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The Effect of Leaching on the Uptake of Heavy Metals (As, Cd, Cr, Ni and Pb) by Pawpaw *(Carica Papaya Linn.)* Growing in Dumpsite and Near Dumpsite in Amarata, Yelga Bayelsa State

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Abstract

Heavy metals such as; As, Cd, Cr, Ni and Pb were determined in different parts (bark, fruits, leaves and roots) of *Carica papaya* (pawpaw) growing in dumpsite and near dumpsite. Atomic absorption spectrometry was employed for the analysis of the heavy metals; As, Cd, Cr, Ni and Pb. From the results obtained, some parts of the *Carica papaya* from the near dumpsite had higher concentrations than the dumpsite due to leaching. These metals were washed off from the dumpsite during wet seasons by running water. The mean concentrations of heavy metals (dumpsite) were 0.23 ± 0.003mg/kg As, 0.26 ± 0.04mg/kg (Cd), 0.45± 0.15mg/kg (Ni) and 0.97 ± 0.18mg/kg (Pb). The mean concentrations of heavy metals in *Carica papaya* plant from near dumpsite were: 0.023 ± 0.003mg/kg Arsenic (As), 0.26 ± 0.039mg/kg (Cd), 0.49± 0.154mg/kg (Ni) and 0.93. ± 0.181 mg/kg (Pb).The mean concentration of Nickel in all parts of the *carica papaya* from near dumpsite was higher than the dumpsite. The observed high mean concentration of heavy metals in *carica papaya* parts from dumpsite is largely due to the composition of the dumpsite. The mean concentrations of lead and cadmium were above the WHO/FAO permissible limits for edible fruits and vegetables while the mean concentrations of Arsenic and Nickel from both locations were below the WHO/FAO permissible limits.
Keywords: Heavy metal; *Carica papaya*; Dumpsite; WHO/FAO; Parts of plant.

1. Introduction

Heavy metals are chemical elements (metals and metalloids) that have relatively high densities five times greater than water (1g/cm^3). Heavy metals have the ability to bioaccumulate in soil and most living tissues and have long persistence time through interaction with soil components and consequently enter food chain through plants or animals [1]. Examples of heavy metals are Cadmium, Nickel, Arsenic, Mercury, Lead, Chromium and etc. Some household and industrial garbage may contain these toxic materials such as lead, cadmium, mercury, manganese from batteries, insect sprays, nail polish, cleaners, plastics, polyethylene or PVC (polyvinyl chloride) made bottles and other assorted products [2]. Anthropogenic source is one of the major causes of inorganic contamination of the environment. Also improper disposal and lack of awareness of the health-risk created by such indiscriminate disposal is also a contributing factor [3]. Heavy metals such as Lead, cadmium, manganese, arsenic and mercury are pollutants that play no physiological function when ingested [4]. Smith, *et al.* [5], reported that the building up of heavy metals in soil from anthropogenic sources could be harmful to crops and human health. Researchers have found out that the current trend in the municipal wastes disposal and management practices may increase the heavy metal burden of the environment [6, 7]. In some cases, wastes are dumped recklessly with no regards to the environmental implications, while in some dumpsites wastes are burnt in the open and ashes abandoned at the sites. The burning of wastes gets rid of the organic materials and oxidized the metals, leaving the ash richer in metal contents [8].

After the processes of oxidation and corrosion, these metals will dissolve in rain water and get leached into soil from where they are picked up by growing plants thereby entering the food chain [9]. Pawpaw (*Carica papaya*) is a spherical or pear-shaped fruit with either yellow (ripe) or green (unripe) colour. The inner cavity of the papaya is black, round seed encased in gelatinous-like substance. The papaya is an excellent source of vitamin C and very good source of nutrients. It also contains dietary fiber, vitamin E, vitamin A and vitamin K [10]. The proper wastes disposal method has been a serious problem in Nigeria [11]. Leachates from refuse dumpsites constitute a source of heavy metal pollution to both soil and aquatic environments. Land pollution by components of refuse such as heavy metals have been of great concern in the last decades because of their health hazards to man and other organisms when accumulated within a biological system. In some communities, most of the dumpsites are used as fertile soils for the cultivation of some fruits and vegetables. Some farmers collect the decomposed parts of the dumpsites and

