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Comparative Effects Of Spent Engine Oil And Unused Engine Oil On The Growth And Yield Of *Vigna Unguiculata*(Cowpea)

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ABSTRACT

The disposal of Spent Engine Oil and Unused Engine Oil into gutters, water drains, open vacant plots and farms are common practice in Nigeria especially by motor mechanics. This research takes a look into the possible effects of this chemical oil on plants growth, germination and the effects of soil contaminated with spent engine oil after different degree of contamination. Also, its negative impacts on human's health on consumption of crops grown on such contaminated soil was established as well as creating opportunity for plant breeders in searching for ways of improving cowpea production in oil-producing areas. A total of twenty-seven plastic containers (5 Litres) were filled with 4 kg of sand-loam soil which were mixed with various concentrations of spent engine oil. There were four different concentrations of oil and unused engine oil graded from 25, 50, 75 and 100mg/l of which each treatment has three replicates. The results show that a negative relationship existed between the oil levels in the soil and the growth parameters (plant height, number of leaves, stem girth, leaf area, yellowness of leaves, shedding of leaves, leaves folding, flowering and pod production) measured. The reductions and morphological effects in the growth characteristics measured in the *V. unguiculata* with spent and unused engine oil increased as the concentration level of the contaminant increases compared to control experiment. The most affected growth parameters occurred with 100mg/l of engine oil on plant height (19.50cm, on the second week), stem girth (0.84cm, on the second week), leaf area (21.40cm^2, on the sixth week) while the number of leaves increases with increase in concentration of engine oil on the eight week with a value of 19.00. However, the lowest number of leaves was also recorded for the soil mixed with 100mg/l of engine oil during the second week. This study therefore showed that the presence of the engine oil has great implications on the sustainability of *V. unguiculata* growth. Meanwhile, the consumption of the contaminated plants by man and animals affects their health, which may eventually lead to their death. This is because of the high level of lead which is above the WHO standard for consumption. Therefore, there is the need for government and appropriate agency to enact a strict law and educate the citizenry on the indiscriminate disposal of these pollutants (spent engine oil and unused engine oil).

Keywords: *Used Engine Oil, Used Engine Oil, V. Unguiculata , Growth Parameters, Concentrations Of Oil, Weeks.*

1. INTRODUCTION AND LITERATURE REVIEW

The disposal of Spent Engine Oil (SEO) into gutters, water drains, open vacant plots, and farms is a common practice in Nigeria especially by motor mechanics. This oil also called spent lubricant or waste engine oil is usually obtained after servicing and subsequently draining from automobile and generator engines Sharifi, Sadeghi, Akbarpour, 2007) and much of this oil is poured into the soil. It is a common and toxic environmental contaminant not naturally found in the environment (Dominguez-Rosado and Pitchel, 2004). Spent oil is produced when new mineral-based crankcase is subjected to high temperature, high mechanical strain (ATSDR, 1997). It is a mixture of different chemicals (Wang *et al.*, 2000) including petroleum hydrocarbons, chlorinated biphenyls, chlorodibenzofurans, lubricative additives, decomposition products and heavy metals that come from engine parts as they wear away (ATSDR, 1997). After undergoing several production processes, additives are usually incorporated to boost some of the oils properties like viscosity, thermal and oxidation stability, etc (Dauda and Obi, 2000). These additives when exposed to the atmosphere have toxic effect to the humans and animals when in contact (Evdokimov and Fooks, 1959).

The spent engine oil gets to the environment due to discharge by motor and generator mechanics (Odjegba and Sadiq, 2002) and from the exhaust system used and due to engine leaks (Anoliefo and Edegai, 2000; Osubor and Anoliefo, 2003). The contamination of the natural environment by petroleum-derived substances contributes to the degradation of land (Sztompka, 1999). The accumulations of Polycyclic Aromatic Hydrcarbons (PAH) in soil are due to many anthropogenic sources such as cooking plants, solid fuel domestic heating, aircraft exhaust, car exhausts and forest fires (Smith, *et.al.*, 2006). Also, chemical additives such as amines, phenols, benzenes, Ca, Zn, Pb, Ba, Mn, P and S which are dangerous to living organisms (Meinz, 1999). Oxidation of lubricating oil hydrocarbons at the point of application is accompanied by release of free radicals that transform to peroxides, subsequent condensation and polymerization of which produce per acids, nephtenic acids, etc (Evdokimov and Fooks, 1989). Nevertheless, this is dependent on the local environmental conditions and on the kind of soil constituents present in the soil-water system. Due to the difference in the composition of the different petroleum products, the petroleum products affect the environment in different manners. For instance, (Wyszkowski and Ziolkowska, 2008) reported that petrol and diesel oil affected the organic carbon and mineral components in soils at different rates. This means the growth and development of organism depending on such soils can be affected at different rates by petroleum products. Germination of *Amaranthus hybridus* seeds were significantly affected in spent engine oil polluted soil (Odjegba and Idowu, 2002). Agbogidi and Nweke (2005) and Agbogidi et al., (2006) showed that crude oil application to soil significantly reduced crop growth and in Okra and five cultivars of Soy beans respectively. Daniel-Kalio and Pepple (2006) reported a significant higher means plant height, leaf area and dry weight of *Comelina begalensis* (day flower) at 0 mg g^{-1} oil pollution than at 50 mg g^{-1} pollution level. Further still, Ibmesin (2010) reported that vegetative cutting of Paspalum (Sour grass) grew well in absence of oil and salinity and that 75% of the test plants survived in low oiling but heavy oiling resulted in mortality.

The most important and common symptoms observed in the plants contaminated with oil and its by-products include the degradation of chlorophyll (Malallah *et al,* 1998), alterations in the stomata mechanisms and reduction in photosynthesis and respiration (Baker, 1970), increase in the production of stress-related phytohormones (Larcher, 2000), accumulation of toxic substances or their by-products in vegetal tissue (Baker, 1970), decrease in size and less production of biomass (Brandt et al., 2006; Daniel-Kalio and Pepple, 2006; Adenipekun *et al*, 2008). Anoliefo and Edegbai, 2000, Anoliefo and Vwioko, 2001; Agbogidi, 2011a; Atuanya, 1987; Odjeba and Sadiq, 2002, Agbogidi and Ejemeta, 2005, Agbogidi, 2010; Adam *et al*, 2003, Clark 2003, worked extensively on the effects of spent engine oil on plants. According to Udo and Fayemi (1975) growth of plants growing in oil polluted soil was generally retarded and chlorosis of leaves results coupled with dehydration of the plants indicating water deficiency.

COWPEA

This is a dicotyledonous plant and it belongs to the family Fabaceae and sub-family faboideae. Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics. In fresh form, the young leaves, immature pods and peas are used as vegetable while several snacks and main dishes are prepared from the grain (Kwartang and Towler, 1994). Islam *et al.,* (2006) noted that cowpea is more tolerant to drought, water logging, infertile soils and acid stress than common beans. Islam *et al.* (2006) further maintained that west and central Africa is the leading cowpea producing regions in the world.
Cowpea is a popular leguminous staple food in Nigeria (Adelaja, 2000; Adaji *et al.,* 2007). It is cultivated and used fresh in derived savannah and rainforest belts thus it is available throughout the year either as vegetable or as a pulse (Singh and Rachie, 1985; Asumugha, 2002; Olopade *et al.,* 2003). Asumugha (2002) maintained that cowpea is the most extensive consumed in various ways . Philip (1999) and Olaleke *et al.,*(2006) maintained that cowpea contains moisture (4.0), ash (37.1), crude fat (31.3), crude fibre (24.0), crude protein (75.3), carbohydrate by difference (82.8), fatty acids (25) and energy mjkg^{-1} (6.5193), a lot of minerals including Na, K, Mg, Ca, P, Cap, Co, Fe, Pb, Cu, Mn, Cd, Zn and Cr.

2. MATERIALS AND METHOD

2.1. Ample collection

The study was conducted in 2014 at the nursery site of the Department of Botany Lagos State University, Ojo Campus, Nigeria. A total of twenty-seven buckets were filled each with 4 kg of sand-loam soil. The sand-loam soil was obtained from the Botanical Garden of Lagos State University. The sand-loam soil was sieved with a mesh of (326m). This is to separate the non-degradable materials out of the soil in order to keep the soil free of unwanted materials which could disturb the proper functioning of soil micro-organisms, proper stretch of the roots and proper organization of the soil. The sieved soil was air-dried before weighing in order to avoid apparent weight of soil which could be brought about by the weight of water. By this procedure, an accurate weight of soil was obtained in relation to the engine oil used.

