ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 6, Issue 1, pp: (1-8), Month: January - March 2018, Available at: www.researchpublish.com

Toxic Effects of Motor Oil Pollution on the Early Seedling Growth Performance of *Adenanthera Pavonina* L

[1]MUHAMMAD ZAFAR IQBAL, [2]SEHRISH KHURSHEED, [3]MUHAMMAD SHAFIQ, [4]MUHAMMAD KABIR, [5]ZIAURREHMAN-FAROOQUI

[1, 2,3,4,5] Department of Botany, University of Karachi, Karachi- 75270, Pakistan

Abstract: **The effect of different concentration of motor oil suspension on the early seedling growth performance of Adenenthera pavonina as compared to control treatment was studied. The oil treatment was significantly ($p<0.05$) affected seed germination of A. pavonina as compared to control treatment. The significant ($p<0.05$) effects of oil polluted soil on root, stem, and total plant dry weight of A. pavonina were also noted. Root / shoot ratio was noticeably varied in 3.50 and 5.0% oil polluted soil than control soil treatment. Principally, 5.0% oil polluted soil treatment exhibited higher percentage of decrease in most of the seedling growth parameter and total plant dry weight of A. pavonina than control. Hence, it was found that the effects on seedling growth parameters were increased with increasing levels of oil pollution. For most of the growth parameters, the mean values obtained were found higher for the control soil and progressively decreased from 5-20 % crude oil polluted treated soils. The plant height, plant cover and root length of plants grown in the contaminated oil polluted soil were adversely affected. The shoot length of the studied seedling in the contaminated soils was significantly reduced as compared to control.**

Keywords: **A. pavonina, contamination, leguminosaeae, motor oil, Pollution, soil.**

1. INTRODUCTION

The petroleum products are enriched with hydrocarbons[1]. The effect of crude oil pollution on soil pH, temperature and flora was studied [2]. The industrial revolution of the past century has resulted in significant damage to environmental resources such as air, water and soil [3]. The conservation of soil which is the base of plant growth became a national demand all around the researchers' communities. The soil profiles are presently continuous exhaustion in several forms, such as: soil erosion, depletion of nutrients and pollution [4-6]. Petroleum and its products are of specific concern in pollution studies due to their structural complexity, slow biodegradability, bio-magnification potential and the serious health hazards associated with their release into the environment resulting contaminating the soil and water alike [7]. The oil pollution significantly affects the soil environment and number of plant species. Effects of waste engine oil pollution on physical and chemical properties of soil have been observed [8-9]. The effects of petrol and diesel oil on content of organic carbon and mineral components in soil recorded [10]. Spent engine oil is the hydrocarbon product of crude oil and it is unsatisfactory for growth of *Azardirachta indica* and *Gliricidia sepium* due to insufficient reaction of the soil and the microbes because of the displacement of air from spaces between soil particles [11]. It has been observed by various researchers also that oil spills have significant effects on agricultural lands, crop, horticultural crops, trees, forest, and their seedlings [12-23]. Seed germination, percentage of seedling emergence, number of root nodules/plant, total soluble sugars, total soluble proteins, free amino acids, total chlorophyll and carotenoids and nucleic acids of the leaves of *Vigna mungo* (L.) Hepper grown in the oil polluted soil decreased significantly due to persistence of hydrocarbon [24]. The study of plant behavior in petroleum contaminated soils allows the identification and selection of oil pollution indicating species [25]. Wyszkowski et al., [26] in his findings reported that the contamination of soil with diesel oil affected the yellow lupine yield and macro-elements contents

