

**EFFECTS OF SPENT ENGINE OIL CONTAMINATION  
REMEDIATED WITH SPENT MUSHROOM SUBSTRATE ON  
THE GROWTH AND YIELD OF AMARANTH (*Amarathus  
hybridus*)**

**BY**

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BENIN CITY**

**SEPTEMBER, 2023**

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**A PROJECT SUBMITTED TO THE DEPARTMENT OF CROP  
SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN  
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**SEPTEMBER, 2023**

## **CERTIFICATION**

This is to certify that this research project is carried out by PASSOVER CHRISTAIN SHELU of the department of Crop Science, Faculty of Agriculture, University of Benin, Benin city, Edo state, Nigeria.

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## **DEDICATION**

This work is dedicated to God Almighty who has been my source of strength from the beginning of my academics to the end, and to my wonderful family who have supported me financially and with prayers and encouragement.

## ACKNOWLEDGMENT

It is pertinent and great importance that i return all glory to the rock of ages and omega of my journey as an undergraduate. To this end, I want to wholeheartedly give thanks to God Almighty who has been faithful to me throughout my undergraduate sojourn in the University of Benin, and also given me the grace and made provisions necessary to make the journey a success, to him that has done this may his name be praised forever. There wouldn't be a need to move on to the next phase of this acknowledge, if I don't appreciate, acknowledge and appreciate my wonderful, elegant and fearfully made foaster parents and my Mom. So i want to appreciate Mr. and Mrs Shelu Mark and Mrs Shelu Ruth for the show of love, support and advice, provision and most importantly for special prayers, thank you so much.

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## ABSTRACT

A screen house potted experience was conducted in the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City in June to August, 2023 to evaluate the effects of different level of spent engine oil (SEO) contamination remediated with spent mushroom substrate (SMS) on the growth and herbage yield of Amaranth (*Amaranth hybridus*). The experiment involved three spent engine oil contamination levels (0, 5 and 10% v/w per 10kg soil) and four spent mushroom substrate application rates (0, 200, 400 and 600 per 10kg soil) laid in a 3 x 4 factorial arrangement fitted into a completely randomized design (CRD) and replicated three times. Data were collected on plant height, stem girth, number of leaves, leaf area and herbage yield. The results of soil analysis before cropping with Amaranth showed that SEO had no effect on particle size of the soil. Organic C, H<sup>+</sup> and Al<sup>3+</sup> in the contaminated soils were higher compared to the control. There was decreased in concentrations of available P, total N, exchangeable cations as the SEO contamination level increased. Plant height, stem girth, number of leaves, leaf area and herbage yield of Amaranth plants grown in the contaminated soils were adversely affected as they were significant (P<0.05) reduced in comparison to their performance in unpolluted soils. Application of SMS enhanced growth and herbage yield of Amaranth. Application of SMS remediated the harmful effect of SEO on the plant as it enhanced the growth of the plant. However, higher rate of SMS application reduced growth and

herbage yield of Amaranth in comparison to the lower rate. Application of 200g of SMS per 10kg soil produced plants with the highest height (89.2cm), thickest stem (3.42cm), highest number of leaves (28.6cm), largest leaf area (2803cm<sup>2</sup>) and herbage yield (59.91tha<sup>-1</sup>). A combination of unpolluted soil treated with 200g and 400g of SMS produced the highest herbage yield with 72.9 and 75.1g, respectively. SMS at 200g is thereby suggested for Amaranth growers.

## CHAPTER ONE

### 1.0

### INTRODUCTION

#### 1.1 Background of study

*Amaranthus hybridus* is a leafy vegetable from East Asia origin, *A. hybridus* widespread in tropical and subtropical regions of the world and in the uplands. It is found in well drained soils in open waste place and cultivated land, especially prefers sandy soils or those rich in humus and fairly moist soils. The plant grows best in soils with no standing water and has good development in soils. Very common in Java below 300 m, goes up to 600 m. One of Nigeria's environmental issues is pollution from used engine oil, which is more pervasive than crude contamination (Odjegba and Sadiq, 2002).

Spills can happen throughout any stage of the product's production, handling, or delivery. According to Oyibo and Agboola (1983), this may be due to pipeline ruptures, accidents, and the disposal of used engine oil. Due to the rise in the number of automobiles and other machinery that utilize this lubricant, local engine oil consumption in Nigeria has recently increased at a very high rate. This has an immediate impact on how quickly used lubricant penetrates and pollutes the environment; it's usual practice to dump used lubricant in gutters, water drains, and vacant lots. among auto mechanics who change the oil in automobiles and power generation equipment. *Amaranthus hybridus* seed germination was severely hampered,

according to Odjegba and Idowu's (2000) findings. Chlorophyll II and protein levels during seedling growth were severely impacted.

