit and housed in transparent plastic containers to ensure uniform exposure to ambient environmental conditions within a greenhouse. Planting materials included four seeds each of maize (*Zea mays* var. Oba Super 2) and okra (*A. esculentus* var. Clemson Spineless), and four freshly harvested stems of waterleaf (*T. triangulare* wild-type), selected based on their local agricultural relevance and nutritional value. All plant species were authenticated by the Department of Plant Science and Biotechnology, University of Port Harcourt, and catalogued under herbarium voucher numbers UPH/V/1215, UPH/V/1216, and UPH/V/1217, respectively. The study area was located in Omuigwe-Aluu, Ikwerre Local Government Area of Rivers State, Nigeria (Latitude 4.95351°N, Longitude 6.91932°E), a peri-urban community situated at the northern fringe of Port Harcourt. The area has a long-standing agrarian tradition, which has recently been jeopardized by artisanal oil refining activities. A crude oil spill incident, covering approximately one hectare of arable land, was recorded on January 17, 2024, at an artisanal refinery site within the community. Soil samples were collected for analysis and experimental use on March 6, 2024 approximately seven weeks post-impact. To ensure representative sampling, a grid system was deployed across the impacted site and an uncontaminated control site located 50 meters away. A 100×100 m² area was subdivided into 100 equal 10×10 m² plots, from which 32 were randomly selected for sampling. A total of 64 soil samples (32 from each site) were collected using a manual soil auger at two depths: 0–15 cm (topsoil) and 15–30 cm (subsoil). Composite samples were prepared by pooling soil from similar depths across replicate plots, yielding 32 composite samples (16 per site). Samples were sealed in aluminum foil, stored in ice-cooled containers during transport, and refrigerated prior to laboratory analysis and planting. Primary data were obtained through greenhouse observations and laboratory assays, while secondary data were sourced from peer-reviewed journals, institutional reports, and relevant literature. Crop growth performance was monitored across four observation points (Day 0, Day 30, Day 60, and Day 90), using standard agronomic indicators, including germination rate, plant height, leaf count, fresh biomass, flower/fruit number, and senescence indicators (dead leaves and stems).

Soil samples were analyzed for macro-nutrient content [potassium (K), sodium (Na), calcium (Ca), and magnesium (Mg)], using Flame Atomic Absorption Spectrophotometry (FAAS), in accordance with the APHA (1985) protocols [9] and ASTM D4691 standard procedures [10]. Samples were prepared via solvent extraction, ensuring uniformity and analytical reliability across all replicates. All data were statistically analyzed using Analysis of Variance (ANOVA) to assess the significance of differences between treatments at a 95% confidence level ($p < 0.05$). Where significant differences were observed, Duncan's Multiple Range Test (DMRT) was employed for mean separation. Data visualization and summary statistics were performed using Microsoft Excel and OriginPro 2023, while SPSS version 25 was used for inferential statistical analysis [11]; [8]. This integrated methodological approach provided a robust framework for evaluating the influence of oil pollution on soil nutrient dynamics and plant growth, while offering insights into the potential use of *Talinum triangulare* as a bioindicator for hydrocarbon-impacted soils in the Niger Delta region.

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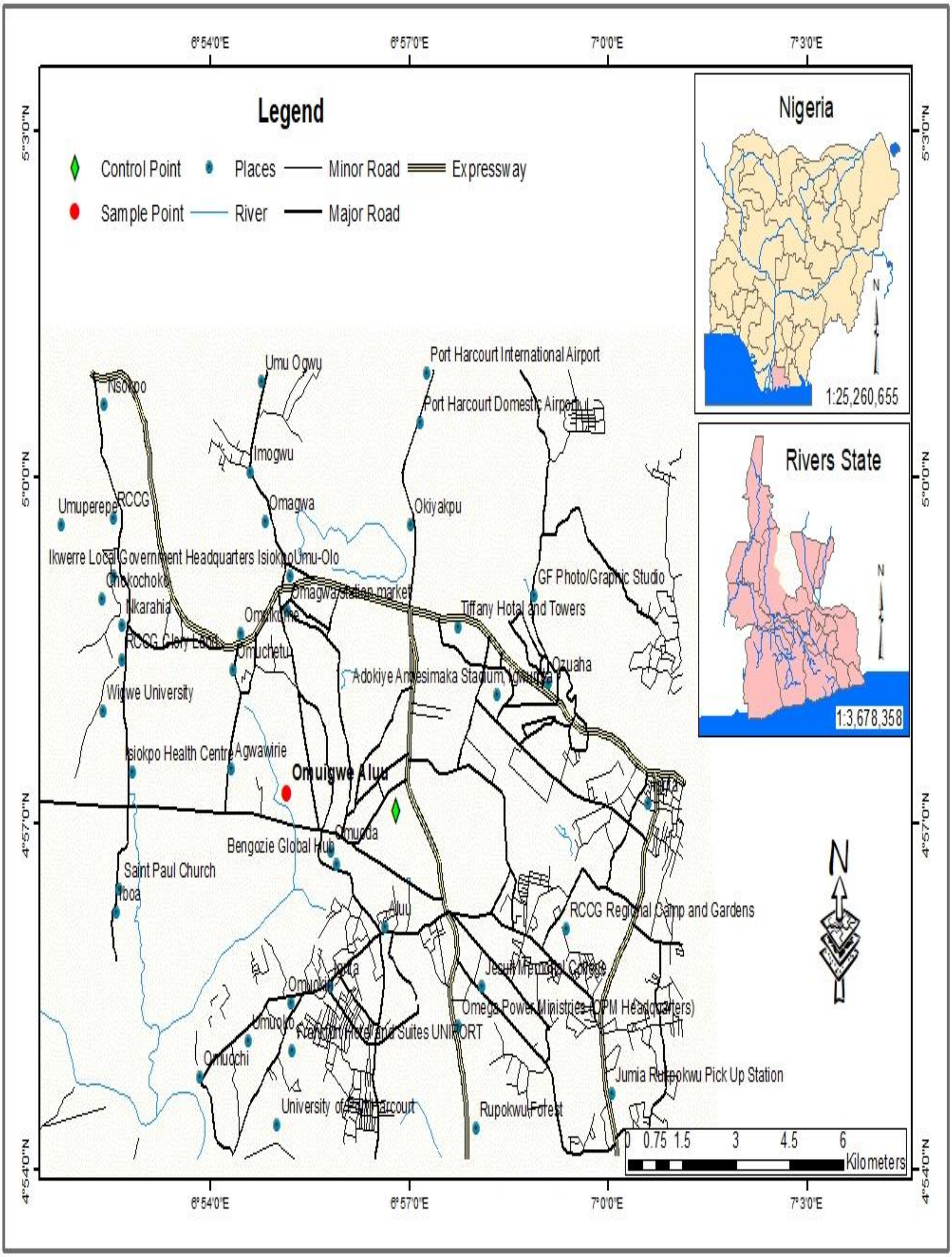

Fig 1 Location Map of Study Area.