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apply to their farms as manure. These cultivated plants take up these metals either as mobile ions in the soil solution through their roots [12, 13] thereby making them unfit for human consumption [14-17]. Although the rate of metal uptake by crop plants could be influenced by factors such as plant species, plant age and plant part, metal species and the composition of the dumpsite [18-20]. Olatunde and Onisoya [21], gave the Assessment of Heavy Metal Concentrations in Pawpaw (Carica papaya Linn.) around Automobile Workshops in Port Harcourt Metropolis, Rivers State, Nigeria. Seven automobile workshops were used in their study. First, 20 m x 20 m quadrats were laid out for soil and C. papaya tissue sampling. They collected one composite soil sample from the topsoil (0-15 cm depth) around each of the automobile workshops. Three C. papaya stands at least 30 cm apart around each workshop were used for their study and from these stands; tissues (root, stem, leaf, and fruit) of C. papaya were collected. Standard laboratory techniques were used to determine the pH, electrical conductivity (EC) and heavy metals (lead (Pb), mercury (Hg), cadmium (Cd), copper (Cu), and zinc (Zn)) in the soil samples and C. papaya tissues. Pair wise t-test was used to determine significant differences ($p<0.05$) in the heavy metal concentrations in soil and C. papaya tissues between the sample and control sites, while correlation statistics were used to determine the relationship of heavy metal concentrations between soil and C. papaya tissues. From their findings C. papaya tissues and supporting soil were significantly higher in pH, EC and heavy metals in the sampled plots than the control plot. The heavy metal concentrations in C. papaya and soil occurred in the decreasing order of Pb>Cu>Hg>Zn>Cd. The fruit of C. papaya had the highest mean concentrations of Pb (51.4±14.1 mg/kg) and Zn (26.4±1.9 mg/ kg), while the leaf had the highest mean concentration of Hg (32.0±2.3 mg/kg). The pH, Cu and Zn in the supporting soil were significantly correlated with the levels in the C. papaya tissues. They also concluded that Bio-accumulation of heavy metals by C. papaya is evident around automobile workshops, and Pb, Hg, Cd concentrations were found to be above the permissible limits for human consumption according to World Health Organization (WHO) standards. They also concluded that the consumption of food materials grown around automobile workshops could pose health risks. Matthews-Amune, *et al.* [22] studied the Heavy metal accumulation in crop plants around Itakpe Iron Mine, Okene, Nigeria. Heavy metal accumulation in plants is of importance due to toxicity effects in humans and other biota. Crop plants were sampled around Itakpe mine, Okene, Nigeria for the determination of the heavy metals cadmium (Cd), copper (Cu), magnesium (Mg), nickel (Ni), lead (Pb) and zinc (Zn) using Flame Atomic Absorption Spectroscopy. Crop plants samples were collected during the dry and rainy seasons and digested with 4:1 mixture of HNO_3 and $HClO_4$. Recovery studies gave 80-120 % for crop plants. The average mean concentration of metallic levels in crop plants were 0.07±0.01, 0.14±0.10, 0.02±0.01, 0.09±0.01, 0.06±0.02, 0.25±0.13 g/g. The heavy metal concentrations of crops grown on control soil were relatively lower than those in the Itakpe mining site soil. The observed concentrations of heavy metals in the studied plants were below the FAO/WHO limit guideline for food. The presence of Zn and Cu in plants and the higher level of metals observed in the mining site farm crops compared with the control farm showed that agrochemicals and mining contribute to the metallic levels in the Itakpe mining environments. Ukpong, *et al.* [23], gave the assessment Of Heavy Metal Content in Soils and Plants around Waste Dumpsites in Uyo Metropolis, Akwa Ibom State, Nigeria. Sampling were done in five randomly chosen dump sites. Twenty soil samples were drawn at the depth of 0-15cm and 15-30cm on each of the two sampling points of the five randomly chosen locations and six samples from three locations away from the dumpsites. The result of their analysis showed that the level of heavy metals were generally higher at surface soils than subsurface soils, with mean values of 1059.2mg/kg and 695.8mg/kg for Iron (Fe) for surface and subsurface respectively against control value of 665.3mg/kg. The mean value for lead (Pb) was 99.1mg/kg and 95.2mg/kg for surface and subsurface respectively against control soil of 15.8mg/kg and 13.6mg/kg for surface and subsurface soils respectively. Nickel (Ni) was 308.5mg/kg and 5.9mg.kg for surface and subsurface respectively and a mean value of 1.13mg/kg (surface) and 0.9 (subsurface) for control. Chromium (Cr) was 2.2mg/kg and 2.1mg/kg for surface and subsurface, respectively. The level of Cr in the samples from control site was 0.3mg/kg for surface and subsurface soil. This indicates a higher concentration of heavy metals at the surface soils than subsurface and a high concentration at waste dumpsites than control sites. They also carried out an assessment of some physicochemical properties of these metals. From their findings, the soils around the dumpsites were acidic with mean pH of 6.1. Organic matter had a mean value of 4.4%, available phosphorus was 23.3mg/kg, clay was 6.8% and effective cation exchange capacity (ECEC) was 10.6%. Afzal Shah, *et al.