ASSESSMENT OF HEAVY METAL STATUS IN SOIL OF DIFFERENT INDUSTRIAL AREAS IN NARAYANGANJ DISTRICT

MD. MANIK MAHMUD

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

MD. MANIK MAHMUD
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Approved by:

ABDUL HALIM
Assistant Professor
Supervisor

DR. JUBAYER-AL-MAHMUD
Associate Professor
Co-Supervisor

DR. JUBAYER-AL-MAHMUD
Associate Professor
Chairman
Examination Committee

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref: Date:

CERTIFICATE

This is to certify that the thesis entitled "**ASSESSMENT OF HEAVY METAL STATUS IN SOIL OF DIFFERENT INDUSTRIAL AREAS IN NARAYANGANJ DISTRICT**" 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. MANIK MAHMUD**, Registration No. **13-05413** 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
Supervisor

Dedicated to

MY BELOVED PARENTS

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ABBREVIATIONS AND ACRONYMS

OM	Organic matter
Cd	Cadmium
Pb	Lead
Ni	Nickel
Cr	Chromium
SD	Standard deviation
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
EU	European Union
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 STATUS IN SOIL OF DIFFERENT INDUSTRIAL AREAS IN NARAYANGANJ DISTRICT

ABSTRACT

On the era of industrialization, land especially to nearside of Dhaka are occupying by different types of industries. As expected, industries are polluting the surrounding environment with their discharge. The study was carried out from July to December 2019 to investigate of heavy metal contamination in industrial waste at Narayanganj in Bangladesh. During the study soil samples were collected from different target location (Dying, Textiles, cement and steel industry as contaminate area and a non-industrial area as check sample) of Bandar, Madanganj, Nabiganj, Shiddhirganj and Meghnaghat of Narayanganj district. Later, different parameter like soil texture, pH, organic matter, Pb, Cd, Cr and Ni were analyzed from the collected sample. All the sites soil was loamy type, pH was almost neutral, and low organic matter was observed. The mean value of Pb, Cd, Cr and Ni in the soil sample of target area in Bandar was 26.8, 0.6, 27.0 and 21.7 mgkg^{-1} respectively. In Madanganj it was 23.5, 0.7, 30.2, and 16.0 mgkg^{-1} respectively. In Nabiganj it was 24.4, 0.80, 31.1 and 16.7 mgkg^{-1} respectively. In Shiddhirganj it was 34.0, 0.8, 36.7 and 23.9 mgkg^{-1} respectively. In Meghnaghat it was 29.2, 0.8, 27.7 and 17.7 mgkg^{-1} respectively. Though heavy metal content of none of the industrial site exceeds the maximum permissible limits, all the samples from industrial sites contained higher heavy metal than the sample collected from non-industrial sites. Industrial waste must not be discharged to any of the open field, river, canal or any other water bodies before recycling. Therefore, industrial waste is a great concern to ecosystem and environment. It destroys the ecosystem function, environment balance and being health hazards. Further study should be carried out to carry out multiple variables related to waste and metal discharge to investigate the crisis so that clear and deeper information of impact may found.

CHAPTER I

INTRODUCTION

Heavy metals are found naturally in the earth, and become concentrated as a result of human activities, or, in some cases geochemical processes, such as accumulation in peat soils that are then released when drained for agriculture. (Qureshi *et al.,* 2003) '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 (Lenetech, 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 gcm^{-3} or 5 times or more, greater than water (Hutton and Symon, 2005). Common sources of heavy metals are mining and industrial wastes; vehicle emissions; lead-acid batteries; fertilizers; paints; treated woods; aging water supply infrastructure (Harvey *et al.,* 2015) and microplastics. Case reports on poisoning of heavy metal and metalloid exposure have been increasing in recent years in Bangladesh. Heavy metals and metalloids are non-biodegradable in nature and can affect human health directly and indirectly (Wang and Shi, 2001). Chronic exposure of heavy metals and metalloids can damage various organs like kidneys, liver, lung, brain, and bones (Tchounwou *et al.*, 2012). Lead is the most prevalent heavy metal contaminant (Di-Maio, 2001). As a component of tetraethyl lead, it was used extensively in gasoline during the 1930s–1970s (Lovei, 1998). Lead levels in the aquatic environments of industrialized societies have been estimated to be two to three times those of pre-industrial levels (Perry and Vanderklein, 1996). Using chromium as an indicator of contamination/exposure from the leather industry, it was the most significant metal contaminant for industry workers ranging from 21.85 to 483 $mgkg^{-1}$ and for industry-neighboring residents at 6.01 to 296.16 $mgkg^{-1}$. Both the workers and neighboring residents were found to be excessively exposed in Bangladesh (Hasan*et al*., 2019).

