



Eco-phytochemical Studies in Selected Food Crops Cultivated in a Small-scale Oil-refining Area of Ikot Oborenyin, Akwa Ibom State, Nigeria

V. G. Etim¹, E. A. Moses^{1*} and E. J. Inam¹

¹Department of Chemistry, Faculty of Science, University of Uyo, Uyo, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors EAM and EJI designed the study and managed the experimental process. Author VGE managed the literature searches, performed laboratory analyses and wrote the first draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/19922

Editor(s):

(1) Radim Vacha, Deputy Director of Research and Development, Research Institute for Soil and Water Conservation, Czech Republic.

Reviewers:

- (1) Anonymous, Malawi College of Forestry and Wildlife, Malawi.
- (2) Anonymous, University of Maiduguri, Nigeria.
- (3) Anonymous, India.

Complete Peer review History: <http://sciencedomain.org/review-history/10696>

Original Research Article

Received 3rd July 2015
Accepted 30th July 2015
Published 24th August 2015

ABSTRACT

Aims: The study aimed at assessing the uptake of essential nutrients by tuber crops from soils at Ikot Oborenyin where small scale oil refining occurs.

Study Design: Experimental study was employed to achieve the aim of the study.

Place and Duration of Study: The study was conducted at the Department of Chemistry and the Department of Soil Science, University of Uyo, Nigeria between October, 2012 and May, 2013.

Methodology: Soils and tuber crops were collected from crude oil refining and non-oil refining areas using composite sampling. Soil pH, electrical conductivity, organic matter (OM), cation exchange capacity, particle size distribution and exchange acidity were analysed using standard protocols. Levels of nitrates, nitrites, sulphates and phosphates were measured using UV-Visible spectrophotometry. Transfer factors and soil contamination indices were computed. Data analyses were done using Pearson's correlation coefficient method.

Results: Results from the study revealed that the soils from the oil refining sites had some of their properties altered; they were loamy sand in texture, slightly acidic with high organic matter

*Corresponding author: E-mail: enomoses27@yahoo.com;

contents. The OM content was higher ($P < 0.05$) in oil refining sites. Trends for the concentration of anions in plants parts were: leaves > stems > tubers. The levels of anions from every parts of the plant analyzed showed that plants from the negative control site were higher in anions content ($P < 0.05$) compared to plants from the test site. In contrast, anions content were higher in the test site compared to the negative control site of the soil samples. Correlation analyses indicate different sources of input of anion to soils.

Conclusion: The study showed the inhibition of uptake of some important nutrients in the soil by plants as a result of crude oil presence. Transfer factor values show that the plant species are poor accumulators of sulphates, nitrites and nitrates but are efficient at bio-accumulating phosphate ions. The information generated in different crops cultivated under control and oil spill mining areas can be used for improvement of soil status and crop production. The data generated thus is useful for future action plan to grow suitable crops and soil correction factor Remediation programs are advocated for the communities.

Keywords: Crude oil; soils; tuber crops; anions; transfer factor; contamination index.

1. INTRODUCTION

Tuber crops are those crops in which the edible carbohydrate-rich storage organs develop wholly or partly from underground stems [1]. They are mainly carbohydrate energy food staples, used by rural and urban communities in fresh and processed food preparations. Some are used as substitute for wheat while others are used as animal feed and raw materials in the textile and pharmaceutical industries [2].

In Nigeria, root and tuber crops are used in the preparation of the major staples eaten and they account for about 15% of the total calories and 8% of the total protein in the daily diet of the average Nigerian [3]. Almost all the plant parts are used as food in one form or the other according to Echebir [4].

Staple food crops require anions such as nitrates sulphates, phosphates and chlorides. The major source of anions to plants is the soil, which makes them available to plants and then humans through the diet. Factors that affect anions uptake by plants, include: availability to root soil interface, specific and sufficient root cell plasma membrane absorption mechanism, interaction with other elements. Others are; Soil moisture, temperature and soil pH [5].

Nitrogen is essential for growth and reproduction of all plant and animal life. It is a basic constituent of proteins. Nitrates, nitrites, amides, free amino acids and small peptides make up most of the non-protein nitrogen fractions in plants. Plants require large amounts of sulphate for growth and development, and this serves as a major entry point of sulphates into the food web [6].

Crude oil, a mixture of many thousands of compounds, can vary in composition from one source to another. This suggests that the effects of crude oil will vary from source to another [7]. Oil pollution of soil leads to build up of essential and non-essential elements in soil and their eventual translocation in plant tissues [8]. Some crude oil components which are toxic can directly affect soil organisms and other soil properties. It also reduces the pH of the soil and reduce productivity in terms of the growth of plants [9].

Levels of anions in staple food crops, soils and water sources in some cities in Nigeria have been reported [5,10,11]. The researchers reported levels of anions in plants and soils beyond international acceptable limits in some cases. Other studies on effect of crude oil spillage on soil property and food production was done by researchers elsewhere [9,11]. The results of their findings showed negative effects on the physical, chemical and biological properties of the soil and plants. However, there is a dearth of information on the effects of crude oil refining on the up-take of essential nutrients by plants at Ikot Oborenyin, Akwa Ibom State, Nigeria; hence the reason for this study. The study is aimed at assessing the effect of crude oil on the uptake of essential nutrients by plants at Ikot Oborenyin where small scale oil refining occurs. The data will be useful in assessing the extent of soil contamination and determining the need for remediation. The results obtained from the study would also provide information for background levels of anion in the root crops cultivated in the study area. The data generated thus is useful for future action plan to grow suitable crops.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Ikot Oboroenyin, a farming settlement in Edemeya, Ikot Abasi local government area of Akwa Ibom State, Nigeria. The study location which lies between latitude 4°36'39"N and longitude 7°35'17"E was used for illegal crude oil refining for a number of years. The sampling area was divided into 3 sections. They are the test site, positive control site and the negative control site.

The test site was an agricultural site adjoining an abandoned local (artisanal) refinery, where food crops such as cocoyam, yam etc. were cultivated. Another site was the abandoned landmass where the oil refining was done. This

site served as the positive control. Samples were also collected from an agricultural site located away from the refinery site and free from traffic and vehicular activities. This is the negative control site. Fig. 1 shows the map of the study area and sampling sites.

2.2 Collection and Preservation of Samples

2.2.1 Soil samples

Composite sampling method was used in sampling the soils. Soil samples from test and control sites were collected at a depth of 0-20 cm. They were placed in clean, well labeled polythene bags and transported to the laboratory.

