**Effect of Different Levels of Crude Oil Contamination On The Germination and Soil Chemical Properties of Soil Grown With *Zea mays L.* and *Abelmoschus esculentus L.***

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**ABSTRACT**

 The research trial was carried out to determine the effect of different levels of crude oil contamination on the soil grown with *Zea mays L*. and *Abelmoschus esculentus L.* in a potted sandy loam soil samples. The experiment was arranged in a completely randomised design (CRD) with four replicates. The factors consisted four different levels of crude oil contamination and two test crops, with each replication containing eight(8) treatments. The soil sample was treated with different levels of crude oil contamination such as 0% , 0.5%, 2% and 5% v/w. The control samples were not treated and contaminated. It was observed that *Zea mays* germinated and grow in 5%v/w crude oil concentration which was high enough to cause mortality in *Abelmoschus esculentus L*. This proved that *Zea mays* was a better candidate for phytoremediation of crude oil polluted soil. Crude oil at a level of 5% increased germination time in *Zea mays* by 24h whereas germination of  *Abelmoschus esculentus L* seeds was totally inhibited at the same level of concentration. However, germination of *Zea mays* seeds occurred at all levels of crude oil pollution although at different rates. The germination time was 5 days in soils with 5% oil concentration . Even though *Zea mays* germinated and grow in all concentrations of crude oil tested, significant (p<0.05) shoot growth retardation still occurred in both cereal and vegetable consequent on crude oil toxicity. The ability of *Zea mays* to grow in all crude oil levels that were harmful to *Abelmoschus esculentus* which made it better suited for growth in oil-contaminated soils, and consequently a better candidate for phytoremediation of such soils than other crops. The results also showed that crude oil contaminations have negative impacts on the soil chemical properties such soil pH, mineral nutrients i.e. nitrogen, phosphorus and potassium contents, soil organic content, exchangeable bases and acids, and Heavy metals. The observable changes in composition of the mineral nutrients in the soil could be attributed to the toxic nature of the petroleum products. This study has demonstrated that soil contamination with different crude oil levels has a high significant effect of retarding the germination of some crops, and mineral composition of soils and creating imbalance in the soil health status resulting to soil infertility.

**Key words:** Zea mays L. ; Abelmoschus esculentus L.; Crude Oil; Soil Chemical Properties; Germination; Hydrocarbon

**I. INTRODUCTION**

 Crude oil and its associated products remain a big threat to the soil environment and ecosystem, and consequently, a big challenging factor in Nigeria as crude oil refining activities improve steadily. This challenging issue around oil producing areas of Nigeria manifests particularly in the loss of soil fertility of agricultural lands, decline in ecosystems functions and services, loss of biodiversity and death of plants, including crops. Adoki et al,2007 reported that crude oil and its products could hinder and retard the germination, growth and yield of crops in any affected areas for varying periods of time. It is pertinent to noted that crude oil hydrocarbons is a big threat to vegetation, germination, shoot growth and yield of most plant species including plants on the surface of rivers (Bamidele et al, 2011;Debojit et al, 2011). According to Chi Yuan et al, 1995,crude oil and its products contains organic compounds such as aliphatic, oleic, naphthenic, benzene and its substituted cycloalkane rings and polycyclic aromatic hydrocarbons, which can distort soil physical and chemical characteristics . These organic hydrocarbon compounds are harmful, obnoxious and toxic in nature which can results to decline and depletion of soil fertility in farm lands. Its introduction to the soil make the affected contaminated soils to lose their physical, chemical and biological activities and can require a reasonable time to remediate and reclaim the soil quality(Wyszkowska et al, 2001).

