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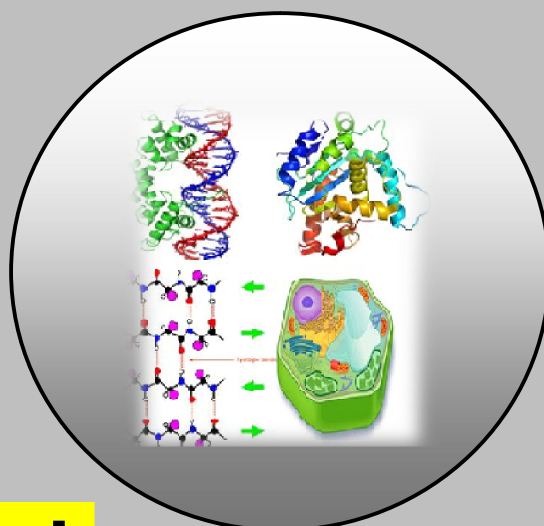

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Metal Concentration in Plant Tissues of *Jatropha curcas* L Grown in Crude Oil Contaminated Soil

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ABSTRACT

This study evaluated the heavy metal concentration in plant tissues of Jatropha curcas grown in crude oil contaminated soil in Asaba, Delta State, Nigeria in 2010. 0.0, 2.0 4.0, 6.0, 8.0 and 10.0% w/w of the oil constituted the treatments. The results showed a buildup of heavy metals in areas of oil impact as the levels of heavy metals including iron, zinc, cadmium, copper, manganese, lead, chromium and nickel were significantly higher ($P \leq 0.05$) in contaminated soils when compared to the uncontaminated subplots. Plant tissues (leaves, stems and roots) analyses also showed significantly higher amounts of heavy metals compared with values obtained from areas not contaminated with crude oil. Although the amounts of metals observed in the present study are below tolerable limits according to World Food and Agricultural Organization and Federal Environmental Protection Agency, with gradual accumulation and biomagnifications of these non-biodegradable elements, a rise to a dangerous or lethal level with their inherent health risks could be envisaged in man and his animals.
Keywords: Heavy Metals, Jatropha curcas Seedlings, Crude Oil and Contaminated Soil.

INTRODUCTION

Heavy metals are non-biodegradable and capable of accumulating in the body of plants and animals through food chain so that when man eats these organisms, they also deposit in the muscles of man resulting in various diseases depending on the metal involved (Abdu and Muazu, 2007). Living organisms require varying amounts of heavy metals. Iron, cobalt, tin aluminum, cupper, manganese, molybdenum and zinc are required by humans. Excessive level could be damaging to the organism (Onwughuta *et al.,* 2010).

Other heavy metals such as mercury, plutonium, Sn and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness while certain elements that are normally toxic are, for certain organisms or under certain conditions, beneficial include vanadium, tungsten and cadmium (Damisa *et al*., 2006). Vwioko *et al*. 2006 and Agbogidi, 2011 reported that oil pollution of soil leads to a build-up of some essential (organic carbon, P. Ca, Mg) and non-essential (Mn, Pb, Zn, Co, Fe, Cu) elements in soil and the eventual translocation in plant tissues.