Spill-related soil pollution has a negative impact on plant growth and nutritional content as well. Researchers like Wang *et al.* (2000), Odjegba and Sadiq (2002), Agbogidi *et al.* (2006), and others have studied the impacts of wasted lubricant oil pollution on soil characteristics and agricultural yields.

A cost-effective method of decreasing the impact of used engine oil on contaminated soil is bioremediation. The word "bioremediation" refers to biological methods used to restore harmed environments. The procedure takes advantage of the catabolic capacity of oil by using microbes in the case of oil spills.

After a crop of mushrooms has been harvested, leftover organic elements are referred to as spent mushrooms. Nitrogen and phosphorus, among other necessary nutrients, are present in the substrate. The vital nutrients found in used mushroom substrate serve the following purposes (Okoh, 2006). They stimulate microbial metabolism by utilizing bacteria to carry out efficient biodegradation in the kind.

Abioye *et al.* (2012) found that an increase in soil organic waste helps to loosen the soil's compact and provides the native bacteria in the soil with enough air to perform their metabolic functions more effectively. By rapidly improving the soil's physical and chemical properties and lowering the overall petroleum hydrocarbon content in the substrate-amended soil, the substrate, which is an organic waste, also serves to

counteract the harmful effects of oil on the microbial community (Jrgensen *et al.*, 2000).This study was undertaken to evaluate the effects of different concentrations of spent engine oil on the growth and yield of amaranth with remediation to spent mushroom.

## CHAPTER TWO

### LITERATURE REVIEW

#### **2.1 Effect of Spent engine oil on dry matter production of vegetables and other crops**

Agbogidi and Ilondu (2013) investigated the impact of engine oil polluted soil on the growth of *Moringa oleifera*. The production of *M. oleifera* dry matter showed reduction in its content with increase in the spent engine oil (SEO) contamination. In contrast to seedlings exposed to SEO, the uncontaminated soil with their undistributed roots were able to absorb enough nutrients for higher dry matter production. This could be due to the fact that root is responsible for the uptake of water and mineral salt (ions), the uncontaminated soils with their undisturbed roots were able to absorb enough nutrients. This is because the root is responsible for uptaking water and salts (ions), not the leaves. As roots are input organs for the absorption and transfer of water, Agbogidi (2010) stated that a reduction in shoot growth is a direct effect of the root growths since roots are the input organs for water and mineral nutrients to be absorbed and transported.

Agbogidi and Ejemete (2005) and Agbogidi and Eshegbeyi (2006) noted that as hydrocarbons from oil-contaminated soils accumulate in the chloroplast of leaves, the photosynthetic ability of the leaves is reduced. This may be due to obstruction of the xylem and phloem vessels, which affects translocation in affected plants and results in

a decrease in photosynthesis and dry matter production. Similar to this, Wang *et al.* (2002) found that growing maize on SEO contaminated sites could result in a 68% reduction in dry matter yield. According to Prasad and Prasad (1987), plants can acquire heavy metals from used engine oil and these can interfere with metabolic processes.

Osaigbovo *et al.* (2013) found that soil contamination with SEO had a negative impact on *Telfairia occidentalis's* dry vine weight, dry leaf weight, and herbage output. In comparison to contaminated plots, control plots had significantly higher dry vine weight, dry leaf weight, and herbage output. According to Anoliefo and Vwioko (1995), this may be related to soil aeration issues and heavy metal toxicity. Oluwanisola and Abdulrahman (2018) compared the yield parameters of *Abelmoschus esculentus*, including the dry weight and fresh weight produced by the control and spent oil treatment plants. A concentration-dependent reduction in these parameters was observed in all treatments with the exception of the 200 ml *A. esculentus* local variety SEO treated plants, as they had a higher dry weight than the 100 ml treatment plants.

The highest dry matter (4.21 t ha<sup>-1</sup>) of soybean plants was obtained in plots contaminated with 1% spent engine oil, while plots with 3% contamination had the lowest dry matter (1.80 t ha<sup>-1</sup>) and grain, which reflected the sizes and conditions of their leaf surfaces for photosynthesis (Ahamefule *et al.*, 2017). Some of the soybean

