**Alleviatory Effect of Compost Amendments of Crude Oil Impacted Soil on the Neutraceutical Composition of *Cucurbita maxima* Duch**

O.G. Okon¹,a*, J.E. Okon²,b, G.D.O. Eneh³

¹Department of Botany and Ecological Studies, University of Uyo, Uyo, Nigeria
²Biological Sciences Department, Akwa Ibom State University, Ikot Akpaben, Nigeria
³Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osuru, Nigeria

*a*okonokongodwin@yahoo.com \(^{b}okjuni4zeeb@gmail.com

**Keywords:** Crude oil, *Cucurbita maxima*, minerals, neutraceutical, proximate, vitamins

**Abstract.** The effect crude oil pollution and amendment treatments using decomposed green manure (*Calopogonium mucoides* Desvaux and *Aspilia africana* (Person) C.D.Adams) on the growth and neutraceutical (minerals, proximate and vitamins A and C) of *Cucurbita maxima* were studied. Crude oil polluted soils were obtained by mixing thoroughly 10 kg of sandy-loam soil with 10, 20, 30, 40 and 50 ml of crude oil, 0 ml served as control. The amendment treatment with green manure of *C. mucoides* and *A. africana* was carried out by adding the different levels of crude oil polluted soils (10 – 50 ml) with 4 kg of the compost manure. The experimental work was carried out in the green house using plastic buckets. Measurement of selected growth parameters such as percentage germination, vine length, leaf area, internode length, leaf number and petiole length was carried out after nine weeks. The results indicated that crude oil pollution significantly (p=0.05) reduced the growth parameters of *C. maxima*. Mineral content, proximate composition and vitamin A and C contents of *C. maxima* also showed pronounced reduction with increase in crude oil concentration. The addition of amendment treatment with green manure of *C. mucoides* and *A. africana* to ameliorate the impeding condition in the crude oil polluted soil significantly (p=0.05) improved the growth parameters and neutraceutical composition of *C. maxima* when compared to the pollution treatment. This study revealed that crude oil pollution negatively affected the growth and neutraceutical composition and generally the productivity of *C. maxima*. From this study, it is evident that *C. mucoides* and *A. africana* enhanced the growth and quality of *C. maxima*. Therefore, *C. mucoides* and *A. africana* should be used for effective and efficient bioremediation practices.

**Introduction**

The environmental impact of oil exploration and exploitation is one of the inevitable consequences of economic development and civilization in a technical age [1, 2]. Crude oil and petroleum product is a major source of energy in Nigeria and the world at large. Oil plays a vital role in shaping the economic and political future of the world. Petroleum industry has created economic boom for Nigeria and at the same time environmental and socio - economic problems [3, 2]. Various activities in crude oil exploration, exploitation, storage and transportation lead to spillage of oil to the environment. Crude oil spills/pollution is a common event in Nigeria and occurs due to a number of causes, including corrosion of pipelines and tankers (accounting for 50% of all spills), sabotage (28%), and oil production operations (21%), with 1% of the spills being accounted for by inadequate or non-functional production equipment [4]. The largest contributor to oil spill, corrosion of pipes and tanks, is the rupturing or leaking of production infrastructures that are described as, "very old and lack regular inspection and maintenance" [4]. The spilled oil pollutes soils and the soils to be less useful for agricultural activities with soil dependent organisms being adversely affected [5]. Adelana et al. [6] described oil spillage as the release of a liquid petroleum hydrocarbon into the environment due to human activity.

Many studies have examined the effects of crude oil exploration and production on plants. Baker [5] associated most physiological defect on plant grown on oil polluted soil as a result of
interference with photosynthesis and transpiration probably by blocking the stomata. Odu [3] reported that during oil spills the surface of vegetation is coated. This coating reduces physiological activities of the plant since the stomata are blocked, thus, preventing transpiration and limiting photosynthesis. Ekundayo [7] studied the effect of crude oil spillage on growth, productivity and nutrient uptake of maize (Zea mays L.) The results showed that in crude oil polluted soils, germination was delayed and the germination percentage was significantly affected by oil pollution. Achuba [8] studied the effect of crude oil contaminated soil at various sub-lethal concentrations on the growth and metabolism of cowpea (Vigna unguiculata) seedlings. The results disclosed that crude oil induced environmental stress in the seedling. Thus, crude oil polluted soils make it difficult for plants to obtain nutrients from the soil thus hampering plant growth.