* [24], also gave the Comparative Study of Heavy Metals in Soil and Selected Medicinal Plants. In their study, essential and nonessential heavy metals like iron (Fe), nickel (Ni), manganese (Mn), zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), and lead (Pb) were analyzed and four selected medicinal plants such as Capparis spinosa, Peganum harmala, Rhazya stricta, and Tamarix articulata were also analyzed by flame atomic absorption spectrophotometry (FAAS). These medicinal plants are extensively used as traditional medicine for treatment of various ailments by local physicians in the area from where these plants were collected. The concentration level of heavy metals in the selected plants were found in the decreasing order of Fe > Zn > Mn > Cu > Ni > Cr > Cd > Pb. Their findings revealed that the selected medicinal plants accumulated these elements at different concentrations. They also recommended that monitoring such medicinal plants for heavy metals concentration is of great importance for physicians, health planners, health care professionals, and policy-makers in protecting the public from the adverse effects of these heavy metals. Ebong, *et al.* [25], reported the heavy metal contents of municipal and rural dumpsite Soils and rate of accumulation by Carica papaya and Talinum triangulare in Uyo, Nigeria. Atomic absorption spectrophotometer was employed in their analysis and the results obtained from municipal dumpsite soil indicated the following mean concentrations: Fe (1711.20 μg/g), Pb(43.28 μg/g), Zn (88.34 μg/g), Ni (12.18 μg/g), Cd (14.10 μg/g) and Cu (56.33 μg/g). These concentrations were relatively higher than the following concentrations: Fe (1016.98 μg/g), Pb (18.57 μg/g), Zn (57.90 μg/g), Ni (7.98 μg/g), Cd (9.25 μg/g) and Cu (33.70 μg/g) recorded for the rural dumpsite soil. From their findings, it was highlighted that plants grown on municipal dumpsites soil accumulated higher concentrations of the metals than those on rural dumpsites. Results obtained from their study also revealed that plants grown on dumpsite soils bio-accumulated higher metal concentrations than their counterparts obtained from normal agricultural soils. The ability of plants to bioaccumulate these metals were also observed as being different from one plant to the other and from one plant parts to the other. And apart from Fe and Zn which recorded higher concentrations in the leaves of the plants studied, other metals recorded higher concentrations in the roots. The general results obtained revealed that the levels of Cd in dumpsite-soil were above the standard while the levels of Cd and Pb in plants were also above the recommended levels in plants. They also recommended that wastes should be properly handled to reduce toxic metal loads at dumpsites. Olayinka, *et al.* [26], determined the Concentrations of Heavy Metals in Municipal Dumpsite Soil and Plants at Oke-ogi, Iree, Nigeria. They examined the concentration of heavy metals (Cd, Co, Cu, Pb, Ni, Mn, Pb and Zn) in dumpsite soil and waterleaf [Talinum triangulare) growing wildly on Oke-ogi dumpsite, Osun state, Nigeria. They collected Soil samples from different layers [0-15cm, 15-30 cm and 0-45 cm) in triplicates and Atomic Absorption Spectrophotometer was used for the determination. Lead had the highest mean ± SD 91.67±13.80 $mgkg^{-1}$followed by Zinc, which was 20.85±4.80 $mgkg^{-1}$. The mean concentration of lead and Zinc in the control site soil was significantly lower than [Pb, 10.67±2.08 $mgkg^{-1}$) and [Zn, 2.58±0.38 $mgkg^{-1}$) respectively. The concentration of lead in both the dumpsite soil and plant were in excess of allowable limit. The concentration of Cobalt in the dumpsite soil [0.02 – 0.72 $mgkg^{-1}$). Iron was the most abundant element in the vegetable with a mean value of 186 $mgkg^{-1}$ followed by Zinc [8.63 $mgkg^{-1}$). From their findings, Heavy metal concentrations followed the order of Pb>Zn>Mn>Cu>Cd>Co in both the control and dumpsite soils, most of which were below the critical permissible concentration level, they recommended that the persistence of theses metals in these soil of the dumpsite may lead to increase uptake by plants. Transfer factor for Cadmium and Manganese was 1, while others values were below 1. They also recommended that elevated heavy metal concentrations at dumpsite need to be properly addressed given the fact, that inorganic wastes are being dumped by the people. This can be done if the sitting of dumpsite is regulated, minimizing waste and remediation techniques, such as bioremediation that have shown potential for their ability to degrade and detoxify certain contaminants.

