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# Effects of Crude Oil Pollution on Soil Physico-Chemical Properties in Crude Polluted Soil of *Arachis Hypogea* and *Citrullus Vulgaris* Potted Plant

**Ubong, I. U.[1] , Sunday, A.E. Reapson[2]**

[1]Institute of Pollution studies. Rivers State University, PMB 5080, Port Harcourt, Rivers State. Nigeria
[2]Institute of Geosciences and Space Technology (IGST), Rivers State University PMB 5080, Port Harcourt, Rivers State. Nigeria

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Corresponding Author:
**Ubong, I. U.**

**ABSTRACT**

The effects of crude oil pollution on the Soil physico-chemical properties in crude polluted soil in potted plant of Arachis hypogea and Citrullus vulgaris were investigated in a green house under controlled environmental condition. Eight wide open black polythene bags, each filled with 10 kg of 2 mm sieved soil was used. Treatment of the soil was carried out by adding varying concentrations of crude oil raging from 0, 0.5, 2 and 5 % into soil samples contained in polythene bags. Each concentration of crude oil was added to each soil sample in each bag and was thoroughly mixed using gloved hands. The Eight polythene bags were separated into two groups of four bags each. Thereafter, 30 seeds of groundnut (Arachis hypogeal L.) were planted into each of the four polythene bags with soil sample treated with varying concentrations of crude oil and 30 Seeds of Egusi melon (Citrullus vulgaris L.) were planted to each of the other four polythene bags of soil sample treated with varying concentrations of crude oil (four bags for groundnut and four bags for egusi melon). The result revealed that, at different pollution levels, crude oil pollution changes soils physical and chemical properties. The type of plants, different plants' growths and time were also observed to co-influence the changes in soil properties by the crude oil pollution. The soils were also observed to stick together with increasing crude oil pollution. This coagulatory effect of increasing crude oil on the soil binds the soil particles into water impregnable soil block, which impaired water drainage and oxygen diffusion. Crude oil pollution of 2 and 5 % significantly reduced the germination and growth of the Citrullus vulgaris (melon) while in Arachis hypogeal (groundnuts), germination increased with increase in crude oil contamination of up to 5 %. At 5 % oil level, all the seeds of groundnut germinated but with time there was a reduction in the growth parameters possibly due to the coagulatory effect of increasing crude oil on the soil, binding the soil particles into water impregnable soil block which impaired water drainage and oxygen diffusion. Again, the tolerance exhibited by groundnuts could possibly be linked to its ability to fix nitrogen. Melon (Citrullus vulgaris L.) and physicochemical properties of the soil was investigated in the green house at the Department of Crop/Soil Science of the Rivers State University, Port Harcourt, Nigeria. Planting was done in a wide open black polythene bag filled with 10 kg of 2 mm sieved soil. Eight polythene bags, each per crude oil concentration, were used (four polythene bags for groundnut and four for melon). Treatment of the soil was carried out by adding varying concentrations of crude oil, namely 0, 0.5, 2 and 5 % into soil sample in the polythene bag. Each bag was thoroughly mixed using gloved hands. Thirty seeds of groundnut (Arachis hypogea L.) were planted into each of the four polythene bags with soil and thirty seeds of melon (Citrullus vulgaris L.) were planted into each of the other four polythene bags of soil sample treated with varying concentrations of crude oil. The result indicated that crude oil pollution of 2 and 5 % significantly reduced the germination and growth of the melon, while in groundnut, germination increased with increase in crude oil pollution of up to 5 %. At 5 % oil level, all the seeds of groundnut germinated but with time there was a reduction in the growth parameters possibly due to the coagulatory effect of increasing crude oil on the soil which bound the soil particles into water impregnable soil block, which impaired water drainage and oxygen diffusion. At different pollution levels, crude oil pollution changes soil physical and chemical properties. The lipid, protein and carbohydrate contents of both seedlings increased with increase in oil concentration of up to 5 %. There was a reduction in the growth parameters possibly due to the coagulatory effect of increasing crude oil on the soil, binding the soil particles into water impregnable soil block, which impaired water drainage and oxygen diffusion..

**KEYWORDS:** Crude Oil, Soil Pollution, Seed Germination, Soil physico-chemical properties, Groundnut (*Arachis hypogeal L.*) and Melon (*Citrullus vulgaris L*)

## 1. INTRODUCTION

Crude oil pollution and its effects in the Niger Delta environment is devastating, as a result of increasing oil exploration and exploitation. This has over the years impacted negatively on the socio-physical environment and socio-economic life of the oil bearing community, thereby threatening the livelihood of the farmers. For farming and of course a higher yield, good and fertile soil is required. In a situation where the land is frequently polluted, such soils are scarce to come by. Soils are affected by oil spillages. The degree of damage to soils, however, depends on the level of contamination. Where contamination is relatively low, the soil could be degraded and microbial activities affected (Anon, 1973). He further stated that this happens especially because of paraffinic nature of Nigerian oil. Udo (1975), observed that the amount of organic carbon, total Nitrogen and exchangeable potassium (K), Iron (Fe) and Manganese increase in the soil with level of crude oil addition while extractable Phosphorous (P), Nitrate nitrogen (NO3- _ N) and exchangeable Calcium (Ca) were reduced. According to Odu (1977), where the pollution is more severe, soils become infertile because nutrients essential to plant growth become scarce, while those that are toxic to plant growth become available. This effect on soil micro-organisms may persist for several years unless the soil is rehabilitated.

Odu (1981), reported that crude oil pollution up to 1 % could easily be degraded by natural rehabilitation in soils and the soil could be expected to increase organic matter in the soil and improve the fertility, physical and chemical properties of the soil. Isirimah et al. (1985), on the effect of crude oil on maize performance and soil chemical properties in the humid zone of Nigeria, observed that available nitrogen decreases with increase in oil level same with the pH while available phosphorus increase with increase in oil level to some extent due to the increase in the pH but later decreases as the pH also decreases.

Wang et al. (2012), in their study of the effect of crude oil contamination on soil physical and chemical properties in Momoge Wetland of China, reported that crude oil contamination significantly increases the soil pH and reduces the available phosphorus concentration in the soil and that the concentration of organic carbon was significantly different from those from other sampling sites. They concluded that crude oil contamination affects the soil physical and chemical properties. In another study, Arocena and Rutherford (2005), observecd in their study of properties of hydrocarbon and salt contaminated flare pit soil, in northern British Colombia (Canada), that hydrocarbon contaminated soil can affect soil physical and chemical properties. Total carbon, exchangeable Ca2+, K+ and Na+, soluble Ca2+, Mg2+, K+, and electrical conductivity were higher in flare pit soil compared to the control. Aislabe et al. (2004), in their study of Hydrocarbon spills on Antartic soil: 'Effect and management', reported that there was an increase in temperature of soil due to decrease in soil surface albedo as a result of surface darkening by the hydrocarbons. That hydrocarbon spill could increase soil carbon, deplete nitrate level, affect the total phosphorus and lower the pH of the soil. They further reported that crude oil contaminated soils are hydrophobic when compared with the pristine site.

Ekundayo and Obuekwe (1997), studied the effect of oil spils on soil physicochemical properties of spill site in a Typic paleudult of midwestern Nigeria and concluded that hydrocarbon can also increase soil total organic carbon. Townsend et al. (2003), Labud et al. (2007) and Sutton et al. (2013), in their studies of crude contaminated soils observed that oil usually causes anaerobic environment in soil by smothering soil particles and blocking air diffusion in the soil pores and this affects soil microbial communities. Economic activities of most Nigerian people are tied to land and the sea. Such activities may include occupations like farming, fishing and hunting. Any disruption of these economic activities may cause disruption in income, forced changed in occupation and unemployment, pollution of drinkable water and pollution of soils. Of all the previous studies reviewed, not much work has been done on the effects of crude oil pollution on soil physicochemical properties in the Niger delta when viewed from the perspective of frequent crude oil pollution resulting from spills. Existing literature did not consider crude oil polluted soil in Arachis hypogea and Citrullus vulgaris' potted plants. This study is therefore aimed at investigating the effects of crude oil pollution on soils physico-chemical properties in crude oil polluted soil of arachis hypogea and citrullus vulgaris' potted plant. The result will help provide information for potential remediation and restoration of crude oil impacted soil in the Niger Delta.

### 1.2 The Study Area

The study area is River State University, Port Harcourt and it is located along the west axis of Port Harcourt between Longitudes 60 50'-70 00'E and Latitudes 40 45'-4048'N. The area is located in tropical humid zone with distinct wet and dry seasons. The wet season is usually long beginning from March and continues through October while the dry season is from November to February being short and are not even free from occasional rainfall (Gobo, 1990). The maximum rainfall occurs between June and October with mean annual rainfall of 2630 mm while the mean monthly temperature ranged between 28 oC and 33 oC, with a monthly minimum between 20 oC and 23 oC. The highest temperature figures are recorded during the months of December to March. The Area has acidic sandy loam top soil classified as – Typic Paleudult.

## 2. MATERIALS AND METHODS

**Study site:** The study site was in greenhouse house located in the Department of Crops/Soil Science of the Rivers State University. Port Harcourt, Nigeria.

### Experimental Treatments and Design

The soil for the experiment was collected from a long uncultivated land located at Okocha, Rumuolumeni, Port Harcourt. The Soil was air dried and sieved with 2 mm sieving nest. The soil was then measured and weighed 10 kg each in a wide open black polythene bag of 140 cm in cicumference and 45 cm in diameter each. Four bags of 2 mm sieved soil of 10 kg each was for Egusi melon seeds and another four bags of 2 mm sieved soil of 10 kg each for groundnut seeds (Arachis hypohea). The groundnut seeds of palm nut (Upright) variety and egusi Melon seeds (Citrullus vulgaris) of land race variety was obtained from Imo State Agricultural Development Programme (ADP). For each set, light crude oil obtained from Port Harcourt Refinery was applied at various concentrations of 0, 50, 200 and 500 mls corresponding to 0, 0.5, 2.0, and 5.0 % based on weight of oil/weight soil. This was done to each of the 10 kg soil for the two sets of groundnut soil (GNS) and Egusi melon soil (EMS) (GNS1, GNS2, GNS3, GNS4 and EMS1, EMS2, EMS3, EMS4) respectively.

The experimental design was completely randomized, replicated three times. The crude oil was applied evenly and well mixed with gloved hands and left for five days. After five days of treatment, 30 egusi melon (Citrullus vulgaris) seeds and 30 groundnut (Arachis hypohea) seeds each, were sown in each of the bags and both coded as GN1, GN2, GN3, and GN4 representing groundnut seeds/seedlings and EM1, EM2, EM3 and EM4 representing Egusi Melon seeds/seedlings. Watering was made every two days interval. As they germinated/grew, the soils were harvested and their physicochemical parameters were measured, analyzed and recorded after every two weeks.

