ASSESSMENT OF HEAVY METAL CONTAMINATION OF THE SOIL IN MUNICIPAL OPEN-AIR DUMPSITES OF DHAKA CITY AND ITS OUTSKIRTS

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CERTIFICATE

This is to certify that the thesis entitled "**ASSESSMENT OF HEAVY METAL CONTAMINATION OF THE SOIL IN MUNICIPAL OPEN-AIR DUMPSITES OF DHAKA CITY AND ITS OUTSKIRTS**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE** embodies the result of a piece of *bona fide* research work carried out by **MD. SHAFIQUL ISLAM**, Registration No. **13-05428** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.

I further certify that such help or sources of information, as have been availed during the course of this investigation have duly been acknowledged.

Date: JUNE, 2020
Dhaka, Bangladesh

ABDUL HALIM
Assistant Professor
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Dedicated to

MY BELOVED PARENTS

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ABBREVIATIONS AND ACRONYMS

DSS	Dump site soil
NDSS	Non-Dump site soil
Cd	Cadmium
Pb	Lead
Ni	Nickel
Cr	Chromium
MSW	Municipal solid waste
LFS	Land fill site
Zn	Zinc
Cu	Copper
As	Arsenic
ppm	Parts per million
pH	Potential hydrogen
S	Sulfur
Mn	Manganese
Hg	Mercury
ha	Hectare
t	Tonne
PLI	Pollution load index
Cfi	Contamination factor
DEPZ	Dhaka Export Processing Zone
μg	Microgram
mg	Milligram
Kg	Kilogram
SD	Standard deviation
Co	Cobalt
FAO	Food and Agriculture Organization
WHO	World health organization
AAS	Atomic Absorption Spectrophotometer
I Geo	Index of GEO accumulation

ASSESSMENT OF HEAVY METAL CONTAMINATION OF THE SOIL IN MUNICIPAL OPEN-AIR DUMPSITES OF DHAKA CITY AND ITS OUTSKIRTS

ABSTRACT

Disposal of the household originated and industrial hazardous materials with municipal solid waste (MSW) into the open dumping sites is the usual practice in Bangladesh. This experiment was carried out from July to December 2019 to assess the heavy metal contamination of the soil collected from the municipal open-air dumpsites of Dhaka city and its outskirts. The samples were collected from four dumpsites as Aminbazar and Matuail dumpsites of Dhaka; Konabari dumpsite of Gazipur and Shiddhirganj dumpsite of Narayanganj to analyze the soil characteristics (soil texture, pH, organic content) with heavy metals content (Cd, Pb, Ni and Cr). Samples were collected by auger sampling method from three soil depth (10-15 cm, 15-30 cm and 30-45 cm) directly from the dumpsite soil (DSS) and non-dumpsite soil (NDSS) with a duration of thirty days (December, 2019). It was observed that soil sample from all the sites was loamy type, pH was almost neutral and contained low amount of organic matter. The results of the analysis showed that the metals content dumpsite soil (DSS) were (Cd: 0.23 – 0.98 $mgkg^{-1}$; Pb: 13.2 – 39.7 $mgkg^{-1}$; Ni: 6.87 – 29.31 $mgkg^{-1}$ and Cr: 14.32 – 43.49 $mgkg^{-1}$) from all three depth of soil from all areas was higher than the content of non-dumpsite soil (NDSS) (Cd: 0.21 – 0.48 $mgkg^{-1}$; Pb: 4.5 – 18.1 $mgkg^{-1}$; Ni: 4.23 – 18.65 $mgkg^{-1}$ and Cr: 2.45 – 28.56 $mgkg^{-1}$). All the sample contained heavy metal concentration not exceeding the permissible limits. Cadmium was richer in Aminbazar, Dhaka but other three metals, lead, nickel and chromium was richest in Shiddhirganj, Narayanganj. There was negligible correlation between all the heavy metals and pH and strongly negative correlation between heavy metals and soil depth. The outcome of this study gives the idea of heavy metals content in dumpsite soil (DSS) samples comparing the non-dumpsite soil (NDSS) samples and indicates the necessity of solid waste stabilization for heavy metal immobilization within the solidified matrix bond and re-use of solidified/stabilized products for sustainable solid waste management.

CHAPTER I

INTRODUCTION

Rapid population growth, urbanization, industrial growth and economic development in developing countries have led to the generation of significant quantities of solid wastes, which are causing serious environmental degradation (Abdallah *et al.*, 2012). As a result, the solid waste generation rate is increasing in the city, which is posing a serious threat to the current waste management and disposal methods (Zahur, 2007). Rapid urbanization has made solid waste management a serious problem today (Vij, 2012). The urban area of Bangladesh generates approximately 16,015 tons of waste per day, which adds up to over 5.84 million tons annually. It is projected that this amount will grow up to 47,000 tons/day and close to 17.16 million tons per year by 2025, due to growth both in population and the increase in per capita waste generation. Based on the present total urban population, per capita waste generation rate is found at 0.41 kg/capita/day in urban area of Bangladesh (Bahauddin and Uddin, 2012). These wastes are dumped without any physical separation of hazardous materials (Haque and Mondal, 2014). Waste disposal into landfills is the most preferred option compared to other options, such as recycling, combustion and composting, because of its low cost, easy operation and simplest technologies practiced for solid waste management (Hasan *et al.*, 2009).

The adverse effects of municipal solid waste dumping sites on the environment and human health cause a wide range of concern; they include the spread of odors, insects, rats, smoke and gases resulting from the decomposition of waste, leachate seeping into surface and groundwater system, as well as, soil contamination due to trace metal from disposed waste (Agamuthu and Fauziah, 2005; Aljaradin and Persson, 2012). Industrial wastes, incinerator ashes, mine wastes, hospital waste, polythene bags, plastics, broken glasses and household hazardous substances are the major sources of trace metal in landfill (Erses and Onay, 2003; Kanmani and Gandhimathi, 2013). All trace metals are regarded as environmental pollutants due to their strong toxic effects at high concentrations (Page *et al.*, 1982). Recent studies have revealed that significant levels of toxic and persistent metals can be transferred from wastes to the soil environment in dumpsites (Cobb *et al.*, 2000; Udosen *et al*., 2006). Eventually, these metals are accumulated by growing plants thereby entering the food chain (Benson and Ebong, 2005). Through the food chain, toxic pollutants can be entered into the human body (Khan *et al.* 2008) and may cause interference of the biological and biochemical processes (Gupta *et al*. 2013). Although toxicity and the resulting threat to human health of any contaminant are, of course, a function of concentration, it is well-known that chronic exposure to heavy metals and metalloids at relatively low levels can cause adverse effects (ATSDR, 2007; 2008). Middendorf and Williams (2000) have critically reviewed early indicators of cadmium damage in kidneys, such as a low-molecular-weight protein (2-microglobulin), usually reabsorbed by the proximal tubules. Glycosuria, aminoaciduria, and the reduced ability of the kidney to secrete PAH are also indicators of nephrons damage by cadmium.

"Heavy metals'' may be termed as the metals that have the character of toxicity and poisonous effect in a low concentration, relatively high in density (Lenntech, 2004). Heavy metals are the compounds that have specific gravity greater than 5 parts. The "heavy metals" is generally a collective term, which applies to the group of metals and metalloids with atomic absorption density greater than 4 g cm^{-3} or 5 times or more, greater than water (Huton and Symon, 2005). Generally heavy metals are termed as the trace elements, microelements, micronutrients, trace inorganic elements and minor elements. So far, it has been identified that there are 38 elements known as the heavy metals, meanwhile most industries discharge with more than thirteen elements (Rizwana, 2016) like as- copper (Co), iron (Fe), mercury (Hg), molybdenum (Mo), cadmium (Cd), chromium (Cr), cobalt (Co), nickel (Ni), lead (Pb), arsenic (As), tin (Sn) and zinc (Zn). In addition to say that mostly some of the heavy metals are insignificant both human and health. But some of these heavy metals are essential in trace amounts, namely Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn) to plants and Nickel (Ni), Chromium (Cr) and Tin (Sn) to animals but Cadmium (Cd), Arsenic (As), Mercury (Hg) and lead (Pb) either not proven essential both for plants or animals. Heavy metals are such a topic to emergence due to their capability to bind on both organic and inorganic colloids.

Heavy metals contamination is one of the great issues as these have the toxicity and ability to accumulate in the biota. The contamination chain of heavy metals almost always follows a cyclic order: industry, atmosphere, soil, water, foods and human. Industrial or municipal waste water irrigation is a common example in almost three fourth of the cities in Asia, Africa, and Latin America (Gupta *et al.*, 2008). Investigations on the accumulation of heavy metals from vegetables grown around the industrial sites have revealed high levels of Ni, Pb and Cd in vegetables. In our country wastages are dumped here and there with no precaution and management strategy. This wastage contains house hold wastages as well as industrial and hospital wastages. This wastage can contain metalloid particles as well as radioactive particles. In all environments industrial wastes are considered as an important source of effluence those of which urges a on spot treatment before positioning in a sewage system (Imorgor *et al*., 2005). The environment of soil and water are in much pressure discharge of effluents of rapidly expanded industries. Most of the industrial chemicals contain metalloids and after using those chemicals the wastages are dumped into those dumping sites most time near the down town. From where the concerning environment can be contaminated. Hospital wastages also contain harmful materials like heavy metals, radioactive chemicals etc. when this chemical are dumped in the dumping site near the locality it can pollute the soil, water and overall environment. With heavy rain this metalloid from those sites can be spread to the nearer water body, or agricultural field even can contaminate the underground water also which people use for consumption. If this heavy metal enters to the food chain the result will be very alarming.

The collected solid wastes from both city corporation areas are disposed at Matuail and Amin Bazar sanitary dumping site, wastes collected from Gazipur city corporation is dumped in Konabari dumping site and Narayanganj municipal wastes are dumped in Shidddhirganj dumping site without any physical segregation of hazardous materials (Haque and Mondal, 2014). In the resource evaluation, quantity and quality are demanded. Thus, heavy metal contents of this dumping site assessment turn a crying issue in context of its use for the environment as well as the human health. A high amount of heavy metals like, Cu, Cr, As, Cd, Fe, Hg, Mn, Ni, Pb, and Zn are found in the industrial effluents and waste disposal. This gradual accumulation of metals causes a higher toxicity and leads to hazards in plants, animals, and human health (Rizwana, 2016). Therefore, it is very important to investigate the heavy metal content of the wastages from the dumping sites as if there is any risk. So, the objective of this study is,

1. To investigate the heavy metal content of the soil collcted from the dumping site
2. To assess the correlation between soil depth and heavy metal content.

CHAPTER II

REVIEW OF LITERATURE

Many research works were performed about heavy metal statuses of soil. Some of important and informative works have so far been done in home and abroad related to this experimentation have been presented in this chapter.

2.1 Heavy metal and Human health risk

According to Engwa *et al.* (2018) several heavy metals are found naturally in the earth crust and are exploited for various industrial and economic purposes. Among these heavy metals, a few have direct or indirect impact on the human body. Some of these heavy metals such as copper (Cu), cobalt (Co), iron (Fe), nickel (Ni), magnesium (Mg), molybdenum (Mo), chromium (Cr), selenium (Se), manganese (Mg) and zinc (Zn) have functional roles which are essential for various diverse physiological and biochemical activities in the body. However, some of these heavy metals in high doses can be harmful to the body while others such as cadmium, mercury, lead, chromium, silver, and arsenic in minute quantities have delirious effects in the body causing acute and chronic toxicities in humans.

Masindi and Muedi (2018) stated that the environment and its compartments have been severely polluted by heavy metals. This has compromised the ability of the environment to foster life and render its intrinsic values. Heavy metals are known to be naturally occurring compounds, but anthropogenic activities introduce them in large quantities in different environmental compartments. This leads to the environment's ability to foster life being reduced as human, animal, and plant health become threatened. This occurs due to bioaccumulation in the food chains as a result of the nondegradable state of the heavy metals. Remediation of heavy metals requires special attention to protect soil quality, air quality, water quality, human health, animal health, and all spheres as a collection. Developed physical and chemical heavy metal remediation technologies are demanding costs which are not feasible, time-consuming, and release additional waste to the environment.

Chen *et al*. (2014) stated that Battery production is one of the main sources of heavy metals that present great harm to human health even in low concentrations. Chromium

(Cr), Cadmium (Cd) and Lead (Pb)were measured in edible portions of vegetables and soils around a battery production area in China, and the potential health risk of heavy metal contamination to the local population via vegetable consumption was evaluated. Their concentrations in edible portions of vegetables were 2.354 (0.078-14.878), 0.035 (0.003-0.230) and 0.039 (0.003-0.178) mg kg^{-1}, respectively. Approximately 3 % of the Cd in the vegetable samples exceeded the maximum concentration allowable by national food safety criteria, although Pb content in all samples were within the criteria. The mean estimated daily intake of Cr, Cd and Pb via dietary consumption of vegetables was 0.011, 1.65×10^{-4} and 1.84×10^{-4} $mgkg^{-1}$ of body weight per day, respectively.

Suruchi and Khanna (2011) stated that heavy metals such as cadmium, copper, lead, chromium and mercury are important environmental pollutants, particularly in areas with high anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms and heavy metal bio accumulation in the food chain especially can be dangerous to the human health. Heavy metals are very harmful because of their non-biodegradable nature, long biological half lives and their potential to accumulate in different body parts. Most of the heavy metals are extremely toxic because of their solubility in water even in low concentrations. Heavy metals are persistent environmental contaminants which may be deposited on the surfaces and then adsorbed into the tissues of vegetables. Plants take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soil.

Zaman *et al*. (2011) stated that few of metal ion enters the food chain and are capable of causing cancer. These effluents require like- Zn and Cu in significant amount but Cd and Pb is in trace amount.

Jarup (2003) found that the main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO. Cadmium compounds are currently mainly used in re-chargeable nickel–cadmium batteries. The general population is exposed to lead from air and food in roughly equal proportions. The use of lead-based paints should be abandoned, and lead should not be used in food containers. In particular, the public should be aware of glazed food containers, which may leach lead into food.

Occupational exposure to arsenic, primarily by inhalation, is causally associated with lung cancer. Clear exposure–response relationships and high risks have been observed. Long-term exposure to arsenic in drinking-water is mainly related to increased risks of skin cancer, but also some other cancers, as well as other skin lesions such as hyperkeratosis and pigmentation changes.