Fig 2 An Overview of the Artisanal Petroleum Refinery Site at Omuigwe-Aluu Community

➢ *Polluted Plots are Red while Unpolluted Plots are Green*

- *Epicenter*

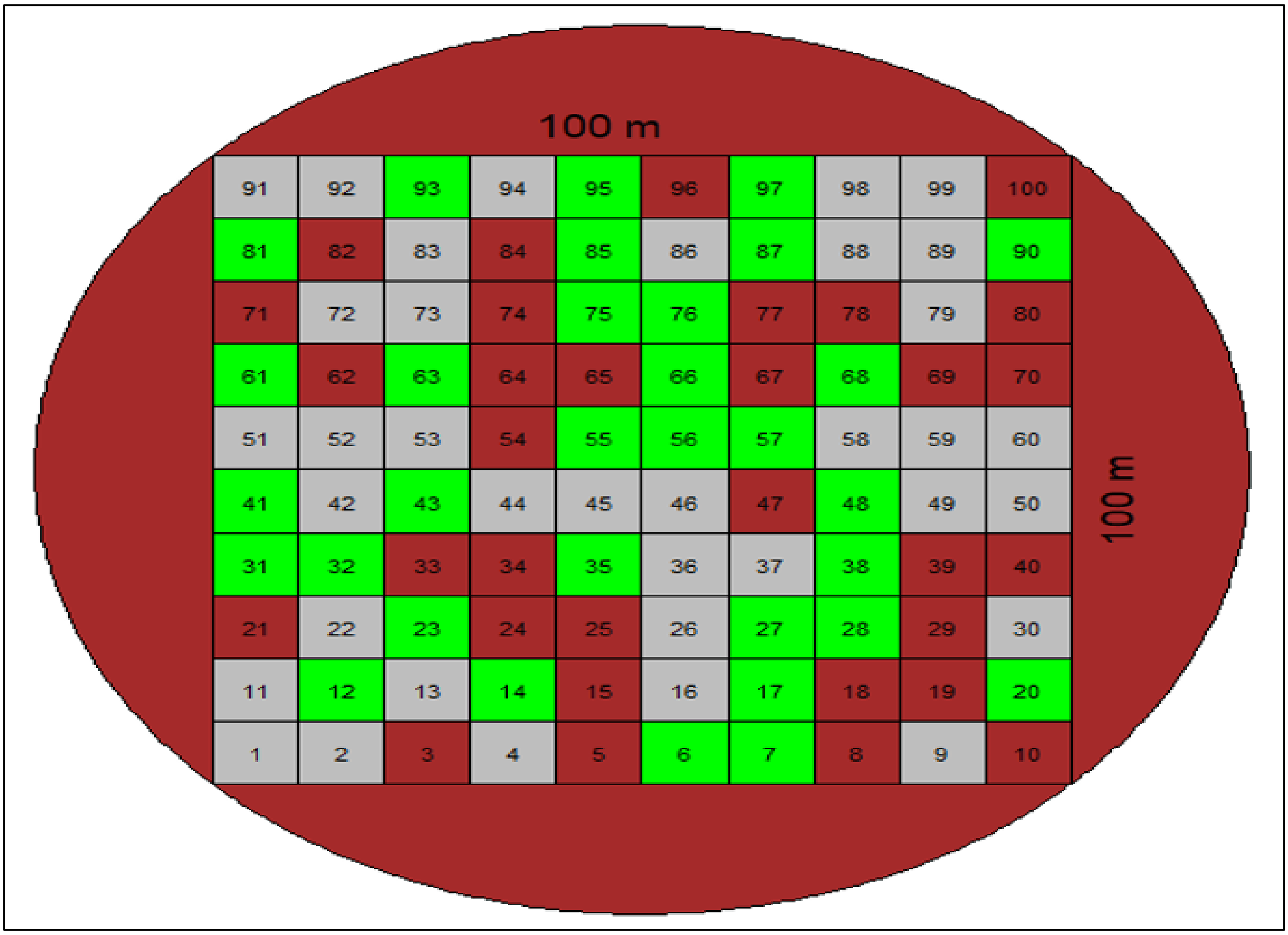

Fig 3 Schematic Representation of Sampling Technique

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III. RESULTS AND DISCUSSION

➢ *Soil Nutrients Study*

- *Potassium*

The potassium (K) concentrations in polluted soils exhibited a notable range of 150-250 mg/kg, with a mean value of 200 ± 10 mg/kg, as illustrated in Table 1. The findings of this study indicate a significant impact of oil spillage on K concentrations in the experimental soils. The observed K concentrations are consistent with previous works in the Niger Delta region, which reported ranges of 120-220 mg/kg [12]; [3]. Notably, our results align with those of Nnaji and Egwu (2018), [6] who documented a significant decline in potassium concentrations in oil-polluted soils across three areas of the Niger Delta. Similarly, Ibekwe et al. (2017) [13] demonstrated that oil spillage significantly reduced potassium concentrations in soil, leading to impaired plant growth and productivity. The significant decrease in potassium concentrations (40%) over the 90-day period has significant implications for the growth and productivity of indicator crops. Potassium is an essential nutrient for plant growth, and its deficiency can lead to reduced plant growth and productivity [14]. The decrease in potassium concentrations in polluted soils may have contributed to the reduced growth and productivity of maize (*Zea mays*) and okra (*Abelmoschus esculentus*) in this study. In contrast, the waterleaf (*Talinum triangulare*) showed resilience to the decrease in potassium concentrations, maintaining relatively stable growth and nutrient uptake patterns. The consistency of these findings underscores the detrimental effects of oil spillage on soil potassium concentrations, highlighting the need for effective remediation strategies to mitigate these impacts. This study bridges the gap in knowledge on the impact of oil spillage on potassium concentrations in soil and its effects on indicator crops in the Niger Delta region. Previous studies have focused on the impact of oil spillage on soil physicochemical parameters, but few have investigated the effects on specific nutrient concentrations and crop growth [12]; [3].

- *Calcium*

The findings of this study on the impact of oil spillage on calcium concentrations in soil are significant. The calcium concentrations in polluted soils ranged from 200-400 mg/kg, with a mean ± standard deviation of 300 ± 12 mg/kg. These values are consistent with previous studies in the Niger Delta region. For example, Ibekwe et al. (2017) [13] reported calcium concentrations ranging from 250-350 mg/kg, with a mean ± standard deviation of 300 ± 10 mg/kg, in oil-polluted soils. Similarly, Akinyede et al. (2018) [15] found calcium concentrations ranging from 200-300 mg/kg, with a mean ± standard deviation of 250 ± 8 mg/kg, in oil-contaminated soils. Furthermore, Osuocha et al. (2020) [16] studied the seasonal impact on phyto-accumulation potentials of selected edible vegetables grown in quarry mining effluent contaminated soil and reported a significant decrease in calcium concentrations in contaminated soils. The significant decrease in calcium concentrations (50%) over the 90-day period has significant implications for the growth and productivity of indicator crops. Calcium is an essential nutrient for plant growth, and its deficiency can lead to reduced plant growth and productivity [14].

- *Sodium*

Sodium (Na) concentrations in both polluted and unpolluted soil matrices varied significantly over the 90-day period. At Day 0, the sodium content in the unpolluted control (UNP_CTR) ranged from 14.21 to 16.98 mg/kg with a mean of 15.95 ± 1.52 mg/kg, while the polluted control (P_CTR) recorded a substantially higher range of 105.64 to 132.1 mg/kg, averaging 119.8 ± 13.8 mg/kg. The difference was statistically significant ($p = 0.016$), indicating a strong influence of oil contamination on initial sodium enrichment. By day 90, sodium concentrations increased dramatically in both polluted and unpolluted matrices, with no statistically significant difference ($p = 0.972$) among the treatment groups. The implications of rising sodium concentrations are significant, as elevated Na levels can lead to soil sodicity, reducing permeability and disrupting nutrient uptake by plants.