 Bamidele 2010 and Lin *et al*, 2009 revealed that soils contaminated with hydrocarbon compounds severely distort and affect seed germination and growth of seedlings, and that no two or three plants exhibit the same degree of resistance to crude oil products. At such the difference is attributable to each plant inherent property as well as seed phytochemistry which is a good pointer to these properties. The two target crops used in this research trial are *Zea mays* and *Abelmoschus* *esculentus*. They are very important staple crops used for food and livestock feeds in different part of the world especially Nigeria. *Zea mays* is one of the key staple cereal crops grown for food, feed and industrial purposes(USAID, 2010; Oyewo et al, 2011)*.* It is also a major source of carbohydrate and vitamins particularly vitamins C and A which can be derived from white and yellow grains respectively(Agoda et al,2011). Industrially, the grain can be used as feeds for livestock. It also serves as a raw materials for starch, flour and alcohol productions.(Oyewo et al, 2011; Agoda et al 2011). *Abelmoschus* *esculentus*  simply known as ladies finger is a vegetable crops which contain sufficiently good quantity of vitamin A and other mineral nutrients such as folic acids, phosphorus, magnesium and potassium. The research trial aims to determine the effect of different levels of crude oil contamination on the germination and chemical properties of soil grown with *Zea mays L*. and *Abelmoschus* *esculentus L*.

**II. MATERIALS AND METHODS**

 The research was conducted in the screen house of Department of crop/soil science, Faculty of Agriculture, Rivers State University, Port harcourt, Nigeria**.** The research was a 4 x 2 factorial experiment arranged in a completely randomised design(CRD) with four replicates. The factors were four(4) levels of crude oil contamination,0%, 0.5%, 2% and 5%v/w and two test crops (Maize and okro), with each replicates containing eight (8) experimental pots. The possible combination of the two target crops and four different levels of crude oil contaminations were eight (8) treatments which include C1Ma, C2Ma, C3Ma, C4Ma; C1Ok, C2Ok, C3Ok, C4Ok and the Control. The crude oil was obtained fresh from Nigeria National Petroleum Cooperation(NNPC) Port Harcourt Refinery, Alesa-Eleme, Rivers state, Nigeria. Sandy loam soil was obtained from the Teaching and Research farm of Rivers State University, Port-Harcourt. The initial soil sample had no exposure to crude oil contamination. The viable target seeds of maize (*Zea mays*) and okro (*Abelmoschus* *esculentus*) were sourced from the International Institute of Tropical Agriculture (IITA), Ibadan and Rivers State Agricultural Development Programme(ADP) and stored at 25-30oC for a day. The Viability tests of the seeds were conducted via submerging the seeds in water by floatation method. The collected soil samples were air-dried, sieved and dispensed in 5kg weights into thirty-two (32) plastic bucket perforated at the bases. The perforated buckets were divided into four replications, with each division containing eight pots which were used for the cultivation of the two test crop plants. Each perforated plastic bucket contained 5kg of soil samples that were contaminated and mixed with one of four different levels of light crude oil concentrations: 0% , 0.5% , 2.0% , and 5% v/w. All control samples were not contaminated or planted. All the perforated buckets with soil samples and crude oil concentrations were permitted to stay for 7 days before planting. Thereafter, viable seeds of maize and Okra were planted in the buckets and watered for every three days by spraying method. The research was done for a month and repeated twice. Data were collected on the following parameters: germination percentage, and Soil pH was done by Electrode method**,** Organic carbon (Black,2000) , available phosphorus by bray II method (Bray et al, 1985), total nitrogen by modified kjeldahl method, heavy metal content by Atomic Absorption Spectrophotometer, Exchangeable bases such Calcium, Magnesium, sodium, potassium by titration method and flame photometer, and Exchangeable acids by titrimetric method . Research data obtained were simply subjected to analysis of variance, while the significant means were separated with least significant difference (LSD) at 5% confidence level (p<0.05).

**III. RESULTS.**

**A. Crude oil concentrations and Crop seed germination.**

 Crude oil concentrations had a significant effect on the seed germination of the test crops. The crude oil significantly (p<0.05) suppressed and hinder the germination of seeds of the test crops. The effect of crude oil on seed germinations was simply presented in the Table 1 and 2. It was observed that crude oil suppressed some seed germination of Okro. Germination of okro was suppressed at 5.0% (v/w) of crude oil whereas in maize, however the seeds germinated in all the levels of contaminations (0% to 5% v/w). Their germination occurred at different rates of 4 days for 0 to 2%, 5 days for 5% . Further, maize germination time was observed to had increased by a day as from 5% crude oil contamination. Table 2 showed that one hundred percent germination was observed in all the two crops only at 0 to 0.5% crude oil concentrations while in maize, there were hundred percentage germination in soils that contained up to 0.5% crude oil contamination . Also. at 2% crude oil concentration, there were only 67% germination of Okro and maize recorded. Again, the result showed that there were only 33% of the maize seeds which were able to germinate up to 5%, whereas at the same concentration, okro seeds were not able to germinate.