Healthy seeds were selected and sorted out. Viability tests were carried out on the seeds using floatation technique. The sand-loam soil was weighed with a weighing balance and set in the respective perforated buckets. The soil was mixed with different volumes of spent engine oil and unused engine oil. The volumes of engine oil used for this project work are graded from 25ml, 50ml, 75ml, to 100ml to a constant level 4 kg of soil. The engine oil was measured with the measuring cylinder graded up to 100±1ml. The engine oil was thoroughly mixed manually with hand protected with gloves.

Three buckets of soil were used for control experiment and were not mixed with either spent engine oil or unused engine oil. The other buckets of soil were divided into two groups of spent and unused engine oil respectively having three replicates for each parameter replicated four times and arranged in randomized complete block design. . The project work was set-up in this manner for a discrete and perfect result.

After these mixtures, the soil was left for a period of seven days without planting. This was done for uniformity of oil, moisture content, air content, temperature, and effective activities of soil micro-organisms (Sanni, 2013). At this incubation period, some unwanted weeds were properly cleared and discarded as the soil was left in a moist, cool environment in the garden.

Watering of the plants was done once daily with 30 ml of water throughout the period of the experiment. The twenty-seven buckets containing the sown seeds in the soil were watered every morning with 30ml of water measured with the measuring cylinder. Over watering was avoided as much as possible. Wetting with 30ml of water was done daily after sowing of seeds. This experiment was properly controlled in the greenhouse of the Department of Botany, Lagos Sate University. Fumigation of the plants as well as the entire environment was done every week to prevent the massive attack of destructive insects.

Emergence of the young seedlings of the plant occurred between the third and fourth day after planting. This was also observed by Agbogidi and Enujeke (2012) on *Arachis hypogeal.*

The data collected in the period of this project work based on the performance of *Vigna unguiculata* in the presence of soil polluted with spent engine oil and unused engine oil accurately taken within the period of the second week, fourth week, sixth week, and eight week are as follows; Plant height; Number of leaves; Stem girth; Leaf area. Data collected were subjected to analysis of variance (ANOVA)

3. RESULTS

3.1. PLANT HEIGHT AGAINST CONCENTRATION AT DIFFERENT DURATION IN RELATION TO TYPES OF CHEMICAL USED

Spent Engine Oil: The highest height of the *Vigna unguiculata* was observed on the eight week having 25mg/L of spent engine oil with a value of 38.12cm while the lowest height was observed in the second week having 100mg/L of spent engine oil with a value of 15.80cm. The height of the control was an intermediary between the lowest height and the highest height with a value of 25.10cm on the second week. This clearly shows that the higher concentration of spent engine oil present, the lower the growth in terms of height and the lower concentration of spent engine oil present, the higher the growth in terms of height. The growth of the control experiment in terms of height ascends progressively in accordance with the time of the experiment. The progressive height of the control experiment proves the absence spent engine oil in the soil. This is showed in table 3.1 and figure 3.1

Unused Engine Oil: The highest height was observed with 25mg/l of unused engine oil having a value of 28.42cm on the fourth week. The next in height was observed with 25mg/l of unused engine oil with a value of 28.11cm on the eight week while the lowest height was observed on the second week having 100mg/L of unused engine oil with a value of 23.21cm. The lower height observed with unused engine oil was due to the higher concentration of unused engine oil. Although, the difference in growth in terms of height observed was not so much when compared to the difference in height of spent engine oil. This is showed in table 3.1 and figure 3.1

3.2. NUMBER OF LEAVES AGAINST CONCENTRATION AT DIFFERENT DURATION IN RELATION TO TYPES OF CHEMICAL USED

Spent Engine Oil: The highest mean value number of leaves was recorded on the eight week having 75mg/L with a mean value of 21.67of the leaves while the lowest number of leaves was recorded on the second week having 25mg/L with a mean value of 5.67 of the leaves. The control experiment had a mean value of 7.67 higher than the lowest mean value of the number of leaves. The presence of spent engine oil aided the production of leaves observed in this project work. This evidenced in the fact that the higher the quantity of spent engine oil, the higher the number of leaves and the lower the quantity of spent engine oil, the lower the number of leaves and the fact that the mean value of the number of leaves of the control experiment is lesser when compared to the mean value of the higher concentration of spent engine oil. This is showed in table 3.1 and figure 3.2

Unused Engine Oil: The highest mean value of the number of leaves was recorded on the eight week having 100mg/L of unused engine oil with a value of 21.00 of the leaves while the lowest number of leaves was recorded on the second week having 100mg/L with a mean value of 8.67 of the leaves. The overall lowest mean value of the number of leaves was recorded with the control experiment on the fourth week with a value of 1.00 of the leaves. This also shows that the production of more leaves was aided by the presence of unused engine oil. This is also evidenced in the fact that the higher the quantity of unused engine oil, the higher the number of leaves and at the same high concentration, a low value was recorded . This is showed in table 3.1 and figure 3.2

3.3. STEM GIRTH AGAINST CONCENTRATION AT DIFFERENT DURATION IN RELATION TO TYPES OF CHEMICAL USED

Spent Engine Oil: The widest stem girth was observed on the sixth week with 50mg/L having a value of 1.28cm while the thinnest stem girth was observed on the second week with 100mg/L with a value of 0.75cm followed by 0.77cm of the fourth week with 75mg/L of spent engine oil. This definitely shows that the girth of the plant is affected by the higher concentration of spent engine oil and was slightly affected by the smaller concentration of spent engine oil. This is showed in table 3.1 and figure 3.3

Unused Engine Oil: The widest stem girth was observed on the sixth week with 50mg/L having a value of 1.30cm while the thinnest stem girth was observed on the second week with 75mg/L with a value of 0.90cm. This also showed that the higher the concentration of unused engine oil, the smaller the growth in terms of stem girth and the lesser the concentration of unused engine oil, the wider the growth in terms of stem girth. This is showed in table 3.1 and figure 3.3

3.4. LEAF AREA AGAINST CONCENTRATION AT DIFFERENT DURATION IN RELATION TO TYPES OF CHEMICAL USED

Spent Engine Oil: The widest area of leaves was observed on the eight week with 25mg/L having an area of 75.01cm^2 while the smallest leaf area occurred on the sixth week with 75mg/L having an area of 17.66cm^2. This automatically depicts that the presence of high concentration of spent engine oil limits the expression of the leaf size and at low concentration of spent engine oil; there was a much better expression of the size of the leaf. This is showed in table 3.1 and figure 3.4

Unused Engine Oil: The widest area of leaves was observed on the eight week with 50mg/L having an area of 43.64cm^2 while the smallest leaf area occurred on the sixth week with 100mg/L having an area of 22.95cm^2. Similar character was showed with unused engine oil as the presence of high concentration of unused engine oil reduced the leaf area of the plant with smaller concentration of unused engine oil. This is showed in table 3.1 and figure 3.4

Table 1: Response of Plant Growth to Spent Engine Oil and Unused Engine Oil in Relation to Concentration and Duration over a Period of Eight Weeks

Conc.(mg/L)	Duration	Plant Height(cm)		No of Leaves (cm)		Stem Girth (cm)		Leaf Area (cm^2)	
		Spent Engine Oil	Unused Engine Oil	Spent Engine Oil	Unused Engine Oil	Spent Engine Oil	Unused Engine Oil	Spent Engine Oil	Unused Engine Oil
Control	2nd week	25.10	25.56	7.67	10.33	.97	1.03	32.10	35.55
	4th week	26.70	26.00	10.33	1.00	.83	1.07	28.28	36.23
	6th week	29.28	29.52	13.00	13.33	1.22	1.30	28.21	28.40
	8th week	35.63	35.58	17.00	16.67	1.22	1.20	49.16	49.51
25mg/L	2nd week	21.51	26.92	5.67	11.00	.96	.93	25.79	27.60
	4th week	24.69	28.42	11.00	13.00	1.12	1.00	31.44	27.58
	6th week	25.87	27.52	11.33	11.67	1.13	1.07	22.15	24.53
	8th week	38.12	28.11	19.00	11.00	1.20	1.20	75.01	23.06
50mg/L	2nd week	23.35	26.80	6.00	9.67	.99	.97	24.92	29.56
	4th week	21.33	27.66	10.00	10.67	1.03	1.03	21.77	29.46
	6th week	22.29	27.03	10.67	12.00	1.28	1.30	43.89	28.86
	8th week	22.80	25.90	11.00	10.67	1.07	1.12	27.48	43.64
75mg/L	2nd week	17.19	25.82	6.00	11.67	.88	.90	18.66	27.53
	4th week	19.78	26.39	9.00	13.67	.77	1.00	24.05	28.94
	6th week	21.15	26.67	13.67	16.33	1.06	1.07	17.66	26.74
	8th week	24.10	26.49	21.67	15.67	1.11	1.07	19.24	41.96
100mg/L	2nd week	15.80	23.21	6.33	8.67	.75	.93	20.43	24.15
	4th week	19.35	24.54	9.67	10.67	.80	1.03	28.93	23.09
	6th week	19.68	24.30	16.00	20.33	1.11	1.03	19.85	22.95
	8th week	22.33	24.19	19.00	21.00	1.06	1.21	19.28	33.43

