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Research Article

ASSESSMENT OF HEAVY METAL ACCUMULATION IN PAWPAW CULTIVATED NEAR DUMPSITES IN NEKEDE MECHANIC VILLAGE, OWERRI, NIGERIA"

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Abstract

This study investigates the accumulation of heavy metals in pawpaw (Carica papaya) cultivated around dumpsites in Nekede Mechanic Village, Owerri, Imo State, Nigeria. The research evaluated the microbial, physicochemical, and heavy metal properties of soils and pawpaw plants from two dumpsite locations, with a control site in Ihiagwa. Total bacterial counts in soil ranged from 2.8x10^7 to 7.0x10^8 cfu/g, while total heterotrophic fungi counts ranged from 1.3x10^4 to 7.0x10^4 cfu/g. Additionally, the total coliform and faecal coliform counts were 1.1x10^5 to 6.0x10^5 cfu/g and 8.0x10^4 to 3.0x10^5 cfu/g, respectively. Various bacterial and fungal species were identified, including Enterobacter, Escherichia, Aspergillus fumigatus, and Fusarium. Heavy metal concentrations in soil were highest at the dumpsites, with values for Fe, Al, As, Cu, Hg, Zn, Pb, Ni, and Cd in the range of 0.00 to 65.17 mg/kg. In comparison, control site concentrations were significantly lower. The mean heavy metal concentrations in pawpaw samples did not significantly differ across sampling locations, except for copper (Cu), which showed significant variation. The levels of cadmium (Cd), zinc (Zn), aluminum (Al), lead (Pb), nickel (Ni), arsenic (As), and mercury (Hg) in pawpaw exceeded the FAO/WHO permissible limits for food crops. Although heavy metal levels were found in pawpaw, the dilution effect due to the plant's water content may have minimized the absorption. Given the potential health risks posed by the high concentrations of these metals, it is advised that pawpaw grown near dumpsites not be consumed. The study recommends improved waste management practices in mechanic villages and suggests cultivating crops at least 50–100 meters away from dumpsites to reduce contamination.

Keywords: Heavy metals, Pawpaw, Bioaccumulation, Dumpsites, Microbial contamination

Introduction

Heavy metals are a diverse and heterogeneous group of elements that possess significant differences in their chemical properties, biological functions, and environmental impacts. The term "heavy metals" refers to those metallic elements that have a specific gravity greater than 5 g/cm³, a characteristic that distinguishes them from lighter elements (Barron, 1990). These metals are typically classified as pollutants because they are persistent in the environment, do not degrade into less harmful substances, and pose severe risks to plant, animal, and human health. Unlike other substances that may undergo biotransformation or degradation, heavy metals accumulate in the environment and organisms, leading to long-term environmental and health hazards.

Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and zinc (Zn) are particularly problematic due to their toxicity, bioaccumulation potential, and ability to persist in ecosystems. These metals do not undergo easy metabolism into other forms and, as a result, they tend to accumulate in the tissues of living organisms over time. The accumulation process in plants, for instance, begins when heavy metals are absorbed from the soil and incorporated into the plant's system. Once absorbed by plants, these metals can enter the food chain when the plant is consumed by herbivores or humans, which can lead to a buildup of toxic concentrations in higher organisms (Barron, 1990).

The bioaccumulation of heavy metals occurs when the concentration of a substance in an organism exceeds the concentration found in its surrounding environment over time. This phenomenon can have adverse effects on living organisms, particularly when the substances accumulate in critical tissues or organs. In plants, bioaccumulation of heavy metals can disrupt physiological functions, stunt growth, and lead to toxic symptoms such as chlorosis, stunted root growth, or even plant death. In humans and animals, bioaccumulation of toxic metals can result in a variety of health issues, including organ damage, neurological disorders, and an increased risk of cancer. Moreover, in environments where heavy metals are present, their ability to enter water supplies or spread through the food chain poses serious ecological risks, impacting biodiversity and public health (Beek, 2000).

One significant pathway of heavy metal contamination is through improper waste management practices, particularly around industrial and urban areas, such as automobile mechanic villages. These regions often become dumping grounds for hazardous materials, including heavy metals from discarded vehicles, batteries, and other toxic waste. In many developing countries, including Nigeria, the improper disposal of these materials results in soil and water contamination, particularly in areas that are not equipped with adequate waste management infrastructure. One such area is the Nekede Mechanic Village in Owerri, Imo State, where soil and water contamination due to automobile-related waste has been observed.

In recent years, studies have shown that the high levels of heavy metals found in soil near mechanic villages, such as Nekede, pose significant risks to both the environment and human health. The presence of these metals in soil can severely impact the quality of crops grown in these areas. In addition to the direct contamination of crops, the movement of contaminants through the soil and into nearby water bodies, such as the Otamiri River, raises concerns about the broader environmental impact of heavy metals. The Otamiri River is a critical source of domestic water for the local community, which raises the stakes for public health as the contamination of water sources with heavy metals could lead to waterborne diseases and other health problems.

Several studies, including the work of Ejiogu et al. (2017), have shown that crops, such as cassava (Manihot esculenta), cultivated in the vicinity of dumpsites near Nekede Mechanic Village, are contaminated with high levels of heavy metals. These studies highlight the potential for bioaccumulation in agricultural products, which may subsequently enter the human food chain. When consumed, these crops can lead to the accumulation of heavy metals in human tissues, posing significant health risks, especially for immuno-suppressed individuals. Long-term exposure to elevated levels of heavy metals can lead to chronic conditions such as kidney failure, liver damage, and neurological impairments. The public health implications of these findings are alarming, particularly for communities with limited access to clean water and proper healthcare.

Among the various crops grown in the area, pawpaw (Carica papaya) is one of the common agricultural products. It is widely consumed both locally and in surrounding areas. However, there is limited research on the accumulation of heavy metals in pawpaw grown around dumpsites, especially in regions where soil contamination from industrial and automotive waste is prevalent. Therefore, the need to investigate the bioaccumulation of heavy metals in pawpaw plants grown near such contaminated areas is paramount. Given the known risks of heavy metal exposure, it is essential to assess the extent of contamination in pawpaw plants and understand the implications for human health.

This study seeks to fill this gap by examining the levels of heavy metal contamination in pawpaw grown near dumpsites in Nekede Mechanic Village, Owerri. The primary objectives of this research include assessing the levels of heavy metals in both the edible and non-edible parts of the pawpaw plant, evaluating the physicochemical properties of the soil in these areas, and determining the microbial contamination in soils near the dumpsites. The study will also investigate whether pawpaw can act as a potential bioremediation tool for heavy metals in contaminated soils and the effect of these heavy metals on the microbial population of the soil. By understanding the bioaccumulation patterns of heavy metals in pawpaw, this study aims to provide critical information for mitigating the health risks associated with consuming contaminated crops and developing strategies for safer agricultural practices in contaminated areas.

The broader significance of this study lies in its potential to inform policy on agricultural safety and waste management in urban and industrial areas. Effective waste management strategies, such as proper disposal of industrial and automobile waste, could significantly reduce the contamination of soils and water sources with heavy metals, thereby improving public health outcomes. Additionally, recommendations derived from this study could help local farmers adopt safer practices, such as cultivating crops at safe distances from dumpsites or using soil remediation techniques, to reduce exposure to harmful contaminants.

