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Evaluation of two okra species [*Abelmoschusesculentus* (L.) Moench and *Abelmoschuscaillei* (A. Chev.) Stevels] exposed to crude oil contaminated soil in Auchi, Edo State, Nigeria

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Six accessions of cultivated okra [*Abelmoschus caillei* (A. Chev.) Stevels and *Abelmoschus esculentus* (L.) Moench] were evaluated for growth parameters in crude oil contaminated soil. Morpho-agronomic characters such as numbers of days from sowing to germination, dry and fresh weight of the accessions in both soil samples was determined. Others were copper (Cu), zinc (Zn), manganese (Mn), cadmium (Cd) and Lead (Pb) concentration in plant parts (leaves and fruits). The growth responses of the different accession varied considerably. Soil chemical analysis revealed decreased levels of pH, phosphorus and potassium in the contaminated soil. The chemical analysis of plants grown in these soils showed that heavy metals like Cu, Zn, Mn, Cd and Pb were present in all the organs of the accession.

Key words: Crude oil, soil, growth parameters, *Abelmoschus esculentus*, *Abelmoschus caillei*, heavy metals.

INTRODUCTION

Okra is a widely cultivated vegetable in tropical and subtropical regions where it is grown for its leaves, fruits, seeds, flora parts and stems. These are edible when young and succulent and dried in powdery form. In these regions, the fresh unripe and tender pods (fruits) are sliced, grated, boiled or steamed or fried and beaten into a gelatinous soup. This soup facilitates the swallowing of relatively rough or coarse textured starchy foods (Schippers, 2000). It is also used raw in salads with egg plants. The mucilaginous exudes is an excellent thickener for stews and soups. The leaves are eaten as spinach; sun dried whole or sliced. Fruits are conserved for year-round consumption. Seeds are removed from the matured pod and sun dried. These are made into powder and used for flavoring. The genus *Abelmoschus* is said to have originated from South East Asia (Hamon and Hamon, 1991). The basis for this claim was because wild relatives abound there. Siemonsma (1991) recognized nine species in *Abelmoschus* based on cytogenetic evidence. The morphological characters such as number, dimensions and persistency of the epicalyx segment, form and dimensions of the capsule (including pedicel) and characteristics of the indementums are unique. In West Africa, the wide varieties of okra cultivars are of two distinct species, the common okra, *Abelmoschus esculentus* (L) Moench and West African okra *Abelmoschus caillei* (A. chev.) Stevels (Charrier, 1984).

A. esculentus is adapted to the Sudano-sahelian zone and the *A. caillei* is referred to as Guinean type in relation to its zone of cultivation (Charrier, 1984; Chedda and Fatokun, 1991; Schippers, 2000). This study focuses on these two cultivated species. Osawaru and Dania-Ogbe

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Table 1. *Abelmoschus* accessions used in the study, their origin and location.

Accession	Origin	Latitude and longitude
47-4	NIHORT	07° 22' N; 03° 52' E
LD-88	NIHORT	07° 22' N; 03° 52' E
OS/AC/001	Benin	06° 20' N; 05° 37' N
OS/AC/002	Benin	06° 20' N; 05° 37' N
OS/AE/006	Benin	06° 20' N; 05° 37' N
OS/AE/OO7	Benin	06° 20' N; 05° 37' N

(2010) reported that both species are wide spread between 12°N and 12°S and most commonly found between 5 and 12°N. The common okra is mainly grown for market gardening in areas with limited rainfall, sometimes under irrigation. West African okra, found throughout the high rainfall zone is cultigens of the region where it is liked for its ability to draw-well. Both are grown mainly for subsistence economy. Cytologically, Singh and Bhatnagar (1975), Siemonsma (1982), Ariyo (1993) and kehinde (1999) reported that West African okra contain 194 diploid chromosomes as against 130 of the common okra thereby indicating that West African okra is a separate species. However, there are overlapping characters in these features that are not clearly or exclusively defined (Josh and Hardas, 1976). *A. caillei* is highly polymorphic and unique in fruit and indumetum characters. The nutritional, industrial and cultural roles of these okra species is documented by Siemonsam and Hamon (2002), Schipper (2000), Grubben (1977), Obire (2002), Chevalier (1940) and Charrier (1984).

In this present study, we investigated the growth performance of *Aesculentus* and *A. caillei* in crude oil contaminated soil to access the metal sink. and Onofeghara (1984) and Udo and Fayemi (1975) reported that "at high concentrations of oil in soils, most plant species suffers serious depression in growth which has been attributed to poor soil conditions, dehydration and impaired nutrient uptake by the roots even when they are present, they are not usually in the absorbable form (ions) rather they are present as compounds. This is created by the presence of crude oil". Wong et al. (2001) reported that acidic condition (pH) favors nutrients absorption and availability of some heavy metals. The bioavailability of components of the contaminants in the plant parts (fruit and leaves) was also determined. Crude oil in soil makes the soil condition unsatisfactory for plant growth.

MATERIALS AND METHODS

Study area

The study area lies within the humid tropical rainforest vegetation at the Experimental Plot of the University of Benin, Department of Plant Biology and Biotechnology (6.20°N and 5.37°E) in a completely randomized block experimental design. Soil sample for the study were obtained from Auchi (7.04°N and 6.16°E), located at the Northern axis of Edo State, Nigeria. It lies within the derived savannah vegetation.

