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Soil Seeds Bank and Floristic Diversity as Affected by Spent Engine Oil

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Abstract:

This study investigated the impact of spent engine oil (SEO) on the regeneration capacity of soil seed bank, growth and floristic diversity of a polluted soil. Top soil (0-10 cm) of 400 g with no previous contamination of SEO was collected from Lafia, Nasarawa State, Nigeria and treated with 0.00%, 2.50%, 5.00% and 10.00% of SEO respectively in a complete randomized design with three replicates. Eight weeks after treatment, five plant species identified growing on 0.0% and 2.50% SEO were *Desmodium canadense, Malvaviscus arboreus*, *Pennisetum purureum*, *Sida acuta* and *Cyperus strigosus*. *Pennisetum purureum* was absent in soil polluted with 5.00% SEO. No plant species was found growing on the soil polluted with 10.00% SEO. Plant diversity decreased as levels of SEO increased, meaning that SEO adversely affect plant diversity and species richness. Also, there was a negative association between the species richness and species evenness. This study concluded that arbitrary dumping of SEO is a threat to diversity of soil seeds bank. Seed germination on SEO polluted soils depends on contaminants concentration and the tolerant level of the plants. Therefore, SEO ≥ 10.00% affect germination, growth and diversity of soil seeds bank thereby making the soil bare and waterlog.

Keywords: Growth, Plant diversity, Soil seeds bank and Spent Engine Oil

1.0 Introduction:

Soil seed banks are aggregations of viable seeds in the soil, potentially capable of replacing adult plants (Baker 1989; Leck *et al*. 1989) which play important role in regeneration (Martins and Engel, 2007), maintenance (Chang *et al.,* 2001) and recovery of vegetation (Huttl and Gerwin, 2007), especially after human or natural disturbances (Baldwin and Mendelssohn, 1998). Compared with aboveground vegetation, seed banks are more tolerant of disturbances, diseases and herbivory. Under harsh environments, maintenance of species diversity and population recruitment depends greatly on seed banks. Seed banks provide propagules that may influence plant community changes after disturbance events and management activities (van der Valk and Pederson 1989). It should be noted that not all plant species form large and persistent soil seed banks. Species that are short-lived aboveground and associated with disturbance often develop the largest and most persistent (long lived) seed banks (Wienk *et al.,* 2004). However, it conserved genetic diversity and limits change to the environment due to seed immigration into the area, thus allowing the species in the environment to remain intact (Leishman *et al.,* 2000).

Seed banks are efficient measures for vegetation recovery in conservation and restoration practices (McDonald *et al.,* 1996), especially on sites with no remnant vegetation or with bare soil (Brown, 1998). A lower rate of plants germination or seedlings emergence in soil contaminated by petroleum or its derivatives has been reported by many authors (Adam and Duncan, 1999, 2002; Vavrek and Campbell, 2002; Méndez-Natera *et al.,* 2004; Sharifi *et al.,* 2007; Ogbo, 2009). According to Adam and Duncan (2002), petroleum hydrocarbons may form a film on the seed, preventing the entry of oxygen and water. Also, toxic hydrocarbon molecules could inhibit the activities of amylase and starch phosphorylase and thereby affecting the assimilation of starch (Achuba, 2006). Henner *et al.* (1999) reported that petroleum hydrocarbons consisting of small molecules and those that are water soluble are more phytotoxic for the germination of seeds. Oil penetrates into plants where it moves in the intracellular spaces and possibly also in the vascular system (Baker, 1970). Hydrocarbons can dissolve in plasmalemma, thus leading to rupture of the plant tissue. The presence of oil in soil creates very unsatisfactory conditions for plant growth; this may be due to insufficient aeration of the soil resulting from the waxy nature of most oil-impacted soils (De Jong, 1980).