The continuous growth of environmental pollution and anthropological disturbances to ecosystems has made the study of abiotic stress responses in plants [27]. The effect of crude oil pollution on soil pH, temperature, number of plant species and vegetation productivity was observed [28]. Effects of crude oil pollution on the growth of some plant species viz. *Zea mays*, *Abelmoschus esculentus*, *Capsicum annum (L.)*, *Lycopersicon esculentum* (Miller) reported [29-30]. The effects of crude oil contaminated soils on seedling growth of six agronomic crop species observed and concluded that *Zea mays* and *Glycine max* seedlings show the greatest potential to enhance remediation compared to the *Meticago sativa*, *Lolium perenne*, *Triticum aestivum* and *Vicia villosa* observed [31]. Pollution of the soil with petroleum derivatives is often observed in municipal soils around industrial plants and in areas where petroleum and natural gas are obtained [32-33]. One of the most common symptoms of the pollutant phytotoxicity is reduction of plant growth. The effect of crude oil contamination on the chlorophyll and carotenoids contents of poplar clones was observed [34]. The effect of different concentrations (1, 2, 3, and 4%) of crude oil on seedling girth of *Abelmoschus esculentus* observed. All the seedling girths in the crude oil-polluted soils were stunted with reduced girth when compared with the plants grown in non-crude oil-polluted soil [35]. Trapp et al. [36] found *Populus nigra* to be more sensitive to diesel fuel than willows, *Salix viminalis* and *S. alba*. A significant reduction ($p<0.05$) in seed germination percentage for *Vigna unguiculata* (Cowpea) recorded as the quantity of the gasoline fuel/diesel mixture 40 and 50 ml added to the soil[37].

Adenenthera pavonina L commonly cultivated in home gardens and often protected in forest clearings and village common areas. *A. pavonina* is a useful tree provides quality of fuel wood, wood for furniture, and shade for economic crops like coffee and spices. The tree has been planted extensively throughout the tropics as a n environmental and has become naturalized in many countries. *A. pavonina* a deciduous tree with height ranging from 6 – 15 m and diameter upto 45 cm. the tree is generally erect having dark brown to greyish bark, spreading crown and multiple stems are common. *A. pavonina* is an endemic to Southeast China and India and has been introduced throughout the humid tropics. It has become naturalized in Malaysia, Western and Eastern Africa and most island nations of both the Pacific and the Caribbean [38]. It belongs to the family Leguminosae and subfamily Momosoideae.

The use of the motor oil increases with the increasing population. Oil pollution is an important problem in many parts of the world. The disposal of motor oil untreated into the immediate environment such as dumping in soil, drainage in waterways, commercial garages, washing of automobiles at petrol pumps finds its easy way of contamination. A lesser is known about the impact of motor oil pollution on plant growth. Therefore, the present study was carried out with the aim to study the effects of motor oil polluted soil on the growth of an important tree *Adenenthera pavonina* L. successfully cultivated in parks and roads side of the Karachi city.

2. MATERIALS AND METHODS

This study was conducted at the Department of Botany, University of Karachi, Pakistan. Seeds of *Adenenthera pavonina* L. were collected from Karachi University Campus. Motor oil was obtained from Motor Transport Workshop located at University of Karachi Campus. Due to hard seed coat, seeds were placed in distilled water for 24 hours and then sown in garden soil. The different concentrations (1.25, 2.5, 3.75 and 5.0 %) of freshly motor oil solution were watered. The fraction of garden soil was one part natural manure and two parts fine sand. The pot was kept moist by adding water when necessary. Ten seeds were sown in each pot replicate treatment. Seeds were sown at 1 cm depth in plastic pots, having 7.3 cm in diameter and 9.6 cm in depth. There were five replicates of each treatment and the experiment was completely randomized. Pots were reshuffled to avoid light / shade or any other greenhouse effects. Pots were irrigated with the motor oil solutions alternately. Seed germination was recorded. Experiment was lasted for fifteen days. In another experiments, the seedlings of *A. pavonina* were grown and maintained in large earthen pots each containing 5 kg of soil. One month after germination, two seedlings were transplanted to each plastic pot containing soil. Each pot was irrigated by the freshly prepared motor oil (1.5, 2.5, 3.75 and 5 %) solution alternately and no nutrient solution was provided. Treatments were replicated five times ad pots arranged in a randomized complete block design on a greenhouse bench. Garden soil was used as control. The fraction of soil was one part manure and two parts fine sand. Every week, pots were reshuffled to avoid light / shade effect or any other greenhouse effects. Experiment was conducted for six weeks. After six weeks all the seedlings were carefully removed from the pots and washed to measure root, shoot, seedling length and plant cover. The height of the plants was measured from the soil level to the terminal bud using a steel scale. The plants were carefully uprooted and the root part rinsed with clean water. The seedlings were finally placed in an oven at 80 degree centigrade for 24 hours to obtained dry weight.