Bioremediation is not a new concept. Since 1989, bioremediation has become a technology that is discussed, applied and considered in many different circumstances [9]. Bioremediation is the use of biological processes to degrade, break down, transform, and/or essentially remove contaminants or impairments of quality from soil and water. Bioremediation is a “treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non-toxic substances”. Technologies can be generally classified as in situ or ex situ. In situ bioremediation involves in treating the contaminated material at the site, while ex situ involves the removal of the contaminated material to be treated elsewhere. Some examples of bioremediation related technologies are biodegradation, phytoremediation, composting, bioaugmentation, and biostimulation [9].

Composting technology is becoming important in the treatment of oil polluted coastal area in Nigeria. It involves the mechanized mixing of contaminated soil or sediment with compost-containing hydrocarbonoclastic bacteria (HCB) under aerobic and warm conditions. Through the addition of post-harvest leaves, stems, cover crops and decomposed green manure of different plants; microbial nitrogen fixation has been co-optimized with petroleum hydrocarbon degradation [10]. It is pathetic that a once rich agricultural environment is being impoverished and made useless by crude oil spillage as a result of continuous and excessive exploitation of crude oil in the south-south region of Nigeria, thus, this study will aid in understanding the alleviatory effect of Calopogonium mucunoides and Aspilia africana compost the growth and neutraceutical composition of C. maxima.

Materials and Methods

Study Area

This research was carried out in Uyo Local Government Area of Akwa Ibom State, Nigeria. Uyo is a city in South-South Nigeria found between latitude 5.02°N and longitude 7.92°E; it has an average temperature of 25.1-27.8°C, an annual rainfall of 3300 mm. The plants (Cucurbita maxima, Calopogonium mucunoides and Aspilia africana) used for this research work were identified by a plant taxonomist in the Department of Botany and Ecological Studies, University of Uyo, Uyo, Nigeria.

Sources of Crude Oil and Experimental Soil

The crude oil used for this research was gotten from the Nigerian National Petroleum Commission (NNPC), Aba Road, Port Harcourt-Nigeria. The experimental soil was excavated from the Department of Botany and Ecological Studies Botanic Garden, University of Uyo-Nigeria.

Pollution and Amendment Treatments

Ten kg of the sandy-loam were weighed using a weighing balance (Ohaus Triple Beam 750-SO Weighing Balance). Polluted soils were obtained by mixing thoroughly 10 kg of sandy-loam with 10, 20, 30, 40 and 50 ml of crude oil and left undisturbed for one week, while unpolluted garden soil (0 ml) was used as control [1]. The amelioration treatment was carried out by adding 4 kg of green manure (Calopogonium mucunoides and Aspilia africana) to various levels; 10, 20,
30, 40 and 50 ml of crude oil polluted soils. The soil samples with or without green manure were left undisturbed for another one week before being placed in plastic buckets (18 x 36 cm). This period helps to facilitate loosening of the oil constituents completely [1].

**Sterilization of Seeds for Planting**

Seeds of *C. maxima* were surface sterilized with 0.01% mercuric chloride solution for 30 seconds, thoroughly washed several times with sterile distilled water and air-dried [11]. During this treatment, floating seeds were discarded while the good ones were used for the research. Five seeds of *C. maxima* were sown directly in each perforated buckets containing polluted, unpolluted and ameliorated garden soil. On germination, the plants were thinned to 3 per pot.

