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Heavy metals content in fadama soils, root, leaf and seed of african locust bean tree (*Parkia biglobosa*) along the river Dilimi in jos north local government area of Plateau state, Nigeria

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Abstract

The aim of the study is to assess the levels of some heavy metal contamination of fadama soils, root, leaf and seed of African Locust Bean (*Parkia biglobosa*) due to irrigation with sewage fed river water. Samples of water, soils, *Parkia biglobosa'* sroot, leaf and seeds were analysed for four heavy metals; Pb, Cd, Mn and Fe using Atomic Absorption Spectrophotometry (AAS). The results showed the presence of some of the heavy metals in *Parkia biglobosa* roots, leaves, seeds and as well in soil and water which were beyond the limits of World Health Organisation. Iron (Fe) was found to be the most abundant in soil samples possibly as a result of drains from mining activities in the area under study. The soil samples gave 1900- 29500 (ppm) Fe , the water samples 7-7.20 (ppm) Fe while the Parkia tree samples gave (Root 686-4800ppm Fe; 37.32- 59ppm Mn; Seed 134-3460ppm Fe; 0.40- 1.92ppm Pb; 15- 46.80ppm Mn; Leaf 198-580ppm Fe ; 30.80-148.80ppm Mn). The values of Fe and Pb recorded for soil, water, root, leaf and seed were higher than the WHO (1993) Standard and FAO/ WHO (2001).Comparing the result of heavy metals in soil, water, root, leaf and seed, it was observed that the concentration of heavy metals were more in the soil and root , confirming a positive correlation between the content of metallic element in the plant and its native soil.

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Introduction

Recently, pollution of general environment has increasingly gathered a global interest. In this respect, contamination of agricultural soils with heavy metals has always been considered a critical challenge in scientific community (Faruk *et al.*, 2006). Due to the cumulative behaviour and toxicity, heavy metals have a potential hazardous effect not only on crop plants but also on human health (Das *et al.*, 1997). To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals at higher concentrations can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment (Lenntech, 2004).

Fadama is a Hausa word meaning the seasonally flooded and floodable plains along major Savannah Rivers and/or depression on the adjacent low terraces (Adeyeye, 2005). Fadama utilization has been a major feature of the agricultural, food economic and demographic experience of the Nigerian dry belt. Fadama utilization ensures availability of valuable agricultural resources in a zone where rain fed agricultural prospects is poor due to the small and erratic nature of rainfall pattern and endemicity of drought. Of a particular threat to Fadama irrigated crops during dry seasons are industrial effluents from factors and manufacturing facilities which contaminate irrigation channels (Awode *et al.,* 2008).

Food contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and air. Therefore, a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water and soil on plant systems seems to be particularly important issues of present day research on risk assessments (Rajest *et al.,* 2004). The main sources of heavy metals to vegetable crops are their growth media (soil, air, nutrient solution) from which these are taken up by the roots and foliage.

Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may accumulate one or more of the heavy metals high enough to cause risks to human health, plants, animals, ecosystems, or other media (D' Amore *et al.,* 2005). The heavy metals essentially become contaminants in the soil environments because their ates of generation via man-made cycles are more rapid relative to natural ones, they become transferred from mines to random environmental locations where higher potentials of direct exposure occur, the concentrations of the metals in discarded products are relatively high compared to those in the receiving environment, and the chemical form (species) in which a metal is found in the receiving environmental system may render it more bioavailable (D'Amore *et al.,* 2005).

Most of our water resources are gradually becoming polluted due to the addition of foreign materials from the surroundings. These include organic matter of plant and animal origin, land surface washing, industrial and sewage effluents (Karnataka State Pollution Control Board, 2002). Rapid urbanization and industrialization with improper environmental planning often lead to discharge of industrial and sewage effluents into rivers. Waste water contains substantial amounts of toxic heavy metal which create problems (Chen *et al.,* 2005; Singh *et al.,* 2004). Excessive accumulation of heavy metals in Agricultural soils through waste water irrigation, may not only result in soil contamination, but also affect food quality and safety (Muchuweti *et al.,* 2006).

At the beginning of the wet season, fadama are marked by a lush of new vegetation before the upland turns green (Turner, 1977). Fadama soils are used for agriculture and allows the production of crops throughout the year and are therefore of economic benefits to the local communities. They are small in size and located in areas regarded as inaccessible and under complicated land ownership arrangements (Alamu, 1996). Fadama lands are under increasing pressure as a result of conflicts arising from competing land uses including haphazard use, intensification of agricultural activities by farmers, pastoralist, fisher folks and other Fadama users (Ardo, 2004).