Pollution as a result of crude oil and crude oil based products, depends both on the type and amount of oil involved, the degree of its weathering or its breakdown, time of the year, species and age of plants involved (Amakiri and Onofeghara, 1984). Engine oil is a blend of base oils and performance enhancing additives. It is the non-volatile fraction of crude oil obtained by the vacuum distillation of crude oil (Adams and Jackson, 1996). Spent engine oil is a mixture of hazardous organic chemicals such as polycyclic aromatic hydrocarbon and heavy metals such as Zn, V, Pb, Al, Ni and Fe, (Wang *et al.,* 2000). These metals come from engine parts as a result of wear and tear (Njoku *et al*., 2012). The spent engine oil or lubricant is usually obtained after servicing and subsequent draining from automobile and generator engines (Uhegbu *et al.,* 2012) and is arbitrarily thrown into the soil surface (Anoliefo and Vwioko 1995). Nigeria alone accounts for more than 87 million liters of spent lubricant annually (Nwankwo and Ifedi, 1988; NDES, 1999). Adequate attention has not been given to its proper disposal. Pollution from spent engine oil is one of the most serious environmental problems in most part of the world, especially developing nations like Nigeria, where it is even more widespread than crude oil spillage and pollution (Nwankwo and Ifedi, 1988; NDES, 1999). Anoliefo and Vwioko (1995) reported that contamination of soil with spent engine oil caused growth retardation in plants, with the effect more adverse for *Lycopersicom esculentum*. Also, Okonokhua *et al.* (2007) supported reduction in growth and yield of plant in contaminated soil. Some of these symptoms include stunted growth and chlorosis (Lepp, 1981). Contamination of the soil environment can also limit protective functions, upset metabolic activity, unfavorably affects its function and chemical characteristics, reduce fertility and negatively influence plant production (Gong *et al*., 1996; Wyszokowiski *et al*., 2004). Spent engine oil imposed some stressful conditions, which may have interfered with water uptake and gaseous exchange in plant (Amakiri and Onofeghara, 1984).

The present study did not focus on the phytoremediation techniques of the polluted soil but investigated the impacts of spent engine oil on the regeneration capacity, growth and development of soil seed bank and weed / floristic biodiversity of a polluted soil. However, some of the species that were able to survive the pollution level and grow from the soil seed bank may be potential candidates for remediating spent oil polluted soils. This is because one of the first steps in the selection of plants for phytoremediation is the identification of species able to grow and develop in oil-contaminated soil.

2.0 Material and Methods:

Top soil (0-10 cm) of 400 g with no previous contamination of spent engine oil (SEO) was collected from lafia, Nasarawa State, Nigeria. The plants growing on the soil were identified so as to have a background information of the potential seed banks in the soil. The soil was air dried and filled into four perforated pots each. Pots were watered till field moisture capacity. The spent engine oil was obtained from an auto mechanic workshop around Lafia town, Nasarawa State, Nigeria. Soils were then treated and thoroughly mixed with different concentrations of spent engine oil as follows: 0%, 2.5%, 5.0% and 10% according to the method of ikhajiagbe and Anoliefo (2010). The experimental design was a complete randomized design with three replicates each. These were kept in a controlled environment for further observations. Eight weeks after treatment (WAT), plant species growing on each treatment were counted, collected, pressed, dried and properly identified using appropriate taxonomic literatures. Plants height and number of leaves were also assessed at two weeks interval for eight weeks. At the end of the experiment, Density, diversity, species richness and evenness were computed using standard methods as shown below. Growth parameters were analyzed statistically using LSD bar error at 0.05% significant level.

