

## Effects of some anthropogenically induced environmental hazards on soil fertility indices, germination and growth of maize and soybeans in Imo State, Nigeria

Ubuoh E. A.\* and Ogbonna P. C.

Department of Environmental Management and Toxicology (EMT)  
Michael Okpara University of Agriculture, Umudike, P.M. 7267, Abia State

\*Corresponding Author (Email: ubuohemmanuel@yahoo.com)

### ABSTRACT

Soil quality assessment is essential for evaluating agro-ecosystems for sustainable food security, but human activities have threatened the soil functionality for agriculture. Therefore, there is need to gather information on environmental hazards such as soil erosion, oil spill, gas flare and waste dumpsites. This was achieved through the analysis of soil and planting of Maize and Soya beans using greenhouse, respectively in sites as: Amucha erosion (SSP<sub>1</sub>), Ohaji/Egbema gas flare (SSP<sub>2</sub>) and oil Spill (SSP<sub>3</sub>), Naze waste dump (SSP<sub>4</sub>) and controls (CSSP<sub>5</sub>). Soils for planting were collected and treatments were replicated five times and data collected were analyzed using ANOVA for RCBD and means separated using F-LSD. Results showed that particle size ranged from 38.7gkg<sup>-1</sup> for silt- 860 gkg<sup>-1</sup> for sand. Sand dominated with no significant (P>0.05) change in particle size in the four locations: SSP<sub>1-4</sub> and CSSP<sub>5</sub> as controls in each site. Mean Soil pH (H<sub>2</sub>O) in degraded sites recorded 5.4 and pH5.5 for control. There were reductions in total nitrogen, available phosphorous, exchangeable cations (Ca<sup>2+</sup>, K<sup>+</sup>, Mg<sup>+</sup>, Na<sup>+</sup>) in the degraded soils affected by human activities. Organic carbon recorded was in the order; Egbema oil spill site (18.7g/kg<sup>-1</sup>) > control (9.2g/kg<sup>-1</sup>) > Naze dump site (7.8g/kg<sup>-1</sup>) > Egbema gas flare site (5.8g/kg<sup>-1</sup>) > Amucha erosion site (4.2g/kg<sup>-1</sup>). The abundance of CEC was in the order: erosion site > Control > gas flare site > oil spill > dumpsite. Germination and growth of maize and soybean were significantly affected by the degraded, with oil spill having zero germination. Farmers are advised not to cultivate degraded soils until effective remediation is carried out and to adhere to conservation agriculture.

**Keywords:** Oil spill, waste dumpsite, Soil erosion, gas flare, Crops.

### INTRODUCTION

One of the most important driving forces of soil degradation are human activities (Bahrami *et al*, 2010), and these activities often influence the natural processes in soil. This change has many interlink effects that can appear through the reduction of chemical and physical qualities of the soil resources. Soil degradation results in decline in soil quality and reduction in its

productivity and environmental regulatory capacity (Wiebe, 2003), and it is one of the most destructive and certainly most extensive phenomena worldwide and is being recognized as a key issue affecting global food security (Tan *et al*, 2005).

Soil degradation is often associated with soil erosion (Oldeman, 1997), gas flaring (Ubuoh, 2012), oil spillage and

