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Efficacy of *Urena lobata* in Phytoremediation of Spent Engine Oil Polluted Soil

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Abstract

Purpose: The research study aimed to determine the efficacy of *Urena lobata* in phytoremediation of spent engine oil polluted soil of Makurdi, Nigeria as to determine the amount of some inorganic pollutants (Cd, Pb, As and Cr) removed from the soil by the annual plant with time.

Methodology: *Urena lobata* was grown in twelve (12) Plastic containers filled with four kilograms (4 kg) of sandy-loam soil contaminated with 0 mL, 20 mL, 40 mL, 60 mL, 80 mL and 100 mL and monitored for twelve weeks (12) after planting.

Findings: The tissue analysis of heavy metals shows that *Urena lobata* has the highest percentage absorbance and remediation capacity of arsenic (0.06 mg/kg) with percentage absorbance of 37.5 % and followed by cadmium 0.04 mg/kg of pollutant with percentage absorbance of 32.56 %. Equally, from the result and analysis obtained on remediation of lead pollutant, *Urena lobata* has remediation capacity of 0.11 mg/kg with percentage absorbance of 8.53 %. Also, *Urena lobata* has absorbance and remediation capacity of chromium pollutant with the mean tissue concentration level of 0.26 mg/kg. The absorption rate by the test plant measured were spent engine oil concentration level dependent. Finally, the results showed that the studied plant (*Urena lobata*) screened for total metal concentration showed value of bio-concentration factor (BCF) < 1 for all heavy metal pollutants, and also high value of translocation factor (TF) > 1 in the following order; Pb (2.000) > As (1.667) > Cr (1.567) > Cd (1.500) mg/kg and as a consequence *Urena lobata* plant was efficient in translocation of metal pollutants from roots to shoots.

Unique contribution to theory, practice and policy: *Urena lobata* can then be considered as potential candidates for phytoextraction and phytoremediation of soils contaminated with Cd, Pb, As and Cr. Facility owners and industrialists should adopt and invest on the use of phytoremediation technologies in the remediation of polluted sites with spent engine oil as the technology can remediate more than one pollutant at a time and environmentally friendly.

Keywords: *Urena lobata, Spent Engine Oil, Phytoremediation, Pollutants*

1.0 INTRODUCTION

Spent engine oil which is also known as used mineral based crankcase oil, is a brown-to-black liquid produced when new mineral-based crankcase oil is subjected to high temperature and high mechanical strain [1]. Spent engine oil is a mixture of several different chemicals [2]. including low and high molecular weight aliphatic hydrocarbons, aromatic hydrocarbons, polychlorinated biphenyls, lubricative additives, chlorodibenzofurans, decomposition products, heavy metal contaminants such as aluminium, chromium, tin, lead, manganese, nickel, and silicon that come from engine parts as they wear down [1]. Most of these components are known to be toxic in nature to different biomass and this has raised considerable concern on the subject of spent oil pollution especially on arable agricultural land. It is usually obtained after servicing and subsequent draining from automobile and generator engines [3]. It gets to the environment due to discharge by motor and generator mechanics [4] and from the exhaust system during engine use leaks [5, 6]. The disposal of spent engine oil into open vacant plots and farms, gutters and water drains is an environmental risk [4] hence it is liquid, it easily migrates into the environment and eventually pollutes either water or soil [7]. Spent engine oil contains pollutants (heavy metals) which interfere with physiological, biochemical and molecular processes of living systems at higher concentrations [8]. These toxic substances present in spent engine oil pose serious risk to human beings, animals and environment when not properly disposed by contaminating food chain through bioaccumulation and bio-magnification. These pollutants also result to a great potential threat to the natural resources such as soil and water, due to their non-degradable and persistence nature in the environment [9].

Urena lobata the test plant belongs to the family, *Malvaceae*, a sub-shrub, which is commonly known as Caesar weed, hibiscus bur, aramina, pink Chinese burr, jute African etc. It is an annual plant in sub-tropic and perennial in the tropics, equally grows in moist regions [10]. The plant is also cultivated in many tropical countries, including South America, Africa, Australia, and the USA (Florida). It is widely distributed in a wild or naturalized state throughout the tropics and subtropics, including South-East Asia. *Urena lobata* is grown as a fibre crop in mainland Africa, Madagascar, Brazil and India and grows 0.6 to 3 m in height with up to 7 cm in basal diameter [10]. It is traditionally used in many countries, including Bangladesh, India and China to treat various ailments [11, 12, 13}. The scientific reports also suggest that *Urena lobata* may be a good source of promising phytotherapeutic chemical moieties [14].