plants subjected to the 2% spent auto-engine oil treatment and the majority of those exposed to the 3% spent oil treatment were found to be chlorotic, while those exposed to the higher oil treatment (3%) failed to yield grains or yielded very little at maturity. Chlorotic leaves will show low photosynthetic efficiency resulting from the absence of chloroplasts and hence may not contribute or contribute little photosynthesis in dry matter build-up and grain filling (Ahamefule and Peter, 2014). As wasted engine oil contamination went beyond 1%, especially during the first planting season, this usually led to the low dry matter deposition and lower grain production reported. Onwusiri *et al.* (2017) noted a significant difference between the dry matter of *T. occidentalis* in the control plots (0%) and those planted in the 4 and 5% levels of wasted oil-contaminated soils (P 0.05). The considerable percentage differences in *T. occidentalis'* fresh and dry weight accumulation may be due to the high oil content of the soil, which allows the roots to absorb ions like salts and water. When compared to seedlings exposed to higher spent engine oil treatment, plants in control soils with undisturbed roots could have taken enough nutrients. Researchers have studied the impact of used engine oil on the growth and yield of particular crops. Clementina O Adenipekun (2008) reported that the effect of SEO on the height, number leaves, leaf area, stem girth, chlorophyll, and moisture contents of *Corchorus olitorius* grown on 0, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, 2.0%, and 3.0% (v/w oil/soil) oil-contaminated soil was investigated. The engine oil at all concentrations delayed the germination of *C.*

*olitorius* by 2 days (compared to control) and there was a general significant reduction in all the growth parameters in plants grown on contaminated soil compared to control plants. The highest leaf area of 26.8 cm<sup>2</sup> was found in the control plant and least was found in the 0.6% soil (0.11 cm<sup>2</sup>) after 3 weeks while no values were recorded on the 0.8–3.0% SEO contaminated soil after 5 weeks of experiment. The highest chlorophyll content was also found in the control plant (11.5 mg/l). This showed that SEO has an adverse effect on the growth of *C. olitorius* plant.

## **2.2 Effect of spent mushroom on crops**

According to Muchena *et al.* (2021), increased rates of Spent mushroom considerably (P 0.05) boosted both the dry mass and fresh mass of spinach (*Spinacia oleracea*). Baby spinach's rise in dry matter with the application of more spent mushroom substrate may be due to better nutrient availability, improved soil structure, and better nutrient release. The discarded mushroom substrate is appropriate for most plants since it has an average pH of 6.6 (ranging from 6.0 to 7.0). The ratio of carbon to nitrogen, which should be 30:1 or less in the perfect compost, is a key indicator of how much nitrogen is available for plant growth. The good 14:1 ratio of the waste mushroom substrate shows exceptional nutritional availability.

The rise in fresh weight may be attributed to the activation of many living organisms in the soil caused by the addition of organic matter. These organisms help plants absorb nutrients from the soil and encourage growth by releasing phytohormones into

the soil. According to Jonathan *et al.* (2011), *Pleurotus pulmonarius* spent mushroom compost added to depleted garden soil generally improved all growth-related factors when compared to control. Similar results were found by Kadiri and Mustafa (2010), who found that loamy soil (controls) alone did not produce the same vegetative growth or yields as composted wasted mushroom substrate (SMS) mixed with loamy soil. Ogbonna *et al.* (2012) research showed that SMS might be employed to boost growth and yield of maize (*Zea mays*).

Other researchers have demonstrated that SMS may be employed in crop production to enable productivity. According to Peksen and Uzun (2008), SMS stimulates soil microflora and improves soil enzymatic activities since it is rich in organic matter and contains macro- and micronutrients for plants and microorganisms. Additionally, It contains calcium carbonate, which has a balancing effect and raises the pH of the soil (Piagessi, 2014). According to Polat *et al.* (2004), there were statistically significant differences between the various levels of spent mushroom compost applications made in lettuce growing in terms of total yield, with applications of two and four tons/ha producing the best results in terms of total and marketable yield.

According to Idowu and Kadiri (2013), SMS provided plants like okra with enough mineral components, increasing the number of leaves and leaf area. The use of discarded mushroom substrate as a transplant media substitute for commercial peat in tomato cultivation has been reported by Eudoxie and Alexander (2011) with similar

results. SMS contained dry matter, crude protein, cellulose, lignin, NDF, and ADF (calcium, potassium, nitrogen, and sodium), which could affect the dry matter of test plants, (Wiafe-Kwagyan and Odamtten, 2004).

Muchena *et al.* (2021) reported SMS substrate significantly affected the length of spinach roots. These findings concur with those made by Sendi *et al.* (2013), who noted that Kai-lan (*Chinese broccoli*) root length was significantly influenced by SMS at harvest. The addition of adequate wasted mushrooms enhances the physical and chemical features of the soil, promoting improved root development, greater nutrient uptake, and water holding capacity, all of which result in a larger fruit production and better fruit quality (Suge *et al.*, 2011)

### **2.3 Effects of spent mushroom on the growth and yield of spent oil on polluted soils**

Liu *et al.* reported that bioremediation is an environmentally safe and less energy-demanding method of removing contaminants from the environment by using living organisms or their bio-products, 2017) and numerous biological processes for treating waste contaminants have been developed today (Asemoloye *et al.*, 2017).