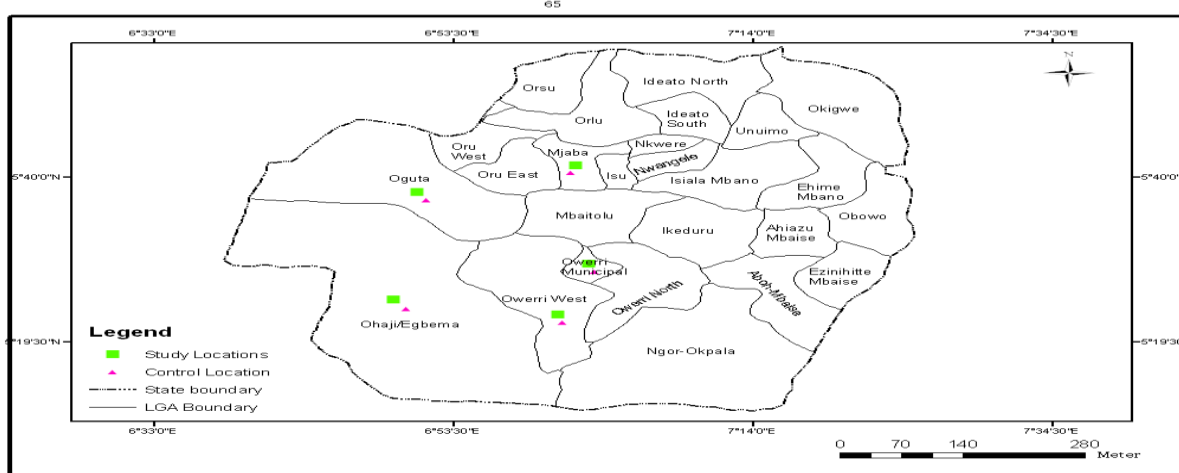
indiscriminate solid wastes dumping (Eneje *et al.*, 2002; Ubuoh *et al.*, 2010), rapid population growth with consequent urbanization and industrialization. These situations have resulted in difficulty in meeting dietary needs by inhabitants as well as reduced preferences for choice of farm products (FAO, 2003). Farmers in these areas have been forced to give up their farmlands, leading to serious implications on food production and livelihoods of the people. The effect of environmental pollution on crops are still very scanty and inadequate in Imo State. Therefore, the need to determine the level of pollution at which the growth and yield crops adversely affected cannot be overemphasized. Hence, the effects of anthropogenic activities on soil

quality with regard to germination and growth of maize and soybean respectively. This provides a basis for farmers and extension officers for food security.

## MATERIALS AND METHODS

### Study Area

The study located between latitude  $4^{\circ} 45^1$  and  $7^{\circ} 15^1$  N and Longitudes  $6^{\circ} 5^0$  and  $8^{\circ} 15^1$  E (Figure 1). Imo state covers an area of  $5,100 \text{ Km}^2$  (Okorie *et al.*, 2012), with a population of about 3,927,563 (Okorie *et al.*, 2012), with mean annual rainfall of about 2500 mm and annual temperature range of  $26\text{-}30^{\circ}\text{C}$  (NIMET, 2014), with relative humidity is generally high in the area especially during rainy seasons.



**Figure 1: Map of Imo state showing study locations**

### Site Selection and Sampling

Sites were selected for the study designated as soil sample point ( $\text{SSP}_{1-4}$ ) as degraded areas and control soil sample points ( $\text{CSP}_{1-4}$ ) as non-degraded areas to include: Amucha Erosion Site ( $\text{SSP}_1$ ), Ohaji/Egbema Gas Flare Site ( $\text{SSP}_2$ ), Egbema oil spill site ( $\text{SSP}_3$ ), Naze waste dumpsite ( $\text{SSP}_4$ ) and Control soil sample ( $\text{CSP}_5$ ) at Amucha Erosion Control Site for Amucha Erosion Site ( $\text{CSP}_1$ ),  $\text{CSP}_2$  and  $\text{CSP}_3$  at Ogbaku for Gas Flare and Oil Spill Sites, and  $\text{CSP}_5$  at Agbala for Naze Waste

Dumpsite. Each of the sites = replicated 4 times according to their topographic position: upper slope (L1, L2, L3, L4), middle slope (L1, L2, L3, L4) and lower slope (L1, L2, L3, L4) giving rise to a total of 36 pots filled with the topsoil from the location from 3 topographic positions.  $\text{UML} \times 4$  replications for each degraded site for maize and 36 pots for soybean were mounted respectively. The planting bags with a uniform weight of 2 kg each were arranged and labeled in the Screen House. The same arrangement was carried out on potted

unpolluted soils which served as control. The oil spill site was not considered because there was no germination. All the treatments and the control planting bags were watered using 50 ml of water for three consecutive days, at 7:00 GMT. After this, three seeds of maize and soybean were planted in each of the planting bag in all the treatment and the control experiment. Watering was continued daily at 7:00 GMT.

### Sampling Procedure

Soil samples were collected at the depths of 0-15cm, 15-30 cm from each of the study locations and control being secondary forest at a distance of 100 cm way from each of the sites with soil auger. Samples were air-dried and passed through 2 mm and 0.5 mm sieves.

### Determination of Soil physical properties

Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Bulk density was determined using core method (Grossman and Reinsch, 2002). Saturated hydraulic conductivity was determined in the laboratory using constant head permeameter (Young, 2000).