3.5. PLANT HEIGHT AGAINST CONCENTRATION IN RELATION TO DURATION

The highest height of *Vigna unguiculata* was obtained on the eight week having 25mg/L of engine oil (spent engine oil and unused engine oil) with a value of 33.11cm of height. The lowest height was observed on the second week having 100mg/L of engine oil with wan height of 19.50cm. The highest height overall was observed with a height of 35.61cm at the eight week. The lower the concentration and accumulation of engine oil, the higher the height and the higher the concentration and accumulation of engine oil, the lower the height of the plant. There was an increase in height with the plant having a lower concentration of engine oil as the time increases from the second week, fourth week, sixth week to eight week which shows that the plant was not so affected with the little amount of engine oil. There was also an increase in the plant height with the highest amount of engine of oil. But, the increase in the height is not as healthy as the height of the plant with the lowest concentration of engine oil. This is showed in table 3.2, fig. 3.5

3.6. NUMBER OF LEAVES AGAINST CONCENTRATION IN RELATION TO DURATION

The largest number of leaves was obtained on the eight week with a mean value of 20.00 numbers of leaves having 100mg/L of engine oil. The lowest number of leaves obtained on the second week with a mean value of 7.50 number of leaves having 100mg/L of engine oil. This shows that the higher the concentration and duration of engine oil, the higher the amount of leaves produced. The production of leaves was initially hindered by the concentration of engine oil at the first two weeks. But, the number of leaves increased as the time increased. This is showed in table 3.2, fig. 3.6

3.7. STEM GIRTH AGAINST CONCENTRATION IN RELATION TO DURATION

The widest stem girth occurred consistently on the sixth week with a mixture of 50mg/L having a value of 1.29cm wide. The thinnest stem girth occurred on the second week with 0.84cm having 100mg/L of engine oil. This shows that the girth of the plant is affected by high concentration of engine oil. But, a lower concentration of engine oil and at a longer duration permits a wider girth. This is showed in table 3.2, fig. 3.7

3.8. LEAF AREA AGAINST CONCENTRATION IN RELATION TO DURATION

The widest leaf area occurred on the eight week with a value of 49.04cm^2 having 25mg/L of engine oil. The widest leaf area was closely related to the leaf area of the control experiment with a leaf area of 49.33cm^2 on the eight week. The smallest leaf area occurred on the sixth week with 21.40cm^2 having 100mg/L of engine oil. The next smallest leaf area (wider than the smallest leaf area) was also observed on the sixth week with 22.20cm^2 having 75mg/L of engine oil. The lower the concentration of engine oil with increase in duration, the higher the expansion of the leaf and the higher the concentration of engine oil, the smaller then leaf area irrespective of the duration. This is showed in table 3.2, fig. 3.8

Table 2: Response of Plant Growth to Spent Engine Oil and Unused Engine Oil in Relation to Concentration and Duration over a Period of Eight Weeks

DURATION	MEAN CONCENTRATION	TYPES OF CHEMICAL	PLANT HEIGHT	NO OF LEAVES	STEM GIRTH	LEAF AREA
2 WEEKS	CONTROL	SPENT ENGINE OIL	25.1	7.67	0.97	32.1
		UNSPENT ENGINE OIL	25.56	10.33	1.03	35.55
	25mg/L	SPENT ENGINE OIL	21.51	5.67	0.96	25.79
		UNSPENT ENGINE OIL	26.92	11	0.93	27.6
	50mg/L	SPENT ENGINE OIL	23.35	6	0.99	24.92
		UNSPENT ENGINE OIL	26.8	9.67	0.97	29.56
	75 mg/L	SPENT ENGINE OIL	17.19	6	0.88	18.66
		UNSPENT ENGINE OIL	25.82	11.67	0.9	27.53
	100 mg/L	SPENT ENGINE OIL	15.8	6.33	0.75	20.43
		UNSPENT ENGINE OIL	23.21	8.67	0.93	24.14
4 WEEKS	CONTROL	SPENT ENGINE OIL	26.7	10.33	0.83	28.28
		UNSPENT ENGINE OIL	26	11	1.07	36.23
	25 mg/L	SPENT ENGINE OIL	24.69	11	1.12	31.44
		UNSPENT ENGINE OIL	28.42	13	1	27.58
	50 mg/L	SPENT ENGINE OIL	21.33	10	1.03	21.77
		UNSPENT ENGINE OIL	27.66	10.67	1.03	21.77
	75 mg/L	SPENT ENGINE OIL	19.78	9	0.77	24.05
		UNSPENT ENGINE OIL	26.39	13.67	1	28.94
	100 mg/L	SPENT ENGINE OIL	19.35	9.67	0.8	28.93
		UNSPENT ENGINE OIL	24.54	10.67	1.03	23.09
6 WEEKS	CONTROL	SPENT ENGINE OIL	29.28	13	1.22	28.21
		UNSPENT ENGINE OIL	29.52	13.33	1.26	28.3
	25 mg/L	SPENT ENGINE OIL	25.87	11.33	1.13	22.15
		UNSPENT ENGINE OIL	27.52	11.67	1.07	24.53
	50 mg/L	SPENT ENGINE OIL	22.29	10.67	1.28	43.89
		UNSPENT ENGINE OIL	27.03	12	1.3	28.86
	75 mg/L	SPENT ENGINE OIL	21.15	13.67	1.06	17.66
		UNSPENT ENGINE OIL	26.67	16.33	1.07	26.74
	100 mg/L	SPENT ENGINE OIL	19.68	16	1.11	19.85
		UNSPENT ENGINE OIL	24.3	20.33	1.03	22.95
8 WEEKS	CONTROL	SPENT ENGINE OIL	35.63	17	1.22	49.16
		UNSPENT ENGINE OIL	35.58	16.67	1.2	49.51
	25 mg/L	SPENT ENGINE OIL	38.12	19	1.2	75.01
		UNSPENT ENGINE OIL	28.11	11	1.2	23.06
	50 mg/L	SPENT ENGINE OIL	22.8	11	1.07	27.48
		UNSPENT ENGINE OIL	25.9	10.67	1.12	43.64
	75. mg/L	SPENT ENGINE OIL	24.1	21.67	1.11	19.24
		UNSPENT ENGINE OIL	26.49	15.67	1.07	41.96
	100 mg/L	SPENT ENGINE OIL	22.33	19	1.06	19.28
		UNSPENT ENGINE OIL	24.19	21	1.21	33.43

4. DISCUSSION

The study of the comparative effect of spent engine oil and unused engine oil on the growth and yield of *Vigna unguiculata* showed that after the oil was thoroughly mixed with the weighed soil , the mixture reduced water infiltration and percolation in the soil. This resulted in water accumulating in small pools. Air-drying of the impacted soils took relatively longer time. On drying, the soil gave a cemented waxy appearance which more or less repelled or resisted water or rewetting. This result indicated that spent engine oil and unused engine oil in the soil has a significant effect on soil properties like nitrogen content, PH, carbon and presence of heavy metals. This observation is in harmony with earlier reports of Atuanya (1987), Agbogidi and Egbuchua (2010) who noted that oil in soil has deleterious effects on the biological, chemical and physical properties of the soil depending on the dose, type of the soil and other factors.

During the period of this project work, it has been showed that the presence of engine oil (spent engine oil and unused engine oil) had a significant and obvious effect on the growth of the plants in terms of height. It was discovered that the shortest height of plant occurred with increased amount of engine oil (50, 75, 100 mg/l). This was also observed by Agbogidi and Ilondu (2013). The total height of the control of *Vigna unguiculata* (35.61cm) was significantly greater than that of plants grown in soil polluted with 50, 75, and 100 mg/l of engine oil. However, there was no much difference in height of control experiment and soil mixed with 25 mg/l (33.11cm) of engine oil. This was in line with Olayinka and Arinde (2012),, Njoku *et al.*, (2008), Kayode *et al.*, (2009) works. The reduction in height of the plant could be due to unfavourable soil conditions mainly due to insufficient aeration following a decrease in the air filled pore spaces (Atuanya, 1987), effects on soil microbes (Ekundayo and Benka-Coker, 1995), presence of toxic oil components/herbicidal properties of the soil (Siddiqui and Adams, 2002), reduced biochemical activities as well as presence of heavy metals (Agbogidi and Egbuchua, 2010) and a disruption in the soil water-plant interrelationship (Agbogidi, 2011a). The reduction in height of *Vigna unguiculata* due to high level of engine oil could also be attributed to deficiency in availability of nutrients needed to maintain physiological processes involved in plant growth, occasioned by nutrient stress due to influence of spent and unused engine oil. These findings agree with the work of Ogbuehi and Ezeibekwe (2010) who reported that crude oil cause deficiency of available nutrients needed to maintain growth especially at apical regions of the crops. These reductions o growth due to high level of pollution are in agreement with findings of Molina Baharahoma *et al.*, (2005) who recorded similar results and inferred that the negative effect could be due to impermeability effect of petroleum hydrocarbons, or immobilization of nutrients mainly nitrogen or inhibitory effect of some polycyclic aromatic compounds. The retardation in the height of *Vigna unguiculata* results in scarcity of the *vigna unguiculata* for man and animal consumption. Also its consumption could lead to drastic adverse effects in health of man.