In conclusion, the rising levels of heavy metal contamination in areas surrounding mechanic villages, especially those with poor waste management practices, present a significant challenge to public health and the environment. As plants such as pawpaw absorb heavy metals from contaminated soils, they pose a potential risk to human health through the food chain. The need for comprehensive studies to assess the extent of contamination, the bioaccumulation potential of crops, and the efficacy of remediation measures is critical to safeguarding both public health and the environment. Through this research, it is hoped that valuable insights will be gained,

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contributing to the development of strategies for addressing heavy metal pollution and promoting safer agricultural practices in contaminated areas.

THE STUDY AREA

Nekede automobile mechanic village is located in Nekede Community, Owerri West Local Government Area of Imo State, Nigeria. The mechanic village is situated along Aba-Owerri Road of Imo State with geographical coordinates as $5^0 26'$ North, $7^0 2'$ East in Owerri West L.G.A (Fig 1).

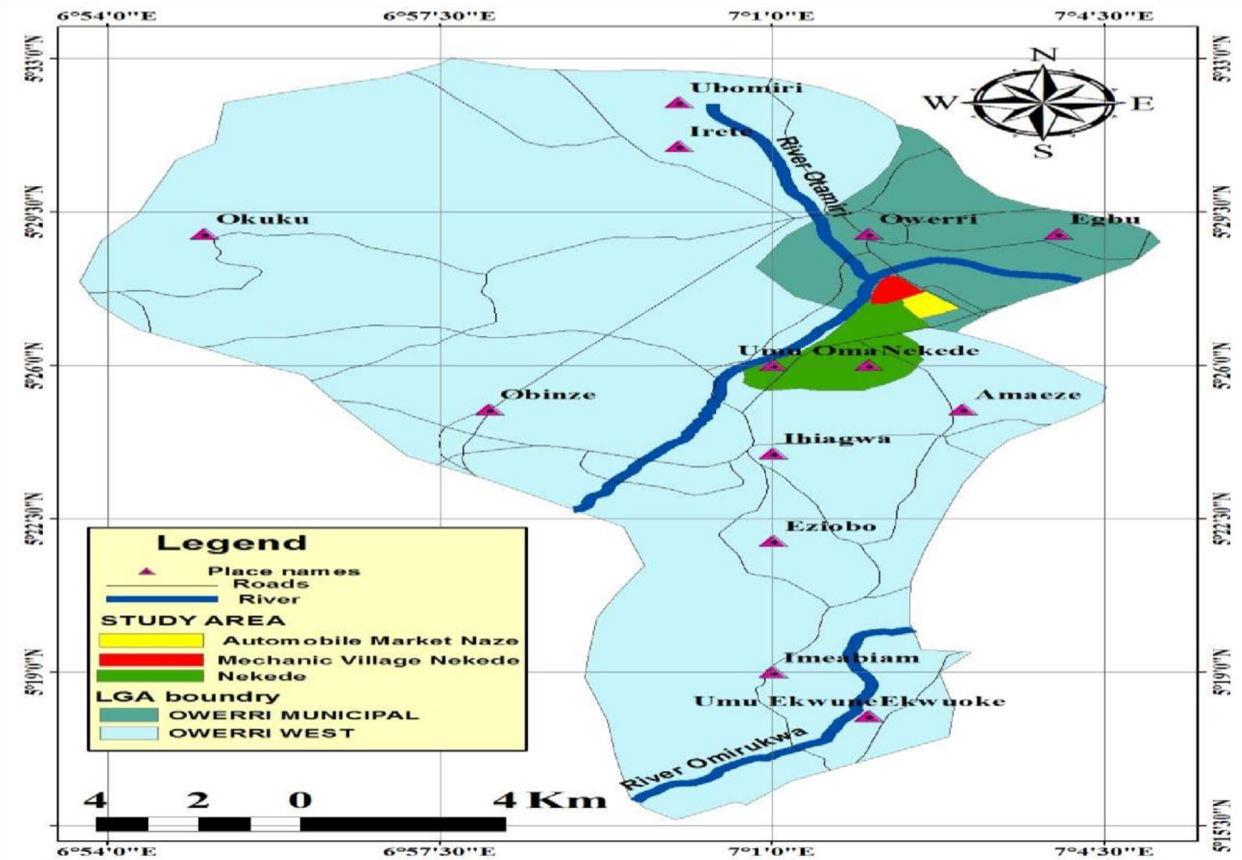

Fig 1. Location map of the study area

METHODOLOGY Sample Collection

Samples of pawpaw (fruits, leaves and roots) were collected and packaged in well-labeled transparent sterile cellophane bags and transported to the laboratory for analyses. Soil samples of the farm lands near the dumpsite where pawpaw plants were cultivated were also collected using soil auger at the depth of 0-30 cm for top and sub

-soils as described by Radojevic & Bashkin (1999). These were also labeled accordingly. The control samples were collected from farmlands at Ihiagwa that have no visible waste dump around them.

Samples Preparations

The pawpaw samples were washed and peeled. A grater was used to grind the samples into pastes and placed into different clean containers.

After grinding, 70 g wet weight of each of the samples were dried using the hot air oven. After drying, the samples were also weighed to determine the dry weight. The samples were milled using mortar and pestle into fine powder. A mesh sieve of 1mm size was used to sieve the ground powdered samples which were then poured into different clean labeled containers for digestion. The leaves and roots also were washed dried using the hot air oven, after which they were ground into finer substances using mortar and pestle for digestion.

Microbiological analyses of soil samples

Media prepared included nutrient agar, MacConkey agar and Saboraund dextrose agar for the study and their preparations were done according to the manufacturer's specifications. The diluent used was distilled water. The media and diluent prepared were sterilized at 121^0C for 15 minutes with an autoclave.

Physico-chemical analysis of soil samples

One gram of each pre-weighed soil sample was dissolved in 20 ml of the prepared acid mixture. To increase the solubility, the sample solution was heated on hot plate until the volume was reduced to 3ml. Then, the solution was cooled and filtered into 25 ml volumetric flask using Whatman 42 filter paper. The filtrate was diluted up to the mark of distilled water (Soylak *et al*., 2004). Parameters determined include: pH and soil conductivity, nitrate phosphate and sulphate

Determination of heavy metals using Atomic Absorption Spectrophotometer (AAS) Atomic Absorption Spectrophotometer (AAS) model FS240AA was used for analyzing the aforementioned heavy metals.

Statistical methods used

Statistical methods employed were: descriptive statistics (Mean, Standard error, and Range), correlation analysis, one-way analysis of variance (ANOVA), Duncan multiple range test (post-hoc test), variation plots (graphs) and principal component analysis. Microsoft excel 2010 version and Statistical Package for Social Sciences (SPSS) version 22 were used in analyzing the data realized.