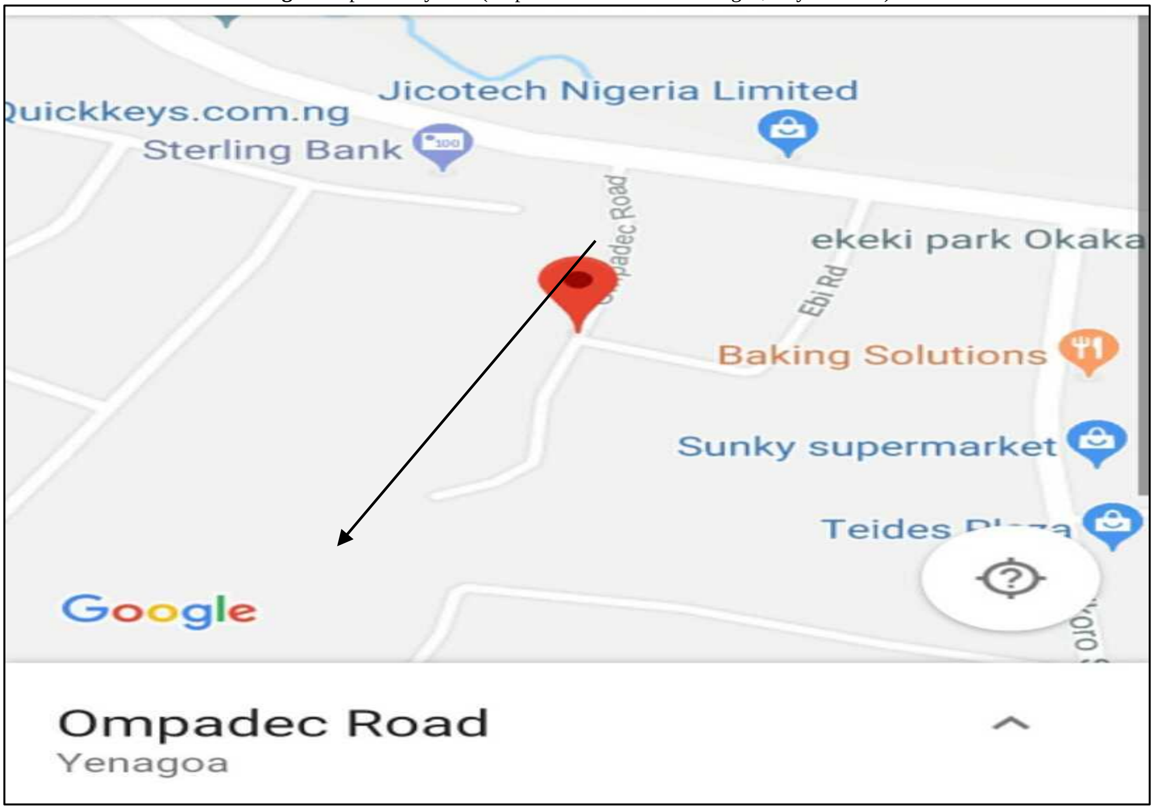
2. Methodolgy

2.1. Materials

Beakers, Measuring cylinder, Whattman Filter paper, hot plate, test container, weighing balance, volumetric flask, Atomic absorption spectrometer, Spatula, digestion flask, digestion block

2.2. Study Area

Fig-1. Map of study area (ompadec road amarata Yenagoa, Bayelsa state)



2.3. Sample Collection

Samples of pawpaw (*carica papaya*) plant parts (fruits, leaves, bark and roots) were collected from two different sampling points; Dumpsite (DS) and Near-dumpsite (ND) in Amarata YELGA, Bayelsa State, Nigeria and were put into polythene bags and were taken to the laboratory.

2.4. Sample Treament

All parts (leaves, roots, barks and fruits) of the plants (*Carica papaya Linn*.) were washed with fresh running water to remove dirt, dust, and other contaminants. Furthermore, all parts of the plant samples *(Carica papaya*) were washed with distilled water for more cleaning. The plant parts (leaves, roots, barks and fruits) were air dried for 24 hours and also dried in an oven at 80º C for 24 hours. The dried plant parts (leaves, roots, barks and fruits) were crushed, powdered and homogenized using an electric blender. The powdered, samples were kept in polyethylene sampling bags separately for further analysis.

2.5. Sample Digestion

A homogeneous solution of aqua regia; HNO_3 and H_2SO_4 in a ratio of 3:1 strength was prepared. 1g of the powdered parts (leaves, roots, barks and fruits) were weighed of each *Carica papaya Linn*. (dump and non-dumpsite) and were dissolved in the aqua regia solution. To increase the solubility, the sample solutions were heated on hot plate at 130^{o}C until the volume was reduced to 3mL.Then; the solutions were cooled, diluted with 15ml of distilled water and filtered into 100mL volumetric flask using Whattman 42 filter paper. The filtrates were made up to the mark [27]. The products of digestion (filtrates) were separately analyzed for heavy metals using a Perkins Elmer Analyst 400 Analytical Atomic Absorption Spectrometer (AAS). The instrument was calibrated before samples were analyzed.

2.6. Statistical Analysis

The Microsoft office excell spreadsheet (2007) Software was applied for statistical analysis, draw diagrams and to compare the concentration of the heavy metals in the different parts of the plant (*Carica papaya Linn*.) with global standards.

3. Results and Discussion

3.1. Results

After the samples were analyzed in an AAS (Atomic Absorption Spectrophotometer), The concentration of arsenic, cadmium, chromium, nickel and lead, from two locations (dumpsite and near dumpsite) at a distance of about 10 meters away from each other are shown in the table below.

