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Uptake of Heavy Metals in Sweet Corn

Petu-Ibikunle, Abiona M.

Faculty of Agricultural Sciences, Department of Crop and Soil Sciences,
National Open University of Nigeria.
Corresponding Author's email: **kunlepetu@gmail.com**
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ABSTRACT
A potted experiment was conducted in Lagos in the year 2016 to investigate the heavy metal content of soil samples collected from some suspected contaminated environments in the suburb of Lagos. To achieve this objective, four soil samples were taken from 4 different locations. Treatments (soil samples) were watered with rain water (as an alternative to distilled water). Sweet corn at fresh cob maturity stage (50 days after sowing), were destructively harvested and the maize cobs were analysed for their heavy metals content, using ICP-MS: Inductively Coupled Plasma - Mass Spectrometer for Toxic Metal Detection. The values of metals obtained were also correlated with the soils Physico-chemical parameters. The values obtained were subjected to Analysis of Variance. The concentration (mgkg-1) of the metals in sweet corn were significatly ($p \geq 0.05$) high. Antimony (1.2-1-4),(Arsenic (2.0-3.3), Cadmium (1.5-2.5), Lead (1.5-3.51), Mercury (1.0-2.0), Tin (1.68-1.7) and Chromium (1.2-1.0). Valuse of heavy metals obtained from the trial were compared with recommended standards values by authorities including : World Health Organization (0.3 - 1 mg /kg), European commission (0.1-1.0 mg /kg), codex general standard (1-2 mg /kg) and European soil protection (1-2 mg /kg), compost and sewage sludge regulations. The correlation analysis further showed that that heavy metal such as Cadmium has strong and positive correlation with soil organic carbon. Sorting of waste into Biodegradable and non-biodegradable components and a biotechnology approach of cleaning (phytoextraction, phytoviolatilization, rhizofiltration or phytostabilization) the heavy metal contaminated soils were recommended.

Keywords: Heavy metals, Environmental Contermination, Human Health and Bioremediation

INTRODUCTION

Human environment is heavily polluted with liquid, solid and gaseous wastes. It is important to mention that the wastes are products of improper disposal of human domestic, industrial and agricultural activities/waste. According to Edosomwan *et al*., (2012), most of the diseases (typhoid, cholera, paratyphoid fever, bacillary dysentery, infectious hepatitis, poliomyelitis, and parasitic worm infection etc.) that strikes human beings in recent discoveries are linked to contaminated food chain. According to Toth (2016), the case is not different with contamination of agricultural soils with heavy metals. Reports by Mosby *et al.*,(1996) reported that that there more than 20 heavy metals including antimony, arsenic, bismuth, cadmium, cerium, chromium, mercury, tin. These metals are mostly found in the environment and they consequently and subsequently end up in diet.When prensent in traced amounts, these heavy metals are required for maintaining good health, while in larger amounts they can be toxic.(Azita and Seid, 2008).

Arsenic contaminations occur in the environment as a result of both natural geological processes and the activities of man (Matschullat, 2000). It is also possible that anthropogenic sources of arsenic according to Smedley and Kinniburgh (2002), include human activities such as mining and processing of ores. It is important to emphasise that some drugs, paints, dyes, soaps, certain pesticides and fertilizers contain arsenic. Concentrated animal feeding operations also add to the release arsenic to the environment in higher amounts. The presence of Arsenic in the environment is of much concern like other heavy metals because of its carcinogenic tendencies. Arsenic have been reported to be responsible for causing cancer of lungs, liver, bladder and skin to humans that are exposed to arsenic by means of air, food and water(Chowdhury *et al.*, 2000: Hoque *et al.*, 2011).

Mercury is considered the most toxic heavy metal in the environment. Mercury is released into the environment by the activities of various industries such as pharmaceuticals, paper and pulp preservatives, agriculture industry, chlorine and caustic soda production industry (Morais *et al.*, 2012). Mercury is also generated naturally in the environment from volcanic emissions. It is then dispersed across the globe by winds, returning to the earth in

rainfall and accumulating in aquatic food chains. Mercury can also contaminate crops sprayed with mercury-containing pesticides. The brain remains the target organ of mercury, yet it can impair any organ and lead to malfunctioning of nerves, kidneys and muscles bronchitis, asthma and temporary respiratory problems. It can cause disruption to the membrane potential and interrupt with intracellular calcium homeostasis (Bernhoft, 2012).