The range of values recorded for the number of leaves experienced fluctuations in relation to concentration and duration of spent engine oil and unused engine oil (75 and 100mg/l). This may be attributed to the increased organic matter present in the sand-loam soil which might have induced increased production of leaves in the cowpea plant (Adewole and Moyinoluwa, 2012). This was in line with the discovery of Fernandes and Henriques, (1991) who discovered that some heavy metals at low concentrations are essential micro-nutrients for plants, but at high concentrations, they may cause metabolic disorders and growth inhibition for most of the plant species. Also, Agbogidi and Bamidele (2007) noted that small amount of hydrocarbon in substrates can enhance growth media and indirectly growth characteristics. At other points in time, when the engine oil was at its high concentration, a lower number of leaves were recorded. This agrees with the findings of Jung, (2008) who observed that as the level of pollution increases, the number of leaves decreases. This could be inferred as having caused by reduction in available macro and micro elements needed for production of leaves. Also, it could be due to the presence of heavy metals and polycyclic aromatic compounds found in spent and unused engine oil which could cause distortion within the plant tissues. This was also reported by Wang et al. (2000).

There was no much difference expressed in the stem girth when compared from the control experiment to 25, 50, 75 and 100 mg/l. This was also observed by Okonokhua *et al.*, (2007) where he reported that there was no significant difference in maize stem girth at all rate studied, though; stem girth values were found to decrease as the concentration increases. The significant difference observed in this study could be attributed to the fact that crops differ in their responses to pollutant (Adenipekun and Kassim, 2006). The widest stem girth occurred on the sixth week with a mixture of 50mg/l having a value of 1.28cm wide. The girth of the control experiment (1.26cm) was of a close range to the value of the 50mg/l engine oil. The expression of the stem girth in figure 3 above showed that the presence of engine oil (spent and unused) does not have a significant effect on the stem girth of *Vigna unguiculata*.

The mean leaf area decline with increase in application of spent engine oil and unused engine oil. The leaf area of 25mg/l was close to that of the control experiment while 50, 75, and 100mg/l are greatly reduced based on the increased of the engine oil. This was also reported by Olayinka and Arinde (2012). Like other growth parameters assessed, plants receiving 100mg/l of engine oil showed the least mean leaf area development (Olayinka and Arinde, 2012). The finding supported the data presented for *Chromolaena odorata and Arachis hypogeal* (Anoliefo, 2003), where the authors reported a marked reduction in leaf area at higher concentration of crude oil and spent lubricating oil, respectively. This reduction in leaf area may be due to limitation of nutrients uptake necessary for expansion of leaf area occasioned by high level of pollutants (Ogbuechi, and Ejioku, 2006). This agrees with findings of Agbogidi *et al.*, (2007) who reported that oil contamination also reduced the soil fertility by causing immobilization of nutrients by microbes. Such immobilization of nutrients leads to difficulty in the uptake of nutrients in oil contaminated soil which will be difficult despite the presence of nutrients in the soil (Ogbuechi, Ezeibekwe and Ejioku, 2006).

The reductions and morphological effects in the various growth characteristics measured were oil-dose dependent. Yellowness of leaves, shedding of leaves, leaves folding, flowering and pod production.

Yellowness of leaves with little patches of light spot coloration was observed on the plants in the soil mixed with 25, 50 and 75 mg/l of spent engine oil. Yellow coloration with grey patches at the middle of the leaf and around the blades was observed on the plants in the soil mixed with 50 and 75 mg/l of unused engine oil. Yellowness of leaves could be due to nutrient immobilization as oil pollution has been reported to cause unavailability of some essential nutrients while some toxic ones may be more readily available (Benka-Coker and Ekundayo, 1997), Agbogidi and Ejemete (2005). Adewole and Moyinoluwa (2012) also reported that severe yellowing of leaves was observed in the soil treated with 25, 50, and 75 mg/l of crude oil, two weeks after planting. This observation also agrees with Opeolu (2000) who reported that light oil pollution caused yellowing of leaves. The reduction of the chlorophyll content of the plant could be due to the interference of the oil on the ability of the plant to absorb some of the mineral nutrients. Minerals like magnesium, iron, boron, and manganese are essential for chlorophyll synthesis (Campbell, 1996, Taylor et al. 1997, Kent 2000). Such interference and the reduced rate of photosynthesis which accompanies reduction of chlorophyll can lead to plant death and stunted growth. Also, the reduced leaf areas of the plants due to the addition of the spent oil can aggravate the photosynthesis level in the plant with resultant poor performance of the plant. All these can lead to low yield of the plant and low availability of the food (Agbogidi *et al.*, 2007).

As at the fourth week, shedding of leaves was randomly and constantly observed on the plants till the stop of the project work on both the spent engine oil and unused the engine oil. The observed leaf drop/fall and wilting could be linked to the inability of the seedlings to absorb water because they were watered like their counterparts in the control experiment (Agbogidi and Eruotor, 2012).this could have stemmed from the alteration caused by the presence of the oil in soil and this observation is in agreement with the findings of Atuanya, . (1987) and Ekundayo, and Obuekwe (1997), that oil in soil affects the physical, chemical and biological properties of the soil. Adewole and Moyinoluwa, 2012 reported that complete shedding of leaves was observed in the sand-loam soil treated with 75mg/l of crude oil 3 weeks after planting, followed by death of seedling. This observation agrees with Opeolu (2000) who reported that light oil pollution caused yellowing of leaves and dropping of leaves soon after planting while heavy oil contaminant resulted in complete shedding of leaves.

Folding of leaves was sharply observed on the plants with 25, 50 and 75mg/l of spent engine oil while plants with 25, 50 and 100mg/l of unused engine oil at the sixth week of the project work. This folding of leaves could also interfere with the proper activities of photosynthesis which accompanies reduction of chlorophyll and leads to stunted growth and death. The folding of leaves also reduces the leaf areas of the plant due to the presence of the engine oil and these can lead to low yield of the plant and low availability of food Agbogidi *et al.,* (2007).

The production of pods as well as flowering was not obviously affected. The production of pods and flowering occurred at about the same period. The pods were produced after six weeks of planting. A normal *Vigna unguiculata* planted in an unadulterated soil produces its pods after 50 days (James 1983). Since there was no significant difference in the production of pods and flowering between uncontaminated and contaminated soil, it shows that there is an element of growth enhancing factor in the engine oil. Agbogidi and Bamidele (2007) noted that small amount of hydrocarbon in substrates can enhance growth media and indirectly growth characteristics. They reported that the observed better performance of cowpea cultivars TVX 3236 and IT84S-2246-4 than the other cultivars indicates species dependent quality of oil effects. Anoliefo and Edegbai (2000) reported that *Solanum melongena* was more tolerant to spent lubricating oil than *Solanum melongena.*

5. CONCLUSION

This study has demonstrated that soil contamination with engine oil (spent engine oil and unused engine oil) can affect the tissues of the *Vigna unguiculata* grown in such environment due to heavy metals that they contained. It is therefore concluded that spent engine oil and unused engine oil as low as 25mg/l is capable of becoming destructive to *Vigna unguiculata* growth, the soil components and its micro-organisms, human and other animal health and to the environment in general. There is therefore the need of government to enact a strict law and educate the citizenry on indiscriminate disposal of these pollutants (spent and unused engine oil) into the environment, especially, farmlands so as to ensure crop safety, food security, prevention of human and animal death and damaging the environment as a whole.

REFERENCES

Adaji, M.J., Olufaja, O.O and Aliyu, L. (2007). Effect of intra-row spacing and stand density on the growth and yield of cowpea (Vigna unguculata (L.) Walp). In: Olufaja, O.O., Omokore, D.F., Akpa, G.N and Sanni, S.A. (eds.). Proceedings of the 41st Annual Conference of the Agricultural Society of Nigeria (ASN) held at the Institute for gricultural Research, Samaru, Ahmadu Bello University, Zaria between 22nd and 26th October, 2007. Pp 153 – 157.