Soil pollution by heavy metals is of serious concern to man due to their persistence in the environment and carcinogenicity to human beings (Duffus, 2002; Manohar *et al*., 2006). They cannot be destroyed biologically but are only transformed from one oxidation state organic complex to another (Lovley *et al.,* 1997; Ross, 2004; Jamal *et al*., 2006). Heavy metal pollution is seen as a great potential health hazard to the environment and human health. Sources of heavy metals include crude oil and its products, industrial effluents, leaching of metal oil, paints and textiles (Obuh *et al.*, 2002; Agbogidi and Egbuachua, 2010). The occurrence of heavy metals in the soil is also affected by urbanization, global development in terms of economic, agricultural and industrial developments as well as anthropogenic emission (Duffus, 2002). On release to the environment, heavy metals contribute to a variety of toxic effects on living organisms by bioaccumulation and biomagnification (Chem *et al*., 2000; Oboh *et al*., 2002; Dembitsky, 2003; Manohar *et al*., 2006). The fragile Niger Delta ecosystem where most of Nigeria's oil is produced has suffered repeated oil spillages stemming from sabotage, accidental discharge, tanker operations and other factors (Agbogidi and Eshegbeyi, 2006; Ekeke *et al*., 2008). These environmental disasters have deleterious effects on agricultural land and significant effects on plant growth and yields (Anoliefo *et al*., 2007; Agbogidi, 2009a) resulting from poor soil conditions, immobilization of nutrients, heavy metals and (Osubor and Anoliefo, 2003; Bamidele *et al*., 2007; Achuba and Peretiemo–Clarke, 2008; Agbogidi 2009b; Agbogidi, 2010).

Jatropha curcas is a perennial shrub whose seeds are used for producing biodiesel (Fairless, 2007; Achen *et al*., 2008). It is traditionally used as hedging plant in parts of India to protect agriculture and livestock. The seeds are also used as insecticides. Once deshelled, the glycerin within the almond of the seed can be used to make soap while the pressed cakes that remain after the oil has been extracted are often used as organic fertilizer because of the high concentration of nitrogen (Achen *et al*., 2007). It is a multipurpose crop as reclamation of marginal soils, good growth under saline conditions, drought tolerant and high water use efficiency, an important energy crop, low labour in plants, does not compete with food crops and it is a wonder bio-fuel crop (Agbogidi *et al.,* 2010; Keyejo *et al.*, 2010). Studies on the metal contents of other plant species abound (Vwioko *et al*., 2006; Agbogidi *et al*., 2007; Agbogidi; 2009a; Agbogidi, 2009b; Agbogidi, 2010). There is however, paucity of documented information on *Jatropha curcas* a multipurpose shrub species. This study was specifically designed to evaluate the metal concentration in plant tissues of *Jatropha curcas* grown in oil contaminated soil.

MATERIAL AND METHODS

The experiment was conducted in 2010 at the nursery site of the Department of Forestry and Wildlife, Delta State University, Asaba Campus (Latitude $6^0$14'N; Longitude $6^0$49'E) (Asaba Meteorological Station, 2010). Soil samples were collected as a pooled sample from the Gmelina plantation behind the departmental nursery. The soil was air-dried and passed through a 2mm sieve. Fruits of *J. curcas* were collected from the mother tree in Anwai (Asaba), planted in the nursery without pre-treatment but with the basic nursery care given. The crude oil was sourced from the Nigeria National Petroleum Corporation (NNPC), Warri in Delta State and applied at 0.0, 2.0, 4.0, 6.0, 8.0 and 10.0%w/w. The soil (1.5kg) crude-oil mixture was poured into bottom-perforated polypots (15/10cm in dimension). One seedling was planted per polypot. The experiment was arranged in a randomized complete block design with four replications. The polypots were watered to field capacity immediately after planting and thereafter, every other day till the end of the trial. The set-up was monitored for 10 weeks after transplanting (WAT) after which the plants were harvested, separated into roots, stems and leaves, over dried at 85^0C for 20 hours following the procedure of Agbogidi and Eshegbeyi, 2006. The plant tissues (roots, stems and leaves) were ground with an agate mortar to achieve fine grinding paste and packaged separately. One gramme of each of the ground plant materials was weighed into a conical flask for wet ashing which involved the decomposition of the plant materials in a mixture of strong acids consisting of nitric, sulphuric and perchloric acids and heated to a temperature of 50^0C in a furnace for 4 hours until grey coloured which indicated that complete ashing had taken place and then wet digested using nitric acid. The digests were later analysed for heavy metals by atomic absorption spectrophotometer using the standard addition method (AOAC, 1985). Composite soil samples were collected from 0-15cm depth prior to treatment application and after harvest. The samples were used to determine soil heavy metal contents. Both analyses were carried out at the Institute of Agricultural Research and Training (IART), Ibadan, Oyo State, Nigeria. Data collected were subjected to analysis of variance and the significant means were separated with the Duncan's multiple range tests using SAS (2005).