Cadmium is a metal contained in soils and rocks, including coal and mineral fertilizers. Cadmium has many applications, e.g. in batteries, pigments, plastics and metal coatings and is widely used in electroplating (Martin and Griswold, 2009), Cadmium is released into the environment through natural activities such as volcanic eruptions, weathering, river transport and some human activities such as mining, smelting, tobacco smoking, incineration of municipal waste, and manufacture of fertilizers.Some food stuffs are naturally rich in cadmium, such as liver, mushrooms, shellfish, mussels, cocoa powder, and dried seaweed. Cadmium is nephrotoxic, initially causing kidney tubular damage. Cadmium can also cause bone damage, either via a direct effect on bone tissue or indirectly as a result of renal dysfunction. After prolonged or high exposure, the tubular injury may progress to glomerular damage with decreased glomerular filtration rate, and eventually to renal failure. Furthermore, recent data also suggest increased cancer risks and increased mortality in environmentally exposed populations(Lars and Agneta 2009).

Chromium is present in rocks, soil, animals and plants. It can be solid, liquid, and in the form of gas. Chromium compounds are very much persistent in water sediments. Insdustial products which turned to sources of chromium include protective metal coatings, metal alloys, magnetic tapes, paint pigments, rubber, cement, paper, wood preservatives, leather tanning and metal plating (Martin and Griswold, 2009). Chromium compounds forms a deeply penetrating hole when in contact with broken skins. Exposure to chromium compounds can result in the formation of ulcers, which will persist for months and heal very slowly, this explains why ulcers on the nasal septum are very common in case of chromate workers.

Lead exposure is mainly from industrial processes and domestic sources. The sources of lead are gasoline and house paint, which has been extended to lead bullets, plumbing pipes, , storage batteries, toys and faucets (Thürmer *et al.*, 2002). A significant level of lead is taken up by plants, fixation also take place in the soil and some flows into water bodies, hence human exposure of lead in the general population is either due to food, smoking, or drinking water (Goyer, 1990).

According to Hext *et al*., (1999), antimony is mosly used as flame repelant, car seat cover,clothing for kids, production of ceramics and batteries. The associated health hazards resulting from the exposure of antimony can really be a serious threat. Sickness like Adam stroke syndrome, depression, head ache and vomiting are some of the common sikness associated with antimony contermination.

Tin plated materials for food and bevrages parkaging result to some tin dissolving into food content. From published data, there appear to be small amount of evidence suggesting that consuption of food or bevrage containing at 200ppm caused gastro intestinal effect (Steve and Tony 2003).

There is no doubt that the government of Nigeria is aware of environmental pollution, this is justified by the creation of Federal Environmental Protection Agency (FEPA), Standard organisation of Nigeria (SON), National Agency for Food and Drug Control (NAFDAC), Organic Agriculture project in Tertiary Institution in Nigeria (OAPTIN) and National Biotechnology Development Agency (NABDA). The function of these agencies ranged between environmental conservation and sustainability, controlling environmental pollution and contaminations in agricultural production and in processed food, ensuring a standard presentation of finished products from consumer's feedback and acceptability point of view. It is however not certain if any of the listed organisations had been charged with the responsibilities of checking for the level of heavy metal contamination in agricultural produce.

The Main objective of this study is to investigate the safety level of the use of compost/organic manure from various environments that were considered the suspected polluted/contaminated environment. It was also intended to assess the level of contaminations by heavy metals on some purposefully sampled areas. And to investigate

the uptake of contaminants (heavy metals) absorbed by sweet corn grown on contaminated soil.

MATERIALS AND METHODS

A pot experiment was established to investigate the heavy metal content of soils collected from some suspected heavy metals contaminated soils. To achieve this objective, four soil samples were taken from different locations. The locations are (T1): Soil from auto mobile lead acid battery chargers workshop. (T2): soil deposited at a construction site for land filling purpose. (T3): An organic (compost manure farm site). (T4): Home-stead garden at Labora Owode (Ibeju lekki) village in Lagos. To maintain the inherent nutrient and heavy metal content of the soils, rain water was used for irrigating the experimental plants. The experimental crop was sweet corn. The seeds were sown on the 31stof December 2014. Four seeds were sown per hill (to make allowance for germination failure due to seed viability and effect of the suspected toxicity on seed germination.