Phytoremediation, more broadly referred to as phytotechnology uses vegetation to contain, sequester, remove, or degrade inorganic and organic contaminants in soil, sediment, surface water, and groundwater. Phytoremediation involves the use of green plants in cleaning soils and water contaminated with different environmental pollutants [15]. Phytoremediation is a plant based bioremediation technologies which employs the engineered use of green plants and their associated micro biota for the in-situ treatment of contaminated soil and ground water [16]. They provide other conservation benefits by protecting and improving natural resources [17]. The process is environmentally friendly and takes advantage of the unique and selective uptake capabilities of plant root systems, together with the translocation, bioaccumulation, and contaminant storage/degradation abilities of the entire plant body [18, 19]. Plants accumulate minerals essential for their growth from the environment alongside with heavy metals from contaminated areas [20].

Phytoremediation is the best alternative to synthetic and other forms of bioremediation like Mycoremediation and Bacteria Bioremediation which are disruptive, destructive, and expensive methods of polluted site remediation. Therefore, plants are a logical choice for remediation of contaminated sites and other land rehabilitation projects because of their unique ability to establish, increase in mass, and renew growth in subsequent seasons, even in extreme soil, landscape, and climate environments. Eventually, vegetation creates aesthetics value and revitalizes the landscape. This paper investigated the efficacy of *Urena lobata* in the phytoremediation of soil polluted with spent engine oil as to determine the amount and effectiveness of the annual plant to stimulate phytoremediation of heavy metals pollutants (Cd, Pb, As and Cr) removed from the soil by the plant with time.

2.0 MATERIALS AND METHODS

2.1 Study Area and Sample Collection

The study was carried out along Road 5, Federal Low cost Housing Estate (Second Gate), North Bank in Makurdi Local Government Area of Benue State, Nigeria on the elevation of 104 m above sea level and located on latitude N 070 45′ 19.1″ of the equator and longitude E 0080 34′ 22.5″ of the meridian using Garmin GPSmap 76Cx geographical positioning device. The garden soil used in the study was collected from a farm land behind the experimental site along Road 5, Federal Housing Estate North Bank Makurdi sited on the elevation of 104 m above sea level and located on latitude N 070 45′ 19.4″ of the equator and longitude E 0080 34′ 22.7″ of the meridian. The spent engine oil was obtained from New Garage motor mechanic workshop Wadata, Makurdi sited on the elevation of 78 m above Sea level and located on latitude N 07° 44′ 36.9″ of the equator and longitude E 0080 31′ 02.9″ of the meridian. Viable seeds of *Urena lobata* was collected within Makurdi metropolis.

2.2 Nursery Bed Preparation and Sowing of Seeds

A suitable fertile and well drained site for nursery bed preparation was identified beside the study area. Weeds, leaves and other litter were cleared from the selected site prior to bed preparation. The topsoil to a depth of about 10 cm deep was dug while stones, roots and debris were removed. A sunken bed of about 1 m wide with suitable length prepared to a height of about 5−10 cm while pre- decompose organic manure was added to the bed to increases seed vigour and allow easier uprooting for transplanting. Viable seeds of *Urena lobata* were broadcast over the levelled nursery bed and watered.

2.3 Spent Engine Oil Characterization

Spent engine oil treatment used in this experiment was analyzed before pollution with garden soil and properties analysed were pH, density, specific gravity, viscosity, flash point and moisture content. The device for spent engine oil characterization was calibrated with buffer four (4) and buffer five (5) before taking the reading. Density, dynamic and kinematic viscosity were measured at the temperature of 0 ºC, 40 ºC and 100 ºC. Moisture content was determined using oven method while dynamic viscosity was measured using viscometer. The result obtained shows the presence of contamination in the spent engine oil with 0.806 g/cm^2 density, 8.56 g/cm^3 dynamic viscosity, 11.04 cm^2/s kinematic viscosity, 0.958 specific gravity, 318 ºC flash point and 0.42 % moisture content. Spent oil pH was determined using universal indicator strip and was found to be slightly acidic with pH of 5.86.