Density = $\frac{\text{Number of plants}}{\text{pot area (cm}^2\text{)}}$

Species diversity, H (Shannon Index method) = -Σpi(Inpi)

Where pi = ni/N

ni is the number of individuals in the ith species

N is total number of individuals

Species Richness (Margalef Index) = $\frac{S}{\sqrt{N}}$

Where S is total number of Species

Species Evenness = $\frac{H}{Log\ S}$

Where H is diversity

3.0 Results and Discussion:

At 0.00% SEO, species E had the greater number of individual species (i) than the other species at 4, 6, and 8 WAT (Figure 1). When SEO was introduced into the soil, species A had a significant greater number of individual species (i) at 2.50% throughout the measured weeks (2, 4, 6 and 8 WAT) (Figure 1). At 5.00% SEO, Species A also showed greater number of individual species (i) in 2 and 8 WAT while species E had greater number of individual species at 4 and 6 WAT (Figure 1). Species A had significant higher number of individual species than other species when SEO was introduced. This means that 2.50% and 5.00% SEO did not inhibit the germination rate of species A *Malvaviscus arboreus*. Seed germination is enhanced when soil is moist (but not too wet), the temperature is appropriate, and the soil is not toxic to the seeds (Cunningham *et al.*, 1996). A good way of knowing whether the plant(s) being considered for phytoremediation will germinate successfully is to carry out germination tests in the contaminated soil (Cunningham *et al.,* 1996).

No plant species was found growing on the soil polluted with 10.00% SEO. This showed that germination of soil seeds bank depends on threshold concentrations of the SEO. Leck and Simpson (1992) reported 30% reduction in germination and appearance of the seedling in seeds bank. Any soil polluted with ≥ 10.00% SEO might definitely affect germination of soil seeds bank thereby making the soil bare. This was supported by Frick *et al.* (1999) who reported that if concentrations of contaminants are too high, on the other hand, can cause toxic effects and may even kill exposed microorganisms and plants thereby, making the soil unsuitable for crop growth. Depending on the degree of contamination, type of soil and soil environment, the soil may remain unsuitable for crop growth for months or years until the oil is degraded to tolerable levels (Atuanya, 1987). Okonokhua *et al.* (2007) also reported that leaves of plants grown in contaminated soils curled upwards from their tips and withered, resulting to death of most of the plants.

The Individual plant species (i) ranged from A>E>C>B>D (Figure 1). The plant species collected and their respective families were listed in Table 1. Soil polluted with 0.00% and 2.50% SEO had an equal greater number of species (S) while soil polluted with 10.00% had no plant species (Table 2). This is in line with findings of Sheikh *et al.* (2013) who reported that soil polluted with high dose of spent engine oil adversely affect growth of plants. The total number of plant species (N) ranged from 2.50%>0.00%>5.00%>10.00% (Table 2). Soil polluted with 2.50% SEO showed greater density than other levels of SEO (Table 2). Species evenness of soil polluted with 5.00% was greater than the other levels of SEO (2.50, 5.00 and 10.00%) and species richness of soil polluted with 0.00% was greater than other levels (Table 2). From this study we can also suggest that there was a direct relationship between plant diversity and plant growth. This was supported by Ikhajiagbe and Anoliefo**,** (2012) who reported that there is a particularly important relationship between biodiversity and plant growth. When soil is unsuitable for plant growth, biodiversity will be destroyed. Soil without SEO had a high value of species richness hence greater diversity was observed than the other polluted soils.

Plant diversity decreased as levels of SEO increased, meaning that SEO adversely affect plant diversity and species richness. Plant diversity ranged from 0.00%> 2.50%>5.00%> 10.00 %. This is in agreement with Ikhajiagbe and Anoliefo**,** (2012) who reported that species richness and plant diversity was greater in soil without SEO and soil amendment. Soil polluted with 5.00% SEO had greater species evenness but lower diversity than others. This suggested that greater species evenness does not totally mean diversity but species richness could mean species diversity. Many investigations also indicated that species richness was a common cause of variation in relative abundance and diversity (Magurran, 1988). Also, when species evenness was high, species richness was low, this suggested negative association between the species richness and evenness. This was in conformity with consistent significant negative relationships observed between species richness and species evenness along the successional gradient (Wilsey *et al.,* 2005).