Major sources of soil heavy metal and metalloid pollution include municipal wastes, industrial effluents, chemical fertilizers, and pesticides (Chen *et al.*, 2005). Rapid industrialization, urbanization, and various anthropological activities also have driven the wide dispersion of lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni) in the environment. Dense river systems allow the heavy metals and metalloids to be dispersed more easily in some parts of Bangladesh.Rivers surrounding Dhaka and Chittagong such, as the Buriganga, Turag, Shitalakhya, and Karnaphuli rivers are highly polluted by Cd, Pb, and Cr (Ali *et al.*, 2016; Banu *et al.*, 2013; Zakir *et al.*, 2006 and Hasan *et al.*, 2009). Industrial effluents and sewage can deteriorate river water in many aspects. Scientists reported that Soil is the final sink or goal for all the trace elements, and the elements. It was expected that the residence time of Cd in the soil might be in the range of 75 - 380 years and more strongly sorbet elements like As, Cu, Ni, Pb and Zn ranged from 1500 - 3000 years (Butt, 2005). In recent times in the nearside of Dhaka metro it has been showed that the cultivation of the vegetables are more rapidly increasing in number matched to the cereal cultivation. A significant use of the waste water in cultivation in these area are more common as there is a great lack of pure water in the rabi season and almost all year round .Therefore there can be great opportunity of passing heavy meats in human food chain. Fish species from polluted rivers also contain elevated concentrations of heavy metals (Ahmed *et al*., 2016 and Islam *et al.*, 2013) Soil near the industrial areas of the big cities in Bangladesh, such as Dhaka, Gazipur, Chittagong, and Bogra, displayed excess heavy metals and metalloids (Rahman *et al*., 2012). Meanwhile, agricultural products from contaminated soil are frequently found to contain high concentrations of heavy metals and metalloids, which may impact human health profoundly (Brevik and Burgess, 2016).

Industrial revolution is leading our economy towards a well developing country. Production has increased by 46 percent since 1981. Also, a group of, cement and steel products is increasing by 200 to 4000 percent over last ten to fifteen years (DoE, 2007). But industrialization has a noticeable adverse effect on our environment. Due to unplanned disposal of industrial wastages the environment is on exposure to various notorious chemicals. About 1200 industries those are polluting in huge with no treatment facilities of wastes (DoE, 2007). These wastages contain heavy metals more often. These heavy metals are depositing to the soil also running through the sewerage, falls to adjacent water body. Sometime heavy rain can play its part for this distribution. (Khan, 2008). Pollutants are receiving by the water bodies like lagoons, ponds and lakes, out becoming vulnerable. A profound contribution of heavy metals to the soil is carried out by the wastewater. This all things are causing a rapid health hazards as plants are absorbing the effluents rapidly.

Bandar, Madanganj, Nabiganj, Shiddhirganj and Meghnaghat are very important industrial area of Narayanganj district. Dying, textile, cement and steel industries are available in these areas. A huge number of agricultural lands are inside these areas that are cultivated with the highly polluted water as irrigation also. In the last few years, productivity faced serious problem and reduced by the influence of wastage that caused lower rice yield, reduced production of livestock and fish culture. So, it is necessary to assess the heavy metal status in these industrial areas.

Therefore, present study aims to achieve the following objectives:

- To determine the heavy metal concentration in the soil of some industrial areas of Narayanganj District.