At fresh cob maturity stage (recorded at 65 days after sowing), the maize cobs were analysed for their heavy metals content. The heavy metal content of the fresh sweet corn was analysed using: ICP-MS: Inductively Coupled Plasma - Mass Spectrometry for toxic Metal (Agilent Technologies, ICP-MS, A Primer*)* as decribed by Frank *et al*., (1992). The high sensitivity of the instrument allowed for detection at the parts-per-trillion (ppt) level. The operation of the ICP-MS was in simplified steps as follows: the fresh cobs to be tested were dissolved in acids and then heated in a closed vessel at 180˚C in a special oven.

Some soil properties were determined by standard laboratory methods. Soil pH was determined potentiometrically in 1:25 soil:water ratio (Hendershot *et al.,* 1993). Organic carbon was estimated using method described by Nelson and Sommers (1982), the organic carbon value was multiplied by 1.724 to obtain the organic matter content. Total available phosphorus was estimated using Bray II method by Olsen and Sommers, (1982). Total N using Kjeidal Digestion and Technicon/Auto analyzer method. The exchangeable acidity was estimated using extraction of exchangeable H^+ and $Al^{3+}$with KCl (Mclaren *et al.,* 1994). The effective cation capacity was estimated by the summation of all the exchangeable base and acidity. Exchangeable base was determined by extraction of ammonia acetate (NH_4O_{AC}) at pH 7.0. Calcium and magnesium were determined using AAS, while sodium and potassium were determined using flame photometer. Statistical Analysis **(**correlation analysis) was used to determine the relationship between some of the heavy metals and some soil properties.

The sweet corn on diferent soils in the potted experiment

RESULTS AND DISCUSSION

Antimony (Table 1b) is significantly (P≥0.05) higher from other metals. Concentration ranged between 1.22-1.40 mg/kg (1220 microgram/kilogram to 1400 microgram/kilogram). The values were higher than the minimum acceptable value (Table 1a) of 0.01-1.0 mg/kg recommended by Codex, European commission on compost and sewage sludge regulations and world health organisation. The values obtained from the

present study are on the high side and thus not consistent with Bowen, (1979) with concentrations of antimony in groundwater and surface water ranging from 0.1 to 0.2 mg/kg. Andrease *et al*., (1981) likewise reportted that marine antimony concentrations are approximately 0.15 mg/kg which is also lower than the 1.4mg/kg obtained from this experiment. The explaination according to WHO (2003) that higher levels of Antimony lower in waters, except in areas affected by acid mine drainage. The concentration of Antimony recorded in thid study is within the acceptable limit and therefore does not cause environmental contermination.

Arsenic concentration (Table 1) of sweet corn sown on soils from potentially conterrminated soils was significantly (P≥0.05) different. Arsenic concentration ranged from 2.0 – 3.3 mg/kg. Sweet corn sown on soil from auto mobile lead-acid battery chargers workshop recorded the highest Arsenic concentration (3.3) which above the acceptable recommended value. The arsenic concentration from soil collected from a civil work constrction site (2.1), compost manure farm site (3.0) and a homestead garden (2.0) fell within the recommended acceptable values (Table 1a) by Codex, European commission, European soil protection, compost and sewage sludge regulations and WHO. Lower concentrations (0.0736mg/kg) were earlier of arsenic was recorded by Uchino *et al*,. (2006). A high concentration of arsenic in the range of 1.5 to 5.0mg/kg in drinking water was also reported by Roychowdhury *et al*., (2003). The results from the various studies could be attributed to the consequenses of the various human industrial and agricultural activities in the various locations. The environments from which the soil samples were collected, except the auto- mobile batery chargers environment were thus considered safe from arsenic contermination.

Cadium level of the study sites (table 1b) was significantly different (p≥0.05) and is within the acceptable limit by WHO (2003), though cadmium concentration in auto mobile lead acid battery chargers work shop was(1.7), soil deposited at a construction site for land filling purpose was (1.6) and Home-stead garden at Labora Owode (Ibeju lekki) Village in Lagos was (1.5) was respectively higher than the acceptable limit(Table 1a) set by Ec, CODEX(table 1). Higher levels of cadimium recorded in the study sites could be attributed to impurities from fertilisers and leaching from discarded batteries. The result is in agreement with Satarug *et al*., (2011). Zhang *et al*.,(2015) with earlier report that Cadmium is predominantly found in fruits and vegetables due to its high rate of soil-to-plant transfer.