Diversity of plants species using Shannon Index Method is shown in Table 3. No diversity was observed at 10.00 % SEO, species A, B, D and E showed equal value of species diversity at 5.00% SEO, species A had greater species diversity at 2.50% SEO and species C had a greater diversity at 0.00% SEO, though there was no much difference with the values of other species. Diversity of plants species ranged from 0.00%> 2.50%>5.00> 10.00 %. When SEO was introduced, number of leaves of species A was maintained throughout the weeks when compared to 0.00% SEO except for plants at 6 WAT (Figure 2). At 6 and 8 WAT, species A had highest plant height at 2.50% SEO (Figure 3). Its greater diversity, growth and number of individual species on polluted soil showed that species A could be a potential phytoremediator, which have ability to remediate the components of SEO such as heavy metals and polycyclic aromatic hydrocarbons. Species A must have absorbed concentrated and precipitated toxic metals from SEO soils and stored it into their biomass.

Number of leaves of species C grown in soil polluted with 0.00% SEO was greater than other level of SEO. There was no significant difference in number of leaves of species D except for at 2.50% and 10.00% SEO (Figure 2). Plant height of species C and D grown in polluted soil (2.50, 5.00 and 10.00% SEO) drastically reduced when compared without pollution (0.00% SEO) (Figure 3). This revealed that spent engine oil affect soil chemistry and hinder the uptake of nutrients by the plant, thereby leading to decreased plant growth (Agbogidi *et al.,* 2007).

At 2, 4, 6 and 8 WAT, species B and E possessed greater number of leaves at 2.50% SEO than other level of SEO (Figure 2). At 2, 4, 6 and 8 WAT, number of leaves and plant height of species B and E was significantly higher at 2.50% SEO than the other levels (Figure 3). Though, species diversity of B and E can not to be compared with diversity of species A, yet they showed greater number of leaves and plant height at 2.50% SEO than 0.00% SEO. *Desmodium canadense,* species B and *Cyperus strigosus* species E could be spent engine oil lover plants. Spent engine oil lover plants are plants that uptake contaminants and still produced greater shoot and root biomass without detrimental effect to the plant, we called them hyperaccumulators. Species B and E must have stored the heavy metals into their body. Soil polluted with 2.50% SEO experienced tolerance to water logging, extreme droughts condition and high growth of species of B and E, these are properties that supported plant species for phytoremediation (Serma, 2011). Also the number of leaves and plant height of species B and E found on soil polluted with 2.50% SEO increased across the duration of the study. This is conformity with Serma (2011) who reported that biomass production level of hyperacumulators depends on the concentration of metals and duration of exposures. Also, *Desmodium canadense,* species B and *Cyperus strigosus* species E belongs to families Fabaceae and Cyperaceae respectively, which are among the 400 plants hyperaccummulator of metals reported by Prasad and Freitas (2003).