SMS a fungus, has been suggested to be an effective bioremediation tool. Several studies had effectively demonstrated that SMS can bind heavy metals and stop them from moving to water sources or from being absorbed by plants from the soil. In contaminated soils, it gets rid of pesticides, chlorinated and non-chlorinated hydrocarbons, and wood preservatives (Li *et al.*, 2014). In addition to establishing and

facilitating plant growth in various contaminated or degraded soils, spent mushrooms also improve soil water content and retention (Kulshreshtha *et al.*, 2014).

After six months of incubation, the fungus *Pleurotus tuber-regium*'s spent mushroom was discovered to have the capacity to increase the nutrient contents which increases growth and yield in soils contaminated with 1 to 40% SEO. In comparison to the control, *tuber-regium* increased organic matter, carbon, and available potassium by 5.19 %, 2.99, and 0.97 cmol kg<sup>-1</sup>, respectively, while decreasing available nitrogen and phosphorus by 4.4 and 0.66 cmol kg<sup>-1</sup>. As opposed to 0.16 nitrogen, 9.32 mg kg<sup>-1</sup> phosphorus, and pH 5.93 in soils incubated with the fungus, higher values of 0.32 nitrogen, 11.42 mg kg<sup>-1</sup> phosphorus, and pH 6.94 were obtained in the control. SEO polluted soils, the mushroom caused an increase in copper content at a concentration of 10 %, followed by decreases at 20 and 40 %. At 20 % SEO concentrations, zinc and nickel bioaccumulation was observed.

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

#### **3.1 Experimental site**

The Screen House of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, served as the site of this trial. (Latitude 6°20'17.34"N, longitude 5°37'32.7°E) Benin City is 86 meters. The weather in Benin City is hot, muggy, and tropical. There is just a brief dry season and rainfall occurs in the majority of the months of the year. In Benin City, the yearly average temperature is 25.7°C. 2679 millimeters of precipitation fell. The topography of Benin City is undulating on an annual basis, and the vegetation is classified as lowland rainforest.

#### **3.2 Experimental materials**

The top soil used for this trial was obtained from the Department of Aquaculture and Fisheries management. The indigenous variety of Amaranth used in this study was purchased at Edaiken Market in Benin City. A mechanic shop in Benin City, Nigeria provided the Spent Engine Oil (SEO). Benin City's Ekiedo Market provided the Organic Fertilizer Spent Mushroom (SM).

#### **3.3 Experimental Design\Layout Treatment and Methods**

The experiment involved four spent mushroom rates (0, 200, 400, and 600g per 10kg soil) and three spent engine oil concentrations (0, 5 and 10% V/W), laid out in a 3 x 4 factorial arrangement fitted into a completely randomized design (CRD), giving a total

of 12 treatment combinations. There were two buckets in each treatment combination, totaling 24 buckets per replication.

### **3.4 Soil Chemical analysis**

Samples were taken from both the unpolluted and polluted soils in order to determine soil physical and chemical properties such as particle size analysis, pH, exchangeable cation (Ca, Mg, K, N, Exchangeable acidity ( $H^+$  and  $AP^+$ ), total organic carbon, total nitrogen, phosphorus, and heavy metals (Cu, pH, Cd) before cropping with Amaranth. After cropping with Amaranth, soils were also taken for chemical properties only. Nelson and Sommers (1982) used the wet dichromate acid oxidation method to quantify total organic carbon. Radojevic and Bashkin (1999) technique was used to determine total nitrogen describe how exchangeable cations and acidity were determined here. Particle size distribution will be determined by hydrometer method (Ibitoye, 2008). Soil pH will be estimated potentiometrically in a glass electrode in de-ionized at a solution to soil 1:1. Organic carbon will be determined by Walkley-Black Dichromate wet-oxidation method (Rhue and Kidder, 1983). Total nitrogen will be measured by Micro-Kjeldahl digested procedure as described by Bremner and Mulvaney (1966). Available phosphorus will be determined by Bray 1 soil extraction and measured by ammonium molybdate-blue colorimetric procedure (Udo *et al.*, 2009) Exchangeable bases (Ca, Mg, K and Na) will be determined by ammonium acetate displacement method, while Ca and Mg will be measured by di-sodium

ethylenediamine tetra-acetic acid (EDTA) titration method, Na and K flame photometry. Exchangeable acidity by titrimetric method.