RESULTS Result of Microbial Count

The results of the microbial counts of the various soil samples from the agricultural farmlands near the dumpsites in Nekede mechanic village and the control site are presented in Table 1. The total bacterial counts (TBC) of the top soil samples ranged from 6.2×10^7 to 1.0×10^8cfu/g while the TBC for the subsoil samples ranged from 2.8×10^7 to 7.0×10^8cfu/g. The total heterotrophic fungal (THF) counts of the topsoil samples ranged from 4.0×10^4 to 1.1×10^5cfu/g while the THF for the sub-soils ranged from 1.3×10^4 to 7×10^4cfu/g. The total coliform counts (TCC) of the topsoil's was of the range $4.0x10^5$ – $6.0x10^5$ cfu/g while the TCC for the sub-soil samples was $1.1x10^5$ - $2.1x10^5$ cfu/g.

Table 1: Total microbial counts (colony forming unit per gram) of the different soil samples from farms 4m away from dumpsites in Nekede mechanic village Owerri.

Soil Samples	TBC cfu/g	THF cfu/g	TCC cfu/g	TFC cfu/g
TS_1	$1.0x10^8$	$6.0x10^4$	$6.0x10^5$	$3.0x10^5$
TS_2	$9.0x10^7$	$1.1x10^5$	$4.0x10^5$	$1.1x10^5$
TS_C	$6.2x10^7$	$4.0x10^4$	$4.0x10^5$	$9.0x10^4$
SS_1	$7.0x10^8$	$1.3x10^4$	$1.4x10^5$	$9.0x10^4$
SS_2	$5.2x10^7$	$7.0x10^4$	$2.1x10^5$	$1.0x10^5$
SS_C	$2.8x10^7$	$3.0x10^4$	$1.1x10^5$	$8.0x10^4$

TBC = Total bacterial count, THF =Total heterotrophic fungi, TCC = Total coliform count,

TFC = Total faecal coliform, cfu/g =Colony forming unit per gram

TS_1= Top soil site 1, TS_2= Top soil site 2, TS_c=Top soil control, SS_1= Sub-soil site 1, SS_2= Sub-soil site 2 and SS_c= Sub-soil control.

The colonial and biochemical characteristics of the bacterial isolates from the different top soil samples in the farms near mechanic waste dumpsites and control site are shown in Table 2.

The following bacteria were isolated and identified: *Enterobacter*, *Escherichia*, *Staphylococcus*, *Pseudomonas*, *Bacillus*, *Vibrio* and *Citrobacter*.

Table 2: Colonial and biochemical characteristics of bacterial isolates from the different top soil samples from farmlands 4m away from dumpsites in Nekede mechanic village Owerri

Soil Samples	Colonial Appearance	Microscopic Characteristics	Gram Stain	Slant	Butt	Gas	H_20	Catalase	Coagulase	Methyl Red	Voge Proskeur	Indole	Motility	Oxidase	Sucrose	Glucose	Lactose	Probable Organism
TS1	a. Rhizoid-like smooth colorless and translucent colony	Short rods	·	A	A	+	-	+	-	+	-	-	+	-	AG	AG	AG	*Enterobacter spp.*
	b. Pink on MacConkey agar, creamy colony on nutrient agar with smooth entire edge.	Slender rods	·	A	A	+	-	+	-	+	-	+	+	-	AG	AG	AG	*Escherichia spp.*
	c. Golden yellow on nutrient agar	Cocci in Clusters	·	A	A	-	-	+	+	-	-	-	-	-	-	A	A	*Staphylococcus spp.*
TS2	a. Dully creamy colony on nutrient agar.	Short rods	·	B	B	-	-	+	-	+	-	-	+	+	-	A	-	*Pseudomonas spp.*
	b. Round white glossy raised membranous growth.	Short rods	·	B	A	-	-	-	-	+	-	-	+	+	A	A	-	*Bacillus spp.*
	c. Creamy colony nutrient agar.	Short rods	·	B	A	- +	-	+	-	+	-	+	+	+	AG	AG	A	*Vibrio spp.*
	d. Pink on MacConkey agar, creamy on nutrient agar with smooth edge.	Scattered small rods	·	A	A		-	+	-	+	-	+	+	+	AG	AG	AG	*Escherichia spp.*

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TS$_C$	a. Round creamy colony on nutrient.	Small rods	A	A	-	-	+	-	+	-	+	+	+	A	A^0	AG	*Citrobacter spp.*
	b. Pink on MacConkey agar, Small creamy on nutrient agar.	Small	A	A	+	-	+	-	+	-	+	+	+	AG	AG	AG	*Escherichia spp.*
	c. Rhizoid-like smooth colorless and translucent colony.	Short rods	A	A	+	-	+	-	+	-	-	+	+	AG	AG	AG	*Enterobacter spp.*

Key: A = Acid production, A^0 = Small acid production, AG = Acid and gas production, + = Positive, B = Alkaline, - = Negative, TS_1= Topsoil site 1, TS_2 =Topsoil site 2, and TS_c= Topsoil control

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The results of the characterization of the fungal isolates from top soil samples from farms near dumpsites in Nekede mechanic village and control site are shown in Table 3.

The fungal isolates include *Aspergillus flavus, Aspergillus fumigatus, Candida spp Epicoccum spp* and *Fusarium spp.*

Table 3: Morphological microscopic appearance and identification of probable fungal isolates from top soil samples in farmlands 4m away from dumpsites in Nekede mechanic village Owerri

Soil Samples	Cultural Morphology	Microscopic Characteristics	Most Probable Organisms
TS1	Granular creamy colony that turns bluish green on aging.	Hyphae is septate and conidiophores arise from thick walls.	*Aspergillus fumigatus*
	The aerial mycelium is well developed, presenting a cottony surface that develops a yellow colour.	Hyphae distinctively septate with irregular sized spores clustered together.	*Epicoccum spp.*
TS2	Granular creamy colony that turns bluish green.	Hyphae is septate and the conidiophores arise from the thick wall.	*Aspergillus fumigatus*
	Fluffy colonies with blackish yellow colour.	Conidiophores borne as short branches from the aerial hyphae with condensed spores surrounding them.	*Aspergillus flavus*
	Colony grows as white patches with a glossy surface.	Clamydospores are numerous, borne singly.	*Candida spp.*
TSC	Colonies are initially white and later purple-red pigment was observed at its edge.	Hyphae are hyaline and sepatate microconidia is 2□m in diameter.	*Fusarium spp.*
	Colonies grow as white patches with a glossy surface.	Clamydospores are numerous, borne singly.	*Candida spp.*

The following fungi were isolated from sub-soil samples from farms near dumpsites in Nekede mechanic village and control site as shown in Table 4. They include: *Candida spp, Aspergillus spp, Penicillium spp,* and *Fusarium spp.*

Table 4: Morphology, Microscopic Appearance and Identification of probable fungal isolates from sub-soil samples in farmlands 4m away from dumpsites in Nekede mechanic village Owerri

Soil Samples	Cultural Morphology	Microscopic Characteristics	Most Probable Organisms
	Colony grew as white patches with glossy surface.	Clamydospore are numerous borne singly.	*Candida spp.*
SS$_1$	Fluffy colonies with blackish yellow colour.	Conidiosphores borne as short branches from the aerial hyphae with condensed spores surrounding them.	*Aspergillus spp.*
SS$_2$	White fluffy colony that turned green later.	Bluish spore bearing structure, conidia in chains.	*Penicillium spp.*
	Colonies grow as white patches with a glossy surface.	Clamydospores are numerous, borne singly.	*Candida spp.*
SS$_C$	Colonies were initially white and later turned to purple-red.	Hyphae are hyaline and septate microconidia are 2□m in diameter.	*Fusarium spp.*

Result of Physicochemical Analysis

The results of the physicochemical parameters of the various soil samples determined are shown in Table 5. The pH range of the top soil samples was 4.5-6.6 while that of sub-soil samples was 5.0-6.5. The electrical conductivity values of the topsoil samples ranged from 20.0 to 184.0µs/cm while the conductivity of the subsoils ranged from 10.0 to 462.0µs/cm. The nutrient contents of the various soil samples are also shown; nitrate (0.9-192.0 mg/g), phosphate (2.6-60.8 mg/g) and sulphate (0.0-160 mg/g).