2.2 Effects of heavy metal problem for soil, plant and environment

Baghaie and Fereydoni (2019) conducted a study, a total 45 samples from edible parts of parsley, mint, chard, fenugreek, cress, basil, coriander, lettuce, and cabbage distributed in the fruits and vegetables central market of Arak were randomly collected and the concentration of heavy metals including lead (Pb), cadmium (Cd), and arsenic (As) in these crop plants was measured using atomic absorption spectrophotometer (AAS). The highest and lowest Pb daily intake and Pb risk index was related to the consumption of cabbage and basil, respectively. And the highest daily intake of Cd and As was related to lettuce consumption, while the lowest daily intake of these metals was related to the consumption of coriander. Among the studied heavy metals, As had the highest hazard quotient (HQ) for non-carcinogenic diseases. The highest HQ belonged to As through lettuce consumption and the lowest one belonged to As through coriander consumption (58 g/day). The HQ for female was higher than that for male. According to the results, the total hazard quotient (THQ) of non-carcinogenic diseases from the total studied vegetables was above the standard level. On the other hand, the HQ for female was higher than that for male.

Ahmed *et al.* (2019) observed the presence of undesirable heavy metals, pesticide residues, and microbial contaminants in fresh produces is a worldwide public health concern. This study was undertaken to evaluate the residual pesticides (Diazinon, Malathion, Cypermethrin, Dimethoate, Quinalphos, and Chloropyrofos), heavy metal contamination (Pb, Cd, and Cr), and microbiological quality and safety of 4 common raw salad vegetables (RSVs) samples from different local markets in Dhaka. Results showed the presence of heavy metals residues were within the acceptable limits of local and international standards.

Shokr (2019) said that mercury and lead are highly toxic heavy metals which are found in the environment and effect on public health hazard. Mercury and lead are chemical elements which cannot be destroyed or broken down through heat treatment or environmental degradation resulting in a variety of human health hazard as lethal, sub lethal, acute and chronic toxicity. The results showed that the mean values of mercury were 1.10±0.02, 0.89±0.01, 0.72±0.01 and 0.57±0.01 ($mgkg^{-1}$) in *C.grapinus*, *O.niloticus*, *S.pilchardus* and *P.pagrus* respectively. While, the mean values of lead were 0.64±0.01, 0.49±0.01, 0.33±0.01 and 0.27±0.01 ($mgkg^{-1}$) in such examined samples respectively.

Akter *et al.* (2019) collected samples from two different steel industries of Narayanganj District, Bangladesh. The samples were then dried, made fine powder and the pellets have been made for irradiation by 2.2 MeV proton beams of current ranges from 10 to 15 nA. Ion Beam Analyzing (IBA) technique Proton Induced X-ray Emission (PIXE) was used for sample irradiation. Data acquisition has been done using MAESTRO-32 software and the data files are analyzed using GUPIX/DAN-32. Elements to be found in the studied samples are: K, Ca, Cr, Mn, Fe, Co, Ni, Cu and Pd. Heavy metal with higher concentration was found in the study area and the concentration of heavy metal decreases with depth. The main objective of the research work is to explore and identify heavy elements presence in soil samples affected by the industrial area for human health.

Uddin *et al.* (2019) conducted a study to establish a database about the contamination status of heavy metals in popular vegetables and their growing soil in Satkhira, Bangladesh; to assess the associated health risks of consumers through target health quotient (THQ) and target cancer risk (TCR) analyses. The average concentration of Mn, Fe, Cu, Zn, Cd and Pb is 33.91, 356.71, 10.27, 33.59, 0.57 and 9.76 mg kg^{-1} in vegetables and 239.34, 3399.38, 22.48, 65.63, 0.68, 11.53 mg kg^{-1} in the growing soil. The concentration of heavy metals has been compared with the standard value recommended by WHO/FAO and it is found that the average concentrations of Fe, Pb, and Cd in the leafy, fruit and root vegetables exceeded the permissible limit. Moreover, the value of THQ, non-carcinogenic parameter, is greater than 1.0 for Fe and Pb in leafy, fruits and root vegetables. Therefore, the THQ of Fe and Pb may pose a potential health risk to human. Besides, the probability of developing cancer is greater than USEPA risk limit (>10-6) and the TCR of Pb shows high cancer risk whereas Cd poses a very high cancer risk. Therefore, the consumption of these vegetables is a matter of concern and regular monitoring is strongly recommended.

Proshad *et al.* (2019) conducted a research to assess the ecological and health risk of heavy metals (Cr, Ni, Cu, As, Cd and Pb) from agricultural soils in the industrial areas of Tangail district, Bangladesh. The mean concentrations of Cr, Ni, Cu, As, Cd and Pb in different soil sampling sites were found 6.73, 29.74, 24.69, 4.79, 2.50 and 19.90 $mgkg^{-1}$, respectively. The mean concentration of the studied heavy metals were found underneath as far as possible set by the Dutch standard, Canadian guidelines and Australian guidelines with the exception of Cd. The geo-accumulation index, contamination factor and toxic unit analysis were discovered low contamination for all metal with the exception of Cd. Potential ecological risk (PER) of soils from all sampling sites showed low to very high risk. Add up to total target hazard quotients (TTHQ) for every single concentrated metal in all-out testing sites were <1 and cancer risk values were under 10-6 demonstrating low non- cancer-causing and cancer risk in grown-up and youngsters for a few exposure pathways.

Li *et al.* (2019) expressed that soil heavy metal pollution has become a worldwide environmental issue that has attracted considerable public attention, largely from the increasing concern for the security of agricultural products. Heavy metals refer to some metals and metalloids possessing biological toxicity, such as cadmium, mercury, arsenic, lead, and chromium. These elements enter the soil agro-ecosystem through natural processes derived from parent materials, and through anthropogenic activities. Heavy metal pollution poses a great threat to the health and well-being of organisms and human beings due to potential accumulation risk through the food chain. Remediation using chemical, physical, and biological methods has been adopted to solve the problem. Phytoremediation has proven to be a promising alternative to conventional approaches as it is cost effective, environmentally friendly, and aesthetically pleasing. This review discusses harmful effects, sources of heavy metals, and the remediation technologies for soil contaminated by heavy metals.

Alam *et al.* (2018) conducted an experiment to determine heavy metals in sediments of six freshwater wetlands of greater Dhaka district from November 1999 to September 2000. To assess the status of heavy metal pollution in the sediments, geo-accumulation factor (Igeo), contamination factor (CF), degree of contamination (CD), and enrichment factor (EF) have been evaluated, with the concentrations of Cd, Mn, Ni, Zn, Cu, Fe, and Pb in the sediments ranging within 0.005 – 0.055 $mgkg^{-1}$, 35.0 – 275.04 $mgkg^{-1}$, 0.35 – 2.19 $mgkg^{-1}$, 0.77 – 12.54 $mgkg^{-1}$, 4.11 – 19.17 $mgkg^{-1}$, 115.60 – 955.94 $mgkg^{-}$

^{1}, and 1.82 – 3.93 mgkg^{-1}, respectively, standing in the following order: Fe > Mn > Cu > Zn > Pb > Ni > Cd. The Igeo for Mn indicates a strongly to extremely polluted condition in wetlands, whereas that of Ni and Pb show moderately polluted condition, and for Zn and Cu, it suggests moderately to strongly polluted conditions. The CF values for heavy metals in sediment have been below 1, indicating low contamination. In addition, Cd < 6 indicates low degree of heavy metal contamination. The EF for heavy metals in wetland sediments are in the following order: Cu>Mn>Pb>Cd>Zn>Ni, suggesting that the sediments very highly rich in Cu, while Mn, Pb, and Cd exhibit significant enrichment. In the studied wetlands the EF for Zn and Ni shows moderate and deficiency to minimal enrichment, respectively. Implications of these findings can be used as baseline information to monitor and assess the degree of sediment pollution in lentic wetlands.

Islam *et al.* (2017) investigated heavy metals in the industrial sludges to assess ecological risk using inductively coupled plasma mass spectrometer (ICP-MS). The ranges of Cr, Ni, Cu, As, Cd, and Pb in the samples were 1.4–9469.7, 4.8993.8, 12.8–444.4, 2.2–223.8, 1.9–46.0 and 1.3–87.0 mgkg^{-1}, respectively. As a whole, the average concentrations of heavy metals were in the decreasing order of Cr >Ni >Cu >As >Pb >Cd. The contamination factor (Cfi) of Cd ranged from 11.2 to 28.9 revealed that the examined sludges were strongly impacted by Cd. The Cfi value demonstrated that sludges from tannery, dye, metal processing and battery manufacturing industries were moderately to very high contamination by Cr, Ni, Cu and As.

Suryawansh *et al.* (2016) studied the concentration levels and sources of heavy metals contamination in road dust samples collected from various locations including four different activity areas: industrial, highways, residential and mixed use in Delhi, India. Metal content in road dust was analyzed by inductively coupled plasma atomic emission spectroscopy. The results showed high concentration levels of Ni, Cr and Pb in industrial areas. Pearson's correlations coupled with principal component analysis revealed that Cd, Cr, Ni and Pb are associated with industrial sources whereas Zn and Cu are mainly contributed by vehicular traffic. Contamination factor analysis showed that road dust samples are significantly contaminated by Zn and Pb. The potential ecological indices indicated high contamination of Cd and moderate contamination of Pb in road dust, but low contamination of Cr, Cu, Ni and Zn. The pollution index of most of the metals was higher than 1, indicating deterioration of road dust quality of

Delhi city due to anthropogenic emissions. The degree of contamination, the potential ecological index and the integrated pollution index reveal that road dust from industrial, mixed use and highway areas are highly contaminated by heavy metals. The road dust from the residential area is also contaminated considerably.

Hossain *et al.* (2016) investigated concentration of some bio-accumulated heavy metals (Cd, Cr, Ni, Fe, Mn and Pb) in four farm raised species of fishes. Among the six heavy metals tested, Fe was maximally accumulated, followed by Ni, Mn, Cr and Cd in flesh and liver of fishes. The concentration of Pb was below the detectable level (BDL) in all fishes. The overall highest concentration (mgkg^{-1}) of metals in flesh of all examined fishes were- Cd (0.775 mgkg^{-1}) and Cr (12.675 mgkg^{-1}) in *Anabas testudineus*, Ni (221.792 mgkg^{-1}), Fe (331.050 mgkg^{-1}) and Mn (17.842 mgkg^{-1}) in *Oreochromis niloticus* respectively. In liver, the highest concentration of five heavy metals were- Cd (1.433 mgkg^{-1}) and Cr (51.590 mgkg^{-1}) in *Oreochromis niloticus*, Ni (278.966 mgkg^{-1}) in *Wallago attu*, Fe (666.262 mgkg^{-1}) in *Oreochromis niloticus* and Mn (50.317 mgkg^{-1}) in *Anabas testudineus*.

Muniruzzaman *et al*. (2014) stated that about 18 percent soil that is polluted are in great risk that cannot be used by plant at any state in Narayanganj.

Atiqur (2011) observed that the availability of heavy metals are much in the tannery compared to the basic dyeing industries.

Mondol *et al.* (2011) conducted an experiment on Tejgaon industrial area is located within the Dhaka City Corporation and is about 5 km north of the city center. Heavy metal concentration at different sampling points varied in different seasons and the maximum amount was observed in the dry season (January). Total Fe, Pb, Cd, Mn, Ni, Zn, Cu and Cr concentrations in water samples during dry season ranged from 0.11-2.78, 0.733-2.171, 0.05-0.1, 0.019-0.34, 0.02-0.17, 0.01-0.348, 0.10-0.846, and 0.02-0.09 mgl^{-1} respectively. The present study revealed that the pollution level was very much alarming and increasing slowly day by day. According to WHO guidelines, during both wet and dry seasons 100% water samples were found in the group of in excess of tolerable level for Pb (0.01 mgl^{-1}). 63, 42, 79, 58 and 95% water samples were found in the group of excess of tolerable level during dry season for Cu, Ni, Cd, Cr and Mn. Only 26% of the plant samples had Ni (< 20 mgkg^{-1}) in the normal range and 74% (20-30 mgkg^{-1}) plant samples were found in the group of in excess of tolerable level" during dry season which was 63% (< 20-30 $mgkg^{-1}$) during wet season. Cadmium and Pb in plant samples found in the group of in excess of tolerable level was 26, 79% (> 10 $mgkg^{-1}$), and 33, 59% (> 20 $mgkg^{-1}$) during wet and dry season, respectively. Plant samples accumulated more and tolerated higher amounts of Cr during dry season. Average concentration of Fe, Mn and Zn at different locations and plant species were 220.81, 279.33 and 239.81 $mgkg^{-1}$ and 212.0, 313.43 and 159.19 $mgkg^{-1}$ during wet and dry seasons, respectively.

Wuana and Okieimen (2011) reviwed scattered literature to critically review the possible sources, chemistry, potential biohazards and best available remedial strategies for a number of heavy metals (lead, chromium, arsenic, zinc, cadmium, copper, mercury and nickel) commonly found in contaminated soils. The principles, advantages and disadvantages of immobilization, soil washing and phytoremediation techniques which are frequently listed among the best demonstrated available technologies for cleaning up heavy metal contaminated sites are presented. Remediation of heavy metal contaminated soils is necessary to reduce the associated risks, make the land resource available for agricultural production, enhance food security and scale down land tenure problems arising from changes in the land use pattern.

Mohuya *et al,* (2010) determined concentrations of cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), and lead (Pb) in the pelagic water of Gulshan-Baridhara Lake were. The samples were collected from ten different spots in summer (April, 2007) and monsoon (August, 2007) seasons. The concentrations of Cd, Cr, Cu, Ni and Pb in the lake water varied from 0.068 - 0.091, 0.048 - 0.225, 0 - 6.135, 0 - 0.062 and 0.023 - 0.067 mg/l during the summer season, respectively. Mean values of the samples collected from mid-points for Cd, Cr, Cu, Ni and Pb of ten stations in summer were 0.083, 0.100, 2.336, 0.074, and 0.046 mg/l, respectively. In monsoon the concentration of above-mentioned heavy metals varied from 0.016 - 0.019 mg Cd/l, 0.005 - 0.035 mg Cr/l, 0.002 - 0.018 mg Cu/l, 0.007 - 0.159 mg Ni/l, and 0.052 - 0.151 mg Pb/l. Mean values of these heavy metals in monsoon were 0.018, 0.018, 0.011, 0.037 and 0.093, mg/l, respectively. The depletion factor was less than unity for Pb and exceptionally high for Cu. Finally, the study revealed that among the heavy metals only Pb concentration exceeded the standard level during the monsoon, otherwise concentrations of all other four heavy metals (viz. Cd, Cr, Cu and Ni) exceeded the standard level of drinking, fishing and surface water as set up by WHO, GOB, USEPA, DOE and FWPCA, for the summer period.

