BIOSTIMULATION POTENTIALS OF COWDUNG ON THE SPENT ENGINE OIL POLLUTED SOIL USING *Panicum maximum*

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Abstract:
This study aimed to determine the bio-stimulation potentials of cow dung on the spent engine oil-polluted soil using Panicum maximum. The cow dung levels were constant in the amount of soil needed, while the spent engine oil varied from 1 % to 3 % and 5 %. By 12 weeks, the plants were harvested. Initial heavy metal properties of soil, cow dung and spent engine oil were analyzed for heavy metal. Growth parameters data were collected and subjected to descriptive statistics to obtain the means and standard deviations. Analysis of variance was used to compare the differences in the heavy metal properties of soil, cow dung, and spent engine oil, as well as the means of growth data and laboratory analysis. The result showed that the heavy metals in soil, cow dung and crude oil varied significantly (P<0.05). The growth parameters studied generally varied considerably (P<0.05), except LL 6 WAP, LL 2 WAP and 4 WAP, which do not differ significantly. Heavy metal properties of the plant and the soil also varied significantly (P<0.05). Convincingly, the result affirms the phytoremediation capability of *P. maximum.*

Keywords: **Cow dung, harvested, heavy metal, *Panicum maximum*, spent engine oil, soil.**

1. Introduction

The *P. maximum* species emerges as an alternative for use in semi-arid environments due to its high nutritional quality forage production capacity and adaptability to different soil-climatic conditions [1]. In this respect, several recent studies have been conducted with this species in semi-arid environments [1, 2]. However, there still needs to be more information about the potential of more forage cultivars as alternatives for forage production in the semi-arid- region, nor is there an understanding of their environmental responses [1]. *Poaceae*, formerly called *Gramineae, is a* grass family of monocotyledonous flowering plants, a division of Poales. The *Poaceae* are the world's single most important source of food [2]. Two studies have been undertaken at Ubon Ratchathani University, Thailand, to study these botanically and agronomically cultivars. In the first study undercutting, Mombasa produced 17 – 21 % more total Dry matter (DM) and 18 – 24 % more leaf DM than Tanzania [3].

Nevertheless, in and beyond the Niger Delta, pollution incidences emanating from spent engine oil have been reported to be more widespread and dominant than that of other petroleum products [4]. Spent engine oil is produced by vacuum distillation of petroleum and usually contains chemical additives, including amines, phenols, benzenes, calcium, zinc, barium, magnesium, phosphorus, sulphur and lead [5]. Spent engine oil is known to contain increased amounts of heavy metals when compared to unused oil [6]. Okonokhua et al. (2007) reported that the proportion and type of these heavy metals in spent engine oil depended on the waste generation process [7]. Various researchers have investigated and reported the ecological toxicity effects of petroleum and spent engine oil. Ahamefule et al. (2015) and Agbogidi and Ejemete (2005) noted that oil (petroleum) in soil has a deleterious impact on the soil's biological, chemical and physical properties depending on the dose, type of oil and other factors [8, 9]. In this vein, Badrul I. (2015) [10] reported that oil tends to accumulate in disposal sitesin the long term and may lead to the formation of oily scum, which according to Shallu et al. (2014), impedes oxygen and water availability to biota and creates anaerobic conditions in the subsoil, which aidsthe persistence of the oil [11]. According to studies, adverse impacts of spent engine oil (SEO) have been observed on plants cultivated on SEO-polluted soils, leading to reduced germination of seeds, yield and increased uptake of toxic components [12].

Due to detrimental effects on soil fertility, contamination of agricultural soil by toxic compoundsfound in petroleum crude renders the soil unusable for landowners. It reduces its suitability for agricultural purposes [13]. For this reason, cleaning up petroleum-contaminated agrarian soil is a global concern for rehabilitating agricultural land and its usage [14]. Using organic manure with phytoremediation is an environmentally safer option because it releases nutrients slowly and acts as a soil conditioner [15-17]. Also, organic manure contains nitrogen, magnesium, sulphur, phosphorus, and potassium that support plant growth [16]. Organic manure improves soil physical and chemical conditions and maintains an adequate supply of soil organic matter with high microbial loads [17]. This enables faster degradation of hydrocarbon contaminants [15-17]. Evidence is provided by Kaimi et al.