Table 5: Physicochemical analyses of the soil samples in farmlands 4m away from dumpsites in Nekede mechanic village Owerri

S/N	Soil Samples	pH	Conductivity (□s/cm)	Nitrate mg/g	Phosphate mg/g	Sulphate mg/g
1	TS$_1$	5.8	184.0	93.0	60.8	70.0
2	TS$_2$	6.6	45.0	32.8	16.4	10.0
3	TSc	4.5	20.0	43.0	2.6	0.0

4	SS_1	6.5	462.0	192.0	29.6	160.0
5	SS_2	6.5	45.0	7.1	16.7	0.0
6	SS_c	5.0	10.0	0.9	7.7	0.0

The result of the mean concentration of heavy metals analyzed in the various pawpaw samples are shown in Table 6.

In the pawpaw fruit (PF) parts, the mean concentration of heavy metals ranged from 0.00± 0.00 to 6.20 ± 0.08 mgkg^{-1} dry weight, in the order As > Al > Hg > Zn > Ni > Cu > Cd > Pb with Ag, Fe and Cr recording zero concentration.

Also, in the pawpaw root (PR) samples, the mean concentration of heavy metals ranged from 0.00 ± 0.00 to 5.18 ± 1.31 mgkg^{-1} dry weight, in the order As > Al > Hg > Cu > Zn > Pb > Cd > Ni > Ag with Fe and Cr recording zero concentration.

However, the mean concentration of the heavy metals in the pawpaw leaf (PL) samples ranged from 0.00 ± 0.00 to 5.33 ± 1.14 mgkg^{-1} dry weight, in the order Cu > As > Al > Hg > Fe > Zn > Ni > Cd > Pb with Ag and Cr recording zero concentration.

Table 6: Concentration of heavy metals in Paw-Paw samples from farmlands 4m away from dumpsites in Nekede mechanic village Owerri

Pawpaw Sample mgkg^{-1}	Cu	Cd	Zn	Al	Pb	Ni	As	Hg	Ag	Fe	Cr
PF_1	0.697	0.056	0.729	6.276	0.000	0.875	6.090	2.435	0.000	0.000	0.000
PF_2	0.013	0.142	1.020	2.758	0.160	0.000	6.310	2.100	0.000	0.000	0.000
PF (mean)	0.36±0.24	0.10±0.03	0.88±0.10	4.02±0.89	0.08±0.06	0.44±0.32	6.20±0.08	2.27±0.12	0.00±0.00	0.00±0.00	0.00±0.00
PFc	0.00	0.07	0.48	2.76	0.00	0.01	4.55	2.62	0.00	0.00	0.00
PR1	1.231	0.058	0.843	4.746	0.049	0.000	3.330	2.570	0.027	0.000	0.000
PR2	0.000	0.159	0.207	2.607	0.175	0.052	7.020	0.000	0.000	0.000	0.000
PR(Mean)	0.62±0.44	0.11±0.04	0.53±0.23	3.68±0.76	0.11±0.05	0.03±0.03	5.18±1.31	1.29±0.90	0.01±0.01	0.00±0.00	0.00±0.00
PRc	0.00	0.14	0.19	3.40	0.09	0.02	5.54	2.37	0.00	0.00	0.00
PL1	3.714	0.092	0.873	4.090	0.000	0.875	3.960	3.542	0.000	0.740	0.000
PL2	6.946	0.197	0.451	5.035	0.148	0.021	6.310	0.002	0.000	0.000	0.000
PL(Mean)	5.33±1.14	0.15±0.04	0.66±0.15	4.56±0.33	0.07±0.05	0.45±0.31	5.14±0.83	1.77±1.25	0.00±0.00	0.87±0.62	0.00±0.00
PLc	0.00	0.18	0.29	3.29	0.21	0.65	2.75	3.65	0.00	0.00	0.00
FAO/W	NA	0.10	NA	NA	0.10	0.15	0.10	0.10	NA	NA	2.30

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± = Standard error of mean, $mgkg^{-1}$ = Milligram per kilogram, PF_1= Pawpaw fruit site 1, PF_2= Pawpaw fruit site 2, PF_C= Pawpaw fruit control, PR_1 =Pawpaw root site 1, PR_2= Pawpaw root site 2, PR_C= Pawpaw root control, PL_1=Pawpaw leaf site 1, PL_2= Pawpaw leaf site 2, PL_C= Pawpaw leaf control

NA = Not Available

The results of the mean concentration of heavy metals in soil samples are shown in Table 7. The mean concentrations of the heavy metals in soil samples (top soils and sub-soils) in site 1 ranged from 0.00 ± 0.00 to 63.27 ± 0.12 $mgkg^{-1}$ dry weight, in the order Fe > Al > As > Cu > Hg > Zn > Pb > Ni > Cd with Ag and Cr recording zero concentration. Also in site 2, the mean concentrations of heavy metals in soil samples ranged from 0.00 ± 0.00 – 65.17 ± 0.42 $mgkg^{-1}$ dry weight, in the order Fe > Al > Cu > As > Zn > Pb > Hg > Ni > Cd with Ag and Cr recording zero concentration. Nevertheless, the mean concentrations of heavy metals in soil samples from the control site ranged from 0.00 ± 0.00 – 1.20 ± 0.85 $mgkg^{-1}$ dry weight, in the order Hg > As > Fe > Al > Cu. Cd, Zn and Pb had the same mean concentration of 0.00 ± 0.00 and Ni 0.01 ± 0.00. Ag and Cr recording zero concentrations.

