Impacts of Heavy Metals Concentration on Two Major Anthropogenic Soils in Ibadan, Nigeria

***Oluwaseun A. AKINYELE[1], Oluseyi E. EWEMOJE[2], A. Isaac BAMGBOYE[2]**

[1]Department of Agricultural and Bio-Environmental Engineering, Federal College of Agriculture, Ibadan, Nigeria
[2]Department of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Nigeria

*Corresponding Author: seunakinyele.oa@gmail.com

Abstract - **Different human activities have altered soil quality and reduce the ability of the soil to perform its essential functions. This study aims to investigate the possible impacts of heavy metals concentration on anthropogenic soils and on the immediate environment. The soil particle size (sand, silt, and clay) was determined by hydrometer method while the soil pH was determined using a digital pH meter. The soil samples were analyzed for selected heavy metals (Pb, Cd, Zn, Cu, Ni) contamination using Atomic Absorption Spectrophotometer (AAS). All the experimental data obtained were statistically analyzed using One-way Analysis of Variance and the means were separated using Duncan Multiple Range Test to check their significance and variations among the parameters of the soil. The particle size revealed that the soil is very sandy leading to high rapid water infiltration and very low nutrient storage capacity while the soil pH showed that the soil is moderately acidic. The heavy metals concentration shows that Lead (Pb) ranges from 0.89 to 7.04 mg/L, Cadmium (Cd): 0.01 to 0.32 mg/L, Zinc (Zn): 5.15 to 23.37 mg/L, Copper (Cu): 0.12 to 1.55 mg/L while Nickel (Ni): 0.06 to 0.28 mg/L. The results indicated significant differences at $P \leq 0.05$ for all the parameters except Cadmium and pH. The wastes from these anthropogenic activities have negative impacts on the soil and the elevated level of heavy metals in the soil also poses health risk on human and immediate environment.**

Keywords—Anthropogenic, Heavy metals, Soil, Auto-mechanic, Cassava processing

1. INTRODUCTION

Environmental pollution caused by heavy metals has adversely affected soil quality and poses a threat on human health and immediate environment which may require a rapid solution. According to [1], several anthropogenic sources of pollutants can contaminate the soil and water environment, such as wastewaters flowing from mines and waste storage, runoff of pesticides from agricultural land, wastes from automobile workshops, and wastewaters from cassava processing mills. The increasing numbers of residents especially in the urban areas are exerting more pressure on soil resources which may change the properties and quality of soils. One of the greatest threats to sustainable development is soil degradation which is gradual contamination and lowering of soil quality due to human activities.

Auto-mechanic activity has remained a major source of proliferation in heavy metal concentration of the soil and the environment in Nigeria [2]. Despite that fact that auto-mechanic activities have proved to produce harmful wastes, the pollution impacts of these activities in Nigeria have received inadequate attention. Therefore, there is need to continually monitor their nature, volume, direct harmful effects and current methods of disposal as well as potential impacts on the environment. The heavy metals most frequently encountered in this waste include copper, lead, cadmium, zinc, manganese and nickel, all of which pose risks on human health and the environment. In mechanic workshops, there are accidental or deliberate releases or discharge of wastes such as petrol, diesel, solvents, grease, and lubricants on the land and the atmosphere. Many of these petroleum products are chemicals that can be very poisonous and dangerous to human health, animals and soils. The use of automobiles has also led to trace element and heavy metals-contaminated soil, which have grave consequences on soil dwelling organisms [3]. According to [3], the toxicity or effects of heavy metals are consequences of an organism's position in the food chain, while in others; they are based on the genetic abnormalities as a result of physiological impairments.

Cassava processing is considered as polluting and a problem on natural resources, especially in highly concentrated industrialized areas. Due to the nature of cassava processing especially for starch extraction, it produces large amounts of effluent which is high in organic content. If untreated this may be displayed in the form of stagnant effluent ponds from which strong odours emanate. The increasing concentration of heavy metals due to cassava processing has led to bioaccumulation of metals in flora and fauna. Heavy metals are not biodegradable so they accumulate in primary organs in the body and over time begin to fester, leading to various symptoms of diseases [4]. Several studies have been conducted on adverse effects of waste effluents on soil and water environment [5]; [6]. Untreated or incompletely treated waste effluent can be harmful to both aquatic and terrestrial life by adversely affecting the natural ecosystem and also long term health effects [7]. This research therefore aims at investigating the possible impacts of heavy metals concentration on the anthropogenic soils and on the immediate environment.

