IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 11 Ver. I (Nov. 2015), PP 85-91
www.iosrjournals.org

Monitoring of Selected Heavy Metals Uptake by Plant around Fagbohun Dumpsite, Ikere-Ekiti, Ekiti State, Nigeria

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Abstract: *This study was conducted to investigate heavy metal (Cd, Cu, Mn, Ni, Pb, and Zn) concentrations in soils and selected plants (Cowpea, Vigna unguiculata; Maize, Zea mays; Milk leaf, Euphorbia heterophylla and Siam weed, Chromoleana odorata) around Fagbohun dumpsite, Ikere-Ekiti, Nigeria. Soils and plants samples were taken at 0 m, 50 m and 100 m sampling distances and control soil sampled taken from the adjacent farmland. The concentration of Pb, Ni, Cu, Zn and Mn in the dumpsite soils showed to be generally lower than the permissible limits except Cd, implying a concerned pollution level. But the metal contents are higher than the permissible thresholds in the plants except Cu, indicating atmospheric deposition of heavy metals in the plants. Accumulation factor (AF) indicates selected plants are of good phyto-extraction potentials except Milk leaf (Cu). Pb, Zn and Mn are highly mobile while Cd and Cu has low mobility in all the plants but Ni is highly mobile only in Maize and Siam weed at 0 m sampling distance.*
Keywords: *Accumulation factor, Dumpsite, Heavy metals, Mobility index, Permissible limits.*

I. Introduction

Proliferation of basic industrial processes as a result of increasing population and urbanization has greater impact on the environment causing pollution. Environmental pollution sources of heavy metals in urban areas are both anthropogenic including industrial emission, traffic emission, fossil fuel combustion, waste disposal and incineration, and agriculture practices [1, 2, 3, 4] and natural, involving rock weathering and ore deposits [5, 6]. Urbanization is promoting a concern for farmers to use contaminated land for food crops production [7]. In urban and peri-urban areas, land contamination with toxic metals is common as a result of industrial and municipal activity [8]. It has been observed that the larger the urban area, the lower the quality of the environment. Hence, solid waste disposal and management have reached a critical stage in major towns and cities of Nigeria [9]. Heavy metals soil contamination is a serious environmental problem. Remarkably, if enters the food chain as a result of their uptake by edible plants growing in the contaminated soils such as dumpsites.

Dumpsite is an old traditional method of waste disposal similar to landfill method of waste management and are often established in disused quarries, mining or excavated pits away from the residential areas [10]. Poor management of dumpsite could create a number of adverse environmental impacts such as leachate that contains the potentially toxic heavy metals which pollute the underground soil bed. The heavy metals concentration in soils should be monitored within the target values and not to exceed the intervention values stipulated by the regulatory bodies. According to Wuana and Okieimen [11], target values indicate the soil quality levels aimed at for soil's sustainability and functionality for human, animal, and plant life while the intervention values indicate the quality for which the functionality of soil for human, animal, and plant life are, or threatened with being seriously impaired. Toxic metals cannot be biodegraded but accumulate in the soil having long persistence time interacting with the soil components and consequently pose environmental problems [12] and enters into food chain through plants or animals [14, 15]. Prolonged consumption of contaminated foodstuff may lead to the unceasing accumulation of toxic metals in the liver and kidney of humans resulting in the disturbance of biochemical processes, such as, liver, kidney, cardiovascular, nervous and bone disorders [15, 16]. Heavy metals contamination in agronomic crops particularly vegetables [17, 18, 19, 20] cannot be underestimated being an important components of human diet and the heavy metals contamination of food items is one of the major aspects of food quality assurance.