The saturated moisture content (SMC) percentage of soil was calculated using the formula:

$$SMC = \frac{\text{Mass at saturation} - \text{Oven dried mass}}{\text{mass of dried soil}} \times 100 \text{ ----(1)}$$

### Determination of Soil Chemical Properties

Soil samples used for analysis were taken from four study locations and four control sites from each study locations making eight (8) soil samples each constituting bulk soil sample. Soil pH was determined using 1:2.5 soil/liquid (water) ratio (Thomas, 1996). Organic carbon was determined by the Walkley and Black procedure as described

by Nelson and Sommers (1982). Available phosphorus was determined using Bray-2 method (Olsen and Sommer, 1992). The exchangeable bases ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$  and  $\text{Na}^+$ ) were extracted with 1N ammonium acetate solution (Maclean, 1965). Total nitrogen was determined by macro Kjeldahl method as described by Bremner (1996). Cation exchange capacity (CEC) was determined by washing the  $\text{NH}_4$  saturated soil sample free from  $\text{NH}_4\text{OAC}$  (Rhodes, 1982). Exchangeable Sodium Percentage (ESP) was used as an index of sodium concentration and was calculated as follows:

$$ESP = \frac{Al}{ECEC} \times 100 \text{ ----(2)}$$

Percentage Base Saturation (PBS) was obtained by dividing sum of exchangeable bases by cation exchange capacity and multiplying by 100.

$$PBS = \frac{\text{Ca}^{2+} + \text{Mg}^{2+} + \text{K}^+ + \text{Na}^+}{CEC} \times 100 \text{ ---- (3)}$$

### Greenhouse Experimentation

The study was carried out at the greenhouse of the Department of Soil Science, Federal College of Land Resources Technology Owerri. Soil samples for the pot experiment were collected from degraded and non-degraded sites for the planting of the test crops. Thereafter, 2.5kg each was weighed into the plastic polythene bags used for the planting of maize and soybean seeds. Improved varieties of maize (*Zea mays*) and soybeans (*Glycine max*) (TGX 728-ID) were sourced from National Root Crops Research Umudike. Improved varieties of maize (*Zea mays*) and soybeans (*Glycine max*) were sourced from National Root Crops Research Umudike. Two (2) seeds were sowed per pot/polythene bag and later thinned down to one (1) stand per pot, two weeks after planting. The inter row and intra row spacing of 0.75m by 0.25m was assumed, since it was a potted experiment, thus giving

a plant population of about 53,333 and 88,888 plants per hectare for maize and soybeans respectively.

### Experimental Design

In the greenhouse study, bulked soil samples collected from AP horizon in each sampling units of the study site was maintained at field capacity (20% gravimetric moisture content) and planted with maize and soya bean in a Completely Randomized Design (CRD) with each treatment replicated 9 times. Growth characteristics were measured at intervals of 4, 8 and 12 weeks after maize and soybean seeds were also sown. Except for seedling emergence that was done at intervals of 4, and 6 days after planting (DAP). Plant height, girth, number of leaves and leaf-area were measured. The number of seeds that germinated were counted daily from four days after planting (DAP), and germination was considered complete on any given pot/polythene bag once there was no further increase in the number of seedlings after 4 to 6 days. The germination percentage was obtained thus:

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds planted}} \times 100 \text{ ---- (4)}$$

The numbers of fully mature and non-senescent leaves per plant were counted starting from 4 to 12 weeks after planting (WAP). Plant height was measured to the nearest centimeter from the base of the plant to the base of unopened apical leaf at 4, 8, and 12 WAP using measuring tape. Leaf areas per plant were determined non-destructively from 4 to 12 weeks after planting (WAP) by length x width method. The diameter of crop girth was measured at the first nodal point at the base of the plant.

### Statistical Techniques

Data on soil physicochemical characteristics and grains measurements were subjected to

Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) software and General statistics discovery (GENSTAT) 3<sup>rd</sup> edition. Significant means were separated using the Least Significant Difference (LSD) at probability level ( $p < 0.05$ ).

## RESULTS

### Physical Properties of the Soil in the Study Area

#### Soil particle size

Sand ranged between 800-860g/kg, with Egbema oil spill site recorded the lowest value and Naze waste dump site being the highest. But control recorded sand content than erosion site. Significantly ( $P < 0.05$ ) higher sand values were recorded in soils of Naze waste dump site than in Egbema gas flare site. The mean value silt ranged between 38.7-56 gkg<sup>-1</sup>, with soil erosion recording low value and oil spill site having highest value against control site recording 49.9 gkg<sup>-1</sup>. clay -size particles ranged from 96.0 g/kg at Naze waste dump site to 148.1 g/kg at Agbala as a control. The least mean values were obtained in silt content which ranged from 38.7g/kg at Amucha erosion site to 66.3 g/kg at Egbema gas flare site (Table 1).