### **3.5 Preparation of the Potting Buckets and Cultural Practices**

To avoid waste accumulation and to provide sufficient aeration, the buckets were perforated at the sides after which 10 kg of the air-dried soil were measured out and placed into the 72 perforated buckets. Soils were carefully mixed with 0, 64, and 124 milliliters (ml) of SEO, representing 0, 5, and 10%, respectively as per treatment and the buckets were labelled appropriately. Amaranth seeds were admixed with sharp sand and a pinch was broadcasted on each of the buckets and irrigated with 300ml of water. At two weeks after seeding, the resultant seedlings were thinned to four seedlings per bucket. Every other day, the plants received regular watering. Pest control and weeding were carried out by hand picking.

### **3.6 Data collection**

Following harvest, soil samples from each treatment were taken separately to determine their chemical properties using standard laboratory procedure.

### **3.7 Statistical analysis**

Data collected were subjected to a variance analysis using the GENSTAT statistical tool. The significant difference mean was separated with the least significant difference (LSD) at the 0.05 level of probability.

## CHAPTER FOUR

### RESULTS

#### **4.1 Physical and chemical properties of soil polluted with Spent Engine Oil and Remediated with Spent Mushroom before Cropping**

The physical and chemical properties of soil contaminated with Spent engine oil and Remediated with spent mushroom substrate (SMS) before cropping with Amaranth are presented in Table 1. As the rate of SEO increased, the pH value decreased but increased with increased with SMS application up to 400g and decreased thereafter. This trend was repeated for total N, available P, exchangeable cations except organic C, exchangeable hydrogen and Aluminium. Total hydrocarbon content was only present in poly bag polluted with SEO. However, SMS reduced total hydrocarbon content. SEO pollution and SMS decrease porosity and increased bulk density. SEO and SMS decreased soil electrical conductivity.

#### **4.2 Height growth of Amaranth plant**

Height of Amaranth plant as influenced by SEO pollution and remediated with SMS is presented in Table 2. Plant height decreased with increasing SEO pollution level in the soil. Throughout the sampling period, plants grown on polypots polluted with SEO of 10% had the shortest plants while unpolluted soils had the taller plants. SMS application significantly influenced the plant height at 3, 7 and 9 WAS. Plants with SMS treatment had the shortest plants but comparable with plants which received 400

and 600g at 3 WAS. Plants treated with 200g of SMS had the tallest plants at 3, 7 and 9 WAS.

**Table 1. Effect of spent engine oil pollution bioremediated with spent mushroom substrate on the physical and chemical properties of the soil**