Adam, R.H., Dominguez, V.I. and Vinalay, L. (2003). Evaluation of Microbial respiration and ecotoxicity in contaminated soils representative of the petroleum producing region of South Eastern Mexico. *Terra.* 20: 253-265.

Adelaja, S.O. (2000). Development and evaluation of some quality parameter of cowpeas (Vigna unguiculata snack). In: Nkama, L., Jideani, J.A. and Ayo, J.A. (eds.). Proceedings of the 24 th Annual Conference of NIFST held at Bauchi, Bauchi State between 20th and 24th November, 2000. Pp 258 – 259.

Adenipekun, C.O., Oyetunji, O.J. and Kassim, L.S. (2008). Effect of spent engine oil on the growth parameters and chlorophyll content of *Cocchorus olitorus* Linn. *Environmentalist.* 28: 446-450.

Adewole, M.G. and Moyinoluwa, D.A. (2012). Effect of crude oil on the Emergence and Growth of Cowpea in Two Contrasting Soil Types from Abeokuta, Southwestern, Nigeria. *Asian Journal of Applied Sciences.* **5**(4): 232-239.

Agbogidi O.M, Eruotor P.G. 2(012) . Morphological Changes due to spent engine oil `contamination and its heavy metal components of Jatropha curcas. In:Baby, S. and Sandhu, P.S. eds. . Proceedings of the International Conference on Bioscience, Biotechnology and Health Sciences ICBBHs' 2012 organized by Planetary Science Centre Research December 14 and 15, 2012 in Singapore. Pp. 88-93.

Agbogidi O.M, Onosode A.T, Okonta B.C.(2006). Susceptibility of Dennettia tripetala (Bak.) F. seeds to crude oil.Journal of Food, Agriculture and Environment, 4(2): 350–352.

Agbogidi, O.M (2010b). response of six cultivars of cowpea (*Vigna unguiculata* L. Walp) to spent engine oil. *African Journal of Food Science and Technology.* **1**(6): 139-142.

Agbogidi, O.M (2011b). eco-toxicological implication of crude oil pollution on *Rhizophora racemosa* (G.F.W. Meyer). *Nature and science.* **9**(1): 45-49.

Agbogidi, O.M. (2011a). Screening six cultivars of cowpea (*Vigna unguiculata* L.Walp) for adaptation to soil contaminated with spent engine oil. *Academia Arena.* **2**(4): 33-40.

Agbogidi, O.M. and Egbuchua, C.O. (2010). Heavy metal concentrations of soil contaminated with spent engine oil in Asaba, Delta State. *Acta Agronomica Nigeriana.* **9**(1 and 2): 1-6.

Agbogidi, O.M. and Ejemeta, O, R. (2005). An assessment of the effect of crude oil pollution on soil properties, germination and growth of *Gambaya albida* (L). *Uniswa Res. J. Agric. Sci. Technol.* **8** (2): 148-155.

Agbogidi, O.M. and Nweke (2005). Effect of crude oil polluted soil on the performance of Okra (*Abalmoschus esculentus* L.). *Moench in Delta State Afr. J. Nat. Sci.* 8: 31-35.

Agbogidi, O.M., .Mariere, A.E. and Ohwo, A. (2013).

Agbogidi, O.M., Nweke, F.U. and Okechukwu, E.M. (2006). Yield performance of five cultivar of soya beans (*Glycine max* L. Merr) as influenced by soil contaminated with crude oil. *Niger Sci.* 8: 31-35.

Anoliefio, G.O. and Vwioko, D.E. (2001). Tolerance of *Chromolaena odorata* (L) K.and R.grown in soul contaminated with spent lubricating oil. *J.Trop. Biosci.* **1**(1): 20-24.

Anoliefo, G, O., Edegai, B.O. (2000). Effects of spent engine oil as contaminant on the growth of two eggplant species *Solanum melongena* and *S. incarnum. J. Agric for fish.* 1: 21-25.

Anoliefo, G.O. and Edegbai, B.O. (2000). Effect of spent engine oil as a soil contaminat on then growth of two egg plant species, *Selenium belonging* L. and *S. inanes* L. *Journal of Agriculture, forestry and fisheries.* 1: 21-25.

Anoliiefo, G.O. and Vwioko, D.E. (1995). Effect of spent lubricating oil on the growth of *Capsicum annum* L. and *Lycopersicon esculentum* miller. *Environmental Pollution.* 88: 361-364.

Asumugha, V. U. (2002). Sensory and functional properties of dry vegetable cowpea product (Akara). In: Ubbanu, C. N., Eke, O. S. and Uzomah, A. (eds.). Proceedings of the 26th Annual Conference of the Nigerian Institute of Food Science and Technology (NIFST) held at the Federal University of Technology, Owerri, Imo State between 4th and 8th of November, 2002. Pp. 66 – 67.

ATSDR (Agency for Toxic Substances and Disease Registry). (1997). Toxicology profile for used mineral based crankcase Oil. Department of Health and Human Services, Public Health Service Press, Atlanta, GA, USA.

Atuanya, E.J. (1987). Effect of oil pollution on physical and chemical properties of oil, a case study of waste oil contaminated Delta Soil in Bendel State, Nigeria. *Journal AppliedScience.* 55: 155-176.

Atuanya, E.J. (1987). Effect of oil pollution on physical and chemical properties of soil, a case study of waste oil contaminated Delta soil in Bendel state, Nigeria. *J. Appl.Sci.* 55: 155-176.

Ayotamuno, M.S., Kogbara, R.B., Egwuenum, P.N. (2006). A comparison of corn and elegant grass in the phytoremediation of a petroleum hydrocarbon polluted agricultural soil in Port Harcourt, Nigeria. *S. Food Aric. Environ.* **4**(384): 216-222.

B.U. Olayinka and O.O. Arinde , (2012). Effects of Spent Engine Oil on Germination and Seedling Growth of Groundnut (*Arachis hypogaea* L.). *Insight Ethnopharmacology*, 2: 5-9

Baker, J.M. (1970). The effects of oils on plants. *Environ. Pollut.* 1: 27-44.

Benka-Coker, M. O., and J. A. Ekundayo, (1995) "Effects of an oil spill on soil physico-chemical properties of a spill site in the Niger Delta Area of Nigeria," *Environmental Monitoring and Assessment*, 36 (2). 93-104,

Benka-coker, M.O. and Ekundayo, J.A. (1995). Effect of an oil spill on soil physic-chemical properties of a spill site in the Niger Delta area of Nigeria. *Environmental Monitoring and Assessment.* 36: 93-104.

Brandt, R., Merkl, N.,Schultze-kranft, R., Infante, C. and Broll, G. (2006). Potential of vetiver (*vetiveria Zizanioides L. Nash*) for phytoremediation of petroleum hydrocarbon-contaminated soils in Venezuela. *Int. J. phytoremed.* 8: 273-284.

Campbell NA (1996). Biology 4t hedn, The Benjamin/Cummings Publishing Company Inc., California, p. 1206.

Clarke, C.J. (2003). Field detected evaluation of organic clay soils contaminated withdieselfuel. *Environ forensics.* **4**(3): 167-173.

Daniel-Kalio, L.A. and Pepple, S.F. (2006). Effect of bonny light crude oil pollution of soil o the growth of dayflower (*Commelina bengalensis*) in the Niger Delta, Nigeria. *J. Applied Sci. Environ. Mgt.* 10: 111-114.

Dauda, M. and Obi, A. M. (2000). Determination of some properties of Engine Oils Manufactured in Nigeria. *Nig. J. of Eng.* **8**(2): 1-8.

Dominguez-Rosado, R.E., Pitchel, J. (2004). Phytoremediation of soil contaminated with used motor oil. 1. Enhanced microbial activities from laboratory and growth chamber studies *Environ.*Ekundayo, E. O. and Obuekwe, C. A. 1997. Effects of oil spill on soil physico-chemical properties of a spill site in a typic paledult of Midwestern Nigeria. Environmental Monitoring and Assessment 45:209-221.

Evdokimov, A.Y and Fooks, I.G. (1989). Ecological problems of rational use of lubricating materials. Neftekhimia, Moscow. 64pp.

Fernandes, J.C. and F.S. Henriques. (1991). Biochemical, physiological,and structural effects of excess copper in plants. Bot. Rev. 57:246--273.

Ibmesin, R.I. (2010). Effect of salinity and wytch crude oil on paspalum conjugation Bergius (sour grass). *J. Bio. Sci.* 10: 122-130.