#### Moisture content (MC)

Moisture content ranged between 13.23-14.54%, with soil erosion having the low mean value and oil spill site with highest value, all above the control site having the lowest value of 3.24%, with control with 17.06 being the highest value (Table 1). Moisture content from control site was however, significantly ( $P < 0.05$ ) higher than values obtained from degraded sites.

#### Bulk density (BD)

Soil bulk density varied significantly ( $P < 0.05$ ) among the degraded sites with

Egbema gas flare site having higher value (1.78mg/m<sup>3</sup>) when compared with Amucha and Naze (1.60mg/m<sup>3</sup>) respectively and Egbema gas spill (1.27 mg/m<sup>3</sup>). These mean values were significantly (P<0.05) higher than the bulk density values of control site (1.19mg/m<sup>3</sup>). Similar results were obtained for total porosity from all the degraded sites (Table 1).

**Total porosity (TP)**

Soil total porosity ranged between 39.62-52.06% lower than the control site having 55.09%. The total porosity of the Control (Agbala) was significantly (P <0.05) higher

than values (55.09%) recorded in all the degraded sites with the following mean values for Egbema oil spill (52.06%), Amucha and Naze (39.62%) and Egbema gas flare (33.13%).

**Hydraulic conductivity (HC)**

Hydraulic conductivity ranged between 0.0038-0.0103 mm/S, with control having the highest value of 0.0142 mm/S. Hydraulic conductivity values were low and varied significantly (P<0.05) among all degraded sites but has a higher value for the control (Table 1).

**Table 1.** The effects of anthropogenic factors on Soil Physical Properties in the study locations

location	sand (gkg <sup>-1</sup> )	Silt (gk <sup>-1</sup> )	Clay (gkg <sup>-1</sup> )	Moisture content (%)	Bulk density (Mgm <sup>-3</sup> )	Total porosity(%)	Hydraulic conductivity(mm/s)
SSP <sub>1</sub>	816	38.7	145.3	14.10	1.60	39.62	0.0067
SSP <sub>2</sub>	831.7	66.3	98	15.69	1.78	33.13	0.0014
SSP <sub>3</sub>	800	56.0	144.0	14.54	1.27	52.06	0.0103
SSP <sub>4</sub>	860	44.0	96.0	13.23	1.60	39.62	0.0038
CSP <sub>5</sub>	801.3	49.8	148.1	17.06	1.19	55.09	0.0142
*LSD(0.05)	28.9	15.9	29.2	3.235	0.107	4.043	0.0029

\*LSD: Least significant difference P≤0.05

**Chemical Properties of the Soil in the Study Area**

**Soil pH (H<sub>2</sub>O)**

The mean soil pH (water) in Table 2, varied significantly (P <0.05) among degraded sites. It ranged from 5.14 at Naze waste dump site to 5.67 at Egbema gas flare site. Mean soil pH (H<sub>2</sub>O) in solid waste dumpsite recorded the lowest value than oil spill and control respectively (Table 2).

**Organic Carbon (OC)**

Mean value of organic carbon ranged from 4.2-18.7 g/kg, with soil erosion having the least value while oil spill recorded the highest value than control with 9.2g/kg. Soil organic carbon differed significantly (P <0.05) among degraded sites (Table 2) with

the highest value recorded in soils of Egbema oil spill site. Similarly, in descending order of magnitude soil organic carbon decreased as follows: Amucha erosion site (4.2 g/kg) <Egbema gas flare site (5.8 g/kg) <Naze dumpsite (7.8 g/kg) < Control –Agbala (9.2 g/kg) <Egbema oil spill site (18.7 g/kg).

**Total Nitrogen(TN)**

Total nitrogen mean value ranged from 0.35-1.64 mg/kg, with soil erosion being the lowest and oil spill with the highest value than control having 0.075 mg/kg.