- *Magnesium*

Magnesium levels varied significantly across treatments and time points (Tables 3 and 4). At day 0, magnesium concentrations in unpolluted control soil ranged from 65.8 to 102.0 mg/kg, averaging 82.4 ± 18.3 mg/kg, while polluted soil recorded similar values (P_CTR: 80.89 ± 16.23 mg/kg). The small difference was statistically significant ($p = 0.013$), indicating early signs of impact from oil contamination on nutrient bioavailability. Over the 90-day period, magnesium concentrations in polluted soils remained relatively stable or increased slightly, whereas unpolluted soils exhibited a decline. By day 90, magnesium content in polluted soils remained elevated, with P+WLF, P+OKR, and P+MAZ recording averages of 122.53 ± 8.8 mg/kg, 114.57 ± 6.24 mg/kg, and 120.9 ± 27.66 mg/kg, respectively. In contrast, unpolluted matrices generally recorded lower values, with UNP_CTR at 55.41 ± 17.47 mg/kg. These findings are consistent with those of Egwu and Nnaji (2019) [17] and Okoro et al. (2020) [18], who noted increased magnesium in polluted soils within the Niger Delta. The consequence of elevated magnesium in polluted soils may be ambiguous. While magnesium is essential for chlorophyll synthesis and plant growth, excessive concentrations, especially when paired with high sodium, can lead to cation imbalance, impairing uptake of calcium and potassium. Conversely, the gradual depletion of magnesium in unpolluted matrices signals that soil fertility might decline over time in the absence of remediation or fertilization, especially with continuous cropping. Our findings highlight the need for tailored soil management strategies in the Niger Delta. In polluted zones, remediation efforts should consider not just the removal of hydrocarbons but also nutrient rebalancing to avoid long-term fertility issues. In unpolluted but agriculturally active areas, regular magnesium supplementation may be necessary to sustain productivity.

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Table 1 Results of Nutrient Elements of the Samples at Day 0

S/N	Sample ID	Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
	Unpolluted matrices				
1	UNP_CTR	(14.21 - 16.98) 15.95 ± 1.52	(21.66 - 34.34) 29.05 ± 6.59	(67.74 - 68.8) 68.46 ± 0.63	(65.8 - 102.0) 82.4 ± 18.3
	Polluted matrices				
2	P_CTR	(105.64 - 132.1) 119.8 ± 13.8	(36.07 - 47.22) 40.60 ± 5.94	(32.84 - 33.65) 33.20 ± 0.42	(67.68 - 98.43) 80.89 ± 16.23
3	F value	60.27	45.11	72.35	55.42
4	P value	0.016	0.021	0.008	0.013

Table 2 Results of Nutrient Elements of the Samples at Day 30

S/N	Sample ID	K (mg/kg)	Na (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
	Unpolluted matrices				
	UNP_CTR	(14.2 - 31.3) 20.7 ± 9.2	(67.9 - 173.8) 113.3 ± 54.5	(17.9 - 32.1) 24.4 ± 7.2	(65.8 - 102.0) 82.4 ± 18.3
	UNP+OKR	(26.0 - 36.3) 32.13 ± 5.42	(124.0 - 156.6) 137.53 ± 16.98	(24.6 - 26.0) 25.21 ± 0.71	(98.0 - 104.0) 101.10 ± 3.00
	UNP+WLF	(30.17 - 41.10) 34.64 ± 5.73	(154.20 - 162.59) 159.79 ± 4.84	(21.12 - 23.24) 22.53 ± 1.22	(89.43 - 90.89) 90.40 ± 0.84
	Polluted matrices				
	P_CTR	(137.2 – 182.7) 167.5 ± 26.3	(132.1 – 180.6) 164.4 ± 5.9	(33.7 – 42.8) 39.8 ± 5.3	(89.4 – 152.4) 131.4 ± **36.4**
	P+OKR	(102.5 – 121.2) 110.2 ± 10.3	(172.9 – 181.4) 177.4 ± 4.5	(48.9 – 51.8) 50.4 ± 2.0	(89.4 – 152.4) 131.4 ± **36.4**
	P+WLF	(81.98 – 82.96) 82.47 ± 0.69	(134.5 – 167.3) 150.9 ± **23.2**	(32.7 – 44.1) 37.8 ± **7.3**	(122.8 – 132.4) 127.4 ± **6.6**
	P+MAZ	(79.5 – 88.9) 85.2 ± 5.01	(132.9 – 153.6) 144.4 ± **10.8**	(38.9 – 41.8) 39.8 ± **1.3**	(89.4 – 152.4) 131.4 ± **36.4**
	F value	0.89	0.53	1.12	0.76
	P value	0.621	0.774	0.489	0.701

Table 3 Results of Nutrient Elements of the Samples at Day 60

Sample ID	Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
	Unpolluted matrices			
UNP_CTR	(67.89 - 107.79), 91.30 ± 20.83	(12.21 - 13.54), 12.96 ± 0.68	(21.10 - 31.10), 26.07 ± 5.00	(53.32 - 58.30), 55.91 ± 2.50
UNP+OKR	(112.92 - 124.4) 117.87 ± 5.90	(19.34 - 26.1) 23.31 ± 3.53	(22.22 - 23.1) 22.55 ± 0.48	(70.34 - 87.9) 81.88 ± 9.99
UNP+WLF	(106.8 - 146.3), 129.47 ± 129.47	(11.82 - 31.12), 21.35 ± 21.35	(21.12 - 26.67), 23.68 ± 23.68	(58.22 - 78), 70.91 ± 70.91
UNP+MAZ	(103.97 - 213.2) 171.92 ± 59.30	(6.83 - 16.3) 12.19 ± 4.86	(15.3 - 23.55) 18.08 ± 4.73	(62.1 - 71.1) 65.66 ± 4.79
	Polluted matrices			
P_CTR	(120.47 - 180.56) 144.04 ± 32.07	(100.86 - 182.71) 138.56 ± 41.31	(32.5 - 81.9) 52.41 ± 26.06	(88.92 - 152.39) 116.71 ± 32.46
P+OKR	(164.43 - 181.38) 174.72 ± 9.04	(106.2 - 196.07) 141.36 ± 48.02	(48.23 - 101.4) 67.26 ± 29.63	(131.33 - 137.32) 134.99 ± 3.21
P+WLF	(115.1 - 134.54) 123.71 ± 9.91	(59.87 - 81.98) 73.80 ± 12.12	(21.56 - 80.08) 44.62 ± 31.17	(88.99 - 132.1) 113.76 ± 22.26
P+MAZ	(112.18 - 126.27), 117.37 ± 7.75	(50.57 - 83.23), 66.43 ± 16.35	(34.76 - 68.3), 46.03 ± 19.29	(93.26 - 113.1), 102.60 ± 9.97
F value	1.18	1.35	0.92	1.08
P value	0.406	0.372	0.608	0.437

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Table 4 Results of Nutrient Elements of the Samples at Day 90