CHAPTER II

REVIEW OF LITERATURE

2.1 Heavy metal and health risks

Hasan *et al.* (2019) investigated a study focused on evaluating the hazard arising from exposure to metals due to industrial contamination. Tissue samples of hair and nails were collected from both the leather industry workers and residents in the vicinity of the industries. Using chromium as an indicator of contamination/exposure from the leather industry, it was the most significant metal contaminant for industry workers ranging from 21.85 to 483 mgkg^{-1} and for industry-neighboring residents at 6.01 to 296.16 mgkg^{-1}. Both the workers and neighboring residents were found to be excessively exposed ($P < 0.05$) to chromium compared with the investigated control group of people living in a distant village area which had no industrial establishments.

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.

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.

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%.

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.

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.

Sattar and Blume (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 stateof 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 soil.

2.2 Heavy metal on municipal waste

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 μgg^{-1} Cu, 806 μgg^{-1} Zn and 382 μgg^{-1} Pb) and abandoned (199 μgg^{-1} Cu, 452 μgg^{-1} Zn and 519 μgg^{-1} Pb) areas that exceeded the permissible limits. The concentrations of DO, BOD, COD and TDS of the untreated leachate were found 1.34 mgL^{-1}, 96 mgL^{-1}, 1343 mgL^{-1} and 7120 mgL^{-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.

Mottalib *et al.* (2016) conducted an experiment and found that out of eight metals examined in tannery effluent contaminated soil in Dhaka leather industrial area, concentration of heavy metals ($mgkg^{-1}$) were found ranged from 994-1120 for Cr; 34.35-39.66 for Cu; 46.70-55.16 for Pb; 24.10-26.73 for Ni; 0.32-0.54 for Cd; 1.49-2.21 for As; 0.44-1.10 for Sb and 20812-21216 for Fe.

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 municipal solid waste at the Matuail dumping site is higher than Khulna dumping site and the metals are predominantly associated with fine soil fraction. The total heavy metals content in municipial solid waste in the study sites were less than the total metals content in municipial solid waste 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. He 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. 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. He 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 than in textile effluents while in adjacent river water is varied both seasonally and specially.

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.

Elahi (2008) stated that Municipal waste water usually high in concentration of several metals like as, Ni, Pb Cr and Cd. Their unlikely use in Agricultural and land for irrigation may lead to result in accumulation in the surface soil (Gupta et al., 2008).

Sattar and Blume (1998) is the pioneer for the determination of maximum number of heavy metals in the soil environment in Bangladesh like Pb, Al, Ti, Cr, Fe, Co, Ni, Cu, Zn,Cd, Sn, Sb, Ba, Hg, Mo, Ag, Th etc. Recently it was reviewed 30 heavy metals related article of Sattar (Ajker Bangladesh, 5 June, 2012).

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.

2.3 Impacts of industrial waste on heavy metal content

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 was 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 grownup and youngsters for a few exposure pathways.

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.

Aldayel *et al.* (2018) found that heavy metals impurities in cosmetic products are common due to their natural abundance. However, they should be kept to a minimum wherever technically feasible. Most people, specially females, use cosmetic and their ingredients on a daily basis. Although human external contact with a substance rarely results in its penetration through the skin and significant systemic exposure, cosmetics produce local (skin, eye) exposure and are used in the oral cavity, on the face, lips, eyes and mucosa. Therefore, human systemic exposure to their ingredients can rarely be completely excluded. Because metals can induce unwanted side effects in humans, to establish their contents in body-care cosmetics is important for quality and health controls. In this work we have selected nine most expensive brands of facial cosmetics (Base jelly, Whitener, Sheen and Face powder) from the Saudi market. Twenty-eight elements were detected by using Inductively Coupled Plasma Mass Spectrometer (ICP-MS) and a flow injection mercury system (FIMS). The mean, maximum and minimum concentrations of each element are reported.

Islam *et al.* (2017) investigated heavy metals in the industrial sludges were 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 mg kg^{-1}, respectively. As a whole, the average concentrations of heavy metals were in the decreasing order: 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.

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 mg/l 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 excess of tolerable level for Pb (0.01 mg/l). 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.

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.