| SEO (%)                     | SMS (g) | pH    | TN (g kg <sup>-1</sup> ) | TOC (g kg <sup>-1</sup> ) | Avail P (mg kg <sup>-1</sup> ) | K     | E C (cmolkg <sup>-1</sup> ) |       |       | E A (cmolkg <sup>-1</sup> ) |                  | THC (mg kg <sup>-1</sup> ) | Sand   | Silt  | Clay  | Porosity (%) | BD (g cm <sup>-3</sup> ) | EC (ds m <sup>-1</sup> ) |
|-----------------------------|---------|-------|--------------------------|---------------------------|--------------------------------|-------|-----------------------------|-------|-------|-----------------------------|------------------|----------------------------|--------|-------|-------|--------------|--------------------------|--------------------------|
|                             |         |       |                          |                           |                                |       | Ca                          | Mg    | Na    | H <sup>+</sup>              | Al <sup>3+</sup> |                            |        |       |       |              |                          |                          |
| 0                           | 0       | 5.80  | 0.65                     | 12.80                     | 8.56                           | 0.40  | 0.86                        | 0.42  | 0.20  | 0.11                        | 0.03             | 0.00                       | 885.00 | 63.00 | 52.00 | 50.00        | 1.10                     | 0.40                     |
| 0                           | 200     | 5.86  | 0.89                     | 23.60                     | 11.30                          | 0.43  | 0.90                        | 0.45  | 0.22  | 0.10                        | 0.03             | 0.02                       | 883.00 | 68.00 | 49.00 | 48.00        | 1.20                     | 0.36                     |
| 0                           | 400     | 6.04  | 2.46                     | 34.40                     | 13.50                          | 0.43  | 1.00                        | 0.44  | 0.25  | 0.10                        | 0.03             | 0.02                       | 881.00 | 68.00 | 57.00 | 48.30        | 1.20                     | 0.27                     |
| 0                           | 600     | 6.00  | 2.51                     | 38.80                     | 15.70                          | 0.42  | 1.05                        | 0.43  | 0.25  | 0.12                        | 0.04             | 0.01                       | 881.00 | 70.00 | 49.00 | 45.50        | 1.25                     | 0.27                     |
| 5                           | 0       | 6.14  | 0.81                     | 26.90                     | 7.06                           | 0.44  | 1.20                        | 0.45  | 0.26  | 0.12                        | 0.04             | 80.30                      | 850.00 | 65.00 | 85.00 | 44.00        | 1.10                     | 0.30                     |
| 5                           | 200     | 5.75  | 1.78                     | 35.50                     | 9.00                           | 0.32  | 0.86                        | 0.35  | 0.18  | 0.20                        | 0.08             | 75.80                      | 848.00 | 72.00 | 80.00 | 44.50        | 1.20                     | 0.34                     |
| 5                           | 400     | 6.08  | 1.93                     | 38.60                     | 9.40                           | 0.41  | 0.89                        | 0.43  | 0.20  | 0.10                        | 0.04             | 71.60                      | 845.00 | 75.00 | 80.00 | 42.00        | 1.20                     | 0.25                     |
| 5                           | 600     | 5.94  | 2.11                     | 41.70                     | 16.00                          | 0.40  | 0.95                        | 0.42  | 0.24  | 0.15                        | 0.05             | 135.30                     | 842.00 | 76.00 | 82.00 | 42.30        | 1.20                     | 0.30                     |
| 10                          | 0       | 6.20  | 0.89                     | 40.60                     | 12.90                          | 0.46  | 1.36                        | 0.45  | 0.25  | 0.08                        | 0.03             | 143.00                     | 838.00 | 79.00 | 83.00 | 45.50        | 1.20                     | 0.30                     |
| 10                          | 200     | 6.34  | 0.93                     | 45.30                     | 15.00                          | 0.45  | 1.40                        | 0.48  | 0.27  | 0.06                        | 0.00             | 132.40                     | 836.00 | 80.00 | 84.00 | 43.00        | 1.25                     | 0.33                     |
| 10                          | 400     | 6.72  | 1.22                     | 51.20                     | 12.30                          | 0.53  | 1.64                        | 0.55  | 0.31  | 0.00                        | 0.00             | 130.50                     | 833.00 | 86.00 | 81.00 | 42.40        | 1.40                     | 0.35                     |
| 10                          | 600     | 6.50  | 2.31                     | 53.80                     | 14.00                          | 0.50  | 1.45                        | 0.51  | 0.28  | 0.00                        | 0.00             | 126.20                     | 830.00 | 88.00 | 82.00 | 40.00        | 1.45                     | 0.36                     |
| <b>SEM</b>                  |         | 0.84  | 0.21                     | 3.34                      | 0.86                           | 0.02  | 0.08                        | 0.01  | 0.01  | 0.02                        | 0.01             | 17.36                      | 6.24   | 2.30  | 4.38  | 0.86         | 0.03                     | 0.01                     |
| <b>LSD<sub>(0.05)</sub></b> |         | 0.155 | 0.379                    | 6.173                     | 1.591                          | 0.028 | 0.148                       | 0.026 | 0.020 | 0.030                       | 0.019            | 32.116                     | 11.537 | 4.259 | 8.094 | 1.585        | 0.0560                   | 0.024                    |

\* SEO - Spent engine oil; SMS - spent mushroom substrate; EC- Exchangeable cation; EA - Exchangeable acidity; EC - Electrical conductivity, TN - Total nitrogen

**Table 2: Height growth (cm) of Amaranth plant as influenced by spent engine oil polluted soil remediated with spent mushroom substrate.**

| Treatment             | Plant height (cm) weeks after sowing |        |        |        |
|-----------------------|--------------------------------------|--------|--------|--------|
|                       | 3                                    | 5      | 7      | 9      |
| Spent engine oil      |                                      |        |        |        |
| 0                     | 19.12a                               | 33.5a  | 49.7a  | 93.8a  |
| 5                     | 13.51b                               | 29.0a  | 38.7b  | 83.4b  |
| 10                    | 5.805c                               | 14.06b | 22.7c  | 44.0c  |
| LSD <sub>(0.05)</sub> | 4.504                                | 13.07  | 4.47   | 7.46   |
| 0                     | 8.36b                                | 20.5a  | 30.6c  | 62.1c  |
| 200                   | 18.16a                               | 27.8a  | 46.0a  | 89.2a  |
| 400                   | 17.77b                               | 26.1a  | 33.46c | 73.9b  |
| 600                   | 12.96b                               | 27.9a  | 38.1b  | 69.9bc |
| LSD <sub>(0.03)</sub> | 5.200                                | Ns     | 5.17   | 8.62   |
| Interaction           | ns                                   | ns     | ns     | ns     |

ns not significant at 0.05 level of probability

Means followed by similar letters in the same column are not significantly different at 0.05 level of probability

### **4.3 Stem girth of Amaranth plant**

Stem girth decreased with increasing rate of SEO pollution (Table 3). Polypots polluted with SEO at the rate of 10% had the thinnest stems which were comparable with polluted rate at 5% at 3 WAS. Amaranth seeds sown in unpolluted soil had the thickest plants but at par with 5% SEO polluted soil at 9 WAS.