Ahmad and Goni (2009) estimated concentrations of Cu, Zn, Pb, Cr, Cd, Fe, and Ni have been in soils and vegetables grown in and around an industrial area of Bangladesh. The order of metal contents was found to be Fe > Cu > Zn > Cr > Pb > Ni > Cd in contaminated irrigation water, and a similar pattern Fe > Zn > Ni > Cr > Pb > Cu > Cd was also observed in arable soils. Metal levels observed in different sources were compared with WHO, SEPA, and established permissible levels reported by different authors. Mean concentration of Cu, Fe, and Cd in irrigation water and Cd content in soil were much above the recommended level. Accumulation of the heavy metals in vegetables studied was lower than the recommended maximum tolerable levels proposed by the Joint FAO/WHO Expert Committee on Food Additives (1999), with the exception of Cd which exhibited elevated content. Uptake and translocation pattern of metal from soil to edible parts of vegetables were quite distinguished for almost all the elements examined.

Mishra (2008) stated that soil that has been polluted with these metals causes the death of plant in a premature stage.

Maldonado (2008) suggested that the metallic in soil that is in little uptake by the plant.

Havorak *et al*. (2006) explored the Pb/Zn smelter for heavy metal contamination and observed that area of arnoldestion soil (Karnnten, Austria) were heavily metal polluted by the lead and Zinc smelting while plant took Pb in low amount. Plant toxicity by Zn was in normal range and for animal feedings, Cadmium exited the threshold level.

Elik (2003) analyzed the street dust samples of Sivas city, Yurkey analyzed that the mean concentration of Pb, Zn, copper and Cd in soil were 197, 206, 68, 84 and 2.60 µg g^{-1}, respectively.

Chowdhury (2003) detected that Fe, Mn, Zn, Cu and Pb from soils of various land use practice from Bangladesh Agricultural University farms, Bhaluka (forest land), Boira farmer's field of Mymensingh district, Board Bazar industrial site of Gazipur. He found that total concentrations of Fe, Mn and Pb in surface soils ranged between 2066.80 – 3951.75, 150.5 – 365.71 and 21.48 – 34.00 mg kg^{-1}, respectively.

Hoque (2003) carried out an experiment for the determination of the status of As and other heavy metals and vegetables of five intensively growing areas of Chapai Nawabganj, he investigated that the mean concentration of Pb, Cd, Fe and Mn in soils were 16.2, 0.26, 4030 and 62.72 µg g^{-1}, respectively.

Huy *et al.* (2003) reported that from untreated water of sewage used in Irrigation was one of the major causes of increasing crops and soil metals and shorter periods of sewage water in irrigation go high of individual metals in soils by 2-80% and increased metals in crops by 14-209%.

Dolly and Ford (2001) stated that the greatest common sources of urban environment area from atmospheric testimony of lead ensuing from the blister of lead petrol, Removal of Pb successions and dye of makeover work. The flashing and washer's used corrugated iron roots, Metallic wheel, past practices of waste are the least common sources.

Kashem and Singh (1999) conducted a study to investigate the heavy metal contamination of soil and vegetation in the vicinity of industries around Dhaka city in Bangladesh. Categorically soils, grass (*Cynoden doctylon* L), water hyacinth (*Eichhornia crassipes* L), rice (*Oryza sativa* L), and arum (*Alocasia esculenta* L) were collected from tannery, ceramic, textile dying and sulphuric acid producing industrial sites. The concentrations of total Cd, Cu, Mn, Ni, Pb and Zn ranged from 0.1–1.8, 28–217, 106–577, 25–112, 17–99 and 53–477 mg kg^{-1} soil, respectively among the industrial sites. The concentrations of some heavy metals ranged from background levels to levels in excess of tolerable limits in agricultural soils. The concentrations of total Cu, Mn, Ni, Pb and Zn decreased with increasing distance from the disposal points of the tannery and the textile dying industries. Cadmium, Cu, Mn, Ni, Pb and Zn showed highly significant ($p < 0.01$) positive correlations with their total and DTPA-extractable contents in soils. The concentrations of most heavy metals were also higher in the vegetation samples of tannery area and the content of Pb (13–45 mg kg^{-1}) in grass samples exceeded the toxic limit. In correlation matrix, plant concentrations of Cu, Mn, Pb and Zn were significantly correlated with their total and extractable contents in soils.

Sattar and Bhume (1998) stated the association of some elements as Co, Zn, Cu, Ni, Fe, Al in soil samples. The author also stated the loading of Co, Zn, Cu and Ni with Clay, Al and Fe, indicate that Fe and Al Hydroxides and clay content play significant roles in the sorption and distribution of these metals in soil. This state of metals enters into food chain and poses a human hazards and Animal health in the area.

Villini *et al*. (1992) stated that environmental quality was adversely affected with the heavy metals in soil. Subsequent acidity by Cd exchange to pH, removed in-between 65-95% to total Cd, Zn, Cu and Pb from the contaminated soils.

Herms (1980) stated, by the accumulation soil pollution by heavy metals Causes the pollution in a great context. A metal that shows a specific graving greater than about 1.5 g/cm^3 is called as heavy metals.

2.3 Heavy metal in dumping site

Othman *et al*. (2019) observed that various types of wastes are the main sources of heavy metal within a landfill system including metal waste components such as food cans, scrap metal, household hazardous waste and electronic waste such as batteries and old computers. For this study comparing soil samples taken from four different sites of landfills at different depths (0-30 cm, 30-60 cm and 60-90 cm) and radiuses (5-10 m, 10-15 m and 15-20 m), for ten heavy metals (Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb). Most of the sites consistently showed higher contamination in deeper soil than the upper layer of the soil.

Hossain *et al.* (2018) conducted an experiment to assess the impact of solid waste disposal on surrounding environment of Matuail landfill site of Dhaka city. The Cu, Zn and Pb concentrations were high in the dumping (360 µg g^{-1} Cu, 806 µg g^{-1} Zn and 382 µg g^{-1} Pb) and abandoned (199 µg g^{-1} Cu, 452 µg g^{-1} Zn and 519 µg g^{-1} Pb) areas that exceeded the permissible limits. The concentrations of DO, BOD, COD and TDS of the untreated leachate were found 1.34 mg L^{-1}, 96 mg L^{-1}, 1343 mg L^{-1} and 7120 mg L^{-1} respectively that exceeded inland surface water standard but after treatment the concentrations of DO, BOD and TDS in the treated leachate pond were found within the permissible limit. The presence of heavy metal in leachate is not contaminated as it is below the toxic limit. The bioaccumulation of fish from treated pond is extremely high of Fe, Mn, Pb and Ni that exceeded the WHOs permissible limit.

Kamal *et al.* (2016) conducted a study to determine trace metal concentrations in soil and different plant parts that grow in the Amin Bazar landfill, Bangladesh. The mean concentrations of trace metal found in the soil were in the following order: zinc (Zn) >

manganese (Mn) > lead (Pb) > copper (Cu) > chromium (Cr) > nickel (Ni). Considering all selected plant species, the mean concentrations of trace metals were in the following order: Zn > Ni >Mn > Cu. On the other hand, considering all measured trace metals, the accumulation trend in plant species were in the following order*: Carica papaya* > *Enhydra flactuans* > *Amaranthus gangeticus* > *Ipomoea aquatica* > *Sesbania cannabina* > *Musa sapientum.* Pb and Cr were not accumulated in the studied plant species. Translocation factor (TF), bioaccumulation factor (BAF) and bioaccumulation coefficient (BAC) were calculated for the assessment of mobility of trace metals from root to shoot, soil to shoot and soil to whole plant, respectively. TF values showed that the plant species effectively translocate trace metals from roots to the shoots, suggesting that they are suitable for phytoextraction. According to BAF all studied plants were excluders for all metals except Ni, and according to BAC, all studied plants were hyperaccumulators of Ni. The daily metal intake and health risk index values of the studied metals, except of Ni, indicated that there is a relative absence of health risks associated with the ingestion of contaminated edible parts of plants.

Islam *et al,* (2015) conducted a study to explore the current status and the economical prospect of the solid waste management at Amin Bazar waste dumping site, Dhaka. The wastes were comprised of plastics (6%), paper (3.5%), glass (0.23%), garden waste (8.5%), food stuffs (72.25%), metals (0.16%) and textile products (3.25%). The pH values of the samples ranged from 6.9 to 7.8 which indicated the neutral condition. Larger portion of the wastes was organic (72%). About 14.38% of wastes were recyclable but there was no recycling and composting facility. Proper recycling of the solid wastes at Amin Bazar can be a source of compost and useful metal resources which may contribute in safe and sustainable environmental management.

Karim *et al.* (2014) collected samples from two open dumping sites at Matuail, Dhaka and Khulna and analyzed for total heavy metals content (Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn) and also heavy metal fraction (water extractable, exchangeable and bio-fraction). The results of the analysis showed that the total metals content in MSW at the Matuail dumping site was higher than Khulna dumping site and the metals were predominantly associated with fine soil fraction. The total heavy metals content in MSW in the study sites were less than the total metals content in MSW at the dumping sites reported from Japan, India and Thailand. The study results showed that both sites contain high bio-available fraction of metals, which may easily be entered into a food chain and may cause health hazards.

Rakib *et al*. (2014) carried out an experiment to assess the heavy metals in Dhaka Metropolitan city. It was found that, the highest content of Pb, Zn, Cr and Cu were found in Hazaribagh and the lowest concentration of Pb, Zn, Cr and Cu was observed in Savar Bazar area in the greater Dhaka City. In addition, the minimum concentration of Pb, Zn, Cr and Cu was found to be 30.02 ppm, 49.91 ppm, 61.24 ppm and 12.21 ppm, respectively. Consecutively, the maximum concentration of Pb, Zn, Cr and Cu was identified 198.16 ppm, 283.21 ppm, 303.89 ppm and 179.80 ppm, respectively. However, the average concentration of Pb, Zn, Cr and Cu was observed 67.60 ppm, 144.20 ppm, 124.70 ppm and 98.90 ppm respectively.

Naser *et al*. (2012) investigated that, the heavy metal contents at the same distance from the road was found in the following order: Ni>Pb>Cd. Examining the Pb, Cd,and Ni content of roadside soil, it can be concluded that the concentration decreases with increasing distance from the motorway, except Cd.

Rahman *et al*. (2012) carried out a survey for the assessment of heavy metal contamination. It was found that average concentration of Fe, As, Mn, Cu, Zn, Cr, Pb, Hg, Ni and Cd in the study area during the dry season was 30,404, 4,073.1, 339, 60,209, 49.66, 27.6, 486.6, 48.1 and 0.0072 $mgkg^{-1}$, respectively. While average concentration of Fe, As, Mn, Cu, Zn, Cr, Pb, Hg, Ni and Cd in the wet season was17,103,2,326.2, 305, 90, 194, 34.2, 23.83, 133.2, 5.5 and 1.04 $mgkg^{-1}$, respectively.

Das *et al*. (2011) examined that Zn concentration in tannery effluents was lower tannin textile effluents while in adjacent river water is varied both seasonally and specially.

Agamuthu and Fauziah (2010) performed a study aims to characterize soil samples from different sites of two waste disposal grounds in Malaysia, to study heavy metal contamination in the landfill environment. Results from the analysis of samples from Panchang Bedena landfill indicated that all heavy metals analyzed were below the Dutch Intervention Standard for Soil Remediation. Pb was at its highest concentration at the upper layer than the lower layer; displaying a decreasing trend at the deeper soil. On the other hand, Fe and Zn depicted increasing trend where the highest concentration was at the deepest soil samples, while the lowest concentration was at the surface soil. Though the heavy metal contamination level was below the serious risk to human exposure, precautionary actions need to be implemented since higher volume of waste disposal in future might cause to alter the intensity of these heavy metal in the landfill soil. The other study area at Kelana Jaya indicated an opposite result. The surrounding soil of the Kelana Jaya ex-disposal site was heavily contaminated with metal elements which exceeded the Dutch Intervention Value. Among the elements at the highest value were arsenic (64.4 $mgkg^{-1}$) and mercury (11.5 $mgkg^{-1}$). This warrants proper remediation or precautionary measure in order to prevent risks to human and the environment.

Shakery *et al.* (2010) found that, the results of soils texture and the concentrations of selected heavy metals, along with Sc, Fe and Al in the three sampled depths show that soil texture spreads out from a clay end-member to a silty - sandy end member with an average ratio of clay over silt and sand being 1.07 and 3.19, respectively. The highest and lowest average organic carbon (OC) content in A and B are (0.1%) and (0.063%), respectively. Soil pH varies between 7.79 and 8.7.

The study of textile pollutants effect on collected soil of agricultural land that is adjacent to textile effluents outlet in Jodhpur shows high build – up of Na (289.5 mg/ 100g), Moderate P (35.8 kg ha^{-1}) and high K (308.2 kg h^{-1}). It was also found that effluents collected directly was more toxic to the one collected from various points of mixing in irrigation water bodies (Cheng and Cheng, 2003).

Marshall (1998) conducted a survey to the heavy metal pollution of roadside soils in Bangladesh. Accumulation of Pb, Ni, Cr, Cu and Zn in roadside soils along Dhaka-Mymensingh highway, possibly due to the heavy traffic of vehicles. On the other hand, sporadic high Zn accumulation was noticed in soils along Dhaka- Aricha, Dhaka-Chittagong and Dhaka-Mymensingh highways, which was ascribed to the industrial discharge.

Barman and Lal (1994) carried out an experiment in industrially polluted field in Kalipur, West Bengal. They reported that the Zn, Cu, Cd and Pb concentration of the soil samples were 309.74 ± 146.47; 41.50 ± 14.52; 6.11 ± 1.65 and 180.43 ± 75.61 μg g^{-1} soils, respectively.

Yanful *et al.* (1988) conducted a study where heavy metal profiles below a 15-year old sanitary landfill overlying a 30 m thick natural clay deposit were presented. Selective chemical dissolution analyses which showed that Fe, Zn, Pb and, to a greater extent, Cu were present in solid organic forms at the interface. It was observed that 75% more Pb was removed by the carbonate-rich bulk soil than the carbonate-free soil. The batch studies also showed that when the p H> 5.2, removal of metal increased significantly due to precipitation as carbonates. From the results it was concluded that the presence of metal sludges in landfills lined naturally or artificially by a carbonate-rich clayey barrier reduced the rate of migration of numerous toxic transition metals and may also decreased the barrier porosity by precipitation. The decrease in porosity will be beneficial to the performance of the barrier due to reductions in both advection and diffusion.

CHAPTER III

MATERIALS AND METHODS

A study was conducted during November, 2019 to January, 2020 to determine the status of heavy metals in dumpsite soils and non-dumpsite soils from four garbage dumping areas of Dhaka, Gazipur and Narayanganj districts. The fine points of materials and methods for the study are presented in this chapter.