(2006) in their study of ryegrass that adding compost manure to the soil increases the rate of removal of Petroleum Hydrocarbons (PHCs) [18]. At the same time, Obasi et al. (2013) reported removing 60–65 % of hydrocarbon from soils treated with manure and municipal bio-waste compost [19]. Unlike these, this study was on the biostimulation of phyto-remediators using cow dung to its prevalence in different environments, making it almost cost-free. Hence, this current study will explain the need to study further the ameliorated impact of waste engine oil on soil using the phytoremediation enhancer. This study aimed to determine the bio-stimulation potentials of cow dung on the spent engine oil-polluted soil using *P. maximum.*

STUDY AREA

The screen house of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, was the location of the study. Within Longitude 070 34’’ E, Latitude 050 29’’ N and at an elevation of 122 m above sea level was the location of Umudike. [20]. Samples of spent engine oil were collected from motor mechanics shops around Michael Okpara University of Agriculture, Umudike.

MATERIALS AND METHODS

Sample collection: at a depth of 0 – 15 cm in crop farms around the Michael Okpara University of Agriculture, Umudike, with the aid of a shovel. Plant samples were collected from the surroundings of Umuahia Township. Having only one factor (spent engine oil), the research design of this experiment was completely randomised. Levels of cow dung were constant to the amount of soil needed. Meanwhile, the spent engine oil varied in 1 %, 3 %, and 5 % of the soil and cow dung content. Control soil samples had zero levels of spent engine oil. Each soil sample was replicated three times.

Preparation of soil sample: Soil samples were sieved with a 2 mm sieve and were mixed in the following way: 0 % of 4000 grams of cow dung + 4000 grams of farm soil = Negative control. 10 % of 4000 grams of cow dung + 3600 grams of soil = Positive control. 10 % of 4000 grams of cow dung + 3600 grams of soil + 40 mills of spent engine oil = 1 %. 10 % of 4000 grams of cow dung + 3600 grams of soil + 120 mills of spent engine oil = 3 %. 10 % of 4000 grams of cow dung + 3600 grams of soil + 200 mills of spent engine oil = 5 %. The treated soil samples were permitted to stand for seven days. Subsequently, three plant samples uprooted with roots of the same height were transplanted into each sack bag filled with the treated soil samples. At the end of 6 weeks of transplanting, the plant samples were removed, and the soil and plant samples were taken to the laboratory for physical and chemical constituent evaluation.

Plant growth parameter measurements: Growth parameters comprising germination count, leaf length, stem girth, leaf number, root length and biomass were determined. Germination count (count per replicate): The number of germinations was done by daily observation of sprouting sample plant seeds per replicate. Leaf length (cm plant -1): The leaf length was measured using a ruler. A meter rule was used to measure upwards, starting from the base to the tip of a plant leaf. Leaf number (number plant -1): The leaf number was collected by counting directly the number of leaves per plant.

Stem girth (cm plant -1): The girth was taken using a mechanical Vernier Caliper. The girth was recorded in centimeters per plant.

Root length (cm plant -1): The root length was taken by placing a ruler from the rooting point to the tip. Root length was recorded in centimeters per plant.

Root number (number plant -1): The root number was collected by counting directly the number of roots per plant.

Biomass (gram plant -1): Placing the various parts on a weighing balance took the weight of the stem, root and leaf. Records were taken in grams.

Analysis of heavy metals: The Aqua Regia method determined heavy metals' bio-available or soluble concentration [21]. Conventional Aqua Regia digestion was performed in 250 ml glass beakers covered with watch glasses. A well-mixed sample of 0.5000 g was digested in 12 ml of Aqua Regia on a hotplate for 3 h at 1100 C. After evaporation to near dryness, the sample was diluted with 20 ml of 2 % (v/v with H2O) nitric acid and transferred into a 100 ml volumetric flask after filtering through Whatman no. 42 filter paper and diluted to 100 ml with Deuterium-Depleted Water (DDW). The filtrates were analysed for Zinc (Zn), Mercury (Hg), Manganese (Mn), Iron (Fe), Lead (Pb), Copper (Cu), Chromium (Cr) and Cadmium (Cd) using an atomic absorption spectrophotometer. The values were compared with the widely used normal and critical levels of the total heavy metal concentration for the contaminant limit (c); the p index was calculated as the ratio between the heavy metal content in the soil and the toxicity criteria (the tolerable levels).