Islam, S., Cowmen, R.C. and Garner, J.O. (2006). Screening for tolerance of stress temperature during germination of twenty-five cowpea (Vigna unguiculata L. Walp) cultivars. Journal of Food, Agric and Environment 4(2):189 – 191.

Kent M (2000). Advanced Biology, Oxford University Press, UK, p. 623.

Larcher, W. (2000). Ecofisiologia vegetal. RiMa, Sao Carlos, 365.

Malallah, G., Afzal, M., Kurian, M., Gulshan, S. and Dhami, M.S.I. (1998). Impact of oil pollution on some desert plants. *Environ. Int.* 24: 919-924.

Meinz, V. (1999). Used oil characterization study. Washington state department of ecological solid and hazardous waste program. *Hazardous waste section Olympia, Washington.* 98: 504-871.

Molina Barahona, L., Voga-Loyo L., Guerro Ramirez, S., Romeo, I., Vega-jarquin, C., Albones, A.(2005). Ecotoxicol Evaluation of DieselContaminated Spoil before and after a Bioremediation and soil ecotoxicity assessment. *Environment Science and Technology.* 31: 1769-1776.

Njoku, K.L., Akinola,M.O. and Oboh, B.O. (2008). Growth and performance of *Glycine max* L. (Merill) in crude oil contaminated soil augmented with cow dung. *Nature and Science.* **6**(1): 48-58.

Odjegba VJ, Sadiq AO (2002) Effect of spent engine oil on the growth parameters, chlorophyll and protein levels of Amaranthus hybridus L.. Environ., 22: 23-28

Odjegba, V.J and Sadiq, (2002). Effect of Spent Oil on the growth parameters, chlorophyll and proteins levels of *Amaranthus hybridus, L. The Environmentalist.* 22: 23-28.

Ogbuehi H.C., Ezeibekwe I.O. and Agbakwuru. U. (2010). Assessment of Crude Oil Pollution the proximate composition and macro element of cassava crop in plants. Owerri, Imo State. International Science Research (2):62-65.

Ogbuehi, H.C. and Ezeibkwe, I.O. (2010). Growth performance of cassava variety NR 8082 in crude oil poluuted soil in Imo State. *International Science Research Journal.* 2: 90-94.

Olapade, A.A. Ugokwe, P.U., Ozumba, A.U. and Solomon, H.M. (2002). Assessment of Premix for moin-moin and akara 1: effect of added ingredient on functional properties of cowpea (Vigna unguiculata) flour. In: Ubbaonu, C.N., Eke, O.S. and Uzomah, A. (eds.) Proceedings of the 26th Annual Conference of the Nigerian Institute of Food Science and Technology (NIFST) held at the Federal University of Technology, Owerri, Imo State between 4th and 8th of November, 2002. Pp. 68 – 70.

Opeolu, B. O. and Fadina, O. O. (2000): Sustainable Agriculture- Women and Pesticides. Proceedings of Gender and Science Technology Association. African Regional Conference, Abuja. Pp 288-289.

Olaleke, A.O., Olorunfemi, O. and Akintayo, T.E. (2006). Compositional evaluation of cowpea (Vigna unguiculata) and scarlet runner bean (Phaseolus coccineus) varieties grown in Nigeria. Journal of Food, Agriculture and Environment 4 (2): 39 – 43.

Osubor CC, Anoliefo GO (2003). Inhibitory effects of spent lubricating oil on the growth and respiratory functions of *Arachis hypogea* L. Benin Sci. Dig, 1: 73-79

Philip, R. D. and McWatters, K. H. (1991). Contribution of cowpea to nutrition and health. Food Technology 9: 127 – 130.

Sharifi M, Sadeghi Y, Akbarpour M (2007). Germination and growth of six plant species on contaminated soil with spent oil. Inter. J. Environ., Sci. Technol., 4(4): 463-470.

Sharifi, M., Sadeghi, Y., Akbarpour, M. (2007). Germination and growth of six plants species

Siddiqui, S. and Adams, W.A. (2002). The fate of diesel hydrocarbons in soils and their effects on the germination of perennial ryegrass. *Environ. Toxicol.* **17**(1): 49-62.

Singh, S. R. and Rachie, K. O. (1985). Cowpea research and utilization. John Wiley and Sons,

Smith, M.J., Flowers, T.H., Duncan, H.J., Alder, J. (2006). Effects of polycyclic aromatic Hydrocarbons on germination and subsequent growth of grasses and legumes in freshly contaminated soil and soil with aged PAHs residues. *Environ. Pollut.* 141: 519-525.

Sztompka, M. (1999). Biodegradation ofn engine oil in soil. Acta microbiologica Polonica. **48** (1): 185-196.

Wang, J. Jia, C.R. Wong, C.K. and Wong, P.K. (2000). Characterization of polycyclic aromatic hydrocarbons created in lubricating aromatic hydrocarbons created in lubricating oil. Water, Air and Soil Pollution 120:381 – 396.

Wyszkowski, M and Ziolkowska, A. (2008). Effect of Petrol and Diesel on ciontent of organic carbon and mineral components in soil. *American Journal of Sustainable Agriculture.* **2**(1): 54-60.

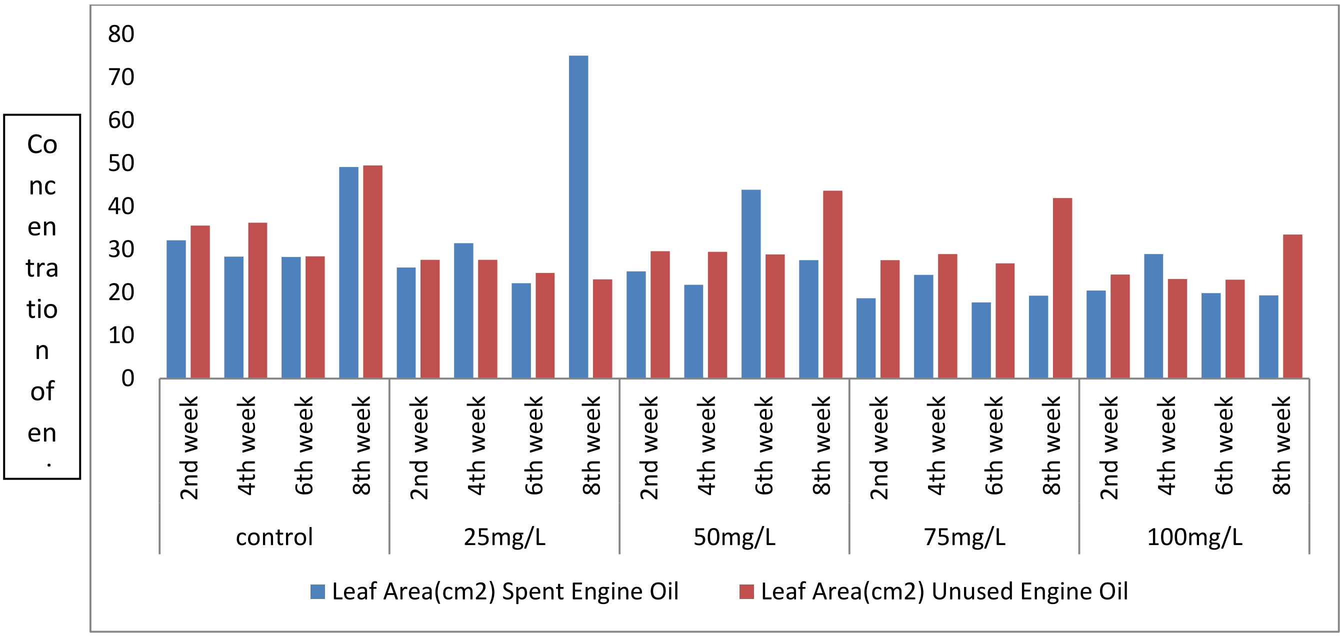

Figure 3.1: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Height of *Vigna unuguiculata*