Table 7: Concentration of heavy metals in soil sample from farmlands 4m away from dumpsites in Nekede mechanic village Owerri

iation plots

The mean concentrations of Cu, Cd, Zn, Al, Pb, Ni, As, Hg, Ag, Fe, and Cr in cassava and their values on corresponding soil samples analyzed are presented in Fig 2-10

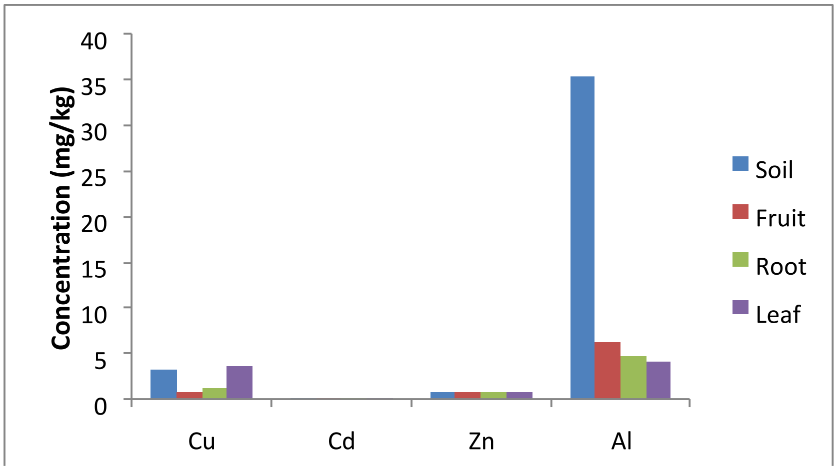

Fig. 2 Mean Concentrations of Cu, Cd, Zn, and Al in Soil and Pawpaw Parts Sampled in Site 1.

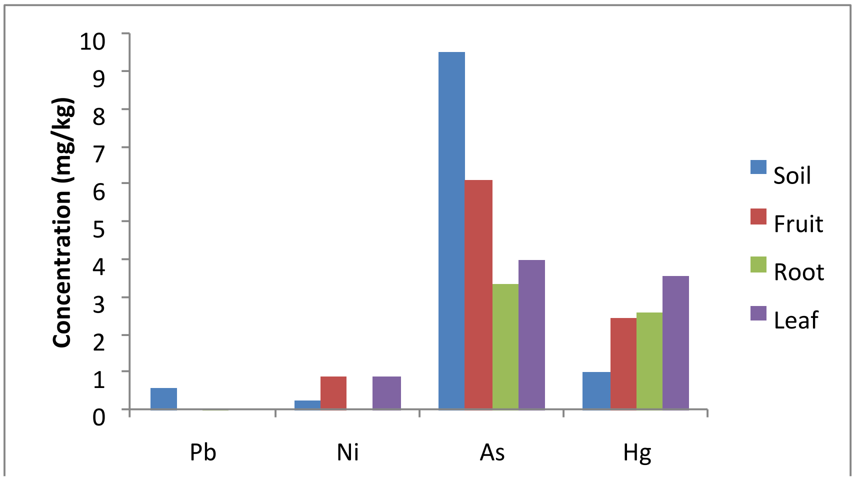

Fig. 3 Mean Concentrations of Pb, Ni, As, and Hg in Soil and Pawpaw Parts Sampled in Site 1.

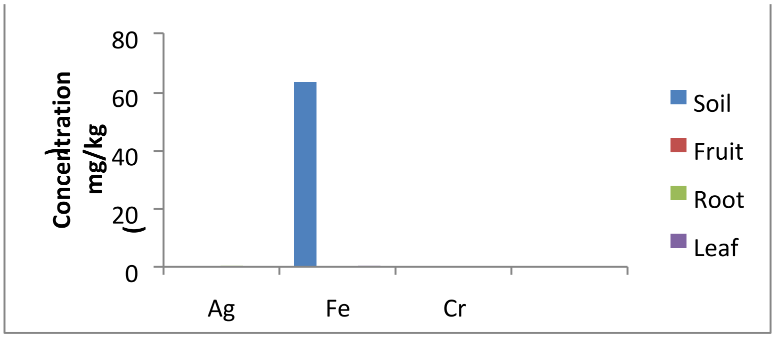

Fig. 4 Mean Concentrations of Ag, Fe, and Cr in Soil and Pawpaw Parts Sampled in Site 1.

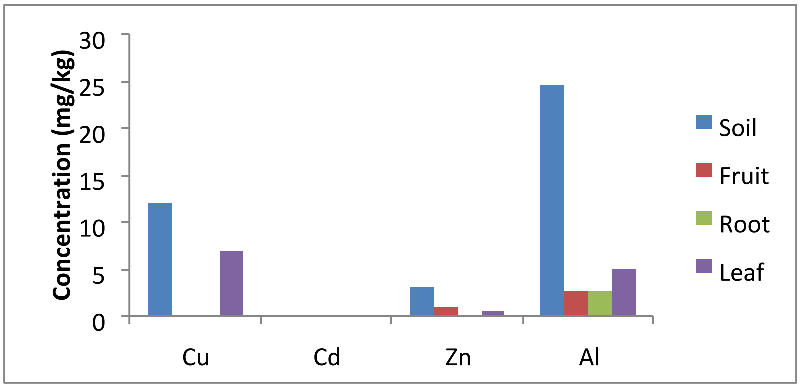

Fig. 5. Mean Concentrations of Cu, Cd, Zn, and Al in Soil and Pawpaw Parts Sampled in Site 2.

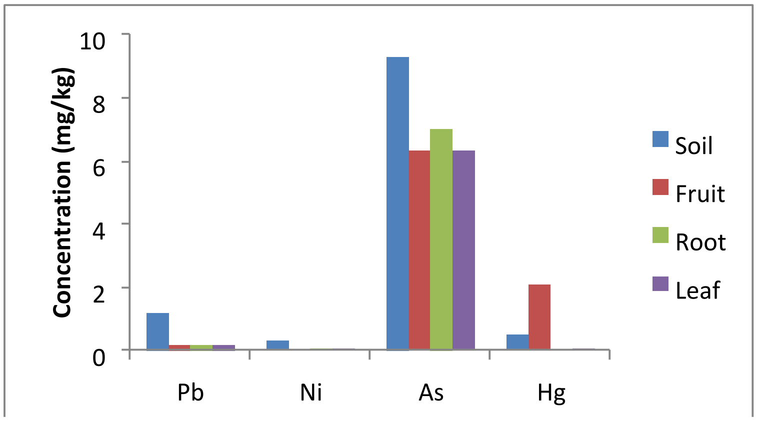

Fig. 6 Mean Concentrations of Pb, Ni, As, and Hg in Soil and Pawpaw Parts Sampled in Site 2.

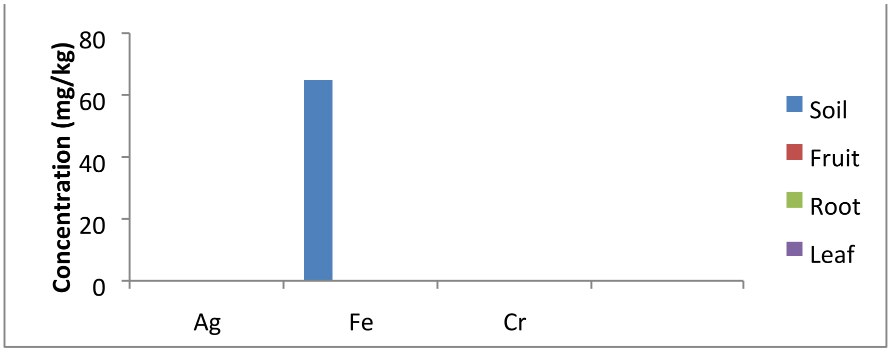

Fig. 7 Mean Concentrations of Ag, Fe, and Cr in Soil and Pawpaw Parts Sampled in Site 2.