2.4 Soil Analysis before Contamination

The garden soil used for the planting was analysed before the pollution with spent engine oil, the soil properties analysed were soil particle size distribution, pH, organic carbon and organic matter. Part of the Soil samples for the research was crushed to break the soil aggregates and air dried under room temperature for some days. Mechanical analysis was done by the hydrometer method using sodium hexametaphosphate as a dispersing agent. The result obtained showed that the soil belongs to sandy-loam textural class with 68.80 % sand, 12.0 % silt and 18.20 % clay. Soil pH was determined using a 1:1 soil: water slurry and measured in a Beckman Zerometric pH meter and found to be slightly acidic with pH of 6.05

2.5 Contamination and Planting of Seedlings

Soil contamination with the spent oil was manually done by thorough mixing four kilogram (4 kg) of soil with different levels of spent engine oil in their respective plastic buckets to obtain 1, 2, 3, 4 and 5 % spent oil contamination. Each of the treatment including the control (0 %) was replicated two (2) times while three (3) viable seedlings were transplanted in each bucket accordingly after three (3) weeks of seed planting in nursery bed and later pruned down to two (2) seedlings per bucket.

2.6 Soil and Plant Analysis for Heavy Metals

Wet digestion method was applied for plant shoot analysis using perchloric acid, nitric acid and sulphuric acid while Mehlich three (3) extraction method were used for soil samples using ammonium fluoride (NH_4F), ethylene diamine tetra-acetic acid (EDTA), ammonium nitrate (NH_4NO_3), acetic acid and nitric acid. The digested soil and plant samples were analysed for the heavy metals (Cd, Pb, As and Cr) using atomic absorption spectrophotometer (AAS). Decants collected from plant shoots and soil digestion were then used for heavy metal analysis using Atomic Absorption Spectrophotometer method while percentage absorbance in shoots of the annual plants was used to assess the phytoremediation potential of *Urena lobata*.

2.7 Basic Indices of Phytoremediation

Bioconcentration factor (BCF) and and translocation Factor (TF) were employed to determine the feasibility of *Urena lobata* for phytoremediation purposes. TF was used to determine the potential of plant under study for the translocation of metals from roots to shoots. Calculation of the bio-concentration factor and the translocation factor were performed to assess whether plants could be categorized as accumulators. Computation was done based on the equation given below as adopted by [21].

Bio-concentration factor root, $BCF^r = C_{root} / C_{soil}$

Bioaccumulation factor shoot, $BCF^s = C_{shoot} / C_{soil}$

Where;

C_{root} = Concentration of metal pollutant in root

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C_{shoot} = Concentration of metal pollutant in shoot

C_{soil} = Concentration of metal pollutant in soil

Then, translocation factor (TF) of examined heavy metals were computed using the below equations as adopted by [21]

$$TF = BCF_{shoot} / BCF_{root}$$

It was calculated from the ratio of the element's presence in the plant's shoots compared to that in the plant's roots. The absorption/accumulation coefficient (AC), defined as the plant/soil concentration quotient was calculated using the formula:

$$AC = C_{plant} / C_{soil}$$

C_{plant} = Concentration of heavy metal in whole plant and C_{soil} = Concentration in soil.

Single pollution index (SPI) was used to calculate some of the complex indices like PLI as determined using the formula as shown below [21]

$$SPI = Cn / GB$$

Cn = content of heavy metal in the soil and

GB=values of the geochemical background of the elements in the reference.

PLI was calculated as the geometric average of SPI base on the formula;

$$PLI = \sqrt[n]{SPI_1 \times SPI_2 \times SPI_3 \times \ldots SPI_n}$$

n =the number of analyzed heavy metals and

SPI=the calculated value of single pollution index

2.8 Percentage Removal of Pollutants by Plants after Remediation

The percentage absorbance of cadmium, lead, arsenic and chromium into the plant tissues of *Urena lobata* planted in both the control and the contaminated soils were calculated at twelve (12) weeks after planting (WAP) using the equation [21]: R (%)= Ci -Cf/Ci x 100

Ci is the contaminant concentration in the soil before (pre) remediation;

Cf is contaminant concentration in the soil after (post) remediation and

R (%) is the percentage removal of contaminant after remediation.

3.0 RESULTS

3.1 Soil Analysis for Heavy Metals after Contamination with different level of Spent Engine Oil

The result of the AAS analysis of the level of pollutants in *Urena lobata* soil sample after contamination is shown on table 1 and figure 1. It was observed that lead has the highest concentration levels when compared with different levels of treatment followed by cadmium, chromium and arsenic. In both the control (0 mL) experiment and the different levels of contamination, it was observed that the value of cadmium, Lead, arsenic and Chromium in soil after contamination were equally lower when compared with permissible limit of [22] on edible plants.