The following Soil physicochemical parameters were measured and analyzed for: Soil particle size, water holding capacity, Soil pH, Exchangeable cations- Magnesium (Mg), Potassium (K), Calcium (Ca), Sodium (Na), Total Nitrogen, Available phosphorous, Exchangeable Acidity, Organic carbon and the contaminant, Total hydrocarbon (THC). The Soil physicochemical parameters were measured and analyzed two weeks, four weeks, six weeks, and eight weeks after application of crude oil and sowing/planting. The soils for both the groundnut and melon's pots harvested every 2, 4, 6, and 8 WAP were taken for physicochemical analysis at the Crop/Soil Science Laboratory of the Rivers State University, Nkporlu, Port Harcourt. The following were the soil physical and chemical analyses:

The Bouyoucous Hydrometer method as described by Udo et al. (2009), was employed in the determination of the soil particle size distribution. The soil was dispersed with 20 ml solution of Sodium hexa-meta-phosphate and sodium carbonate and the textural class was determined using the textural triangle. In determining the water holding capacity, some quantity of soil sample was added into a funnel that has been tightly covered with cotton wool or filter paper and the content was placed in 250 ml conical flask. The soil was saturated with water by occasionally pouring water when dried for 48 hrs. A representative of the soil was placed on a wash glass or a crucible and weighed when wet and the reading taken with a weighing balance. The wet soil was dried in the oven for at least two days and the dry weight was taken. The weight of the wash glass or crucible was also taken. The difference in wet and dry weight was noted. The difference between wet weight of soil and dry weight of soil gave the water content of soil (x) while the difference between dry weight of soil and weight of empty crucible gave the actual weight of dry soil (y). Water Holding Capacity was calculated as:

$$\text{Water Holding Capcity (\%)} = x/y \times 100.$$

The soil pH was determined in soil suspension (1:1) of soil to water ratio using electrode pH mater. Twenty grames of air-dried, sieved soil sample was weighed into 50 ml breaker and 20 ml of distilled water was added to it. This was allowed to stand for 30 minutes and stirred occasionally with glass rod. The pH meter was calibrated with pH 7.0 and pH 4.0 buffer standards before being used to measure the soil pH by inserting the electrode into the partly settled suspension. Organic carbon was determined by the wet combustion, method of Walkley and Black as described by Udo et al. (2009). The organic carbon determined by the wet combustion method of Walkley and black, as described by Udo et al. (2009), was then multiplied by 1.724 to get the organic matter content (organic matter contains approximately 58 % carbon). Available phosphorus was determined by Bray and Kurtz method as described by Udo et al. (2009).

Exchangeable cations, Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg) were extracted according to the ammonium acetate extraction method of Thomas (1992), as described by Udo et al. (2009). The filtrate was used for the determination of Sodium (Na) and Potassium (K) by flame photometry, and Calcium (Ca) and Magnesium (Mg) by EDTA titration method. Total Nitrogen in the soil samples was determined by the Macro Kjedah's method as described by Udo et al. (2009).

The exchangeable acidity in the soil was determined using volumetric analysis (titration). Exchangeable Acidity is produce in the soil by the presence of exchangeable aluminum and Hydrogen (Al and H). The total hydrocarbon concentration (THC) of the soil was determined by shaking 10 g of a representative fresh soil sample with 20 ml of toluene and oil extracted determined by the absorbance of the extract at 420 nm in a spectrophotometer. Oil or total hydrocarbon concentration was then calculated with reference to the standard curve, moisture content and multiplication by the appropriate dilution factor.

**3. RESULTS**

The results of the physical and chemical properties of crude oil contaminated soil of both egusi melon and groundnut's potted plants are presented in Tables 1 and 2. The data in Tables 1 and 2 showed that the textural class of the soil was sand loamy. The soil was physically observed to have stuck together with increase in crude oil treatment. Soil with 2 and 5 % oil treatment were physically observed to have stuck together more than those with 0.5 % oil treatment and the untreated soil (control).

The Water Holding Capacity (WHC) of the soil with melon (Table 1), increased with increase in oil levels. The highest was 54.30 % in soil with 5 % crude oil contamination 8 weeks after contamination. In groundnut pots (Table 2). It was observed that the WHC steadily increased with increase in percentage oil levels every two weeks after oil application when compared with the control. The highest was 45.31 % in soil with 0.5 % oil treatment 6 weeks after oil application and the lowest was 32.42 % in the control soil for same period.

The soil pH 2 weeks after planting in melon pots (Table 1), was acidic, decreasing with increase in contamination; from 6.30 in untreated soil (control) to 5.90, 4, 6 and 8 weeks after planting. There was a further decrease in pH which cut across both the untreated soil to all the categories of treatment. The highest pH was 6.30 and the lowest was 5.60. While Table 2 showed that in groundnut, soil pH which was more acidic, ranging between 5.60 and 5.70. The highest was 5.8 in soil with 0.5 % crude contamination 8 weeks after planting while the lowest was 5.40 % in the untreated soil (control) 6 weeks after oil application. The relationship between crude oil concentration to the soil pH showed that for melon Soil was not significant while in groundnuts soil, at $p<0.05$, 2% oil level showed significant differences in pH at 4 WAP.

The exchangeable magnesium Table 1, showed that in melon pots 2 weeks after planting, decreased from 1.8 cmol/kg in control to 0.4 cmol/kg in soil with 0.5 % treatments 6 weeks after planting and then increased to 2.0 cmol/kg in soil with 2.0 % treatment 6 weeks after planting and then decreased again. In 8 weeks after planting, there was an increase in magnesium-4.0 cmol/kg in soil with 0 % treatment which then decreased to 3.2 cmol/kg in soil with 0.5 % then 0.6 cmol/kg in soil with 2.0 % treatment and 1.0 cmol/kg in soil with 5 % treatment. The highest soil magnesium was 4.0 cmol/kg in untreated soil (control) 8 weeks after planting, while the lowest was 0.4 cmol/kg in soil with 0.5 % treatment 6 weeks after planting. While in groundnut Pots, Table 2 showed that exchangeable magnesium increased with increase in crude oil contamination and with time. The highest was 5 cmol/kg in soil with 0.5 % crude oil treatment 8 WAP while the lowest was 0.8 cmol/kg in untreated soil (control) 2 WAP.

The the exchangeable potassium in melon Table 1, was relatively stable until 6 weeks to 8 weeks after planting when it began to decrease. This means that the decrease was with time and not directly link to the soil crude oil contamination. While Table 2 revealed that in groundnut pots there was a slight decrease in potassium 2 and 4 weeks after planting and then increased slightly again 6 and 8 weeks after planting. The highest was 0.13 cmol/kg in soil with 5% crude oil application and the lowest is 0.07 cmol/kg in untreated soil.

The soil exchangeable calcium in melon pots Table 1, slightly decreased and later increased until 8 weeks after planting when it began to decrease significantly. This means that the decrease was more with time and little with soil crude oil contamination while Table 2 showed same in groundnut, but calcium significantly decreased with increase in crude oil contamination and time in the 6 WAP to 8 WAP when compared with that of melon and the control of 0 % oil treatment. The correlation analysis of crude oil contamination on exchangeable Calcium for soil with melon, at $p<0.05$, 2 % oil level showed inverse relationship 8 WAP while there was no relationship in soil with groundnuts.

**Table 1: Effects of Crude Oil Pollution on Soil Physico-chemical Properties of Melon Seeds/Seedlings 2, 4, 6 and 8 WAP**

| WEEKS AFTER PLANTING (WAP) | SEED/SEEDLING SOIL SAMPLE | SOIL % TREATMENT WITH CRUDE OIL | SOIL pH in $H_20$ 1:2.5 | % org. C | AVAIL. P mg/kg | %TN TOTAL NITROGEN | Mg Cmol/kg | Ca Cmol/ kg | Na Cmol /kg | K Cmol/ kg | TOTAL EXCH ACIDITY Cmol/kg | THC mg/kg | SOIL PARTICLE ANALYSIS % Silt | % Clay | % Sand | Textural class | GRAVIMETRIC WATER CONTENT (GWC) (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2WAP | EMS1 | 0 | 6.3 | 1.10 | 34.1 | 0.003 | 1.80 | 3.60 | 0.55 | 0.10 | 0.44 | ND | 6.2 | 8.4 | 85.4 | Sand | 34.92 |
| | EMS2 | 0.5 | 6.0 | 1.46 | 17.5 | 0.003 | 1.00 | 3.20 | 0.52 | 0.10 | 0.68 | 505.23 | 4.2 | 8.4 | 87.4 | Sand | 32.68 |
| | EMS3 | 2.0 | 5.9 | 1.85 | 30.4 | 0.01 | 1.00 | 4.00 | 0.59 | 0.11 | 0.68 | 2802.90 | 2.2 | 10.4 | 87.4 | Loamysand | 49.50 |
| | EMS4 | 5.0 | 5.9 | 3.00 | 30.4 | 0.003 | 1.20 | 3.80 | 0..55 | 0.11 | 0.32 | 7691.84 | 4.2 | 8.4 | 87.4 | Sand | 35.58 |
| 4WAP | EMS1 | 0 | 5.6 | 0.82 | 33.2 | 0.02 | 1.40 | 3.20 | 0.47 | 0.06 | 2.40 | ND | 2.5 | 11.2 | 86 | Loamy sand | 35.43 |
| | EMS2 | 0.5 | 5.6 | 1.11 | 21.2 | 0.01 | 1.40 | 3.60 | 0.43 | 0.13 | 0.20 | 554.07 | 4.5 | 9.2 | 86.3 | Sand | 35.23 |
| | EMS3 | 2.0 | 5.7 | 1.74 | 32.2 | 0.004 | 0.8 | 3.60 | 0.50 | 0.10 | 0.16 | 4269.67 | 6.5 | 7,2 | 86.3 | Sand | 44.60 |
| | EMS4 | 5.0 | 5.6 | 2.50 | 31.3 | 0.003 | 1.00 | 3.00 | 0.38 | 0.09 | 0.20 | 8180.73 | 4.5 | 7.2 | 86.3 | Sand | 31.39 |
| 6WAP | EMS1 | 0 | 5.6 | 2.05 | 30.4 | 0.004 | 0.60 | 3.60 | 0.42 | 0.07 | 0.20 | ND | 6.5 | 7.5 | 86 | Sand | 33.41 |
| | EMS2 | 0.5 | 5.7 | 1.21 | 31.3 | 0.01 | 0.40 | 3.80 | 0.47 | 0.06 | 0.16 | 554.07 | 4.5 | 9.5 | 86 | Sand | 38.14 |
| | EMS3 | 2.0 | 5.7 | 1.29 | 28.5 | 0.01 | 2.00 | 3.00 | 0.39 | 0.08 | 0.16 | 3291.85 | 4.8 | 7.8 | 87.4 | Sand | 35.11 |
| | EsdMS4 | 5.0 | 5.7 | 1.93 | 29.5 | 0.004 | 0.60 | 3.60 | 0.48 | 0.12 | 0.20 | 14536.27 | 4.8 | 9.8 | 85.4 | Sand | 38.84 |
| 8WAP | EMS1 | 0 | 5.7 | 2.83 | 33.2 | 0.004 | 4.00 | 2.80 | 0.57 | 0.08 | 0.16 | ND | 4.6 | 10 | 85.4 | Sand | 37.90 |
| | EMS2 | 0.5 | 5.8 | 1.37 | 27.6 | 0.004 | 3.20 | 1.80 | 0.35 | 0.10 | 0.08 | 2314.07 | 6.6 | 8 | 85.4 | Sand | 45.14 |
| | EMS3 | 2.0 | 5.7 | 1.37 | 29.5 | 0.01 | 0.60 | 2.40 | 0.30 | 0.08 | 0.16 | 5736.29 | 2.8 | 9.2 | 88 | Sand | 40.16 |
| | EMS4 | 5.0 | 5.6 | 1.85 | 29.5 | 0.02 | 1.00 | 2.40 | 0.30 | 0.12 | 0.16 | 1091.83 | 2.8 | 9.2 | 88 | Sand | 54.30 |
| Soil before Planting | SBP | 0.00 | 5.6 | 2.96 | 33.2 | 0.01 | 1.00 | 3.60 | 0.49 | 0.11 | 0.16 | ND | 2.8 | 11.2 | 86 | Loamy sand | 38.51 |
| SEM±(P<0 .05) | | | 0.04 | 0.02 | 1.08 | 0.001 | 0.29 | 0.15 | 0.02 | 0.005 | 0.14 | 1017.93 | 0.35 | 7.11 | 0.23 | | 1.61 |