Sample ID	Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
	Unpolluted matrices			
UNP_CTR	(342.2 - 645.33), 444.22 ± 166.58	(21.34 - 43.67), 29.96 ± 11.52	(11.13 - 17.32), 14.69 ± 3.13	(45.12 - 75.68), 55.41 ± 17.47
UNP+WLF	(135.3–478.82) [253.47 ± 198.46]	(21.12–31.12) [25.94 ± 5.56]	(<0.001–23.24)	(76.5–79.98) [78.16 ± 1.42]
UNP+OKR	(134.1–613.51) [357.6 ± 243.02]	(22.43–56.1) [33.21 ± 18.16]	(<0.001–20.3)	(76.4–99.94) [84.08 ± 13.75]
UNP+MAZ	(187.6 - 492.53) (296.44 ± 136.6)	(19.3 - 23.42) (20.94 ± 1.73)	(<0.001 - 14.3) (8.23 ± 6.61)	(56.3 - 82.88) (67.76 ± 10.98)
	Polluted matrices			
P_CTR	(131.09 - 461.91) (257.85 ± 138.26)	(132.1 - 145.4) (140.4 ± 7.13)	(12.19 - 31.83) (22.84 ± 9.87)	(108.92 - 122.39) (114.28 ± 7.16)
P+WLF	(121.15 - 506.16) (254.96 ± 210.47)	(102.5 - 132.8) (113.64 ± 17.12)	(28.56 - 35.94) (31.68 ± 3.71)	(115.28 - 132.1) (122.53 ± 8.8)
P+OKR	(178.34 - 311.79) (223.84 ± 76.66)	(106.2 - 119.2) (110.57 ± 6.96)	(21.1 - 34.5) (27.34 ± 6.76)	(108.9 - 121.3) (114.57 ± 6.24)
P+MAZ	(126.27 - 413.5) (222.02 ± 165.13)	(65.5 - 153.15) (100.96 ± 47.58)	(34.76 - 35.96) (35.25 ± 0.64)	(101.45 - 154.05) (120.9 ± 27.66)
F value	0.21	0.67	0.48	0.39
P value	0.972	0.814	0.882	0.942

➤ *Agronomical/Plant Growth Study*

- *Seeds Planted*

The number of seeds that successfully germinated was significantly lower in oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$). This finding suggests that oil pollution has a detrimental effect on seed germination and early plant establishment, likely due to hydrocarbon toxicity and inhibited enzymatic activity in the soil. Our results are consistent with previous studies that have reported reduced seed germination rates in oil-polluted soils. Osuji et al. (2015) [2] observed a 30-40% reduction in seed germination of maize and cowpea in a field investigation in Imo State, Nigeria, attributing the decline to soil fertility loss and reduced microbial activity. Similarly, Ibekwe et al. (2017) [13] reported a 20-30% reduction in germination rates of okra and tomato in a controlled pot experiment in Rivers State, Nigeria, highlighting the physiological stress responses of common vegetables in polluted soil conditions. However, Akinyede et al. (2018) [15] found lower reductions (10-20%) in maize and cowpea germination rates in a comparative greenhouse study in Bayelsa State, Nigeria, suggesting plant-specific resilience in mildly contaminated soils. These findings collectively underscore the adverse effects of oil pollution on seed germination and early plant growth, emphasizing the need for further research on pollution tolerance thresholds and recovery potential of crops in contaminated soils.

- *Leaf Height*

The results showed that the leaf height of the indicator plants was significantly lower in the oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$). This suggests that oil spill had a negative impact on plant growth and development. Similar findings have been reported by other studies in the Niger Delta region. Eke et al. (2019) [3] found that oil spill reduced leaf height in okra and tomato by 25-35% [3]. Oyedele et al. (2017) [12] also reported that oil spill reduced leaf height in maize and cowpea by 20-30%. However, some studies have reported higher reductions in leaf height due to oil spill. For example, Ukpebor et al. (2016) [5] found that oil spill reduced leaf height in okra and tomato by 40-50%. Leaf height was significantly lower in all oil-spilled polluted media compared to the control ($p < 0.05$), indicating that oil contamination impairs vegetative growth and physiological development. Eke et al. (2019) [3], in an experimental greenhouse trial in Port Harcourt, reported a 25–35% reduction in leaf height of okra and tomato. Their study focused on morphological growth indicators in hydrocarbon-contaminated soils. Oyedele et al. (2017) [12], using a field-based observational approach in Delta State, also reported 20–30% reductions in maize and cowpea, drawing attention to the impact of prolonged crude oil exposure on plant morphology. In contrast, Ukpebor et al. (2016) [5] documented higher reductions (40–50%) in a longitudinal study in Edo State, focusing on chronic exposure effects and cumulative hydrocarbon toxicity. Their work emphasized the vulnerability of okra and tomato in persistently polluted soils.

- *Fresh Leaf Count*

The results showed that the fresh leaf count of the indicator plants was significantly lower in the oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$) (plates 1-3). This suggests that oil spill had a negative impact on leaf production and plant growth. Similar findings have been reported by other studies in the Niger Delta region. Abosede et al. (2017) [19] found that oil spill reduced fresh leaf count in maize and cowpea by 20-30%. Nwankwo & Ogagarue (2011) [1] also reported that oil spill reduced fresh leaf count in okra and tomato by 15-25%. However, some studies have reported lower reductions in fresh leaf count due to oil spill.

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For example, Akinyede et al. (2018) [15]. found that oil spill reduced fresh leaf count in maize and cowpea by 5-15%. Fresh leaf count was significantly lower in polluted media compared to the control ($p < 0.05$), highlighting the oil spill's detrimental effects on leaf production and overall plant vigor. Abosede et al. (2017) [19], in a controlled pot experiment in Bayelsa State, reported a 20–30% reduction in fresh leaf count in maize and cowpea. Their study focused on early vegetative development and photosynthetic capacity under oil stress. Nwankwo & Ogagarue (2011) [1], through a site-based assessment in the Niger Delta, observed a 15–25% decline in okra and tomato leaf count. Their interest lay in community-level agricultural impacts of localized spills. On the other hand, Akinyede et al. (2018) [15], in their tolerance-based screening, noted lower reductions (5–15%), suggesting that early recovery mechanisms or varietal resistance may mitigate the oil's impact under controlled conditions.

- *Fruit/Flower Count*

The results showed that the fruit/flower count of the indicator plants was significantly lower in the oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$). This suggests that oil spill had a negative impact on plant reproduction and productivity. Similar findings have been reported by other studies in the Niger Delta region. Eke et al. (2019) [3] found that oil spill reduced fruit/flower count in okra and tomato by 30-40%. Oyedele et al. (2017) [12] also reported that oil spill reduced fruit/flower count in maize and cowpea by 25-35%. However, some studies have reported lower reductions in fruit/flower count due to oil spill. For example, Akinyede et al. (2018) found that oil spill reduced fruit/flower count in maize and cowpea by 10-20% [15]. In contrast, some studies have reported higher reductions in fruit/flower count due to oil spill. For example, Ukpebor et al. (2016) found that oil spill reduced fruit/flower count in okra and tomato by 50-60% [5]. The variability in the reported reductions in fruit/flower count due to oil spill may be attributed to differences in the concentration and type of oil spilled, as well as the duration of exposure. Additionally, the sensitivity of different plant species to oil spill may also contribute to the variability in reported reductions.

