Heavy Metal Concentration of Dumpsite Soil and Accumulation in *Zea mays (corn)* Growing in a Closed Dumpsite in Manila, Philippines

Leah Amor S. Cortez and Johnny A. Ching

***Abstract*—The study determined the heavy metal concentrations (Cu, Zn, Cd and Pb) in dumpsite soil and accumulation in *Zea mays* (corn) growing in the area. The area of study is a closed dumpsite in Manila, Philippines covered with rich vegetation and being used as agricultural land. Soils and plants were sampled and analysed using atomic absorption spectrophotometer (AAS). Concentrations of the metals in the dumpsite soil and plant parts were found to be in higher concentrations compared to normal farmland which served as the control. Significant differences of heavy metals accumulations were observed per plant parts. Traces of metals were found in highest concentrations in the roots of all studied plants. Pb was found to be the only metal in plant parts exceeding the permissible limit given by WHO/FAO. The findings suggest that further study and proper legislation on the use of dumpsite soils must be taken into consideration.**

***Index Terms*—Cadmium, corn, copper, lead, zinc.**

I. Introduction

Soil contamination by heavy metals as a result of anthropogenic activities specifically in closed dumpsites is a major environmental concern all over the world. Closed dumpsites are often converted into agricultural land. Mining and smelting of metalliferous ores and metal scraps, electroplating, application of fertilizer and pesticides, sludge dumping and municipal waste have been identified as the sources of heavy metal contamination of the soil [1].

In the study in Nigeria, dumpsite rich soils is being used for cultivating fruits and vegetables without regards to the risk of toxic metal absorption by fruits and vegetables. People living near the area plant vegetables and other crops for their own consumption and for profit purposes.It showed that most closed dumpsite in their place contained high amount of heavy metals. Alarming result revealed that dumpsite soil contained above standard level of Cd. Levels of Cd and Pb in plants were also above the recommended level [2].

Heavy metals are described as those metals with specific gravity higher of more than 5 g/cm. Most common elements are copper, nickel, chromium, lead, cadmium mercury and iron. Some elements, such as iron and nickel are essential to the survival or all forms of life if they are low in concentrations. However, elements like lead, cadmium and mercury are toxic to living organisms even in low concentrations, and they cause anomalies in metabolic functions of the organism especially in greater quantities [3].

Zea mays (corn) is said to be the second most important crop in the Philippines and first in other countries. Some household depend on corn as source of livelihood. This crop can be easily be grown in almost any type of the soil, thus it is also being cultivated in polluted places such as neglected land areas and closed dumpsites without regarding the risk it may give to the consumers.

For over 40 years, Smokey Mountain served as a waste disposal facility for Greater Manila Area. Today, Smokey Mountain is a developed area with high tenements for its residents. Fumes from methane emitted by the garbage which was once the indicator of the dumpsite is now totally gone. Some remainder waste was now covered by different kinds of plants. Residents in the area cultivated the land and planted some vegetables and other crops for their consumption. The hazard of this practice has not been yet given importance. Heavy metal concentration of soil in the area as well as the heavy metal accumulation of plant is not yet identified.

It was this apprehension that led to this research on the determination of metal concentrations in soils and plant samples obtained within the community area of closed Smokey Mountain dumpsite in Tondo, Manila. Specifically to assess the environmental status of the area in terms of heavy metal concentrations in the soil and to determine the heavy metal accumulation in the roots, stems and leaves of corn plants growing within the community area of the closed dumpsite.

II. Materials and Methods

A. Sampling Sites

This study was conducted in the community area of the closed dumpsite of Smokey Mountain in Tondo, Manila, approximately, 0.5 km^2 in area with around 3,000 families [4]. At present, the abandoned dumpsite soil is being used for agricultural purposes by the residents wherein they cultivate vegetables and other food crops for consumption and business. The entire dump is wooded and covered by an abundance of spontaneous vegetation.

Soil and plant samples were also collected in an agricultural land located approximately 90 km away from the study site which served as the control.

B. Collection of Plant and Soil Samples

Soils were sampled using an auger at the same locations as the plant at 15 cm rooting zone [5], indicated that the top soil layers as better indicators of metallic burdens. Fifteen

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soil samples were randomly collected and each five bulked, for three composite replicates.

Zea mays plants were collected at different distances and along four different directions from the center of the community area. Purposive sampling technique was used in the collection of the plant species. The choice of plant was based on the distance to the source of contamination and the availability at the point of collection. The whole plant parts including the roots, leaves and seeds/grain were collected. Two to six replicate samples were collected from each location within the area of 4.0 m^2. The samples were mixed to form a composite of the particular plant, stored and transported in a plastic bag to the laboratory for detailed analysis.