**Available phosphorus (AP)**

Available phosphorous ranged from 1.41 – 3.99 mg/kg in the sites. The trend is as follows: Amucha erosion site is the least (1.41mg/kg), followed by Egbema gas flare

site (1.99 mg/kg), Naze waste dump site (2.87 mg/kg), Control site (3 mg/kg), and Egbema oil spill site (3.99 mg/kg) the highest. The increasing trend is as follows: Amucha erosion site is the least (1.41mg/kg), followed by Egbema gas flare site (1.99 mg/kg), Naze waste dump site (2.87 mg/kg), Control site (3 mg/kg), and Egbema oil spill site (3.99 mg/kg) the highest. Phosphorus availability in these degraded soils could be related to pH distribution and organic carbon content. For instance the Egbema oil spill site has a pH of 5.62 and organic carbon content of 1.87g/kg which could have contributed to the highest value of P obtained.

**Eexchangeable bases (EB)**

Mean values of Eexchangeable bases like Ca<sup>2+</sup> ranged from 1.69-2.45cmol/kg between soil erosion site and solid waste dumpsite higher than control with 2.17 cmol/kg , Mg<sup>2+</sup> ranged from 1.06-1.32cmol/kg between solid waste and soil erosion with control having 1.25 coml./kg, K<sup>+</sup> ranged between 0.12-0.22 coml./kg between oil spill and soil erosion with control recording 0.21 coml./kg and Na<sup>+</sup> ranged from 0.129-150 coml./kg between solid waste dumpsite and soil erosion greater than control 0.149 cmol/kg..

**Table 2.** The effects of Anthropogenic activities on the chemical properties of the soils in the study location

Locations	pH	OC	TN	Avail. P.	Ca <sup>2+</sup>	Mg <sup>2+</sup>	K <sup>+</sup>	Na <sup>+</sup>	CEC	Al <sup>3+</sup>	H <sup>+</sup>	TEA	BS
SSP <sub>1</sub>	5.28	4.2	0.35	1.41	1.69	1.32	0.22	0.150	5.16	0.67	0.63	1.41	79.8
SSP <sub>2</sub>	5.67	5.8	0.51	1.99	2.10	1.24	0.19	0.143	4.41	0.77	0.40	1.99	74.9
SSP <sub>3</sub>	5.62	18.7	1.64	3.99	1.80	1.21	0.12	0.141	4.33	0.60	0.42	3.99	74.4
SSP <sub>4</sub>	5.14	7.8	0.63	2.87	2.45	1.06	0.21	0.129	4.31	0.63	0.39	2.87	69.7
CSSP <sub>5</sub>	5.54	9.2	0.075	3.00	2.17	1.25	0.21	0.149	5.00	0.73	0.50	3.00	76.7
LSD <sub>(0.05)</sub>	0.30	2.8	0.02	1.19	0.52	0.31	0.05	0.039	0.52	0.14	0.23	1.19	7.21

**Cation exchange capacity (CEC)**

Cation exchange capacity mean values ranged from 4.31–5.16 cmol/kg between solid waste and soil erosion higher than control with 5.00 cmol/kg. Al<sup>3+</sup> mean value ranged from 0.60-0.67 cmol/kg between oil spill and soil erosion lower than control with 0.73 cmol/kg, H<sup>+</sup> ranged between 0.39-0.63 cmol/kg between solid waste and soil erosion greater than control with 0.50 cmol/kg, and these values varied significantly (P<0.05). Though the CEC values reported are low, the exchange sites are dominated by basic cations in both degraded and control sites. The trend in the distribution of cation is: Amucha erosion site>Control (Agbala) >Egbema gas flare site >Egbema oil spill >Naze waste dump site.

**Total exchangeable acidity (TEA)**

TEA ranged from 1.41-3.99 between oil spill and soil erosion higher than control with 3.00 .

**Base saturation (BS)**

Mean value of base saturation ranged from 69.7-79.8% between solid waste dumpsite and soil erosion site greater than control site with 76.7%.

## Crop Performance

### Seedling Emergence

Table 3 shows the seedling emergence in the degraded and control sites of the study area. From the results there were no significant differences ( $P>0.05$ ) in seedling emergence for maize at 4DAP, 6DAP among the sites, except Egbema oil spill site which recorded zero emergence. Maize seedlings emerged in the other three degraded sites at 4DAP, and 6DAP. At 4DAP and 6DAP, maize seedlings consistently showed low values of emergence amongst sites where emergence

occurred. But the trend changed at 6DAP, when lowest value (1.00) of emergence was recorded in Amucha erosion site. The result shows that the soils affected by oil spillage constrained emergence of seeds of maize and soya bean, implying that these soils were unable to attenuate the effect of oil spillage at the time of planting. None emergence of maize and soya bean seeds could be attributed to anaerobic conditions created by crude oil on soils which substantially reduced availability of oxygen for germination.