**Determination of Growth Parameters**

Percentage germination was calculated as the seeds emerged from the soil 5 days after sowing. The percentage germination in each treatment was calculated using the formula:

\[
\text{Percentage Germination} = \left( \frac{\text{Number of Seeds Germinated}}{\text{Number of Seeds Sown}} \right) \times 100.
\]

Measurement of growth parameters included shoot length, root length, petiole length and internode length were taken 9 weeks using a measuring tape (cm). Leaf number was counted. Leaf area (LA) was determined using a graph by multiplying the leaf length by leaf width (widest portion) with the correlation co-efficient (r) which was 0.72.

**Wet Digestion of Sample:** For wet digestion of sample, 2 g of the plant samples was taken in digesting glass tube. Twelve ml of hydrochloric acid was added to the plant samples. The mixture was kept overnight at room temperature (27°C). Four ml perchloric acid (PCA) was added to these mixtures and was kept in the fumes block for digestion. The temperature was increased gradually, starting from 50°C and increasing up to 150°C. The digestion was completed in about 70 - 85 min as indicated by the appearance of white fumes. The mixture was left to cool and the contents of the tubes were transferred to one hundred millilitres (100ml) volumetric flasks and the volumes of the contents were made to one hundred millilitres (100ml) with distilled water. The wet digested solution was transferred to plastic bottles and labelled accurately. The digest was stored and used for mineral determinations [12].

**Determination of Minerals**

Mineral contents: calcium (Ca), magnesium (Mg), potassium (K) and phosphorus (P) of plant samples were determined by atomic absorption spectrophotometer (AAS), flame photometry and spectrophotometry according to the methods of [13, 14].

**Proximate Composition**

**Determination of Crude Protein:** Protein in the sample was determined by Kjeldahl method [13]. The samples were digested by heating with concentrated sulphuric acid (H₂SO₄) in the presence of digest mixture. The mixture was then made alkaline. Ammonium sulphate thus formed, released ammonia which was collected in 2% boric acid solution and titrated against standard HCl. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor (6.25) and the amount of protein was calculated. Percent crude protein content of the sample was calculated by using the following formula: 

\[
\text{% Crude Protein} = 6.25 \times \frac{(SB) \times N \times 0.014 \times D \times 100}{W_l \times V \times 0.014}.
\]

where \( S \) = Sample titration reading; \( B \) = Blank titration reading; \( N \) = Normality of HCl; \( D \) = Dilution of sample after digestion; \( V \) = Volume taken for distillation; 0.014 = Milli equivalent weight of Nitrogen [15].
Determination of Ash: For determination of ash, clean empty crucible was placed in a muffle furnace at 600°C for 1 h, cooled in desiccator and weight of empty crucible was noted (W1). One g of each sample was taken in crucible (W2). The sample was ignited over a burner with the help of blowpipe, until it charred. The crucible was placed in muffle furnace at 550°C for 2 – 4 h. The appearance of grey white ash indicated complete oxidation of all organic matter in the sample. After ashing, furnace was switched off. The crucible was cooled and weighed (W3). Percent ash was calculated by following formula:

\[
\% \text{ Ash} = \frac{\text{Difference in wt. of Ash}}{\text{Wt. of Sample}} \times 100
\]

\[
\text{Difference in wt. of Ash = W}_3 - W_1.
\]

Determination of Crude Fat (Lipid): Dry extraction method for fat determination was used. It consisted of extracting dry sample with some organic solvent, since all the fat materials e.g. fats, phospholipids, sterols, fatty acids, carotenoids, pigments, chlorophyll etc. were extracted together. Therefore, the results were to frequently refer to as crude fat. Fats were determined by intermittent soxhlet extraction apparatus. Crude fat was determined by ether extract method using soxhlet apparatus. Approximately 1 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Weighed, cleaned and dried the receiving beaker was filled with petroleum ether and fitted into the apparatus. Turn on water and heater to start extraction. Siphoning allowed ether to evaporate and disconnect beaker before last siphoning. The extract was transferred into clean glass dish with ether washing and evaporated ether on water bath. Then the dish was placed in an oven at 105°C for 2 h and cooled in a desiccator.