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 6, Issue 1, pp: (1-8), Month: January - March 2018, Available at: www.researchpublish.com

Reduction in seedling growth parameter was determined as follows:

C-T/C X 100 (C=Control, T= treatment)

The means as well as standard errors were calculated. Data collected were subject to one-way analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) using personal computer software packages COSTAT version 3.00 statistically analysed. Level of significance for these tests was at P <0.05.

3. RESULTS

The effect of different levels (0%, 1.25%, 2.50%, 3.75%, 5.0%) of motor oil suspension on the seedling growth performances of *A. pavonina* was observed (Table 1-2). The oil pollution contamination significantly ($p<0.05$) affected the root, shoot length and plant height as compared to control. The mean root, shoot and plant height of *A. pavonina* was found high in control soil treatment. The treatment of 5% motor oil suspension soil highly decreased root, shoot and seedling length of *A. pavonina* as compared to control soil (Table 2). The mean values obtained for *A. pavonina* root length (5.38 cm), shoot length (6.17 cm) and seedling length (12.00 cm) were highest in control soil. The treatment of 1.25, 2.50, 3.75 and 5.0% motor oil suspension soil did not produce any significant effect on shoot length, stem dry weight and root / shoot ratio for *A. pavonina* as compared to control soil. The mean values obtained for *A. pavonina* root length (5.38 cm), shoot length (6.17 cm) and seedling length (12.00 cm) were recorded highest in control soil. The low mean values obtained for root length (3.66 cm), shoot length (5.88 cm) and seedling growth (10.76 cm) were found for the 2.5% motor oil treated soils. Further increase in suspension of oil polluted soil treatment at 3.75% significantly decreased the seedling growth (10.00 cm) and root growth (3.74 cm) of *A. pavonina* as compared to control. Seedling length (9.20 cm), shoot length (5.64 cm) and root length (3.56 cm) were found significantly lowest when treated with 5.0 % motor oil suspension soils as compared to control treatment. A slight increase in shoot length (6.32 cm) of *A. pavonina* were found for the 2.5 % and 3.5% oil treated soils as compared to 1.25% oil polluted soil treatment. The treatment of various concentration of motor oil polluted soil responded differently to root / shoot ratio of *P. aculeata* as compared to control soil. The mean values obtained for root / shoot ratio 0.940, 0.882, 0.630, 1.02 and 0.96 for *P. aculeata* seedlings were found for the 0, 1.25, 2.5, 3.75 and 5.0% motor oil treatment, respectively. The significant effects of motor oil polluted soil on root, shoot and seedling dry weight were also recorded. A significant ($p<0.05$) relationship was found to exist between the inhibitory effects of oil polluted soil on seedling dry weight with the increase in polluted soil treatment concentrations as compared to control. Principally, 5.0% motor oil polluted soil exhibited great reduction in seedling dry weight of *A. pavonina* as compared to control. Similarly biomass production of *A. pavonina* in terms of total seedling dry weight (0.05 g), root dry weight (0.018 g) and shoot dry weight (0.032 g) was recorded in 5.0% oil polluted soil as compared to control soil treatment.

Table 1: Effects of different concentration of motor oil solution on seedling growth of *Adnenthera pavonina* as compared to control.

Growth parameters	Motor oil solution concentration (%)				
	0	1.25	2.5	3.75	5.0
Seed germination (%)	82.00c±0.30	82.00c±0.30	70.00b±0.30	68.00b±0.30	50.00a±0.30
Root length (cm)	5.38b±0.41	3.66a±0.20	4.24a±0.20	3.74a±0.11	3.56a ±0.20
Shoot length (cm)	6.17a±0.03	5.88a±0.20	6.32a±0.20	6.32a±0.30	5.64a ±0.13
Plant height (cm)	12.00c±0.44	9.54a±0.30	10.76b±0.10	10.00ab±0.40	9.20a±0.30
Plant cover (cm)	34.33b±3.33	2.50b±1.33	2.50a±0.00	2.50a±0.00	2.50a±0.00
Plant dry weight (g)	0.250b±0.01	0.054a±0.01	0.058a±0.02	0.048a±0.01	0.050a±0.01
Root dry weight (g)	0.027b±0.009	0.016ab±0.002	0.010a±0.00	0.016ab±0.004	0.018ab±0.01
Stem dry weight (g)	0.060a±0.006	0.038a±0.011	0.048a±0.02	0.032a±0.001	0.032a±0.01
Root / shoot ratio	0.940a±0.062	0.882a±0.330	0.630a±0.20	1.02a±0.33	0.961a±0.30
Statistical significance determined by analysis of variance. Numbers followed by the same letter in same row are non-significantly different ($p<0.05$) according to Duncan's Multiple Range Test (D.M.R.T.) Symbol used : ± = Standard error					