**B. Crude oil concentrations and soil chemical properties of the grown test crops**

The soil chemical properties, before and after crude oil contaminations, were shown in Table 3. Crude oil concentrations had significant(p<0.05) effected on some of the chemical properties of the soil contaminated, and sown with the test crops. Though the soil was an acidic, sandy loamy soil with no exposure of hydrocarbon content. The soil had originally soil pH of 6.17, nitrogen of 0.134% , available phosphorus of 69.93 mg/kg and organic carbon content of .84%. With the introduction of crude oil, it was observed that the soil pH was not significantly affected, and organic carbon content of the soil increased significantly as the crude oil concentrations increases whereas at 5% soil treatment, the available phosphorus was significantly reduced to 51.12 and 48.99 mg/kg in maize and okro respectively. Also, at 5% contaminated soil, the total nitrogen content was slightly increased to 0.17 and 0.22% in maize and okra respectively. This increased nitrogen at 5 percentage occurred 4 weeks after planting.

The soil pH, before contamination, was 6.17 slightly lower than the soil pH at the end of the research trial for the different treatments. At 0.5% to 5%v/w concentrations of crude oil treated soils, the pH was slightly and significantly increased to 6.26 and 6.25 for maize okro respectively when compared to the soil pH before contamination.

 It was also observed that the increased levels of crude oil contamination in the soils enhanced the percentage organic carbon content of the rhizosphere soils of Maize (4.70) and okro (4.88) when compared to the soils before contamination which is 1.84. There was a record decrease in available phosphorus as the introduction of crude oil increased when compared to the result of the control in the rhizosphere soil of the test crops. Analysis of variance showed that effect of different treatments on available phosphorus of the rhizosphere soil of the test crops was significantly (P<0.05) different. Available phosphorus of the planted soil also reduced with the introduction of crude oil to 51.12 in maize, and 48.99 in okro. There were significant reductions on the exchangeable bases such as sodium, potassium and magnesium nutrients in the planted soil of each crops when compared to the uncontaminated soil.

 Table 3 detailed the presentations of the heavy metal concentration in both the contaminated and uncontaminated rhizosphere soil of the test crops (maize and okro). It was also observed that crude oil concentrations significantly (p<0.05) affected the individual elements of heavy metal concentration in the soil the test crops. The table indicated the concentration of lead in all the test crop soils. It was observed that there were high concentration of heavy metals in contaminated soil of maize (5.07) while low concentration was observed in contaminated contaminated soil of okro (4.89). In the same vein, there were higher concentration of iron in contaminated soil of maize,1262, and oko ,1397 as compared to uncontaminated soil ,923.5. Similar trend occurred in cowpea,1314. There were also higher concentration of manganese in contaminated soil of maize,389.7 whereas lowest concentration of manganese was observed in uncontaminated soil of the test crops,253.60. The same trend was observed in contaminated soil of okro,393.8 when compared to uncontaminated soil . However, higher concentrations of these heavy metals have negative effects on the soil and the crops. Following the trend, there were highest concentration of zinc in contaminated soil of maize,85.76 whereas lower concentration of zinc was noticed in uncontaminated soil of the crops, 67.55. Similarly, zinc concentration for okro was 102.7 while higher concentration of copper in contaminated soil of maize and okro were 24.3 and 24.66 respectively.

**IV. DISCUSSION**

**A. Crude oil contaminations and the germination of test crops**

Table 2 showed the effect of **c**rude oil contaminations on the germination of the two crops. At high crude oil concentrations, There were significant (p≤0.05) harmful effects on the germination of maize and okro crops. At 5% level of crude oil concentrations, there was complete inhibition of germination in Okra whereas in maize, germination happened. However, maize crop tolerated and germinated at every level of crude oil contaminations . According to Malek-Hossein *et al*, 2007, the observed inhibition of germination of okro at 5% level of crude oil contamination buttressed the point that at high levels of contamination there were significant effect of crude oil on the germination of *Medicago sativa* (alfalfa) which resulted to the germination inhibition of *Medicago sativa* (alfalfa) . In the same vein, Amadi *et al*, 1996 reported that high concentrations of organic hydrocarbons could inhibit the germination of most crops. This could be attributed to the inherent toxicity characteristics of these hydrocarbon compounds. Hydrocarbon compounds, when introduced to the soils, mask the surface of the soil by forming a thin film, creating unhealthy soil conditions for the germination of crops. As a result, soil aeration, water infiltration rates and soil microbial characteristic will be drastically reduced and altered.