Plant collections

The accessions obtained from home gardens in Benin City were made and identified based on the identification given by the gardeners due to their high yield and superior quality (Table 1). Further identification was done using IBPGR (1984) and Stevels (1988, 1990).

Soil collection and analysis

Two samples of about 100 kg each were collected at the premises of Nigeria National Petroleum Corporation (NNPC) sub-station measuring 2 × 2 km^2 in Auchi. One of the soil samples was collected 30 m away from a site that was reported to have been contaminated with crude oil in February, 2008 during a test run on newly fixed pipelines. The crude oil was reported to have overflow from a pit of about (60 × 60 × 30) m^3 into adjoining farms from a radius distance of 100 m^2 away from the terminal point of the spill. After seven days, 2.75 kg of each soil was prepared and transferred into thirty polythene bags for field trials. The two soil samples collected for experimentation were subjected to soil analysis at the Soil Science Laboratory, Nigerian Institute for Oil Palm Research (NIFOR). The method used for the analysis is as outlined by Ogunwale and Udoh (1990). Total elemental content, organic nutrient and presence of heavy metals were determined.

Planting and plant husbandry

The 30 bags from the two soil samples were transferred to the experimental plot. Two plots of (6 × 3) m^3 one each for the contaminated and control were demarcated on the site with a distance of 3 m apart, spacing bags was done 7 m in each plot. These bags were left on the field for seven days before planting was done. Seeds of the six accessions collected were subjected to floatation test and viable seeds were selected for field trials. Planting was done simultaneously on the two plots. Bags for each soil sample were arranged in a randomized block design and each accession with five replications. Crops were rain fed throughout the period of experimentation. There was no fertilizer application during trials. After 2 weeks of sowing, each stand on both plots (where germination occurred) were thinned to a plant per stand. Weeding was done weekly. Pest control was done using methods outlined by Osawaru and Dania-Ogbe (2010).

Determination of germination and germination percentage

Daily visit was made to the plots for 14 days. Emerged seedlings

Table 2. The chemical properties of the two soil samples.

Soil sample	% (ppm)						Meq/100 soil				
	pH	C	N	P	Na	K	Ca	Mg	H+	Al+	ECEC
Control	7.7	0.93	0.10	11.25	0.34	0.24	9.60	3.84	0.10	0.00	14.12
Contaminated	7.6	1.38	0.14	6.41	0.35	0.13	9.84	3.90	0.10	0.00	14.32

Soil sample	mg/kg soil							
	Cu	Mn	Pb	Fe	Zn	Cr	Ni	Cd
Control	2.79	1.46	3.56	7.58	2.69	0.13	-	0.78
Contaminated	7.26	5.54	8.44	50.60	5.58	0.49	-	1.46

Table 3. The particle size analysis in percentage of the two soil samples.

Soil sample	Clay (%)	Silt (%)	Sand (%)
Control	4.10	1.70	94.20
contaminated	3.10	4.70	92.20

were counted in each plot and from each bag for the accessions and percentage determined using method outlined by Osawaru and Dania-Ogbe (2010).

Analysis of data and plant organs composition

Plant parts (leaves and fruits) from the six accessions grown in the control and contaminated soil samples were harvested. Leaves from the third to fifth nodes and the first fruits of the accessions were harvested and weighed fresh. The parts were oven dried for three days. After which the dry weight of the samples were taken. The oven dried materials were ground using an electric grinding machine. The ground samples were then subjected to heavy metal analysis using dry ash method as outlined by Ogunwale and Udoh (1999) at the Nigerian Institute for Oil Palm Research near Benin City, Nigeria. All the data obtained in the study was subjected to analysis using Microsoft Excel 2007 windows.

RESULTS

Chemical analysis of soil

The result of the soil samples used for the study is presented in Tables 2 and 3. The values obtained for C, N, I, Na, Ca, Ma and ECEC were higher in the crude oil contaminated soil. The values obtained for P and K were higher in the control. $A1^+$ was undetected in both soil samples H^+. The pH value of the contaminated soil was slightly closer to mental value than the control uncontaminated soil. The particle size analysis (Table 2) shows that the contaminated soil had less clay and more silt in comparison with the control soil.

Germination and germination percentage

The results of germination are presented in Figures 1 and 2. The result from the control soil shows that OS/AC/001, OS/AE/006 and OS/AE/007 had high percentages when compared with other accessions while that obtained from contaminated soil showed low germination percentages. Figures 3 and 4 show the concentration of Cu in the leaves and fruits of okra accessions. In the control and contaminated soil, OS/AC/001 and OS/AC/002 had no Cu in their fruits. Accession OS/AC/002 had the highest amount of Cu concentration in the control soil with accession OS/AE/006 having the highest value in the contaminated soil. Accession LD-88 and OS/AE/006 had the highest concentration of copper in their fruits in the contaminated and control soils, respectively. Figures 5 and 6 show the concentration of Zn in the leaves and fruits of okra accessions. In the control, soil LD-88 had the highest concentration of Zn in leaves and fruits. In the contaminated soil, OS/AE/007 had highest amount Zn in the leaves while accession LD-88 had the highest concentration of Zn in the fruits. Figures 7 and 8 shows the concentration of Pb in the leaves and fruits of okra accessions. In the control, soil OS/AE/006 had the highest concentration of Zn in leaves while 47-4 had the highest concentration in the fruits. In the contaminated soil, LD-88 had highest amount of Pb in the leaves while accession 47-4 had the highest concentration of Pb in the fruits.