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 6, Issue 1, pp: (1-8), Month: January - March 2018, Available at: www.researchpublish.com

Table 2: percentage reduction in growth of *Adnenthera pavonina* treated with different concentration of motor oil solution as compared to control.

Growth parameters	Motor oil solution concentration (%)			
	1.25	2.5	3.75	5.0
Seed germination (%)	0	14.63	17.07	39.02
Root length (cm)	31.97	23.58	30.48	33.82
Shoot length (cm)	4.70	2.43^{+}	2.42^{+}	8.63
Plant height (cm)	20.50	10.33	10.33	23.33
Plant cover (cm)	92.72	92.72	92.72	92.72
Plant dry weight (g)	78.40	76.80	80.81	80.00
Root dry weight (g)	40.74	62.96	40.74	33.33
Stem dry weight (g)	36.66	20.00	46.66	46.66
Root / shoot ratio	6.17	32.97	8.51^{+}	2.12^{+}
+ = Percentage increase				

4. DISCUSSION

Pollution caused by petroleum and its derivatives is the most prevalent problem in the environment. The release of oil into the environment by oil spills is receiving worldwide attention [39]. The results of the present study showed variability in seedling growth performance of *A. pavonina* as compared to control soil treatment. In present studies the treatment of different level of oil polluted soil concentration showed a clear variation in seedling growth performance of *A. pavonina* as compared to control soil treatment. Seedling length of *A. pavonina* was variable and appeared to be driven mostly by the treatment of different level of oil polluted soil treatment. The toxic effects of spent engine oil on chlorophyll and protein levels of *Amaranthus hybridus* L. germination of perennial rye grass and maize growth performance reported in earlier studies [40-42]. This study demonstrated that motor oil application at highest concentration (5%) in soil has significant effect on the seedling growth performance of *A. pavonina*. These obtained results are in conformity with the findings of other researcher's recorded toxic effects of oil as a soil contaminant on the growth of plant species [43-44]. Marked decrease in plant cover for *A. pavonina* was recorded when treated with different concentration of oil pollution as compared to control. Similar trend of decline in leaf growth was recorded by Anoliefo and Edegbai [45]. Similarly, The negative effects of oil contamination on reduction of the total biomass and the length of the roots in *Avena sativa* L., *Secale cereale* L. and *Hordeum vulgare* L. observed and suggested that these plants could be used as test organisms in analyzing the toxicity of this pollutant in soil and water [46-47]. In another investigation, Maranho *et al.* [48] investigated the effect of petroleum pollution on the leaf structure of *Podocarpus lambertii* Klotzsch ex Endl. (Podocarpaceae), and concluded that leaf anatomy revealed a large variability related to pollution. Our data also showed the negative influence of oil polluted soil on leaf area of *A. pavonina* as compared to control soil treatment. The relatively low plant cover was observed in motor oil polluted soil at all the concentration of (1.25, 2.50, 3.75 and 5.0%) and can be attributed to the toxic or un-favorable effect of oil contamination. The availability of motor oil in soil makes unsuitable environment for the development of root growth for *A. pavonina*. Certainly there are certain toxic compounds present in the oil that affect the plant growth. The oil is phytotoxic because it creates unsatisfactory conditions for plant growth ranging from heavy metal toxicity to inhibited aeration of the soil [49].