Table 1: Plant Species Identified

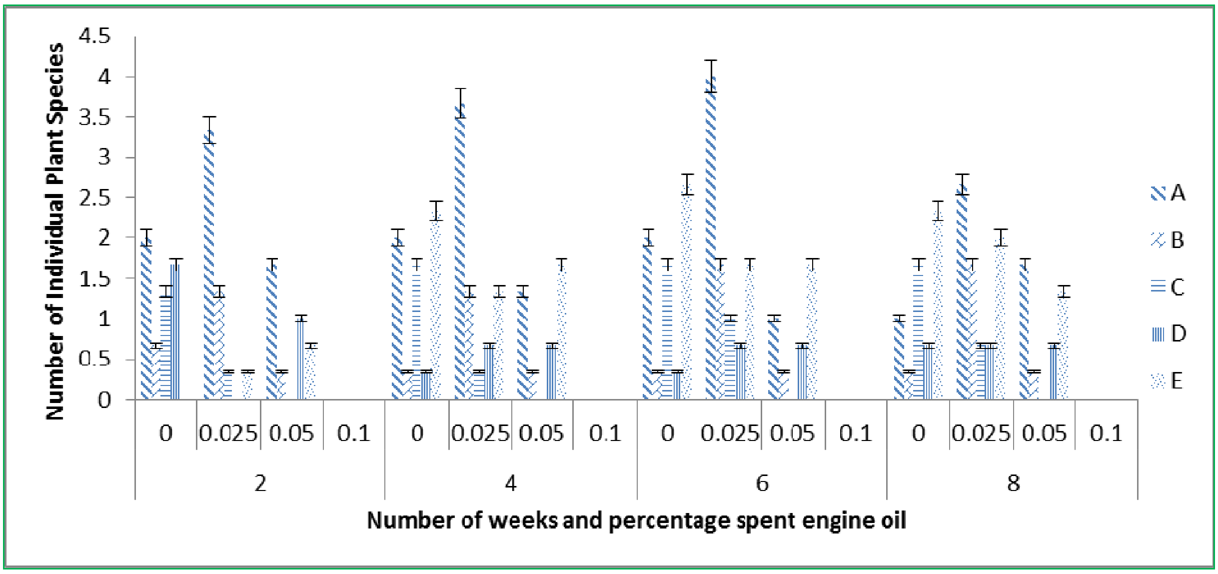
SPECIES	BOTANICAL NAME	FAMILY
A	*Malvaviscus arboreus* var. drummondii	Malvaceae
B	*Desmodium canadense* L.	Fabaceae
C	*Pennisetum purureum*	Poaceae
D	*Sida acuta* Burm.F.	Malvaceae
E	*Cyperus strigosus* L.	Cyperaceae

Table 2: Density, Species Evenness and Richness under Different Levels of SEO

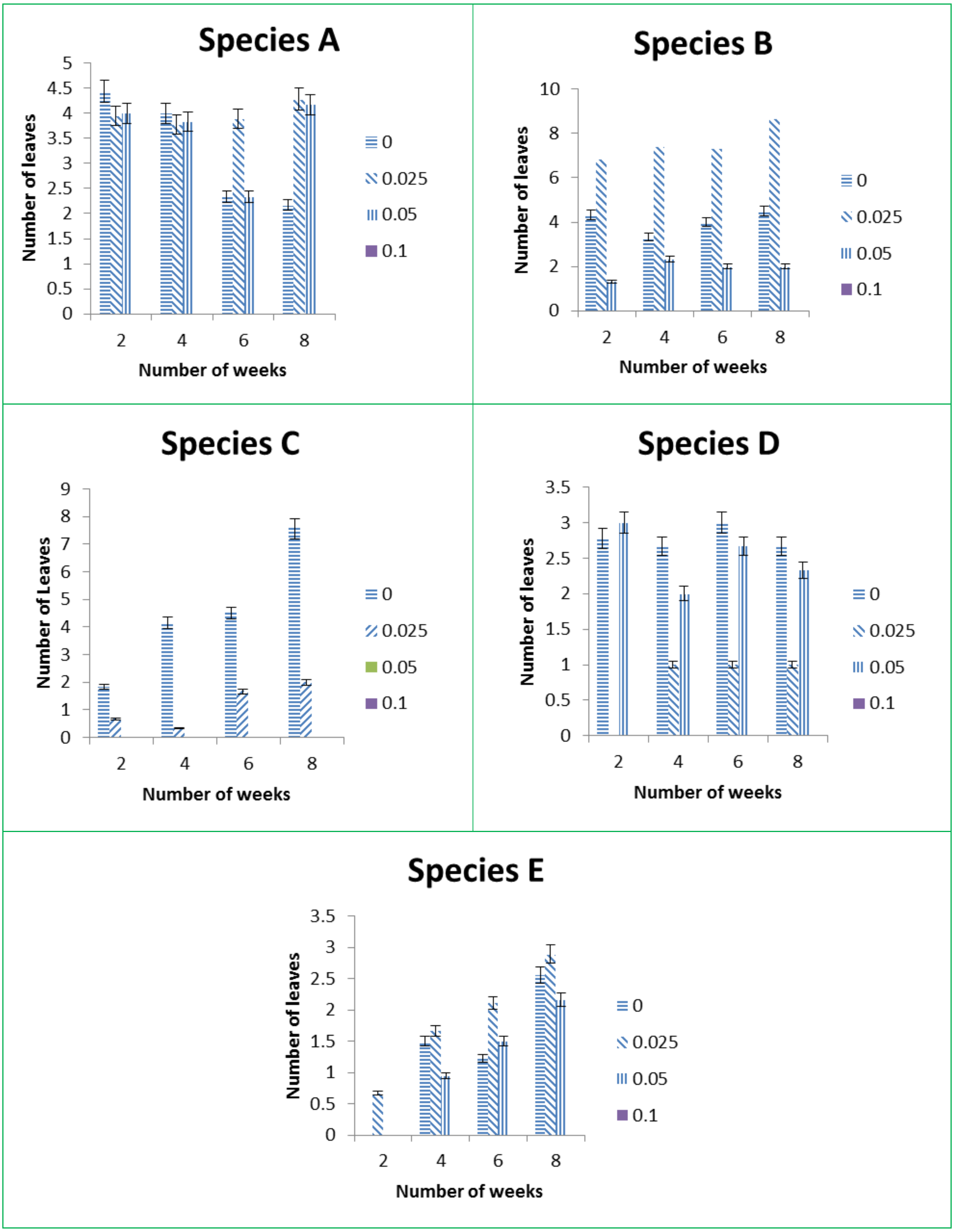
Treatment	S	TN	LogS	Species Evenness	Species Richness	Density
0%	5	6	0.70	2.31	2.04	0.85
2.50%	5	9	0.70	2.16	1.67	1.28
5%	4	4	0.60	2.33	2.00	0.57
10%	0	0	0.00	0.00	0.00	0.00