Figures 9 and 10 shows the concentration of Cd in the leaves and fruits of okra accessions. In the control, soil OS/AE/006 had the highest concentration of Cd in leaves while LD-88 had amount in the fruits. In the contaminated soil, OS/AC/001 had the highest amount of Cd in the leaves while accession 47-4 had the highest concentration of Cd in the fruits. Figures 11 and 12 show the concentration of Mn in the leaves and fruits of okra accessions. In the control, soil OS/AC/001 had the highest concentration of Mn in leaves while 47-4 had

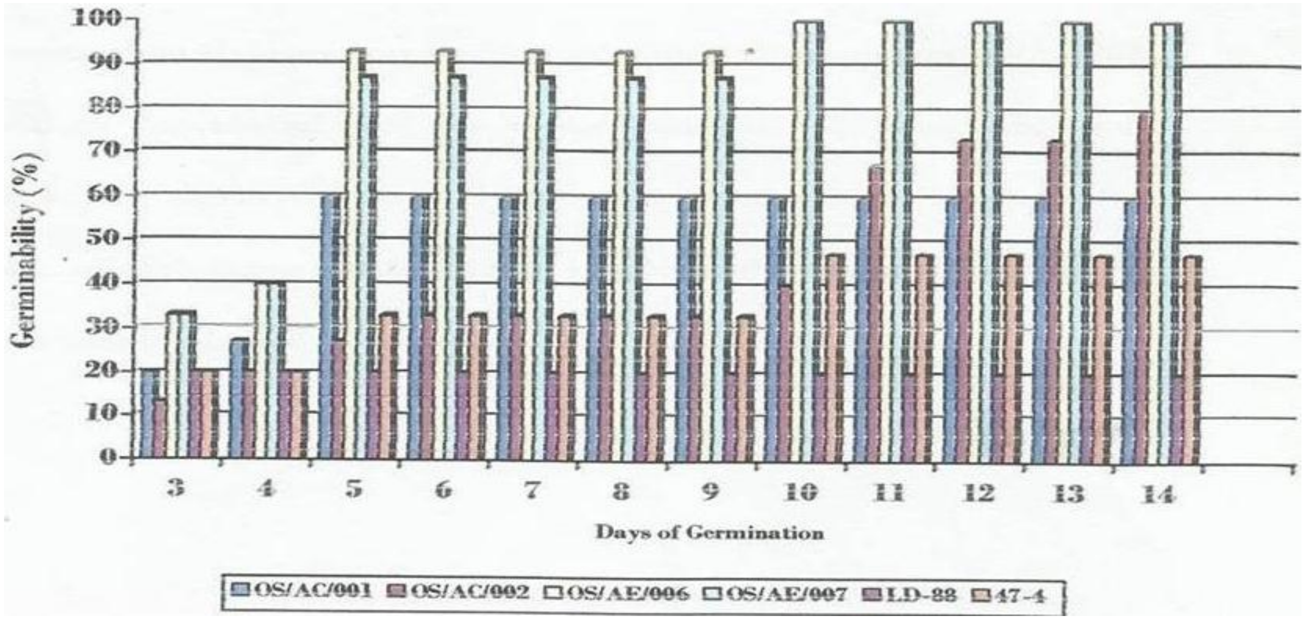

Figure 1. Germination percentage in control soil. Germination was initiated on the third day. Accession OS/AC/001, OS/AE/006 and OS/AE/007 had higher germination percentages than the other accessions.