3.1 Location

Dhaka, Gazipur and Narayangonj districts are the three of most populated and industrialized area of Bangladesh are the districts under Dhaka Division. Dhaka is the capital of Bangladesh, Gazipur metropolitan is the biggest city corporation and Narayangonj is called the Dundee of east. All are very highly populated as well as polluted cities of Bangladesh.

3.2 Climatic conditions

Dhaka, Gazipur and Narayangonj are closely situated cities having similar climatic conditions is generally marked with monsoon climate with moderate temperature, considerable humidity and moderate rainfall. The rainy season starts from mid-May and continues up to the month of mid-September in these areas.

3.3 Sampling sites

Forty eight (48) soil samples were collected from dumpsite (DSS) and non-dumpsite (NDSS: closer area to the dumping site) area of sampling sites Amin bazar and Matuail of Dhaka district, Konabari of Gazipur district and Shiddhirganj of Narayangonj district. From each site 6 sample were collected from directly from the dumping site and 6 samples collected from outside area of the dumping site (control).

3.4 Short description of sampling area

3.4.1 Amin Bazar dumping site

The Amin Bazar dumping site is situated within the low-lying floodplain of the Karanachhali river in Savar Upazilla of Dhaka district. The area is located at 23°47′48″N and 90°17′50″E. The area is used as a dumpsite from 2007 and at the first stage of its operation it was an open dumpsite. Now this site possesses the characteristics of sanitary semi-aerobic landfill site which facilitates rapid decomposition of wastes with the total area of about 20.234 hectares. The area is inundated during each monsoon between June to October. There are two villages, Konda and Baliarpur, within a distance of 1 km from the site.

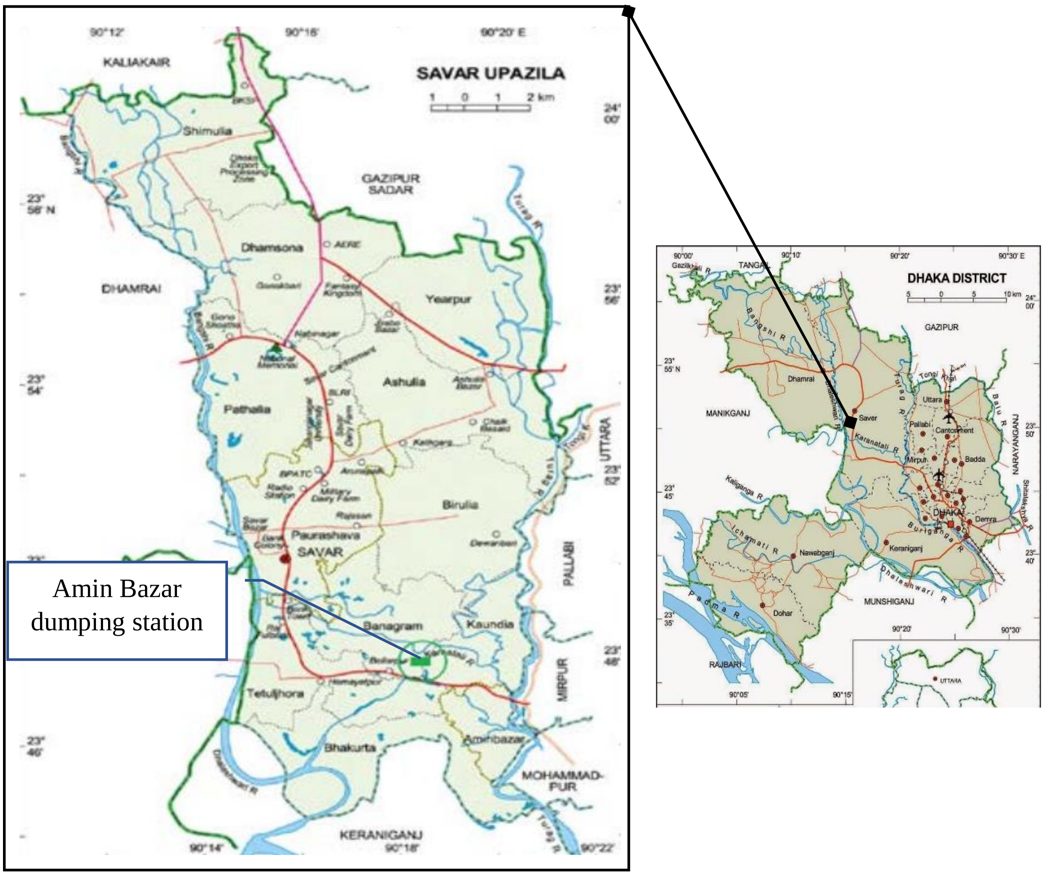

Figure 1: Showing the location of Amin Bazar dumping station, Dhaka district

3.4.2 Matuail dumping site

Matuail dumping site is located on the north of Dhaka Demra highway which lies between latitude 23°42.97' and 23°43.35' N and longitude 90°26.83' and 90°27.2' E. Approximately1800 to 2000 tons of waste is coming here every day and the manner of disposal is simply dumping and spreading of waste (Hossain *et al.*, 2018). It is a semi-aerobic landfill which is in pipe system, half circle of it is solid in lower part and upper half is perforated where natural air is passed by. Leachate from dumping site is stored in leachate pond, which is treated with lime, $FeSO_4$, polymer etc. and stored in another pond (treated leachate pond) then discharged. Some fishes are cultured in treated pond. AGIS-GPS based location map of Matuail landfill site is shown in Fig. 1.

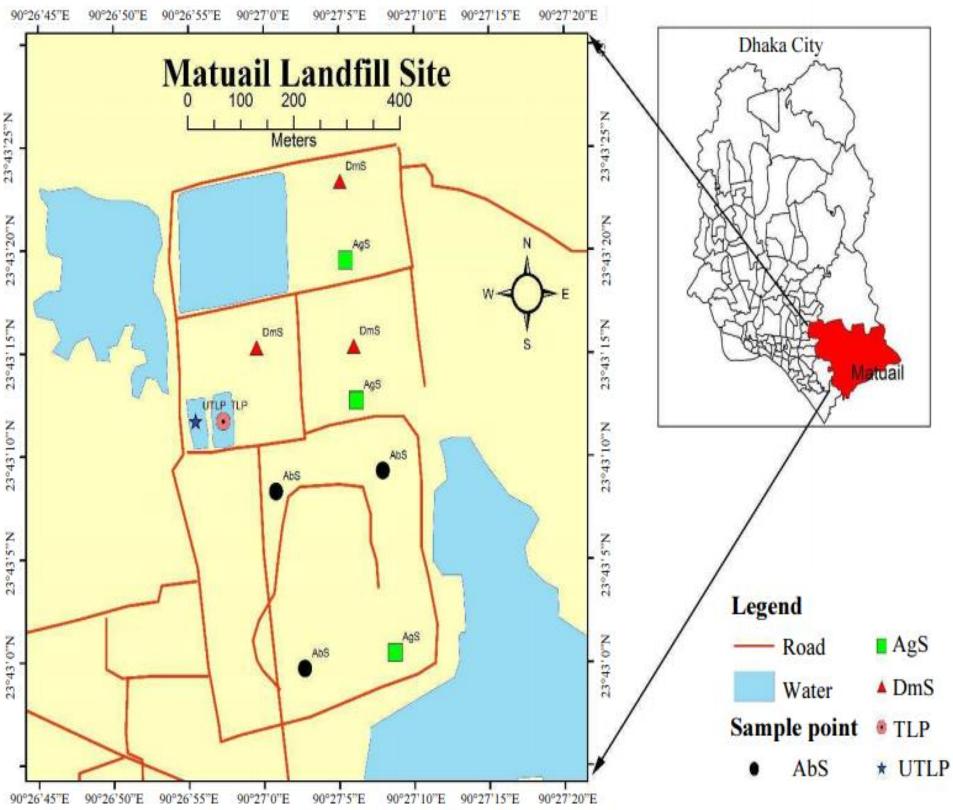

Figure 2: Showing the location of Matuail dumping station**,** Dhaka district

3.4.3 Konabari dumping site

The site of Konabari dumping station is at Konabari union in Gazipur sadar upazila. Konabari union, where numerous textile dyeing and other industries are located is located along the bank of Turag River and bounded by Kaliakair union on north and west, Kashimpur union on south and Basan union on east. The area was located approximately at the latitude of 24.022ºN to 23.968º N and longitude of 90.304ºE to 90.355º E. The altitude of the area was approximately 10 meters from the sea level (Banglapedia, 2013) and situated beside the Tangail-Gazipur highway. The dumping site is located in bank of Turag river.

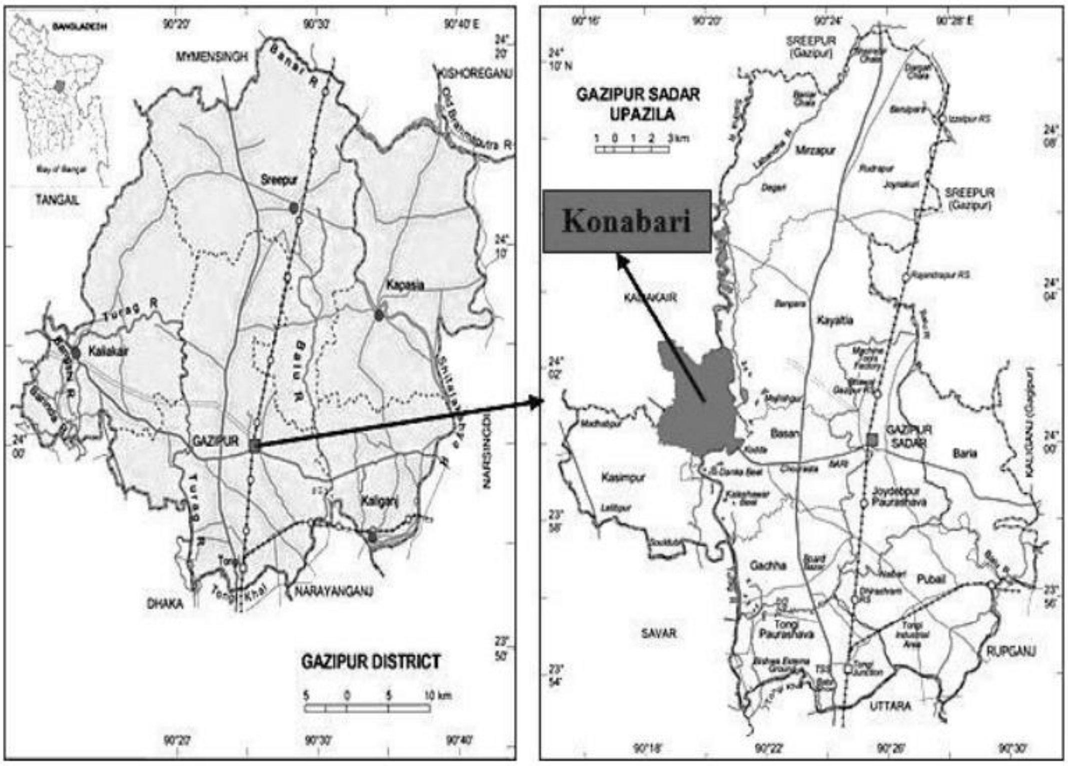

Figure 3: Showing the location of Konabari dumping station

3.4.4 Shiddhirganj dumping site

Shiddhirganj dumping station is situated in Siddhirganj in Narayanganj city. The area was located approximately at the latitude of 23°41′N and longitude of 90°31′E. Siddhirganj, is one of the oldest industrial cities of Bangladesh. It is located in the bank of Shitalakshya River, Narayanganj. The Siddhirganj Industrial Zone has more than 15 thousand factories and industrial establishments. Adamjee Jute Mills was established in Siddhirganj in 1951 and was once the largest jute mill in the world. This city is also one of the largest exporters in the country. and it was also called the Dundee of the East.

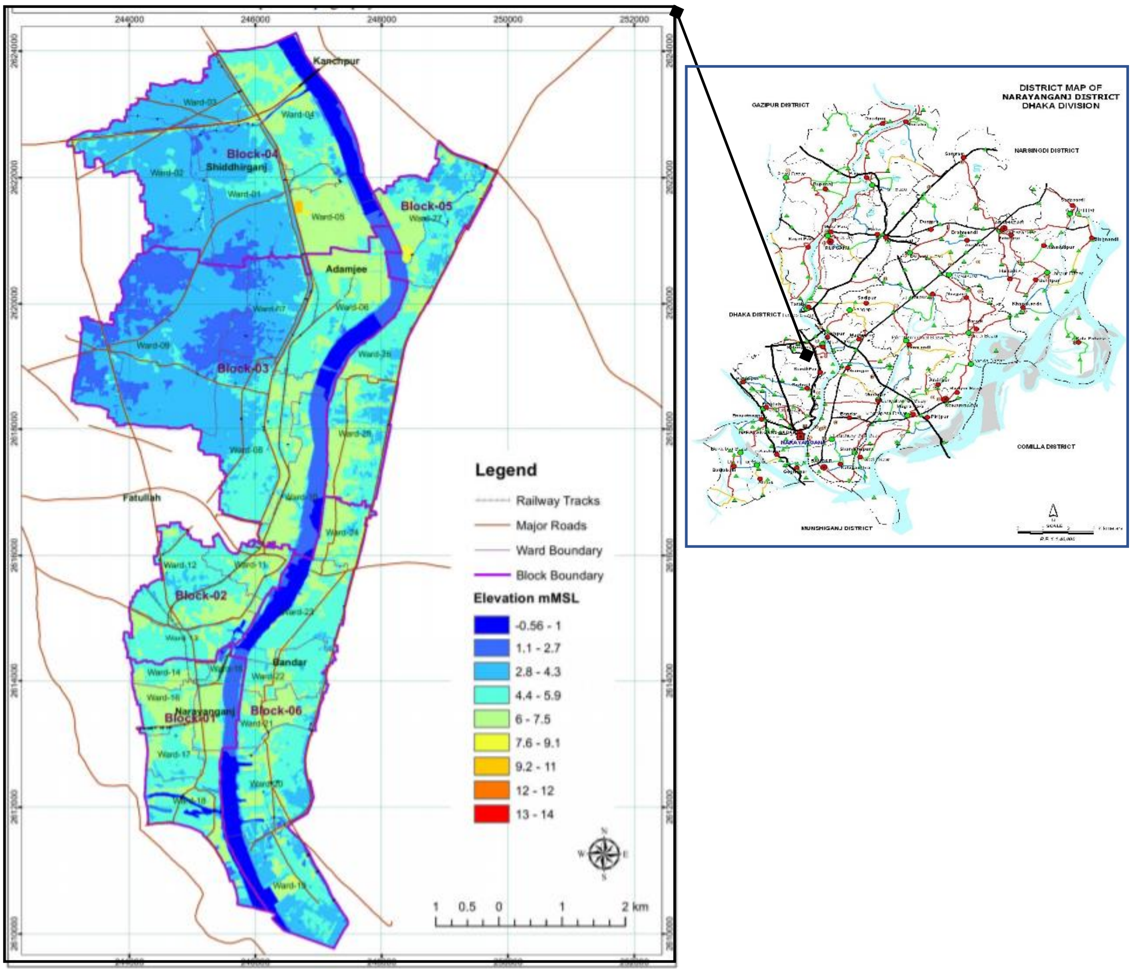

Figure 4: Showing the location of Shiddhirganj dumping station, Narayanganj district

3.5 Collection of soil samples

Two types of samples were collected from each site,

1. Dumpsite soil (DSS) and
2. Non-dumpsite soils (NDSS)

Soil samples were collected from three layers as:

1. First layer (0-15) cm
2. Second layer (15- 30) cm
3. Third layer (30-50) cm

The samples collected randomly from each location were made into a composite sample. Polluting materials and other exogenous materials were observed and noted then cleaned with ambient water from the collected soil samples, air-dried, ground and passed through 2-mesh sieve. The samples that were collected kept in plastic bags. All the soil samples were put into the individual polythene bag with distinct marking and tagging and labeling, were brought to the Soil research Lab, Soil Resources Development Institute (SRDI), Regional Office, Farmgate, Dhaka for soil analysis.