**Table 3.**Seedling emergence on degraded soils and Control at 4 and 6 (DAP)

Sample Location	Study Location	4 (DAP )	6 (DAP)
SSP <sub>1</sub>	Amucha erosion site	1.31	1.00
SSP <sub>2</sub>	Egbema gas flare site	1.42	1.08
SSP <sub>3</sub>	Egbema oil spill	0.00	0.00
SSP <sub>4</sub>	Naze waste dump site	1.46	1.28
CSSP <sub>5</sub>	Control	1.29	1.03
LSD <sub>(0.05)</sub>		0.62	0.66

### DAP: Days After Planting

#### Girth of Maize

Table 4 shows Girth of maize at 4WAP, 8WAP, and 12WAP. At 4WAP, the girth of maize was not significantly different with the exception of soils of Egbema oil spill site. Highest value of girth was recorded on

soils of Naze waste dump site (1.98 cm). However, statistically at ( $P<0.05$ ), different values of girth were obtained amongst soil units at 8WAP and 12WAP with highest recorded values found in soils of Naze waste dump site in both temporal spaces.



**Table 4.**Girth of Maize in degraded and non-degraded soils at 4, 8 and 12 (WAP) in the study locations

<b>Location</b>	<b>4 (WAP)</b>	<b>8 (WAP)</b>	<b>12 (WAP)</b>
Amucha erosion site.	1.54	2.69	3.22
Egbema gas flare site	1.82	2.54	3.36
Egbema oil spill site	0.00	0.00	0.00
Naze waste dump site	1.98	4.46	4.95
Control	1.64	2.43	3.19
<b>LSD(0.05)</b>	<b>0.67</b>	<b>1.57</b>	<b>1.68</b>

WAP = Weeks after planting

**Number of leaves of Maize**

The number of leaves per plant at 4WAP, 8WAP, and 12WAP are shown on Table 23. Similar trend occurred, there were no significant difference ( $P > 0.05$ ) at 4WAP, 8WAP, and 12WAP, where the number of

leaves did not vary in all the sites where emergence were recorded. At the time interval, maize leaves were found to be greater in Naze waste dump site with values being 5.67, 12.50, and 14.17 at 4WAP, 8WAP, and 12WAP respectively (Table 5).

**Table 5.**Number of leaves of maize in degraded and non-degraded soils at 4, 8 and 12 (WAP) in the study locations

<b>Locations</b>	<b>4 (WAP)</b>	<b>8 (WAP)</b>	<b>12 (WAP)</b>
Amucha erosion site (SSP <sub>1</sub> )	4.67	10.11	10.78
Egbema gas flare site (SSP <sub>2</sub> )	5.17	11.33	12.17
Egbema oil spill site (SSP <sub>3</sub> )	0.00	0.00	0.00
Naze waste dump site (SSP <sub>4</sub> )	5.67	12.50	14.17
Control (CSSP <sub>5</sub> )	4.18	10.13	10.77
<b>LSD(0.05)</b>	<b>2.11</b>	<b>4.83</b>	<b>5.28</b>

**Height of Maize**

Table 6 shows the height of maize at 4WAP, 8WAP, and 12WAP in all the sites. There was no statistical significant difference ( $P < 0.05$ ) in the height of maize in all the soil

units where emergence was observed. However, the highest values were observed at Naze waste dump site at 8WAP and 12WAP but this trend changed at 12WAP when the control site gave 98.39 cm.

**Table 6.**Height (cm) of maize at 4, 8 and 12 (WAP) in degraded soils

<b>Location</b>	<b>4 (WAP)</b>	<b>8 (WAP)</b>	<b>12 (WAP)</b>
Amucha erosion site	14.25	73.92	84.83
Egbema gas flare site	17.25	77.83	92.25
Egbema oil spill site	0.00	0.00	0.00
Naze waste dump site	19.50	78.92	103.00
Control	16.46	81.72	98.39
<b>LSD(0.05)</b>	<b>7.16</b>	<b>38.11</b>	<b>42.97</b>



### Girth of Soya beans

Results on soybeans girth in Table 7 shows no significant difference ( $P > 0.05$ ), amongst degraded sites, including the control at 8WAP and 12WAP. But at 4WAP there were significant differences among the

degraded sites of Amucha erosion site, Egbema gas flare site, and Control site, except Naze waste dump site that recorded 1.22 cm. However, the girth of Soya bean was highest on soils affected by gas flaring at Egbema (1.33 cm) at 8WAP, and (1.45 cm) at 12WAP.