SMS significantly influenced stem girth throughout the sampling periods. Polypots without SMS treatment produced plants with the thinnest stem. However, at 3 WAS, only polypots treated with SMS at 200g produced plants with thicker stem than control polypots. At 3-9 WAS, polypots fortified with 200g of SMS had the thickest stems which was comparable with other application rate (400 - 600g) at 9 WAS

### **4.4 Number of leaves of Amaranth plant**

The highest number of leaves was recorded in 0% SEO at 3, 5, 7 and 9 WAS (Table 4). However, Height of plants observed in soil polluted with SEO at 5% were comparable with that of unpolluted soil at 5 and 9 WAS. Polypots treated with 200g of SMS had the highest number of leaves per plant at 3-9 WAS. However, the number of leaves per plant provided by polypots treated with 200g of SMS were compared with those treated with 400 and 600g of SMS.

**Table 3: Stem girth (cm) of Amaranth plants as influenced by spent engine oil polluted soil remediated with spent mushroom substrate**

| Treatment             | Stem girth (cm)    |       |       |       |
|-----------------------|--------------------|-------|-------|-------|
|                       | Weeks after sowing |       |       |       |
|                       | 3                  | 5     | 7     | 9     |
| Spent engine oil      |                    |       |       |       |
| 0                     | 1.70a              | 1.72a | 2.06a | 3.58a |
| 5                     | 1.48b              | 1.32b | 1.46b | 3.33a |
| 10                    | 0.68b              | 0.88c | 1.11c | 2.27b |
| LSD <sub>(0.05)</sub> | 0.197              | 0.168 | 0.169 | 0.691 |
| 0                     | 0.98b              | 1.08c | 1.36b | 2.39b |
| 200                   | 1.69a              | 1.66a | 1.71a | 3.42a |
| 400                   | 1.21b              | 1.21b | 1.43b | 3.23a |
| 600                   | 1.27b              | 1.26b | 1.47b | 3.19a |
| LSD <sub>(0.03)</sub> | 0.228              | 0.194 | 0.195 | 0.798 |
| Interaction           | ns                 | ns    | ns    | ns    |

ns not significant at 0.05 level of probability

Means followed by similar letters in the same column are not significantly different at 0.05 level of probability

**Table 4: No of leaves of Amaranth plants as influenced by spent engine oil polluted soil remediated with spent mushroom substrate**

| Treatment             | No of leaves / plant |        |         |       |
|-----------------------|----------------------|--------|---------|-------|
|                       | 3                    | 5      | 7       | 9     |
| Spent engine oil      |                      |        |         |       |
| 0                     | 12.00a               | 13.75a | 21.67a  | 30.5a |
| 5                     | 10.92b               | 12.92a | 17.92b  | 28.9a |
| 10                    | 6.33c                | 8.00b  | 13.67c  | 16.8b |
| LSD <sub>(0.05)</sub> | 0.858                | 0.923  | 1.602   | 1.82  |
| 0                     | 8.22c                | 9.44b  | 13.89c  | 21.3c |
| 200                   | 11.00a               | 12.78a | 20.56a  | 28.6a |
| 400                   | 10.00b               | 12.00a | 17.44b  | 25.3b |
| 600                   | 9.78b                | 12.00a | 19.11ab | 26.3b |
| LSD <sub>(0.03)</sub> | 0.991                | 1.066  | 1.849   | 2.10  |
| Interaction           | ns                   | ns     | ns      | ns    |

ns not significant at 0.05 level of probability

Means followed by similar letters in the same column are not significantly different at 0.05 level of probability

#### **4.5 Leaf area**

Leaf area varies significantly among different levels of SMS and different concentrations of SEO (Table 5). The largest leaf area was recorded in 0% SEO at 3, 5, 7 and 9 WAS while polypots polluted with SEO at 10% had the smallest leaf area. Polypots treated with 200g SMS had the largest leaf area at 3, 5, 7 and 9 WAS but at par with 400-600g at 7 WAS. Untreated polypots had the smallest leaf area which were comparable with 400 and 600g SMS at 3 and 9 WAS.