Motor oil contamination at 3.75 and 5.0% affected root growth performance of *A. pavonina* due to development of unsuitable growth condition by oil pollution. Plants are highly sensitive to oil contamination. Oil in soil creates unsatisfactory conditions for plant growth [50] probably due to insufficient aeration of the soil [51]. The contamination with petroleum affects the development of plants due to different physical effects. The oil film that covers the roots, modifying water absorption and nutrients considered as the main physical effect [52-54]. According to Bona and Santos [55] oil diminishes the soil capacity for retaining water, thus interfering with plant growth. Seedlings biomass of *A. pavonina* was least productive in oil contaminated soil sample and most productive than control soil sample treatment. The continuous decrease in seedling growth of growth parameter of *A. pavonina* in this study revealed that it is due to abiotic stress. Increase in the crude oil contamination which contains a wide variety of elements such as carbon, hydrogen, sulphur, nitrogen and oxygen might be an important cause of decline in average shoot length of *A. pavonina*. There was a

similar trend of negative effects on the productivity of *A. pavonina* recorded. The addition of different level of crude oil can leads to some physical and chemical changes in the soil resulting reduction in seedling growth performance of *A. pavonina*. The presence of the toxic pollutants from the crude oil in soil can be an important cause of decrease in seedling growth and ultimately resulted in reduction of biomass production performance for *A. pavonina*. Effects of oil polluted soil on the growth and metabolism of *Vigna unguiculata* L. Walp, and some desert and some tropical grasses and leguminous plants [56-60] .

5. CONCLUSION

Few studies have reported the presence of motor oil suspension in the soil affected plant growth around the world. There is little known about the effects of motor oil pollution on the seedling growth of *A. pavonina* in the country. The present study also confirmed the toxic effects of motor oil suspension on the seedling growth of *A. pavonina.* There is a need to further assess the phytochemical constituents of the seedlings of this plant. The present study also concludes that the changes in the seedling growth performances of *A. pavonina* in terms of seedling growth and biomass production was recorded due to treatment of different concentration of motor oil suspension with soil. Plant height, plant cover and root growth of *A. pavonina* grown in the contaminated soil were adversely affected. A clear reduction in the root, shoot, seedling length and productivity was observed at 5% motor oil polluted soil treatment as compared to control. The significant changes in seedling growth performance of *A. pavonina* grown in the motor oil contaminated soil can be served as good pollutant indicator for planation of *A. pavonina* in oil pollution monitoring. Similar types of studies are suggested for other plant species to ascertain their possible use of plantation in oil polluted contaminated areas.

REFERENCES

[1] T.L.Potter and K.E. Simmons. “Composition of petroleum mixtures. Massachusetts: Amherst Scientific Publishers”. 91p. 1998.

[2] B. Debojit, B. “Effect of crude oil on soil, species number, biomass and productivity following an accident blowout of an oil well in a terrestrial ecosystem“**.** Nature Env Polln Techno, 5(3): 477– 482. 2006

[3] J. Abedi-Koupa, R Ezzatian, M Vossoughi-Shavar, S Yaghmae, M Borghe, M. “The Effects of microbial population on phytoremediation of petroleum contaminated soils using tall Fescue“. International Journal of Agriculture and Biology, 9(2): 242-246. 2007

[4] J Wyszkowska, J and J Kucharski. “Biochemical Properties of soil contaminated by petrol“. Polish J. Environ. Studies, 9(6): 476-485. 2000.

[5] MRT Palmroth, J Pichel, JA Puhakka. “Phytoremediation of subarctic soil contaminated with diesel fuel“. Bioresource Technology 84: 221–228. 2002.

[6] S Odat and M Alshammari. “Seasonal Variations of Soil Heavy Metal Contaminants along Urban Roads: A Case Study from the City of Hail, Saudi Arabia”. Jordan Journal of Civil Engineering, 5 (4): 581 – 591. 2011

[7] Kathi, S; Khan, AB. 2011. Phytoremediation approaches to PAH contaminated soil. Indian Journal of Science and Technology, 4 (1): 56-62.

[8] EI Atuanya. “Effect of waste engine oil pollution on the physical and chemical properties of the soil: A case study of waste contaminated Delta Soil in Bendel State”. Nigerian Journal of Applied Science, 5: 155-176.1987.