**B. Crude oil contaminations and soil chemical characteristics of the grown crops soil.**

Crude oil contaminations had a significant effects on some soil chemical properties. As the introduced crude oil concentrations increases, soil chemicals such as organic carbon increase significantly (p<0.05). This was as a result of carbon inherent in the organic hydrocarbon compounds. As the hydrocarbon compounds increased in the contaminated soil ,under normal circumstances, there would be a reduction in soil quality, thereby reducing soil fertility and crop productivity. The crude oil introduction would mask up soil air pore spaces, and as a result, water infiltration rates, and movement including air would be reduced. With this development, there would be reduction of biological activities, and disruption of biochemical conversions which are necessary for essential nutrients and some minerals to become available to the crop. Interestingly, soil pH was not significantly affected by the crude oil contaminations. Chibuike *et al*, 2013 reported that reduced soil pH, high organic carbon content and organic matter, minerals like sodium and iron could be observed in crude oil contaminated soils. Obire *et al*,2002 also observed that soil sodium and iron could be increased in crude oil-contaminated soils. It is pertinent to note that crude oil, due to its toxicity nature, could inhibit both macro and micronutrients in the soil, except organic carbon that could increase with the introduction of crude oil concentrations. The results, in table 3, showed that there were significant reductions (P<0.05) of soil sodium, potassium, magnesium and calcium as crude oil were introduced, when compared to uncontaminated soil which act as control. Table 3 indicated that any crude oil contaminated soils have increased heavy elements such as iron, copper, zinc, magnesium, lead and so on . There were high concentration of heavy metals in all contaminated soils. Among the heavy metals present, there were high concentration of lead in contaminated soil of maize ,5.07 whereas the low concentration of lead was observed in okra crop,4.89 when it was compared with uncontaminated soil

(the control). This showed that maize crop could be a strong hyper-extractor which is useful in the process of phytoremediation of crude oil contaminated soil. Marinescu *et al*,2010 reported that heavy elements present in soil contaminated areas could form coordinated bonds and complexes such as Ammonia, water, and nitrogen oxide or other elements with potassium, calcium and magnesium. As a results, such bound ions loss their ionic properties and become undetectable in solution. The results indicated that available phosphorus was significantly(p<0.05) affected as the crude oil concentrations increased. According to Okoro et al,2005, crude oil contaminations reduce the levels of soil nitrate and phosphorus, and other macro-elements. On the other hand, Wyszkowska *et al*,2001 reported that there were an increase in some mineral nutrients like nitrogen, phosphorus and potassium on the crude-oil contaminated soils amended with with inorganic fertilizer. In addition, Some mineral nutrients such as calcium, magnesium, and phosphorus are required for seed and plant growth (Cunningham *et al*, 1996). However, based on the results, maize tolerated all levels of crude oil concentrations, withstanding the toxicity nature of organic hydrocarbon compounds, and could grow in concentrations that were capable to retard the growth of other crops. This inherent traits showed that the crop could act as phytoremediation agents to remediate contaminated soils. This is because for any crop to be utilized in the process of bioremediation, it must have the capacity to tolerate, germinate and grow in hydrocarbon contaminated soils. Chin-A-woeing(1998) defined phyto-remediation as the process by which biological techniques, with respect to the use of plants or microbial agents, are developed for the purpose to remediate contaminated soil and water.