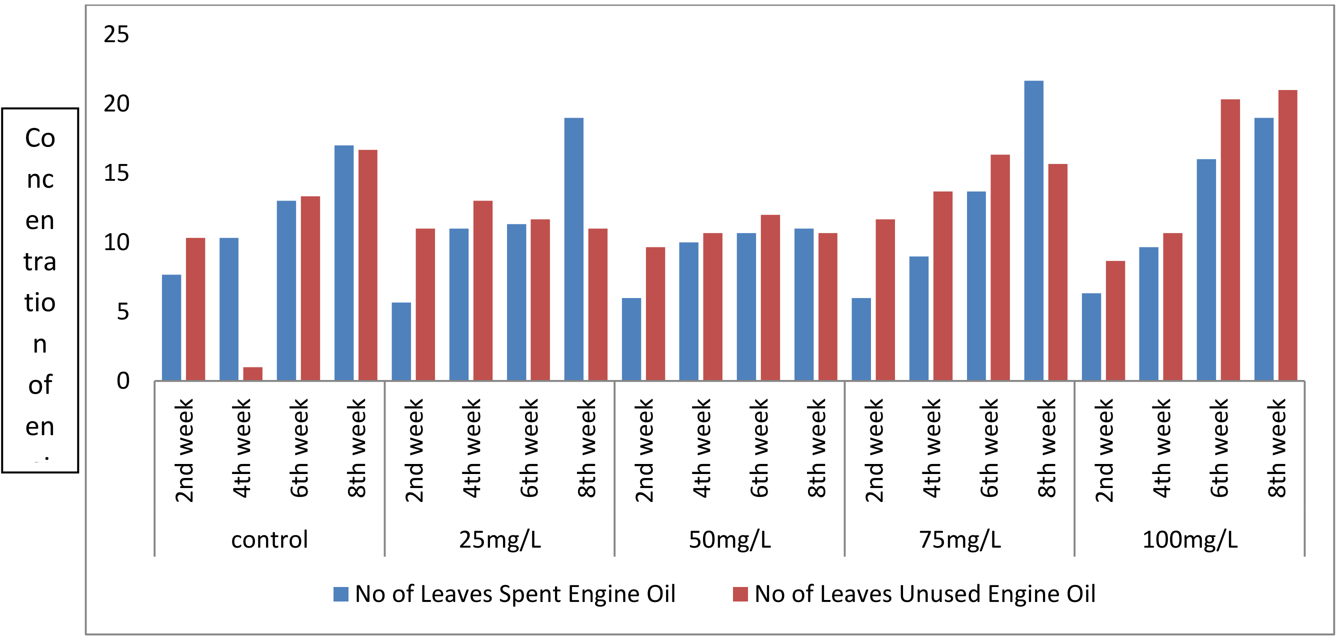

Figure 3.2: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Number of Leaves of *Vigna unuguiculata*

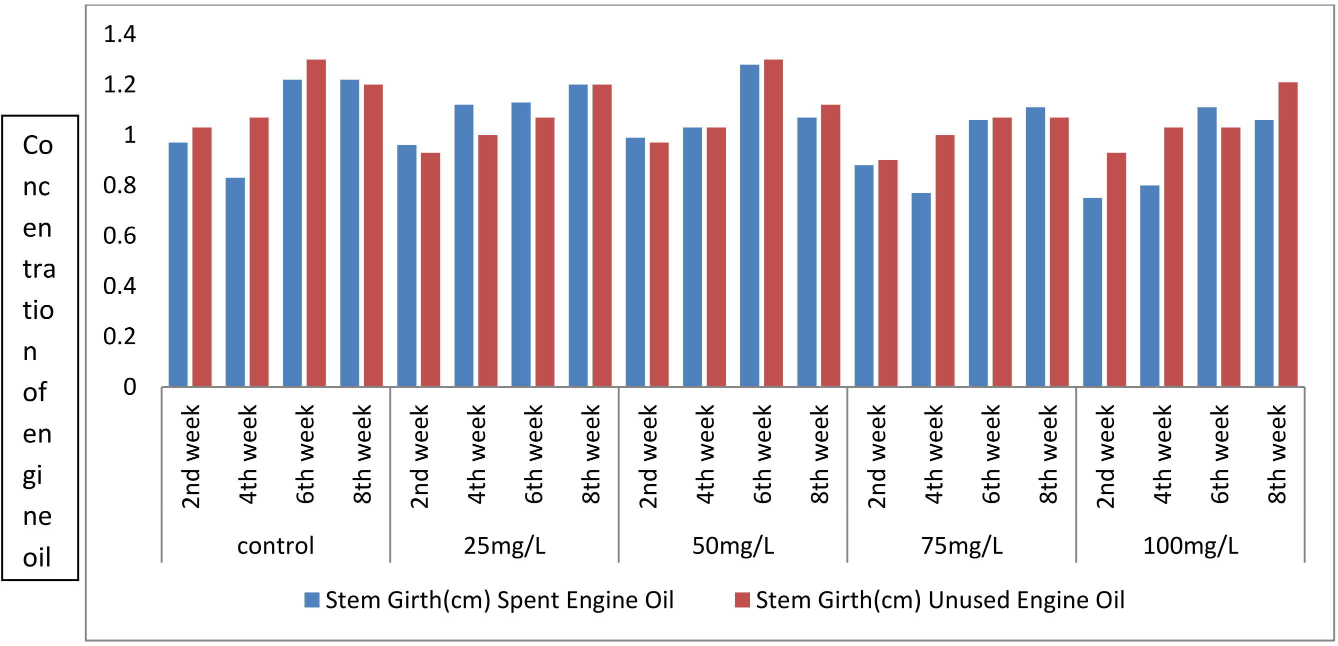

Figure 3.3: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Stem Girth of *Vigna unuguiculata*

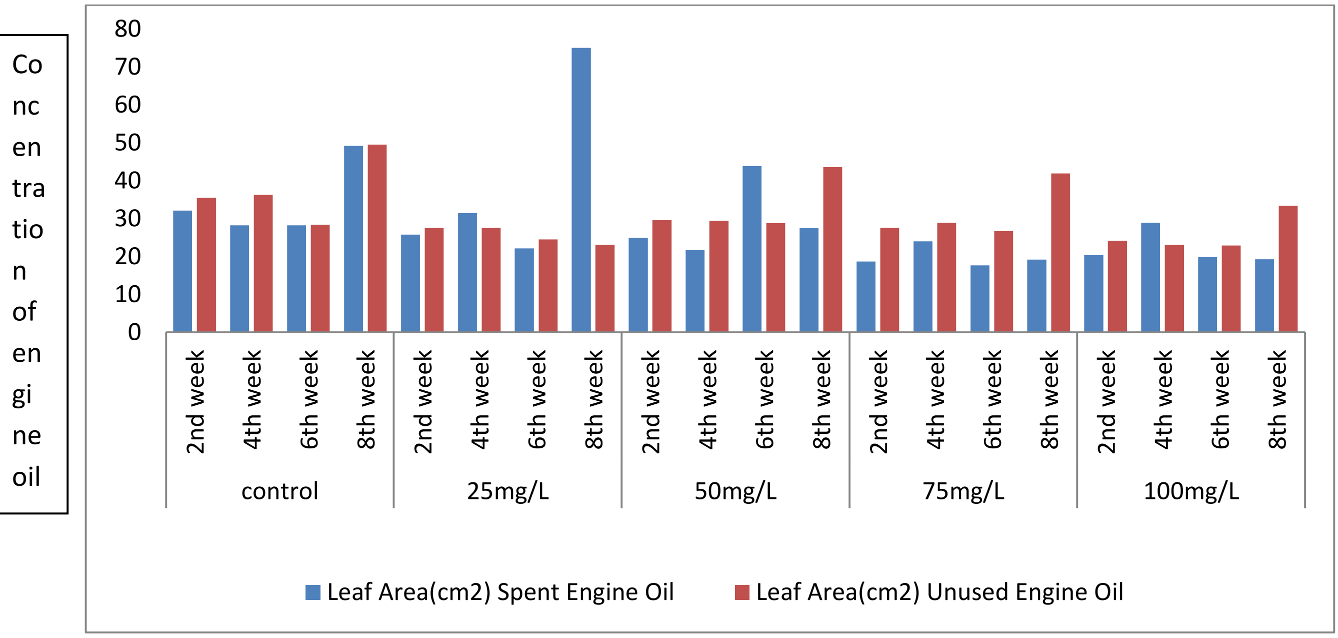

Figure 3.4: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Leaf Area of *Vigna unuguiculata*