African locust bean tree, *Parkia biglobosa*, is a perennial leguminous tree that belongs to the Mimosoideae family. It grows in the Savannah region of West Africa up to the southern edge of the Sahel Zone 13°N (Platt, 1980). The tree is not normally cultivated but can be seen in the wild in the Savannah region of Nigeria. The seeds are well known for their uses in production of local condiment common known as Dadawa (Hausa) or Iru (Yoruba). It is a good source of timber and is useful in making pestles, mortar, bows, hoe handles and so on.

Furthermore, *Parkia biglobosa* is such plant legumes with an outstanding protein quality and its protein quality and amino acid composition has been reported (Nordeide *et al.*, 1996; Ega *et al.*, 1988; Glew *et al.*, 1997; Cook *et al.*, 2000; Lockett *et al.*, 2000).

The objectives of this study are toquantify and determine the level of heavy metals in Fadama soils and *Parkia biglobosa* tree (Root, leaf and seeds) along the bark of River Dimili in Jos North Local Gover-nment Area of Plateau State Nigeria, Having long term uses of untreated sewage water for irrigation as well as indiscriminate release of toxic effluents into the river may affect the metal contents of the river and *Parkia biglobosa*.

Materials and methods

Analytical reagent (Anala R) grade chemicals and water were used throughout the study. All glassware and plastic containers used were washed with detergent solution followed by 20% (v/v) concentrated Trixonitrate (IV) acid and then rinsed with water and finally with distilled water (Audu and Lawal, 2005).

For the purpose of determining heavy metal levels in the soil, water, leaves, roots and seeds the species *Parkia biglobosa,* samples were collected (soil, water leaves, seeds, and roots) from three sites shown in Table 1,2, 3,4 and 5.

Table 1. Total concentration of metal in *Parkia biglobosa* leaves.

LEAVES	Site	Pb (ppm)	Cd (ppm)	Mn (ppm)	Fe (ppm)
	1	1.68	0.00	30.80	580.00
	2	0.00	0.00	39.00	474.00
	3	0.00	0.00	148.80	198.00
	AVG	0.56	0.00	72.87	417.33
	ST-DV	0.97	—	65.88	197.20
	WHO-ML	0.10	0.30	500.00	425.00

Table 2. Total concentration of metal in *Parkia biglobosa* seed.

SEED	Site	Pb (ppm)	Cd (ppm)	Mn (ppm)	Fe (ppm)
	1	0.40	0.00	46.80	3460.00
	2	1.92	0.00	15.00	134.00
	3	0.00	0.00	30.20	174.00
	AVG	0.77	0.00	30.67	1256.00
	ST-DV	1.01	—	15.91	1908.82
	WHO-ML	0.10	0.30	500.00	425.00

Table 3. Total concentration of metal in *Parkia biglobosa* root.

ROOT	Site	Pb (ppm)	Cd (ppm)	Mn (ppm)	Fe (ppm)
	1	5.20	0.00	59.00	4800.00
	2	0.00	0.00	37.32	686.00
	3	0.00	0.00	50.00	1560.00
	AVG	1.73	0.00	48.77	2348.67
	ST-DV	3.00	—	10.89	2167.43
	WHO-ML	0.10	0.30	500.00	425.00

Table 4. Total concentration of metal in *Parkia biglobosa* soil.

SOIL	location	Pb (ppm)	Cd (ppm)	Mn (ppm)	Fe (ppm)
	1	43.50	0.00	274.00	23000.00
	2	15.20	0.00	301.20	29500.00
	3	12.36	0.00	258.00	19000.00
	AVG	23.69	0.00	277.73	23833.33
	ST-DV	17.21	—	21.84	5299.37
	WHO-ML	0.10	0.30	500.00	425.00

Table 5. Total concentration of metal in river water.

WATER	Site	Pb (ppm)	Cd (ppm)	Mn (ppm)	Fe (ppm)
	1	0.00	0.00	0.00	7.20
	2	22.92	0.00	0.00	7.20
	3	0.00	0.00	0.00	7.00
	AVG	7.64	0.00	0.00	7.13
	ST-DV	13.23	—	0.00	0.12
	WHO-ML	0.10	0.30	500.00	425.00

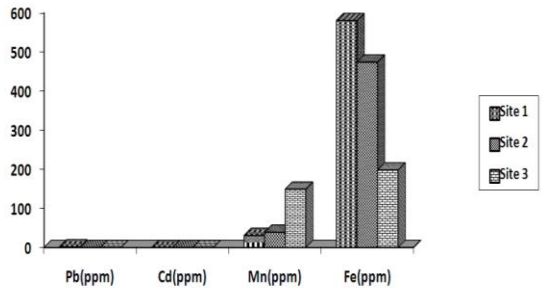

Fig. 1. Concentration of heavy metals in *Parkia biglobosa* leaves.