RESULTS AND DISCUSSION

As shown in Table 1, there was a buildup of heavy metals in areas of oil impact, as the levels of heavy metals including iron, zinc, cadmium, copper, manganese, lead, chromium and nickel were significantly higher ($P \leq 0.05$) in these areas when compared to the uncontaminated subplots. Plant tissue analyses (leaves, stems and roots) also showed significantly higher amounts of heavy metals compared with tissues obtained from areas not contaminated with crude oil (Tables 2, 3 and 4) respectively. These findings agree with earlier reports of Hall, 2002, Osubor and Anoliefo, 2003, Okafor and Nwarijei, 2006, Oyin and Kassim, 2006, Abdua and Muazu, 2007, Agbogidi *et al*. 2007, Damisa *et al*. 2008, Agbogidi and Egbuchua, 2010 and Agbogidi, 2010 that heavy metals abound in soils contaminated with petroleum hydrocarbons. The presence of heavy metal varies from site to site depending upon the source of individual pollutants.

Achuba and Peretiemo–Clarke, 2008 reported that excessive uptake of metals by plants may produce toxicity in human nutrition when consumed. For example, Cd and Zn can lead to acute gastrointestinal and respiratory damages and acute heart, brain and kidney damages. High concentrations of heavy metals in soil can negatively affect plant growth and yield as these metals interfere with metabolic functions in plants including physiological and biochemical processes, inhibition of photosynthesis and respiration (Osubor and Anoliefo, 2003; Agbogidi *et al*., 2007; Achuba and Peretiemo-Clarke, 2008). Other effects of heavy metals in plants according to Onweremadu and Doruigbo, 2007, Nwite *et al*. 2008, Nwuch and Ngoji. 2008, Nwachukwu *et al*. 2010, include degeneration of main cell-organelles and even leading to death. Oboh *et al*., 2002, reported that Pb is known to cause some biochemical and structural changes in fresh water snail when accumulated in the flesh of snail. Soil contamination with heavy metals may also cause changes in the composition of soil microbial community and other biological and biochemical properties as well as the physical and chemical properties of the soil following the lowering of soil pH. The results of this study showed that a positive interaction existed between oil contamination and heavy metal concentration support the earlier reports of Alloway, 1995, Chee *et al*. 2006, Vwioko *et al*. 2006, Onweremadu and Doruigbo, 2007 and Chukwuma *et al*., 2010. In conclusion, this study evaluated the metal concentration in plant tissues of *Jatropha curcas* grown in crude oil contaminated soil in Asaba, Nigeria. The results showed that there was a buildup of heavy metals in the soils of oil impact when compared with the uncontaminated subplots. Plant tissue analyses also indicated significant higher metal contents relative to the control. This study has demonstrated that soil contamination with crude oil can lead to a gradual accumulation of heavy metals which have a direct effect on the tissues of the plants grown in such environment. Although the amount of metals observed in the present study are below the tolerable units (FAO, 1985, FEPA, 2002), with gradual accumulation and bio-magnification of these non-biodegradable elements, could lead to a rise to a dangerous or lethal level with their inherent health hazard could be envisaged in man and his animals. This study also indicated that organisms including plants accumulate metals from their environments and the accumulation of these metals is a strong indication of environmental degradation.

Table 1. Heavy metal concentration (mgkg^{-1}) of soils under various crude oil treatment.