Soil and plant samples of the same species were also collected from a farm site approximately 90 km away from the study site, to serve as the basis of comparison from a non-polluted source [6].

C. *Preparation for Analysis*

Prior to the determination of heavy metal concentration, plant samples were dried at 50°C then ashed in the furnace at 450°C. One-half gram of dry samples was digested with 4 ml of 65% HNO_3, and 1 ml of 37% HCl for 20 min in a microwave oven. Remaining soil and sand particles were removed by a filter paper after digestion. The digested and filtered samples were diluted with 0.2% HNO_3. At the same time, blank solutions of 1 ml chloride acid and 4 ml of HNO_3 were prepared.

Soil samples were oven-dried at 100–105°C. A representative sample was taken by quartering technique and grinded using mortar and pestle to pass a 2-mm sieve. About 0.5 g of the samples were weighed into a porcelain crucible and ignited at 450°C in furnace to destroy organic matter, then digested twice with 10 ml of a mixture of 1:1 mixture of concentrated HNO_3 and HF in a 100 ml polyprylene beaker and placed over a water bath for evaporation till dryness. The residue were dissolved in 20 ml of 2M HNO_3 and diluted to mark in 100-ml volumetric flask. This was done at the Biology Research Laboratory (PCH201) of De La Salle University-Dasmariñas in Dasmariñas, Cavite.

D. *Concentration Analysis*

The concentration of the following heavy metals, Cu, Zn, Cd, and Pb, in both ashed plants and digested soil samples were analyzed using the graphite furnace atomic absorption spectrophotometry (AAS) of the Chemistry Research Center of De La Salle University in Manila.

E. *Data Gathering and Statistical Analysis*

To determine the significant difference in the heavy metal concentrations among collected plant species and the pattern of variations in the heavy metal content found in different parts of the collected plant species, two-way analysis of variance (ANOVA) was used. Tukey method was used as post-statistical treatment data to determine the level of significance using statistical program in Microsoft Excel®. t-test was also used to determine the variations in heavy metal content per parts of plants.

III. Results

Table I indicates the concentrations (ppm) of heavy metals in soil samples from the dumpsite and control. Soils collected from the dumpsite were found to contain significantly (p<0.05) more metals than those collected from a farm land.

TABLE I: Metal Concentrations in Dumpsite Soil and Farm Soils.

Collection Sites	**Concentration (ppm)**			
	Cooper	**Zinc**	**Cadmium**	**Lead**
Normal metal content in soil	2-200	10-300	2-200	2-200
Farmland	4.271^{X}	3.464^{X}	0.076^{X}	1.764^{X}
Dumpsite	15.184^{AY}	53.283^{AY}	0.167^{BY}	15.465^{AY}

Letters XY show the significant difference between rows (farm and dumpsite). Letters AB show the significant differences between columns (Cu, Zn, Cd and Pb). Different letters indicate significant statistical (p<0.05)

Results obtained show that soils from the dumpsite recorded higher metal (Cu, Zn, Cd, Pb) concentrations than their corresponding levels at the normal farmland. All heavy metals investigated in the dumpsite have significant differences from those obtained in the control. This is in agreement with the results obtained on similar studies [5], [7]. High levels of these metals in the dumpsite may be associated to its anthropogenic nature. Urban waste piled up in the dumpsite can be the main source of these metals and therefore sorting and recycling of wastes should be intensified to reduce the quantity of these metals at dumpsites.

In the analysis of the concentrations of heavy metals in the dumpsite soil, it could be noted that Zn had the highest concentration (53.283 ppm). Large disparity was observed between Cu (15.184 ppm) and Pb (15.465 ppm) concentrations with Zn. Cd (0.166 ppm) has the least concentration of all the heavy metals in the dumpsite. However, despite the variations in concentration levels obtained for these metals, the data gathered were still within normal ranges: Cu 2-100 ppm, Zn 10-300 ppm, Pb 2-200 ppm, and Cd 2-200 ppm for soil heavy metal content [5]. Metal concentration of the soil might be affected by the age of the dumpsite.

The investigated dumpsite has been closed since 1990, thus this may be connected to the below average limit of heavy metal concentration in the soil. Heavy metals concentrations in the soil may be lessen by leachate dripping from the soil to the lower part of the area. This conclusion is supported by the result of the studies done by Sustainable Project Management (SPM) done in 1993 and 2007 in leachate of the closed dumpsite. Even though these heavy metal concentrations fell below the critical permissible concentration level, it seems that their persistence in the soils of the dumpsite may lead to increase uptake of these heavy metal by plants [8].