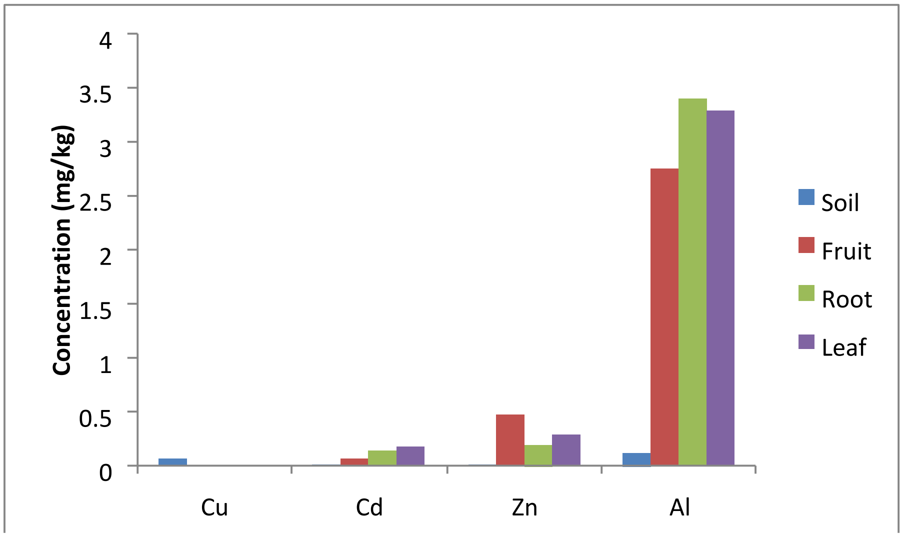

Fig.8. Mean Concentrations of Cu, Cd, Zn, and Al in Soil and Pawpaw Parts Sampled in Site 3 (Control).

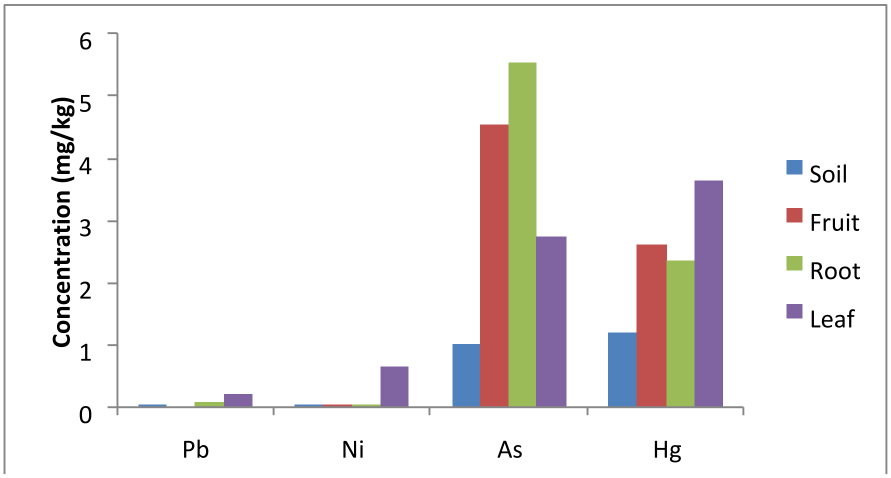

Fig.9. Mean Concentrations of Pb, Ni, As, and Hg in Soil and Pawpaw Parts Sampled in Site 3 (Control).

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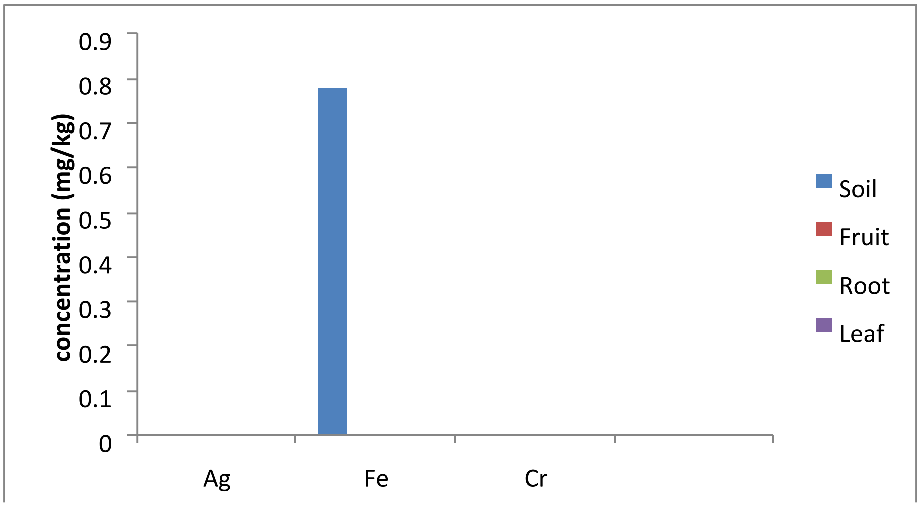

Fig. 10. Mean Concentrations of Ag, Fe, and Cr in Soil and Pawpaw Parts Sampled in Site 3 (Control).

STATISTICAL ANALYSES OF RESULTS SOIL SAMPLES

The One-way Analysis of Variance (ANOVA) test revealed that the significant values of F; Cu (0.013), Cd (0.000), Zn (0.023), Al (0.000), Pb (0.000), Ni (0.003), As (0.000) and Fe (0.000) differed significantly across the sampling locations (SL) at $P<0.05$. However, the levels of Hg (0.666) were not significantly different across the sampling locations. The posthoc Duncan multiple Range Test revealed that the levels of Cu and Zn differed between SL_2 and other locations, the levels of Cd, Ni and As differed between SL_3 and the other locations, and the levels of Al, Pb and Fe differed in all the locations (Table 8).

Heavy metal	Sampling Location (SL)		
Cu	SL1	SL2	SL_3(Control)
	3.297^{b}	12.043^{a}	0.055^{b}
Cd	0.211^{a}	0.185^{a}	0.009^{b}
Zn	0.872^{b}	3.112^{a}	0.009^{b}
Al	35.449^{a}	24.577^{b}	0.131^{c}
Pb Ni	0.535^{b} 0.218^{a}	1.155^{a}	0.009^{c}
		0.324^{a}	0.002^{b}
As	9.495^{a}	9.285^{a}	1.007^{b}
Hg	1.000^{a}	0.500^{a}	1.200^{a}

Fe	63.271^{b}	65.169^{a}	0.778^{c}

Table 8: Mean separation in concentration of heavy metals in soils across the sampling locations using Duncan Multiple Range Test (P<0.05)

Values with same superscripts along same row are not significantly different at P<0.05 SL_1=Sample location 1, SL_2= Sample location 2 and SL_3=Sample location 3 (control).