Table 1: Level of Pollutants in *Urena lobata* Soil sample after Contamination

Spent oil Conc. (mL)	Levels of pollutants in the soil (mg/kg)			
	Cd	Pb	As	Cr
G_0	0.34	1.25	0.09	0.18
G_{20}	0.37	1.29	0.12	0.23
G_{40}	0.39	1.32	0.16	0.28
G_{60}	0.42	1.37	0.19	0.31
G_{80}	0.43	1.40	0.23	0.38
G_{100}	0.46	1.44	0.27	0.41
Means	2.41	8.27	1.06	1.79

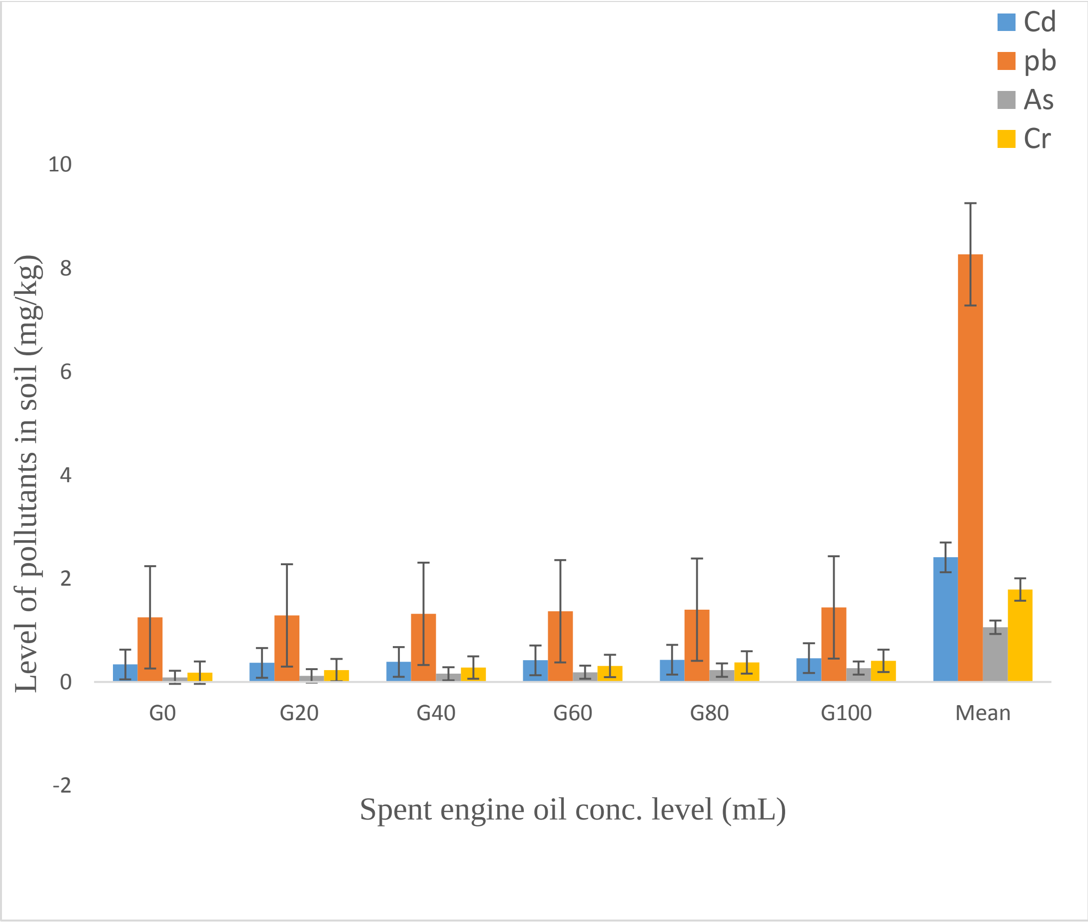

Figure 1. Level of Pollutants in *Urena lobata* Soil sample after Contamination

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3.2 Soil Analysis for Heavy Metals at Twelve weeks after Planting (12WAP)

Levels of pollutants were observed in the soil containing *Urena lobata* at 12 weeks after harvesting. In both the control and the different levels of contamination, lead still has the highest concentration levels when compared followed by chromium, cadmium and arsenic. It was observed that the value of most pollutants in soil at twelve weeks after harvesting were lower than the permissible limit of cadmium (0.3 mg/kg), lead (2 mg/kg), arsenic (1 mg/kg) and chromium (1.30 mg/kg) recommended by WHO [22] on plants. It was also observed that soil treated with 100 mL of spent engine oil had the higher mean level of lead followed by cadmium, chromium and arsenic while the soil treated with 60 mL had the highest level of cadmium (0.41 mL) (Table 2 Figure 2).