3.6 Soil analysis

Collected soil samples were analyzed for both physical and chemical properties using the standard techniques as follows,

3.6.1General observations

General observation was done firstly in time of sampling to observed what types of materials are dumped in that area. Observation was done by naked eye and materials observed was noted in a paper.

3.6.2 Physical properties

Mechanical analysis of soil samples was done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the Marshall's triangular co-ordinate following USDA system (Marshall, 1962).

3.6.3 Soil pH

Soil pH of the collected samples were measured with the help of a glass electrode pH meter, the soil and water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.6.4 Organic matter

Organic carbon of soil samples was measured volumetrically by wet oxidation method of Walkley and Black (1935). The organic matter content was calculated by multiplying the percent organic carbon by Van Bemmelen factor (1.73). (Page *et al.,* 1989)

3.6.5 Digestion of soil samples

The collected soil samples weighing 1.0 g were transferred into a dry clean digestion vessel. Then Nitric acid (HNO_3), 5 ml. was added to the vessel and allowed to stand it overnight with covering the vessel to vapor recovery device. On the following day, the digestion vessel was placed on a heating block and was heated at a temperature slowly raised to 120° C for 2 hours. After cooling, 2 ml of hydrogen per oxide (H_2O_2) was added into it and kept for few minutes. Again, the vessel was heated at 120°C. Heating was momentarily stopped when the dense white fumes occurred, after which the volume was reduced to 3-4 ml. The digest was cooled, diluted to 50 ml with deionized water and filtered through Whatman No.#42 filter paper into plastic bottle.

3.7 Determination of total Cd, Pb, Ni and Cr

3.7.1 Determination of Cadmium

Total Cadmium concentration was determined from the digest by Analytik JenanovAA 400P Atomic Absorption Spectrophotometer at 193.70 nm (Analytik Jena, 2017, country of origin: Germany).

3.7.2 Determination of Lead

Total Lead concentration was determined from the digest by Analytic JenanovAA 400P Atomic Absorption Spectrophotometer at 217.00 nm (Analytik Jena, 2017, country of origin: Germany).

3.7.3 Determination of Nickel

Total nickel concentration was determined from the digest by Analytik JenanovAA 400P Atomic Absorption Spectrophotometer at 224.80 nm (Analytik Jena, 2017, country of origin: Germany).

3.7.4 Determination of Chromium

Total Chromium concentration was determined from the digest by Analytik JenanovAA 400P Atomic Absorption Spectrophotometer at 213.90 nm (Analytik Jena, 2017, country of origin: Germany).

3.8 Statistical analysis

Range, mean and standard deviation of the contents of heavy metals of collected soils were calculated by MS-Excel. Correlation statistics was done to observe the interrelationship among the heavy metals with soil pH by using SPSS software. MS-Excel was used in drawing the correlation graphs.

CHAPTER IV

RESULTS AND DISCUSSION

The environment and its compartments have been severely polluted by heavy metals produced from different anthropogenic activities. This has compromised the ability of the environment to foster life and render its intrinsic values. This leads to the environment's ability to foster life being reduced as human, animal, and plant health become threatened. This occurs due to bioaccumulation in the food chains as a result of the nondegradable state of the heavy metals. Remediation of heavy metals requires special attention to protect soil quality, human health, animal health and all spheres of living bodies.

4.1 General observation

General observation of the sample was done by naked eye to just sort out what kind of polluted materials are present in the soil sample. Though all the sample contains more or less similar kind of materials within the soil of sampling site, all of the dumping sites presented more polluting materials then the outside areas. Polluting materials were abundant in the surface soil, then the subsurface soil. Deep layer of soil was almost free from physical polluting materials. Most abundant was the garments and industrial wastes, polythene bags and household plastic materials like broken piece of kitchen materials, toys, machineries etc. Broken pieces of metals and wires were also seen in the soils. Amazingly, there were almost no plastic bottle in the soil as the plastic bottles usually sorted and collected before dumping by the Tokays to sell them to pawnshop for recycling. A list of generally observed materials are presented below.

Table1: General observation of soil in the sampling sample

Dumping sites	Materials found by general observation in the sampling site
Amin Bazar	Industrial wastes Leather wastes, polythene bags, Broken piece of kitchen tools, Broken plastic toys, garments wastes, electric wire, metal wire, glass bottle, Biodegradable bags, etc.
Matuail	Polythene bags, biodegradable bags, garments wastes, industrial wastes, household wastes, broken piece of kitchen tools, Broken plastic toys, electric wire, metal wire, glass bottle, etc.
Konabari	Polythene bags, garments wastes, industrial wastes, household wastes, Broken piece of kitchen tools, Broken plastic toys, electric wire, metal wire, glass bottle, Biodegradable bags, etc.
Shiddhirganj	Polythene bags, garments wastes, electric wire, metal wire, glass bottle, Biodegradable bags, leather wastes, Broken piece of kitchen tools, Broken plastic toys, etc.

4.2 Physical properties of soil sample

Physical properties were analyzed for better understanding of the sampling sites. Percentage of sand, silt and clay were determined to classify the soil according to the textural class. Textural classes were seen silty clay for Amin bazar of Dhaka, silty loam type soil in Matuail of Dhaka, clay loam type soil in Konabari of Gazipur and silty clay type in Shiddhirganj of Narayanganj. Soil particle percentage is presented in the table 2. Soil texture is very important for agriculture as as well heavy metal content. It defines the water permeability of soil. Highly permeable soil lets trace elements leach deeper with rain and irrigation water may differentiate between different heavy metal content. On the other hand, for the low permeable soil trace elements may be held by the soil upper surfaces.

Table 2: Physical properties of sampling sites

Sampling sites	Sand (%)	Silt (%)	Clay (%)	Textural class
Site 1	40.2	36.7	23.1	Silty Clay
Site 2	30.2	49.9	19.9	Silt Loam
Site 3	34.9	38.1	26.9	Clay Loam
Site 4	39.2	37.9	22.9	Silty Clay

Note: Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.3 Chemical properties of soil

4.3.1 pH of soil

The pH in the soil ranged from 5.96 to 7.56 (Table 3) in the sapling area. In the analysis the highest mean value of pH (7.36) found in the site 2 which was Matuail for DSS and Shiddhirganj, Narayanganj (7.00) for NDSS. Also, the lowest mean value of pH (6.68 and 6.35)) was found in site 1 which is Amin Bazar, Dhaka for both dumpsite and NDSS.

The average pH ranged hierarchically were Site 1< Site 4< Site 3< Site 2 for DSS and Site 1< Site 3< Site 2< Site 4 for NDSS. The value ranged at Amin Bazar, Dhaka from 6.39- 6.97, in the area of Matuail, Dhaka it ranged from 7.15- 7.56, In Konabari, Gazipur it was 6.52- 7.38 and at Shiddhirganj, Narayangonj ranged 6.37- 7.07.

The desirable pH range for optimum plant growth varies among crops. While some crops grow best in the 6.0 to 7.0 range, others grow well under slightly acidic conditions. Soil properties that influence the need for and response to lime vary by region. Knowledge of the soil and the crop is important in managing soil pH for the best crop performance. Many researchers like Zakir *et al.* (2014), Zakir *et al.* (2015), (2014), Hoque *et al.* (2014) and others found neutral pH in the dumpsite. But pH in matuail dumpsite 7.76 and in Khulna dumpsite 7.95 were observed by Karim *et al.* (2014).

Table 3: pH level of the soil in sampling sites

Sampling sites	**DSS**		**NDSS**	
	pH range	**Mean**	**pH range**	**Mean**
Site 1	6.39- 6.97	6.68	5.96- 6.73	6.35
Site 2	7.15- 7.56	7.36	6.40- 7.02	6.71
Site 3	6.52- 7.38	6.95	6.45- 6.87	6.66
Site 4	6.37- 7.07	6.72	6.87- 7.13	7.00

Note: Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.3.2 Soil organic carbon

Variation was found in organic carbon content of sampled soils. The range of organic carbon were between 1.32% to 1.78% for DSS and 0.59% to1.02% for NDSS. The lowest amount of organic carbon was recorded from the site 2 for DSS (1.32%) and site 4 for NDSS (0.59%). The highest amount of organic carbon was found from the site1 for DSS and site 3 for NDSS. The variation occurred in soil organic carbon may be due to different types of dumping wastages at different sites. Usually huge amount of organic wastages is dumped in the dumping site every day. May be this is the reason why the DSS contain more amount of organic carbon than the NDSS. Among the DSS sample, Amin Bazar of Dhaka contained the highest amount of organic matter content. NDSS from Konabari of Gazipur contained the highest amount of organic carbon within this category. In general, the organic matter content in Bangladesh soil is quite low (BARC, 2005).

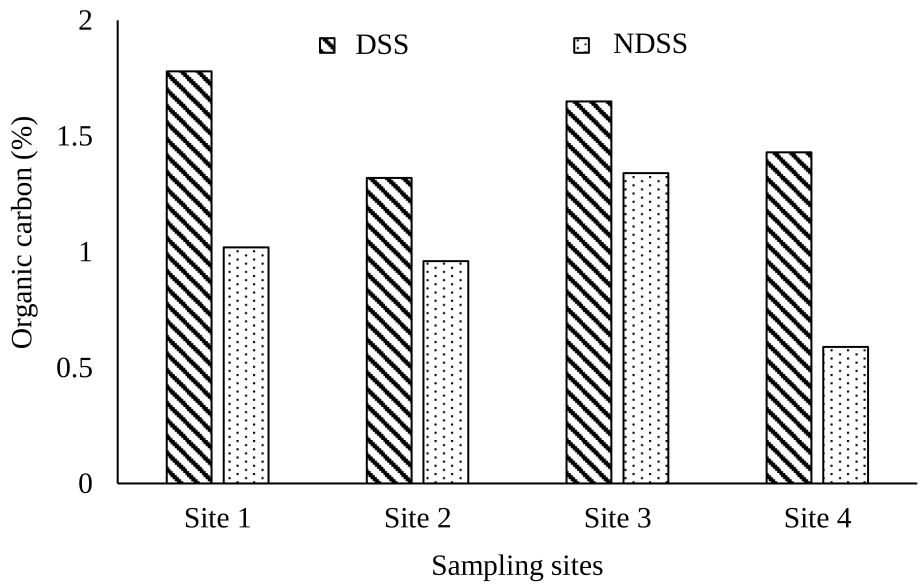

Figure 5: Organic carbon content of soil sample

Note: Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.4 Cadmium content of soil

The Cadmium content of soil value ranged from 0.21- 0.98 $mgkg^{-1}$ in this area is presented in table 4.

4.4.1 Cadmium content in DSS

The range of cadmium content for DSS samples were from 0.23 $mgkg^{-1}$ to 0.98 $mgkg^{-1}$. For the DSS the value of cadmium content was highest in the soil that was collected from site 1 (0.80 $mgkg^{-1}$ $mgkg^{-1}$) and the lowest value was in the soil from site 4 (0.41 $mgkg^{-1}$). The mean values of these sample were in the following order Site 4< Site 3< Site 2< Site 1 area for DSS. The value ranged at Amin Bazar of Dhaka from 0.45- 0.98 $mgkg^{-1}$, In the area of Matuail, Dhaka it ranged from 0.39-0.83 $mgkg^{-1}$, at Konabari, Gazipur it was 0.28-0.65 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 0.29-0.51 $mgkg^{-1}$.

4.4.2 Cadmium content of NDSS

The range of cadmium content for NDSS samples was from 0.21 $mgkg^{-1}$ to 0.48 $mgkg^{-1}$. For the NDSS the mean value that was collected from site 1 contained the highest amount of cadmium (0.45 $mgkg^{-1}$) and the lowest mean value was in the soil of Site 4 (0.27 $mgkg^{-1}$). The mean value of these sample was in upmost in the following order Site 4< Site 2< Site 3< Site 1 area for NDSS. The value ranged at Amin Bazar, Dhaka from 0.41-0.48 $mgkg^{-1}$, In the area of Matuail, Dhaka it ranged from 0.29-0.41 $mgkg^{-1}$, at Konabari, Gazipur it was 0.43-0.48 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 0.21- 0.31 $mgkg^{-1}$.

Research work performed by Zakir *et al.* (2014) showed similar result found 1.23- 6.95 $mgkg^{-1}$ of cadmium in Dhaka city area while Zakir *et al.* (2015) seen 0.08 - 1.60 $mgkg^{-1}$ cadmium in Gazipur. In Shialkot, Pakistan Malik et al. (2010) observed 36.8 mg of cadmium.