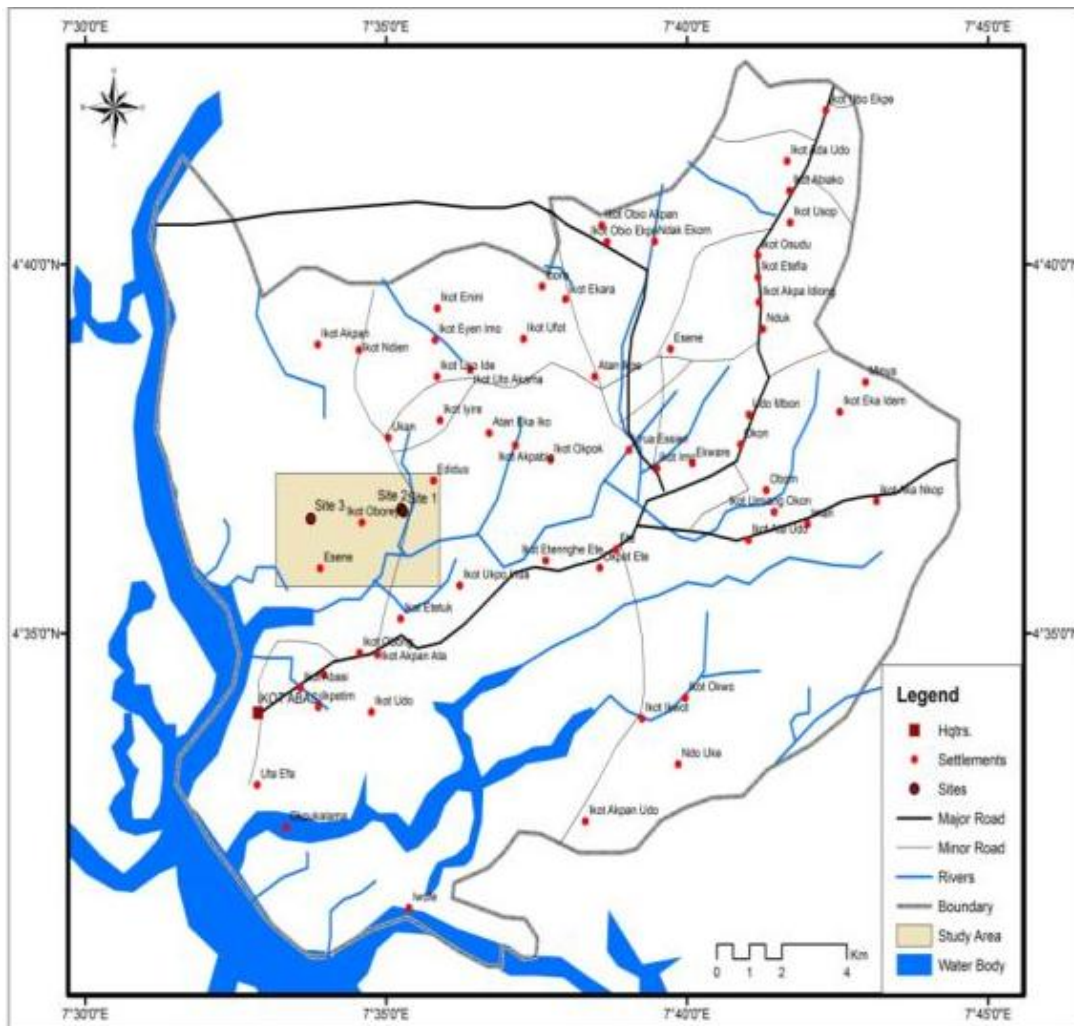


Fig. 1. Map of Ikot-Abasi showing study area and sampling sites

At the laboratory, part of the soil samples were air-dried, crushed and passed through 2 mm mesh sieve while the other part were stored under -18°C. The air-dried soil samples were subsequently analyzed for the following parameters: pH, electrical conductivity, organic matter, cation exchange capacity, particle size, anions content (nitrate, nitrite, sulphate and phosphate).

2.2.2 Food crops

Four different root-tuber crops (*Manihot esculenta*, *Colocasia esculenta*, *Dioscorea rotundata*, and *Dioscorea dumentorum*) were compositely sampled from test and negative control sites and transported to the laboratory in well labeled bags. At the laboratory, the leaves, stems and tubers were separated from each other, washed to remove sand and dirt. Parts of the samples were dried, crushed, sieved and placed in clean plastic containers with lid while the other part were freshly analysed. The remaining parts of the tubers were stored under -18°C.

2.3 Extraction for Cations (Ca, Mg, Na and K)

Samples for cations were extracted using ammonium acetate. Approximately 2.5 g of the soil samples were weighed into shaking cups. Fifty (50) ml of 1N NH₄OAc solution was added to the samples and shaken in a mechanical shaker for 2 hours. The solutions were filtered with filter papers and the extracts stored for the determination of Ca and Mg by EDTA titration method and Na and K by flame photometry method.

2.4 Digestion of Plant and Soil Samples

The dry samples were crushed in a mortar and the resulting powder digested by weighing 0.3 g of oven-dried, ground and sieved (2 mm) samples into an acid-washed porcelain crucible. Five (5) ml of perchloric (HClO₄) acid and 20 ml of nitric (HNO₃) acid were added, covered with continuous heating for one hour. The mixture was cooled and filtered through a Whatman no. 541 filter paper into a 60 ml volumetric flask and made up to the mark with distilled water. The same process was followed in the digestion of the soil samples using 1 g of the dried, ground and sieved samples.

2.5 Determination of Physico-chemical Properties of the Soils

2.5.1 Determination of organic matter

The organic matter content was determined by the dichromate wet-oxidation method as described by [12]. The value was multiplied by 1.732 to obtain organic matter content.

2.5.2 Soil electrical conductivity

This was measured in the extract obtained from 1:25 soil and water suspension using a conductivity meter [13].

2.5.3 Soil pH

Ten (10) g each of the air dried soil samples were weighed into three different 50 ml beakers, 20 ml of distilled water was added to each beaker and the mixture was allowed to stand for 30 minutes with occasional stirring using glass rod. The electrode of the pH meter was inserted into the partly settled suspension and the pH of the solution was recorded [14]. The results were the mean of three sequential readings.

2.5.4 Determination of exchangeable cations

This was extracted with neutral ammonium acetate (NH₄OAc). Calcium and magnesium were determined in the extract by EDTA titration. Potassium and sodium was determined by the use of a flame photometer [15].

2.5.5 Determination of exchange acidity

The exchangeable acidity was extracted with one normal potassium chloride solution. The exchangeable acidity and the exchangeable aluminum were determined by titration as described by Thomas [16]. The exchangeable hydrogen was obtained by subtracting exchangeable aluminum from exchangeable acidity.

2.5.6 Determination of particle size distribution

This was determined by the hydrometer method as described by Gee and Bauder [17].