Several parameters has been used to investigate heavy metal uptake by plants grown on a contaminated soils. Chojnacka *et al.* [21] and [22, 23] used (bio)accumulation factor, (B)AF (ratio of metal concentration in plant to metal concentration in soil) to investigate heavy metal uptake by plants. Zabin and Howladar [24] and [17, 25] has also investigated heavy metal uptake by plants using mobility index (MI) or translocation factor (TF) which is the ratio of metal concentration in one part of plant (root, stem or leaves) to the metal concentration in the former part (soil, root or stem). Similarly, [17, 26, 27] used enrichment factor (EF) and it is defined as a relative abundance of a chemical element in soil compared to the relative abundance in a local con-trol site. These factors are based on the root uptake of metals and the surface absorption of atmospheric metal deposits [28]. Phytoextraction is the accumulation of sufficient heavy metals concentration by plants, translocate and store such metals at the aboveground parts [29] thereby reducing the heavy metals concentration in the soils to regulatory levels with relatively few repeated cropping [30, 31]. Phytostabilization on the other hand is the process by which the root plants exudates to stabilize, demobilize and bind the heavy metal contaminants into the soil matrix through accumulation, thereby reducing their bioavailability [32]. Many studies showed that there is difference in metal accumulation between different plant species, and even though the same plant species have different uptake and translocation properties to heavy metals in plant parts [33, 34, 35, 36].

There are no records of accessing the heavy metal concentration in both soils and plants growing naturally in and around Fagbohun dumpsite. This study therefore, was conducted to determine the heavy metals (cadmium, Cd; copper, Cu; lead, Pb; manganese, Mn; nickel, Ni and zinc, Zn) content in soils and selected plant species growing naturally at Fagbohun dumpsite, and to evaluate the potential of heavy metals accumulation and mobility in these plants at Fagbohun dumpsite using accumulation factor (AF) and mobility index (MI).

II. Materials and Methods

2.1. Description of the Study Area

Fagbohun dumpsite is located in Ikere-Ekiti, Ekiti State, Nigeria and geographically located at the coordinates 7°30'N and 5°14'E. The dumpsite is bordered by an automobile workshop, road network and normally receives commercial and domestic wastes. It has been put into use as dumpsite for more than two decades. The area is characterized with an average annual rainfall of 2239 mm distributed over a period of seven months rainy season (April – October) with a bi-modal peak in June and September. It has a relative humidity of 60-80% and the minimum and maximum temperature of 23°C and 32°C respectively.

2.2. Sample collection

Three composite soil samples were collected at a depth of 0 – 15cm from the soil surface, at a distance of 50m interval starting from the center of the dumpsite (0m, 50m and 100m). Control soil sample was taken from the adjacent farmland to the dumpsite. Four plants; Cowpea, Maize, Milk leaf and Siam weed, representing the major plants growing in the area of Fagbohun dumpsite were also collected at the same distances the soils were sampled for the study. At each sampling points, three replicates of each plants were collected by carefully uprooting them. All samples were separately kept in a sampling bags before transported to the laboratory.

2.3. Preparation and analysis of samples

The soil samples were air dried, crushed and sieved with a 0.5 mm mesh size sieve. The selected heavy metals available in soil samples were leached in the laboratory according to [37]. 1g each of the prepared soil samples were accurately weighed into a series of acid washed beakers covered with wash glass; 30 mL of 1:1 HNO_3: deionized water were added to each of the beakers containing the soil. They were each boiled gently on a hot plate in the hood while stirring intermittently until the volume reduced to about 5 mL. Exactly 10 mL of 1:1 HNO_3: deionized water were again added and the procedure was repeated. The second 5 mL for each case were diluted appropriately with standard flasks and preserved at 4°C.

The plant samples were thoroughly washed with deionized water to remove all adhering soil particles. The plant samples were weighed to determine the fresh weight and dried in an oven at 80ºC for 72 hours to determine their dry weight [38]. The dry samples were crushed in a mortar and the resulting powder digested by weighing 0.5 g of oven-dried ground and sieved sample (<1 mm) into a nitric acid-washed porcelain crucible and placed in a muffle furnace for four hours at 500ºC. The crucibles were removed from the furnace and cooled. 10 mL of 6M HCl was added, covered and heated on a steam bath for 15 minutes. Another 1 mL of HNO_3 was added and evaporated to dryness by continuous heating for one hour to dehydrate silica and completely digest organic compounds. Finally, 5 mL of 6 M HCl and 10 mL of water were added and the mixture heated on a steam bath to complete dissolution. The mixture was cooled and filtered through a Whatman no.1 filter paper into a 50 mL volumetric flask and made up to the mark with distilled water.