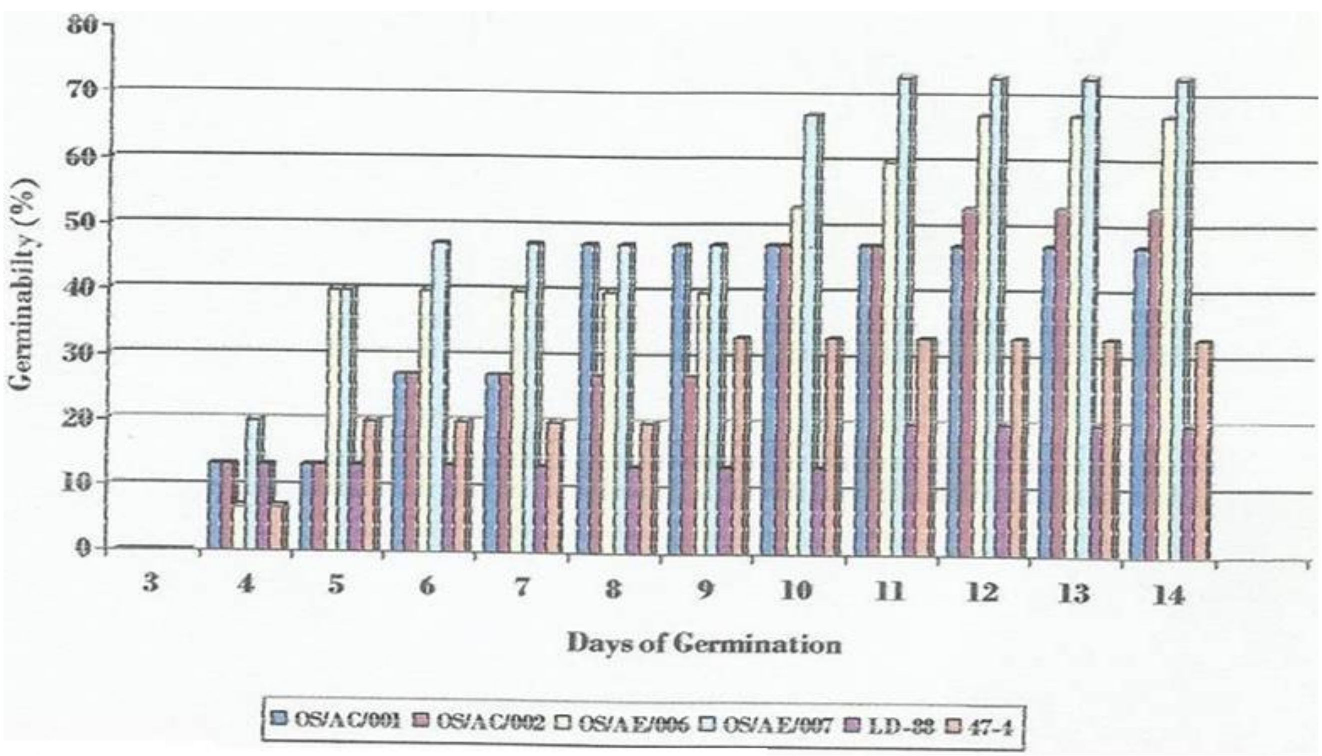

Figure 2. Germination percentage in the crude oil contaminated soil. Germination was initiated on the fourth day. Accession LD-88 and 47-4 never attained 50% germination.

amount in the fruits. In the contaminated soil, OS/AC/001 had the highest amount Mn in the leaves while accession LD-88 had the highest concentration of Mn in the fruits. Table 4 shows the fresh and dry weight of harvested

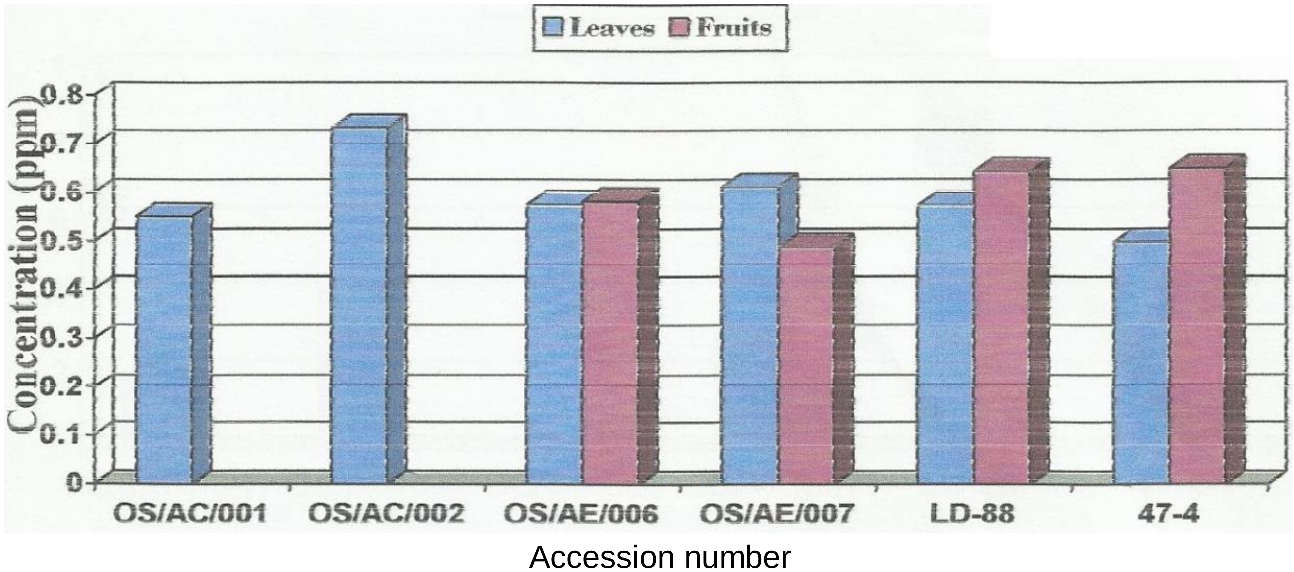

Figure 3. Concentration of copper in the leaves and fruits of the six accessions in control soil sample.