Table 3: Diversity of Plant Species under Different Levels of Spent Engine Oil

Treatment	Species	ith species	Pi	Inpi	Species Diversity -Σpi(Inpi)	Plants Diversity (H)
0%	A	1	0.17	-1.77	0.30	
0%	B	1	0.17	-1.77	0.30	
0%	C	2	0.33	-1.11	0.37	
0%	D	1	0.17	-1.77	0.30	
0%	E	3	0.50	-0.69	0.35	
						1.62
2.50%	A	3	0.33	-1.11	0.37	
2.50%	B	2	0.22	-1.51	0.33	
2.50%	C	1	0.11	-2.21	0.24	
2.50%	D	1	0.11	-2.21	0.24	
2.50%	E	2	0.22	-1.51	0.33	
						1.51
5.00%	A	2	0.50	-0.69	0.35	
5.00%	B	1	0.25	-1.39	0.35	
5.00%	C	0	0.00	0.00	0.00	
5.00%	D	1	0.25	-1.39	0.35	
5.00%	E	2	0.50	-0.69	0.35	
						1.40
10.00%	A	0	0.00	0.00	0.00	
10.00%	B	0	0.00	0.00	0.00	
10.00%	C	0	0.00	0.00	0.00	
10.00%	D	0	0.00	0.00	0.00	
10.00%	E	0	0.00	0.00	0.00	
						0.00