PAWPAW SAMPLES

Table 9: Mean separation in concentration of heavy
Pawpaw samples across
levels of Cd, Zn, Al, Pb, Ni, As, Hg, Ag and Fe were not significantly different across the sampling locations.
the sampling locations using Duncan Multiple Range Test (P<0.05)
Values with same superscripts along same row are not significantly different at P<0.05
Subscript "s" refers to concentrations of heavy metal in soil samples
Subscript "p" refers to concentration of heavy metals in pawpaw samples

The Pearson correlations (r) between levels of the heavy metals in soil and cassava parts sampled are shown in Table 10. At P<0.05, Pb in soil correlated negatively with Pb in the plant parts (r = -0.775). However, at P<0.01, Fe in soil correlated positively with Fe in the plant parts (r = 0.886).

The One-way Analysis of Variance (ANOVA) Test revealed that the significant values of F; Cd (0.521), Zn (0.264), Al (0.574), Pb (0.796), Ni (0.319), As (0.540) and Hg (0.658) were not significantly different across the sampling locations. However, the levels of Cu (0.002) differed significantly across the sampling locations (SL) at P<0.05. The Post-hoc Duncan Multiple Range Test as presented in Table 4.13 on pawpaw samples across the sampling locations showed that the levels of Cu differed between SL3 and and the other locations, whilst the

Heavy metal	**Sampling Location (SL)**		
	SL1	**SL2**	**SL_3 (Control)**
Cu	0.355^{b}	0.617^{b}	5.330^{a}
Cd	0.099^{a}	0.109^{a}	0.145^{a}
Zn	0.875^{a}	0.525^{a}	0.662^{a}
Al	4.017^{a}	3.677^{a}	4.563^{a}
Pb	0.080^{a}	0.112^{a}	0.074^{a}
Ni	0.0438^{a}	0.026^{a}	0.448^{a}
As	6.200^{a}	5.175^{a}	5.135^{a}
Hg	2.264^{a}	1.285^{a}	1.772^{a}
Ag	0.000^{a}	0.014^{a}	0.000^{a}
Fe	0.000^{a}	0.000^{a}	0.870^{a}

Table 10: Correlation (r) matrix between the concentration of heavy metals in soil and pawpaw samples from farmlands 4m away from dumpsites in Nekede mechanic village, Owerri

The relationship between heavy metals and microorganisms in soils from the waste dumpsite as explored with the Pearson Correlation (r) is shown in Table 11. At P<0.05, Al ions correlated positively with Total Coliform Counts (TCC) (r = 0.905). At P<0.01, Pb correlated negatively with TCC (r = -0.962).

Table 11: Correlation (r) matrix between the heavy metals and microorganisms measured in soils 4m away from dumpsites in Nekede Mechanic Village, Owerri.

	Cu	Cd	Zn	Al	Pb	Ni	As	Hg	Fe
TBC	-0.194	0.108	-0.236	-0.179	0.327	-0.039	-0.056	-0.452	0.082
THF	-0.050	-0.333	0.035	0.292	-0.336	0.194	0.552	0.021	-0.350
TCC	-0.664	0.638	-0.655	0.905*	-0.962**	-0.751	-0.019	0.655	-0.778
TFC	-0.417	0.798	-0.466	0.600	-0.688	-0.798	-0.501	0.786	-0.385

	Cus	**Cds**	**Zns**	**Als**	**Pbs**	**Nis**	**Ass**	**Hgs**	**Ags**	**Fes**
Cu_p	-0.615									
Cd_p		-0.572								
Zn_p			-0.589							
Al_p				-0.236						
Pb_p					0.364					
Ni_p						-0.599				
As_p							0.231			
Hg_p								-0.541		
Ag_p									0.635	
Fe_p										0.001

* = significant at P<0.05, ** = significant at P<0.01, TBC = Total Bacteria Count, THF = Total Heterotrophic Fungi, TCC = Total Coliform Count, TFC = Total Faecal Coliform

DISCUSSION

The results of the microbial counts of the various soil samples from agricultural farmlands near the dumpsites in Nekede mechanic village showed that there were higher counts of the various microorganisms both in the top and sub- soil samples when compared with soil samples from the control farm at Ihiagwa.

This may be attributed to the availability of nutrients in the dumpsites. Apart from the dumping of auto-mechanic waste, faeces and other domestic waste are also disposed of in such dumpsites, and these contain high level of nutrients that would support the proliferation of these microorganisms such as the members of the family *Enterobacteriacae*, faecal coliforms and some saprophytic fungi that feed on dead decaying organic materials.

The physico-chemical properties of the various soil samples revealed that the pH of the top soil samples in sites 1, 2 and 3 (control site) ranged from 4.5 to 6.6.

Top soil control (TS_C) had pH 4.5 which is acidic while top soil site 1(TS_1) and Top soil site 2 (TS_2) had pH values of 5.8 and 6.6 respectively indicating less acidity. In the sub-soil samples, the pH ranged from 5.0 to 6.5 whereas the control site (SS_C) recorded the lowest pH of 5.0 (acidic) and pH of 6.5 for subsoil site 1 (SS_1) and subsoil site 2 (SS_2) showing that they were still less acidic.

This suggests that the soil samples from the farmlands near the dumpsite were less acidic; this agrees with the findings of Uba *et.al*, (2008) Elaigwu *et.al*, (2007) and Gupta & Sinha, (2006). The degree of acidity and /or alkalinity is considered a master variable that affects nearly all soil properties. While some organisms are unaffected by rather broad range of pH values, others may exhibit considerable intolerance to even minor variations in pH.

For example, the amount of acid or alkaline in soils determines availability of many nutrients for plant growth and maintenance (Arias *et.al*, 2005). Thus, as a key player in soil microbial reactions, pH values may as well have implication on availability and uptake of metals by plant and microorganism.

The electrical conductivity of the top soil samples ranged from 20.0 to 184.0 µs/cm with TS_1 (184.0 µs/cm), TS_2 (45.0µs/cm) and TS_C (20.0 µs/cm). The electrical conductivity of the subsoil samples ranged from 10.0- 462.0 µs/cm with SS_1 recording the highest (462.0 µs/cm), SS
2 (45.0 µs/cm) and the least SS_C (10.0 µs/cm).

This implies that the soil samples near the dumpsite recorded higher conductivity values than the control sample. Similar results were reported for some dumpsites at Zaria (Uba *et.al*, 2008). The high conductivity values of soil samples at dumpsites may be linked to the presence of metal(s) which is one of the constituents of the refuse dumpsites and it implies that there are more soluble salts in the soil (Arias *et.al*, 2005; Karaca, 2004; Singer & Munns, 1999).

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The high levels of nutrients (nitrate, phosphate and sulphate) in the soil near the waste dumpsites may have contributed to the good growth of plants around these sites as in line with the findings of Obasi *et.al*, (2012).

In the pawpaw samples, for contaminated sites the fruits had heavy metal accumulation in decreasing order as As>Al>Hg>Zn>Ni>Cu>Cd>Pb while the control site was, As>Al>Hg>Zn>Cd>Ni which is similar to the order in contaminated sites.

In pawpaw root samples, the heavy metals accumulation in decreasing order was As>Al>Hg>Cu>Zn>Pb>Cd>Ni>Ag while in control site the order was As>Al>Hg>Zn>Cd>Pb>Ni.