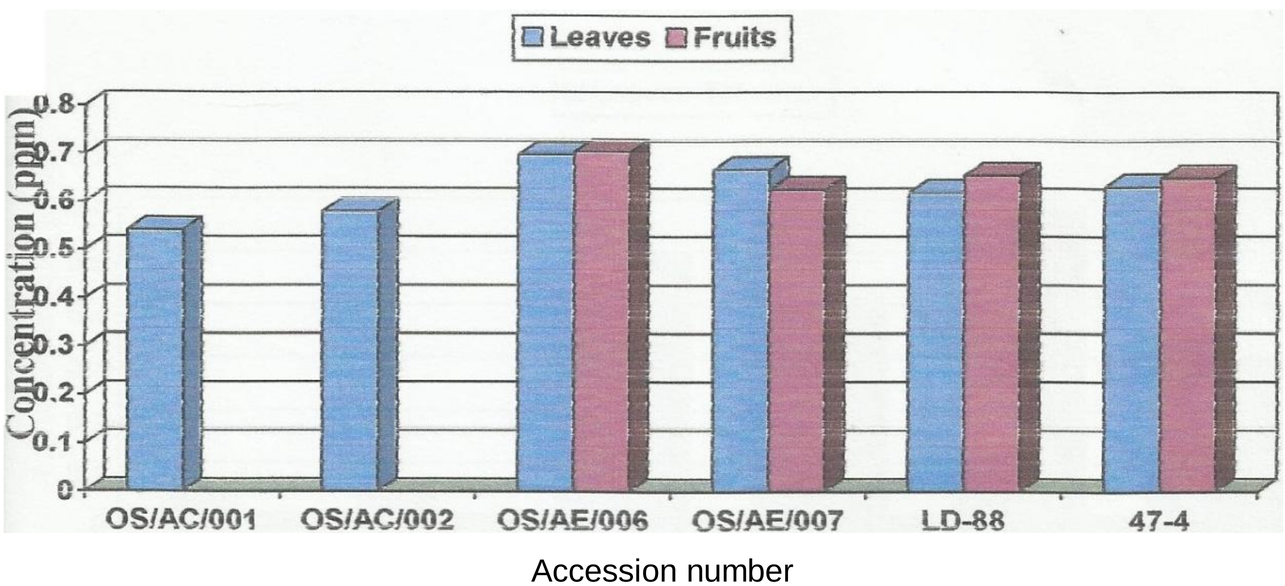

Figure 4. Concentration of copper in the leaves and fruits of the six accessions grown in contaminated soil sample.

organs of the okra accessions in the control and contaminated soil. The highest fresh weight of fresh fruit and leaves was obtained from OS/AE/006.

DISCUSSION

Growth in plants is generally adversely affected when exposed to crude oil (Baker, 1970; De-jong, 1980). The degree to which the plant growth is affected depends greatly on the level of contamination (Anoliefo, 1991). Similarly, the growth of six accessions especially those of the land races (OS/AC/001, OS/AC/002, OS/AE/006 and OS/AE/007) were generally mostly affected in the crude oil contaminated soil. The substantial damage on the soil by the crude oil was observable in the cultivated accessions of common okra and West African Okra. In the control soil: OS/AC/001, OS/AC/002, OS/AE/006 and OS/AE/007 showed variation in growth and development from the growth in the contaminated soil. It can be suggested that the depression in growth is as a result of the poor soil condition occasioned by the crude oil.

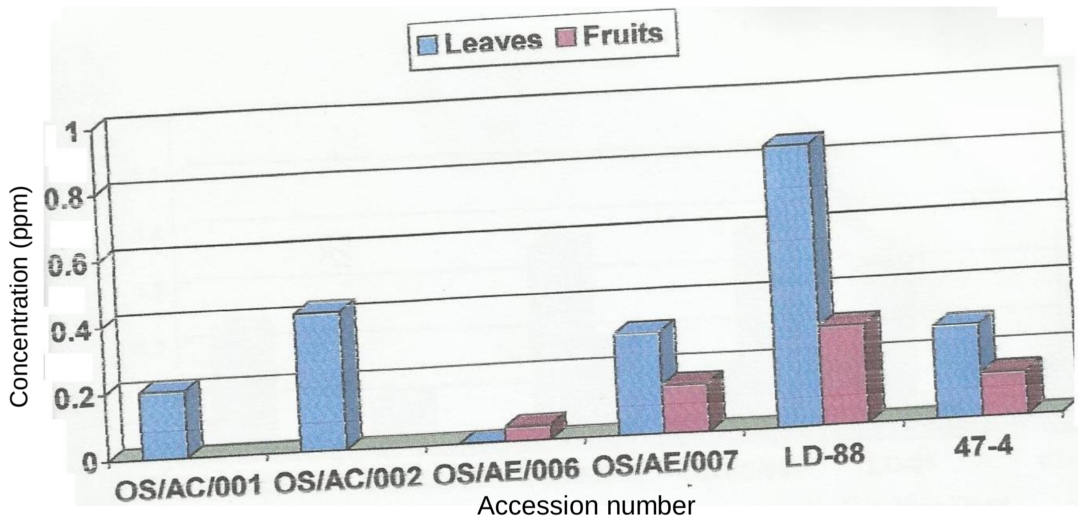

Figure 5. Concentration of zinc in the leaves and fruits of the six accessions grown in the control soil sample.

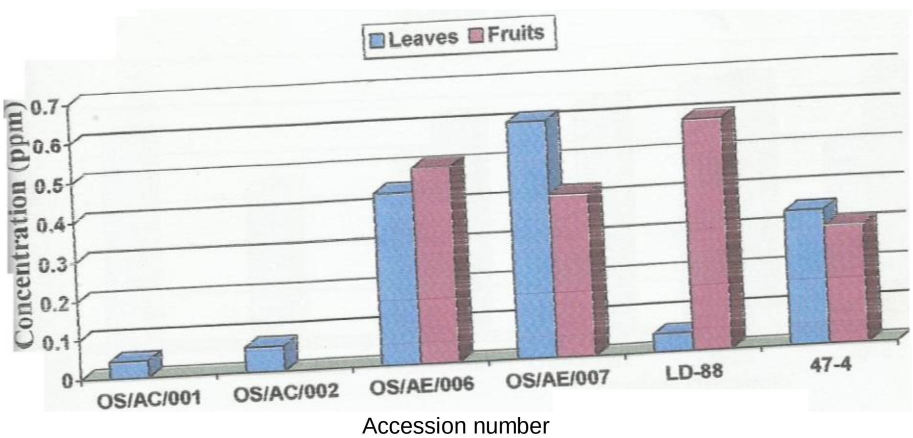

Figure 6. Concentration of zinc in the leaves and fruits of the six accessions grown in the contaminated soil sample.