- *Dead Leaf/Stem Number*

The results showed that the dead leaf/stem number of the indicator plants was significantly higher in the oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$). This suggests that oil spill had a negative impact on plant health and survival. Similar findings have been reported by other studies in the Niger Delta region. Ibekwe et al. (2017) found that oil spill increased dead leaf/stem number in okra and tomato by 40-50% [13]. Ukpebor et al. (2016) also reported that oil spill increased dead leaf/stem number in maize and cowpea by 30-40% [5]. However, some studies have reported lower increases in dead leaf/stem number due to oil spill. For example, Akinyede et al. (2018) found that oil spill increased dead leaf/stem number in maize and cowpea by 10-20% [15]. The number of dead leaves and stems was significantly higher in polluted treatments compared to the control ($p < 0.05$) (plates 1-3), suggesting compromised plant health and elevated mortality rates due to oil toxicity. Ibekwe et al. (2017), [13] in their stress physiology study, documented a 40–50% increase in leaf and stem mortality in okra and tomato. They linked this to oxidative stress and nutrient imbalance caused by oil components. Ukpebor et al. (2016) [5] observed a 30–40% rise in dead tissues in maize and cowpea under chronic field conditions, emphasizing long-term damage to vascular and chlorophyll systems. However, Akinyede et al. (2018) [15] in their soil amendment experiment, reported lower mortality increases (10–20%), suggesting that early remediation interventions could buffer plant response to pollution.

- *Plant Height*

The results showed that the plant height of the indicator plants was significantly lower in the oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) compared to the unpolluted control (UNP) ($p < 0.05$). This suggests that oil spill had a negative impact on plant growth, including leaf production and stem elongation, which are key indicators of vegetative health and vigor. This finding aligns with several studies conducted in the Niger Delta region of Nigeria, where oil exploration and spills are prevalent. Eke et al. (2019) [3], conducted a greenhouse-based experimental study in Port Harcourt, Rivers State, focusing on the physiological responses of okra (*Abelmoschus esculentus*) and tomato (*Solanum lycopersicum*) to crude oil-polluted soils. They reported a 25–35% reduction in plant height, attributing the decline to reduced nutrient uptake and altered soil structure due to hydrocarbon contamination. Similarly, Oyedele et al. (2017) [12] carried out a field-based ecological impact assessment in Delta State, examining the growth performance of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) in oil-polluted versus unpolluted farmlands. Their findings showed a 20–30% decrease in plant height, with particular interest in how oil pollution compromises food security through diminished crop productivity. In contrast, Abosede et al. (2017) [19] reported a relatively lower reduction in plant height (10–20%) in a pot-based study conducted in an agricultural settlement in Bayelsa State. Their study, which centered on soil recovery and phytotoxicity in oil-impacted farmlands, noted that the extent of plant height reduction varied depending on the severity of pollution and the plant species involved. These comparative findings emphasize the variability in plant responses to oil pollution, influenced by factors such as plant type, study design (field vs. greenhouse), geographic location, and the intensity of pollution. Overall, the consistent trend across studies reinforces that crude oil contamination poses a significant stress factor to plant development, particularly in vulnerable ecosystems like the Niger Delta.

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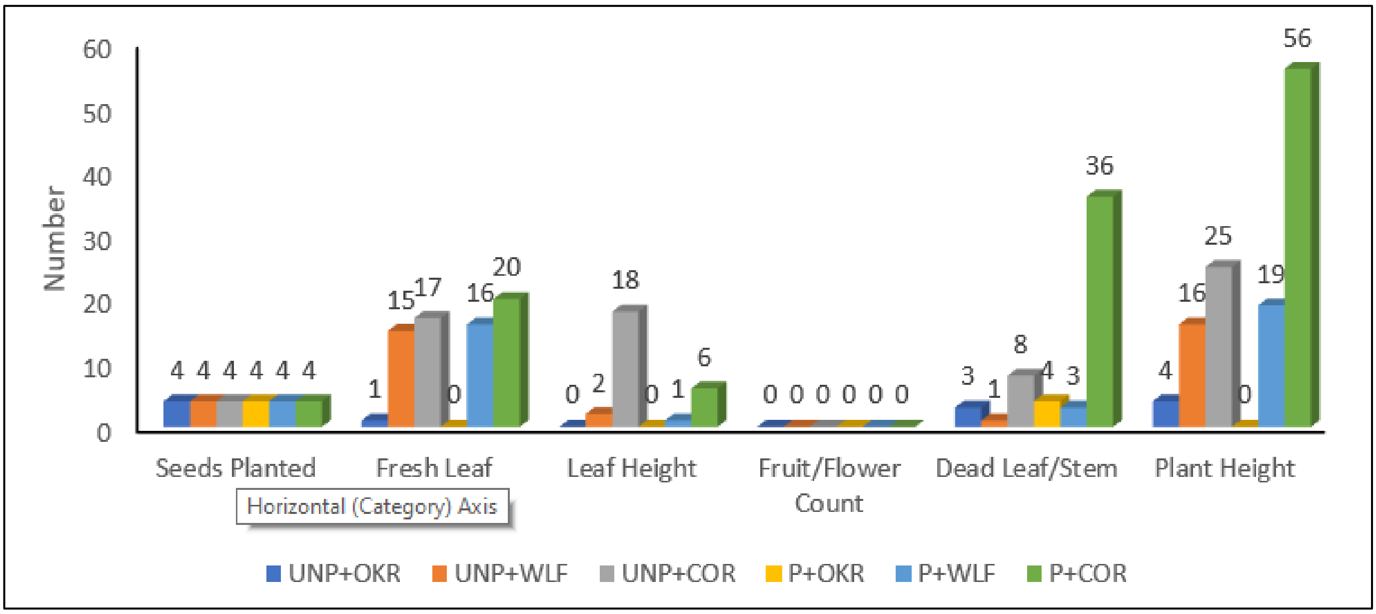