**NOTE:**
**WAP= Week After Planting; EMS=Melon Seed/Seedling; GNS=Groundnut Seed/Seedlings; ND=Not detectable**

**Table 2: Effects of Crude Oil Pollution on Soil Physico-chemical Properties of Groundnut Seeds/Seedlings 2, 4, 6 and 8 WAP**

| WEEKS AFTER PLANTING (WAP) | SEED/ SEEDLING SOIL SAMPLE | SOIL % TREATMENT | SOIL pH in $H_2O$ 1:2.5 | % org. C | AVAIL. P mg/kg | %TN (TOTAL NITROGEN) | Mg Cmol/kg | Ca Cmol/kg | Na Cmol/kg | K Cmol/kg | TOTAL EXCH ACIDITY Cmol/kg | THC mg/kg | SOIL PARTICLE ANALYSIS | | | | GRAVIMETRIC WATER CONTENT (GWC) (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | % Silt | % Clay | % Sand | Textural class | |
| 2WAP | GNS1 | 0 | 5.6 | 1.44 | 34.1 | 0.01 | 0.80 | 4.20 | 0.61 | 0.11 | 0.76 | ND | 4.2 | 8.4 | 87.4 | Sand | 32.70 |
| | GNS2 | 0.5 | 5.7 | 0.66 | 32.2 | 0.01 | 1.20 | 3.80 | 0.52 | 0.10 | 0.20 | 456.30 | 2.2 | 8.4 | 89.4 | Sand | 38.96 |
| | GNS3 | 2.0 | 5.7 | 1.64 | 29.5 | 0.01 | 1.40 | 3.60 | 0.52 | 0.09 | 0.20 | 3291.85 | 6.2 | 6.4 | 87.4 | Sand | 40.04 |
| | GNS4 | 5.0 | 5.7 | 2.63 | 29.5 | 0.01 | 1.20 | 3.80 | 0.47 | 0.09 | 2.40 | 8180.73 | 4.2 | 8.4 | 87.4 | Sand | 41.63 |
| 4WAP | GNS1 | 0 | 5.6 | 1.39 | 28.5 | 0.01 | 1.00 | 3.60 | 0.52 | 0.07 | 0.16 | ND | 5.4 | 9.2 | 85.4 | Sand | 36.30 |
| | GNS2 | 0.5 | 5.6 | 1.13 | 30.4 | 0.01 | 1.00 | 3.40 | 0.41 | 0.09 | 2.40 | 651.85 | 6.8 | 7.2 | 86 | Sand | 42.29 |
| | GNS3 | 2.0 | 5.6 | 1.52 | 32.2 | 0.01 | 1.40 | 3.00 | 0.43 | 0.09 | 0.12 | 3780.73 | 4.5 | 7.5 | 88 | Sand | 38.63 |
| | GNS4 | 5.0 | 5.7 | 3.0 | 30.4 | 0.02 | 1.40 | 3.00 | 0.39 | 0.10 | 0.28 | 10625.17 | 4.5 | 7.5 | 88 | Sand | 36.84 |
| 6WAP | GNS1 | 0 | 5.4 | 2.89 | 33.2 | 0.003 | 1.20 | 3.40 | 0.48 | 0.09 | 0.16 | ND | 4 | 11.2 | 84.8 | Loamysand | 32.42 |
| | GNS2 | 0.5 | 5.7 | 1.11 | 30.4 | 0.01 | 2.20 | 3.20 | 0.41 | 0.11 | 0.12 | 505.18 | 4 | 9.2 | 86.8 | Sand | 45.31 |
| | GNS3 | 2.0 | 5.7 | 1.56 | 29.5 | 0.004 | 2.80 | 2.20 | 0.43 | 0.11 | 0.16 | 3291.85 | 4 | 9.2 | 86.8 | Sand | 37.44 |
| | GNS4 | 5.0 | 5.6 | 2.09 | 25.8 | 0.01 | 1.80 | 2.40 | 0.41 | 0.11 | 0.12 | 12091.83 | 6.6 | 6 | 87.4 | Sand | 41.74 |
| 8WAP | GNS1 | 0 | 5.7 | 2.83 | 30.4 | 0.003 | 1.40 | 2.60 | 0.30 | 0.07 | 0.16 | ND | 2.8 | 9.2 | 88 | Sand | 37.88 |
| | GNS2 | 0.5 | 5.8 | 1.33 | 31.3 | 0.001 | 5.00 | 3.00 | 0.30 | 0.10 | 0.12 | 798.52 | 4.8 | 9.2 | 86 | Sand | 40.78 |
| | GNS3 | 2.0 | 5.7 | 1.35 | 29.5 | 0.03 | 2.00 | 2.40 | 0.52 | 0.11 | 0.16 | 2314.07 | 2.8 | 11.2 | 86 | Loamysand | 41.11 |
| | GNS4 | 5.0 | 5.7 | 1.72 | 29.5 | 0.01 | 2.60 | 2.80 | 0.59 | 0.13 | 0.16 | 14536.27 | 2.8 | 9.2 | 88 | Sand | 37.36 |
| Soil before Planting | SBP | 0.00 | 5.6 | 2.96 | 33.2 | 0.01 | 1.00 | 3.60 | 0.49 | 0.11 | 0.16 | ND | 2.8 | 11.2 | 86 | Loamysand | 38.51 |
| Sem±(p<0 .05) | | | 0.02 | 0.17 | 0.49 | 0.001 | 0.026 | 0.144 | 0.022 | 0.003 | 0.19 | 12096.73 | 0.34 | 0.36 | 0.29 | | 0.85 |

**NOTE:**

**WAP=Week After Planting; EMS=Melon Seed/Seedling; GNS=Groundnut Seed/Seedlings; ND=Not detectable**

The exchangeable sodium in melon pots, was relatively stable until 4 to 8weeks after planting when it began to decrease (Table 1). This means that the decrease was with time and not directly linked to the soil crude oil contamination while in groundnuts'pot Table 2, there was a decrease in sodium with increase in percentage oil level up to middle of 8weeks after planting before a slight increase of 0.52 cmol/kg and 0.59 cmol/kg in soil with 2 and 5 % crude oil contamination when compared with the control of 0% crude oil treatment. The soil total nitrogen in melon's pot, decreased with increase in time after planting in soil with 0.5, 2 and 5% crude oil contamination (Table 1) while in groundnut pot Table 2 the total nitrogen concentration was stable throughout except in few cases where there was decrease of up to 0.001 and 0.004% in soil with 0.5 and 2 % crude oil contamination 6 and 8weeks after planting when compare with 0.003 % total nitrogen in the control of 0 % crude oil contamination in same period. In groundnut, Table 2 showed that percentage nitrogen was almost stable at 0.01 %, 2 and 4 weeks after planting but from 6 and 8 weeks, decrease in percentage nitrogen was observed in soil with 0, 2.0, 0, 0.5 and 2 % oil treatment respectively.

There was a decrease in soil available phosphorus in melon soil (Table 1). The highest was 34.02 mg/kg in the control and the lowest was 17.409 mg/kg in soil with 0.5 % oil treatment. While in groundnut soil, Table 2 showed that in 2 weeks after planting, the available phosphorus decreased with increase in crude oil contamination from 34.07mg/kg in control to 29.46mg/kg in 5 % oil level. Then 4 weeks after planting, the available P increase with increase in crude oil treatment from 28.54 mg/kg in the control to 30.38 mg/kg in 5 % oil level and from 6 to 8 weeks, the available phosphorus began to decrease again with increase in crude oil contamination.

The soil exchangeable acidity in melon pots, decreased with increase in oil levels and with time when compared with the control Table 1. In groundnut pots, Table 2 showed that there was also a decrease in exchangeable acidity with increase in oil levels when compared with the control except in soil with 5 and 2 % oil level where there was 2.40 cmol/kg, 2 and 4 weeks after planting.

The organic carbon in melon pots, slightly increased with increase in oil levels and decreased with time (Table 1). It was highest in soil with 5 % treatment at 3.0 % organic carbon 2 weeks after planting when compared with the control which was 1.10 % organic carbon in the same period followed by 2.5, 1.93 and 1.85 %, 4, 6 and 8 weeks organic carbon after planting in the same 5 % oil level when compared with the control which was 0.82, 2.05 and 2.83 % organic carbon in the same period, respectively. In the control, the organic carbon increased with time. Also, in groundnut pots Table 2, organic carbon increased with increase in oil levels from 2 to 6 weeks after planting and then decreased at 8 weeks after oil application when compared with the control.

Organic carbon in soil with 0.5 % treatment was lesser when compared with soil with other treatment levels. The highest content of organic carbon was 3.0 % in soil with 5 % oil treatment 4 weeks after planting. The THC in the soil of melon and groundnut pots, increased with increase in oil concentration (Tables 1 and 2). It was also observed that increase in crude oil treatment tended to make the soil stick together. Soil with 2 and 5 % oil treatment were physically observed to have stuck together than that with 0.5 % oil treatment and the untreated soil (control).

### 3.2 Correlation studies between crude oil level and Soil physical and chemical properties

#### 3.2.1 Soil physical and chemical properties

##### 3.2.1.1 Water holding capacity

The results of the correlation an.alysis from Figures 1-4 showed that there was a positive relationship between the crude oil levels and the soil Water holding Capacity (WHC) in melon and Groundnuts' pot 2 WAP and 8 WAP. 4 WAP, there was a positive relationship between crude oil levels and soil WHC in melon pot only and not in that of ground nuts pot while there was no relationship between crude oil levels and soil WHC in both pots of egusi melon and groundnuts 6 WAP.