2. METHODOLOGY

Study Area and Soil Sampling

The soil samples used for the experiment were collected from two different sites (Auto-Mechanic Workshop and Cassava Processing Mill) at different locations within Ibadan, Nigeria. The samples were replicated three times and taken at two selected sites for each activity however the samples used as control were taken at 50 m away from the selected sites for each activity. The samples of auto-mechanic activity were taken at Odo-Ona and Ologuneru while that of cassava processing activity were collected at Odo-Ona and Eleyele. All the soil samples were taken with a soil auger at a root depth of 30 cm except that for bulk density and moisture content which were taken separately using a core sampler of 4.80 cm high and 2.55 cm radius. The soil samples were kept in polyethylene bags and labelled appropriately before transported to the laboratory, where they were air-dried for seven days. The soil samples were pulverized and sieved with a 2 mm mesh-sized sieve.

Soil Analysis

The sieved soil samples were thereafter analysed using ASTM and ASAE standard test methods. The soil particle size was determined by hydrometer method as described by [8] and [9], from which the values of sand, silt and clay were obtained. The soil pH was determined using a glass electrode digital pH meter i.e. by potentiometric method as described by [10]. The heavy metals namely: lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu) and nickel (Ni) were analysed. The soil samples were first extracted by 0.1 N of Hydrochloric Acid (HCl) as described by [11]. The extracts were then analysed to determine the heavy metals present using Atomic Absorption Spectrophotometer (AAS).

Data Analysis

The experimental data obtained were statistically analysed by One-way Analysis of Variance (1-way ANOVA) and the means were separated using Duncan Multiple Range Test (DMRT) to check their significance and variations among the parameters of the soil.

3. RESULTS AND DISCUSSION

(a) Particle Size Distribution

Table 1: Particle Size Distribution and pH of the Two Selected Soils

Parameter	Auto-Mechanic Site 1	Auto-Mechanic Site 2	Auto-Mechanic Control	Cassava Processing Site 1	Cassava Processing Site 2	Cassava Processing Control	Nature of Significance at $P \leq 0.05$
Sand (%)	85.47 ± 0.83^b	81.47 ± 0.83^c	85.53 ± 0.95^b	88.57 ± 0.65^a	85.47 ± 0.83^b	84.20 ± 1.00^b	Significant
Silt (%)	9.20 ± 0.10^a	9.13 ± 0.12^a	7.20 ± 0.10^b	5.20 ± 0.20^c	7.43 ± 0.15^b	9.33 ± 0.23^a	Significant
Clay (%)	5.50 ± 0.10^d	9.37 ± 0.25^a	7.37 ± 0.21^b	5.27 ± 0.31^d	6.23 ± 0.21^c	7.37 ± 0.25^b	Significant
pH	6.35 ± 0.18	6.10 ± 0.22	6.09 ± 0.59	6.31 ± 0.54	6.19 ± 0.73	6.02 ± 0.45	Not Significant

*Means with same superscript in a row are not significantly different at $P \leq 0.05$ by Duncan Multiple Range Test (DMRT)

The soil particle size (Table 1 and Figures 1, 2, 3) at the first site of auto-mechanic was 85.47% sand, 9.20% silt, and 5.50% clay, and at the second site, the particle size was 81.47% sand, 9.13% silt, and 9.37% clay at the depths of 0 - 30cm respectively. At cassava processing, it was obtained to be 88.57% sand, 5.20% silt, and 5.27% clay at site 1, and 85.47% sand, 7.43% silt, and 6.23% clay at site 2. It was observed that the soils of both sites have very high sand content leading to high rapid water infiltration and lowest water holding and very low nutrient storage capacity resulting in high carbon-nitrogen ratio. Both soils have almost balanced values of silt and clay with high amount of sand content. The particle size distribution puts the soils in the sandy or silty or clayey and textural classification. It is expected that the concentrations of elements of interest, Pb, Cd, Zn, Cu, and Ni may increase with depth, possibly due to leaching from the surface. The study has shown that the anthropogenic activities have significant difference at $P \leq 0.05$ on the particle density of the soils.