Lead concentration (Table1b) of sweet corn was significantly (p≥.05) high in auto mobile lead acid battery chargers work shop and home-stead garden at labora owode (ibeju lekki) village in lagos,the led concentration for the two sites were with the 3.51 and 2.3mg/kg respectively. These values(Table 1a) are higher than the 1.0 and 1.5 mg/kg recommended as acceptable limits by Codex, European commission, European soil protection, compost and sewage sludge regulations as well as WHO. This result is similar to what was reported by Azita and Seid, (2008) who recorded Lead concentration in 2 out of 10 water samples (0.055 and 0.053 mg/L). Lead concentration recorded slightly exceeded the recommended limit of 0.05 mg/l. According to Azita and Seid, (2008) accumulation of heavy metals (Pb, Cd) on soils irrigated with wastewater and sludge could lead to higher concentration that may pose potential environmental and health risks particularly on the long term basis**.** Similarly**,** the high level of lead detected in the corn from grown on the soil from the auto mobile battery charger may be a consequence of the deposition of lead from improperly disposed battery waste at the site; this may also pose a severe health risk to lives in the location.

Mercury content (Table1) of sweet corn was significantly high (p≥0.05) in auto mobile lead acid battery chargers work shop, soils deposited at a construction site for building foundation filling purpose, compost manure from an organic farm site and home-stead garden at Labora Owode village in Lagos were higher than the maximum acceptable limits recommended (Table 1a) by Codex, European commission, European soil protection, compost and sewage sludge regulations and also WHO. The highest concentration of mercury was recorded in sweet corn harvested from soil taken from auto mobile battery charger workshop (2.0mg/kg) and soil from wetland refuse dumping site (1.55 mg/kg). The present result conforms with Raque and Eleazer (2012) and Bieby *et al*.,(2011), showing that Mercury is a persistent environmental pollutant with bioaccumulation ability in fish, animals, and human beings. Mercury salts and organomercury compounds are among the most poisonous substances in our environment.

Chromium (Table1b) was significantly (P≥0.05) higher in home-stead garden at labora owode (Ibeju Lekki) village in lagos (2.01 mg/kg) a value higher than the max acceptable limit (Table 1a) recommended by Codex, European commission, European soil protection, compost and sewage sludge regulations and WHO. The 1.8, 1.5 and 1mg/kg recorded from auto mobile lead acid battery chargers work shop, soils deposited at a construction site for land filling purpose, and compost manure from an organic farm site were also above the recommended acceptable limits by the 3 regulatory bodies.The result of the present study can be explained from the report of Khan *et al*.,(2008). The indication is that there is a posibility of substantial build up of heavy metals in wastewater-irrigated soils, wastewater/wetlands, and improperlly disposed solid waste that consequently conterminates the environment. This was in further agreement with Abdulmumini *et al*., (2014) report that Industrial effluents are major source of water pollution in Nigeria. Exposure to chromium compounds can result in the formation of ulcers, which will persist for months and heal very slowly. Ulcers on the nasal septum are very common in case of chromate workers. Exposure to higher amounts of chromium compounds in humans can lead to the inhibition of erythrocyte glutathione reductase, which in turn lowers the capacity to reduce methemoglobin to hemoglobin.

Tin content (1.9mg/kg), of sweet(Table1) corn harvested from soil collected from homestead was significantly (P≥0.05) highest while the Tin content of soils from land filling at civil engineering work constuction site ranked next (1.7mg/kg). The values obtained were above max acceptable limit recommended (Table 1a) by Codex, European commission, European soil protection, compost and sewage sludge regulations and WHO. This result may be cosequent of the serries of deposition of waste materials made from tin deposited at various domestic/household environments. The explaiantion is that Tin is commonly used for parkaging of most beverages, juice drinks, alcohols, edible oil etc. This result agreed with the explaination of Afolayan *et al*., (2012) that, groundwater contamination is the function of types of waste, season, topography, soil, underlying geology, surface water ingression and direction of groundwater flow.