Data analysis: Data collected was subjected to descriptive statistics to obtain the means and standard deviations. Analysis of variance was used to compare the difference in the heavy metal properties of soil, cow dung and spent engine oil. Means of growth data and laboratory analysis were subjected to analysis of variance (ANOVA). Statistically significant means at 5 % probability were separated using the Duncan multiple range test. All the tests were done using the Statistical Package for Social Sciences (SPSS) version 26.

RESULTS

Initial heavy metal properties of soil, cow dung and spent engine oil (SEO) are presented in Table 1a.

TABLE 1a
Initial heavy metal properties of soil, cow dung and spent engine oil (SEO)

Sample	Zn	Ni	Mo	Hg	Pb	Mn	Fe
Soil	0.01^b	1.62^a	11.05^a	0.03^b	-ve	0.95^a	0.53^a
CD	0.06^a	0.87^b	6.71^b	0.04^a	-ve	0.44^b	0.01^c
SEO	0.01^b	0.44^c	3.35^c	-ve	ve	-ve	0.27^b
CV	2.01319	0.0722	0.01004	4.2459	-	0.1977	0.2150
LSD	0.00184	0.0023	0.0023	0.0029	-	0.0029	0.0018
Pr(>F)	<0.001***	<0.001***	<0.001**S*	<0.001***	-	<0.001***	<0.001***

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient ofvariation), LSD (Least significant difference), and CD (Cow dung).

From the result, Zn ranges from 0.01 of soil and SEO to 0.06

CD. The effect of heavy metal properties of soil varied significantly different (P<0.05). Ni ranges from 0.44 of SEO to 1.62 soil. The impact of heavy metal properties of soil varied significantly different (P<0.05). Mo ranges from 3.35 of SEO to 11.05 soil. The effect of heavy metal properties of soil varied significantly different (P<0.05). Hg ranges from 0.03 of soil to 0.04 CD. The impact of heavy metal properties of soil varied significantly different (P<0.05). Pb has a negative value. Mn ranges from 0.44 of the CD to 0.95 of the soil. The effect of heavy metal properties of soil varied significantly different (P<0.05). Fe ranges from 0.01 of CD to 0.53 of soil. The impact of heavy metal properties of soil varied significantly different (P<0.05).

Initial heavy metal properties of soil, cow dung and spent engine oil (SEO) are presented in Table 1b.

TABLE 1b
INITIAL HEAVY METAL PROPERTIES OF SOIL, COW DUNG AND SPENT ENGINE OIL (SEO)

Sample	Cu	Co	Cr	Cd	Ba	B	K
Soil	0.24^{a}	0.007^{b}	0.09^{a}	0.03^{a}	21.74^{a}	0.74^{a}	1.72^{a}
CD	0.09^{b}	0.01^{a}	0.02^{b}	-ve	9.05^{b}	0.35^{b}	1.14^{b}
SEO	0.02^{c}	0.006^{b}	0.02^{c}	-ve	6.74^{c}	0.17^{c}	0.98^{c}
CV	1.0483	6.9282	1.6132	7.9016	0.00799	0.1375	0.0779
LSD	0.0039	0.0018	0.0023	0.0026	0.00318	0.0018	0.00318
Pr(>F)	<0.001***	0.0026**	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), and CD (Cow dung).

From the result, Cu ranges from 0.02 of SEO to 0.24 of soil. The effect of heavy metal properties of soil varied significantly different (P<0.05). Co ranges from 0.007 of soil to 0.01 CD. The impact of heavy metal properties of soil varied significantly different (P<0.05). Cr ranges from 0.02 of SEO to 0.09 soil. The effect of heavy metal properties of soil varied significantly different (P<0.05). Cd has 0.03 of soil and –ve for CD and SEO. The effect of heavy metal properties of soil varied significantly different (P<0.05). Ba ranges from 6.74 of SEO to 21.74 of soil. The impact of heavy metal properties of soil varied significantly different (P<0.05). B ranges from 0.17 for SEO to 0.74 for soil. The effect of heavy metal properties of soil varied significantly different (P<0.05). K ranges from 0.98 of SEO to 1.72 of Soil. The impact of heavy metal properties of soil varied significantly different (P<0.05).

The germination count P. maximum grown on different levels of spent engine oil is presented in Table 2.