Crude oil level in soil %(w/w)	Heavy metal concentrations								
	Fe	**Zn**	**Cd**	**Cu**	**Mn**	**Pb**	**Cr**	**Ni**	**Means**
0.0	0.62	0.99	0.52	0.06	0.04	0.51	0.63	2.22	0.70d
2.0	0.72	1.42	0.69	0.09	0.07	0.65	0.76	2.40	0.85d
4.0	1.70	1.56	0.97	0.18	1.14	1.50	1.45	5.62	1.78c
6.0	3.28	2.05	1.99	8.88	4.50	1.87	2.40	11.02	3.50b
8.0	4.65	2.81	2.07	1.23	4.76	2.10	2.86	14.06	4.32b
10.0	6.57	4.08	2.64	2.11	9.14	3.72	4.85	22.20	6.91a
Means	2.92	2.15	1.48	0.76	3.28	1.74	2.16	9.59	

Means with different letters are significantly different at $P \leq 0.05$ using Duncan's multiple range tests.

Table 2. Heavy metal concentration (mgkg^{-1}) of leaves of *Jatropha curcas* various crude oil treatment.

Crude oil level in soil %(w/w)	Heavy metal concentrations								
	Fe	**Zn**	**Cd**	**Cu**	**Mn**	**Pb**	**Cr**	**Ni**	**Means**
0.0	0.34	3.94	0.22	3.14	1.09	0.24	0.70	1.31	1.37e
2.0	1.96	4.61	0.62	3.64	2.64	3.41	1.76	1.46	2.51d
4.0	2.64	4.89	0.98	4.86	2.87	3.80	2.72	2.06	3.10c
6.0	2.98	5.78	1.30	5.71	4.38	4.21	3.41	2.56	3.79b
8.0	3.10	6.01	1.48	5.89	5.00	4.72	3.92	3.81	4.24b
10.0	3.96	6.35	1.88	6.01	5.87	5.06	4.62	4.96	4.84a
Means	2.50	5.26	1.08	4.88	3.64	3.57	2.86	2.69	

Means with different letters are significantly different at P≤0.05 using Duncan's multiple range tests.

Table 3. Heavy metal concentration (mgkg^{-1}) of stems of *Jatropha curcas* various crude oil treatments.

Crude oil level in soil %(w/w)	Heavy metal concentrations								
	Fe	**Zn**	**Cd**	**Cu**	**Mn**	**Pb**	**Cr**	**Ni**	**Means**
0.0	1.03	3.21	0.71	0.61	0.44	0.02	1.02	1.66	1.09e
2.0	2.40	3.41	1.24	1.61	3.84	0.76	1.81	2.14	2.15d
4.0	3.86	3.79	1.48	2.32	5.38	1.87	3.05	2.73	3.06c
6.0	4.61	5.60	2.34	2.76	7.56	2.53	3.86	3.06	4.04b
8.0	4.96	6.73	2.86	3.48	7.96	3.86	4.42	3.78	4.64a
10.0	6.06	7.76	3.02	3.99	8.72	4.01	5.04	4.30	5.24a
Means	3.65	5.08	1.94	2.46	5.65	2.03	3.2	2.95	

Means with different letters are significantly different at P≤0.05 using Duncan's multiple range tests.

Table 4. Heavy metal concentration (mgkg^{-1}) of roots of *Jatropha curcas* various crude oil treatments.

Crude oil level in soil (%w/w)	Heavy metal concentrations								
	Fe	**Zn**	**Cd**	**Cu**	**Mn**	**Pb**	**Cr**	**Ni**	**Means**
0.0	1.11	2.76	1.11	4.01	1.32	3.70	1.21	1.46	2.09f
2.0	3.64	2.96	2.51	4.71	1.80	4.21	2.80	4.73	3.42e
4.0	5.44	4.71	3.68	5.73	2.40	4.73	4.62	6.26	4.70d
6.0	8.10	9.73	4.34	7.41	2.86	5.68	10.70	7.81	7.08c
8.0	10.00	12.16	5.06	7.87	4.81	6.71	12.60	9.92	8.64b
10.0	12.01	14.7	7.38	8.02	5.64	8.62	14.13	2.62	10.39a
Means	6.72	7.84	4.01	6.29	3.14	5.61	7.68	7.13	

Means with different letters are significantly different at P≤0.05 using Duncan's multiple range tests.

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