Cadmium content (Table1) of almost all the sweet corn significantly (P≥0.05) exceeded the permissible limits max acceptable limit recommended (Table 1a) by Codex, European commission, European soil protection, compost and sewage sludge regulations and WHO . Arsenic content was highest in cereals followed by Cadmium and Lead. The variations observed was attributed to use of fertilizers (which contributed to cadmium content). According to Saif *et al*, (2005) in a study carried out in industrial area of New Delhi, 2 of the 10 groundwater samples (0.0153 and 0.0104 mg/L) analysed exceeded the cut off set by WHO of 0.01mg/l for Cadmium**,** while in the present study Cadmium was much more higher and above the recommended safe level for consuption. Also similar to the result of this experiment is the reports of McLaughlina *et al*.,(1999) and Simmons *et al*., (2005) with a result that of all the elements, cadmium (Cd) is the most important worhy of consideration in terms of food-chain contamination. In places where soils are overloaded with this element, it is usually through the agricultural, industrial or urban activities of man.

Table 1a :Levels of Heavy Metals (mg/kg) Detected in Sweet Corn Planted on Conterminated Soils.

METAL	Description of crop item.	*proposed general limit European Commission. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs mg/kg*	*Max acceptable conc (ppm) Codex general standard for conterminants and toxin in food.*	*Statutory Order on Application of Waste Products for Agricultural Purposes well as compost maximum and mean admitted yearly loads of PTEs in European soil protection, compost and sewage sludge regulations mg /kg*
Antimony	Cereals and Vegetables	NA	1	1.001
Arsenic	Cereals and Vegetables	NA	1.4	3.00
Cadmium	Cereals and Vegetables	1	1	1.5
Lead	All foods	2	0.05	1.001
Mercury	All foods	1	0.05	1.5
Tin	All foods	1	0.05	1.500
Cr	All foods	NA	0.01	2.000

SOURCE: NAFDAC:2005

Table 1b:Levels of Heavy Metals (mg/kg) Detected in Sweet Corn Planted on Conterminated Soils.

Heavy Metal	T1	T2	T3	T4	LSD P≥0.05
Antimony	1.22a	1.2b	1.3ab	1.4a	0.1898
Arsenic	3.33a	2.1c	3.0b	2.0d	0.0899
Cadmium	1.7b	1.6c	2.5a	1.5c	0.1998
Lead	3.51a	1.1d	1.5c	2.3b	0.1913
Mercury	2.00a	1.0d	1.2c	1.55b	0.1912
Tin	1.68b	1.7b	1.55b	1.9a	0.1634
Cr	1.80b	1.5c	1.00d	2.01a	0.1913

T1: Soil from auto mobile lead acid battery chargers work shop.
T2: soil deposited at a construction site for land filling purpose.
T3: An organic (compost manure farm site).
T4: Home-stead garden at Labora Owode (Ibeju lekki). Village in Lagos.
Means separated by same alphabets along the column are not significantly different from one another at LSD (P≥0.05).

CONCLUSION

The biotic environment is conterminated with heavy metals. The contermination is a consequence of man industrial and domestic activities. The level of heavys contermination of the compost manure in the experiment is an indication that the our organic manure (based on findings from this research) had high level of impurities It is evident from the present study the quality of food consumed may be a major determinant for health risk from the specific heavy metal. Cereals were consumed in larger quantities and therefore major contributors of various metals in the study population. It is relevant to quickly mention that most cosmetic creams (used by ladies) and insecticides used by famers are also contains fairly high concentration of heavy metals.

RECOMMENDATION

Most tropical soils ordinarilly need inputs like fertilizer / organic materials to enhance the nutrients need of the agricultural soils. Based on the findings from this study, it is recommended that: (a) Sorting of waste would should be done to prevents contamination of the environment with both domestic and industrial wastes. This is achievable when subsequent to sorting, wastes are properly disposed with the aprropriate technologies of disposing. (i) hazardous, non-hazardous (ii) biodegradable and non biodegradable and (iii) medical components of wastes. (b) It is also recommended that industrial and domestic environments should be suffiiciently seperated from agricultural environments. (c) It is also suggested that concious effort be made to ascertain the heavy metal content of organic manure/fertiliser prior to field application.