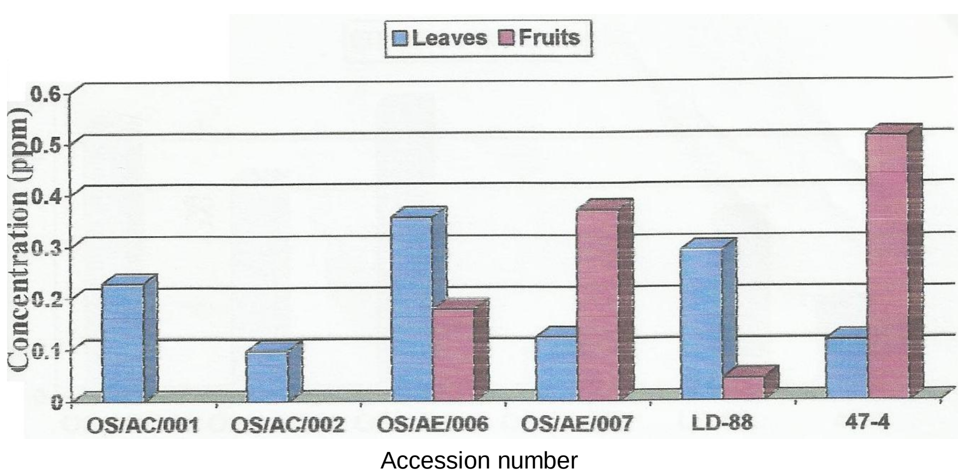

Figure 7. Concentration of lead in the leaves and fruits of the six accessions grown in the control soil sample.

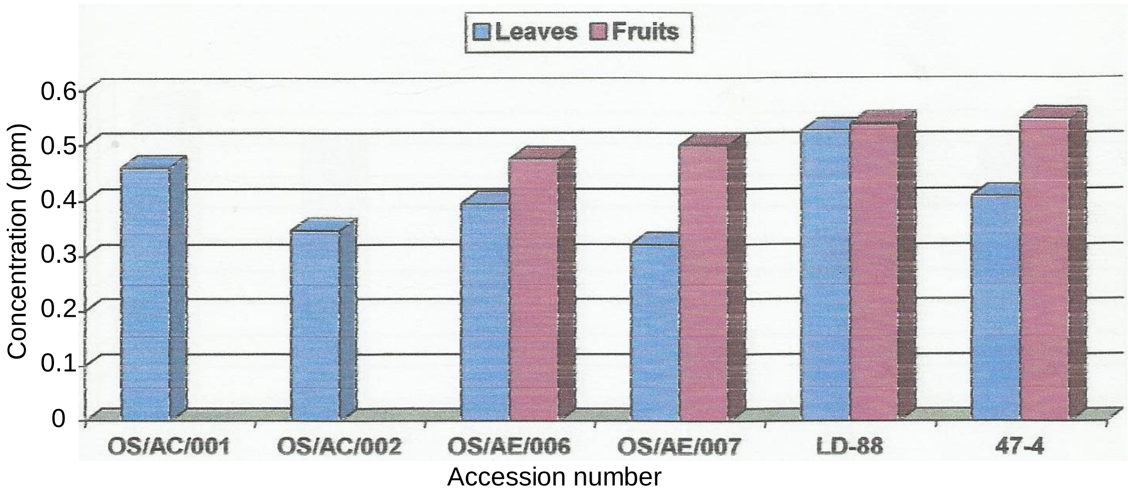

Figure 8. Concentration of lead in the leaves and fruits of the six accessions in contaminated soil sample.

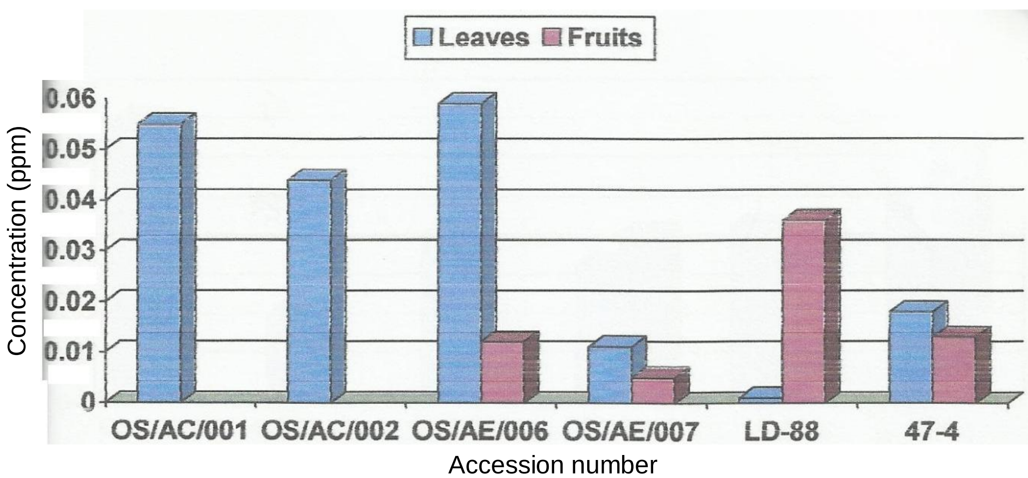

Figure 9. Concentration of cadmium in the leaves and fruits of the six accessions grown in control soil sample.