TABLE 2
Germination count P. maximum grown on different levels of spent engine oil

Treatment	7 DAP	8 DAP	9 DAP	10 DAP	11 DAP	12 DAP
NC	1.33	1.33	1.33	1.33	1.33	1.33
PC	0.00	0.00	0.00	0.00	0.00	0.33
1 %	1.33	1.67	1.67	1.33	1.33	1.33
3 %	0.00	0.67	0.67	0.67	0.67	1.00
5 %	0.33	1.00	1.00	1.00	1.00	1.00
CV	129.099	95.8315	95.8315	89.3765	89.3765	77.4597
LSD	1.409	1.6272	1.6272	1.4092	1.4092	1.4092
Pr(>F)	0.1264^{NS}	0.2633^{NS}	0.2633^{NS}	0.2597^{NS}	0.2597^{NS}	0.5339^{NS}

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), CD (Cow dung), NC (Negative control), PC (Positive control), and DAP (Days after planting).

From the result, 7 DAP ranges from 0.00 of PC to 1.33 of NC and 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). 8 DAP ranges from 0.00 of PC to 1.67 of 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). 9 DAP ranges from 0.00 of PC to 1.67 of 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). 10DAP ranges from 0.00 of PC to 1.33 of NC and 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). 11DAP ranges from 0.00 of PC to 1.33 of NC and 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). 12DAP ranges from 0.33 of PC to 1.33 of NC and 1 %. Effect of germination count P. maximum grown on different levels of spent engine oil varied significantly (P<0.05).

The growth response of P. maximum grown on different levels of spent engine oil is presented in Table 3.

TABLE 3
Growth response of *P. maximum* grown on different levels of spent engine oil

Treatment	LL 2WAP	LL 4WAP	LL 6WAP	SG 2WAP	SG 4WAP	SG 6WAP	NL 2WAP	NL 4WAP	NL 6WAP
NC	32.00	30.33	34.20^{bc}	1.70	1.73	2.07	4.67	5.00	7.67
PC	3.00	0.00	17.33^{c}	0.50	0.00	1.60	0.67	0.00	2.67
1 %	23.00	36.00	60.24^{ab}	2.10	1.17	1.43	5.00	6.33	12.00
3 %	19.80	54.33	63.83^{a}	1.37	3.13	1.53	4.33	8.67	17.67
5 %	24.67	27.87	44.23^{ab}	1.47	0.73	1.27	3.67	3.33	9.33
CV	67.2099	66.1591	33.5664	50.3178	106.892	32.3136	80.2887	95.351	64.3135
LSD	25.0578	35.7553	26.8496	1.30599	2.6318	0.9288	5.3558	8.095	11.544
Pr(>F)	0.2^{NS}	0.0738^{NS}	0.0174*	0.1665^{NS}	0.1715^{NS}	0.4367^{NS}	0.426^{NS}	0.247^{NS}	0.1326^{NS}

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), CD (Cow dung), NC (Negative control), PC (Positive control), WAP (Weeks after planting), LL (leaf length), SG (Stem girth), NL (Number of leaves).

From the result, LL 2 WAP ranges from 3.00 of PC to 32.00 of NC. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). LL 4 WAP ranges from 0.00 of PC to 54.33 of 3 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). LL 6 WAP ranges from 17.33 of PC to 63.83 of 3 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). SG 2 WAP ranges from 0.50 of PC to 2.10 of 2 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). SG 4WAP ranges from 0.00 of PC to 3.13 of 3 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). SG 6 WAP ranges from 1.27 of 5 % to 2.07 of NC. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly at (P<0.05). NL 2 WAP ranges from 0.67 of PC to 5.00 of 1 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). NL 4 WAP ranges from 0.00 of PC to 8.67 of 3 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). NL 6WAP ranges from 2.67 of PC to 17.67 of 3 %. The effect of the growth response of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05).

The root growth and biomass of P. maximum grown at different levels of spent engine oil are presented in Table 4.