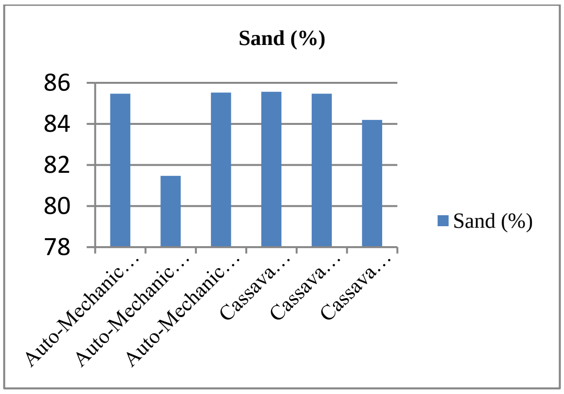

Figure 1: Effects of the Anthropogenic Activities on Particle Size (Sand)

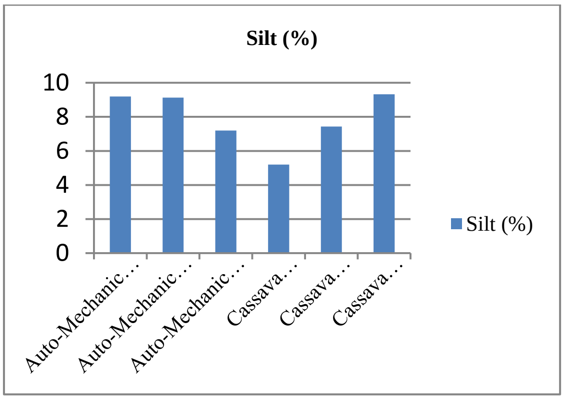

Figure 2: Effects of the Anthropogenic Activities on Particle Size (Silt)

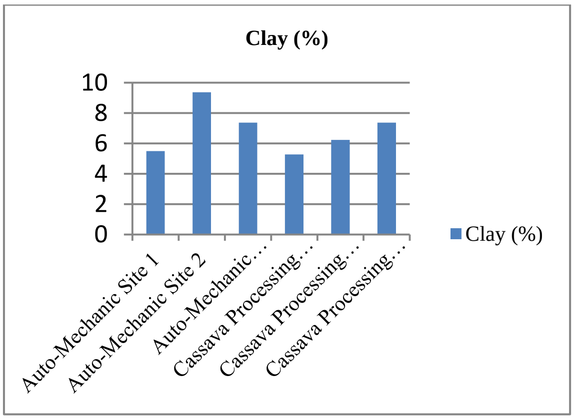

Figure 3: Effects of the Anthropogenic Activities on Particle Size (Clay)

(b) Soil pH

The soil pH (Table 1 and Figure 4) for auto-mechanic workshops ranges from 6.09 to 6.35 while that of cassava processing area 6.02 to 6.31, which indicated that the soils in these areas are acidic. This suggests that the effluent from cassava processing and engine oil from auto-mechanic activities imparted acidic properties to the soil. The acidity could be attributed to the presence of cyanide and toxic substance in the cassava mill effluent and the engine oil respectively. Acidic soils frequently experience deficiencies in calcium, phosphorus and magnesium while alkaline soils demonstrate deficiencies in phosphorus and many micronutrients. The availability of aluminium and manganese can also approach toxic levels in acidic soils and impair plant growth. Acidic soil often causes the stunting and yellowing of leaves, resulting in the decrease in growth and yield of crops as the pH levels falls. The pH values reported in this study are in the same range with those reported by [12] and [13]. The values are however higher than those reported by [14] and [15]. The pH values (Table 2) obtained in this study indicated a generally high tendency for high availability of the metals hence; this increases the risk of heavy metals plant uptake. It is therefore observed that the anthropogenic activities from both sites might have imparted greatly and significantly on the soils though the pH values were not significantly different at $P \leq 0.05$. The soil pH acts indirectly on plant growth by affecting availability of nutrients, the presence of toxins and the growth of soil microorganisms [16].

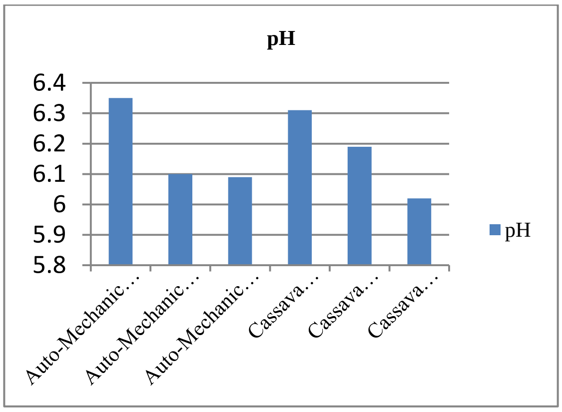

Figure 4: Effects of the Anthropogenic Activities on Soil pH

(c) Heavy Metals Concentration

Different studies have shown that urban soils receive loads of contaminants that are usually greater than rural areas, due to the higher amount of anthropogenic activities of urban settlements [17]. This is largely confirmed by this study judging from the concentrations of the heavy metals investigated in the main sites and the control areas. As recorded by [18] and [19], it is important to note that there are no soil quality guidelines for heavy metals in soils in Nigeria. Therefore the results obtained on heavy metals in this study as shown in Table 2 and Figures 5, 6, 7, 8 are discussed in the context of the standards set elsewhere.