#### **4.6 Herbage yield of Amaranth as influenced by SEO bioremediated with SMS**

SEO and SMS application interaction on herbage yield of Amaranth is presented in Table 6. Unpolluted soil treated with 400g produced plants with the highest herbage yield of 75.1  $\text{tha}^{-1}$  but not significantly higher than that of 200g SMS with 72.9 $\text{tha}^{-1}$ . Herbage yield decreased with increasing rate of SEO pollution while it increased with increasing application rate to 200g and decreases thereafter.

**Table 5: Leave area of Amaranth plants as influenced by spent engine oil polluted soil remediated with spent mushroom substrate**

| Treatment             | Leaf area (cm <sup>2</sup> ) |        |       |       |
|-----------------------|------------------------------|--------|-------|-------|
|                       | Weeks after sowing           |        |       |       |
|                       | 3                            | 5      | 7     | 9     |
| Spent engine oil      |                              |        |       |       |
| 0                     | 368a                         | 549a   | 1035a | 2865a |
| 5                     | 274b                         | 375b   | 663b  | 1872b |
| 10                    | 52c                          | 97c    | 294c  | 1161c |
| LSD <sub>(0.05)</sub> | 48.3                         | 142.08 | 231.6 | 389.9 |
| 0                     | 192b                         | 219c   | 537b  | 1472b |
| 200                   | 354a                         | 503a   | 875a  | 2803a |
| 400                   | 196b                         | 342bc  | 614ab | 913b  |
| 600                   | 184b                         | 297c   | 630ab | 1676b |
| LSD <sub>(0.03)</sub> | 52.3                         | 164.9  | 266.9 | 450.2 |
| Interaction           | ns                           | ns     | ns    | ns    |

ns not significant at 0.05 level of probability

Means followed by similar letters in the same column are not significantly different at 0.05 level of probability

**Table 6: Herbage yield of amaranths as influenced by spent engine oil bio remediated with spent mushroom substrate**

| Spent engine oil pollution (%) | Spent mushroom substrate |       |       |       | Mean  |
|--------------------------------|--------------------------|-------|-------|-------|-------|
|                                | 0                        | 200   | 400   | 600   |       |
| 0                              | 49.0                     | 72.9  | 75.1  | 63.8  | 65.2a |
| 5                              | 46.6                     | 46.0  | 48.8  | 35.3  | 44.06 |
| 10                             | 2.6                      | 54.7  | 14.7  | 39.5  | 27.9c |
| Mean                           | 32.7c                    | 57.9a | 45.2b | 46.2b |       |
| LSD (0.05) SEO                 | 6.53                     |       |       |       |       |
| LSD (0.05) MMS                 | 7.54                     |       |       |       |       |
| LSD (0.03) SEO x SMS           | 13.06                    |       |       |       |       |

SEO- spent engine oil, SMS spent mushroom substrate

## CHAPTER FIVE

### CONCLUSION, DISCUSSION AND RECOMMENDATION

#### 5.1 Discussion

Soil pollution by spent engine oil has poses a great menace to agricultural productivity and thus create poverty and hunger among the populace. It was observed from this experiment that oil in agricultural soil affects agricultural productivity. This study showed that various level of SEO supported the growing of Amaranth plants. However there were variation in plant height, stem girth, number of leaves, leaf area and herbage yield. Plant height, stem girth, number of leaves, leaf area and herbage yield grown in the contaminated soils were adversely affected as they were significantly reduced in comparison to their performance in unpolluted soils.

Oil pollution in agricultural soil in whatever form is toxic to the plant and soil microenvironments. It has been observed by Adenipekun *et al.*, (2006) that crude oil affects agricultural soil and this in turns affect the physiological, ecological and anatomical development of plants grown on such soils and this in consonance with the outcome of the present studies.

Germination of *Abelmoschus esculentus* (Okra) plant was delayed in crude oil polluted soil, though this effect was concentration dependent. This is in agreement with the result obtained by Oyetunji *et al.*, (2009) that oil in soil above 2% concentration affects the growth of okra adversely and severely. The finding align with Nwoko *et al.*,

(2007) where they found that presence of crude oil in the plant-soil microenvironment appears to affected the amount of water available to the plant are reduced which in turn reduced crop yield.

## **5.2 Conclusion and recommendation**

Spent mushroom substrate can serve as a suitable bioremediation medium for polluted soil. This study basically affirms the positive impact of SMS on polluted soils. Notably, a 200g SMS in 10kg of polluted soil is thereby suggested for achieving the highest plant height, thickest stem, greatest leaves count, large leaf area and highest herbage yield.

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