TABLE 4
Root growth and biomass of *P. maximum* grown on different levels of spent engine oil

Treatment	LLR	NR	LW	RW	SW
NC	22.67	27.33	3.33	16.33	6.00
PC	9.67	12.67	1.00	3.67	2.00
1 %	25.33	38.00	14.33	33.33	20.33
3 %	29.00	51.67	32.00	80.67	62.00
5 %	26.00	37.33	9.67	26.67	27.00
CV	34.88742	63.5314	122.0794	157.8428	172.4282
LSD	14. 30181	38.6039	26.7995	92.27353	73.61331
Pr(>F)	0.08804^{NS}	0.3043^{NS}	0.1559^{NS}	0.4493^{NS}	0.4332^{NS}

Mean With different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), CD (Cow dung), NC (Negative control), PC (Positive control), WAP (Weeks after planting), LLR (length of longest root), NR (Number of roots), LW (leaf weight), RW (Root weight), SW (Stem weight), NS (not significant).

From the result, LLR ranges from 9.67 of PC to 29.00 of 3 %. The effect of root growth and biomass of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). NR ranges from 12.67 of PC to 51.67 of 3 %. The effect of root growth and biomass of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). LW ranges from 1.00 of PC to 32.00 of 3 %. The effect of root growth and biomass of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). RW ranges from 3.67 of PC to 80.67 of 3 %. The effect of root growth and biomass of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05). SW ranges from 2.00 of PC to 62.00 of 3 %. The effect of root growth and biomass of P. maximum grown on different levels of spent engine oil varied significantly (P<0.05).

Heavy metal properties of soil six weeks after planting are presented in Table 5.

TABLE 5
Heavy metal properties of soil six weeks after planting

Treatment	Cd	Cr	Pb	Hg	Zn
NC	0.11^{a}	0.10^{b}	-ve	0.13^{a}	0.22^{a}
PC	0.03^{c}	0.14^{a}	0.08	0.00^{d}	0.10^{d}
1 %	0.02^{d}	0.06^{e}	-ve	0.00^{c}	0.12^{b}
3 %	0.00^{e}	0.06^{d}	-ve	0.00^{d}	0.09^{e}
5 %	0.07^{b}	0.07^{c}	-ve	0.04^{b}	0.12^{b}
CV	0.3673	0.82317	-	1.9480	0.5410
LSD	0.0018	0.0018	-	0.0018	0.0018
Pr (>F)	<0.001***	<0.001***	-	<0.001**	<0.001***

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), Cd (Cadmium), Cr (Chromium), Pb (lead), Hg (Mercury), Zn (Zinc).

From the result, Cd ranges from 0.02 of 3 % to 0.07 of 5%. The effect of heavy metal properties of soil six weeks after planting varied significantly (P<0.05). Cr ranges from 0.06 of 3 % to 0.07 of 5 %. The effect of heavy metal properties of soil six weeks after planting varied significantly (P<0.05). Pb ranges from 0.00 % of NC to 0.08 % of PC. The effect of heavy metal properties of soil six weeks after planting heavy metal properties of soil six weeks after planting varied significantly different (P<0.05). Hg ranges from 0.00 of 3 % to 0.04 of 5 %. The effect of heavy metal properties of soil six weeks after planting varied significantly (P<0.05). Zn ranges from 0.12 of 1 % to 0.12 of 5 %. The effect of heavy metal properties of soil six weeks after planting varied significantly (P<0.05).

The heavy metal properties of *P. maximum* grown on different SEO levels six weeks after planting are presented in Table 6.

TABLE 6
Heavy metal properties of P. maximum grown on different levels of SEO six weeks after planting

Treatment	Cd	Cr	Pb	Hg	Zn
NC	0.12^{d}	0.03^{c}	0.00^{d}	0.05^{d}	0.04^{d}
PC	0.29^{c}	0.19^{a}	0.68^{a}	0.15^{c}	0.25^{b}
1%	0.36^{b}	0.17^{b}	0.53^{b}	0.19^{b}	0.27^{a}
3%	0.07^{e}	0.01^{d}	0.00^{d}	0.03^{e}	0.13^{c}
5%	0.38^{a}	0.17^{b}	0.45^{c}	0.19^{a}	0.27^{a}
CV	0.2873	0.6059	0.2117	0.5744	0.3700
LSD	0.0018	0.0018	0.0018	0.0018	0.0018
Pr(>F)	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***

Mean with different superscript alphabets are significantly different (P<0.05). CV (Coefficient of variation), LSD (Least significant difference), Cd (Cadmium), Cr (Chromium), Pb (lead), Hg (Mercury), Zn (Zinc).