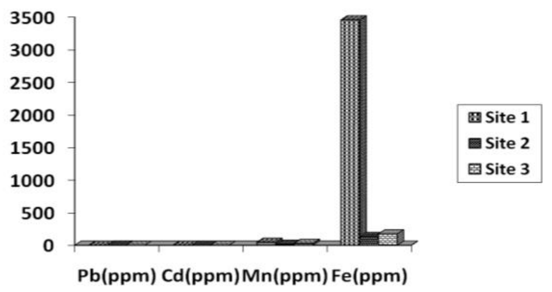

Fig. 2. Concentration of heavy metals in *Parkia biglobosa* seed.

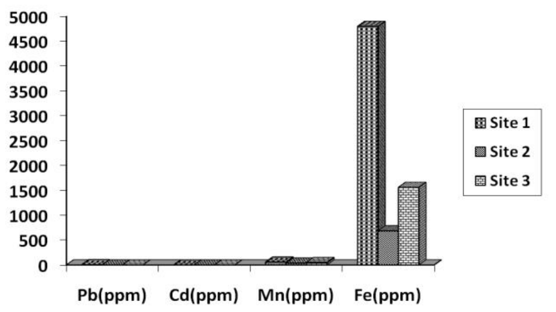

Fig. 3. Concentration of heavy metals in *Parkia biglobosa* Root.

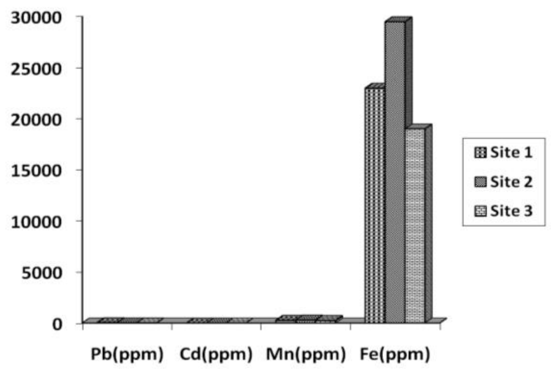

Fig. 4. Concentration of heavy metals in soils of the study area.

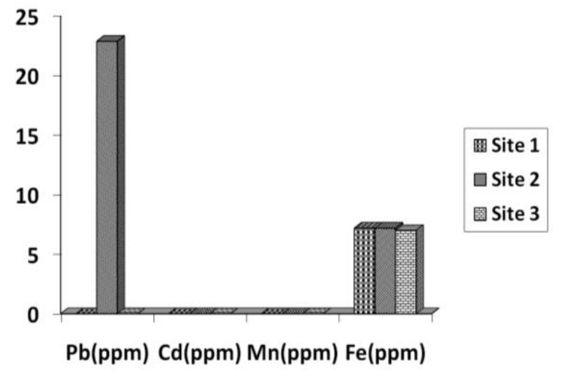

Fig. 5. Concentration of heavy metals in the river water of the study area.

Plant Sampling, Preparation and Analysis

The mature leaves, roots and dried fruit pods (seed) were randomly sampled (Ayaz *et al.,* 2002; Asolu and Asaolu, 2002) from different branches of locust bean trees at farmlands along the bank of River Dilimi in Jos North Local Government Area of Plateau State.

The samples were transported to the laboratory in air tight polythene bag where the pods were opened manually. The pulp and seeds were separated with aid of mortar and pestle, sieve to pass through 20 mesh sieve and stored in air tight polythene bags inside desiccators until they were analyzed.

The sample of plant *Parkia biglobosa* was rinsed with distilled water repeatedly. These were dried in an oven at 65°C for about 2 days and ground using cross beater grinding mill. After then, 0.5g of ground plant sample was digested with 5ml of nitric acid and 3ml of Hydrogen peroxide. The digestion temperature was about 160°C. 0.5g of air dried and ground plant part of *Parkia biglobosa*was digested as above.

The analysis of lead, cadmium, manganese andiron content in plant was performed by AAS (Atomic $Abs_3orption$ Spectrophotometry). The guidelines for maximum limit (ML) of heavy metal in *Parkia biglobosa* was adopted from WHO (1993), Standard and FAO/WHO (2001).