Table-1. Showing the concentration of heavy metals in carica papaya plants from waste dumpsite

METALS	As	Cd	Cr	Ni	Pb
BARK	0.024	0.231	ND	0.374	0.895
FRUITS	0.024	0.291	ND	0.678	1.075
LEAVES	0.024	0.289	ND	0.419	1.158
ROOTS	0.018	0.217	ND	0.338	0.754

From table 1, the concentrations of Arsenic (As) in the plant *(Carica papaya)* parts from waste dumpsite were; 0.024mg/kg (bark), 0.024mg/kg (fruits), 0.024mg/kg (leaves) and 0.018mg/kg (roots) respectively. The bark, fruits, and leaves had the same concentration value of 0.024mg/kg which was the highest and then the roots had the least concentration with 0.018mg/kg. The concentrations of Cadmium in the various plant parts were; 0.231mg/kg (bark), 0.291mg/kg (fruits), 0.289mg/kg (leaves) and 0.217mg/kg respectively. The fruits had the highest concentration with 0.291mg/kg and the least concentration was found in the roots of the plant (carica papaya). Chromium (Cr) was not detected in all the studied parts of the plant (carica papaya) in the waste dumpsite. The concentrations of Nickel (Ni) in the studied parts of the plant (carica papaya) were; 0.374mg/kg (bark), 0.678mg/kg (fruits), 0.419mg/kg (leaves) and 0.338mg/kg (roots) respectively. The fruits had the highest concentration with 0.678mg/kg and the least concentration was observed in the roots of the studied plant (carica papaya). The concentrations of Lead (Pb) in the various plant (carica papaya) parts were; 0.895mg/kg (bark), 1.075mg/kg (fruits), 1.158mg/kg (leaves) and 0.754mg/kg (roots) respectively. The highest concentration was found in the leaves of the plant with 1.158mg/kg and the least concentration value was observed in the root with 0.754mg/kg.

A chart showing the concentrations of heavy metals in carica papaya plant in waste dumpsite.

Fig-2. A chart showing the concentration of heavy metals (As, Cd, Cr, Ni and Pb) in cariaca papaya parts (bark, fruits, leaves and roots) from waste dumpsite

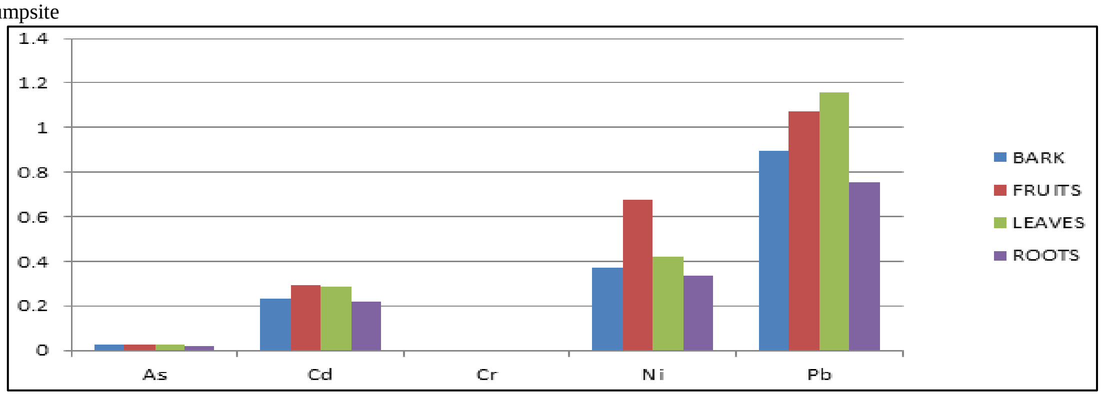


Table-2. Showing the concentration of heavy metals in *carica papaya* plants from near-dumpsite

METALS	As	Cd	Cr	Ni	Pb
BARK	0.020	0.216	ND	0.409	0.763
FRUITS	0.020	0.301	ND	0.716	1.194
LEAVES	0.028	0.222	ND	0.415	0.889
ROOTS	0.024	0.216	ND	0.429	0.88