The concentration of Pb, Ni, Cd, Cu, Zn, and Mn in soil and plant samples was determined in triplicates directly on each of the final solution using Atomic Absorption Spectroscopy (AAS).

2.4. The accumulation factor (AF) or Transfer Factor (TF)

The accumulation factor or transfer factor is the index of the plants' ability to accumulate metals from the soils and was calculated as follows [21, 22, 23].

$$AF = \frac{Cplant}{Csoil}$$

Where, Cplant and Csoil are the concentration of the heavy metal (mg kg^{-1}) in the plant parts and the soils respectively.

2.5. Mobility Index (MI) or Translocation Factor (TF)

The mobility index or translocation factor is the index of heavy metals to move from the soils to the leaves through roots and stems. It was calculated as follows [24, 17, 25].

$$MI = \frac{\text{Concentration of metal (mg kg}^{-1}\text{) in the receiving level}}{\text{Concentration of metal (mg kg}^{-1}\text{) in the source level}}$$

Statistical analysis of data was carried out using Microsoft Office Excel 2010 and the figures were presented with mean values of triplicates.

III. Results and Discussion

3.1. Concentration of heavy metals in the Fagbohun dumpsite and control soils

The The Fig. 1 showed the mean concentration of heavy metals in the soils from the Fagbohun dumpsite and the control soil. The concentration of the heavy metals in the centre of the dumpsite (0 m) is more than 40% higher than the content in the control soil except for Ni. The mean values of the heavy metals decrease as you move away from the studied dumpsite except for Ni which had its highest mean value of 18.16 mg kg^{-1} at 100 m sampling distance. Of all the metals, Mn had the highest mean value of 449.83 mg kg^{-1} (0 m) while Cu had the lowest mean value of 7.83 mg kg^{-1} (50 m). Generally, the dumpsite soils had higher mean values for the heavy metals than the control soil except for Cu at 100 m sampling distance.

The Cu mean concentration were 8.50 and 18.00 mg kg^{-1} in the control and dumpsite soils respectively. The mean concentrations of Cu in the studied area were generally below the 38.9 mgkg^{-1} world unpolluted soil average reported [39] and were far below the threshold level of 100 mg kg^{-1} [40]. Likewise, the Cu content in the studied dumpsite was over 50% less than the target and intervention values of 36.0 and 190.0 mg kg^{-1} [41]. Herselman *et al.*, [42], reported the range of Cu in soils of South Africa to be between 3–117 mg kg^{-1}, with an established maximum tolerable level (MTL) value of 100 mg kg^{-1}. The mean cadmium (Cd) concentration varied from 0.35 mg kg^{-1} in the control soil to 27.50 mgkg^{-1} at the dumpsite (0 m). The world average soil Cd concentration is estimated at 0.41 mg kg^{-1} [39]. This should raise an immediate concern, since the values recorded at the various sampling distances in the dumpsite were higher than the guideline value of 3 mg kg^{-1} stipulated by European Union [40] and the 17 mg kg^{-1} intervention value specified for Nigeria soils [41]. The high Cd concentration in the soil may be attributed to large quantities of automobile battery dumped at the study area, and it has been reported that batteries are good source of several heavy metals including Pb, Cd, and chromium (Cr) that present great health risk even in low concentration [43].