Table 2: Heavy Metals Concentration of the Two Selected Soils

Parameter	Auto-Mechanic Site 1	Auto-Mechanic Site 2	Auto-Mechanic Control	Cassava Processing Site 1	Cassava Processing Site 2	Cassava Processing Control	Nature of Significance at $P \leq 0.05$
Lead, Pb (mg/L)	7.04 ± 0.31^{b}	4.72 ± 0.33^{c}	1.14 ± 0.06^{d}	1.12 ± 0.08^{d}	0.89 ± 0.13^{d}	16.17 ± 0.17^{a}	Significant
Cadmium, Cd (mg/L)	0.04 ± 0.02	0.05 ± 0.02	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.32 ± 0.42	Not Significant
Zinc, Zn (mg/L)	21.35 ± 0.23^{b}	23.37 ± 0.42^{a}	8.40 ± 0.44^{c}	5.15 ± 0.05^{e}	7.70 ± 0.20^{d}	23.03 ± 0.21^{a}	Significant
Copper, Cu (mg/L)	0.80 ± 0.10^{c}	1.55 ± 0.05^{a}	1.00 ± 0.20^{b}	0.12 ± 0.03^{d}	0.13 ± 0.06^{d}	0.83 ± 0.08^{bc}	Significant
Nickel, Ni (mg/L)	0.28 ± 0.08^{a}	0.16 ± 0.06^{b}	0.15 ± 0.03^{b}	0.06 ± 0.01^{c}	0.11 ± 0.01^{bc}	0.18 ± 0.02^{b}	Significant

*Means with same superscript in a row are not significantly different at $P \leq 0.05$ by Duncan Multiple Range Test (DMRT)

Lead (Pb) concentration, as shown in Table 2 and Figure 5, were 7.04 mg/L and 4.72 mg/L for auto-mechanic sites, and 1.12 mg/L and 0.89 mg/L for cassava processing sites while for the controls, auto-mechanic was 1.14 mg/L and cassava processing was 16.17 mg/L. The value obtained at the control site of cassava processing was deemed significantly higher than other values, followed by auto-mechanic sites 1 and 2. All the Pb values obtained were lower than 1162 mg/kg reported by [20] for auto mechanic workshop area in Owerri, South-East Nigeria. As reported by [21], the levels are in line in South-South Nigeria and also those in industrial areas in North-West Nigeria, and also by [22] in central Nigeria. According to [23], the acceptable limits of lead concentrations vary widely with countries. Virtually all the levels of Pb obtained in this study are higher than the acceptable limits for soils according to World Health Organization (WHO) in several countries. The high concentration especially at cassava processing control could be attributed to the overall high level of contamination of the environment with this metal (Pb), which can be traced to largely to the activities in the cassava processing areas. It was reported that Pb has the highest composition of heavy metals in waste oils from auto-mechanics [24]. It is possible that these levels of Pb are elevated by amount of waste oil, presence of automobile emissions, and expired motor batteries indiscriminately dumped by battery chargers and auto mechanics in the surrounding areas. It could also be attributed to the waste effluents released during the processing of cassava to garri, fufu, etc., which contain hydrogen cyanide. It was observed that the anthropogenic activities imparted significantly on the soils and that the levels of concentration of Pb were significantly different ($P \leq 0.05$).