[9] EO Ekundayo and CO Obuekwe. “Effects of oil spill on soil physic-chemical properties of a spill site in a paleudult of Midwestern Nigeria”. Environmental Monitoring and Assessment, 45: 209-221. 1994.

[10] M Wyszkowski and A Ziolkowska. “Effect of petrol and diesel oil on content of organic carbon and mineral components in soil”. American- Eurasian J. Sust. Agric., 2(1): 54-60. 2008.

[11] L.O. Alamu. “Effect of Oily Effluent on leaf characteristics of insitu park plants in Guinea Savanna Agroecological Zone of Nigeria”. International Journal of Academic Research in Business and Social Sciences, 2 (6): 238-251. 2012.

[12] EJ Udo and AA Fayemi. "The effect of oil pollution of soil on germination, growth and nutrient uptake of corn". Journal of Environmental Quality, 4: 537-540. 1975.

[13] R Bartha. "The effects of oil spills on trees". J. Arboric, 3: 142-147. 1977.

[14] VJ Odjegba and AO Sadiq. "Effects of spent engine oil on the growth parameters, chlorophyll and protein levels of Amaranthus hybridus L." The Environmentalist 22: 23–28. 2002.

[15] M Wyszkowski and J Wyszkowska. "Effect of enzymatic activity of diesel oil contaminated soil on the chemical composition of oat (Avena sativa L.) and maize (Zea maize L.)". Plant, Soil Environ., 51(8): 360-367. 2005.

[16] VJ Odjegba and JO Atebe. "The effect of used engine oil on carbohydrate, mineral content and nitrate reductase activity of leafy vegetable (Amaranthus hybridus L.)". J. of Applied Sci. and Environmental Management 11(2): 191–196. 2007.

[17] CO Nwoko, PN Okeke, OO Agwu, IE Apkan. "Performance of Phaseolus vulgaris L. in a soil contaminated with Spent Engine Oil". African J. of Biotechno, 6(16): 1922-1925. 2007.

[18] KL Njoku, MO Akinola, BO Oboh. "Germination, survival and growth of accession of Glycine max L. (Merril) (Soybean) and Lycopersicon esculentum L.(Tomato) in crude oil polluted soil". Res. J. Environ. Toxicol. 2(2): 77-84. 2008

[19] EM Ogbo. "Effect of diesel fuel contamination on seed germination of four crop plants- Arachis hypogea, Vigna unguiculata, Sorghum bicolor and Zea mays". Afr. J. Biotechnol. 8(2): 250-253. 2009

[20] EM Ogbo, M Zibigha, G Odogu. "The effect of crude oil on growth of the weed (Paspalum scrobiculatum L.) – phytoremediation potential of the plant". African J. of Environ. Sci. and Techno 3(9): 229–233. 2009.

[21] O Kekere, B Ikhajiagbe, BR Apela. "Effects of crude petroleum oil on the germination, growth and yield of Vigna Unguiculata walp L." J. of Agri. and Biological Sci., 2(6), 158-165. 2011.

[22] AA Oyedeji, AO Adebiyi, MA Omotoyinbo, CO Ogunkunle. "Effect of Crude Oil-Contaminated Soil on Germination and Growth Performance of Abelmoschus esculentus L. Moench—A Widely Cultivated Vegetable Crop in Nigeria". American J. of Plant Sci. 3: 1451-1454. 2012.

[23] TP Ojimba and AG Iyagba. "Effects of crude oil pollution on horticultural crops in Rivers State, Nigeria". Global J. of Sci. Frontier Res. Agri. and Biol., 12(4): 37-43. 2012.

[24] K Ilangovan and M Vivekanandan. 1992. "Effect of oil pollution on soil respiration and growth of Vigna mungo (L.) Hepper." The Sci. of The Total Environ., 116 (1-2): 187-194. 1992.

[25] LT Maranho, F Galvao, GIB Muniz, YS Kuniyoshi, KH Preussler. "Size variation of tracheids in the stem of Podocarpus lambertii Klotzsch ex Endl., Podocarpaceae". Acta Botanica Brasilica, 20 (3): 633-640. 2006a.