The mean Mn concentration in the control soil was 268.41 mg kg^{-1} while the dumpsite (0 m) had 449.83 mg kg^{-1} and were below the world mean concentration of 488 mg kg^{-1} estimated by [39] for uncontaminated soils and also far below the threshold level of 2000 mg kg^{-1} given by European Union [40]. The high content of Mn could be attributed to its use in electroplating of motor vehicles' parts which form a substantial part of the waste dumped at the studied site. Manganese has not been considered to be a polluting metal in soils and its maximum allowable concentration (MAC) value in agricultural soils is estimated at the range 1500–3000 mg kg^{-1} [39]. Shanahan [44] reported up to 2700 mg kg^{-1} Mn concentration in contaminated soils of riparian areas. The highest mean concentration (18.16 mg kg^{-1}) of Ni in the studied area was recorded at 100 m sampling distance away from the dumpsite. Generally, the Ni mean concentration values in both control and dumpsite soils were below the threshold level of 50 mg kg^{-1} [40], target value of 35.0 mg kg^{-1} [41] and posed none known threat/hazard associated with nickel. The concentrations of HNO_3-extractable Ni varied in Norwegian surface agricultural soils from 6.25 to 136.88 mg kg^{-1} with an average of 30.43 mg kg^{-1} [45]. According to [42], soils of South Africa contain Ni within the range of 3.43–159 mg kg^{-1}, and the maximum permissible level in agricultural soils, established in 1997, is 50 mg kg^{-1}.

Mean concentration of Zn in the control soil and the dumpsite (0 m) were 98.52 and 161.85 mg kg^{-1} respectively. This apparent diminishing of Zn concentration away from the dumpsite almost certainly confirms the waste as the potential source of contamination and their concentration in plants. The Zn values were below the 300 mg kg^{-1} threshold level in soil [40]. However, the Zn concentration in the dumpsite soils were higher than the world unpolluted soil average concentration of 70 mg kg^{-1} [39] and the target value of 140.0 mg kg^{-1} [41] but the mean values were generally far below the intervention value of 720 mg kg^{-1} set for soils of Nigeria by DPR [41]. Range for Zn in soils of South Africa is given as 12–115 mg kg^{-1}, at established highest MTL value of 185 mg kg^{-1} [42]. Likewise, lead, Pb mean concentration in the soils were lower than the threshold and world mean values of 100 and 27 mg kg-1 respectively for uncontaminated soils, as stipulated and reported by [40] and [39] respectively. The mean Pb contents were also below the target value of 85.0 mg kg^{-1} stipulated by DPR [41] for Nigeria soils. Basically, the heavy metal concentrations in the soils were in the order of Mn > Zn > Cd > Pb > Cu >Ni in the Fagbohun dumpsite (0 m) and Mn > Zn > Ni > Cu > Pb > Cd in the control site.

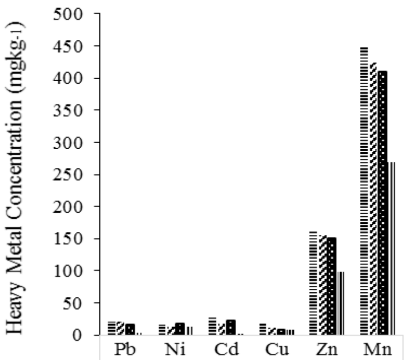
3.2. Concentration of heavy metals in sampled plants

The The mean concentration of heavy metals in the sampled plants; Maize (0 m), Siam weed (50 m) and Milk leaf (100 m), growing in the Fagbohun dumpsite were shown in the Fig. 2. The obtained results indicated that heavy metals concentrations in the plants varied with the plant type and levels of heavy metals in the soil.