References

Abdulmumini, A., Gumel S. M and Jamil, G.(2014) Industrial Effluents as Major Source of Water Pollution in Nigeria: An Overview. *American Journal of Chemistry and Applications*. 1(5): 45-50

Afolayan, O.S., Ogundele, F.O and Odewumi, S.G.(2012) Hydrological Implication of Solid Waste Disposal on Groundwater Quality in Urbanized Area of Lagos State, Nigeria *International Journal of Applied Science and Technology*. 2 (5):74-82

Andrease, M.O., Asmode, J.F., Foster, P and Van't dack, L. (1981). Determination of antimony(III), antimony(V) and methylantimony species in natural waters by atomic absorption spectrometry with hydride generation. Anallytical Chemistry 53:1766-1771 in**:** Lúcio Mendes CabralVânia Neves Moreira Juliano; Luiza Rosario Sousa Dias; Camila Braga Dornelas; Carlos Rangel Rodrigues; Michele Villardi; Helena Carla Castro; Terezsa Cristina dos Santos (2008) Speciation of antimony (III) and antimony (V) using hydride generation for meglumine antimoniate pharmaceutical formulationsquality control Mem. Inst. Oswaldo Cruz .103:2-8

Azita, B. and Seid, A.M. (2008) Investigation of heavy metals uptakes by vegetable crops from metal contaminated soils. *World Academy of Science, Engineering and Technology* 43: 56-58

Bernhoft, R.A.(2012) Mercury toxicity and treatment: a review of the literature. *Journal of Environment and Public Health*.;2012:460508. doi: 10.1155/2012/460508. Epublication 2011 December 22.

Bieby, V. T., Siti Rozaimah S. A., Hassan, B., Mushrifah I., Nurina, A. and Muhammad, M. (2011) A Review on Heavy Metals (As, Pb, and Hg) Uptake by Plants through Phytoremediation *International Journal of Chemical Engineering* Volume 2011 (2011), Article ID 939161, 31 pages. http://dx.doi.org/10.1155/2011/939161

Bowen, H.J.M., (1979). Environmental Chemistry of the Elements. Academic Press, London, UK, 333 p. Brownlow, AH., 1979. Geochemistry. Prentice Hall, Inc..

Chowdhury, U.K, Biswas B.K, Chowdhury T.R, Samanta G, Mandal BK, Basu GC, and Chakraborti D. (2000) Groundwater arsenic contamination in Bangladesh and West Bengal, India. *Environ Health Perspect*.;108(5):393–397

Chu, N. K., Nguyen. V. N and Ngoc, S.T (2010) Heavy metal contamination of Natural soils arround a Chromate mine in Vietnam. *Soil and plant nutrition.* 56(2): 344-356.

Edosomwan, E.U., Mgbemena, L.C., Opara, K.N. and Petu-Ibikunle. A. M. (2012) Geohelminths eggs contamination of Vegetables sold in Major Markets in Benin City, Edo State Nigeria. *World Journal of Applied Sciences and Technology*.3 (2): 65-71

Frank. V, Hans, V., Richard. D and Carlo, V. (1992) The use of Internal Standard of ICP-MC. *Elsevier* 39 (7): 737-742.

Goyer, R.A. (1990) Lead toxicity: from overt to subclinical to subtle health effects. *Environ Health Perspect*. 86:177-81.

Henson, M.C and Chedrese, P. J. (2004) Endocrine disruption by cadmium, a common environmental toxicant with paradoxical effects on reproduction. *Experimental Biology Med* (Maywood) 229(5):383–392.

Hendershot, W.H., Lalande, H and Duqyette, M. (1993): Soil reaction and exchangeable acidity. In: carte M.R. (ed). Soil sampling and methods of analysis Can. Soc. Soil Sci., Lweis Publisher London, 141-145

Hext, P.M., Pinto. P.J and Rimmel, R.A. (1999) Subchronic feeding study of antimony trioxide in rats. *Journal of Applied Toxicology*, 19:205–209

Hoque, M.A., Burgess, W.G., Shamsudduha M, and Ahmed KM. (2011) Delineating low-arsenic groundwater environments in the Bengal Aquifer System, Bangladesh. *Applied Geochemistry*. 26(4):614–623

Khan, S.Q. Cao Y., Huang,, Y and Zhu G. (2008) Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, *China. China Journal of Science of*

Food and Agriculture .152 (3):686-692

Lars, J. and Agneta, A. (2009) Current status of cadmium as an environmental health problem *Toxicology and Applied Pharmacology*. 238, (3) 201-208.