[26] M Wyszkowski, J Wyszkowska, A Zoilkowska. "Effect of soil contamination with diesel oil on yellow lupine yield and macroelements contents". Plant, Soil Environ. 50(5): 218-226. 2004.

[27] M Alkio, TM Tabuchi, X Wang, A Coloncarmona. "Stress responses to polycyclic aromatic hydrocarbons in Arabidopsis include growth inhibition and hypersensitive response-like symptoms". J. of Exp. Bot., 56 (421): 2983-2994. 2006.

[28] FI Achuba. "The effect of sublethal concentrations of crude oil on the growth and metabolism of cowpea (Vigna unguiculata) seedlings". The Environmentalist 26: 17–20. 2006.

[29] JO Amakitri and FA Onafeghara. "Effects of crude oil pollution on the growth of Zea mays, Abelmoschus esculentus and Capsicum frutescens." Oil Petro Chemical Pollution Journal, 2(4): 199-205. 1983.

[30] GO Anoliefo and DE Vwioko. "Effects of spent lubricating oil on the growth of Capsicum annum (L.) and Lycopersicon esculentum (Miller)". Environmental Pollution, 88: 361-364. 1994.

[31] I Issoufi, RL Rhykerd, KD Smiciklas. "Seedling growth of agronomic crops in crude oil contaminated soil". J. Agron. Crop Sci., 192: 310. 2006.

[32] G Adam, K Gamoh, DG Morris, H Duncan. "Effect of alcohol addition on the movement of petroleum hydrocarbon fuels in soil". Sci. Total Environ. 286(1/3): 15-25. 2002.

[33] CJ Clark. "Field detector evaluation of organic clay soils contaminated with diesel fuel". Environ. Forensics, 4(3):167-173 2003

[34] A Pilipovič, S Orlovič, N Nikolič, M Borisev, B Krstič, S Rončevič. "Growth and physiological parameters as markers for selection of poplar clones for crude oil phytoremediation." Šumarski list 5–6, CXXXVI: 273–281. 2012.

[35] AA Oyedeji, AO Adebiyi, MA Omotoyinbo, CO Ogunkunle. "Effect of Crude Oil-Contaminated Soil on Germination and Growth Performance of Abelmoschus esculentus L. Moench—A Widely Cultivated Vegetable Crop in Nigeria". American J. of Plant Sci, 3: 1451-1454. 2012.

[36] S Trapp, A Kohler, LC Larsen, KC Zambrano, U Karlson. "Phytotoxicity of fresh and weathered diesel and gasoline to willow and poplar trees". J. of Soil Sediments 1:71–76. 2001.

[37] KL Njoku, MO Akinola, BG Taiwo. "Effect of gasoline diesel fuel mixture on the germination and the growth of Vigna unguiculata (Cowpea)". African J. of Environ. Sci. and Technol. 3 (12): 466-471. 2009a.

[38] ADA Adedapo, YO Osude, AA Adedapo, JO Moody, AS Adeagbo1, OA Olajide, JM Makinde. "Blood pressure lowering effect of Adenanthera pavonina seed extract on normotensive rats". Rec. Nat. Prod. 3:2: 82-89. 2009.

[39] VS Millioli, EC Servulo, LGS Sobral, DD Decarvalho. "Pollution caused by petroleum and its derivatives is the most prevalent problem in the environment. The release of crude oil into the environment by oil spills is receiving worldwide attention". Global NEST J. 11(2): 181-188. 2009.

[40] NO Isirimah, K Zoufa, P Loganathan. "Effect of crude oil on maize performance and soil chemical properties in the humid forest zone of Nigeria". Discovery and Innovation, 1: 95-98. 1989.

[41] VJ Odjegba, and AO Sadiq. "Effects of spent engine oil on the growth parameters, chlorophyll and protein levels of Amaranthus hybridus L". The Environmentalist 22: 23–28. 2002.

[42] S Siddique and WA Adams. "The fate of diesel hydrocarbons in soils and their effect on the germination of perennial rye grass". Environmental Toxicology, 17(1): 49-62. 2002.