The mean concentration of Pb in plants sampled at varying distance at the Fagbohun dumpsite vary from 35.12 to 42.07 mg kg^{-1}. These values indicates that Pb content in the plants growing in the dumpsite area posed threat to the health of both human and animals that consumes these plants as the values were well higher than the generalized agronomic crops' permissible level of 0.5-10 mg kg^{-1} by [39] and European Union [40] permissible level of 0.43 mg kg^{-1} for vegetables. Necessary mitigating measures should be taking to remove the excess Pb from Fagbohun dumpsite. In general, root vegetables are moderate accumulators and leafy vegetables are high accumulators [46]. Silanpaa and Johnson [47], following their worldwide experiment in 30 countries, reported Pb concentration in young wheat and corn plants to range from 0.2 to <1 mg kg^{-1} with highest Pb contents observed in plants from Belgium, Hungary, Italy, Malta, and Mexico. The mean Cu concentration in the plants were below the permissible levels of 20 mg kg-1 [40] for vegetables and the generalized permissible level of 5-20 mg kg^{-1} for agronomic crops [39]. Reimann *et al.*, [48] and Fishelson *et al.*, [49] stated that plants growing on Cu-polluted sites tend to accumulate higher amounts of it, especially near industrial areas, and in soils treated with Cu-bearing herbicides. The Zn mean concentrations in the sampled plants were more than 50% above the stipulated permissible levels of 50-100 mg kg^{-1} [39] for various crops and 50 mg kg^{-1} for vegetables [40]. The high Zn concentration in the sampled plants is explainable, since Zn is an essential trace element for humans, animals and higher plants [50, 51].

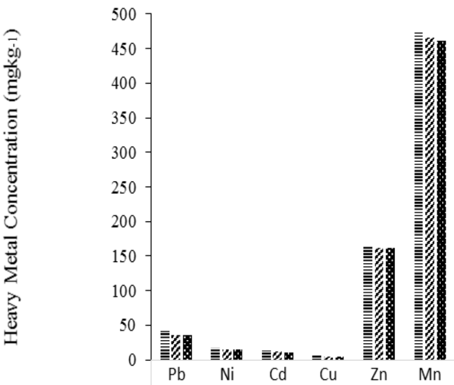
Cadmium, Cd and Nickel, Ni concentrations in the sampled plants from the dumpsite were generally above the permissible levels of 0.2 mg kg^{-1} [39, 40] and 1-10 mg kg^{-1} [39] for generalized agronomic crops and vegetables posing health risk to food chain in the studied area. The Cd and Ni content of plants is of great concern as their pathway to man and animals. Eriksson [52] reported Ni content in barley and wheat grown in Sweden at mean values of 0.15 and 0.16 mg kg-1 respectively. Conversely, [53] reported a much higher Ni content for meadow grass (13–75 mg kg^{-1}) and forest grass (10–100 mg kg^{-1}) from Taiga zone of Western Siberia. [39], wrote that Cd and Ni are readily available to plants from both air and soil sources and its concentration increases rapidly in plants grown in polluted areas. The mean concentration of Mn in the sampled plants vary 461.26 to 475.33 mg kg-1 and were above the 300 mg kg^{-1} permissible level stipulated by [39] for generalized agronomic crops but were below the 500 mg kg^{-1} stipulated by [40] for vegetables. Mn concentration above 1000 mg kg^{-1} in plants has often been reported for several more resistant species or genotypes [54, 44, 55]. The hyperaccumulator plants (*Phytoacca Americana* L.) absorbed Mn from the contaminated soil up to 13,400 mg kg^{-1} in leaves [56].

Generally, the heavy metals concentrations in the sampled plants at the Fagbohun dumpsite decreases as you move away from the dumpsite (0 m) and the trend appeared as Mn > Zn > Pb > Ni > Cd > Cu.



	Pb	Ni	Cd	Cu	Zn	Mn
0 m	20.16	15.83	27.5	18	161.9	449.8
50 m	20.33	12.5	18.34	11.5	156	423.3
100 m	16.33	18.16	22.33	7.83	150.7	409.3
Control	4.13	12.2	0.35	8.5	98.52	268.4

Figure 1. Concentration of heavy metals in Fagbohun dumpsite and control soils



	Pb	Ni	Cd	Cu	Zn	Mn
0 m/Maize	42.07	17.66	13.63	7.07	164.81	475.33
50 m/Siam Weed	35.71	15.66	11.47	4.89	162.26	466.34
100 m/Milk Leaf	35.12	14.93	11.09	4.51	161.14	461.26