Martin, S. and Griswold, W. (2009) Human health effects of heavy metals. *Environmental Science and Technology Briefs for Citizens*. 15:1–6.

Matschullat, J. (2000) Arsenic in the geosphere – a review. *Science and Total Environment*. 249(1–3):297–312.

McLaughlina. M. J., Rparkerb, D and Mclarkec, J. (1999) Metals and micronutrients – food safety issues. *Field Crops Research.* 60 (1–2) :143-163

Morais, S., Costa., F.G and Pereira, M.L. (2012) Heavy metals and human health. In: Oosthuizen J, editor. *Environmental health* – emerging issues and practice. pp227–246.

Mosby, C.V., Glanze. W.D., and Anderson, K.N. (1996). Medical Encyclopedia, The Signet: Revised Edition.

NAFDAC, (2005) National Agency for Food and Drug Administration and Control. Miscelenous Report (11) March 2005.

Nelson, D. W and L. E. Sommers. 1982. Total Carbon, Organic Carbon and Organic Matter in: Sparks, D. L. (Eds.), Methods of Soil Analysis. Part 3. SSSA Books Series No 5 SSSA Madison.

Raque, A and Eleazar, R. (2012) Phytotoxicity of Mercury in Plants: A Review. Journal of Botany .Volume 2012 (2012), Article ID 848614, 6 pages. http://dx.doi.org/10.1155/2012/848614.

Regoli, L. (2005) The Relative Contributions of Different Environmental Sources to Human Exposure and the EU Cadmium Risk Assessment Meeting of UNECE Task Force on Heavy Metals. Presentation for the UNECE Long-Range-Trans-boundary Air Pollutants – Task Force on Heavy Metals; 16:18.

Roychowdhury, T., Tokunaga. H, and Ando, M. (2003) Survey of arsenic and other heavy metals in food composites and drinking water and estimation of dietary intake by the villagers from an arsenic-affected area of West Bengal, India. *Science and Total Environ*.; 308(1-3):15-35.

Saif, S., Haq M. and Memon, K. (2005). Heavy Metals Contamination Through Industrial Effluent to Irrigation Water and Soil in Korangi Area of Karachi (Pakistan). *International Journal of Agriculture and Biology* 7(4): 646-648

Satarug, S. Garrett, S.H., Sens, M.A and Sens, D.A (2011). Cadmium, environmental exposure, and health outcomes. *Ciência & Saúde Coletiva*. 16(5):2587–2602.

Simmons, R.W., Pongsakul, P., Saiyasitpanich. D and Klinphoklap, S. (2005). Elevated Levels of Cadmium and Zinc in Paddy Soils and Elevated Levels of Cadmium in Rice Grain Downstream of a Zinc Mineralized Area in Thailand: Implications for Public Health. *Environmental Geochemistry and Health*.27(5/6): 501–511

Smedley, P.L and Kinniburgh, D.G.,(2002) A review of the source, behavior and distribution of arsenic in natural waters. *Applied Geochemistry*. 17:517–568

Steve, B. and Tony.K. (2003). Tin in Canned food: A review and understanding of occurence and effect. 41(12): 1651-1662.

Thürmer, K., Williams, E and Reutt-Robey. J. (2002) Autocatalytic oxidation of lead crystallite surfaces. *Science*. 297(5589):2033–2035.

Toth, G. Hermann, T. Da silva. M.R. and Montanerella, L. (2016). Heavy metals in agicultural soils of European union with implication for food safety. *Journal of Environment*. 88:299-309.

Uchino, A., Roychowdhury, T., Ando. M and Tokunaga. H. (2006). Intake of arsenic from water, food composites and excretion through urine, hair from a studied population in West Bengal, India. *Food and Chemical Toxicology.* 44:455–461

WHO, (2003) World Health Organization . Antimony in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality.WHO/SDE/WSH/03.04/74

Zhang, X., Zhong, T., Liu, L ands Ouyang, X. (2015) Impact of Soil Heavy Metal Pollution on Food Safety in China. *PLoS ONE* 10(8): e0135182.

https://doi.org/10.1371/journal.pone.0135182.

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