**V. CONCLUSION**

 Maize tolerated and resisted the toxic effects of soil contaminated organic hydrocarbon compounds more than okra crops. The results were observed by its ability to germinate and grow in the soil contaminated with crude oil concentrations, which were high enough to retard the growth and developments of okra crops. This inherent property of maize crop to tolerate high crude oil contaminations showed that the crop can be utilised to act as phytoremediation tool for the reclamation of soil contaminated with crude oil, since the potential of any crop in the process of phytoremediation is solely enhanced and determined by its inherent traits to tolerate and grow in contaminated habitat. This research trial proved that;(i) all the test crops (maize and okra) can tolerate soil contaminated with crude oil at lower levels of contamination. It was also observed that some of the crops were significantly and harmfully affected by higher concentrations of crude oil contamination. But maize (*Zea mays),* except okra, germinated even at high concentration of crude oil, showing its ability to act as a phytoremediation tool for crude oil contaminated farmlands,( ii) the soil chemical analysis of the research implied that crude oil concentrations created unfavourable condition to the soil status, thereby, making oil contaminated soils unfit for crop productivity. Further, the results indicated that crude oil hydrocarbon compounds have great impact on the soil pH, mineral nutrients of nitrogen, phosphorus, and potassium , organic carbon content, and soil biota. Heavy metal contents of the soil were also affected by the crude oil products, while some metals increased as the crude oil concentrations in the soil increased with its attendant effect to the soil health and crop productivity.

**VI. RECOMMENDATIONS**

There is need for further research to unravel the factors responsible for the variation observed in degrees of susceptibility to crude oil toxicity between maize and okro, and also the factors responsible for the decline in soil quality in crude oil contaminated soils.

**TABLE 1. Different levels of crude oil contamination on germination time of the test crops.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Crop plants |  0% |  0.5% |  2.0% |  5.0% |
| Maize | 4 ± 0.5 | 4 ± 0.5 | 4 ± 0.5 | 5 ± 0.6 |
| Okro  | 4 ± 0.5 | 4 ± 0.5 | 4 ± 0.5 |  X |

 Maize, and Okro LSD0.05 = 4.04,

 Significant at 5% (p<0.05),

values given as mean ± S.E

x = No germination.

**TABLE 2**. **Percentage germination of the plants in sandy loam soil polluted with varying concentration of**

**crude oil.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Crops | 0% | 0.5% | 2% | 5% |
| Maize | 100 | 100 | 67 | 33 |
| Okro | 100 | 100 | 67 | X |

x =No Germination

**TABLE 3. Chemical properties of uncontaminated and contaminated rhizosphere soil with maize and okro**

|  |  |  |  |
| --- | --- | --- | --- |
| Soil Properties | Before Pollution |  Maize (% v/w)0 0.5 2 5 | Okro (% v/w)0 0.5 2 5 |
| **PH** **Organic Carbon (%)****Total Nitrogen (%)****Available P. (mg/kg)****Exch. Bases (mol/kg)**  C Mg Na K**Exch . Acidity****Heavy Metals** Fe  Cu  Zn Mn Pb | 6.171.840.13469.932.271.200.060.081.56923.518.2067.55253.604.90 | 6.11 6.21 6.23 6.261.58 2.52 2.91 4.700.09 0.16 0.13 0.1767.76 53.52 52.2 51.122.31 2.51 2.72 2.531.16 1.15 1.21 1.110.05 0.04 0.06 0.050.08 0.07 0.06 0.061.52 1.71 1.42 1.611042 1051 1122 1262 20.3 19.36 22.5 24.3 82.2 85.6 82.7 85.76373.7 347.12 371.2389.75.01 5.02 5.01 5.07 | 6.11 6. 15 6.24 6. 251.12 2.91 2.04 4.880.07 0.14 0.12 0.2268.67 53.66 51.66 48.992.35 2.41 2.71 2.491.14 1.08 1.21 1.310.05 0.04 0.05 0.040.08 0.07 0.07 0.061.51 1.64 1.60 1.671085 1022 1126 1397 22.16 24.36 22.3 24.6683.7 100.4 85.36 102.7373.7 332.1 398.1 393.8 5.00 5. 00 4.89 5.04 | Cowpea (%v/w)0 0.5 2 5s | OKro (%v/w)0 0.5 2 5 |

Maize ,Okro ; LSD0.05 for pH= ns, ns ;

Organic Carbon = 2.42 , 0.7 :

Available Phosphorus = 2.20 , 0.93 ;

Total Nitrogen = 0.20 , 0.4

Exchangeable Acids = 1.08,0.53 ;

Iron(Fe) = 4.12, 3.90;

Copper (Cu) = 1.72, 0.52 ;

Lead (Pb) = 0.32, 0.20

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