From the result, Cd ranges from 0.07 of 3% to 0.38 of 5%. The effect of heavy metal properties of P. maximum grown on different SEO levels six weeks after planting varied significantly (P<0.05). Cr ranges from 0.01 of 3% to 0.19 of PC. The effect of heavy metal properties of P. maximum grown on different SEO levels six weeks after planting varied significantly (P<0.05). Pb ranges from 0.00 of NC and 3% to 0.68 of PC. Effect of heavy metal properties of P. maximum grown on different SEO levels six weeks after significantly different (P<0.05). Hg ranges from 0.03 of 3% to 0.19 of 5%. The effect of heavy metal properties of P. maximum grown on different SEO levels six weeks after planting varied significantly (P<0.05). Zn ranges from 0.04 of NC to 0.27 of 1%. The effect of heavy metal properties of P. maximum grown on different SEO levels six weeks after planting varied significantly (P<0.05).

DISCUSSION

The Effect of soil's heavy metal properties varied significantly (P<0.05) in soil's initial heavy metal properties, Cow dung and spent engine oil. This result showed that spent engine oil is the proven source of heavy metals in the ecosystem. This study agrees with the work of Merkl et al. (2004), who studied phytoremediation in the tropics, the effect of crude oil on the growth of tropical plants, and reported higher chemical properties in the soil before contamination than those in the spent engine oil [22]. The study on the phytoremediation potential of P. maximum (guinea grass) for selected heavy metal removal from contaminated soils by Olatunji et al. (2014) showed that the initial soil chemical constituents had varying heavy metal levels [23]. The findings demonstrated considerable variation ($P<0.05$) in the levels of heavy metals in soil, cow dung, and spent engine oil. Compared to soil and spent engine oil, cow dung had a lesser effect on the amounts of heavy metals in the growth media. Adebiyi et al. (2023) supported their study on the impact of manure and Glomus hoi on heavy metals and soil properties of spent engine oil-contaminated soil [24]. They concluded that the heavy metal content of the oil was relatively high, with an iron (Fe) concentration of 77.15 mg/L, a zinc (Zn) concentration of 18.25 mg/L, a lead (Pb) concentration of 12.48 mg/L, a cadmium (Cd) concentration of 10.51 mg/L, and a copper (Cu) concentration of 14.92 mg/L. It was also noted that the high levels of heavy metals in Spent-engine oil make it a potentially hazardous material.

The P. maximum germination result revealed that germination happened seven days after starting. The negative control sample had higher germination throughout the observation than the other samples. Higher concentrations of soil treated with Spent engine oil prevented germination. This observation could result from the physiological stress due to the presence of oil in the soil. Okafor and Chidozie (2015) supported this in their work on the impact of different soil amendments on crude oil-polluted soil and the performance of maize [25]. They concluded that there was an emergence across the pots. However, CD and Ct showed complete emergence. The treatments had no significant effect at $p\leq0.05$; the total percentage emergence showed 92%. Onuh et al. (2008) agreed with their on the impact of poultry manure and cow dung on crude oil polluted soil's physical and chemical properties [26]. They noted that the germination of maize seed was impaired by crude oil pollution, and the effect increased with an increase in pollution. However, with the application of organic manure, the germination of maize seeds was improved, attaining optimal levels with the poultry manure.

In the early weeks of observation, the plant's leaf length was influenced by the concentration of spent engine oil. As a result, the size of the leaf decreased as the pollution level increased. The stem girth number of the leaf numbers showed a similar observation. However, in the later weeks of observation, the plants treated with spent engine oil had higher growth in girth, leaf and number of leaves formed. This result could be due to cow dung amelioration, which reduced the phytotoxicity of engine oil spent on the soil. Hence, this showed that the P. maximum adapted and remediated the polluted soil. This study agreed with the work of Akujobi et al. (2011) on the effect of nutrient amendments of diesel oil-polluted soil on plant growth parameters [27]. They discovered that the pollution level hurt the leaf area, with the highest impact observed in the 10% diesel oil pollution in the 16th week (14 cm2). Adebiyi and Salami (2023) agreed in their work on the effect of manure and Glomus hoi on heavy metals and soil properties of spent engine oil-contaminated soil [24]. They concluded that soil amendments such as cow dung, poultry manure, Glomus hoi and Gliricidia sepium leaves provided numerous benefits for soil health and plant growth. Also, Fayinminnu et al. (2021) supported their study on the evaluation of poultry manure and cow dung on Solanum lycopersicum planted on spent oil-polluted soil, stating that the increase in the growth and yield performance of S. lycopersicum observed in this study may be due to the addition of soil amendments in the polluted soil. Growth and yield parameters were higher in poultry manure (PM) treatment over others [28].