The percentage crude fat was determined by using the following formula:

\[
\% \text{ Crude fat} = \frac{\text{Wt. of ether extract}}{\text{Wt. of sample}} \times 100
\]

Determination of Carbohydrates (CHO): The carbohydrate content was obtained by the difference (i.e. subtracting the values obtained for crude protein, crude lipid, crude fibre and ash from 100) as proposed by [16].

Determination of Crude Fibre: A moisture free and ether extracted sample were first digested with dilute H2SO4 and then with dilute KOH solution. The undigested residue collected after digestion was ignited and the loss in weight after ignition was registered as crude fibre. Calculations were done by using the formula:

\[
\% \text{ Crude Fibre} = \frac{W_1 - W_2}{W_0} \times 100
\]

where \(W_1 = \text{Weight of undigested residue}; W_2 = \text{Weight after ignition}; W_0 = \text{Weight of sample.}

Vitamin Analysis

Determination of Vitamin A (Axerphthol): Five g of powdered samples were weighed and dissolved in 100 ml of chloroform and stored in an amber coloured bottle at -10°C. Thirty % of trichloracetic acid (TCA) reagent was added and titrated with methyl chloride (CH2Cl2) and observed for colour change (end point). The vitamin A content was then calculated [17].

Determination of Vitamin C (Ascorbic acid): Five g of the powdered samples were weighed into an extraction tube and 100 ml of EDTA/TCA (2:1) extracting solution were mixed and the mixture shaken for 30 min. This was transferred into a centrifuge tube and centrifuged (Buckets, Model 80-2) at 3000 rpm for 20 min. It was transferred into 100 ml volumetric flask and made up to 100 ml mark with the extracting solution. Twenty ml of the extract was pipetted into volumetric flask and 1% starch indicator was made. This was added and titrated with 20% CuSO4 solution to get a dark end point [13].
Statistical Analysis

One way Analysis of Variance (ANOVA) was used to compare significant difference in the means of the growth parameters, means were compared using Duncan’s multiple range test. Linear Regression technique was used to assess plant response to pollution and amendment treatment using the statistical package SPSS 10.0 (Statistical Package for Social Sciences). However, a probability level of p=0.05 was considered statistically significant.

Results and Discussion

The shoot length, petiole length, number of nodes, leaf area and percentage germination of *C. maxima* were significantly (p=0.05) reduced at all levels with increase in crude oil concentration, while the internode length of *C. maxima* showed slight reductions with increase in the concentration of crude oil pollution. There was no significant (p=0.05) difference in root length at all concentrations of crude oil pollution (Table 1).

**Table 1. The Effect of Crude Oil Pollution on the Growth Parameters of *C. maxima* Grown for 9 weeks**

<table>
<thead>
<tr>
<th>Conc. (ml)</th>
<th>Shoot length (cm)</th>
<th>Petiole length (cm)</th>
<th>Internode length (cm)</th>
<th>Percentage germination (%)</th>
<th>Number of nodes</th>
<th>Leaf area (cm²)</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>160.80±17.33³</td>
<td>23.42±1.20³</td>
<td>17.24±2.41³</td>
<td>100±0.00³</td>
<td>70.00±0.41³</td>
<td>55.60±2.81³</td>
<td>17.84±0.98³</td>
</tr>
<tr>
<td>10</td>
<td>137.71±3.22⁶</td>
<td>10.70±0.98⁶</td>
<td>17.00±2.11⁶</td>
<td>90.0±0.42⁶</td>
<td>48.21±0.53⁶</td>
<td>37.81±0.99⁶</td>
<td>16.12±0.67⁶</td>
</tr>
<tr>
<td>20</td>
<td>130.41±4.10⁶</td>
<td>10.31±0.78⁶</td>
<td>9.24±1.10⁶</td>
<td>75.0±0.53⁶</td>
<td>29.52±0.41⁶</td>
<td>38.71±0.99⁶</td>
<td>16.12±0.67⁶</td>
</tr>
<tr>
<td>30</td>
<td>127.30±1.76⁶</td>
<td>11.30±0.56⁶</td>
<td>13.21±1.42⁶</td>
<td>15.0±0.44⁶</td>
<td>20.11±0.33⁶</td>
<td>24.85±0.75⁶</td>
<td>13.21±0.72⁶</td>
</tr>
<tr>
<td>40</td>
<td>117.01±2.21⁶</td>
<td>11.80±0.63⁶</td>
<td>8.41±0.87⁶</td>
<td>15.0±0.44⁶</td>
<td>15.21±0.09⁶</td>
<td>19.74±0.70⁶</td>
<td>11.49±0.47⁶</td>
</tr>
<tr>
<td>50</td>
<td>89.14±1.04⁶</td>
<td>10.43±0.72⁶</td>
<td>6.21±0.82⁶</td>
<td>5.00±0.25⁶</td>
<td>4.80±0.03⁶</td>
<td>10.89±0.45⁶</td>
<td>9.82±0.08⁶</td>
</tr>
</tbody>
</table>