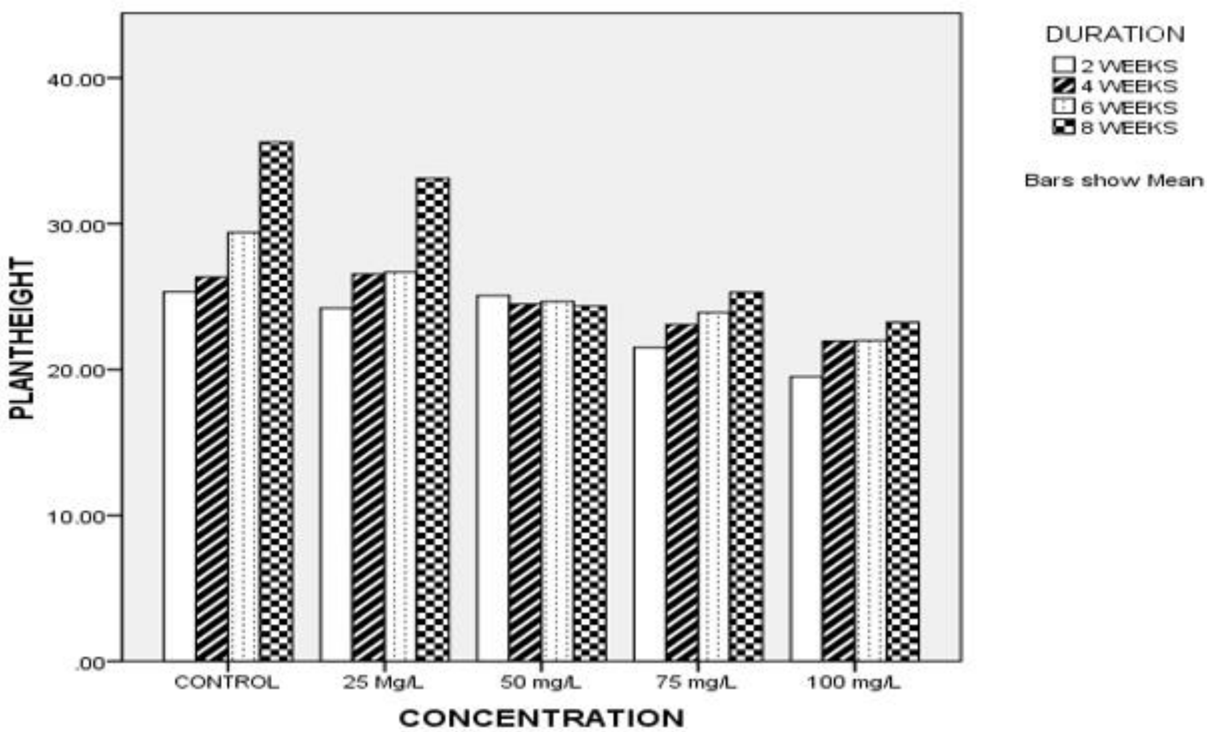

Figure 3.5: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Plant Height of *Vigna unuguiculata*

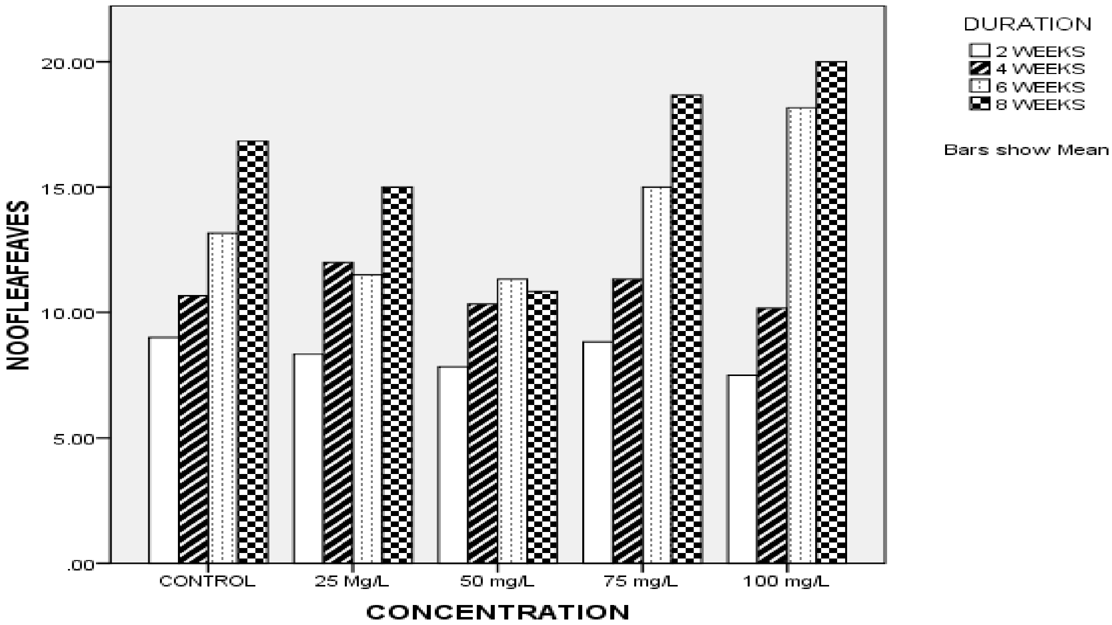

Figure 3.6: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Number of Leaves of *Vigna unuguiculata*.

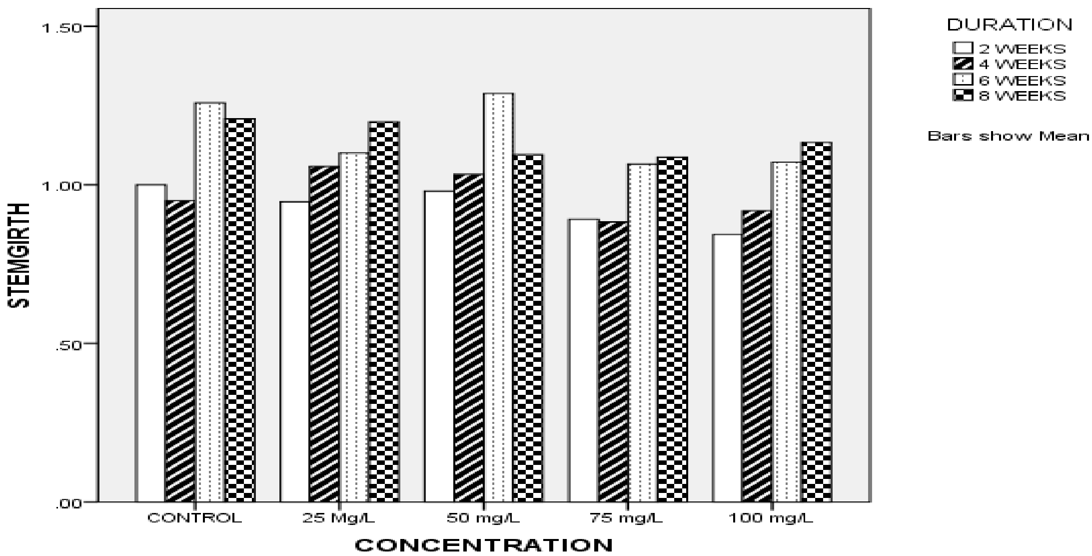

Figure 3.7: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Stem Girth of *Vigna unuguiculata*

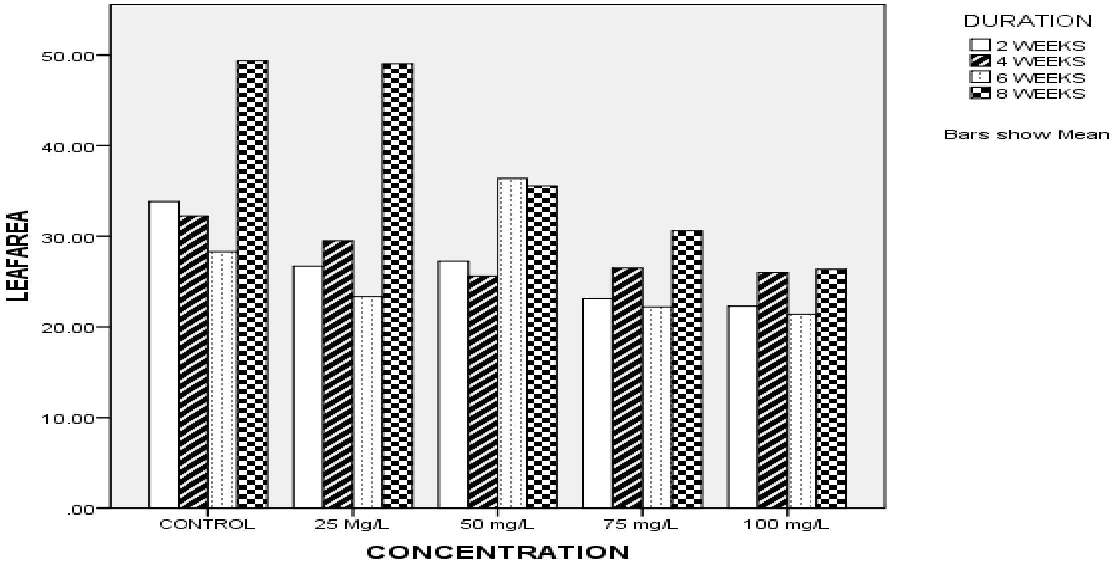

Figure 3.8: Graphical Illustration of Graded Concentrations of Spent Engine Oil and Unused Engine Oil in Relation to Duration on the Leaf Area of *Vigna unuguiculata*