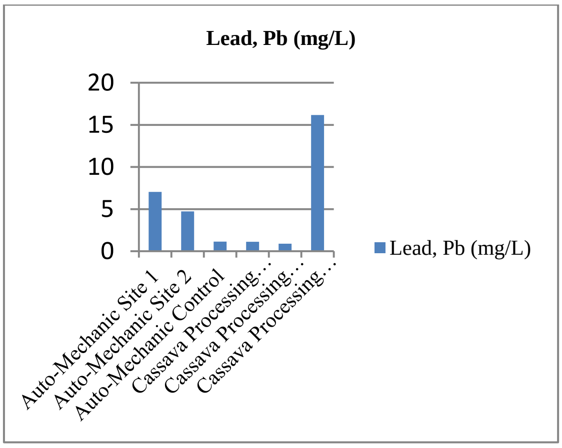

Figure 5: Effects of Lead Concentration on the Anthropogenic Soils

Cadmium (Cd) concentration, as shown in Table 2 and Figure 6, of in both soils are low and almost in the same range of values except at cassava processing control. It was reported by some researchers that cadmium is regarded as one of the most toxic heavy metals even at low concentration as obtained in this study. The concentrations obtained at both sites are still relatively within the acceptable limits in Germany (Lacatusu 2000) and World Health Organization (WHO) standard. This elevated Cd concentration at the control of cassava processing site is consistent with that of [25] who investigated heavy metals in soils of auto-mechanic shops and refuse dump sites in some parts of Makurdi, Central Nigeria, as well and reported a range of 0.6 - 3.5 mg/kg. The results are also in the same range reported by [26] and [17]. The mean Cd levels especially in the auto-mechanic area confirm that the auto-mechanic workshop environment is generally Cd enriched. The main source of environmental Cd pollution is the ferrous-steel industry [27]; the accumulation of Cd in the areas studied is likely to come from lubricating oils, vehicle wheels and metal alloys used for hardening of engine parts (Dabkowska-Naskret, 2004), and cassava processing wastewater. Cadmium is a “modern metal” used increasingly in corrosion prevention and often used instead of zinc for galvanizing iron and steel. The Cd concentrations showed no significant difference at $P \leq 0.05$ but it is cleared that the anthropogenic activities had imparted on the soils.

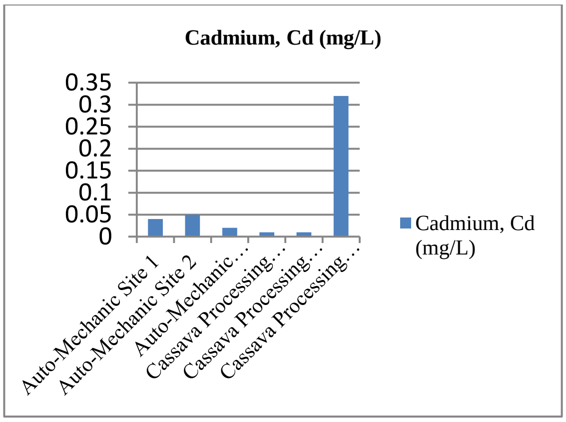

Figure 6: Effects of Cadmium Concentration on the Anthropogenic Soils

Zinc (Zn) concentration, as shown in Table 2 and Figure 7, in auto-mechanic soils had a mean range of 21.35 mg/L and 23.37 mg/L while the values of cassava processing were recorded to be 5.15 mg/L and 7.70 mg/L. The control value at cassava processing was also found to be high at 23.03 mg/L compared to that of auto-mechanic, 8.40 mg/L. There was significant difference at $P \leq 0.05$ among the concentrations of Zn which showed that the anthropogenic activities had imparted greatly on the soils. These high values especially at the auto-mechanic area suggest that, there is anthropogenic contribution. Since no industry exists in the vicinities of these areas, the elevation of Zn levels could be from the auto-mechanic workshops as Zn is noted to be a part of several additives to lubricating soils [26]. However, the concentrations of Zn in this study are small compared with many other studies [29]; [20] and [30], although it is comparable to that of soils in Cameroon, South East Korea and that of Yauri, North-West Nigeria [31]. Presence of zinc in the soil of cassava processing area could be attributed to corrosion of metal parts of the cassava milling machine. Zinc is also a component of crude oil and machine exhaust [32]. The Zn concentrations obtained are above the maximum allowable limits according to World Health Organization (WHO).