Figure 2. Concentration of heavy metals in selected plants from Fagbohun dumpsite

3.3. Accumulation factor of heavy metals in Fagbohun dumpsite

Table 1 summarizes the heavy metals accumulation factor (AF) in sampled plants from the study area. Accumulation factor of heavy metals is essential to investigate the human health risk index [23]. Values greater than 1 indicate a net accumulation by the plant and potential to phyto-extract heavy metals [57, 58] whereas values below 1 show net accumulation in the soil. Generally, therefore, the plant species sampled are hyperaccumulators for Pb, Ni, Cd, Zn, Cu and Mn as the AFs are greater than 1 except the milk leaf which showed to be of low accumulation potential for Cu (0.88, 0.98 and 0.01 at 50 m and 100 m sampling distances correspondingly). However, the milk leaf had the highest accumulation factors for Pb (13.03) and Cd (18.40). The generally high accumulation of the heavy metals in the sampled plants may be due to atmospheric deposition of the metals from non-ferrous metal activities, fossil combustion, etc. which can be absorbed into foliage and translocated into the plants. In green spinach grown near waste dumpsites in Gombe, Nigeria, [17] reported accumulation factors of 2.41, 2.07 and 1.29 for Cd, Pb and Zn respectively. The trend of heavy metals accumulation by the sampled plants at the studied dumpsite was generally in the order of Pb > Mn > Zn > Ni > Cd > Cu. Chen *et al.* [59], reported that Cu^{2+} ions inhibit Ni^{2+} ions influx and uptake competitively as they are absorbed by the same transport system in plants. But the findings in this work showed that Ni accumulation is higher than that of Cu which contradicted the early findings of [24] that Cu was much more accumulated than Ni in all plant species studied in their work. This higher Ni content may be attributed to lithogenic factors.

3.4. Mobility index (MI) or translocation factor (TF) of heavy metals in Fagbohun dumpsite

According to [60], MI or TF is an essential indicator that allows the assessment of mobility or translocation of heavy metals in plants. The mobility indices of heavy metals in the sampled plants were presented in Table 2. Mobility index greater than 1 indicates high mobility of such heavy metal from the source level to the receiving level (plant parts). Pb, Zn and Mn showed high mobility or translocation potentials in all the sampled plants' parts. An indication that the plant roots are able to solubilize and take up the heavy metals from very low levels in the soil, even from nearly insoluble precipitates. However, Ni only had mobility indices above 1 in Maize and Siam weed at 0 m sampling distance and in Milk leaf (Soil-Roots) and Siam weed (Roots-Stems) both at 50 m sampling distance. Whereas, the mobility indices indicates low mobility potentials (MI < 1) for Cd and Cu in all the sampled plants' parts except the milk leaf that showed a greater mobility (MI = 7.33) potential for Cd at 100 m sampling distance. This together with other plants species with mobility factor higher than 1 has the ability to take up and translocate the studied heavy metals into the plant parts thereby suitable as phyto-stabilizers. The mobility index (MI) of the heavy metals in Fagbohun dumpsite generally followed an order: Pb > Mn > Zn > Ni > Cd > Cu.

Table 1. Accumulation factor of heavy metals in Fagbohun dumpsite

Sampling Distance (m)	Sampled Plant	Pb	Ni	Cd	Cu	Zn	Mn
0	Maize	6.20	3.34	1.48	1.17	3.05	3.17
	Siam Weed	5.18	3.58	1.81	1.17	3.09	3.31
50	Maize	5.90	2.37	1.25	1.67	3.14	3.34
	Milk Leaf	4.37	2.56	1.89	0.88	3.11	3.17
	Siam Weed	6.16	2.85	1.83	1.98	3.24	3.24
100	Milk Leaf	4.10	2.47	1.88	0.98	3.25	3.13
	Cowpea	4.57	2.37	2.52	1.55	3.21	3.14
	Milk Leaf	13.03	0.72	18.4	0.01	3.21	3.13