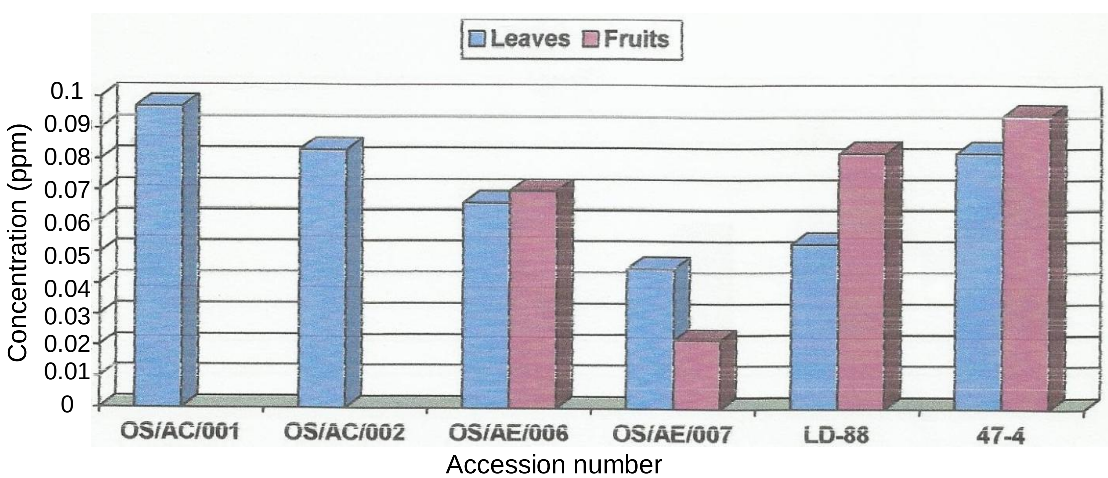

Figure 10. Concentration of cadmium in the leaves and fruits of the six accessions in contaminated soil sample.

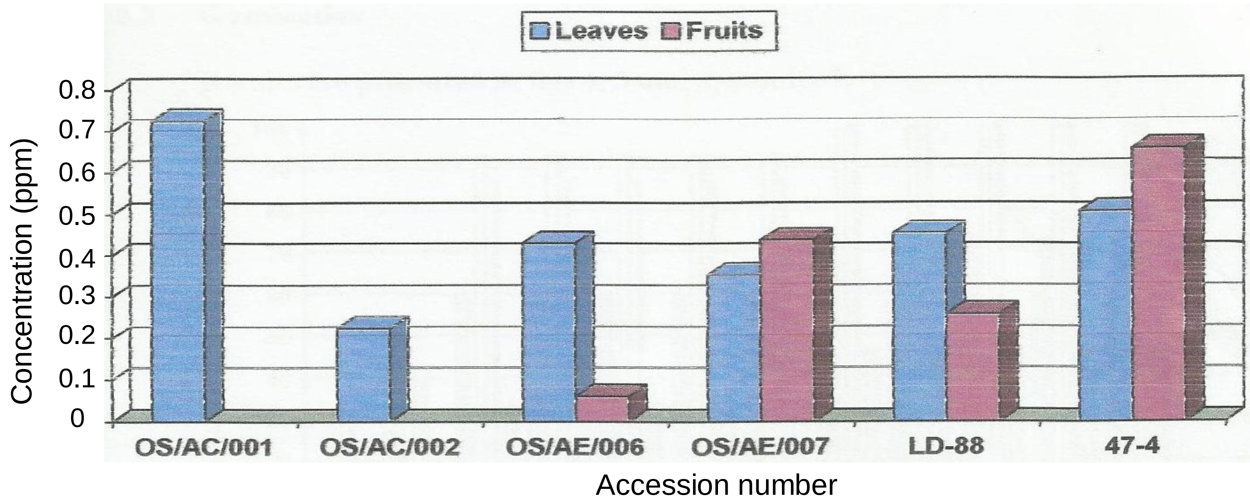

Figure 11. Concentration of manganese in the leaves and fruits of the six accessions grown in control soil sample.