Data were processed and expressed as S.E.M of four replicates. Values with different superscript are statistically significant (p=0.05).

The amelioration treatment using *Calopogonium mucoides* and *Aspilia africana* significantly (p=0.05) increased the shoot length, petiole length, internode length, percentage germination, number of nodes, leaf area and root length of *C. maxima* at all levels compared to the pollution treatment (Table 2). The shoot length of *C. maxima* was slightly stimulated at 10 ml above the control. Similarly, the leaf area of *C. maxima* was stimulated at 10 ml and 20 ml above the control (Table 2).

**Table 2. The Effect of Amendment Treatment of Crude Oil Polluted Soil on Growth Parameters of *C. maxima* Grown for 9 weeks**

<table>
<thead>
<tr>
<th>Conc. (ml)</th>
<th>Shoot length (cm)</th>
<th>Petiole length (cm)</th>
<th>Internode length (cm)</th>
<th>Percentage germination (%)</th>
<th>Number of nodes</th>
<th>Leaf area (cm²)</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>160.80±17.33³</td>
<td>23.42±1.20³</td>
<td>17.24±2.41³</td>
<td>100±0.00³</td>
<td>70.00±0.41³</td>
<td>55.60±2.81³</td>
<td>17.84±0.98³</td>
</tr>
<tr>
<td>10</td>
<td>198.23±4.82³</td>
<td>14.31±0.89³</td>
<td>18.75±1.77³</td>
<td>100±0.00³</td>
<td>65.00±0.48³</td>
<td>63.12±2.31³</td>
<td>17.06±0.53³</td>
</tr>
<tr>
<td>20</td>
<td>156.76±5.32³</td>
<td>15.36±0.93³</td>
<td>9.77±0.49³</td>
<td>85.0±0.58³</td>
<td>31.80±0.27³</td>
<td>64.30±4.41³</td>
<td>16.54±0.88³</td>
</tr>
<tr>
<td>30</td>
<td>149.31±3.75³</td>
<td>13.71±0.67³</td>
<td>9.09±0.09³</td>
<td>70.00±0.43³</td>
<td>31.65±0.32³</td>
<td>42.31±1.34³</td>
<td>16.55±0.32³</td>
</tr>
<tr>
<td>40</td>
<td>130.11±1.09³</td>
<td>11.99±0.68³</td>
<td>9.06±0.06³</td>
<td>50.00±0.12³</td>
<td>29.11±0.41³</td>
<td>38.82±2.20³</td>
<td>14.21±0.41³</td>
</tr>
<tr>
<td>50</td>
<td>100.03±0.94³</td>
<td>11.87±0.44³</td>
<td>8.90±0.04³</td>
<td>50.00±0.12³</td>
<td>21.79±0.22³</td>
<td>22.14±0.98³</td>
<td>12.41±0.72³</td>
</tr>
</tbody>
</table>