2.5.7 Determination of nitrate and nitrite in food crops and soils samples

The concentration of nitrate and nitrite analyzed in each of the food samples were carried out

using fresh samples. The samples were prepared immediately returning from the field [18]. Nitrate was determined spectrophotometrically using Brucine Calorimetric Method. Nitrate was measured at absorbance of 470 nm [19].

Nitrite was determined using a colorimeter and the absorbance read at 520 nm [19].

For soil samples, 10 ml of the digested soils samples were used instead of fresh samples.

2.5.8 Determination of sulphates in food crops and soils samples

Sulphate was determined by measuring 10 ml of the digested samples into 25 ml volumetric flasks. Distilled water was added to bring the volume to 20 ml. 1 ml of gelatin-BaCl₂ was added and the volumes made up to mark with distilled water. Absorbance was measured at 420 nm.

Concentration of elements in the food crops samples were calculated using the formula

$$\text{Concentration } (\mu\text{g/g}) = \text{absorbance} \times 38.09 \times \text{extraction factor} \times \text{dilution factor}$$

2.5.9 Determination of phosphates in food crops and soils samples

Vanadomolybdate (Yellow) method was used in the determination of phosphate in the digested plant samples. Phosphate was determined using hach direct reading 2000 spectrophotometer as described by Akan et al. [20].

3. DATA ANALYSIS

3.1 Transfer Factors (TF) for Heavy Metals and Anions

Transfer factor (TF) is the ratio of the concentration of anions in a plant to the concentration of anions in soil [10]. TF for the anions were computed based on the method described by Harrison & Chirgawi, [21], according to the following formula:

$$TS = Ps (\mu\text{g g}^{-1} \text{dry wt}) / St (\mu\text{g g}^{-1} \text{dry wt})$$

Where Ps is the plant anions content originating from the soil and St is the total anions contents in the soil. Concentration of all the metals in plants

from control site were significantly higher than their concentrations from test site for all plants parts.

3.2 Contamination Index

The calculation of contamination index of the metals in the soil samples was done using the standard regulatory limits in as the background. The data's obtained from calculation of the contamination index were grouped into four grades ranging from unpolluted to very highly polluted. They are as follows 0-0.99 = uncontaminated; 1.0-1.19 = moderately to highly contaminated. 1.2-1.99 = highly contaminated; 2.0-3.5 = very highly contaminated [22].

3.3 Statistical Analyses

Data collected were subjected to statistical tests of significance using Analysis of Variance (ANOVA) at $p < 0.05$ to assess pairs results in the test and the negative control of the leaves, stems and tubers of the tuber crops. Correlation coefficient was used to determine the association between the test and negative control of the leaves, stems and tubers of the root crops at $p = 0.05$. All statistical analyses were done by SPSS software for windows.

4. RESULTS AND DISCUSSION

4.1 Physico-chemical Properties of the Soil Samples

The results of the physico-chemical properties of the soil samples are shown in Table 1. The values for organic matter (OM) contents were 6.24%, 4.96% and 3.68% for positive control, test and negative control respectively. The OM content was higher in the positive control site and lower in the negative control site. Analysis of variance revealed significant ($P < 0.05$) differences in organic matter contents among the 3 sampling sites. OM plays an important role in soil structure, aggregation, infiltration and retention of water, and other physical characteristics. The results for OM content could be as a result of the presence of crude oil which comprises mainly of organic content, thereby transferring it to the soil to increase its OM. Results obtained are similar to those of other studies [5,10,11]. The electrical conductivity (EC) of the soils were 38 $\mu\text{s/cm}$, 30 $\mu\text{s/cm}$ and 19 $\mu\text{s/cm}$ for positive control, test and negative control respectively. From the EC results of this

study, the soil is classified as extremely saline with high salt content [23]. Similar results range were reported by [9,24] from soils affected by crude oil.

The soil pH values were 4.3, 5.3 and 5.4 for positive control, test and negative control sites. There was no significant difference ($P>0.05$) in the pH values of the soil samples, indicating little or no effect of the oil activities on soil pH values. The pH values obtained from this study may enhance the bioavailability and transport of essential nutrients, some of which are beneficial to plants studied.

The cation exchange capacity (CEC) in the soil samples were the combination of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) and exchange acidity (EA) content of the soil. CEC actually measures the soil's ability to hold cations by electrical attraction. The CEC values were 5.71 cmol/kg, 8.53 cmol/kg and 7.67 cmol/kg for positive control, test and negative control sites respectively. The CEC gives an indication of the soils potential to hold plant nutrients. Increasing the organic matter content of any soil will help to increase the CEC since it also holds cations like the clays [11]. In general, the CEC of most soils increases with an increase in soil pH. From the results, the percent of exchange site occupied by cations were obtained by the base saturation values and they were 75.48%, 75.38% and 77.84% for positive control, test and negative control sites respectively. More

of Ca was present in the soils, while the least cations present was Na. The CEC of the soil follows the order: Ca > Mg > K > Na.

The exchange acidity shown in Table 1 is the amount of the total CEC occupied by the acidic cations (H^{+1} and Al^{+3}). The values were 1.40 cmol/kg, 2.10 cmol/kg and 1.70 cmol/kg for positive control, test and negative control sites respectively. The more acidic a soil is and the lower the soil pH value, the closer the acidity number will be to the CEC number. The present results show low acidic cations content in the soil and thus less exchangeable acidity and high base saturation.

Particle size analysis of the soils revealed the levels of sand (%) in the three areas to be: 85.62, 89.62 and 95.62 for positive control, test and negative control sites respectively; levels of silt (%) as 4.00, 2.00 and 0.00 and clay (%) as 10.38, 8.38 and 4.38 all for positive control, test and negative control sites respectively. In general, the results revealed the soils in the sample areas to be loamy sand in texture and slightly acidic with high organic matter contents. In the present study, soil properties such as pH, organic matter and organic carbon may contribute on uptake anions by plants. The amount of nutrients mobilized in soil environment is a function of pH, properties of metals, redox conditions, soil chemistry, organic matter content, clay content, cation exchange capacity and other soil properties [25].