The accumulation order of the heavy metals for pawpaw leaf samples in contaminated sites was Cu>As>Al>Hg>Fe>Zn>Ni>Cd>Pb decreasingly while the control site had the order was Hg>Al>As>Ni>Zn>Pb>Cd.

The order of abundance or concentration of the heavy metals in the soil samples from mechanic village site 1 was Fe>Al>As>Cu>Hg>Zn>Pb>Ni>Cd. In contaminated site 2, the order was Fe>Al>Cu>As>>Zn>Pb>Hg>Ni>Cd while in the control site the order of abundance of the heavy metals was Hg>As>Fe>Al>Cu>Cd/Zn/Pb>Ni. Cd, Zn and Pb had the same mean concentration and were equal in abundance in the soil of control site.

The availability of some of these heavy metals in the soil, especially in the contaminated sites, was due to the activities that are embarked on in the automobile mechanic village. Iron and iron alloy (Steel) are by far the most common metals, and ferromagnetic materials in everyday use and sources include metal processing and plating, paints (car paints) and steel (Sautra, 2008). The higher levels of Cu in the automechanic locations may also be traceable to high use of copper conductors and wires, tubes, solders and myriads of other maintenance items made of Cu.

According to Alloway (1990) and Lenntech (2009), when Cu ends up in soils, it strongly attaches to organic matter and minerals. As a result, it does not travel far after release. Pb can find its way to the soil through use of leaded fuels, old lead plumbing pipes or old orchard sites where lead arsenate was used (Traunfeld & Clement, 2001).

Mercury (Hg), due to several industrial activities such as car-painting, petrochemical usage and agricultural sources like fertilizers and fungicides sprays (Resaee *et.al,* 2005), can find its way into the soil. Chromium (cr) exists as metal alloy and pigment for paints, cement, paper, rubber and other materials (Sautra, 2008).

The values of cadmium (Cd) in the soils in the mechanic village may be because Cd is a “modern metal” used increasingly in corrosion prevention (Alloway, 1990). Mostly, it is often used instead of zinc (Zn) for galvanizing iron and steel (Turker *et.al*, 2005). Cd is also produced inevitably as bye product of zinc refining, since the metal occurs naturally within the raw ore (Idodo-Umeh & Ogbeibu, 2010).

From the variation plot, the concentration of Cu in the soil was higher than those accumulated by the plant parts with pawpaw parts accumulating more than cassava parts.

Al ions correlated positively with Total Coliform Count (r=0.095) at P<0.05, and Pb correlated highly negatively with TCC at P<0.01 (r = -0.962). This means that the presence of Al seems to support the growth of the coliform microorganisms while Pb had inhibitory effects on the coliform organisms.

CONCLUSION

The high levels of the heavy metals in the soil, four (4) meters away from the dumpsites in Nekede automobile mechanic village recorded in this study pose health risks to the inhabitants of such area, and people who farm around the dumpsites. It also raises significant environmental concern on the levels of soil contamination which may out of run-off find its way into the nearby river, "Otamiri River" that serves as source of domestic water at study area.

The plants in this study absorbed these heavy metals in their various parts and these plants are often consumed by man as part of his food; if consumed in high concentration they can lead to bioaccumulation of these heavy metals in the tissues, and can also elicit diseases, especially in the immuno-suppressed or immuno-compromised individuals.

This study indicated that the micro-organisms in the soil samples were in quantum indicating high proliferation due the presence of other nutrients in the dumpsites, and some of their ability to utilize the trace metals as nutrients.

There were also some local trees and weeds in such environment that could be acting as phytoaccumulators to some of these heavy metals which made them not to be highly concentrated in the plants sampled.

The safest place to cultivate is from 50m to 100m upstream of the dumpsites. This is because downstream of the dumpsite flows into the Otamiri River and naturally all flows whether surface or underground are in the direction of river channels. In this case, the Otamiri River channel serves as the main recipient of all flows. Concentration of heavy metals in the initial stage will be localized around the dumpsites but with time, it will increase downward towards the river. Hence, strict adherence to proper disposal of auto-mechanic wastes should be followed, while farmers in such areas are advised to refrain from planting around the mechanic villages as the soils there are highly contaminated by heavy metals which tantamount to possible uptake by plants in such area but should cultivate from 50m and above upstream of the dumpsites.

REFERENCES

Agency, for Toxic Substances and Disease Registry (ATSDR) (2005). US Department of Health and Human Services. Division of Toxicology and Environmental Medicine Arsenic.

Alloway B.J. (1990). Soil processes and the behavior of metals. In: Heavy metals in soils,
B.J Alloway. Blackie and Son Ltd Glasgow

Arias, M.E., Gonzalez-perez J.A., Gonzalez-Villa F.J. & Ball A.S. (2005).Soil: A new challenge for Microbiologists and chemists. *Microbio*., 8:13-21.
Barron, M.A. (1990). "Bioconcentration" will Water Born Organic Chemical Accumulate in Aquatic Animals? In: *Environmental Science and Technology*. 24(2): 1612-1618.
Beek, B. (2000). Bioaccumulation; New Aspects and Developments. In: Handbook of Environmental Chemistry, vol. 2 Reactions and Processes. New York: Springer – Veriag, 21-22.
Elaigwu, S.E., Ajibola, V.O. & Folaranmi, F.M. (2007). Studies on the impact of municipal waste dumps on surrounding soil and air quality of two cities in Northern Nigeria. *Journals of Applied Science*, 7:421-425.
Gupta A.K. & Sinha S. (2006).Chemical fractionation and heavy metal accumulation in the plant of *Sesamum indicum* (L.) Var T55 in soil amended with tannery Sludge; Selection of single extractants. *Chemosphere*, 64:161-173.
Idodo−Umeh, G. & Ogbeibu, A.E. (2010). Bioaccumulation of heavy metals in cassava tubers and plantain fruits grown in soil impacted with petroleum and non−petroleum activities. *Research Journal of Environmental Science.* 4:33−41.
Karaca A. (2004). Effect of organic wastes on the extractability of cadmium, copper, nickel and zinc in soil.*Geoderma*,122:297-303.
Lenntech W. (2009). Chemical properties, Health and Environmental effects of copper. Lennitech water treatment and purification Holding B.V. www.lenntech.com/periodic/elements/cu.htm
Resaee, A., Derayat, J., Mortazari, S.B., Yamini, Y. & Jafarzadeh, M.T. (2005). Removal of Mercury from chlor-alkali industry waste water using Acetobacter Xylium Cellulose. *American Journal of Environmental Sciences*, 1(2):102-105.
Sautra, S.C. (2008). Metals in the Environment, In: Environmental Science, 2nd Ed. New Central Book Agency, Kolkaka. 450-465.
Singer M.J. & Munns D.N. (199). Soil: An introduction.4th Edn Prentice –Hall; Inc; New Jersey, U.S.A 1-254
Uba, S., Uzairu, A., Harrison, G.F.S., Balarabe, M.L. & Okunola, O.J. (2008). Assessment of heavy metals bioavailability in dumpsites of Zaria Metropolis, Nigeria. *African Journal of Biotechnology,* 7:122-130.