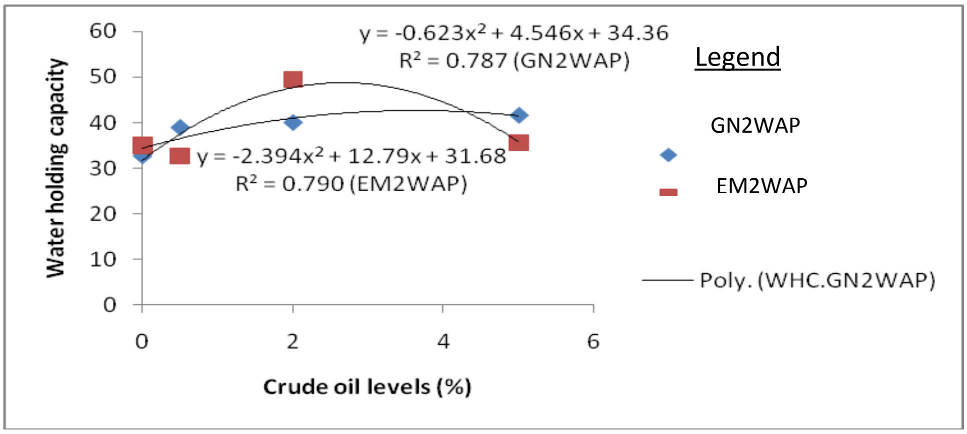


**Fig. 1:** Relationship between levels of crude oil pollution and soil WHC at 2 WAP in groundnut and melon.
**EM = Melon; GN = Groundnut; WAP = Week After Planting;WHC = Water holding Capacity**

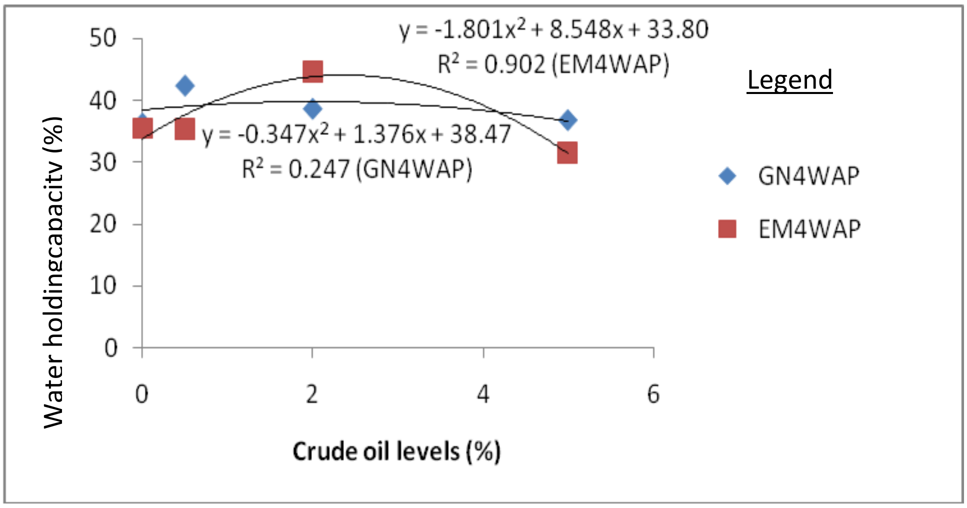


**Fig. 2:** Relationship between levels of crude oil pollution and soil WHC at 4 WAP in groundnut and melon.

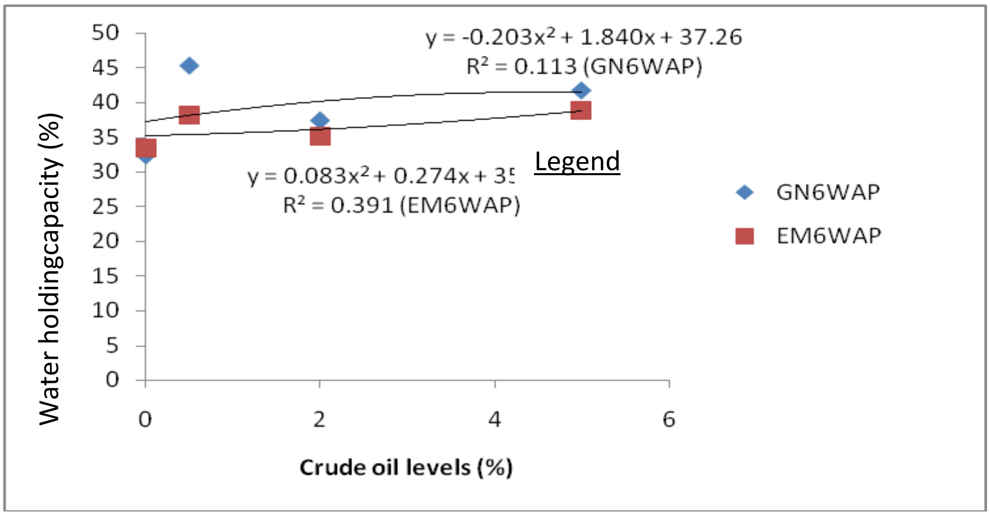


**Fig. 3:** Relationship between levels of crude oil pollution and soil WHC at 6 WAP in groundnut and melon.

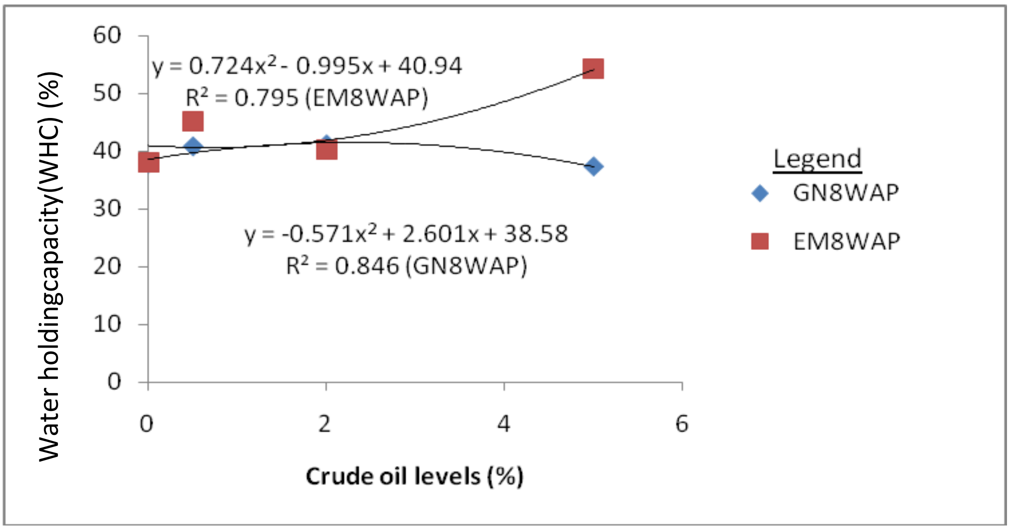


**Fig. 4:** Relationship between levels of crude oil pollution and soil WHC at 8 WAP in groundnut and melon.

### 3.2.1.2 pH

Figures 5-8 showed that there was a positive relationship between the crude oil levels and the soil pH of groundnuts while there was inverse relationship between the crude oil levels and the soil pH of melon all throughout the periods.