Table 1. Physico-chemical properties of the soil samples from Ikot Oboroenyin, Ikot Abasi L.G.A

Soil properties	Positive control	Test site	Negative control
OM (%)	6.24±1.2	4.96±0.8	3.68±1.1
EC (µs/cm)	38.00±7.6	30.00±5.3	19.00±4.7
pH	4.30±0.2	5.30±0.3	5.40±0.2
Ca (cmol/kg)	2.88±0.3	4.80±0.4	4.32±0.3
Mg	1.20±0.2	1.36±0.2	1.40±0.3
Na	0.09±0.006	0.08±0.004	0.08±0.002
K	0.14±0.05	0.19±0.07	0.17±0.04
BC	4.31±0.3	6.43±0.8	5.97±0.7
EA	1.40±0.4	2.10±0.7	1.70±0.8
CEC	5.71±0.7	8.53±0.4	7.67±1.2
BS	75.48±10.2	75.38±12.6	77.84±8.6
Particle sizes			
Sand (%)	85.62±11.7	89.62±8.7	95.62±12.5
Silt	4.00±0.4	2.00±1.7	0.00
Clay	10.38±1.5	8.38±1.3	4.38±0.9

Results are means of 3 determinations ± standard deviations
 OM = Organic matter, EC = electrical conductivity, EA = exchangeable acidity
 $BC = Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}$ (exchangeable base cations);
 $CEC = EA + BC$ (cation exchange capacity); $BS = 100 \cdot BC / CEC$ (base saturation)

4.2 Nitrate Levels in Food Crops

Concentration of nitrates in food crops are shown in Fig. 2. The highest concentration of nitrate in *Colocasia esculenta* was found in leaves (154.67±6.80: negative control), while the least concentration was found in the tuber (53.76±4.67: test). Similar trend was observed for *Manihot esculenta*, *Dioscorea dumentorum*, *Dioscorea rotundata*; the concentration ranged from 38.83±3.58 (tuber: test) to 304.11±9.51 (leaves: negative control).

Generally, from the results, the highest concentration of nitrate was found in plants obtained from negative control compared to those obtained in test site. The levels of anions from every parts of the plant analyzed showed that plants from the negative control site were richer in anions content compared to plants from the test site suggesting that crude oil in the soil might have inhibited the uptake of anions by the plants. Edema et al. [24] worked at crude oil impacted and control sites at Iwhrehkan in

Ughelli North Local Government are of Delta state, had a similar result that phosphate, sulphate and nitrate ionic concentrations were higher in the control compared to impacted soil, indicating that crude oil spillage could make vital plant nutrients unavailable to plants.

The value of nitrate in the food crops showed that the leaves of the plants were richer in nitrate content than the stems and tubers of the plants. The content of nitrate in the different parts of the plant analyzed was in the following order: leaves > stems > tubers. Similar studies was carried out by [26] in soil and vegetable samples from Gongulon agricultural site, Maiduguri, Borno State, Nigeria, concluding that nitrate contents of various part of a plant differ in the order of leaf > stem > root > tuber > bulb > fruit > seed. Reports by [27] showed that vegetables that are consumed with their roots, stems and leaves have a high nitrate accumulation, whereas melons and those vegetables with only fruits as consumable parts have a low nitrate accumulation.

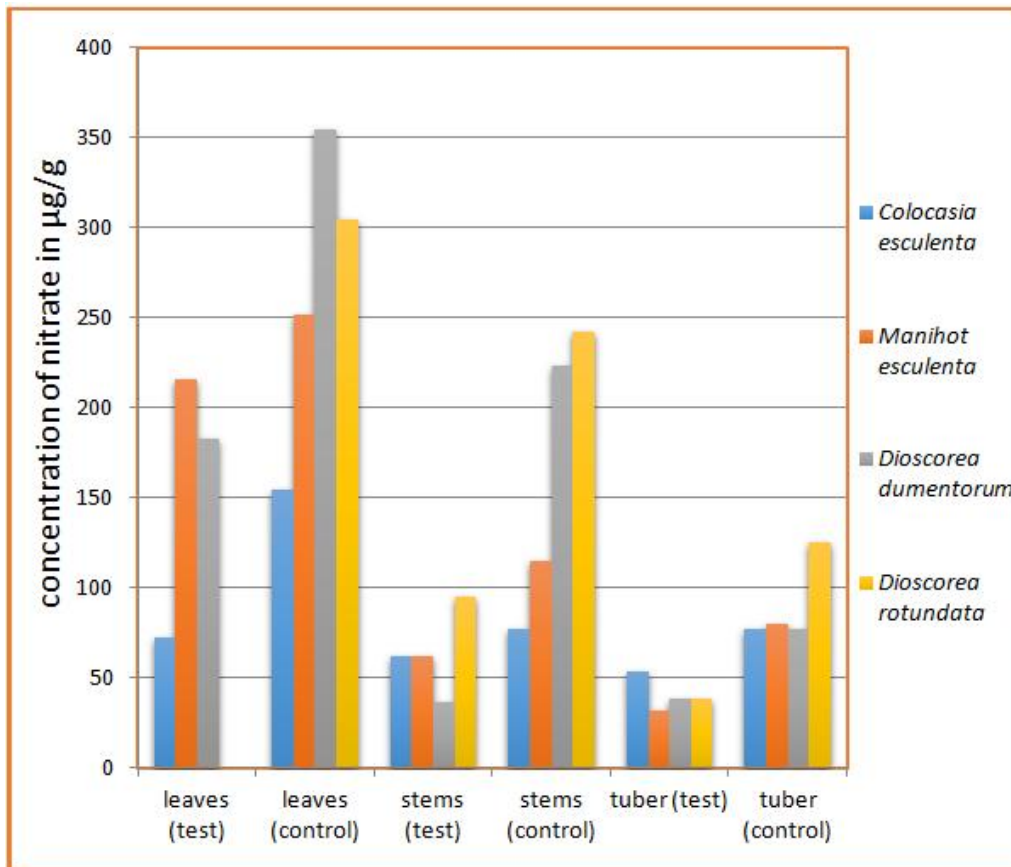


Fig. 2. Levels of nitrate (µg/g) in food crops obtained from test and negative control sites

Statistical test of significance using Analysis of Variance (ANOVA) revealed marked significant differences ($P < 0.05$) between the nitrate contents of all the food crops in the test and negative control sites. The relationships between test and negative control concentrations of nitrates in the leaves, stems and tubers of the plants were established using Pearson's correlation coefficient method. Low positive to negative correlation values were observed among test and negative control sites in each of the leaves, stems and tubers of the food crops, indicating that they were influenced by difference anthropogenic sources from difference directions.

4.3 Nitrite Levels ($\mu\text{g/g}$) in Food Crops

The result of the concentration of nitrite in the food crops in Fig. 3 showed that the highest

concentration of nitrite in *Colocasia esculenta* was found in the leaves (4.15 ± 0.10 : negative control), the least was found in the tuber (0.86 ± 0.35 : test). In *Manihot esculenta*, the concentration ranged from 1.10 ± 0.06 (tuber: test) to 7.47 ± 0.09 (leaves: negative control). For *Dioscorea dumentorum*, the maximum concentration was found in the leaves (2.74 ± 0.08 : negative control), while the minimum value was found in the tuber (1.50 ± 0.06 : test). For the concentration of nitrite in *Dioscorea rotundata*, the highest concentration was found in the leaves (4.93 ± 0.07 : negative control), while the least was found in the tubers (1.50 ± 0.06 : test). In the leaves of the plants, the highest concentration of nitrite was found in *Manihot esculenta* (7.47 ± 0.09 : negative control) while the least was found in *Colocasia esculenta* (1.73 ± 0.09 : test).