Table 4: Cadmium content (mgkg^{-1}) of soil sample collected from the study area

Dumping sites	DSS				NDSS			
	Layer 1	**Layer 2**	**Layer 3**	**Mean (±SD)**	**Layer 1**	**Layer 2**	**Layer 3**	**Mean(±SD)**
Site 1	0.96	0.98	0.45	0.80 (±0.25)	0.47	0.48	0.41	0.45 (±0.03)
Site 2	0.81	0.83	0.39	0.68 (±0.20)	0.39	0.41	0.29	0.36 (±0.05)
Site 3	0.65	0.62	0.28	0.52 (±0.17)	0.48	0.43	0.38	0.43 (±0.04)
Site 4	0.51	0.48	0.23	0.41 (±0.13)	0.29	0.31	0.21	0.27 (±0.04)
Range	0.23 – 0.98				0.21 – 0.48			

Note: DSS: Dumpsite soil, NDSS: Non-dumpsite soil, Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj; SD= Standard deviation

4.4.3 Comparison of cadmium content between DSS and NDSS

DSS samples contained higher amount of cadmium (0.80, 0.68, 0.52 and 0.41 $mgkg^{-1}$) than content NDSS sample (respectively 0.45, 0.36, 0.43 and 0.27 $mgkg^{-1}$) in all sites studied. This a conclusion that dumping of various types of waste materials increases the amount of cadmium content in soil. Esakku *et al*. (2003); Esakku *et al*. (2008) and Prechthai *et al*. (2008) stated that dumping site has an impact on increasing heavy metal on soil.

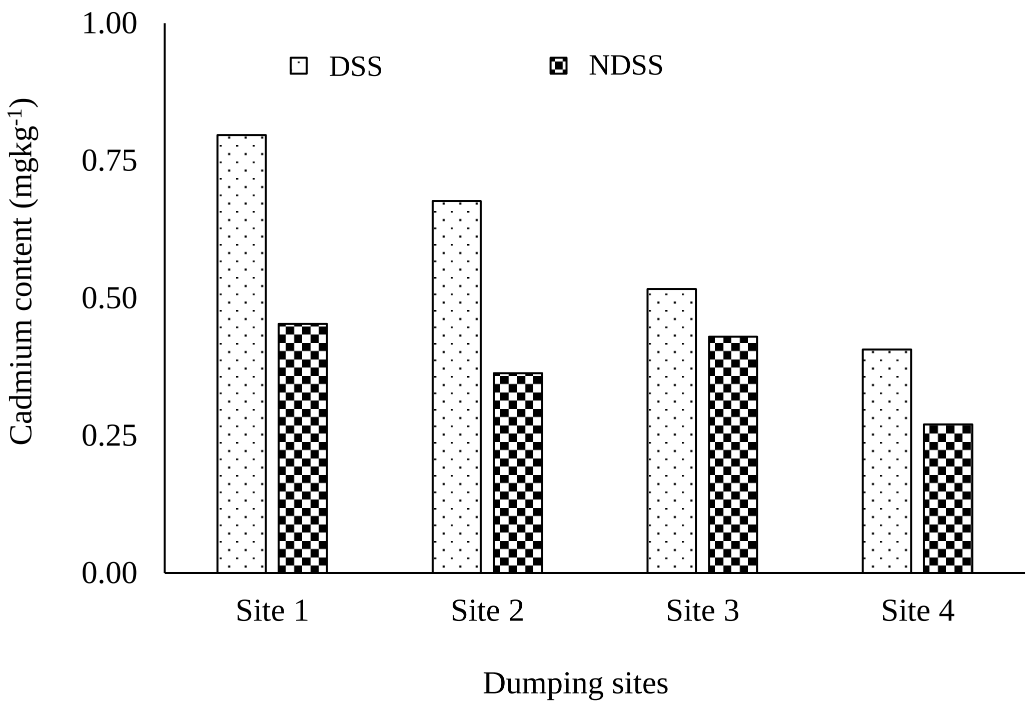

Figure 6: Comparison of cadmium content between DSS and NDSS

Note: DSS: Dumpsite soil, NDSS: Non-dumpsite soil, Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.5 Lead content of soil

The Lead content was in the range of 4.5 – 39.7 $mgkg^{-1}$ observed in those area is presented in table 5.

4.5.1 Lead content in DSS

The range of lead content for DSS samples were from 13.2 $mgkg^{-1}$ to 39.7 $mgkg^{-1}$. The highest mean value of lead content was found for DSS sample was site 4 (33.4 $mgkg^{-1}$) and the lowest mean value of lead content was for site 3 (20.6 $mgkg^{-1}$). The analyzed soil sample were in the context of following chronological order as Site 3 < Site 2 < Site 1 < Site 4. The value ranged at Amin Bazar, Dhaka from 20.3- 34.3 $mgkg^{-1}$, in the area of Matuail, Dhaka it ranged from 19.1-28.8 $mgkg^{-1}$, at Konabari, Gazipur it was 13.2-25.6 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 22.3-39.7 $mgkg^{-1}$.

4.5.2 Lead content of NDSS

The range of lead content for NDSS samples were from 4.5 $mgkg^{-1}$ to 18.1 $mgkg^{-1}$. The highest mean value of lead content was found for NDSS sample was site 4 (14.5 $mgkg^{-1}$) and the lowest mean value of lead content was for site 3 (7.2 $mgkg^{-1}$). The analyzed soil sample were in the context of following chronological order as Site 3<Site 2< Site 1 < Site 4. The value ranged at Amin Bazar, Dhaka from 7.1-11.4 $mgkg^{-1}$, in the area of Matuail, Dhaka it ranged from 4.5-8.5 $mgkg^{-1}$, at Konabari, Gazipur it was 5.5-8.4 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 8.1-18.1 $mgkg^{-1}$.

In Matuail dumpsite, 5.66 - 87.79 $mgkg^{-1}$ and Khulna dumpsite,11.18 - 69.6 dumpsite $mgkg^{-1}$ lead was observed by Karim *et al*. (2014). Research work performed by Zakir *et al.* (2014) showed lead content found 2.3 - 9.6 $mgkg^{-1}$ of in Dhaka city area and Zakir *et al.* (2015) seen 0.44 - 127.45 $mgkg^{-1}$ lead in Gazipur which was also within similar to present study. In Shialkot, Pakistan 121.4 $mgkg^{-1}$ of lead was observed by Malik *et al.*, (2010).

Table 5: Lead content (mgkg^{-1}) of soil sample collected from the study area

Dumping sites	DSS				NDSS			
	Layer 1	**Layer 2**	**Layer 3**	**Mean (±SD)**	**Layer 1**	**Layer 2**	**Layer 3**	**Mean (±SD)**
Site 1	34.3	35.5	20.3	30.0 (±6.9)	11.4	13.1	7.1	10.5 (±2.5)
Site 2	28.8	27.5	19.1	25.1 (±3.4)	8.5	9.3	4.5	7.4 (±2.1)
Site 3	25.6	23.0	13.2	20.6 (±5.3)	7.7	8.4	5.5	7.2 (±1.2)
Site 4	39.7	38.1	22.3	33.4 (±7.9)	18.1	17.4	8.1	14.5 (±4.6)
Range	13.2 – 39.7				4.5 – 18.1			

Note: DSS: Dumpsite soil, NDSS: Non-Dumpsite soil, Site 1: Amin Bazar, Dahaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj; SD= Standard deviation

4.5.3 Comparison of lead content ($mgkg^{-1}$) between dumpsite and NDSS

Soil sample collected from dumpsite area contained higher amount of lead (30.0, 25.1, 20.6 and 33.4 $mgkg^{-1}$) compared to control area (10.5, 7.4, 7.2 and 14.5 $mgkg^{-1}$ respectively). Industrial wastes that are rich in lead were dumped in the dumping site which may increase the level of lead in the dumpsite area. Karim *et al.*, (2014) and Hoque *et al.*, (2014) stated that dumping as a reason for increasing lead content of soil in Bangladesh.

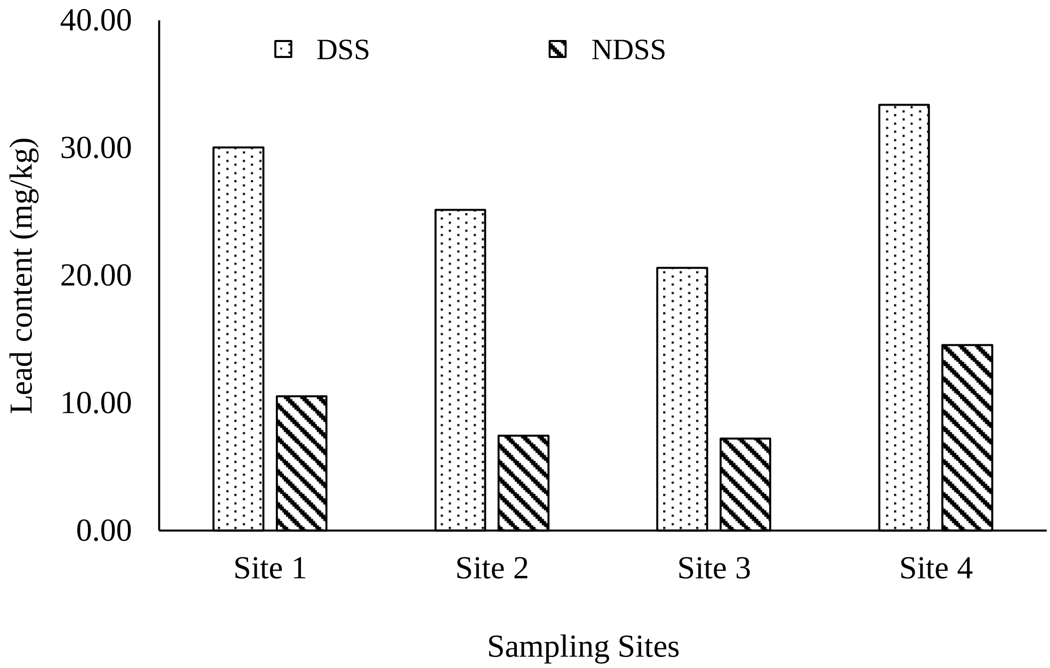

Figure 7: Comparison of lead content between dumpsite and NDSS

Note: DSS: Dumpsite soil, NDSS: Non-dumpsite soil, Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.6 Nickel content of soil

The value of Nickel content ranged from 4.23- 29.31 $mgkg^{-1}$ in this area is presented in table 6.

4.6.1 Nickel content of DSS

The range of nickel content for DSS samples were from 6.87 $mgkg^{-1}$ to 29.31 $mgkg^{-1}$. For the DSS the mean value that was found analyzing the collected soil sample were the highest in the soil that was collected from site 4 (42.07 $mgkg^{-1}$) and the lowest mean value was in the soil of site 1 (7.83 $mgkg^{-1}$). The mean value of these sample was in the following order Site 1< Site 3< Site 2< Site 4 area for DSS. The value ranged at Amin Bazar, Dhaka from 6.87- 10.76 $mgkg^{-1}$, In the area of Matuail, Dhaka it ranged from 14.89-26.67 $mgkg^{-1}$, at Konabari, Gazipur it was 15.34-16.54 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 19.12 - 28.78 $mgkg^{-1}$.

4.6.2 Nickel content of NDSS

The range of nickel content for NDSS samples were from 4.23 $mgkg^{-1}$ to 18.65 $mgkg^{-1}$. For the control the mean value that was found analyzing the collected soil sample were the highest in the soil that was collected from site 1 (927.33 $mgkg^{-1}$) and the lowest mean value was found in the soil of site 1 (5.32 $mgkg^{-1}$). The mean value of these sample was in the following order Site 1< Site 3< Site 2< Site 4 area for NDSS. The value ranged at Amin Bazar, Dhaka from 4.23-6.87 $mgkg^{-1}$, in the area of Matuail, Dhaka it ranged from 12.63-15.87 $mgkg^{-1}$, at Konabari, Gazipur it was 9.54-16.54 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 13.12-18.65 $mgkg^{-1}$.

In Matuail dumpsite, 0.84-9.89 $mgkg^{-1}$ and Khulna dumpsite, 0.42-0.90 dumpsite $mgkg^{-1}$ nickel was observed by Karim *et al*. (2014). Research work performed by Zakir *et al.* (2014) showed nickel content found 4.46 -23.34 $mgkg^{-1}$ of in Dhaka city area.

Table 6: Nickel content ($mgkg^{-1}$) of soil sample collected from the study area

Dumping sites	DSS				NDSS			
	Layer 1	**Layer 2**	**Layer 3**	**Mean (±SD)**	**Layer 1**	**Layer 2**	**Layer 3**	**Mean (±SD)**
Site 1	10.76	9.86	6.87	9.16 (±1.66)	4.23	4.87	6.87	5.32 (±1.1)
Site 2	26.67	24.65	14.89	22.07 (±5.1)	15.87	12.63	14.89	14.46 (±1.4)
Site 3	16.54	16.32	15.34	16.07 (±0.5)	9.54	11.56	16.54	12.55 (±2.9)
Site 4	28.78	29.31	19.12	26.74 (±4.7)	18.65	17.21	13.12	16.33 (±7.9)
Range	6.87 – 29.31				4.23 – 18.65			

Note: DSS: Dumpsite soil, NDSS: Non-Dumpsite soil, Site 1: Amin Bazar, Dahaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj; SD= Standard deviation

4.6.3 Comparison of nickel content between dumpsite and NDSS

In comparison nickel content between dumpsite and NDSS sample the difference is clearly visible. DSS samples contained higher amount of nickel (9.16, 22.07, 16.07, 25.74 mgkg^{-1}) than the NDSS sample (5.32, 14.46, 12.55 and 16.33 mgkg^{-1}) in all the sites studied. It can be concluded that dumping of various types of waste materials increase the amount of nickel content in soil. Shiddhirganj having steel industries may be a major reason of heavy metal increase (Akter et al, 2019). Karim *et al*, (2014) and Hoque *et al*, (2014) stated that dumping as a reason for increasing lead content of soil in Bangladesh.