Water Sampling, Handling and Analysis

Water samples were collected at three different points located within the study area. Samples of water were taken along the river where *Parkia biglobosa* is grown. About 5ml of HNo_3 acid was added to clean 250ml polythene bottles, before adding about 100ml of river water. The HNo_3 acid was for the purpose of acidifying and preserving the water samples. The chemical composition of the water was determined in the laboratory.

Soil Sampling, Processing and Analysis

Composite surface soil (0-10cm) sample from the *Parkia biglobosa* experimental sites were collected separately and were properly labeled.

The soil samples were then air-dried and crushed to pass through a 2mm mesh sieve. Maximum levels (ML) of heavy metals in the soil shall be determined in accordance to (FAO, 1991).

Results

Level of heavy metals in Parkia biglobosa (Leaf)

Most of the laboratory research on biosorption of heavy metals indicates that no single mechanism is responsible for metal uptake. In general, two mechanisms are known to occur, Viz 'absorption', which refers to binding of materials onto the 'surface' and 'sorption', which implies penetration of metals into the inner matric (Ramraj *et al.,* 2000). Either one of these or both the mechanism might take place in the transportation of metals into the plant body. Leaf of *Parkia biglobosa* was analyzed for some heavy metal content. The concentration (ppm) of heavy metals in the leaf of *Parkia biglobosa* was highest for Pb. The concentration for Cd, Mn and Fe were within the permissible limit.

Accumulation of these heavy metals in the leaves might be due to the use of sewage fed river water for their cultivation and irrigation. From these results, it is found that the presence of Pb in *Parkia biglobosa* (0.56 ppm) is beyond the permissible limit. Lead is a toxic element and high concentrations are unaccepted.

Fe is present in appreciable amount in the leaves. Different vegetable species accumulate different metals, depending on environmental conditions, and metal species present. Studies have shown that uptake and accumulation of metals by different plant species depend on several factors, and various researchers have identified several factors (Bringham and Page and Hahler and Ganje, 1975, Dowdy and Larson and Titrud and Latterel 1978).

Discussion

Levels of Heavy Metals in The Seeds (Parkia biglobosa)

Heavy metals varied with site, the order of toxic heavy metal contamination in seeds is as follows: Fe >Pb>Mn. The heavy metal content of the sample is shown in table 2.

It is observed that the most abundant metallic element is iron (Fe), whose values ranged from 134-3460(ppm) for the seed sample. However, substantial amount of lead (Pb) e were found in the fruits, which ranged from 0.40-1.92(ppm).

Lead is a toxic element and high concentration can result in acute and chronic damage to the nervous system. The seed sample gave values of manganese (Mn) which ranged from 15-46.80(ppm). The average total concentration of manganese (Mn) was lower than the permissible limits (limits are based on WHO guidelines).

Levels of Heavy Metals in Root (Parkia biglobosa)

Root samples showed the presence of Fe, Pb and Mn (ppm) considered in the study. Their concentration is represented in table 3. The order of toxic heavy metal contamination in roots is as follows: Fe >Pb>Mn. From table 3, iron (Fe) concentration ranged from 686 – 4800(ppm). However, concentration of Fe and Pb were higher than the permissible limit of WHO. It was found that the concentration of Mn falls within permissible limits.

Levels of Heavy Metals in the Soil and Water

Soil samples of irrigated land used for growing crop plants and vegetables showed the presence of three metals out of the four considered in the study. The highest concentrations were found in Fe and Pb, however Mn values are found to be significant in the study site. The soil samples gave higher values of Fe than root, seed and leaf and water samples. The order of toxic heavy metal contamination in soil is as shown: Fe >Pb>Mn. This result is obtained from table 4. Heavy metal content of the water samples is shown in table 5. From the table, it is observed that highest metallic element in the water samples studied is lead (Pb). The high level of Pb can be attributed to the mines wastes, which often get into the water used for irrigation. The values of Fe in the water samples were lower than those in the soil, root, leafand seed samples.

Conclusion

The soils on the bank of River Dilimi are polluted. This is due to the fact that untreated industrial waste discharged into the river contaminates it with heavy metals; Fe, Pb and Mn. Highlights from this study showed the availability of varied levels of some heavy metal pollutant in the soils and wastewater with their resultant availability in *Parkia biglobosa's* roots leaves and seeds harvested from the same site. Irrigation by wastewater has indirectly engendered accumulation of heavy metals in the agricultural soils as well as in the *Parkia biglobosa* planted in them, such that their concentrations in the soils and *Parkia biglobosa* (except Cd and Mn) exceed the recommended permissible levels by World Health Organization. Hence, soil, water and plant monitoring together with the prevention of metals entering the plant, is a prerequisite in order to prevent potential hazards of irrigation with Dilimi River water.

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