The concentrations of metals in soils collected from the dumpsite can be ordered as Zn>Pb>Cu>Cd. Despite the variations, results in the dumpsite soil indicated that there were no significant differences between the three metals Zn, Cu and Pb. However, Cd showed significant difference among the investigated metals (p<0.05). Cd most often occurs in small quantities associated to the zinc ores. This exists in low concentrations in all soils. Almost all Cd in soil is only obtained as by-products of Zn, Cu, and Pb ore refining operation. This can be associated in the result observed in this study. Nevertheless, results obtained have shown that waste dumpsite may contribute significant levels of toxic metals to the environment and therefore sorting, recycling and reducing of waste should be intensified to lessen the quantity of these heavy metals at dumpsites.

Heavy metal concentrations in different parts of collected plant from the Smokey mountain dumpsite and control soils are given in Table II and Table III. This study was limited to the roots, leaves and seeds of *Zea mays* (corn) which were found in the dumpsite and its counterpart farm.

TABLE II: ESSENTIAL MICRONUTRIENT UPTAKE AND DISTRIBUTION IN CORN

Collection sites	**Concentration (ppm)**					
	Cooper			**Zinc**		
	Roots	**Leaves**	**Seeds**	**Roots**	**Leaves**	**Seeds**
Dumpsite	3.299^{XA}	1.031^{XB}	0.943^{XB}	14.83^{XA}	3.799^{XB}	3.279^{XB}
Farmland	2.624^{YA}	0.197^{YA}	0.145^{YA}	3.025^{YA}	2.065^{XA}	1.737^{YA}
*WHO/FAO		40ppm			60ppm	

Letters XY show the significant differences between collection sites (rows). Different letters indicate significant statistical.
Letters ABC show the significant differences between plant parts per metal (columns). Different letters indicate significant statistical.

TABLE III: NON-ESSENTIAL ELEMENT UPTAKE AND DISTRIBUTION IN CORN

Collection sites	**Concentration (ppm)**					
	Cadmium			**Lead**		
	Roots	**Leaves**	**Seeds**	**Roots**	**Leaves**	**Seeds**
Dumpsite	0.089^{XA}	0.084^{XA}	0.081^{XA}	4.811^{XA}	0.555^{XB}	0.676^{XB}
Farmland	0.052^{YA}	0.014^{YB}	0.021^{YC}	0.286^{YA}	0.122^{YB}	0.112^{YB}
*WHO/FAO		0.2ppm			0.3ppm	

Letters XY show the significant differences between collection sites (rows). Different letters indicate significant statistical.
Letters ABC show the significant differences between plant parts per metal (columns). Different letters indicate significant statistical.

Generally, most of the plant parts harvested from the dumpsite recorded to have significant and high concentrations of heavy metals ($p<0.05$) than their counterparts from control site as presented in Table II and Table III. This could be attributed to the high metal contents in the dumpsite soils which were eventually accumulated by plants grown on them. This also indicates that the concentrations of metals in plants are dependent upon their concentrations in the habitual soil environment [5].

Corn plant is one source of food by human and animals. Corns can be cultivated both in agricultural and urban soils. Corn is one food crop abundant in the study sites. Tables II and Table III showed the different concentrations of heavy metals in parts of corn found both in dumpsite and farmland. Corn parts gathered from the dumpsite accumulated higher heavy metal concentrations than their counterparts from the control and showed significant differences ($p<0.5$). Among all plant parts, roots accumulated the highest metal contents in the dumpsite wherein concentrations from highest to lowest were Zn 14.83, Pb 4.11, Cu 3.299 and Cd 0.089, respectively. Highest uptake of metals in roots compared to other parts was also observed in similar studies [9], [6]. The cited authors found that high accumulation of metals, specifically Zn, was found in the roots of corn and this might be attributed to the species ability to tolerate the metal toxicity. High concentration of metals might also be due to roots direct exposure to the contaminated soil. It was found that corn has a possibility of heavy metals accumulation (i.e. Cu and Zn) in roots, for the highest tolerable level of heavy metal contamination of soil [6].

When Zn is adequate in the soil Cd uptake of plant will not increase [2]. Thus, higher presence of Zn in the soil can also be related to the plant uptake of Cd. It can be noted that Cd has the least concentration among all metals observed.

Heavy metals accumulations in leaves and seeds of corn were also observed, wherein leaves and seeds from the dumpsite have higher metal concentrations with significant differences than those found in farmland. Accumulation of Cd and Pb were observed in similar studies in shoots and seeds of corn, same result in the present study in which leaves have higher concentrations of metals than seeds. High tolerance to heavy metals in corn plants can be seen in the result.