Table 2: Pollutants in Soil at 12 weeks (after harvesting)

	Levels of pollutant at 12 WAP (mg/kg)			
Spent oil Conc. (mL)	Cd	Pb	As	Cr
G_0	0.30	1.13	0.08	0.16
G_{20}	0.34	1.18	0.09	0.20
G_{40}	0.38	1.21	0.10	0.23
G_{60}	0.41	1.26	0.16	0.27
G_{80}	0.29	1.31	0.18	0.31
G_{100}	0.31	1.34	0.18	0.36
Mean	2.03	7.41	0.79	1.53

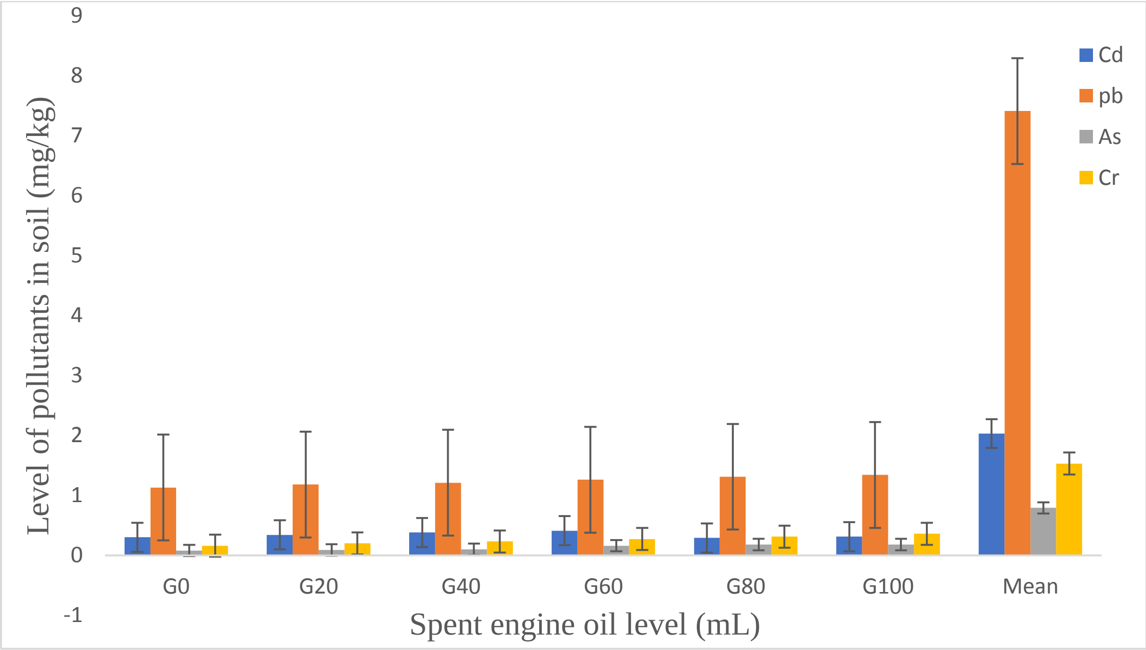

Figure 2. Pollutants in Soil Containing *Urena lobata* at 12 weeks (after harvesting)

The highest percentage removal was noticed on the plant treated with 40 mL and the pollutant was arsenic with 37.50 % absorbance followed by 100 mL with 33.33 % absorbance. The least percentage absorbance of arsenic was noticed in the treated with 60 mL spent engine oil. In cadmium, 100 mL (32.61 %) spent engine oil has the highest percentage absorbance followed by 80 mL (32.56 %), 0 mL (11.77 %), 20 mL (8.11 %), 40 mL (2.56 %) and 60 mL (2.38 %); while in lead the highest absorbance was on the 0 mL (9.60 %) treated soil. This was followed by 20 mL (8.53 %), 40 mL (8.35 %); 60 mL (8.03 %) 100 mL (6.94 %) and 80 mL (6.43 %). It was equally observed that the highest percentage of chromium absorption by *Urena lobata* plants was the soil treated with 80 mL of spent engine oil followed by 40 mL (17.86 %), 20 mL (13.04 %), 60 mL (12.90 %) and 100 mL (12.20 %) while the control (11.11 %) had the least percentage absorption (Table 3 and Figure 3).