From table 2, the concentrations of heavy metals in carica papaya parts from near dumpsite were; 0.02mg/kg (bark), 0.02mg/kg (fruits), 0.028mg/kg (leaves) and 0.0.024mg/kg (roots) respectively. The concentration of Arsenic was found to be higher in the leaves of the studied plant (carica papaya) with concentration of 0.028mg/kg followed by the roots (0.024mg/kg) but, both the bark and fruits of the studied plant had equal concentrations of 0.02mg/kg respectively. The concentrations of Cadmium (Cd) were; 0.216mg/kg (bark) 0.301mg/kg (fruits), 0.222mg/kg (leaves) and 0.216mg/kg (roots) respectively. The fruits had the highest concentration of Cadmium (Cd) with 0.301mg/kg followed by the leaves with concentration of 0.222mg/kg. Both the bark and roots had the same concentrations of 0.216mg/kg respectively. Chromium (Cr) was not also detected in all the studied parts (bark, fruits, leaves and roots) of the plant (carica papaya). Nickel (Ni) had concentration values of 0.409mg/kg (bark), 0.716mg/kg (fruits), 0.415mg/kg (leaves) and 0.429mg/kg (roots) respectively. The highest concentration of Nickel (Ni) was found in the fruits with 0.716mg/kg and the least concentration value was found in the bark with 0.409mg/kg. The concentrations of Lead (Pb) in the studied parts of the plant (carica papaya) were; 0.763mg/kg (bark), 1.194mg/kg (fruits), 0.889mg/kg (leaves) and 0.880mg/kg (roots) respectively. The fruits had the highest concentration of Lead (Pb) with 1.194mg/kg and the least concentration value was found in the bark of the plant (carica papaya).

Fig-3. A chart showing the concentration of heavy metals (As, Cd, Cr, Ni and Pb) in carica papaya parts (bark, fruits, leaves and roots) from near dumpsite

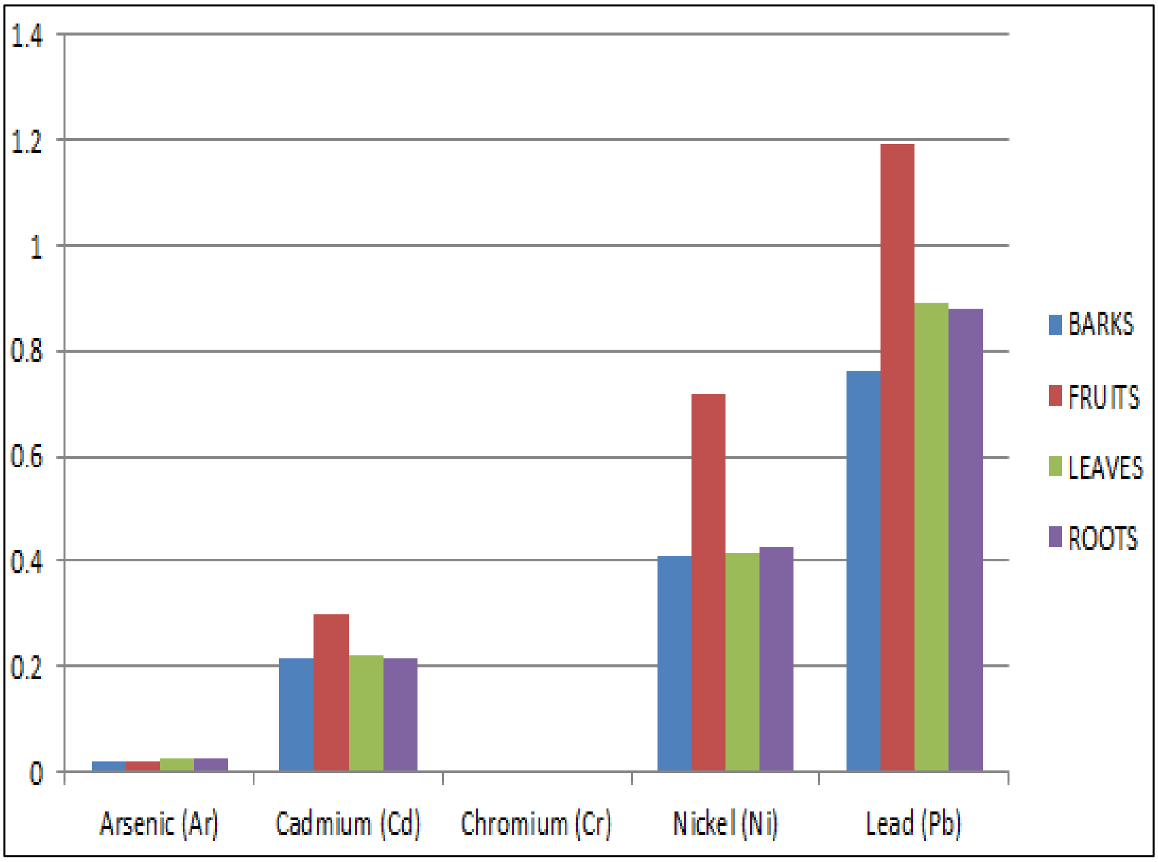


Table-3. Showing the mean ± standard deviation for carica papaya parts (bark, fruits, leaves and roots) in waste dumpsite and near dumpsite

HEAVY METALS	MEAN±STANDARD DEVIATION (mg/kg) DUMPSITE	MEAN±STANDARD DEVIATION (mg/kg) NEAR DUMPSITE
Arsenic (As)	0.23 ± 0.003	0.023 ± 0.004
Cadmium (Cd)	0.26 ± 0.040	0.24 ± 0.042
Chromium (Cr)	NOT DETECTED	NOT DETECTED
Nickel (Ni)	0.45 ± 0.151	0.49 ± 0.15
Lead (Pb)	0.97 ± 0.181	0.93 ± 0.18