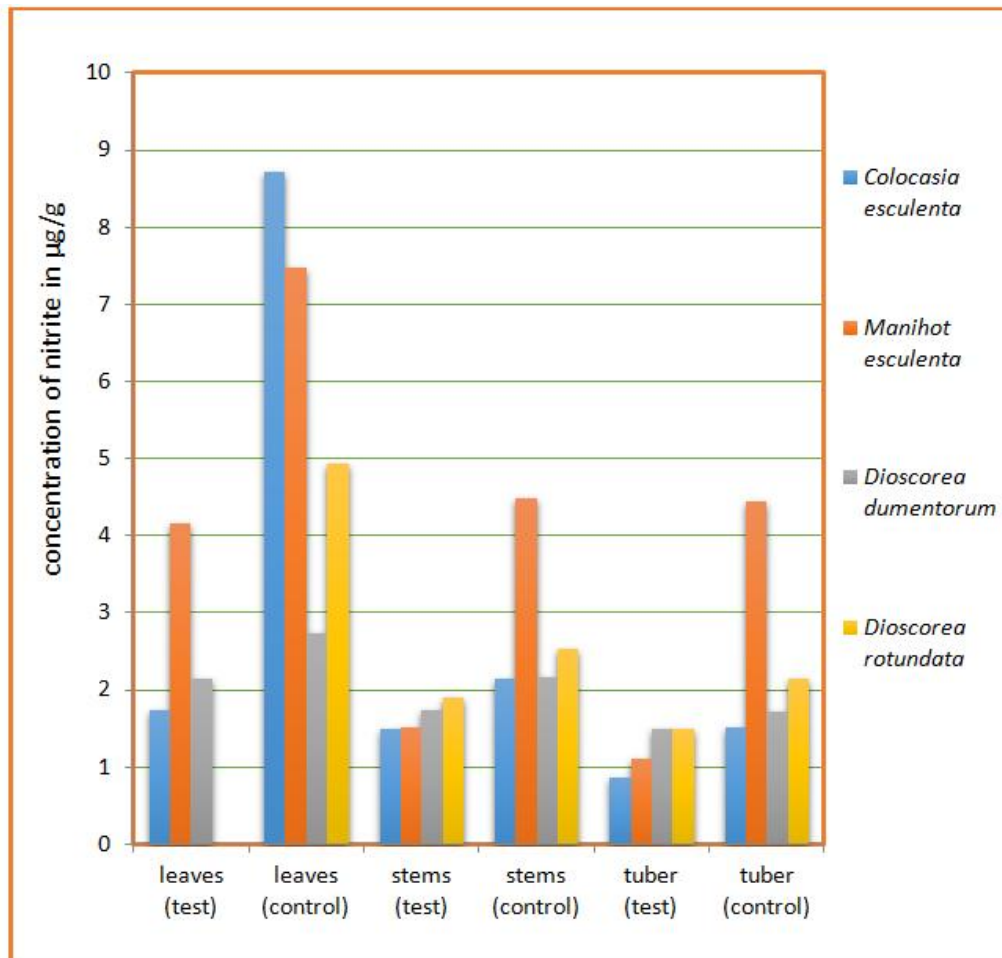


Fig. 3. Levels of nitrite ($\mu\text{g/g}$) in food crops obtained from test and negative control sites

In the stems, the highest concentration was found in *Manihot esculenta* (4.48 ± 0.09 : control) while the least was found in *Colocasia esculenta* (1.49 ± 0.07 : test). In the tubers, the highest concentration was found in *Manihot esculenta* (4.45 ± 0.10 : negative control) while the least was found in *Colocasia esculenta* (0.86 ± 0.35 : test).

Generally the highest concentration of nitrite was found in the negative control site compared to test site. It can be suggested that crude oil inhibited the uptake of nitrite by plants. This agrees with the work by [24] where anions were higher in the control site than the test site. The trend for the concentration in parts of the plants follows the order: leaves > stems > tubers. Statistical test of significance revealed marked significant differences ($P < 0.05$) among the nitrite contents of all the food crops in the two sample

sites. Correlation analysis revealed negative to low positive value between the two sites indicating different sources of inputs of the anions to the two sites. The different inputs may be due to different farm practices, type and mode of application of fertilizers, herbicides or other agrochemicals.

4.4 Sulphate Levels ($\mu\text{g/g}$) in Food Crops

Results for the concentration of sulphate in Fig. 4 show that, in *Colocasia esculenta*, the highest concentration was found in the leaves (1918.02 ± 18.53 : negative control) while the least was found in the tuber (766.88 ± 8.76 : test). Concentration of sulphate in parts of the plants followed the order: leaves > stems > tubers.