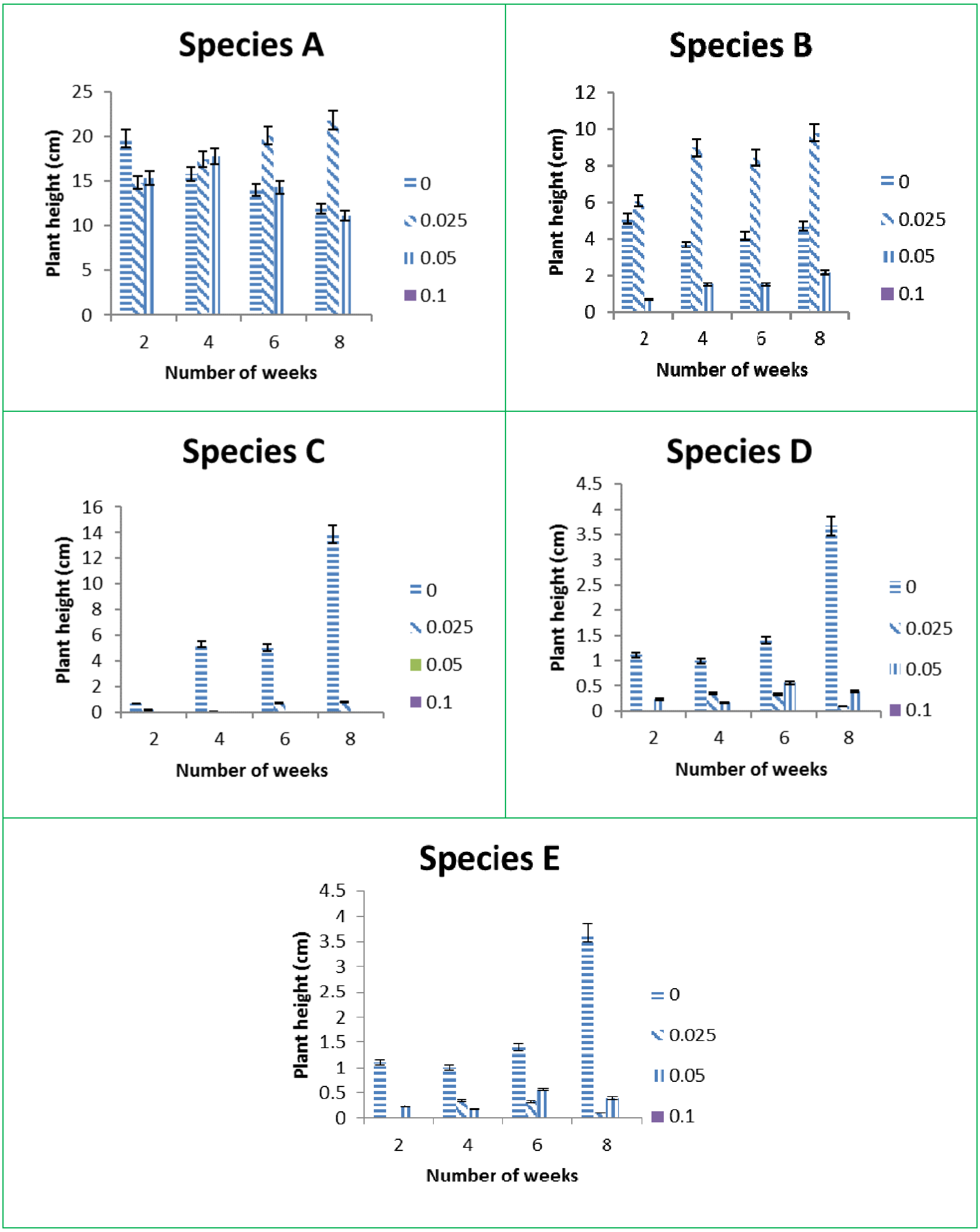


Legend: A= *Desmodium canadense,* B= *Malvaviscus arboreus*, C= *Pennisetum purureum*, D= Sida *acuta* and E= *Cyperus strigosus*, 2, 4, 6 & 8 = Number of weeks, 0, 0.025, 0.05 & 0.1= Spent Engine oil in percentage



Legend: 0, 0.025, 0.05 & 0.1= Spent Engine oil in percentage

Figure 2: Effect of Spent Engine oil on Number of leaves of Plant Species



Legend: 0, 0.025, 0.05 & 0.1= Spent Engine oil in percentage

Figure 3: Effect of Spent Engine oil on Number of leaves of Plant Species

4.0 Conclusion:

Soil seeds bank is a major source of re-establishment and maintenance of some aboveground plant populations and plant biodiversity. Therefore, arbitrary dumping of spent engine oil should be avoided. Also, plant species *Malvaviscus arboreus* was found to be potential phyto-remediators of spent engine oil hence, further study should be conducted to affirm its phytoremediation properties.

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