Data were processed and expressed as mean S.E.M of four replicate. Values with different superscript are statistically significant (p=0.05).
The result of this study showed that crude oil pollution significantly (p=0.05) reduced the selected growth parameters of C. maxima. This could be as a result of the toxic nature of crude oil which may have damaging effect on plant tissues leading to ineffective absorption and distribution of nutrients. The results agree with the work of Ekpo et al. [18] who reported reduction in shoot length and general growth of soybean (Glycine max) as a result of unsatisfactory soil conditions associated with decrease in air filled space and increased demand of oxygen by oil decomposing microorganisms. Similarly, Udo and Oputa [19] reported stunted growth of plants in oil polluted soil as a result of toxicity to the plant shoot and root as well as poor absorption of nutrient and water by plants. This finding is also similar to that of [20] who observed significant reduced growth of engine oil on the leafy vegetable (Amaranthus hybridus L.) as a result of reduced availability of mineral elements.

The addition of green manure (Calopogonium mucunoides and Aspilia africana) to ameliorate the negative conditions in the crude oil polluted soil significantly (p=0.05) improved the growth of C. maxima when compared with that of only the pollution treatment. This is in line with other reports e.g. Eremrena and Akonye [21] reported that Centrosema pubescens and inorganic fertilizer as single or combined treatment improves the soil condition and enhance the growth of Manihot esculenta in crude oil polluted soil by creating an enabling environment for the microorganisms to thrive; thus degrading the toxic hydrocarbons in soil, making it harmless and creating an environment that supports plant growth and development. Also, Eneje et al. [22] reported amelioration effect of Calopogonium mucunoides either singly or in combination with poultry droppings on crude oil polluted soil and plant growth as a result of improvement in selected chemical properties (pH, OC, total nitrogen, available P, Ca, K, and Mg) of the soil.

The composition of minerals such as magnesium, calcium, phosphorus and potassium in C. maxima observed from this study was significantly (p=0.05) reduced with increase in crude oil pollution (Fig. 1). This agrees with the work of Agbogidi et al. [23] who reported that plant mineral elements (P, N, Na, K, Ca and Mg) of Treculia africana was affected by crude oil in soil, with all the elements showing significant (p=0.05) reductions with increasing oil pollution levels. Similarly, Agbogidi et al. [23] also reported that crude oil in soil exerts a significant effect on soil nutrient status as well as plant nutrient uptake. The amelioration treatment using compost of C. mucunoides and A. africana had significant (p=0.05) improving effect on the magnesium, calcium and potassium content of C. maxima which were all stimulated above the control. This could be attributed to the improvement of the soil conditions due to the manorial effect of the plants used and availability of essential nutrients for plant uptake and improvement. Eneje et al. [22] corroborates this fact with their report that the application of organic materials such as poultry and green manure singly or in combination improved selected chemical properties (pH, OC, total nitrogen, available P, Ca, K, and Mg) of the soil, thus, providing the plant with required nutrients. However, phosphorus experienced slight reduction; this could be due to the poor mobility of this mineral in the soil (Fig. 2).
Figure 1. Effect of crude oil pollution on (a) potassium (b) magnesium (c) calcium and (d) phosphorus content of \textit{C. maxima}.

Figure 2. Effect of compost amendments on (a) potassium (b) magnesium (c) calcium and (d) phosphorus content of \textit{C. maxima}.

The effect of crude oil pollution on proximate composition of \textit{C. maxima} showed a pronounced decrease in protein, lipid, caloric value and fibre content (Fig. 3). The decrease in these parameters may be as a result of oxidative stress induced by the presence of petroleum hydrocarbons and destruction of plant cells which may possibly lead to the decrease in proximate content (Fig. 2). Results agree with the work of Ohiri et al. [24] who reported similar reduction in protein content of \textit{Telfairia occidentalis}, \textit{Talinum triangulare} and \textit{Amaranthus hybridus} grown on crude oil polluted soil. Similarly, Nwaogu and Onyeze [25] reported a progressive reduction in the mean concentrations of protein thiol and total thiol attributed to increased oxidative protein damage due to the reactive intermediates from spent engine oil. However, there was a progressive increase...
in carbohydrate and ash content of *C. maxima*, this could be as a result of conversion or breakdown of molecules of protein and fat and their conversion to carbohydrate structure in leaves or it could be physiological response of this crop to stress [26]. Ogbuehi et al. [27] reported that crude oil pollution increased carbohydrate content of cassava (*Manihot esculentus*) as a result of redistribution of assimilates from leaves to roots in order to maintain root growth under stress conditions. An increase in ash and fibre content was observed in this study. This is in line with other studies e.g. Ujowundu et al. [28] who reported increase in ash content of breadfruit and Bambara groundnuts from hydrocarbon polluted areas. The increased ash content from polluted area suggests presence of elevated levels of inorganic residue [29]. However, there was progressive increase in the protein, caloric value and lipid content of *C. maxima* in response to the amelioration treatment with *Calopogonium mucunoides* and *Aspilia africana*. Slight reduction of ash and fibre was also observed with the remediation treatment. This could be attributed to the improvement of the soil conditions and availability of essential nutrient for improvement of plant growth (Fig. 4).