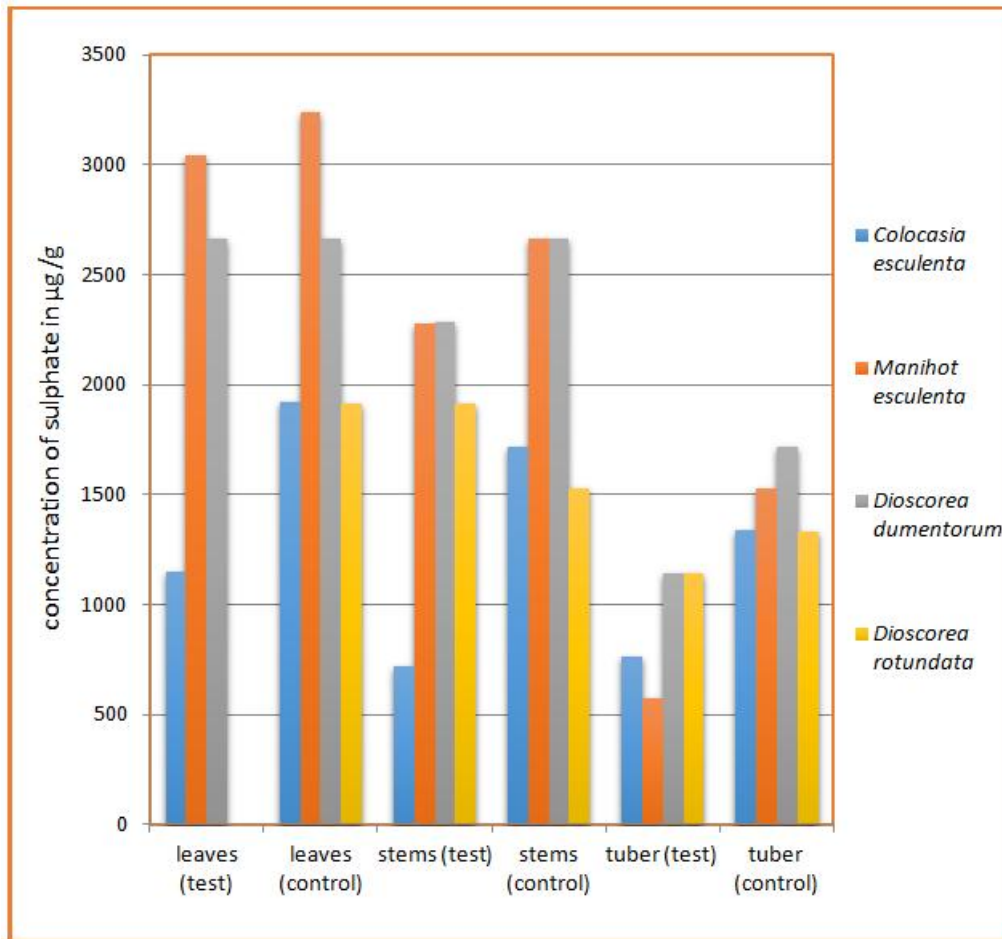


Fig. 4. Levels of sulphate ($\mu\text{g/g}$) in food crops obtained from test and negative control sites

From the results generally, concentration of sulphate was high in plants obtained from negative control site than from plants obtained from test site. Statistical test of significance revealed marked significant ($P < 0.05$) differences among the sulphate contents of all the food crops in the two sample sites, except in the leaves and the stems of *Dioscorea dumentorum* which there was no significant difference ($P > 0.05$) between the test and negative control. Correlation analysis revealed negative correlation which may be due to other sources of sulphate to the plants from inputs other than crude oil refining.

4.5 Phosphate Levels ($\mu\text{g/g}$) in Food Crops

Results for the concentration of phosphate in Fig. 5 showed that, in *Colocasia esculenta*, the values ranged from 183.30 ± 6.98 (tubers: test) to 545.08 ± 9.12 (leaves and stems: negative control). In *Manihot esculenta*, the values ranged from 182.96 ± 9.45 (tubers: test) to 816.94 ± 8.61 (leaves: negative control). The concentration of nitrite in *Dioscorea dumentorum* ranged from 187.76 ± 9.93 (tuber: test) to 722.61 ± 11.33 (leaves: negative control), while in *Dioscorea rotundata*, the values ranged from

182.80 ± 9.68 (tubers: test) to 823.22 ± 13.66 (leaves: negative control). For the leaves of the plants, the highest concentration of phosphate was found in *Dioscorea rotundata* (823.22 ± 13.66 : negative control) while the least was found in *Colocasia esculenta* (453.90 ± 9.64 : test). For the stems, the values of phosphate ranged from 366.65 ± 8.44 (*Manihot esculenta*: test) to *Dioscorea rotundata* (724.20 ± 9.54 : negative control). In the tubers, the highest concentration of phosphate was found in *Manihot esculenta* (364.74 ± 11.49 : negative control) while the least was found in *Dioscorea rotundata* (182.80 ± 9.68 : test).

The results showed that negative control contained the highest concentration of phosphate than test and the concentration in the parts of all the plants followed the order: leaves > stems > tubers. The phosphate level from the negative control site was significantly higher than the test site. This could be due to the fact that crude oil inhibits the uptake of some vital elements by the food crops [24].

The leaves of *Dioscorea rotundata* in the test site all withered before the time of sampling.

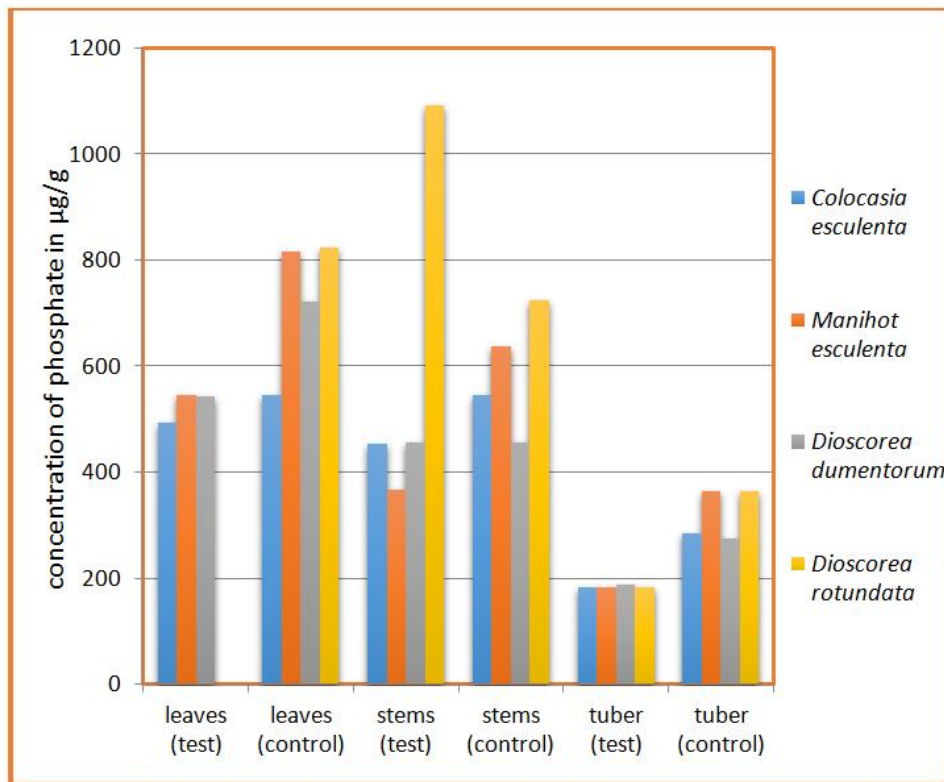


Fig. 5. Levels of phosphate ($\mu\text{g/g}$) in food crops obtained from test and negative control sites

4.6 Anion Levels in the Soil Samples

The results of anions levels of the soils obtained from positive control, test and negative control sites are presented in Fig. 6. The concentration of nitrate was very high in soil obtained from test site (427.91 ± 8.81); this was followed by the positive control site (395.75 ± 7.12), and lastly negative control site (286.77 ± 10.86). Generally the level of concentration of nitrate follows this order: test > positive control > negative control. The concentration of nitrite in the soil follows the order: test > positive control > negative control. The mean values were 7.75 ± 0.07 , 7.13 ± 0.11 and 3.22 ± 0.09 respectively. The mean concentrations for sulphate were 1529.05 ± 12.29 , 2283.32 ± 12.19 and 762.34 ± 10.35 for positive control, test and

negative control sites respectively. The mean concentrations of phosphate were 161.00 ± 9.27 , 179.46 ± 10.38 and 124.46 ± 10.08 for positive control, test and negative control sites respectively. In both sulphate and phosphate, the concentration followed the order: test > positive control > negative control.