In the controlled samples, the root number was lesser; this was also observed in the plant's biomass at harvest. This result could also be due to adaptation skill P. maximum due to cow dung amelioration, which reduced the phytotoxicity of spent engine oil in the soil. Nonetheless, P. maximum's capacity might be linked to the plant's capacity in bioremediation [25]. Their work on the impact of different soil amendments on crude oil-polluted soil and the performance of maize was supported by the conclusion that the performance of maize was also negatively affected, as was the yield per hectare in unamended polluted soil. Fayinminnu et al. (2021) agreed in their work on the impact of crude oil spillage pollution and chemical remediation on agricultural soil properties and crop growth by stating that there was a significant moisture content reduction ($p = 0.01$) in the polluted soil compared to unpolluted soil [28]. Thus, crude oil spillage reduces soil moisture availability and holding capacity or increases moisture deficit in agricultural soils, damaging plant growth and yield. Essien and John (2010) postulated that diesel oil, like other petroleum products, adversely affects the development and performance of plants, as indicated in the results [29]. The effect of diesel oil on plant height observed here was similar to those reported on the impact of spent oil on Amaranthus hybridus.

Furthermore, because there was less heavy metal in the control samples, there was heavy metal residue in the soil due to spent engine oil contamination. Most soil samples did not contain lead and other toxic elements. Higher metal levels found in soil contaminated by spent engine oil indicated that spent engine oil lowered the plant's ability to remediate. They were considering the initial decrease in heavy metal levels in the soil. This result could be due to the amelioration of cow dung and the phyto-accumulation ability of the plant studied.

Olatunji et al. (2014) concluded that the concentration of metals in P. maximum tissues decreased in the order root > stem > foliage. The phytoremediation of Pb2+, Cr3+ and Cd2+ contaminated soils with P. maximum seems promising under the experiment's conditions [23]. Ukoh et al. (2019) reported a significant reduction of the heavy metals in vegetated soils for P. maximum and A. compressus at the end of their study compared to the heavy metals in the soils at the beginning of the study ($p<0.05$). P. maximum removes Zn better than A. compressus [30]. However, it was not significant. A similar conclusion was made by Ifediora et al. (2021), stating that waste engine oil-contaminated soil hurt the grass species studied [31]. Certain harmful metals, such as mercury, have negligible or nil amounts of heavy metals in the plant. As the already present metals demonstrate, this results from the plant’s capacity to absorb metals. Ernest et al. (2018) reported the nonexistence of lead, nickel, chromium, and cadmium in P. maximum exposure to hydrocarbon contamination [32]. A similar conclusion was stated by Berefo (2014) in the study on the Phytoremediation of heavy metal-contaminated soil using Senna hirsuta (L.), Panicum maximum (Jacq.) and Helianthus annuus (L.) [33]. They stated that their ability to tolerate and hyperaccumulate high levels of As, Zn, Pb, Cu, Cd and Au made them suitable species for phyto mining these heavy metals. Adebiyi and Salami (2023) observed increased heavy metal content in spent engine oil-polluted soils [24]. The increased level of heavy metals observed in the soil could be attributed to the high level of heavy metals in the spent engine oil. Heavy metals are also more available in acidic soils than neutral or alkaline soils.

CONCLUSION

This investigation showed that natural sources of heavy metals include soil, spent engine oil, and cow manure. Along with the treatment, it was revealed that there were significant differences ($P<0.05$) in the plant germination, root, and biomass. Increased spent engine oil treatment samples had a detrimental effect on P. maximum germination. However, the leaf, stem, and root performed better among the plants treated with spent engine oil, indicating that P. maximum is suitable for phytoremediation. The phytoremediation capability of P. maximum is also marked by lower levels of heavy metals in the soil following the growth phase and by the presence of heavy metals in plant tissue. Consequently, the results provided evidence that cow dung supplements modify the properties of spent engine oil-polluted soils and improve nutritional status, thereby restoring the fertility of the soil for agricultural purposes. Cow dung is accessible in Nigeria, and its use in remediating spent engine oil pollution is encouraged.

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