[43] Anoliefo, GO; Vwioko, DE ; Mpamah, P. 2003. Regeneration of Chromolaena odorata (L) K. & R. in crude oil polluted soil: A possible phytoremediating agent. Benin Science Digest, 1: 9-14. 2003.

[44] Vwioko, DE; Fashemi, D.S. 2005. Growth response of Ricinus communis L. in spent lubricating oil polluted soil. Journal of Applied Science and Environmental Management, 9 (2): 73-79. 2005.

[45] GO Anoliefo and BO Edegbai. "Effect of crude oil as a soil contaminant on the growth of two egg plant species, Solanum melongena L. and S. incanum". J. Agriculture, Forestry and Fisheries, 1: 1-25. 2001.

[46] VN Petukhov, VM Fomchenkov, VA Chugunov, VP Kholodenko. "Plant biotests of soil and water, polluted with petroleum and petroleum products". Applied and Environmental Micro., 36 (6): 652-655. 2000.

[47] N Merkl, R. Schutze-Kraft, C. Infante. "Phytoremediation in the tropics – influence of heavy crude oil on root morphology characteristics of graminoids". Environmental Pollut. 138(1): 86–91. 2005b.

[48] LT Maranho, F Galvao, GIB Muniz, YS Kuniyoshi, KH Preussler. "Size variation of tracheids in the stem of Podocarpus lambertii Klotzsch ex Endl., Podocarpaceae". Acta Botanica Brasilica, 20 (3): 633-640. 2006a.

[49] NE Edema, BO Obadoni, H Erheni, UE Osakwuni. "Eco-Phytochemical Studies of Plants in a Crude Oil Polluted Terrestrial Habitat Located at Iwhrekan, Ughelli North Local Government Area of Delta State". Nature and Science,7(9): 49-52. 2009.

[50] E DeJong. "The effect of crude oil spill on cereals". Environmental Pollut., 22: 187-196. 1980.

[51] MJ Rowell. "The effects of crude oil spills on soil. In: Toogood, J.A. (Eds.). The reclamation of agricultural soils after oil spills." Department of Soil Science, University of Alberta, Edmonton, pp. 1-33.1977.

[52] JG Xu and RL Johnson. "Root growth, microbial activity and phosphatase activity in oil-contaminated, remediate and uncontaminated soils planted to barley and field pea". Plant and Soil, 173 (11): 3-10. 1995.

[53] MW Hester and IA Mendelssohn. "Long-term of a Lousiana brackish marsh plant community from oil – spill impact: vegetation response and mitigating effects of marsh surface elevation". Marine Environmental Res., 49: 233-254. 2000.

[54] SR Pezeshki, MW Hester, Q Lin, JA Nyman. "The effects of oil spill and clean up on dominant US gulf coast marsh macrophytes: a review". Environmental Pollution, 108 (2): 129-139. 2000.

[55] C Bona and OG Santos. "Adaptações fisiológicas de espécies vegetais crescendo em solo contaminado com petróleo". Curitiba: FUNPAR; UFPR. Relatório Técnico. 52 p. 2003.

[56] DA Jessup and FA Leighton. "Oil pollution and petroleum toxicity to wild life in Noninfections Diseases of Wildlife". A. Fairbrother, L.N. Locke, and G.L. Press (eds 2nd) Edition. Iowa State University Press, Ames Iowa. Pp. 141-156. 1996.

[57] G Malallah, M Afzal, M Kurian, S Gulshan, MSI Dhami. "Impact of oil pollution on some desert plants". Environment International 24 (8): 919–924. 1998.

[58] NR Merkl, C Schutze-Kraft, C Infante. "Phytoremediation in the tropics the effect of crude oil on the growth of tropical plants". Bioremediation Journal 8: 177–184. 2004.

[59] N Merkl, R Schutze-Kraft, C Infante. "Assessment of tropical grasses and legumes for phytoremediation of petroleum -contaminated soils". Water, Air, and Soil Pollution 165: 195–209. 2005a.

[60] OM Adedokun and AE Ataga. "Effects of amendments and bioaugumentation of soil polluted with crude oil, automotive gasoline oil, and spent engine oil on the growth of cowpea (Vigna unguiculata L. Walp)". Sci. Res. Essay. 2(5):147-149. 2007.