**Table 7.** Girth of Soyab eans (cm) at 4, 8, 12 (WAP) in degraded soils in the study Area

Location	4 (WAP)	8 (WAP)	12 (WAP)
Amucha erosion site.	1.16	1.30	1.41
Egbema gas flare site	1.19	1.33	1.45
Egbema oil spill site.	0.00	0.00	0.00
Naze waste dump site.	1.22	1.28	1.40
Control	1.14	1.26	1.39
<b>LSD<sub>(0.05)</sub></b>	<b>0.03</b>	<b>0.09</b>	<b>0.08</b>

### Height of soya beans

Table 8 shows the heights of soya bean at 4WAP, 8WAP, and 12WAP. In the entire time regime, The height of soya bean varied significantly ( $P = 0.05$ ). Highest values of

soya bean were reported on soils affected by Naze waste dump site at 4WAP (8.23 cm) and 8WAP, (14.56 cm). At 12WAP, soya bean height of (23.83 cm) from Egbema gas flare site surpassed values from the other site.

**Table 8.** Height of soybean (cm) at 4, 8, 12 (WAP) in degraded soils in the Study Area

Locations	4 (WAP)	8 (WAP)	12 (WAP)
Amucha erosion site	8.10	14.19	18.54
Egbema gas flare site	8.20	14.03	23.83
Egbema oil spill site	0.00	0.00	0.00
Naze waste dump site	8.23	14.56	22.50
Control	7.47	11.23	16.77
<b>LSD<sub>(0.05)</sub></b>	<b>0.71</b>	<b>2.79</b>	<b>4.40</b>

### Number of Soybean Leaves/plant, Leaf-Area, Pods/plant, Seeds/pod and Grain Yield at Maturity

Table 9 shows that the number of leaves of soya bean differed significantly ( $P < 0.05$ ). However, number of leaves of soya bean was statistically similar in soils affected by Naze waste dump site and Egbema gas flare site. Amucha erosion site had the least

number of leaves (14.58) possibly due to loss of essential plant nutrients as a result of water erosion. The leaf area ( $P < 0.05$ ) was not significantly different for all the sites. Soya bean pods per plant was not statistically different for Amucha erosion, Egbema gas flare and control sites, except with Naze waste dump site that yielded the highest amount of pods per plant. Also soya

bean seeds per pod did not significantly differ for Amucha erosion site, Egbema gas flare site and control site except for Naze waste dump site which yielded the highest amount of seeds/pod. Soya bean grain yield indicated that those grown on Amucha

erosion site, Egbema gas flare site, and Control sites were statistically the same but differed significantly ( $P < 0.05$ ) with results from Naze waste dump site which had the highest yield.

**Table 9.** Number of soybean leaves/plant, leaf-Area, Pods/plant, seeds/pod and grain yield at maturity

Location	SyLvsPlant	SyLfArea	Pods/plant	Seeds/pod	GrainYLD(g)
Amucha erosion site	14.58	5.41	14.08	2.58	12.67
Egbema gas flare site	16.42	5.28	14.42	2.67	17.92
Naze waste dump site	17.08	5.38	19.83	2.92	35.00
Egbema oil spill site	0.00	0.00	0.00	0.00	0.00
Control	14.58	5.05	9.58	2.50	15.5
LSD(0.05)	3.297 (ns)	0.676 (ns)	6.98	0.546 (ns)	8.24

NS = not significant at 0.05 probability level, SyLvs = Soybeans number of leaves, SyLf = Soybeans leaf YLD = Yield

## DISCUSSION

Sand-size particles dominated the study locations. Marinescu *et al.* (2000) in their studies reported that sand proportion remained the same for both polluted and unpolluted soils, suggesting that crude oil pollution did not alter sand percentage except at 10 – 15 cm depth. Similar results on particle size fraction were reported by Onweremadu *et al.* (2009). One can infer that the nature of the parent material (Coastal plain sands) could be responsible for the particle size distribution.