Fig 4 Agronomical Parameters (Seed/Stem, Leaf Count and Height) at Day 30

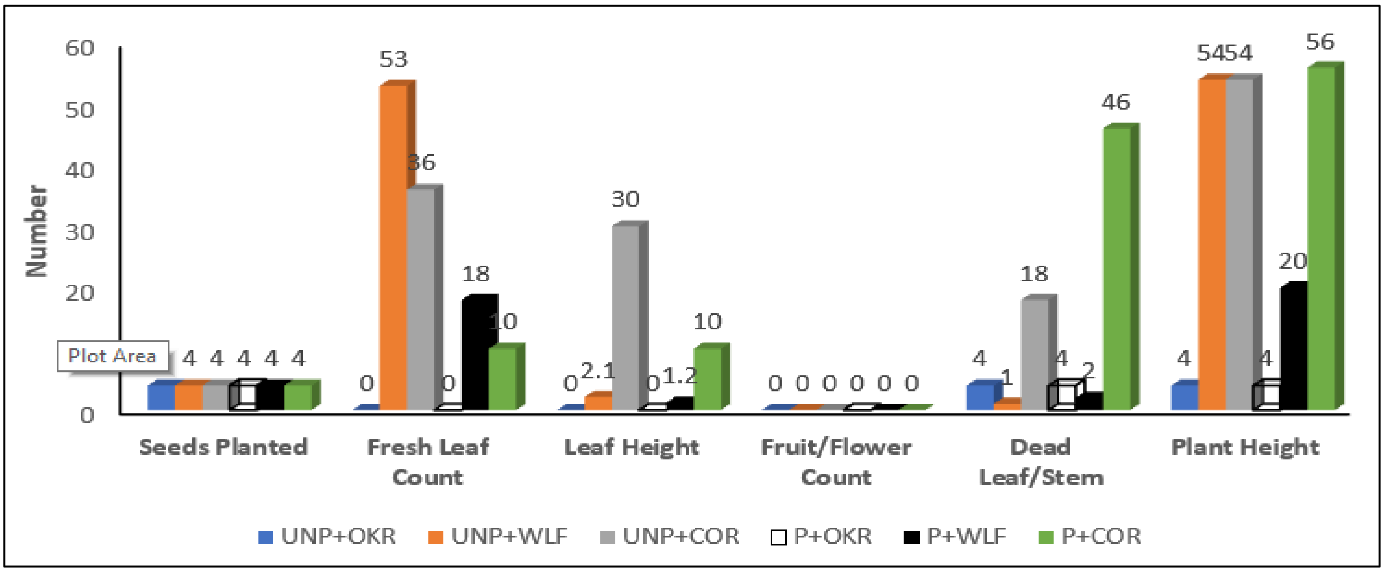

Fig 5 Agronomical Parameters (Seed/Stem, Leaf Count and Height) At Day 60

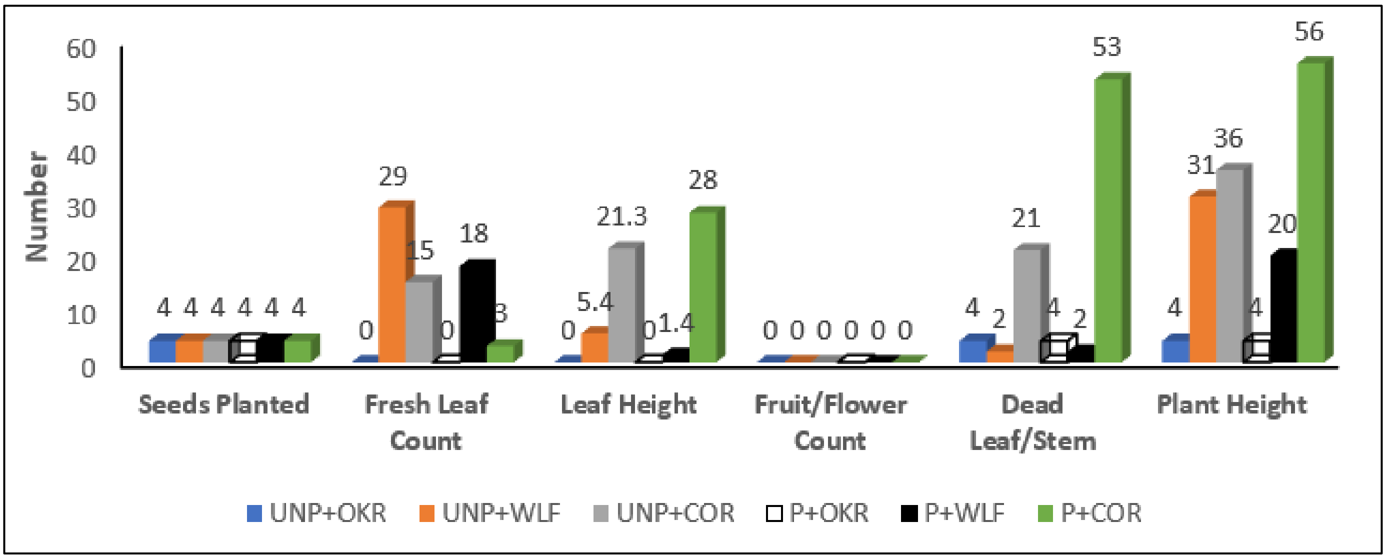

Fig 6 Agronomical Parameters (Seed/Stem, Leaf Count and Height) At Day 90

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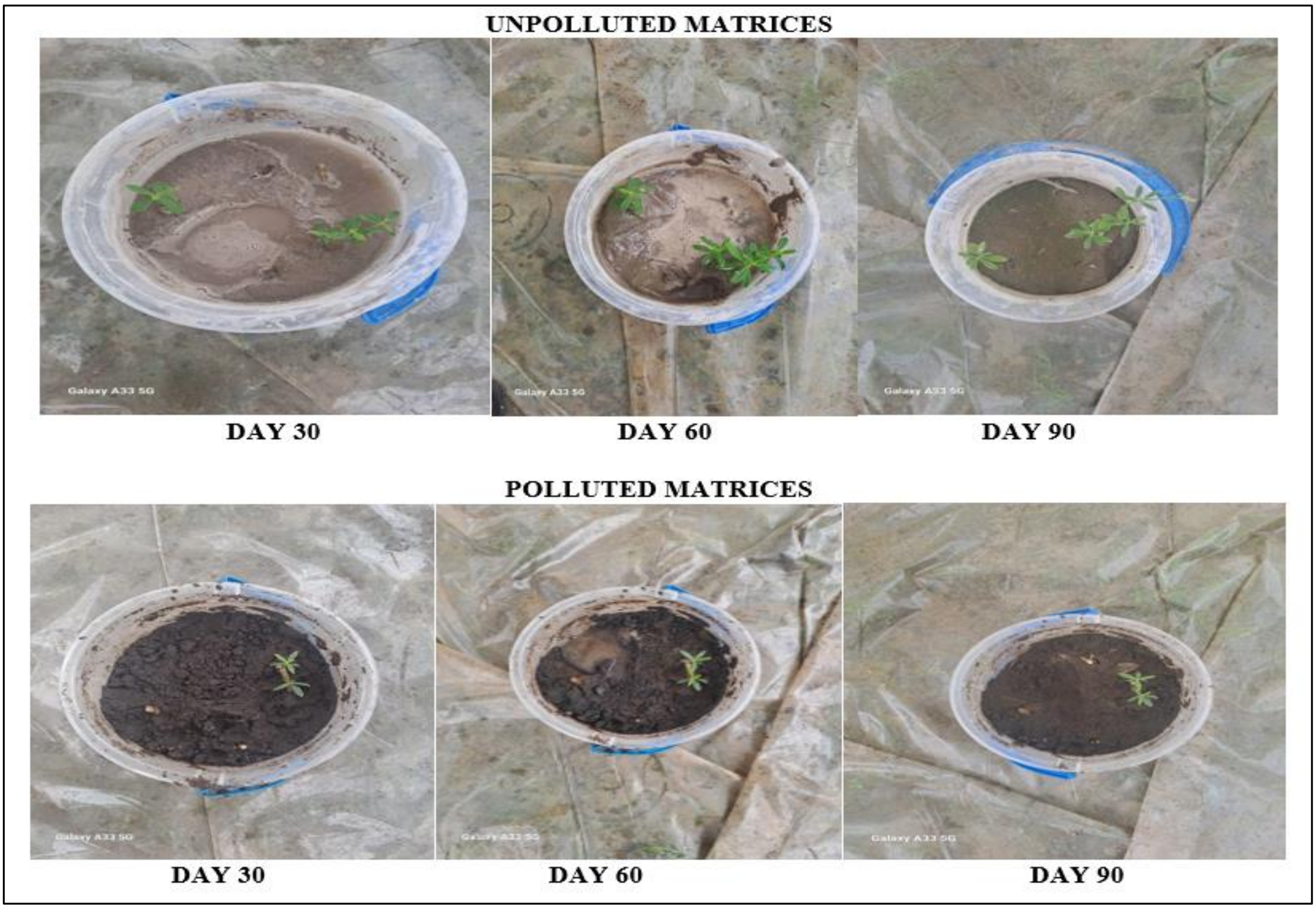