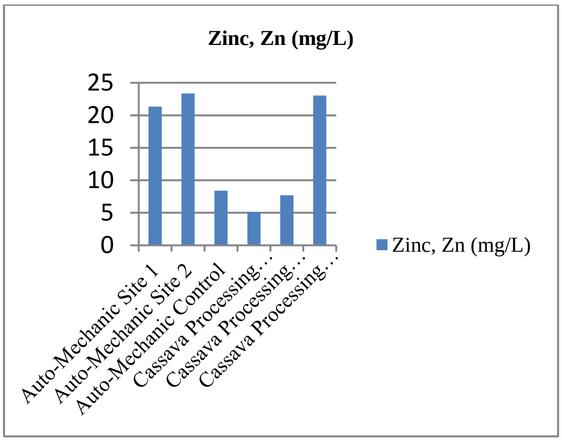

Figure 7: Effects of Zinc Concentration on the Anthropogenic Soils

Copper (Cu) concentration, as shown in Table 2 and Figure 8, obtained at the auto-mechanic area were slightly higher than those at the cassava processing except at the control site of cassava processing. There is mild range of distribution of Cu in the both sites with mean values of 0.80 mg/L and 1.55 mg/L for auto-mechanic, and 0.12 mg/L and 0.13 mg/L for cassava processing. According to World Health Organization (WHO), the concentrations of Cu obtained do not exceed the maximum permissible limits for heavy metals in soils and water. Likewise, when compared to the values obtained by some researchers; (100 mg/kg) in Australia, Canada, Poland, Great Britain, Japan (125 mg/kg), and Germany (50 mg/kg) [23]. The concentration of Cu could be ascribed to automobile wastes containing electrical and electronic parts, such as copper wires, electrodes and copper pipes and alloys from corroding vehicle scraps which have littered the vicinity of auto-mechanic workshops for a long time, with metals released from the corrosion gradually leaching into the soil [20]. Copper is a component of bronze and brass and is used as a corrosive resistant and decorating painting in machine such as cassava milling machine. The presence of Cu in the soils of cassava processing could also be attributed to the wearing or abrasion of the cassava milling machine parts and emission of these metals through the exhaust of the machine [33]; [34]. There is slight significant difference at $P \leq 0.05$ among the concentrations of Cu in the soils however the anthropogenic activities had contributed to the release of this heavy metal into the soil.

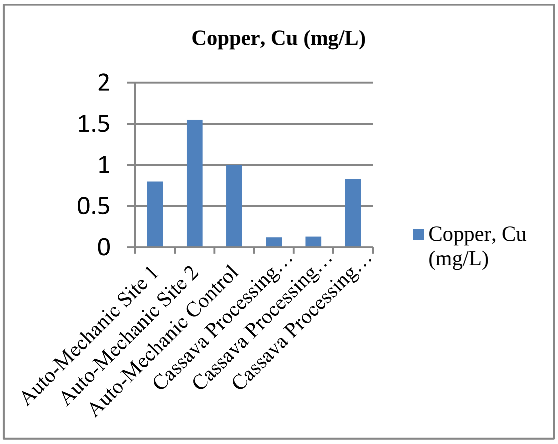

Figure 8: Effects of Copper Concentration on the Anthropogenic Soils

Nickel (Ni) concentration, as shown in Table 2 and Figure 9, in the soils investigated shows a distribution mean of 0.28 mg/L and 0.16 mg/L for auto-mechanic sites and 0.06 mg/L and 0.11 mg/L for cassava processing sites, while the mean values of 0.15 mg/L and 0.18 mg/L were obtained for the respective control sites. The results are lower than values of 11.5 mg/kg in [19] and 17.38 - 16.52 mg/kg recorded by [18]. Like the other metals, the distribution of Ni in this location could be attributed to the disposal of spent automobile batteries from the nearby auto-battery chargers and various paint wastes which have contributed to the contamination of the soil samples [21]. However, in all cases, the concentrations of Ni obtained were below the maximum allowable limits for heavy metals in soils and water according to World Health Organization (WHO), which suggests that, for now, there is little anthropogenic contribution which indicates low significant difference at $P \leq 0.05$ among the Ni concentrations.

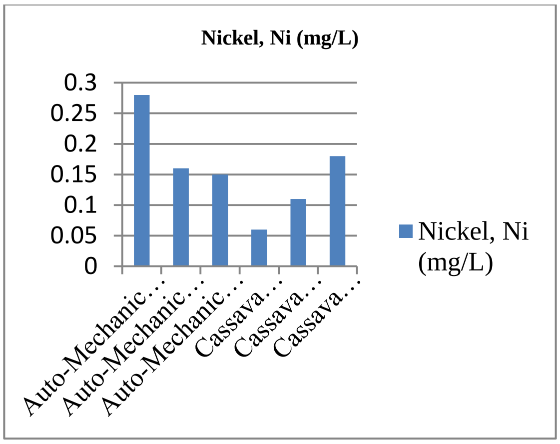

Figure 9: Effects of Nickel Concentration on the Anthropogenic Soils

4. CONCLUSIONS

The research examined the impacts of heavy metals (Pb, Cd, Zn, Cu, Ni) concentration) on anthropogenic soils, as it affects the human lives and the immediate environment. The following conclusions were made based on the results obtained from this research.