The moisture content is low and there was no significant variation in soil moisture content in all the degraded sites. This could have been brought about the coating of soil surfaces by the hydrophobic hydrocarbons, reducing the water holding capacity of the soil due to reduction in the binding capacity of clay.

From the result, high bulk density and low porosity were recorded in degraded sites than control discouraging easy root penetration to facilitate plant establishment and growth.

The differences in soil total porosity may be due to differences in organic matter content of the sites. Njoku and Mbah (2012) observed that, the introduction of urban wastes to soil reduces bulk density and increases total porosity.

Hydraulic conductivity values were low and varied among all degraded sites but have a higher value for the control leading to decrease in macro spore of the degraded soils. The decreased macro pores in the soils, led to an increase in hydraulic conductivity (Hüseyin, 2017). Barnes *et al.*, (2014) linked the reduction in soil hydraulic conductivity of sandy soil to a reduction in porosity imposed by the fine-grained particles.

The results of soil pH depict strong to moderate acidity in all the degraded soils including control site. These low pH values have obvious implications on the availability of essential nutrients in the soil system (Oyem and Oyem, 2013).

The study reveals that there was significant effect of cropping cycle and the municipal solid waste from the dumpsite on

the emergence of maize and soybean than control. The result conformed with the findings of Onweremadu *et al.* (2011), Simeon and Ambah (2013), explained that municipal dumpsites added organic matters to the soil that aided soil fertility for crop production through soil mineralization.

There were reductions in soil chemical properties: total nitrogen, available phosphorous, Exchangeable cations ( $\text{Ca}^{2+}$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ) were susceptible to reduction in the degraded soils, base saturation, exchangeable acidity and effective cation exchange capacity (CEC) show a general decreasing trend in degraded soils compared to unpolluted soils. This is in accordance with reports of Ubuoh *et al.* (2010) who reported reduction in chemical characteristic of soil due to human activities in southeastern Nigeria. The cation exchange capacity of the degraded soils was significantly lower than agricultural land in Agbala being control. This can be attributed to the relatively high organic carbon content and low pH in the soil (Manrique *et al.*, 1991).

Result indicated zero germination and growth of maize and soybean in oil polluted soils in the area, while there was normal germination and growth in the control. The result is in tandem with the finding of Cara *et al.* (2014) observed that seeds planted with crude oil polluted had no germination and growth but seeds in control pots had normal growth in Bayelsa State. The decrease in heights and girths of plant in crude oil-polluted soil may be due to the non-availability of adequate water, which possibly affected the nutrient uptake and mobility (Oyedemi *et al.*, 2012).

Generally, improvement in maize emergence (E %), girth, leaves and, height were observed in waste dumpsite than other study locations and control site respectively. The result is in consonant with earlier works

carried out by Carmine *et al.* (2004), Ubuoh *et al.* (2012), Simeon and Ambah (2013), who observed that maize grown on municipal solid waste, did better than the control samples. However, the girth of Soya bean was highest on soils affected by gas flaring, and non in oil spill at Egbema. Differences in soil condition as morphology (porosity and bulk density) as well as root geometry may have influenced it (Odjugo and Osemwenkhae, 2009). Despite the germination and growth of maize and soya bean in gas flare site, planting within unacceptable soil temperature limit will reduce fruit yield, cause stunted plant growth, cause the leaves to be yellowish and prevent or reduce seed germination (Oseji, 2010).

#### CONCLUSION

The degraded soil status as established by this investigation have deleterious effects on the physical properties of the soils in terms of high bulk density which is an indication of low soil porosity and soil compaction restricting root growth, leading to poor yield of crops. Similarly the chemical properties of the soil such as cation exchange capacity, organic-matter, exchangeable bases and soil reaction (pH) were very low. Crop germination was delayed as well as inhibited (zero sprouting) in Ohaji/Egbema oil spill site. Ohaji/Egbema gas flare site had reduced crop yields, while Amucha erosion site had the least crop yield essentially due to water erosion. However, Naze waste dump site proved an exception to the general trend, in terms of exceptional increase in yield. Therefore to enhance the fertility for optimum crop yields, soil conservation practices separation of municipal waste for organic agriculture through composting, reinjection/ stoppage of gas flaring and cleansing of oil spilled land should be encouraged.

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