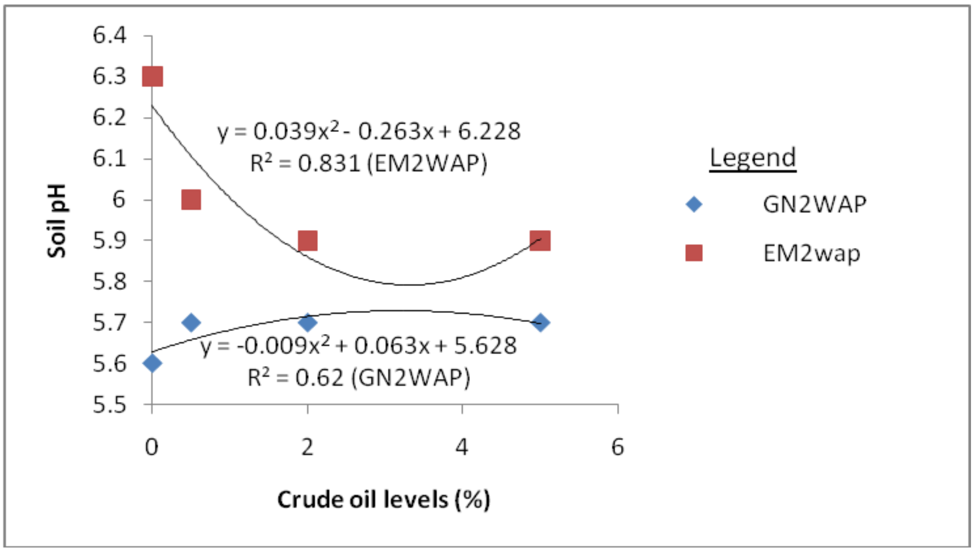


**Fig. 5:** Relationship between levels of crude oil pollution and soil pH at 2 WAP in groundnut and melon

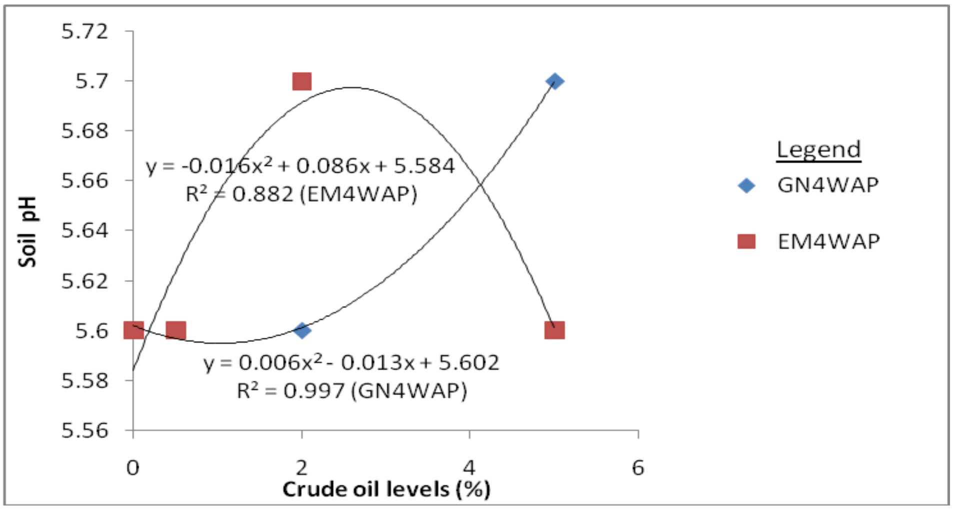


**Fig. 6 :** Relationship between levels of crude oil pollution and soil pH at 4 WAP in groundnut and melon.

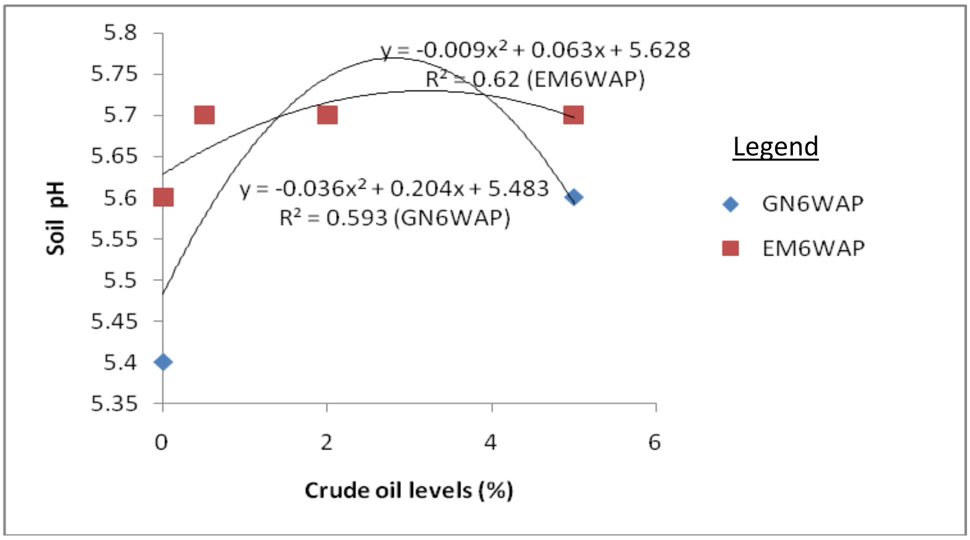


**Fig. 7:** Relationship between levels of crude oil pollution and soil pH at 6 WAP ( in groundnut and melon).

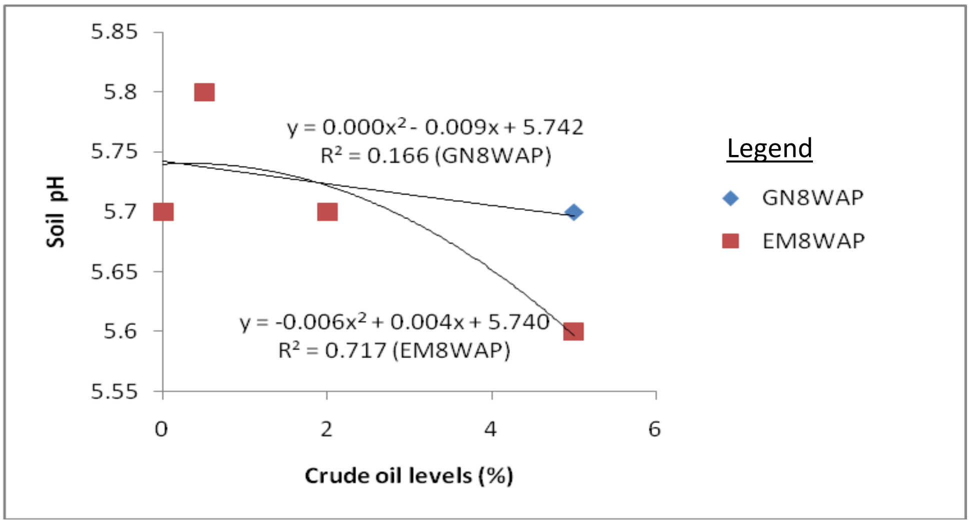


**Fig. 8:** Relationship between levels of crude oil pollution and soil pH at 8 WAP in groundnut and melon.

### 3.2.1.3 Total hydrocarbon (THC)

Figures 9-12 showed that there was direct and positive relationship between the crude oil levels and the soil THC of groundnuts and melon throughout the periods. \

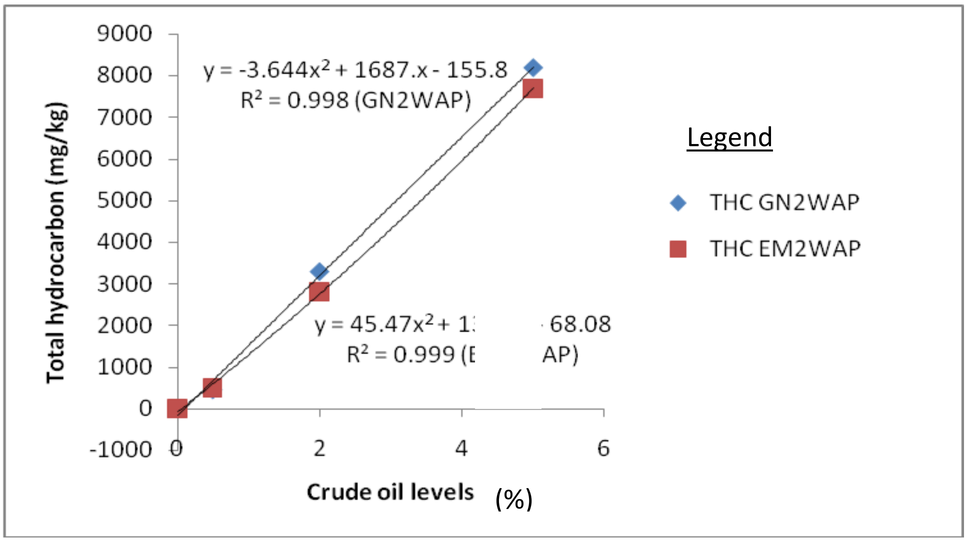


**Fig. 9:** Relationship between levels of crude oil pollution and soil total hydrocarbon (mg/kg) at 2 WAP in groundnut and melon.

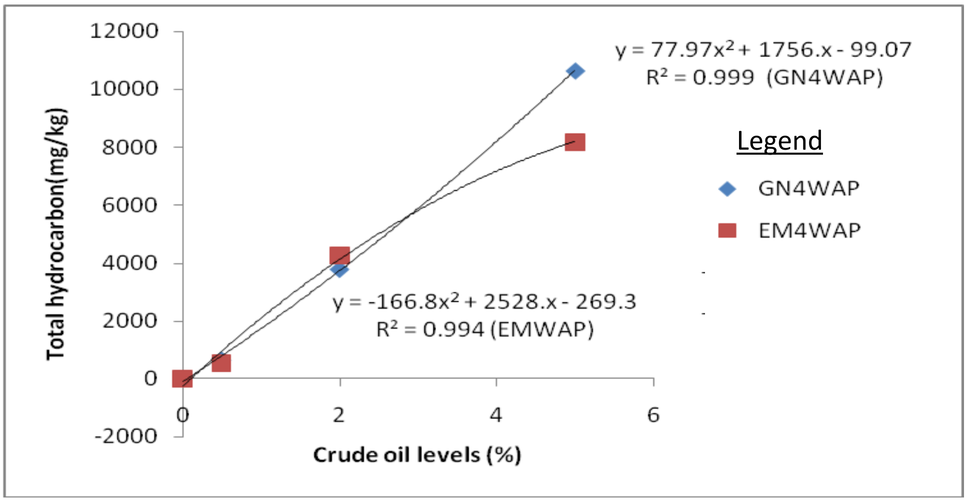


**Fig. 10:** Relationship between levels of crude oil pollution and soil total hydrocarbon (mg/kg) at 4 WAP in groundnut and melon.

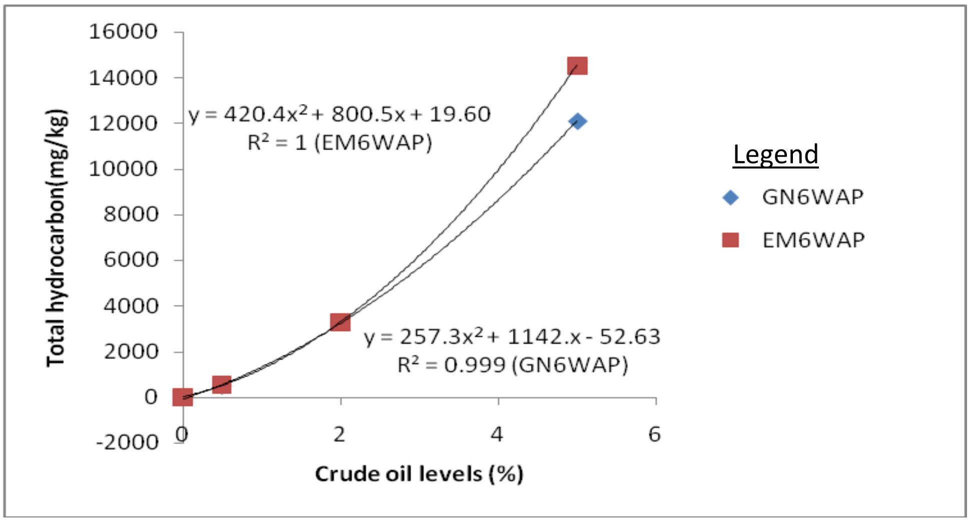


**Fig. 11:** Relatioship between levels of crude oil pollution and soil total hydrocarbon (mg/kg) at 6 WAP in groundnut and melon.

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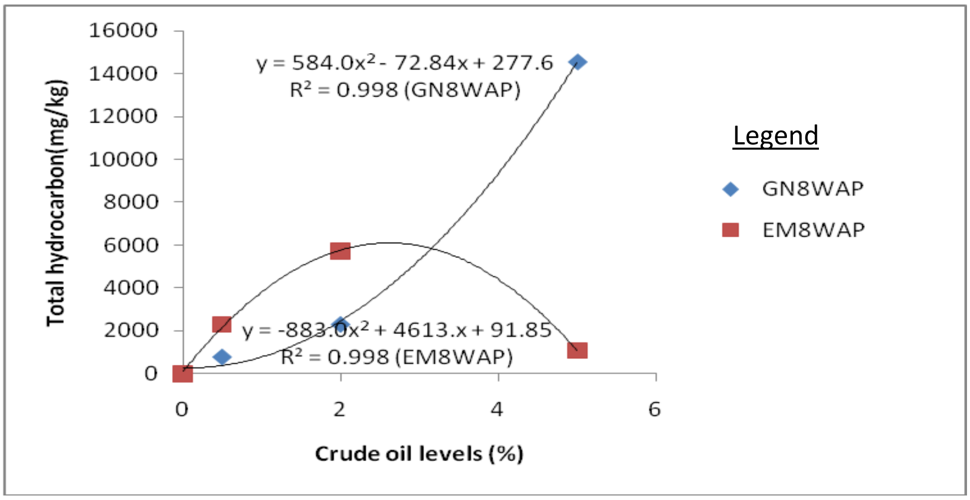


**Fig. 12:** Relationship between levels of crude oil pollution and soil total hydrocarbon (mg/kg) at 8 WAP in groundnut and melon.

### 3.2.1.4 Organic carbon

Figures 3-16 showed that there was a direct relationship between the soil organic carbon and crude oil levels of groundnuts and melon pots 2 and 4 WAP. 6 WAP, there was an inverse relationship for melon pots only and no relationship for groundnuts pot while in 8 WAP, there was an inverse relationship between the soil organic carbon and crude oil levels of both groundnuts and melon pots .