The concentration of all the anions showed significant ($P < 0.05$) differences amongst the positive control, test and negative control sites. Variations between study sites could be attributed to differences in anthropogenic activities, like the crude oil activities, different farming practices such as excessive usage of fertilizers, herbicides and other agrochemicals.

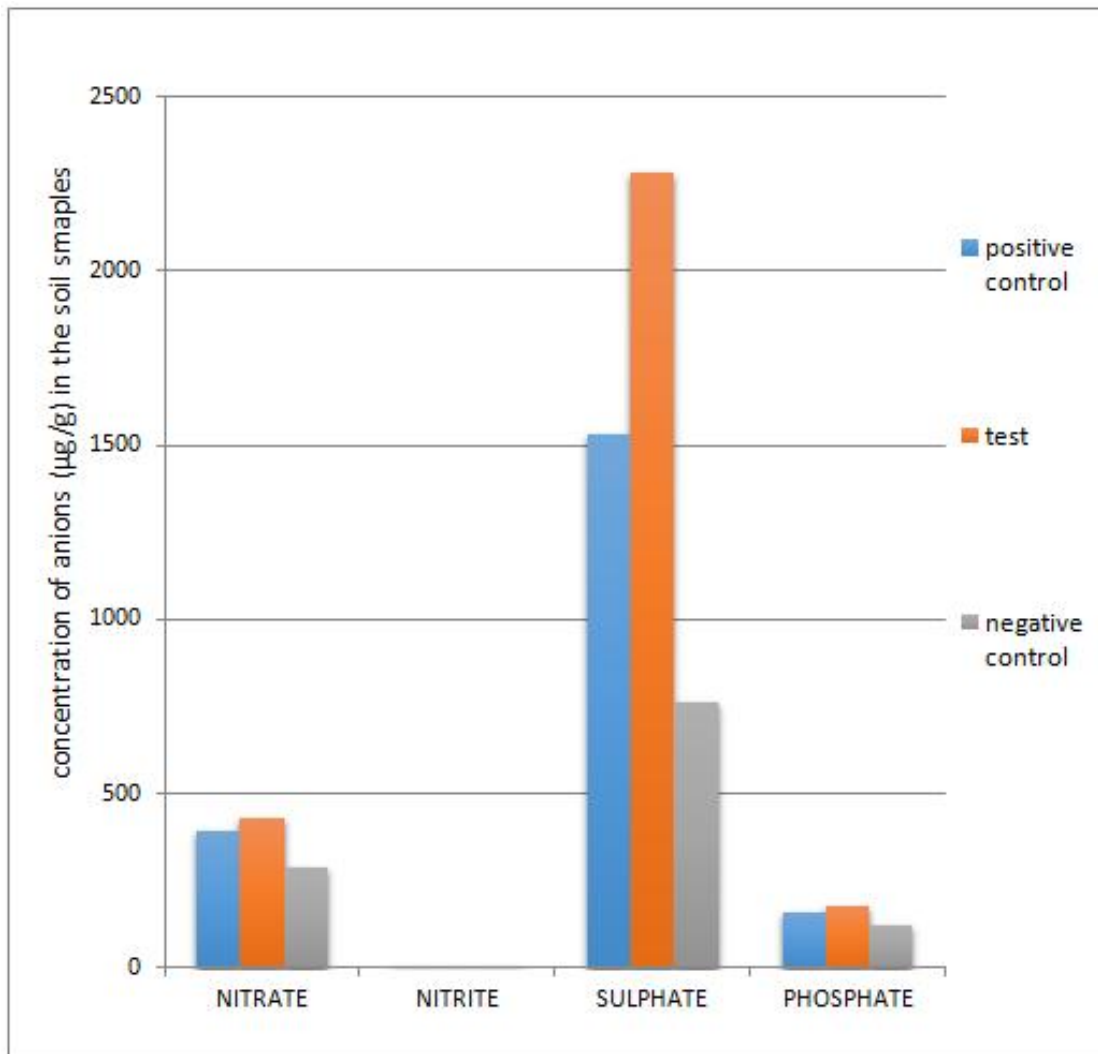


Fig. 6. Anions level in the positive control, test and negative control sites

Table 2. Transfer factors of anions from soil to tubers of food crops obtained from Ikot Oboroenyin, Ikot Abasi L.G.A.

Anions	<i>Colocasia esculenta</i>		<i>Manihot esculenta</i>		<i>Dioscorea domenturum</i>		<i>Dioscorea rotundata</i>	
	Test	Negative control	Test	Negative control	Test	Negative control	Test	Negative control
Nitrate	0.12	0.26	0.07	0.27	0.09	0.27	0.09	0.43
Nitrite	0.19	0.66	0.19	0.53	0.14	1.38	0.11	0.47
Sulphate	0.33	1.75	0.25	2.00	0.50	2.25	0.50	1.74
Phosphate	1.02	2.28	1.02	2.93	1.04	2.20	1.02	2.91

4.7 Transfer Factor of the Anions from Soil to Tubers of the Food Crops

Transfer factors (TF) for the anions from soil to tubers of the plants identify the efficiency of a crop species to accumulate a given anion. TF >1 indicates bioavailability of anions to plants based on the root uptake of the anions [10]. The results in Table 2 above showed that the negative control site had higher TF values for a given plant species compared to the control. This corroborates fact that crude oil inhibited uptake of anions by the plants. It also corroborates the reports of other studies [9,24]. TF values for sulphates nitrites and nitrates were mostly below one (<1) for the both sites showing that the plant species are poor accumulators of the stated anions. Conversely TF values for phosphates greater than one (>1). Indicating the efficiency of the plant species to bio-accumulate phosphate ions.