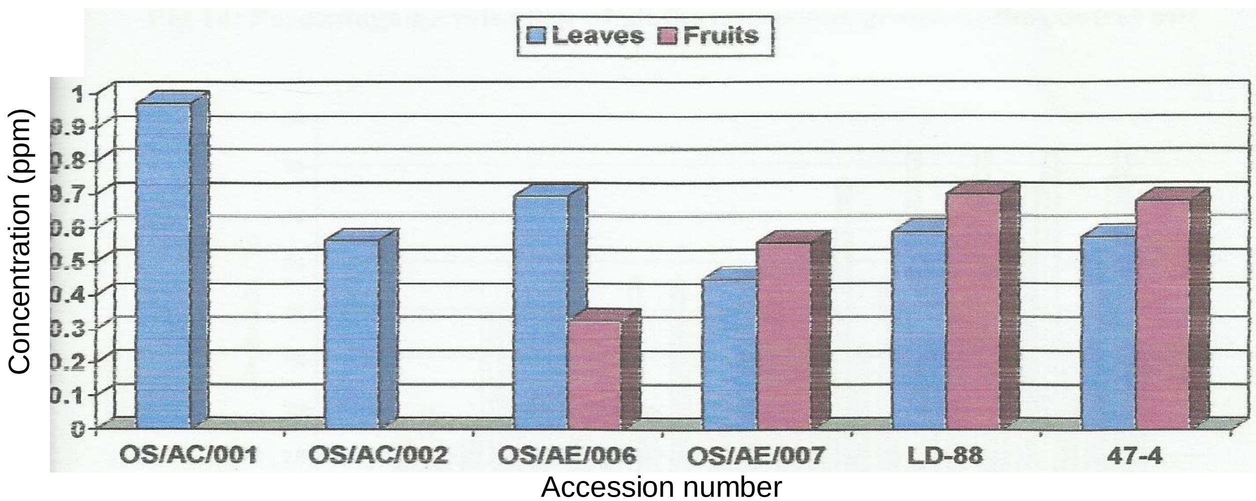

Figure 12. Concentration of manganese in the leaves and fruits of the six accessions grown in contaminated soil sample

However, accession LD-88 and 47-4 had little or no variation in germination growth and development in both soil samples. The analysis of the soil sample used in this study showed that the chemical elements Na, N and the ion H^+ in both control and the contaminated soil samples had no significant different. The concentration of C, P and K was observed to be higher in the control soil than in the contaminated soil. Ca, Mg, Mn, Pb, Fe, Zn, Cr, Cd and Cu concentrations were higher in the contaminated soil compared to the control (uncontaminated) soil. Ni and Al^{3+} were not detected in both soils (Table 2).

The soil pH was alkaline, 7.7 in control and 7.6 in contaminated soil. It can be suggested that contamination of alkaline soils tends to reduce the soil pH to a less alkaline or a neutral one. This is in agreement with the report of Vwioko et al. (2008) which states that crude oil contamination of soil increases the pH of the soil from acidic to neutral. Similarly, the particle size analysis of the two soil samples showed that crude oil contamination of soils may be responsible for the difference in the soil silt content.

Germination was initiated in the third day by the six accessions in the control soil sample with a gradual increase of percentage germination recorded day by day. Accessions OS/AC/001, OS/AE/006 and OS/AE/007 had 60 and above germination percentage on the fifth day which is in accordance with FAO (1998) recommended seed standard for agronomic practice.

The reverse was observed for accessions OS/AC/002 which had above 50 on the eleventh day LD-88 and 47-4 which did not have up to 50% germination percentage eve on day 14. In the contaminated soil, germination

Table 4. Fresh and dry weight of harvested plant organs from six accessions of okra grown in crude oil contaminated and control soil.

Accession number	Treatment	Fruit		Leaves	
		Fresh (g)	dry (g)	Fresh (g)	dry (g)
OS/AC/001	Control	-	-	2.70	0.77
	Contaminated	-	-	2.95	0.45
OS/AC/002	Control	-	-	3.00	1.00
	Contaminated	-	-	2.10	0.58
OS/AE/006	Control	6.54	1.00	3.20	0.82
	Contaminated	4.90	0.29	3.00	0.22
OS/AE/007	Control	6.50	0.89	3.00	0.54
	Contaminated	4.73	0.41	3.22	0.39
LD-88	Control	6.52	1.00	2.00	0.89
	Contaminated	5.55	1.00	2.00	0.65
47-4	Control	6.00	1.00	2.00	0.41
	Contaminated	5.00	0.87	2.06	0.40

was imitated on the fourth day in the six accessions. It took accessions OS/AE/006 and OS/AE/007 twice the number of days that was needed for them to attain 50% germination in the contaminated soil. OS/AC/002 had above 50% on the fourteenth day, OS/AC/001 was unable to reach 50% germination on the fourteenth day while accessions LD-88 and 47-4 never up to 50% germination, the same percentage germination was maintained with that of the control soil sample. The relatively low germination percentage of LD-88 and 47-4 in both soil samples may be due to the revival of the seeds from the storage bank of NIHORT two months before planting. During this period, the seeds were stored at a room temperature which may have induced shock on them. This may have resulted in low percentage germination. The fresh weights of fruits and leaves of the four accessions of *A. esculentus* exhibited a strong response to the crude oil contaminations. Among these accessions, the fruits and leaves of OS/AE/006 and OS/AE/007 grown in control soil gave weight values that were considerably higher than those from plants in the contaminated soil. The harvested plant parts of accessions LD-88 and 47-4 showed a little variation in weight for parts grown in both soil samples. Higher moisture content of parts was recorded for the control plants than in the contamination soil.

The contaminants in the soil may be responsible for the water content of plant parts hamster plant grown in the contaminated soil. There were observable differences on the dry weights of harvested plant parts in both soils are plants harvested from the control soil gave higher values. The leaves of both *A. caillei* accessions had higher dry weight values when compared with the four accessions of *A. esculentus* growth in both soils; highest values were recorded with the accessions in the control soil.

In conclusion, the environment is constantly affected by human activities. By-products and products of these activities especially from mining and oil exploration are deleterious to man and other biodiversity especially when released into the environment. They serve as a cycling matter in the ecosystem. Okra as a plant biodiversity has been shown to be vulnerable to crude oil in this study and when grown in soil polluted with crude oil, are likely to be contaminated with heavy metals and unsafe for human consumption due to the storage of these heavy metal on the edible parts.

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