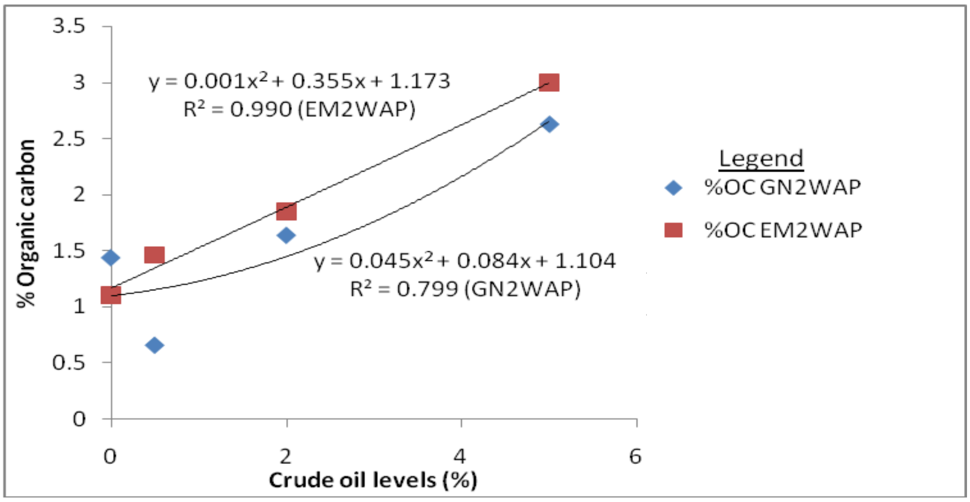


**Fig. 13:** Relationship between levels of crude oil pollution and soil % organic carbon 2 WAP in groundnut and melon.

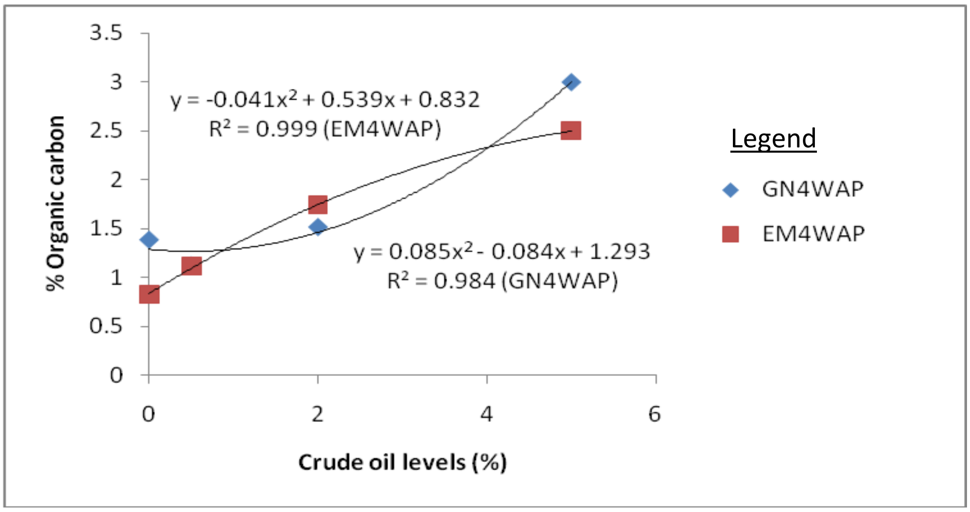


**Fig. 14:** Relationship between levels of crude oil pollution and soil % organic carbon at 4 WAP in groundnut and melon.

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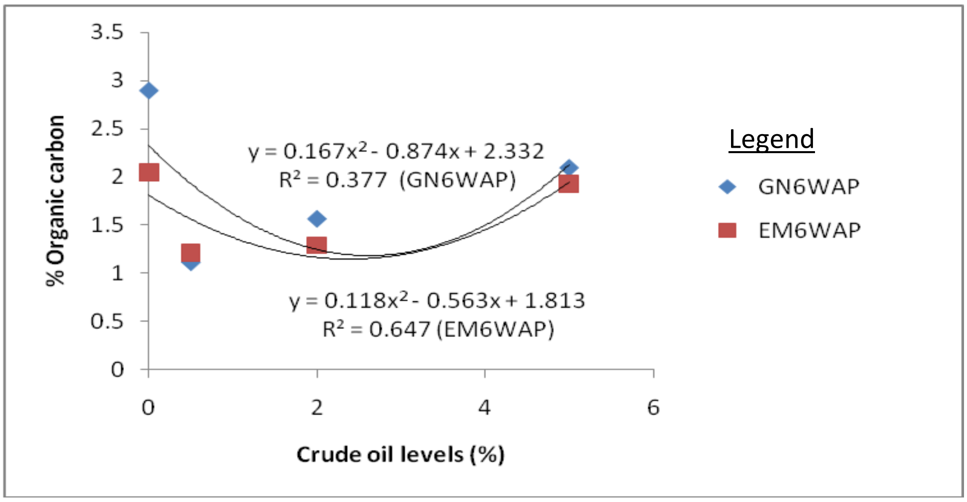


**Fig. 15:** Relationship between levels of crude oil pollution and soil % organic carbon at 6 WAP in groundnut and melon.

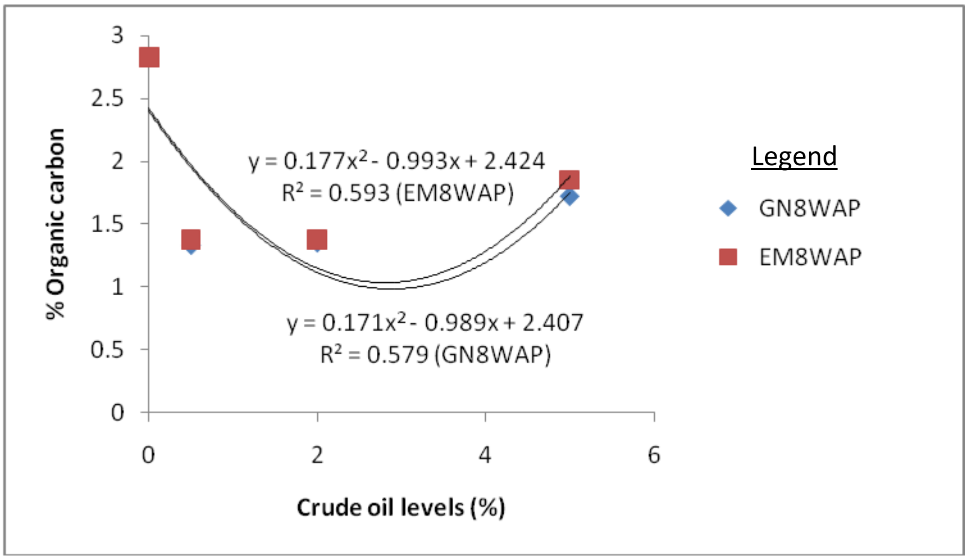


**Fig. 16:** Relationship between levels of crude oil pollution and soil % organic carbon at 8 WAP in groundnut and melon.

### 3.2.1.5 Available phosphorus.

Figures 17-20 showed that there was a relationship between the oil levels and soil available phosphorus in groundnuts pots and no relationship in melon pots except that of 6 WAP.

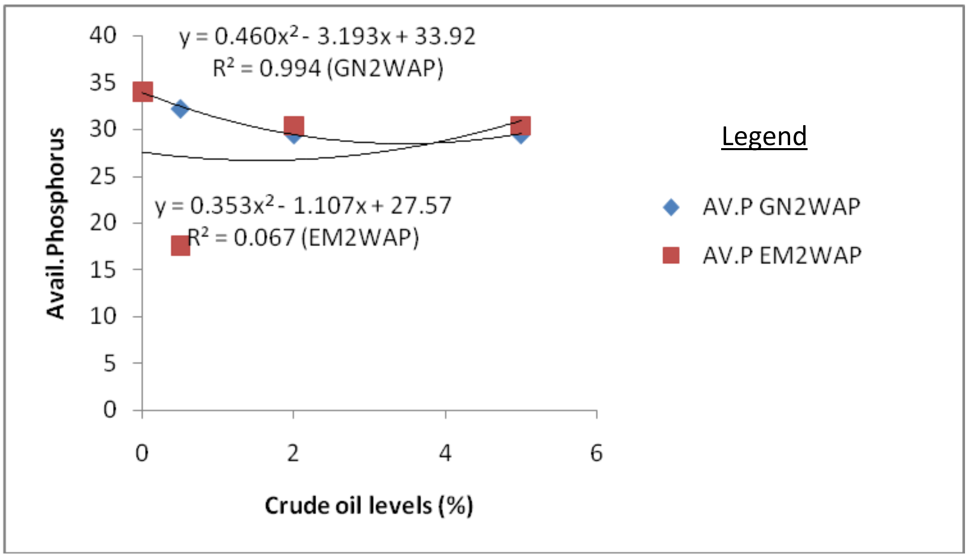


**Fig. 17:** Relationship between levels of crude oil pollution and soil available phosphorus at 2 WAP in groundnut and melon

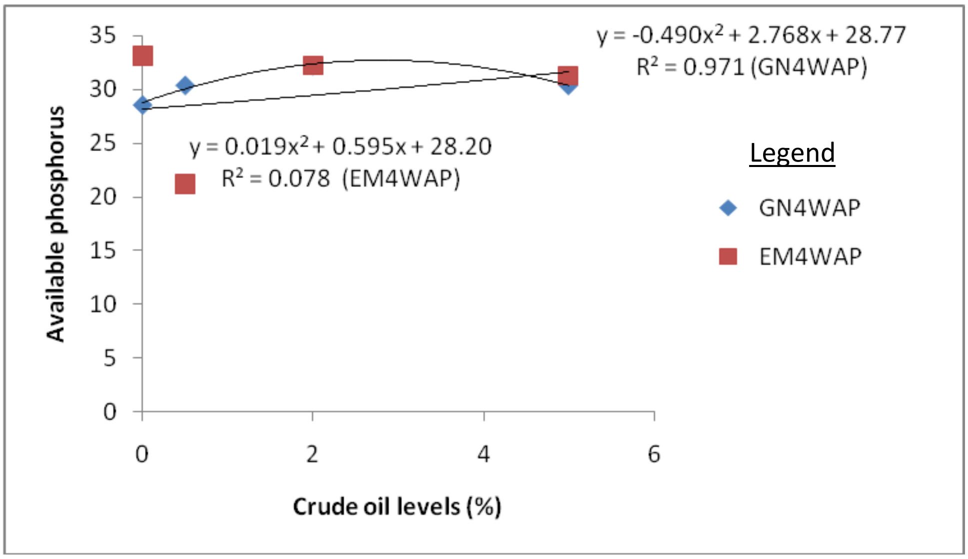


**Fig. 18:** Relationship between levels of crude oil pollution and soil available phosphorus at 4 WAP in groundnut and melon