Table 3: Percentage Removal of Pollutants by *Urena lobata*

Spent oil Conc. (mL)	Percentage absorbance (%)			
	Cd	Pb	As	Cr
G_0	11.77	9.60	11.11	11.11
G_{20}	8.11	8.53	25.00	13.04
G_{40}	2.56	8.33	37.50	17.86
G_{60}	2.38	8.03	15.29	12.90
G_{80}	32.56	6.43	21.74	18.42
G_{100}	32.61	6.94	33.33	12.20

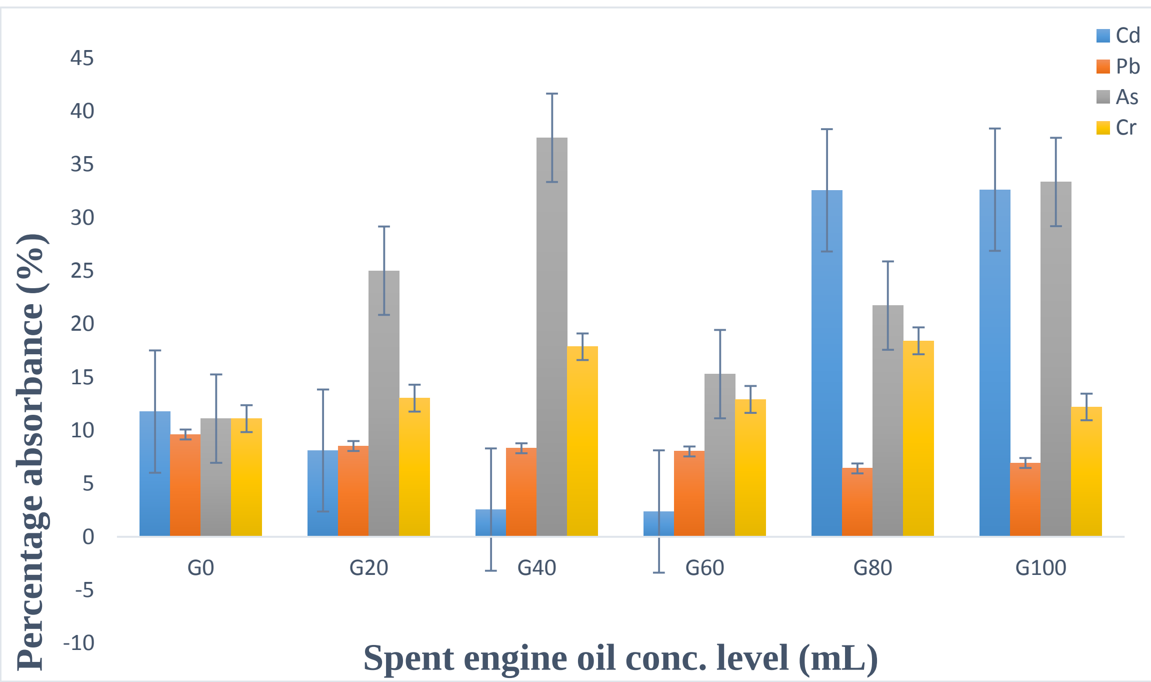

Figure 3: Percentage Absorbance of Heavy Metal pollutants in Plant Tissue of *Urena lobata* on Contaminated Soil sample after twelve weeks of planting.

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3.3 Plant Tissue Analysis for Heavy Metals at Twelve Weeks after Planting (12 WAP)

Level of pollutants were observed at 12 weeks after harvesting as represented on table 4 and Figure 2. In both the control and the different levels of contamination, lead had the highest concentration levels when compared followed by chromium, cadmium and arsenic. It was observed that the value of the pollutants in soil at twelve weeks after harvesting were lower than the permissible limit of [22] on plants. It was also observed that soil treated with 100 mL of spent engine oil has the higher mean level of lead followed by cadmium, chromium and arsenic while the soil treated with 60 mL had the highest level of cadmium (0.41 mL).

Table 4: Tissue Analysis of *Urena lobata* Treated with different Spent Oil Level at 12 WAP

Spent oil Conc.(mL)	Levels of pollutant at 12 WAP (mg/kg)			
	Cd	Pb	As	Cr
G_0	0.010[a]	0.034[a]	0.014[a]	0.190[a]
G_{20}	0.010[a]	0.036[b]	0.015[a]	0.210[b]
G_{40}	0.019[b]	0.038[c]	0.018[b]	0.210[c]
G_{60}	0.024[c]	0.043[d]	0.022[c]	0.240[d]
G_{80}	0.027[d]	0.046e	0.022[c]	0.270[e]
G_{100}	0.029[e]	0.049f	0.025[d]	0.290[f]
Means	0.020±0.002	0.041±0.001	0.019±0.001	0.235±0.009

Means with different alphabets within the same column are significantly different at

$P \leq 0.05$

3.4 Phytoremediation of pollutants by Plant

The highest absorption level of the plant after remediation occurred on the 100 mL spent engine oil polluted soil with 0.15 mg/kg (32.61. %) cadmium followed by lead on 60 mL polluted soil with 0.11 mg/kg (8.03 %) as shown in table 5. Equally, *Urena lobata* was able to remediate 0.09 mg/kg of arsenic and 0.07 mg/kg of chromium which where all found to be below the WHO permissible limit on plants.