It can be noted in the results that accumulation of heavy metals Zn, Cu and Cd in all plant parts are within the given permissible limit by WHO/FAO on both dumpsite and agricultural land as shown in Table II and Table III wherein 40ppm (Cu), 60ppm (Zn) and 0.2ppm (Cd) are permissible heavy metal concentrations [10].

Among the heavy metals determined, concentrations of Pb on roots, leaves and seeds of corn grown on dumpsite soil went beyond the allowable limit of WHO/FAO (0.3ppm), with concentrations 4.811ppm, 0.555ppm, 0.676ppm respectively. This result is alarming since seed is being consumed by human and animals and the leaves are being fed to some farm animals. Bioaccumulation and toxicity of Pb must be taken into consideration. It can be noted that many metals act as biological poison even at parts per billion (pbb) levels.

Result from the study for the presence of Pb in the cultivated corn in dumpsite soils further strengthens the possible reason of increasing number of lead poisoning among humans. It is widely known the Pb has adverse effect on neurological and haematological of children and even adults [1]. Some other heavy metals are essential in very small concentrations for the survival of all life forms, such as, copper, iron, zinc, chromium and molybdenum and others. However, these can also be toxic in higher concentrations.

IV. CONCLUSION AND RECOMMENDATION

This research work has revealed that soils in the dumpsite have high concentration content of heavy metals Cu, Zn, Pb and Cd than its counterpart agricultural land. Consequently, plants grown on dumpsite soils accumulated higher concentration of heavy metals than plants grown on the normal farm soils; hence, efforts should be intensified to discourage the practice of cultivating at dumpsite soils which is a common practice of residence in Smokey Mountain, Tondo Manila.

Moreover, the alarming high concentration accumulated in corn grown in the dumpsite soil must be given attention. Despite the age of the closed dumpsite, Pb still occur and accumulated by other crops being grown. Cosuming of food with high metal content is exposing the individual into possible health risks.

These finding suggest that there is a need for attention to legislate for solutions to the problems of heavy metal contents of closed dumpsites. Further studies on similar sites and other plants must be given priority.

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REFERENCES

[1] V. Mudgal, N. Madaan, A. Mudgal, R. B. Singh, and S. Mishra. (2010). Effect of Toxic Metals on Human Health. *The Open Nutraceutical Journal* 3. PP. 94-99. [Online]. Available: http://www. Academia.edu

[2] A. Chaab and G.H. Savaghebi. (2010). Effect of Zinc Application on the Cadmium Uptake of Maize Growth. Segment Journals. AGS 1515. [Online]. Available: http//:e-segment.com

[3] S. E. Manahan, *Fundamentals of Environmental Chemist*ry, 2nd ed. CRC Press, LLC Boca Ralton, Florida, 2001, pp. 853-861.

[4] A. Celdran, "Smokey Mountain Development at Remediation Program," presented at the 13th Poverty and Environment Partnership Meeting, Manila, Philippines, 2007.

[5] G. Ebong, M. Akpan, and V. Mkpenie, "Heavy metal contents of municipal and rural dumpsite soils and rate of accumulation by *Carica papaya* and *Talium traingulare* in Uyo, Nigeria," *E-Journal of Chemistry*, vol. 5, no. 2, pp. 282-290, 2007.

[6] A. Sekara, M. Poniedzialek, J. Ciura, and E. Jedrszcyk, "Zinc and copper accumulation and distribution in tissues of nine crops: implication for phytoremediation," *Polish Journal of Environmental Studies*, vol. 14, no. 6, pp. 829-835, 2005.

[7] M. Ogundiran and O. Osibanjo, "Heavy Metal Concentrations in Soils and Accumulation in Plants Growing in a Deserted Slag Dumpsite in Nigeria," *African Journal of Biotechnology*, vol 7, pp. 3053–3060, 2008.

[8] N. E. Okoronkwo, S. A. Odemelam, O. A. Aro, "Levels of Toxic Elements in Soil of Waste Dumpsite," *African Journal of Biotechnology*, vol. 5, no. 13, pp. 241 -244, 2006.

[9] R. John, P. Ahmad, K. Gadgil, and S. Sharma, "Heavy Metal Toxicity: Effect on Plant Growth, Biochemical Parameters and metals accumulation by Brssica junea L.," 2009.

[10] S. Nii Odai, E. Mensah, D. Sipitey, S. Ryo, and E. Awuah. (2008). Heavy Metals Uptake by Vegetables Cultivated on Urban Waste Dumpsites: Case Study of Kumasi, Ghana. *Research Journal of Environmental Toxicology*. [Online]. Available: http://scialert.net

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