1. The auto-mechanic workshops and cassava processing areas studied were polluted with lead, cadmium, zinc, copper, and nickel.
2. The heavy metals contamination has anthropogenic sources which point to the activities in the auto-mechanic workshops and cassava processing site.
3. The high level of heavy metals poses health risks to inhabitants of those areas that engage in backyard farming and also contaminate the nearby water sources.
4. These anthropogenic activities also have negative (pollution) impacts on the environment, which calls for strict regulation on the areas and how waste coming from these vicinities can be disposed of properly.

REFERENCES

[1] Y. Song, J. Ji, C. Mao, Z. Yang, X. Yuan, G.A. Ayoko and R.L. Fros, Heavy Metal Contamination in Suspended Soils of Changjiang River - Environmental Implications. Geoderma, 2010, 159: 286–295.

[2] M.B. Adewole and L.U. Uchegbu, Properties of Soils and Plants Uptake within the Vicinity of Selected Automobile Workshops in Ile-Ife South-western, Nigeria. *Ethiopian Journal of Environmental Studies Management*, 2010, 3:3.

[3] U.C. Gupta and S.C. Gupta, Trace Element Toxicity Relationship to Crop Production, Livestock and Human Health, Comm. Soil Science, *Plant Anal.*, 1998, 29 (11-12):1491-1522.

[4] T.O. Siyanbola, K.O. Ajanaku, O.O. James, J.A.O. Olugbuyiro and J.O. Adekoya, Physicochemical Characteristics of Industrial Effluents in Lagos State, Nigeria. *Global Journal of Pure and Applied Science and Technology (GJPAST)*, 2011, 1: 49-54.

[5] R.K. Chaturvedi, K.P. Sharma, K. Sharma, S.M. Bhardwaj and S. Subhasini, Plankton Community of Polluted Waters around Sanganer, Jaipur. *Journal of Environmental Pollution*, 1999, 6: 77-84.

[6] D.T. Sponza, Necessity of Toxicity Assessment in Turkish Industrial Discharges (Examples from Metal and Textile Industry Effluents). *Environmental Monitoring Assessment*, 2002, 73 (1): 41-66.

[7] V.J. Joshi and D.D. Santani, Physicochemical Characterization and Heavy Metal Concentration in Effluent of Textile Industry. *Universal Journal of Environmental Research and Technology*, 2012, 2(2): 93-96.

[8] C.J. Bouyoucous, A Recalibration of the Hydrometer Mechanical Analysis of Soil. *Agronomy Journal*, 1951, 43:434-438.

[9] J.O. Agbenin, Laboratory Manual for Soil and Plant Analysis (Selected Methods and Data Analysis). Faculty of Agriculture, Institute of Agricultural Research, Ahmadu Bello University, Zaria, 1995, 7-71.

[10] N.C. Brady and R.R. Weil, The Nature and Properties of Soil, 12th Edition, *Prentice Hall, Incorporation*, 1990, p.363.

[11] C.A. Black, Methods of Soil Analysis, Pp. 1090-1100. Agronomy No. 9, Part 2. *American Society of Agronomy, Madison, Wisconsin*, 1965.

[12] M. Rashad and F.A. Shalaby, Dispersion and Deposition of Heavy Metals around Municipal Solid Waste (MSW) Dumpsites, Alexandria, Egypt. American-Eurasian, *Journal of Agricultural Environmental Science*, 2007, 2(3), 204-212.

[13] P.O. Oviasogie and A. Ofomaja, Available Mn, Zn, Fe, Pb and Physicochemical Changes Associated with Soil Receiving Cassava Mill Effluent, *Journal of Chemical Society, Nigeria*, 2007, 31(1) 69-73.

[14] A.O. Ano, S.A. Odomelam and P.O. Ekwueme, Lead and Cadmium Levels in Soils and Cassava (manihot esculenta grantz) along. Enugu- Port Harcourt Express Way in Nigeria, *Elect. J. Environ. Agric. Food Chem.*, 2007, 6(5), 2024-2031.

[15] A.A. Amusan, D.V. Ige and R.J. Olawale, Human Ecology. *Environmental Science Journal*, 2005, 17, 167 – 171.

[16] Thumma, Dawn Walls, How does pH level affect the plant growth, 2000.

[17] B.A. Adelekan and A.O. Alawode, Concentrations of Municipal Refuse Dumps to Heavy Metals Concentrations in Soil Profile and Ground Water, Ibadan, Nigeria. *Journal of Applied Bioscience*, 2011, 40:2727-2737.