Table 5: Level of Pollutants Remediated by *Urena lobata* at 12 weeks after Planting

Spent oil Conc. (mL)	Levels of pollutant at 12 WAP (mg/kg)			
	Cd	Pb	As	Cr
G_0	0.04	0.12	0.01	0.02
G_{20}	0.03	1.11	0.03	0.03
G_{40}	0.01	0.02	0.06	0.05
G_{60}	0.01	0.11	0.03	0.04
G_{80}	0.04	0.09	0.05	0.07
G_{100}	0.15	0.10	0.09	0.05
Mean	0.28	0.55	0.27	0.26

The evaluation of *Urena lobata* accumulation of Cd, Pb, As and Cr by approximate BCF, AC, TF and Single pollution index is shown in table 6. The BCF values of shoots and roots of all the plant under study for Cd, Pb, As and Cr are less than one (1<) and root BCF for was in the following order; Cr (0.060) > As (0.009) > Pb (0.004) and Cd (0.004). The shoot BCF was Cr (0.094) > As (0.015) > Cd (0.006) > Pb (0.004) and TF > 1 in the following order; Pb (2.000) > As (1.667) > Cr (1.567) > Cd (1.500) mg/kg. The Single Pollution Indices (SPI) were equally in the following order; Cd (22.556) > Pb (0.436) > As (0.185) > Cr (0.017) mg/kg while Pollution Load index (PLI) of *Urena lobata* (0.409) was calculated.

Table 6: Elemental Values (mg/kg) of Annual Plant Tissues (Shoots and Roots) after Remediation

Pollutants	SH	RO	WT	BCF^S	BCF^r	TF	AC	SPI
Cd	0.013	0.007	0.020	0.006	0.004	1.500	0.010	22.556
Pb	0.027	0.014	0.041	0.004	0.002	2.000	0.002	0.436
As	0.012	0.007	0.019	0.015	0.009	1.667	0.0240	0.163
Cr	0.144	0.091	0.235	0.094	0.060	1.567	0.154	0.017

Key:

SH = Shoot, RO = Root, WT = Whole Plant, BCF^S = Bio-concentration factor Shoot, BCF^r = Bio-concentration factor root, TF = Translocation factor, AC = Absorption/Accumulation coefficient, SPI = Single Pollution Index

4.0 DISCUSSION

The levels of Cadmium (Cd) absorbed in the different treatments concentration of soils at 12 weeks after planting (after remediation) ranges between 0.04 mg/kg and 0.15 mg/kg with highest percentage removal of 32.61 % occurring on the soil treated with 100 mL of spent engine oil. On Lead (Pb), it was observed that the remediation level ranges between 0.02 mg/kg and 0.12 mg/kg with highest percentage removal value of 9.60 % occurring on the control treatment (0 mL) while the highest percentage removal after remediation of arsenic (As) occurred on the 40 mL spent engine oil polluted soil (37.50 %) with absorbance level range of 0.01 mg/kg and 0.09 mg/kg. Equally, the levels of Chromium (Cr) absorbed in the different treatments concentration of soils at 12 weeks after planting ranges between 0.02 mg/kg and 0.07 mg/kg with highest percentage removal of 18.42 % occurring on the soil treated with 80 mL of spent engine oil. It was also observed that *Urena lobata* soil with 60 mL spent engine oil pollution had the least percentage removal of cadmium (2.38 %) while the least percentage removal of lead was observed on the soil polluted with 80 mL spent engine oil. Also, the least percentage removal of arsenic pollutant (11.11 %) occurred on the control (0 mL) treatment while the least percentage absorbance was also noticed on the soil treated with 0 mL (control experiment).