IV. Conclusion

The concentration of Pb, Ni, Cu, Zn and Mn in the soils of Fagbohun dumpsite revealed to be generally lower than the permissible limits and target value except Cd, implying a concerned pollution level of Cd. Whereas, all the selected metals studied were of higher concentrations far above the agronomic permissible thresholds except Cu in all the selected plants growing at the dumpsite, thereby posing health risk to the food chain through human and animals. The high contents of these heavy metals in the plants tissues despite the low concentrations observed in the soils is due to long period of uptake by the plants and that the heavy metals are readily available to the plants in their soluble forms in the soil solution.

The severity of heavy metal pollution in plants can be understood by computing common pollution indices. The high accumulation factors (> 1) of the heavy metals validates the high accumulated contents of these heavy metals in the plants growing at the Fagbohun dumpsite. This is an indication that the plants except Milk leaf (Cu) are potential phyto-extractors and that the soil is not the only source of these heavy metals in the plants growing at the dumpsite. The study also revealed that Pb, Zn and Mn were highly mobile in the all the sampled plants from soil to leaves through roots and stem while on the other hand, Cd and Cu were of low mobility in the plants growing at Fagbohun dumpsite. However, Ni showed to be of high mobility from soil to the leaves of Maize and Siam weed at the centre of the dumpsite (0 m) through the roots and stems but of low mobility or translocation potential in other plants at both 50 m and 100 m sampling distances. Mobility index greater than 1 is an implication that such plant is a potential phyto-stabilizer for such heavy metal.

Table 2. Mobility index of heavy metals in Fagbohun dumpsite

Sampling Distance (m)	Sampled Plant	Plant Part	Pb	Ni	Cd	Cu	Zn	Mn
0	Maize	Soil-Roots	2.24	1.07	0.52	0.45	1.02	1.06
		Roots-Stems	1.80	1.16	0.48	0.35	1.01	1.05
		Stems-Leaves	2.20	1.10	0.48	0.36	1.10	1.05
	Siam Weed	Soil-Roots	1.70	1.16	0.59	0.44	1.03	1.00
		Roots-Stems	1.61	1.22	0.56	0.32	1.02	1.09
		Stem-Leaves	1.86	1.18	0.66	0.40	1.04	1.10
50	Maize	Soil-Roots	1.78	0.70	0.38	0.59	1.03	1.06
		Roots-Stems	1.92	0.89	0.41	0.45	1.04	1.14
		Stems-Leaves	2.19	0.78	0.46	0.62	1.06	1.13
	Milk Leaf	Soil-Roots	1.58	1.06	0.63	0.37	1.03	1.06
		Roots-Stems	1.26	0.77	0.62	0.19	1.03	1.05
		Stems-Leaves	1.52	0.71	0.64	0.31	1.04	1.06
	Siam Weed	Soil-Roots	1.87	0.87	0.56	0.84	1.05	1.06
		Roots-Stems	2.06	1.04	0.64	0.50	1.09	1.14
		Stems-Leaves	2.22	0.96	0.62	0.64	1.09	1.13
100	Milk Leaf	Soil-Roots	1.45	0.09	0.57	0.35	1.05	1.06
		Roots-Stems	1.35	0.79	0.67	0.38	1.09	1.04
		Stems-Leaves	1.29	0.78	0.67	0.25	1.10	1.02
	Cowpea	Soil-Roots	1.53	0.80	0.86	0.58	1.06	1.05
		Roots-Stems	1.45	0.80	0.87	0.57	1.07	1.04
		Stems-Leaves	1.60	0.76	0.78	0.40	1.07	1.04
	Milk Leaf	Soil-Roots	4.67	0.30	7.33	0.001	1.09	1.06
		Roots-Stems	4.34	0.23	6.12	0.0003	1.06	1.03
		Stems-Leaves	3.98	0.19	4.64	0.0002	1.04	1.02

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