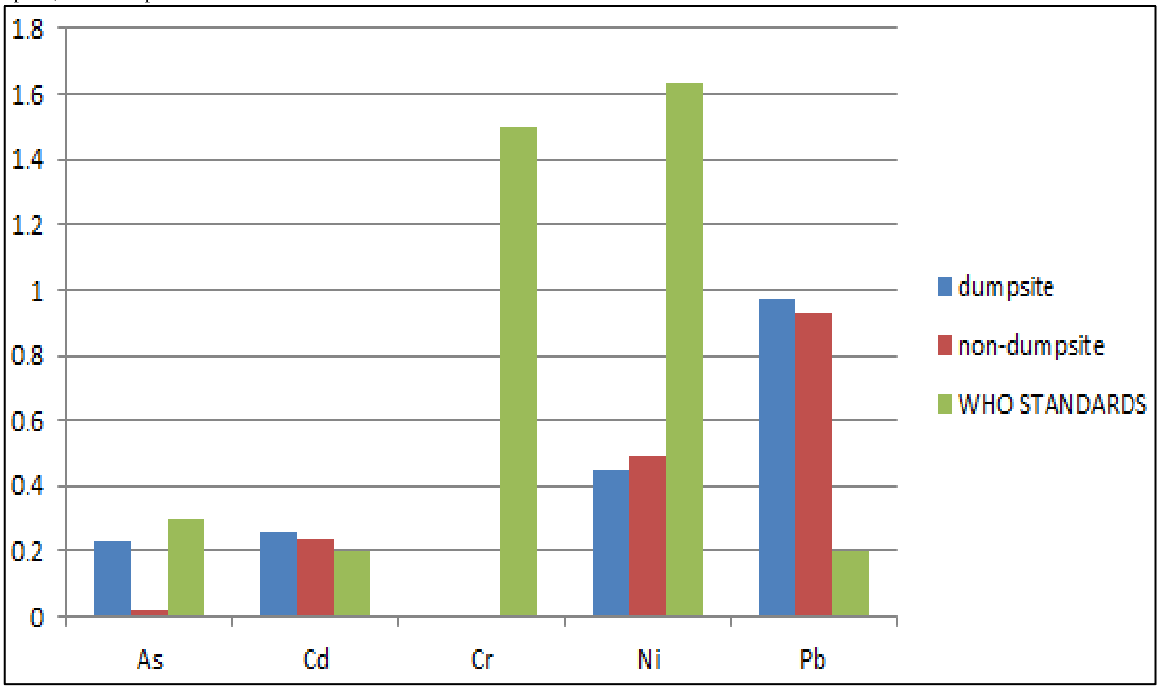
From table 3, the mean concentrations of the heavy metals in Carica papaya growing in dumpsite were 0.23 ± 0.003<0.26 ± 0.040<0.45 ± 0.151<0.97 ± 0.181 mg/kg for arsenic, cadmium, Nickel and Lead respectively and 0.023 ± 0.004<0.24 ± 0.042<0.49 ± 0.15<0.93 ± 0.18 mg/kg for arsenic, cadmium, Nickel and Lead respectively. Chromium was not detected. The high mean concentration of heavy metals in Carica papaya stand at the dumpsite is attributed to the fact that the dumpsite had significant amount of these toxic metals more than the near dumpsite.

3.2. Comparison Between the Mean Concentrations of Heavy Metals In Carica Papaya With Who/Fao Standard Limits

Table-4. Showing the mean concentrations of heavy metals in dumpsite, near dumpsite and WHO standards

HEAVY METALS	MEAN±STANDARD DEVIATION (mg/kg)		PERMISSIBLE MAXIMUM LIMITS (mg/kg)
	DUMPSITE	NEAR DUMPSITE	
ARSENIC	0.23 ± 0.003	0.023 ± 0.003	0.3kg/mg (EFSA)
CADMIUM	0.26 ± 0.039	0.24 ± 0.042	0.20 (WHO and FAO, 2007)
CHROMIUM	NOT DETECTED	NOT DETECTED	1.5mg/kg (WHO)
NICKEL	0.45± 0.154	0.49 ± 0.149	1.63mg/kg (WHO and FAO)
LEAD	0.97 ± 0.181	0.93 ± 0.184	0.20 (WHO and FAO)

Fig-5. A chart showing the comparison between the mean concentrations of heavy metals (As, Cd, Cr, Ni and Pb) in carica papaya plants growing in dumpsite, near dumpsite and WHO standards



3.3. Discussion

Factors influencing the bioavailability of heavy metals in plants are reported to be soil pH, organic matter, cation exchange capacity, moisture, presence of microorganisms, plant species, plant age, soil texture, time interval of metallic soil input, topography, nutrient availability and interaction among the metals with total metal concentrations in soils and soil pH controlling their intake.