![Figure 3](image1.png)

**Figure 3.** Influence of crude oil pollution on the proximate composition of *C. maxima*

![Figure 4](image2.png)

**Figure 4.** Influence of compost amendments on crude oil impacted soil on the proximate composition of *C. maxima*

From this study crude oil pollution resulted in reduction in vitamin A and vitamin C content of *C. maxima* (Fig. 5). *C. maxima* showed high contents of vitamins as obtained from unpolluted soil relative to polluted soil. Results agree with the work of Ujowundu et al. [28] who made similar observation on the nutritional composition of *Treculia africana* and *Vigna subterranean*. Similarly,
Ohiri et al. [24] reported a slight decrease in vitamin C content of vegetables grown on bioaugmented and natural attenuated site. The results of this work is in consistence with that of Nwaoguikpe et al. [30] who reported a decrease in vitamin C concentration in *Talinum triangulare* planted on crude oil polluted site. However, there was progressive response of these vitamins to the amelioration treatment. These vitamins are involved in intermediary metabolism in plants and animals. Vitamins act as part or whole coenzyme to some specific enzyme system [28]. It plays important role in both enzymatic and non-enzymatic oxidative stress defense systems. Vitamin C plays essential role in several physiological processes in plants, including growth, differentiation and metabolism, Vitamin C functions as a reductant for many free radicals, thereby minimizing the damage caused by oxidative stress [28]. When consumed in diet, vitamin A helps to maintain good sight and prevents diseases of the eye. Vitamin C, on the other hand, has anti-infective properties, promotes wound healing and strong immune system [31]. Vitamins are essential nutrients that promote growth, development, reproduction, digestion, disease reduction, and overall health and life maintenance [28]. The amelioration treatment using *Calopogonium mucunoides* and *Aspilia africana* had significant (p=0.05) improving effect on vitamin A and C content of *C. maxima* which were all stimulated above the control except for 50 ml treatment of Vitamin A (Fig. 6).

![Figure 5](image-url)

**Figure 5.** Effect of crude oil pollution on the vitamins composition of *C. maxima*

![Figure 6](image-url)

**Figure 6.** Influence of compost amendments on crude oil impacted soil on the vitamins composition of *C. maxima*

**Conclusions**

The results of this research revealed that crude oil pollution negatively affected the growth, proximate composition and mineral contents of *Cucurbita maxima*. Irregular reduction in vitamins (A and C) constituents of *C. maxima* was also observed; crude oil generally affected *C. maxima*...
reducing its growth and quality. From this study, it is evident that *Calopogonium mucunoides* and *Aspilia africana* enhanced the growth and quality of *C. maxima*. Therefore, *Calopogonium mucunoides* and *Aspilia africana* is recommended for effective and efficient bioremediation practices as it is cheap and can be used by local farmers living in this crude oil affected areas. However, *Cucurbita maxima* are vulnerable to the effect of oil spill as shown from the present study. This crop should not be cultivated as a sole crop in areas polluted with oil and its associated products as plant parts serve as sink to heavy metals which are dangerous to human health.

**Conflict of Interest**

The authors declare that there is no conflict of interest between them.

**References**