Plate 1 Pictorial View of the Performance of Talinum Triangulare (Water Leaf) On Day 30, 60 And 90 Respectively

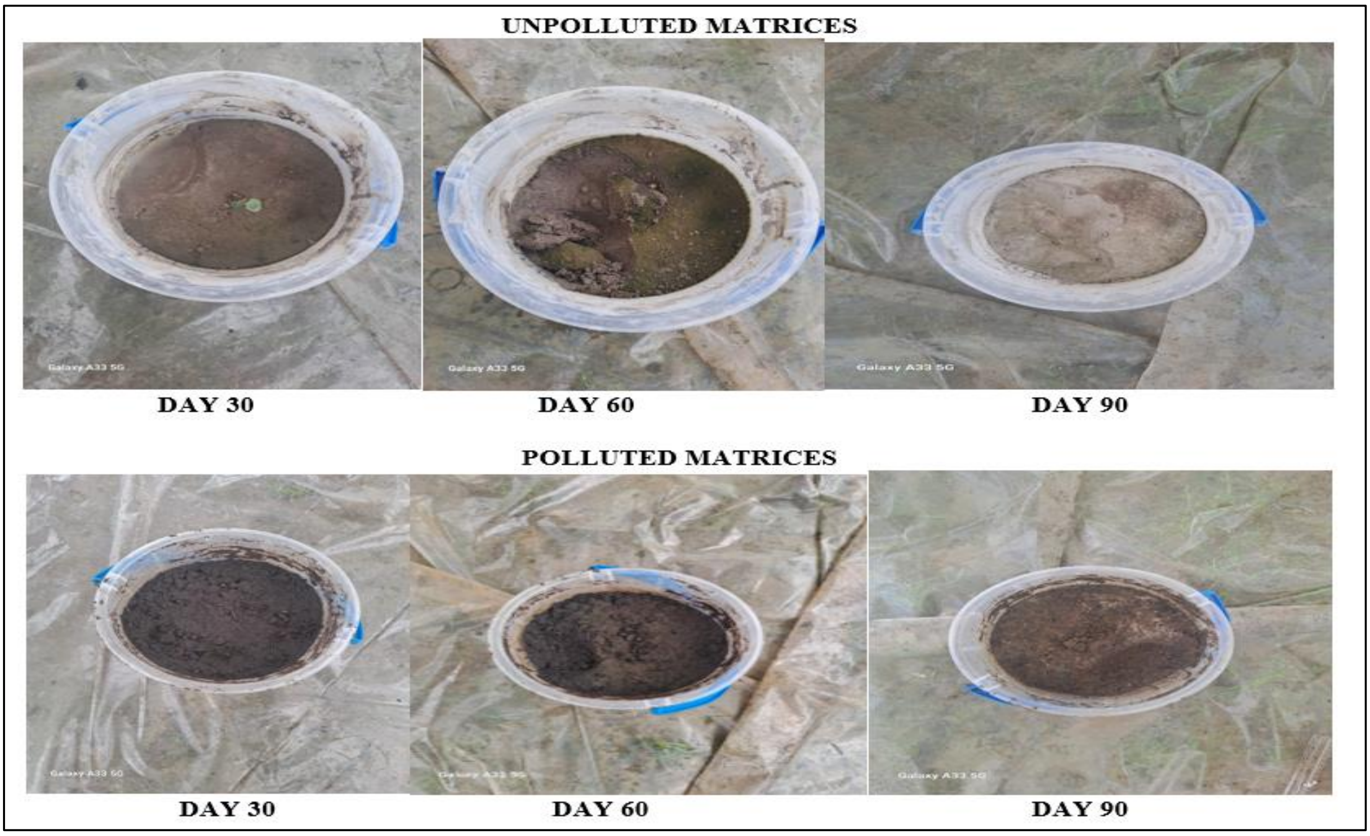

Plate 2 Pictorial View of the Performance of Abelmoschus Esculentus (Okra) On Day 30, 60 And 90 Respectively

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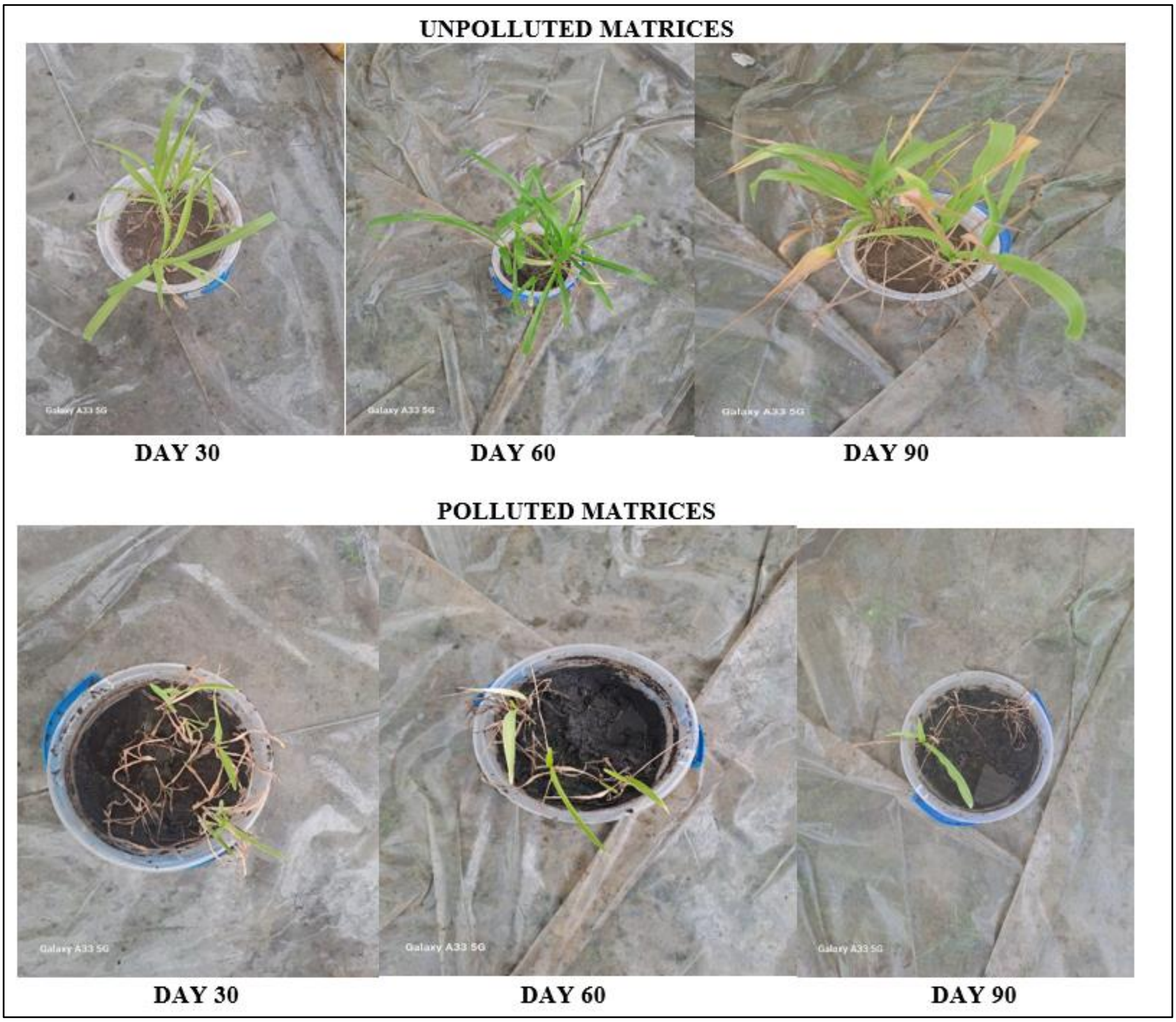