[18] C.M.A. Iwegbue, N.O. Isirimah, C. Igwe and E.S. Williams, Characteristic Levels of Heavy Metals in Soil Profiles of Automobile Mechanic Waste Dumps in Nigeria. Environmentalist, 2006, 26:123 - 128.17

[19] A.R. Ipeaiyeda, M. Dawodu and T. Akande, Heavy Metals Concentration of Topsoil and Dispersion in the Vicinities of Reclaimed Auto-Repair Workshops in Iwo, Nigeria. Res. J. Appl. Sci. 2007, 2(II):1106-1115.

[20] M.A. Nwachukwu, H. Feng and J. Alinnor, Trace Metal Deposition in Soil from Auto-Mechanic Village to Urban Residential Areas in Owerri, Nigeria. *Proceedings of Environmental Science*, 2011, 4: 310-322

[21] I.I. Udousoro, I.U. Umoren and E.O. Asuquo, Survey of Some Heavy Metal Concentrations in Selected Soils in South Eastern Parts of Nigeria. *World J. Appl. Sci. Technol.* 2010, 2(2):139 - 14.

[22] A.A. Pam, R. Sha'Ato and J.O. Offem, Contributions of Automobile Mechanic Sites to Heavy Metals in Soil: A Case Study of North Bank Mechanic Village Makurdi, Benue State, Central Nigeria. *J. Chem. Biol. Physical Sci.* 2013, 3(3):2337-2347.

[23] R. Lacatusu, Appraising Levels of Soil Contamination and Pollution with Heavy Metals. In: H. J. Heineke, W., Eckelmann, A.J., Thomasson, R.J., Jones, A., Montanarella, L., and Buckley, B. (Eds.). European Soil Bureau- Research Report No. 4, Section 5(7):393-403. *The European Soil Bureau, Joint Research Centre, I-201020 ISPRA – Italy, 2000.*

[24] I. Oguntimehin and K.O. Ipinmoroti, Profile of Heavy Metals from Automobile Workshops in Akure, Nigeria. *Journal Environmental Science and Technology*, 2008, 1(7):19 - 26.

[25] L. Luter, T.J. Akaahan and S. Attah, Heavy Metals in Soils of Auto-Mechanic Shops and Refuse Dumpsites in Makurdi, Nigeria. *Journal of Applied Science and Environmental Management*, 2011, 15(1):207-210.

[26] E.S. Abenchi, O.J. Okunola, S.M.J. Zubairu, A.A. Usman and E. Apene, Evaluation of Heavy metals in Roadside Soils of Major Streets in Jos Metropolis, *Nig. J. Environ. Chem. Ecotoxicol.* 2010, 2(6):98 -102.

[27] S. Onder, S. Dursun and A. Demirbas, Determination of Heavy Metal Pollution in Grass and Soil of City Centre Green Areas (Konya, Turkey). *Polish J. of Environ.* 2007, 16(1):145 - 154.

[28] H. Dabkowska-Naskret, The Mobility of Heavy Metals in Urban Soils Used for Food Production in Poland. Land Contamination and Reclamation, 2004, 12(3):205-212.

[29] A.M. Nwachukwu, H. Feng and K. Achilike, Integrated Study for Automobile Wastes Management and Environmentally Friendly Mechanic Villages in the Imo River Basin, Nigeria. *African Journal of Environmental Science and Technology*, 2010, 4 (4): 234 - 294.

[30] D.T. Shinggu, V.O. Ogugbuaja, T.T. Barminas and I. Toma, Analysis of Street Dust for Heavy Metal Pollutants in Mubi, Adamawa State, Nigeria. *Int. J. Physical Sci.* 2007, 2(II):290-293.

[31] M.I. Yahaya, G.C. Ezeh, Y.F. Musa and S.Y. Mohammad, Analysis of Heavy Metals Concentration in Roadside Soil in Yauri, Nigeria. *Afri. J. Pure Appl. Chem.* 2010, 4(3):22-30.

[32] D.C. Adriano, Trace Elements in Terrestrial Environment (2nd edition) Springer-Verlay Company, New York, 2001.

[33] V. Pizl and G. Josens, Earthworm Communities along a Gradient of Urbanization, *Environmental Pollution*, 1995, 90(1), 7-14.

[34] S.A. Osakwe, Distribution of Heavy Metals in Soils around Automobile Dumpsites in Agbor and Its Environs, Delta State, Nigeria, *J. Chem. Soci. Nigeria*, 2010, 35(1), 53-60.