5. CONCLUSION

The physico-chemical study of agricultural sites in Ikot Oboroenyin, Ikot Abasi Local Government Area of Akwa Ibom State was under research. The soils and some root-tuber crops in the vicinity were measured for some parameters like the pH, organic matter, cation exchange, and particle size using standard methods, anions content using the UV-visible spectrometry. Soils in the sample areas loamy sand in texture and slightly acidic with high organic matter contents. These characteristic are typical of crude oil polluted areas. In the present study, soil properties such as pH, organic matter and organic carbon may contribute on uptake anions by plants. The anions content in the food crops were higher in the negative control site compared to the test site. This could be attributed to the fact that crude oil may have hindered the uptake of some important nutrients in the soil by plants. In contrast, anions content were higher in the test

site compared to the negative control site of the soil samples. TF values for sulphates nitrites and nitrates were mostly below one (<1) for the both sites showing that the plant species are poor accumulators of the stated anions. Conversely TF values for phosphates greater than one (>1). Indicating the efficiency of the plant species to bio-accumulate phosphate ions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iyagba AG. A review on root and tuber crop production and their weed management among small scale farmers in Nigeria. Journal of Agricultural and Biological Science. 2010;5(4):52-8.
2. Quin FM. Realising the potentials of root crops in the 21st century: Modalities for Sub-Saharan Africa. In: Akoroda MO, Ngeve JM. (Eds.). Proceeding of the 7th Tri-ennial Symposium of the International Society for Tropical Root Crops - Africa Branch (ISTRAC-AB) held on Oct. 11-17, 1998. 2001;20-6.
3. Odeunmi EO, Oluwaniyi OO, Sanda AM, Kolade BO. Nutritional compositions of selected tubers and root crops used in nigerian food preparations. International Journal of Chemistry. 2007;17(1):37-43.
4. Echebiri RN, Edaba MEI. Production and utilization of cassava in Nigeria: Prospects for food security and infant nutrition. Production Agriculture and Technology. 2008;4(1):38-52.
5. Edeogu CO. Nitrate, sulphate, phosphate and chloride status of staple food crops, soil and water as indicator of environmental base anion pollution load in

- Ebonyi State, Nigeria. Journal of Biological Sciences. 2007;7(5):745-51.
6. Takahashi H, Watanabe-Takahashi A, Smith FW, Blake-Kalff M, Hawkesford MJ, Saito K. The roles of three functional sulphate transporters involved in uptake and translocation of sulphate in *Arabidopsis thaliana*. The Plant Journal. 2000;23:171–82.
 7. Onwurah INE, Ogugua VN, Onyike NB, Ochonogor AE, Otitoju OF. Crude oil spills in the environment, effects and some innovative clean-up biotechnologies. Int. J. Environ. Res. 2007;1(4):307-20.
 8. Vwioko DE, Anoliefo GO, Fashemi SD. Metals concentration in plant tissues of *Ricinus communis* L. (Castor Oil) grown in soil contaminated with spent lubricating oil. Journal of Applied Science and Environmental Management. 2006;10: 127-34.
 9. Wokocha GA, Emeodu D, Sopruchi I. Impact of crude oil spillage on soil and food production in Rivers State, Nigeria. Journal of Money, Investment and Banking. 2011;19:29-34.
 10. Uwah EI, Abah J, Ndahi NP, Ogugbuaja VO. concentration levels of nitrate and nitrite in soils and some leafy vegetables obtained in Maiduguri, Nigeria. Journal of Applied Sciences in Environmental Sanitation. 2009;4(3):233-44.
 11. Moses EA, Uwah EI. Effects of crude oil pollution on some soil fertility parameters in IkotOborenyin, IkotAbasi, Akwalbom State, Nigeria. Merit Research Journal of Environmental Science and Toxicology. 2015;3(2):17-24.
 12. Nelson DM, Sommers LE. Total carbon, organic carbon and organic matter. In: Park DLS (eds) Methods of soil Analysis part 3 – Chemical Methods, SSA Book Series, 5, Madeson, Wisconsin USA. 1996; 961-1010.
 13. Hutchinson TC. Preliminary studies on the effects of a stimulated oil spill on arctic terrestrial vegetation. Oil and the Canadian environment. In: Mackay D, Harrison W. (eds.) Proceedings-institute of Environmental sciences and Engineering. University of Toronto. 1973;142.
 14. Association of Analytical Chemists (AOAC). Official Methods of Analysis of the Association of Analytical Chemists. 14th Ed. AOAC. Inc. Arlington, Virginia, USA. 1999;53–5.
 15. Udo EJ, Ibia TO, Ogunwale JA, Ano AO, Esu IE. Manual of soil, plant and water analysis. Sibon Books Limited, Lagos; 2009
 16. Thomas GW. Exchangeable Cations, In: Methods of soil analysis- Part 2. Chemical and microbiological properties. 1996;9(2): 159-164.
 17. Gee GW, Bauder JW. Particle size analysis. In: Arnold Klte (eds). Method of soil Analysis, Part 1- Physical and mineralogical methods, SSSA Book Seria 5, Madison, Wisconsin, USA. 1986; 383-412.
 18. Radojevic M, Bashkin NV. Practical environmental analysis. Royal Society of Chemistry and Thomas Graham House, Cambridge. 1999;180–430.
 19. LaMotte. Smart spectro water and waste water procedure analysis manual. LaMotte Incorporated. 2000;68–180.
 20. Akan JC, Abdulrahman FI, Ogugbuaja VO, Ayodele JT. Heavy metals and anion levels in some samples of vegetable grown within the vicinity of challawa industrial area, Kano State, Nigeria. American Journal of Applied Sciences. 2009;6(3): 534-42.
 21. Harrison RM, Chirgawi MB. The assessment of air and soil as contributors of some trace metals to vegetable plants I. Use of a Filtered Air Growth Cabinet. Science of the Total Environment. 1989; 83:13–34.
 22. Akpoveta OV, Osakwe SA, Okoh BE, Otuya BO. Physicochemical characteristics and levels of some heavy metals in soils around metal scrap dumps in some parts of Delta State, Nigeria. Journal of Applied Sciences and Environmental Management. 2010;14(4):57–60.
 23. Boulding JR. Description and sampling of contaminated soils. A field Guide. 2nd Ed. Boca Raton, Lewis Publishers, FL. 1994; 5.
 24. Edema N, Obadoni BO, Erheni H, Osakwuni UE. Eco-phytochemical studies of plants in a crude oil polluted terrestrial habitat located at Iwhrekan, Ughelli North Local Government Area of Delta State. Nature and Science. 2009;7(9):49-52.
 25. Sauvé S, Hendershot W, Allen HE. Solid-solution partitioning of metals in contaminated soils: Dependence on pH, total metal burden, and organic matter.

- Environmental Science Technology. 2000; 34:1125–131.
26. Akan JC, Abdulrahman FI, Sodipo OA, Lange AG. Physicochemical parameters in soil and vegetable samples from gongulon agricultural site, Maiduguri, Borno State, Nigeria. Journal of American Science. 2010;6(12):78-87.
27. Zhou ZY, Wang MJ, Wang JS. Nitrate and nitrite contamination in vegetables in China. Food Reviews International. 2000; 16:61-76.

© 2015 Etim et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://sciencedomain.org/review-history/10696>