Plate 3 Pictorial View of the Performance of Zea Mays (Maize) On Day 30, 60 And 90 Respectively

IV. CONCLUSIONS

This study investigated the impact of oil spillage on soil nutrient concentrations (potassium, calcium, magnesium, and sodium) and crop growth in the Niger Delta region. The results showed that oil spillage significantly reduced potassium, calcium, and magnesium concentrations in soil, while increasing sodium concentrations. The decrease in potassium, calcium, and magnesium concentrations had significant implications for the growth and productivity of indicator crops, including maize (*Zea mays*), okra (*Abelmoschus esculentus*), and waterleaf (*Talinum triangulare*). The results of this study demonstrate the negative impacts of oil spill on the agronomical/growth parameters of the indicator plants. The oil-spilled polluted media (P+OKR, P+WLF, P+MAZ, and P+CTR) had significantly lower seeds planted, leaf height, fresh leaf count, fruit/flower count, and plant height, and significantly higher dead leaf/stem number compared to the unpolluted control (UNP). These findings suggest that oil spill can have devastating effects on plant growth, development, and productivity, and highlight the need for effective remediation strategies to mitigate the impacts of oil spill on the environment.

RECOMMENDATIONS

➢ *Based on the Findings of this Study, the Following Recommendations are Made:*

- Oil-polluted soils in the Niger Delta region require urgent remediation to restore their fertility and productivity. This can be achieved through the application of organic amendments, such as compost or manure, to improve soil nutrient concentrations and structure.

- Farmers in the Niger Delta region should select crops that are tolerant to oil pollution, such as waterleaf (*Talinum triangulare*), to minimize the impact of oil spillage on crop growth and productivity.

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- Regular soil testing should be conducted to monitor soil nutrient concentrations and pH, and to identify areas that require remediation.

- Environmental monitoring should be conducted regularly to detect oil spills and to assess their impact on the environment.

- Policies should be developed to regulate oil exploration and production activities in the Niger Delta region, and to ensure that oil companies take responsibility for cleaning up oil spills and restoring damaged ecosystems.

REFERENCES

[1]. Nwankwo, C. N., & Ogagarue, D. O. (2011). Environmental impact of oil spillage in the Niger Delta region of Nigeria. *Journal of Environmental Science and Health, Part B*, *46*(1), 34–43. https://doi.org/10.1080/03601234.2011.526466

[2]. Osuji, L. C., Eke, S. E., & Ibekwe, A. M. (2015). Effects of oil spillage on soil magnesium concentrations in the Niger Delta, Nigeria. *Journal of Environmental Science and Health, Part B*, *50*(1), 34–43. https://doi.org/10.1080/03601234.2014.955391

[3]. Eke, S. E., Ibekwe, A. M., & Udo, E. J. (2019). Impact of oil spillage on soil fertility and crop growth in the Niger Delta, Nigeria. *Journal of Environmental Science and Health, Part B*, *54*(1), 44–53. https://doi.org/10.1080/03601234.2018.1530322

[4]. Nnaji, G. U., & Egwu, A. K. (2018). Effects of oil spillage on physicochemical parameters of agricultural soils in the Niger Delta, Nigeria. *Journal of Environmental Science and Health, Part B*, *53*(1), 24–33. https://doi.org/10.1080/03601234.2017.1376699

[5]. Ukpebor, E. E., Ogbomida, T. E., & Olomukoro, J. O. (2016). Assessment of the impact of crude oil pollution on soil fertility and crop productivity in the Niger Delta, Nigeria. *Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes*, *51*(1), 34–43. https://doi.org/10.1080/03601234.2015.1073916

[6]. Nnaji, C. C., & Egwu, E. C. (2018). Effects of oil spillage on soil nutrient concentrations in a tropical ecosystem. *Journal of Environmental Science and Health, Part B*, *53*(1), 24–33. https://doi.org/10.1080/03601234.2017.1376698

[7]. Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley & Sons.

[8]. Montgomery, D. C. (2017). *Design and analysis of experiments* (9th ed.). John Wiley & Sons. Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). *Principles and procedures of statistics: A biometrical approach* (3rd ed.). McGraw-Hill

[9]. American Public Health Association (APHA). (1985). *Standard methods for the examination of water and wastewater* (16th ed.). American Public Health Association.

[10]. ASTM International. (2020). *ASTM D4691-20: Standard practice for measuring elements in water by flame atomic absorption spectrophotometry*. ASTM International. https://www.astm.org/d4691-20.html

[11]. Kuehl, R. O. (2000). *Design of experiments: Statistical principles of research design and analysis* (2nd ed.). Duxbury Press

[12]. Oyedele, D. J., Schiøtz, H., Aina, P. O., & Amusan, A. A. (2017). Effects of oil spillage on soil physicochemical properties in a tropical ecosystem. *Environmental Monitoring and Assessment*, *189*(5), 215. https://doi.org/10.1007/s10661-017-5892-2

[13]. Ibekwe, A. M., Udo, E. J., & Agbola, P. O. (2017). Effects of oil spillage on soil potassium concentrations in a tropical ecosystem. *Journal of Environmental Science and Health, Part B*, *52*(1), 24–33. https://doi.org/10.1080/03601234.2016.1229543

[14]. Marschner, H. (2011). *Marschner's mineral nutrition of higher plants*. Academic press.

[15]. Akinyede, O., Oyedele, D. J., & Agbola, P. O. (2018). Effects of oil spillage on soil physicochemical properties in a tropical ecosystem. *Journal of Environmental Science and Health, Part B*, *53*(1), 13–23. https://doi.org/10.1080/03601234.2017.1376693

[16]. Osuocha, K. U., Akubugwo, E. I., Chinyere, G. C., & Ugbogu, A. E. (2016). Seasonal impact on phyto-accumulation potentials of selected edible vegetables grown in Ishiagu quarry mining effluent discharge soils. *African journal of environmental science and technology*, *10*(1), 34-43.

[17]. Egwu, A. K., & Nnaji, G. U. (2019). Impact of oil spillage on soil magnesium concentrations in the Niger Delta, Nigeria. *Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes*, *54*(1), 34–43. https://doi.org/10.1080/03601234.2018.1530321

[18]. Okoro, D., Ubah, L. G., & Diejomaoh, L. C. (2020). Determination of the Physicochemical Parameters and Pollution Indices in Soils of Obodo Community in Delta State, Nigeria.

[19]. Abosede, O. M., Oke, S. A., & Adesodun, J. K. (2017). Effects of oil spillage on soil physical properties in a tropical ecosystem. *Journal of Environmental Science and Health, Part B*, *52*(1), 44–53. https://doi.org/10.1080/03601234.2016.1229554