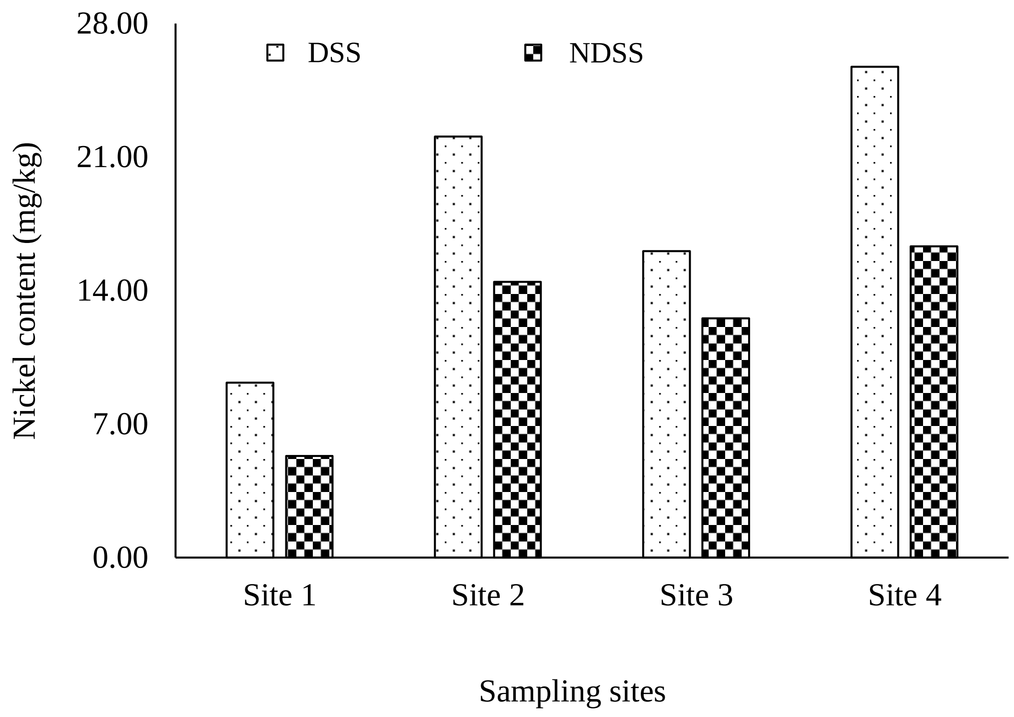

Figure 8: Comparison of nickel content between dumpsite and NDSS

Note: DSS: Dumpsite soil, NDSS: Non-dumpsite soil, Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.7 Chromium content of soil

The Chromium content was in the range of 2.45-43.49 mgkg^{-1} observed in those area is presented in table 7.

4.7.1 Chromium content of DSS

The range of chromium content for DSS samples were from 14.32 mgkg^{-1} to 43.49 mgkg^{-1}. The highest chromium content was found from DSS sample was found in site 4 (59.70 mgkg^{-1}) and the lowest content from site 2 (18.49 mgkg^{-1}). The analyzed soil sample were in the context of following chronological order as Site 2< Site 3< Site 1< Site 4. The value ranged in Aminbazar, Dhaka from 29.34-33.68 mgkg^{-1}, in the area of Matuail, Dhaka it ranged from 14.32-21.06 mgkg^{-1}, At Konabari, Gazipur it was 33.45-43.49 mgkg^{-1} and at Shiddhirganj, Narayanganj ranged 33.45-73.49 mgkg^{-1}.

4.7.2 Chromium content of NDSS

The range of chromium content for NDSS samples were from 2.45 mgkg^{-1} to 28.56 mgkg^{-1}. All the sites contained lower amount of chromium for the control samples. The highest chromium content was found for NDSS sample was site 4 (21.90 mgkg^{-1}) and the lowest content was for site 3 (6.20 mgkg^{-1}) and site 2 (6.25 mgkg^{-1}) are almost identical. The analyzed soil sample were in the context of following chronological order as Site 3< Site 2< Site 1 < Site 4. The value ranged in Aminbazar, Dhaka from 6.45-14.65 mgkg^{-1}, in the area of Matuail, Dhaka it ranged from 4.98-6.65 mgkg^{-1}, At Konabari, Gazipur it was 2.45-7.56 mgkg^{-1} and at Shiddhirganj, Narayanganj ranged 12.56-28.56 mgkg^{-1}.

In Matuail dumpsite, 10.10 - 81.19 mgkg^{-1} and Khulna dumpsite, 1.72 - 2.96 mgkg^{-1} chromium was observed by Karim *et al*. (2014). Research work performed by Zakir *et al.* (2014) showed chromium content found 0.00 - 80.78 mgkg^{-1} of in Gazipur city area which was similar to present study. In Shialkot, Pakistan 155.0 mgkg^{-1} of chromium was observed by Malik *et al.* (2010).

Table 7: Chromium content ($mgkg^{-1}$) of soil sample collected from the study area

Dumping sites	DSS				NDSS			
	Layer 1	Layer 2	Layer 3	Mean (±SD)	Layer 1	Layer 2	Layer 3	Mean (±SD)
Site 1	33.68	38.46	29.34	33.83 (±3.7)	14.56	14.65	6.45	11.89 (±3.8)
Site 2	21.06	20.09	14.32	18.49 (±3.0)	6.65	7.12	5.98	6.58 (±0.5)
Site 3	33.43	28.96	15.67	26.02 (±7.5)	7.56	8.59	2.45	6.20 (±2.7)
Site 4	43.49	42.15	33.45	39.70 (±4.5)	28.56	24.58	12.56	21.90 (±6.8)
Range	14.32 – 43.49				2.45 – 28.56			

Note: DSS: Dumpsite soil, NDSS: Non-Dumpsite soil, Site 1: Amin Bazar, Dahaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj; SD= Standard deviation

4.7.3 Comparison of chromium content between dumpsite and NDSS

The difference of chromium content between dumpsite and NDSS sample was noticeable. DSS samples contained higher amount of chromium (33.83, 18.49, 26.02 and 39.70 $mgkg^{-1}$) than the NDSS sample (11.89, 6.58, 6.20, 21.90 $mgkg^{-1}$) in all four sites studied. Dumping of various types of waste materials increases the amount of chromium content in soil. Studying with two steel industry it was found that heavy metal is highly increased by steel industry wastages (Akter *et al*, 2019). Karim *et al.,* (2014) and Hoque *et al*, (2014) stated that dumping as a reason for increasing lead content of soil in Bangladesh.

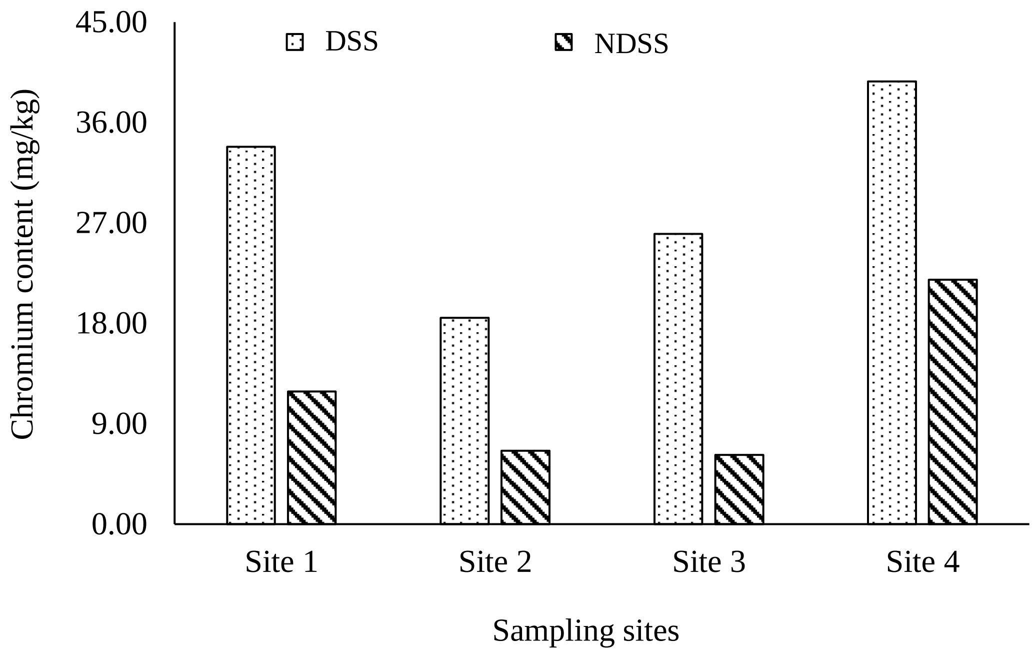

Figure 9: Comparison of chromium content between dumpsite and NDSS

Note: DSS: Dumpsite soil, NDSS: Non-dumpsite soil, Site 1: Amin Bazar, Dhaka; Site 2: Matuail, Dhaka; Site 3: Konabari, Gazipur; Site 4: Shiddhirganj, Narayangonj

4.8 Comparison of heavy metal contents among DSS, NDSS and in normal soil according to WHO

Here from this comparison among the values of DSS, NDSS and WHO, it is obvious that the concentration of heavy metals in soil is increasing at an alarming rate. Though the current rate of heavy metals concentration in soil comparatively low, it must be obnoxious and deadly in near future. Mostly the value of nickel concentration in DSS almost lethal and near to reach ceiling, where the concentration of Cd, Pb and Cr is also increasing but lower than the concentration of nickel. The concentration of Ni, Cr, Cd and Pb in DSS ranges between (6.87 - 29.51), (14.32 - 43.49), (0.23 - 0.98) and (13.2 - 39.7) $mgkg^{-1}$ while the concentration of Ni, Cr, Cd and Pb in NDSS ranges between (4.23 - 18.65), (14.32 - 43.49), (0.23 - 0.98) and (13.2 - 39.7) $mgkg^{-1}$. According to WHO, the threshold of these elements 35 $mgkg^{-1}$, 100 $mgkg^{-1}$, 0.8 mg/kg^{-1} and 85 $mgkg^{-1}$. So if any protective measure doesn't to be taken, the concentration of there metals must touch the ceiling point pushing every creature to a dysfunctional step. So for the optimization of these metal contents in soil necessary steps must be followed soon.

Table 8.: Comparison of heavy metal contents among DSS, NDSS and threshold level in soil according to WHO

Elements	Heavy metal content range in DSS ($mgkg^{-1}$)	Heavy metal content range in NDSS ($mgkg^{-1}$)	Threshold level according to WHO ($mgkg^{-1}$)
Cd	0.23 – 0.98	0.21 – 0.48	0.8
Cr	14.32 – 43.49	2.45 – 28.56	100
Pb	13.2 – 39.7	13.2 – 39.7	85
Ni	6.87 – 29.31	4.23 – 18.65	35

^{X} Target values are specified to indicate desirable maximum levels of elements in Source: WHO (1996) from Ogundele *et al.* (2015)

4.9 Correlation between pH and heavy metal content

All the heavy metal contents showed positive and weak correlation with soil pH. Correlation between soil pH and Cadmium was very weak (R^2 = 0.0387). Soil pH and lead was weakly correlated to each other (R^2 = 0.1015). Soil pH and Nickel was positively correlated to each other which was also weak (R^2 = 0.4248). Correlation between soil pH and chromium was very weak which was negligible.