Cadmium is a non-essential metal and it is considered very toxic therefore the permissible limit level recommended by WHO in plants is 0.3 mg/kg [23]. In some of the collected soil samples, concentration of cadmium was recorded above the maximum permissible limit set by WHO although there were reductions after remediation with the annual plant. Lead is a non-essential heavy metal that causes oxidative stress and contributes to the pathogenesis of lead poisoning by

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disrupting the delicate antioxidant balance of the mammalian cells. Lead as a soil contaminant is a widespread issue; It accumulates with age in bones aorta, and kidney, liver and spleen. It can enter the human body through uptake of food, water and air. High level accumulation of Pb in body causes anaemia, colic, headache, brain damage, and central nervous system disorder [24]. As a non-essential heavy metal, WHO permissible limit of lead in plant is 2-10 mg/kg [23]. Lead concentrations in the soil and shoots of the annual plant after remediation were recorded below the permissible limit. Arsenic is widely common metalloid, very often classified as heavy metals. The general populations have exposure to arsenic compounds, mainly via intake of drinking water and food. It can be in two chemical forms such as organic or inorganic. Inorganic arsenic compounds are more toxic than organic arsenic compounds. The inorganic form of arsenic may cause cancers of the bladder, lungs, liver and skin. At lower levels of exposure, arsenic can cause vomiting and nausea. Also, it causes severe disturbances of the central nervous and cardiovascular systems, and eventually death. According to the WHO, the maximum permissible limit of arsenic in plants is established as 1 mg/kg. Comparing the obtained results with the permissible limit, arsenic was in values which correspond with literature data.

Chromium plays a vital role in the metabolism of cholesterol, fat, and glucose, its deficiency causes hyperglycaemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic [25]. The permissible limit of Chromium for plants is 1.30 mg/kg recommended by WHO [23]. In the annual plant, concentration of chromium was below the permissible limit. In all the collected soil samples, concentration of chromium was also recorded below the permissible limit set by. From this study, it was deduced that there was an uptake of 11.77 % Cd, 9.60 % Pb, 11.11 % As and 11.11 % Cr by *Urena lobata* from the controlled soil sample and an uptake of highest absorption values of 32.61 % Cd, 8.53 % Pb, 37.50 % As and 18.42 % Cr concentration from the different polluted soil sample levels into the shoot of the *Urena lobata* plants. Therefore, it can then be concluded that *Urena lobata* is a phytoextractor of the targeted heavy metals and is a good phytoremediation annual plant.

Biological concentration factor (BCF) and Translocation Factor (TF) are important concept in environmental risk assessment since it gives quantitative information regarding the ability of a contaminant to be taken up by organisms from the water. It is often used as one of the first screening parameters for persistent, bioaccumulative, and toxic substances. The capability of plants to accumulate and endure heavy metals can be evaluated through bioconcentration factor (BCF) and translocation Factor (TF). Bioconcentration factor (BCF) is described as the ability of plants for elemental accumulation from the substrate [26]. It is defined as the ratio of concentration of metals in plant tissues to that of the soil while the accumulation/absorption coefficient (AC) is defined as the plant/soil concentration quotient.

The translocation factors for heavy metals in plants should be more than one in order to be considered as bioaccumulators [27]. Hyperaccumulator plants can accumulate high concentrations of heavy metals at the tissue surface. The bioconcentration factor is a calculated value that indicates the ability of plants to remove metal compounds from the soil/substrate. Meanwhile, the translocation factor is a value that indicates the ability of the compound to be transferred from plant roots to other organs [28]. Plants that have bioconcentration and translocation factors >1 can be used as bioaccumulators. Bioconcentration values > 2 are considered to be high values. Plants can be used as phytostabilizers if they have bioconcentration factors >1 and translocation factors < 1 and as phytoextractors if they have bio-concentration factors <1 and translocationfactors >1 [29]. Plants having a shoot BCF >1 are pertinent for phytoremediation while plants having a root BCF >1 and TF < 1 possess phytostabilisation potential. Plants having both a phytostabilization and metal-tolerance capacity could potentially be useful for phytoremediation purposes. In the present work, computation of of phytoremediation in indices suggested the potential application of *Urena lobata* as a phytoextractor.

5.0 RECOMMENDATION

Urena lobata had BCF of < 1 for all heavy metal pollutants, and also high value of translocation factor (TF) > 1 for Pb (2.000), As (1.667), Cr (1.567) and Cd (1.500) mg/kg, hence and could be considered as an efficient plant in the translocation of metal pollutants from roots to shoots. Therefore, it is a potential candidate for phytoextraction and phytoremediation of soils contaminated with Cd, Pb, As and Cr. Facility owners and industrialists should adopt and invest on the use of phytoremediation technologies in the remediation of polluted sites with spent engine oil as the technology can remediate more than one pollutant at a time as an environmentally friendly biotechnology.

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