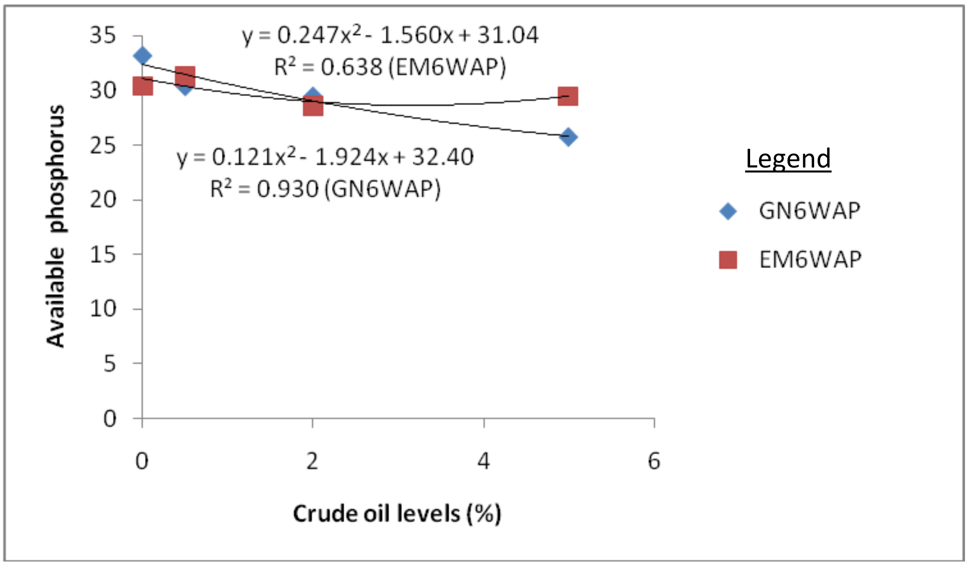


**Fig. 19:** Relationship between levels of crude oil pollution and soil available phosphorus at 6 WAP in groundnut and melon.

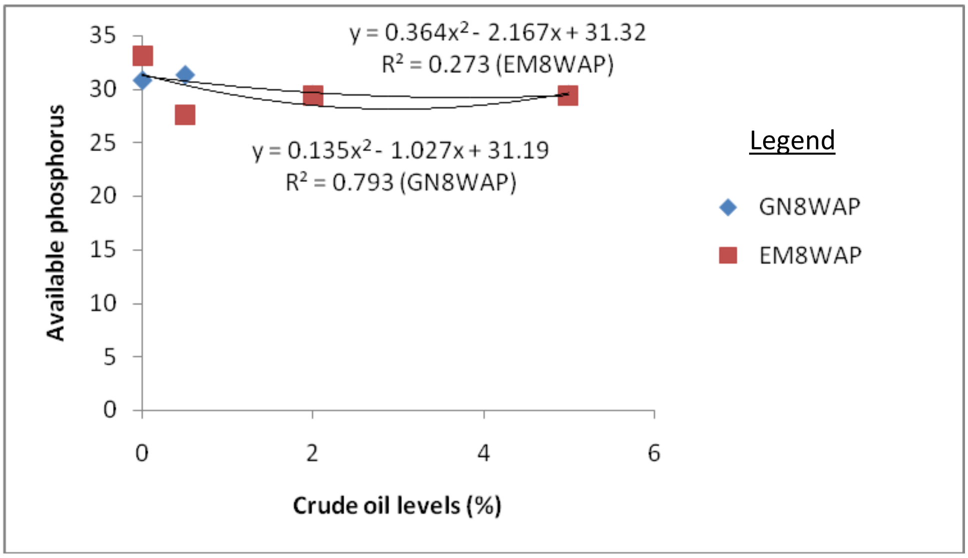


**Fig. 20:** Relatioship between levels of crude oil pollution and soil available phosphorus at 8 WAP in groundnut and melon.

**4. DISCUSSION**

The effect of various levels of oil treatments on soil physico-chemical properties, seeds germination and plant growth of melon and groundmut seeds and seedlings, composite component as shown in Tables 1-2 and Figs. 1-20, revealed that oil treatment at 2 and 5 % adversely afected all the agronomic characters of melon than of groundnut. Increase in the amount of crude oil treatment make the soil to stick together. Soil with 2 and 5 % oil treatment were observed to be stuck together than that with 0.5 % and the untreated soil. This coagulatory effect of soil particles impaired water drainage and air diffusion and these findings are in accordance with the previous report of (Gill et al., 1992; Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013).

The gravimetric water content of the soil with melon Table 2, increased with increase in oil levels. The highest was 54.30 % in soil with 5 % crude oil contamination 8 weeks after planting. In groundnuts, (Table 2) also revealed that the gravimetric water content steadily increases with increase in oil levels every two weeks after oil application when compared with the untreated (control). The highest was 45.31 % in soil with 0.5 % oil treatment 6 weeks after planting and the lowest was 32.42 % in the untreated soil at the same period. The increase in the gravimetric water content with increase in oil level may also be due to the coagulatory effect of soil particles which impaired water drainage and air diffusion and these findings are also in accordance with the previous reports of (Gill et al., 1992; Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013). Also, hydrophobic crude oil coats soil particles, blocks soil pores and reduces the permeability of water and air ( Bennett et al., 1993; Roy et al., 1999; Khamehchiyan et al., 2007), and thus affect the soil water content.

Isirimah et al. (1989), Aislabe et al. (2004), and Wang et al. (2013), reported that crude oil pollution affects soil physical and chemical properties and that the effect is high with increase in crude oil concentration. In this studies, the pH of the soil was acidic for both melon and groundnut which decreased and increased with time. The pH seemed not to have been affected by the oil level in soil of both plants. Magnesium increased with increased in crude oil treatment in both soil with melon and groundnut seedlings but more in groundnut. This observation is in line with the findings of Amadi et al. (1993), who noted increase in the cations of soil treated with crude oil. However, correlation result showed that there was a significant difference ($p<0.05$) with Mg in crude oil levels of up to 5 % in soil with melon and groundnut 4 weeks after oil application. The increase in magnessium in higher oil levels may have enhanced plant growth and tolerance in the groundnut seedlings and higher lipids content in both plants because magnessium is known to enhance chlorophyll formation, phosphorus uptake, normal cell division, oil intake and plant growth (Omoruyi et al., 1999).

The correlation result showed that there was no significant difference ($p>0.05$) on Potassuim in soil of both plants due to oil application. The decrease in K observed in melon 6 and 8 weeks after planting was with time and not directly link to soil crude oil contamination. On Sodium, 2 % oil level also had inverse relationship on sodium 8WAP in soil with melon and no relationship in soil with groundnut. The reduction in K and Na is in support of Agbogidi et al. (2007); who noted decrease in K and Na in soil treated with crude oil. Calcium decreased significantly 8 weeks after oil application in soil with melon and 6 and 8 weeks in soil with groundnuts. However there was no significant difference ($p>0.05$). These defficencies of Calcium resulting from increased crude oil levels in soil with melon may have been responsible for the malfunction of the leaves (glue of leaves) observed in stunted plant in crude oil levels 2 and 5 % in melon and may have also accounted for the gradual reduction in leave area (sizes) in groundnut in soil with oil levels of 2 and 5 %, especially in 5 % oil treatment with time. This was in agreement with already established fact on deficiency of calcium in plant (Omoruyi et al., 1999). Total nitrogen, though low in the soil of both plants, crude oil level of 2 % had significant effect ($p<0.05$) 6 WAP and 8 WAP while 0.5 % oil level had inverse effect ($p<0.01$) 8 WAP on total nitrogen in soil with melon while there was no significant effect in soil with groundnut. The total nitrogen in soil with groundnut seedlings was relatively stable. The low Total nitrogen observed is in support of Agbogidi et al. (2007), who noted decrease in Total nitrogen in soil treated with crude oil due to the nutrient immobilization by microbes leading to loss of soil fertility. Available phosphorus, Oil level of 5 % had significant effect ($p<0.05$) on available P, 4 WAP and inverse effect ($p<0.05$) 6 WAP in soil with groundnut while there was no relationship in soil with melon. The decrease in available phosphorous observed in melon may be due to decrease in pH because it is known that increase in pH up to about 5.5-6.0 or decrease in pH will lead to increase or decrease in available phosphorous (Isirimah et al., 2003 and Ikpe et al., 1997). The higher phospherus observed in groundnut may also be due to the higher pH in the soil because it is known that high pH increases phosphorus availability up to a pH of about 5.5 - 6.0 (Isirimah et al., 2003 and Ikpe et al., 1997).

The total exchangeable aluminium was nil in soil of both plants. The absence could be the reason for the higher level of phosphorous in the soil. It is known that the presence of aluminium in soil inhibits availability of phosphorous and another reason for low aluminium may be due to low leaching as a result of the hydrophobic action on the soil (Agbogidi et al., 2007). The total exchangeable acidity was relatively steady and shown no relationship when correlated.

The total hydrocarbon kept increasing with increase in crude oil level and with time with positive significant effects on both plants. The corelation results showed that ($P<0.05$) significant difference exist at different pollution levels. Increase in crude oil treatment tends to make the soil stick together. Soil with 2 and 5 % oil treatment were physically observed to be stuck together than that with 0.5 % oil treatment and the untreated soil (control). This coagulatory effect of oil on the soil, binding the soil particles into a water impregnable soil block seemed to have impaired water drainage and air movement in the soil. Organic carbon increased with increase in crude oil contamination. These observation also agreed with the findings of Ekundayo and Ebuekwe (1997), who observed and reported increase in carbon content of crude polluted soil in southern Nigeria. The increased organic carbon had a significant direct effect ($p<0.05$) in 5 % oil levels 2 WAP in soil with groundnut but no significant effect in soil with egusi melon. Organic carbon in soil with 0.5 % treatment was smaller when compared with soil with other treatment levels and this could be responsible for the initial delay and not complete germination of the groundnut seeds planted in soil with 0.5 % oil treatment because plant needs more carbon to grow. The correlation analysis of crude oil contamination on organic carbon in the soil with melon and groundnut showed that there was a significant difference. At $p<0.05$, oil levels showed a significant effect on organic carbon especially on soil with melon. Since plant needs carbon to grow, increase in carbon with crude oil level could be another reason for the higher tolerance ability in groundnut seedlings.

The results on seeds germination/emergence and plant growth revealed that treatment levels of 0 - 0.5 % had a significantly higher effect on germination and emergence in melon than 2 and 5 % oil levels. Emergence in case of the later was less than 50 %. This is in agreement with earlier report by Isirimah (1989), that light oil concentration of about 1 % is beneficial to plant. The result revealed that 0.5 % crude oil contamination enhanced seed germination in melon when compared to the control, and above 0.5 % adversely affected seeds germination and emergence of melon. These effects ranged from delay in germination to retarded emergence as shown in Figs. 13-16 which are also in agreement with Gill et al. (1992), Cambel and Valvrik (1997), Rhykerd et al. (1998), Ekundayo et al. (2001), Spiares et al. (2001), Adewole et al. (2002), Agbogidi and Nweke (2005), Townsend et al. (2003); Labud et al. (2007), and Sutton et al. (2013), that growth of plant on oil polluted soil was, generally retarded and chlorosis of leaves results coupled with dehydration of the plant indicating water deficiency.