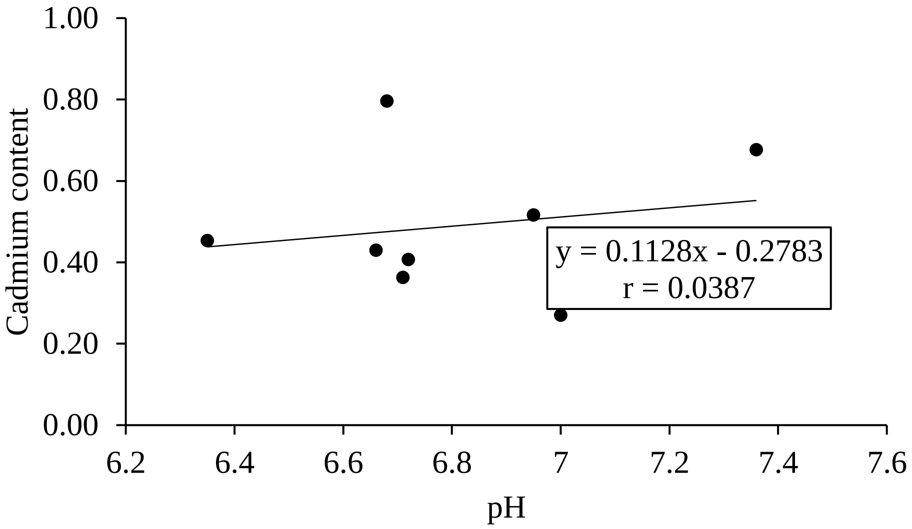

Figure 10: Correlation of soil pH with cadmium content

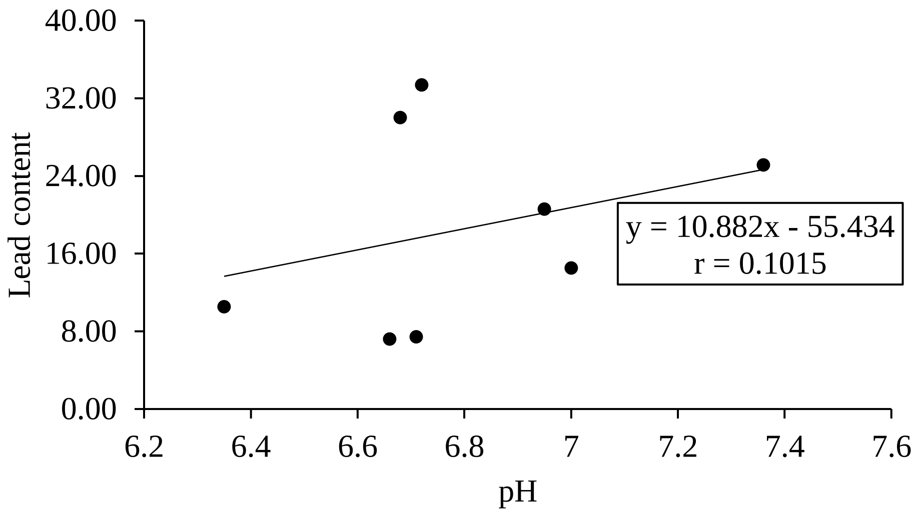

Figure 11: Correlation of soil pH with lead content

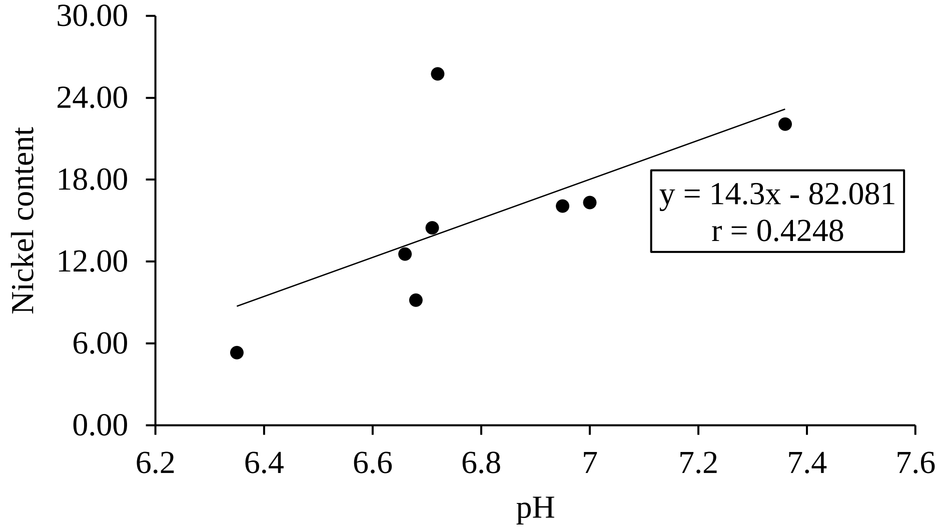

Figure 12: Correlation of soil pH with nickel content

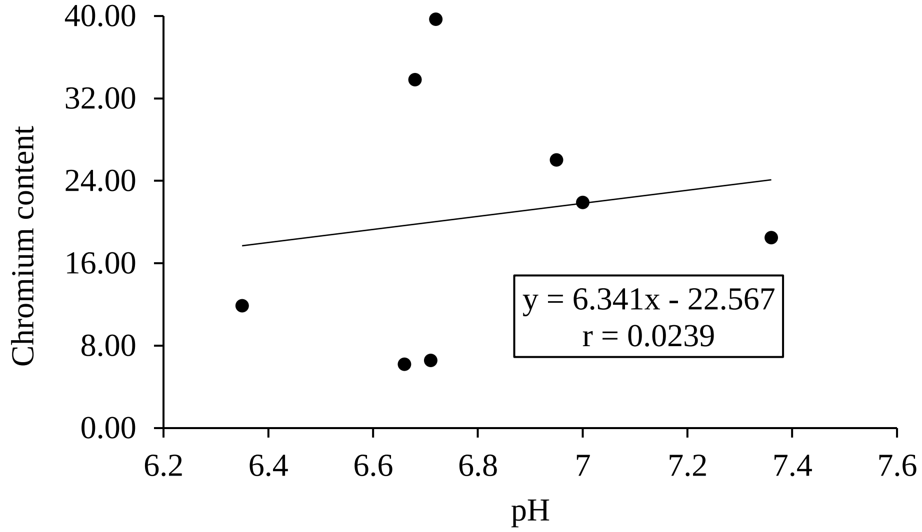

Figure 13: Correlation of soil pH with chromium content

4.10 Correlation between soil depth and heavy metal content

All the heavy metal contents showed strong and negative correlation with soil depth, that means, the more depth we go, the lower amounts of metal contents we get. Because the wastes lay on the surface soil and metal contents from the waste leach under slowly. Correlation between soil depth and Cadmium was strong and inversed (r = 0.7595). Soil depth and lead was strongly correlated to each other (r = 0.8099). Soil depth and nickel was negatively correlated to each other which was also weak (r = 0.7937). Correlation between soil depth and chromium was also strong and negative (r = 0.7885). These results revealed that the content of these heavy metals decreases with the increase in depth of soil.

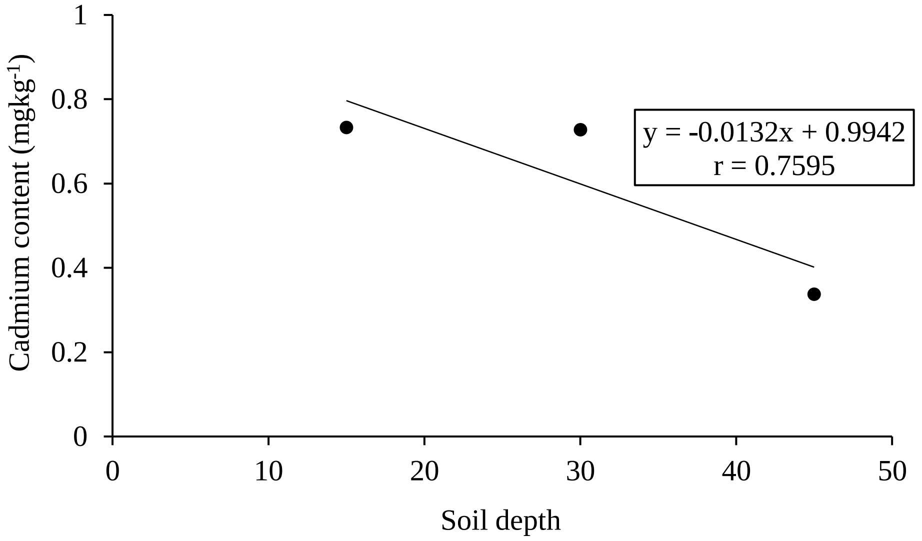

Figure 14: Correlation between soil depth and cadmium content

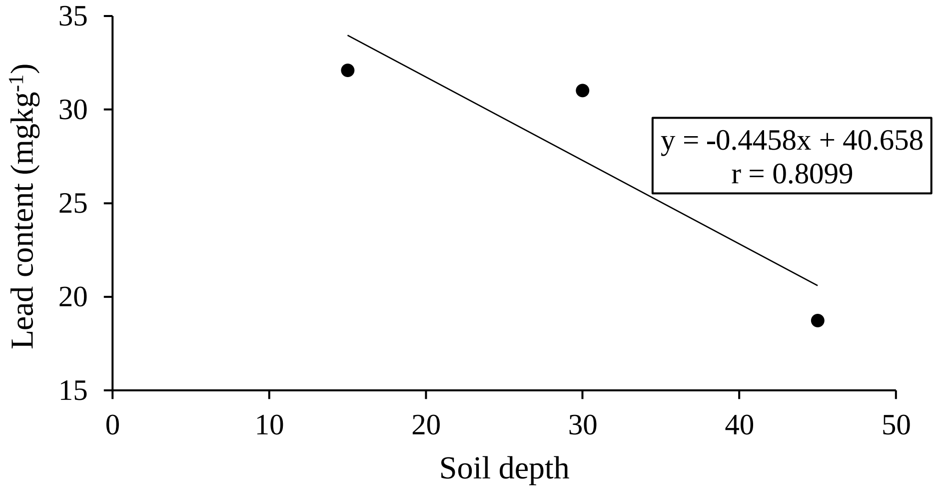

Figure 15: Correlation between soil depth and lead content

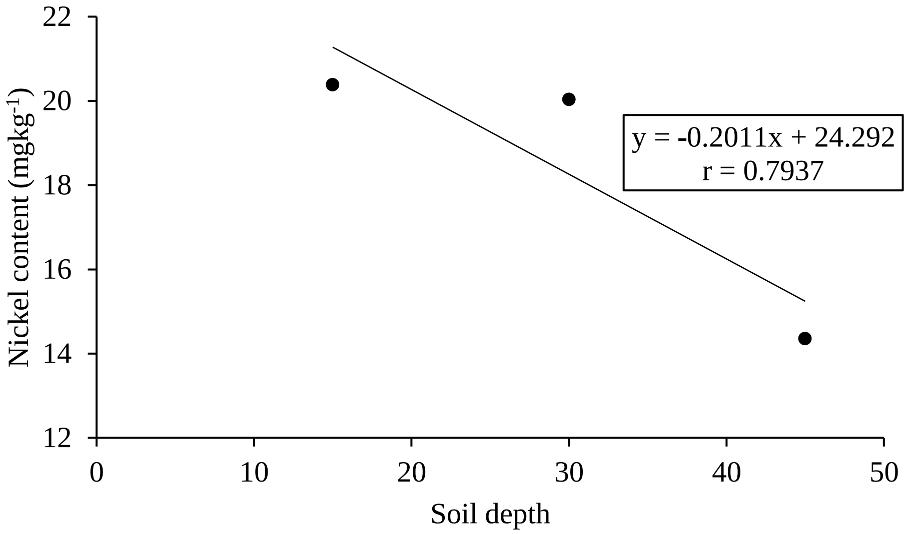

Figure 16: Correlation between soil depth and nickel content

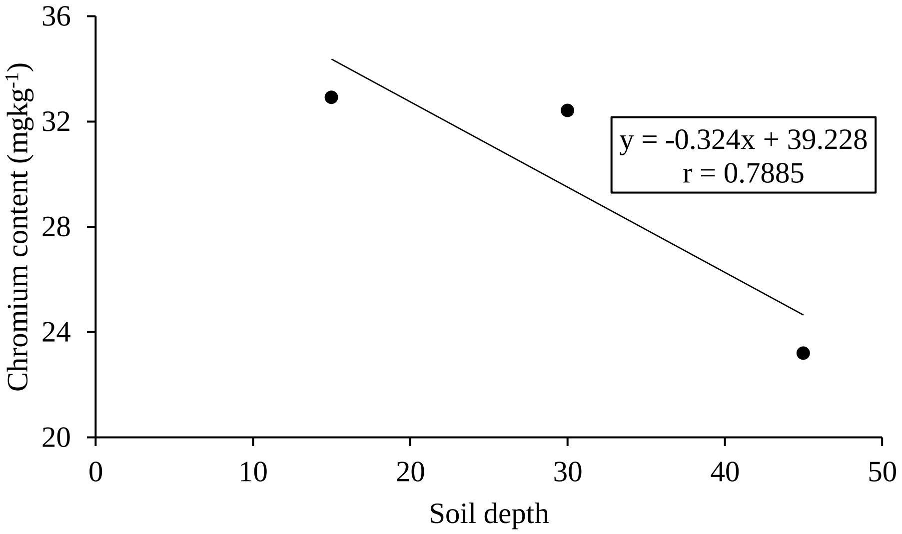

Figure 17: Correlation between soil depth and chromium content

CHAPTER V

SUMMERY AND CONCLUSION

SUMMERY

Soil is one of the most important factors of environment. During the conduction of the study soil samples were collected from different selected dumping site as Amin Bazar, Dhaka; Matuail, Dhaka; Konabari, Gazipur and Shiddhirganj, Narayanganj to assess the impact of wastages of these dumping site located in theses region on environment and agricultural productivity and to compare the content with soil from outside of dumpsite areas to understand the environmental risk. A total number of 48 soil samples were collected from the target site in the selected dumping site. Later, the collected samples were analyzes targeting the parameter like textural class, pH, OM, Cd, Pb, Ni and Cr. All the soil sample textural classes were similar and dominant in clayey and loamy nature, pH value was almost neutral for all of the sample ranged 5.96-7.56. Organic content was also low for most of the sample but samples from dumping waste presented comparatively higher amount of organic matters.

The cadmium content of soil sample ranged between 0.21- 0.98 $mgkg^{-1}$. Highest cadmium was collected from Amin Bazar (0.80 $mgkg^{-1}$) and the lowest mean value was in the soil of site Shiddhirganj (0.41 $mgkg^{-1}$). The value ranged at Amin Bazar, Dhaka from 0.45- 0.98 $mgkg^{-1}$, In the area of Matuail, Dhaka it ranged from 0.39-0.83 $mgkg^{-1}$, at Konabari, Gazipur it was 0.28-0.65 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 0.29- 0.51 $mgkg^{-1}$. DSS sample contained higher amount of cadmium than NDSS sample

The lead content was in the range of 21.25 - 38.81 $mgkg^{-1}$, where the highest amount (48.7 $mgkg^{-1}$) was found in Shiddhirganj dumping site. For the DSS sample, the value ranged at Amin Bazar, Dhaka from 25.3- 54.3 $mgkg^{-1}$, in the area of Matuail, Dhaka it ranged from 29.1-37.5 $mgkg^{-1}$, at Konabari, Gazipur it was 13.2-25.6 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 22.3-65.7 $mgkg^{-1}$. NDSS sample contained lower amount of lead compared to DSS sample.

The nickel content value ranged from 4.23- 48.78 $mgkg^{-1}$. The highest nickel content was collected from Shiddhirganj (42.07 $mgkg^{-1}$) and the lowest mean value was in the soil of Aminbazar dumping site (7.83 $mgkg^{-1}$). The value ranged at Amin Bazar, Dhaka from 6.87- 8.76 $mgkg^{-1}$, In the area of Matuail, Dhaka it ranged from 14.89-26.67 $mgkg^{-1}$, at Konabari, Gazipur it was 15.34-16.54 $mgkg^{-1}$ and at Shiddhirganj, Narayangonj ranged from 33.12-48.78 $mgkg^{-1}$ for DSS sample. NDSS sample contained lower amount of lead compared to DSS sample.

Chromium content was in the range of 2.45-21.06 $mgkg^{-1}$. The highest chromium content was found for DSS sample was Shiddhriganj (59.70 $mgkg^{-1}$) and the lowest content was for Matuail (18.49 $mgkg^{-1}$). The value ranged for DSS sample in Aminbazar, Dhaka from 29.34-38.46 $mgkg^{-1}$, in the area of Matuail, Dhaka it ranged from 14.32-21.06 $mgkg^{-1}$, At Konabari, Gazipur it was 15.67-33.43 $mgkg^{-1}$ and at Shiddhirganj, Narayanganj ranged 33.45-73.49 $mgkg^{-1}$. NDSS sample contained lower amount of lead compared to DSS sample.

Correlation between soil pH and Cadmium (r = 0.0387), Soil pH and lead (r = 0.1015), Soil pH and Nickel (r = 0.4248) and soil pH and chromium (r = 0.0239) all are weakly correlated to each other.

Correlation between soil depth and Cadmium (r = 0.7595), soil depth and lead (r = 0.8099) soil depth and nickel (r = 0.7937) and soil depth and chromium (r= 0.7885) was negative and strong.

CONCLUSION

Heavy metal pollution is a serious global environmental problem as it adversely affects plant growth and genetic variation. It also alters the composition and activity of soil microbial communities. Soil from all the experimented four sites were loamy types with almost neutral pH with lower content of organic matter. Heavy metal content of soil sample collected from all the dumping sites was in permissible amount but comparing to the sample that was collected far from polluted site, the content was way higher. There was negligible correlation between the heavy metals and soil pH but correlation between heavy metals and soil depth was strong and negative. May be, due to dumping of various industrial wastages to these dumping sites, risks are increasing day by day. The heavy metal contents leach from dumping sites and get mixed with the natural water resources. As a result, there might be a high risk of surface and groundwater contamination along with soil pollution that make heavy metals enter into food chain through the bio-accumulation. So it is the demand of time to take immediate measures to minimize the soil and water pollution by metal contents around the environment for the survival of human beings.

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APPENDICES

Appendix 1. Comparison of heavy metal contents among DSS, NDSS and threshold level in soil according to WHO

Elements	Heavy metal content range in DSS ($mgkg^{-1}$)	Heavy metal content range in NDSS ($mgkg^{-1}$)	Threshold level according to WHO ($mgkg^{-1}$)
Cd	0.23 – 0.98	0.21 – 0.48	0.8
Cr	14.32 – 43.49	2.45 – 28.56	100
Pb	13.2 – 39.7	13.2 – 39.7	85
Ni	6.87 – 29.31	4.23 – 18.65	35

[X] Target values are specified to indicate desirable maximum levels of elements in unpolluted soil. Source: WHO (1996) from Ogundele *et al.* (2015)

Plate 1: One of the four dumping sites for soil sample collection

Plate 2: Some of the collected samples