3.4. Arsenic (As)

Even at low concentrations, exposure to Arsenics may give rise to a variety of adverse symptoms, the most common ones being cancer in liver, lung, skin, bladder and kidney [5]. Arsenic in solution is readily available for uptake by plant roots or sub-merged shoots. In soil, however, the total Arsenic (As) concentration does not always reflect the availability of Arsenic to plants and other organisms. The composition of the soil has a large influence on the availability of Arsenic. The mean concentrations of arsenic in carica papaya (dumpsite and near dumpsite) were 0.23 ± 0.003mg/kg and 0.02 ± 0.004 respectively. The higher concentration of Arsenic in the papaya sample from the waste dumpsite is as a result of the composition of the dumpsite. These concentrations were lower than the permissible limit of 0.3 mg/kg given by the European food safety authority [28].

3.5. Cadmium

Cadmium (Cd) is a non-essential element in food and natural waters and it accumulates principally in the kidneys and liver [29]. Cadmium causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and immune system [30]. In the present study, its mean concentrations were higher in the near dumpsite than the dumpsite (0.26 ± 0.04 mg/kg) and (0.24 ± 0.04 mg/kg) . This shows that the waste at the dumpsite contains significant amount of cadmium and must have been leached to some distance away from the dumpsite due to the topography of the surrounding during the rainy seasons. Flooding also contributes to the washing and leaching activities of the soil, these metals are washed down from the dumpsite (upslope) towards the near dumpsite (down-slope) of the study area which is about 10 meters apart. Carica papaya samples from the two locations (dumpsite and near dumpsite) had mean concentrations 0f 0.26 ± 0.04 mg/kg and 0.239 ± 0.042 mg/kg for dumpsite and near dumpsite respectively. The mean concentrations of cadmium in both locations had values higher than the WHO/FAO permissible limit (0.20mg/kg) for edible plants. Cadmium in the body is known to affect several enzymes.

3.6. Chromium

Chromium plays a vital role in the metabolism of cholesterol, fat, and glucose. Its deficiency causes hyperglycemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic [31]. Chromium was not detected in (carica pawpaw) plant parts from both locations. This may be as a result of the nature of the dumpsite or its composition and the activities ongoing in the surroundings.WHO's permissible limit of chromium in plant is 1.5mg/kg, the concentration of Chromium in the carica papaya plants from the two locations were beyond the detectable range.

3.7. Nickel

Nickel (Ni) is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded. This can cause various kinds of cancer on different sites of the body. The mean concentrations of nickel in both samples were 0.452± 0.1541 mg/kg and 0.492 ± 0.149mg/kg for dumpsite and near dumpsite respectively and were below the WHO/FAO permissible limit of 1.63 mg/kg in edible plants. Although the mean concentration of Nickel in the near dumpsite had higher values than the dumpsite which is also as a result of topography, leaching, flooding and other environmental factors. Nickel in plants could be attributed to cadmium–nickel batteries in electrical gadgets and some paints used to polish the surfaces of the gadgets which might have spread in the dumpsite. High concentration of nickel can lead to health risks. According to Khan, *et al.* [27], Nickel deficiency results in liver disorder.

3.8. Lead

There is report that at least 50% of lead (Pb) contamination is found on the surface of vegetables. The mean concentrations of lead (Pb) in carica papaya plants from both locations were 0.972± 0.181and 0.932± 0.184mg/kg for dumpsite and near dumpsite respectively. This shows that the waste at the dumpsite contains significant amount of lead than the near dumpsite. This may also be as a result of emissions of air, gas, or vapor streams, and fugitive emissions such as dust from storage areas or waste piles. Metals from airborne sources are generally released as particulates contained in the gas stream. Some metals such as As, Cd, and Pb can also volatilize during high-temperature processing. These metals will convert to oxides and condense as fine particulates unless a reducing atmosphere is maintained.

4. Conclusion/Recommendation

4.1. Conclusion

The introduction of industrial and municipal solid wastes into our environment has contributed greatly to the increased levels of heavy metals in plants grown in dumpsite. The consumption of Carica papaya linn. growing in dumpsite and within the premises of the dumpsite may constitute a serious threat to the health of people living around such areas. Because of seasonal rainfall, leaching, topography and other run-off during the wet season, metals from the upper layer of soil were washed down from the dumpsite to some distance (about 10 meters) away and hence, the increase in the concentrations of heavy metals (As, Cd, Cr, Ni and Pb) in the different parts (bark, fruits, leaves and roots) of the carica papaya growing near the dumpsite.

4.2. Recommendation

Proper care should be taken before consuming edible plants such as vegetables and fruits growing near refuge dumpsite as they may contain substantial amount of these toxic heavy metals from the nearby dumpsites.

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