The low level of crops germination and emergence in high level of oil treatment in melon is attributed to poor wetability and aeration (Gill et al., 1992 and Aislabe et al., 2004). On the other hand, the groundnut seeds sown in the soil with various treatment levels showed that germination and emergence increased with increase in oil levels and that low oil levels of 0.5 % was observed to suppresed germination in groundnut and oil level above 0.5 % and 5 % enhanced germination in groundnuts.. Treatment levels of 2 and 5 % had a significantly higher germination and emergence than in the untreated soil (control) and 0.5 %. Emergence in case of 5 % oil level was over 80 %. The result of this study showed that there are crops like groundnut that can tolerate higher levels of oil treatment. The tolerance ability may be from the fact that it has ability to withstand drought and oxygen defficiency and was able to maintain a steady food component throughout the duration as shown in Figs. 13 - 16. Also since plants need carbon to grow, increased in organic carbon with increase in crude oil could also be another reason for this tolerance. More also, since groundnut is a leguminous plant, its ability to fix Nitrogen is probably another reason for this tolerance. Nitrogen is most often the element limiting to plant growth.

It is a constituent of chlorophyll, plant protein, nucleic acid and other substances (Isirimah et al., 2003).

On the effect of crude oil on growth parameters of melon e.g. plant height, length and area of leaves and weight were not affected by oil treatment up to 0.5 % but higher levels reduced all the parameters significantly. Retardation of growth in higher levels of oil treatment than lower levels was observed by Isirimah et al. (1989), and Ekpo et al. (2012), that plant height, dry matter yield and grain of maize were not affected by oil treatment of 1 % but higher levels reduced all these character significantly and that the higher the quantity or concentration of the crude oil in the soil, the more effect it will have on germination and growth of plant. Isirimah et al. (1989), supported that crude oil pollution up to 1 % could easily be degraded by natural rehabilitation in soils as the oil could be expecteded to increase organic matter in the soil and improve the fertility, physical and chemical property of the soil. Previous studies cited above have all shown that oil has adverse effects on plant growth. From this study, similar results have been observed where there were significant differences in growth between the untreated (control) and the treated plants. In the study also, it was observed that the the extent of retardation in growth was due to the concentration of crude oil applied, especially in melon plants.

In grounduts, plant height, length and area of leaves and weight were not affected by oil treatment up to 0.5 % but was mild in 2 % pots on the leaf areas. But in the 5 % oil level, the effect was more significant than that of 2 %. The reason for the pronounced effect in groundnut with 5 % oil level, especially with time, may be due to the higher rate of coagulatory effect on the soil, binding the soil particles into water impregnable soil block which seriously impaired water drainage and oxygen diffusion (Gill et al., 1992). Oil usually causes anaerobic environment in soil by smoothering soil particles and blocking air diffusion in the soil pores (Townsend et al., 2003; Labud et al., 2007 and Sutton et al., 2013). Also Rhykerd et al. (1998), Opeolu, (2000), Spiares et al. (2001), Odjegba and Sadiq (2002), Agbogidi and Nweke (2005), Kelechi et al. (2012), noticed a significant reduction in height of seedlings, leaf length and number of leaves for all levels of treatment relative to the control which was also in agreement with the findings of this study but mainly with the melon and at 5 % oil level in groundnut.

The carbohydrate in groundnut seedlings increased steadily from 0 –5 % treatment but higher in 2 and 5 % treatment; the Carbohydrate in melon increased from 0.5- 5 % oil levels. The protein in groundnut increased from 0 % to 5 % treatments but higher in 0.5 -5 % treatment but in melon, the protein increased from 0.5 -5 % oil level, higher in 0.5 % and 5 % oil levels. Lipids were high in 0.5 – 5 % oil level, higher in 0.5 % oil level and lower in the untreated soil (control) with seedlings of melon while in groundnut, the lipids were high in 2 – 5 % oil level and lower in 0 - 0.5 % treatment.

The results showed that crude oil of up to 5 % had a significant effect on the food components and stimulate higher production of the food components. The observed increased in the carbohydrate, protein and lipid contents with increasing oil level in soil did not agree with the observation of Agbogidi et al. (2007), who reported that crude oil pollution reduced the protein and fat content of maize (Zea mays L.) and that of Jaja and Barber (1999) who also reported reduction in the carbohydrate content of rice (Oryza sativum) with increasing crude oil pollution. However, Ogbo (2009) obsercved that rice ( Zea mays L ) and groundnut (Arachis hypogeaL) have more potentials for use in phytoremediation of oil contaminated soil which this study also agreed with, because of the high tolerance of groundnut in high level of crude oil polluted soil. The reason for the increase in the above food component with increase in oil levels of up to 5 % is probably due to their adaptive significance and the ability to fix nitrogen in the top layer of the soil for the groundnut seedlings. Moreso, the increase in magnessium in higher oil levels may have enhanced plant growth and tolerance in the groundnut seedlings. and higher food content (carbohydrate, protein and lipid content) in both plants. Another reason is that magnesium is known to enhance chlorophyll formation, phosphorus uptake, normal cell division, oil intake and plant growth (Omoruyi et al., 1999).

Correlation studies (Figs. 1-4) of the effects of crude oil on soil physico-chemical parameters revealed that on the gravimetric water content (GWC) significant differences ($p<0.05$) existed at different pollution levels in soil with melon at 2, 4, and at 8 WAP and none in 6 WAP while in grandnut, signifcant differences exist in 2 and 8 WAP and no significant difference ($p>0.05$) existed in 4 and 6 WAP. On pH, significant difference ($p<0.05$) existed at different pollution levels in soil with melon, 2, 4, 6 and 8 WAP and in groundnut, 2.4 and 6 WAP and no significant difference ($p>0.05$) existed at 8 WAP. These findings are also in agreement with the previous reports of other scientists (Isirimah et al., 1989 and Ikpe et al., 1997) and that increase or decrease in pH may be due to increase or decrease in available phosphorus.

On Organic carbon, there were significant differences ($p<0.05$) throughout the period in soil with melon and groundnut except for soil with groundnut 6 WAP, where there were no significant differences. For available phosphorus, significant diferences existed in soil with both plants except in soil with melon 8 WAP; same with Total nitrogen except in soil with groundnut 2 and 6 WAP. For magnesium, there were significant differences ($p<0.05$) throughout the period in soil with melon and groundnut except for soil with groundnut 8 WAP, where there were no significant differences. For calcium, significant differences ($p<0.05$) existed in soil with groundnut, 2,4 and 6 WAP and none in 8 WAP, while in soil with melon significant diferences ($p<0.05$) existed only in 4 and 6 WAP and none in 2 and 8 WAP. For Total hydrocarbon (THC), there were significant differences ($P<0.05$) throughout the period in soil with melon and groundnut and this was direct showing increased THC with increasing crude oil levels all through. These findings on the above soil physicochemical parameters are in agreement with previous reports of Isirimah et al. (1989); Ekundayor and Obuekwe (1997), Aislabe et al. (2004), Arocema and Rutherford, (2005) and Wang et al. (2012), that crude oil pollution affects and changes soil physical and chemical properties. However, some changes were also observed to be with time.

The studies on germination,emergence and growth parameters, revealed that crude oil significantly affected ($P<0.05$) the germination rate of melon and groundnut at different pollution levels throughout the periods. There relationship was direct in groundnut as increase in crude oil levels led to increase in germination while in melon, it was an inverse (negative) relationship as increase in oil levels led to a decrease in germination. The correlation on plant heights (height/length of stem) revealed that there were significant differences ($P<0.05$) throughout the period in melon and groundnuts except in groundnuts 2 WAP, where there was none. There were inverse (negative) relationships on both plants showing decrease in height of both plants with increasing crude oil levels all through but the effect was more on melon.The same scenario was also observed in leaf length and leaf area; only that in this case, there was no exception. Crude oil significantly affected ($P<0.05$) the leaf length and leaf area all throughout the period. These findings are in areement with the previous reports of Isirimah et al. (1989); Rhykerd et al. (1998), Opeolu (2000), Spiares et al. (2001), Odjegba and Sadiq (2002), Agbogidi and Nweke (2005) and Kelechi et al. (2012).

The correlation studies on food composite (carbohydrate, protein and lipids) revealed that there were significant differences ($p<0.05$) in carbohydrate of melon and groundnut thoughout the preiod except in groundnut 8 WAP where there was none.The carbohydrate of groundnut increased with increased in oil levels throughout the period when compared with the control while that of melon tended to increase with increased in oil levels 2 and 4 WAP and decreased with increased oil levels 4 and 8 WAP when compared with the control. For protein, there were significant differences ($P<0.05$) in groundnut 2 and 6 WAP and none ($P>0.05$) 4 and 8 WAP and the relationships were direct all through; while in egusi melon, there were significant differences ($P<0.05$) 2, 4 and 6 WAP and none 8 WAP. The relationship was direct 2 and 4 WAP. In lipids, there were significant differences ($P<0.05$) in groundnut all throughout the period showing increse in lipids with increased oil levels when compared with the control while in melon the oil levels had a significant effect ($P<0.05$) 2 and 6 WAP and none ($P>0.05$) in 4 and 8 WAP.

Although the general conclusion in literature on the effect of oil on soil is that it is beneficial at a very low concentration and detrimental at higher concentration which this study also confirmed though in this study, 0.5 % oil level was considered as the upper safe level. According to Isirimah et al. (1989), whose report supported that about 2 % oil (by weight) in soil imposes serious detrimental effect on agronomic crops and seeds and that complete elimination of growth resulted from 3.3 % oil (by weight) in soil. This study however reveals that the effect of 2 % and above 3.3 % oil level (by weight) as suported by Isirimah et al. (1989), are not for all agronomic crops and seeds. Our data support the report only on melon seeds and seedlings and not in groundnut seeds and seedlings because the groundnut seeds and seedlings in soil with 2 % oil levels germinated though not all and grew very well while those in soil with 5 % oil levels had all their seeds germinated and growing well until they began to have a mild effect which increased with time.

## 5. CONCLUSION

From the data obtained in this study, the following conclusions can be made:

1. Crude oil has significant effects (positive or negative) on the germination, growth, proximate composition of melon and groundnut and soil physical and chemical properties.
2. That crude oil of 2 % and above has a detrimental effect on melon germination and growth.
3. That Groundnut seeds and seedlings have a high tolerance rate in soil with crude oil pollution of up to 5 % oil levels.
4. That increase in crude oil level binds soil particles together into water impregnable soil block which impaires water drainage and oxygen diffusion.
5. That increase in concentration of crude oil in soil up to 5 % can stimulate increased in the production of some food components like lipids, protein and carbohydrate in both melon and groundnut.
6. That groundnut seed/seedling withstands the crude oil pollution than melon hence the effect of the pollution was higher in melon than in groundnut.
7. That crude oil pollution changes soil physical and chemical parameters at differnt pollution levels

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