Brown *et al.* (2003) investigated the potential for biosolids products to reduce Pb availability in soil was tested on a high Pb urban soil with biosolids from a treatment plant that used different processing technologies. Amendments were added to a Pb-contaminated soil (2000 $mgkg^{-1}$ Pb) at 100 gkg^{-1} soil and incubated for 30 days. Reductions in Pb bioavailability were evaluated with both in vivo and in vitro procedures. The in vivo study entailed feeding a mixture of the Pb-contaminated soil and AIN93G Basal Mix to weanling rats. Three variations of an in vitro procedure were performed as well as conventional soil extracts [diethylene triamine penta acetic acid (DTPA) and $Ca(NO_3)_2$] and sequential extraction. Addition of the high Fe compost reduced the bioavailability of soil Pb (in both in vivo and invitro studies) by 37% and 43%, respectively. Three of the four compost materials tested reduced Pb bioavailability more than 20%. The rapid in vitro (pH 2.3) data had the best correlation with the in vivo bone results (R 0.9). In the sequential extract, changes in partitioning of Pb to Fe and Mn oxide fractions appeared to reflect the changes in vivo Pb bioavailability. Conventional extracts showed no changes in metal availability. These results indicate that addition of 100 $gmkg^{-1}$ of high Fe and Mn biosolids composts effectively reduced Pb availability in a high Pb urban soil.

Sattar and Bhume (1999) reported that the total Pb concentrations of road dusts at city areas varied from 57.70 - 212 $mgkg^{-1}$, but from rural areas 6.20 – 17.10 $mgkg^{-1}$, low Pb was observed from rural area.

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 (*Cynodendoctylon* L), water hyacinth (*Eichhorniacrassipes* 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 $mgkg^{-1}$ 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. Cd, 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 $mgkg^{-1}$) 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.

2.4 Heavy metals in soil, water and plant

Uddin *et al.* (2019) conducted a study is 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 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.

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. 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. To date, based on the natural ability of extraction, approximately 500 taxa have been identified as hyperaccumulators of one or more metals. In addition, further research integrating biotechnological approaches with comprehensive multidisciplinary research is needed to improve plant tolerance and reduce the accumulation of toxic metals in soils.

Zhang *et al***. (**2019) found that the contamination of soil and plants with heavy metals, which has detrimental influences on plant growth, water purification, and food safety, has emerged as a serious global issue. To better understand the spatial variations of contamination of heavy metals associated city development and land use types, we collected soil samples and *Magnolia grandiflora* branches to quantify lead (Pb) and cadmium (Cd) contents of the roadside, industrial, residential, and park greenbelts in Hefei City, China. He found that Pb content in soil was the highest in roadside greenbelts and the lowest in parks with industrial and residential greenbelts being intermediate, while Cd in soil was the highest in greenbelts close to city center and decreased with the distance to city center. Pb in *M. grandiflora*, however, did not differ among greenbelt types but decreased with distance to the city center. Cd in *M. grandiflora* was the highest in roadside and lowest in parks and also decreased with the distance to the city center. Across all greenbelt types and the distances to the city center, Pb and Cd contents were positively correlated in soil and plants. Our findings suggest that vehicle traffic, population density, and age of urbanization collectively contribute to soil and plant contamination of Pb and Cd.

Kladsomboon *et al***.** (2019) evaluated the heavy metal (As, Cd, Cu, Hg, Pb, and Zn) contamination in soil, surface water, and crops in Uthai District, Ayutthaya Province, Thailand, an agricultural area located near an industrial park. In contrast, the concentrations of As and Hg in surface water exceeded the permissible limits. For the crops, all heavy metal values in eggplant, kale, and rice were at safe levels. However, in basil, both Hg and Cu levels exceeded the permissible limits, and in coriander, Hg content exceeded the permissible limit. Additionally, the potential health risks of heavy metal exposure through consumption of local crops were assessed using target hazard quotients (THQs) and hazard indices (HIs). The former values of the crops varied. 100.0% for As, 40% for Cd, 60% for Cu, 20% for Pb, and 30% for Zn of the analyzed samples had THQs above 1. This indicated that consumers were probably exposed to some non-carcinogenic health risk (except for Hg which was 0%). Of greater concern, the HI values of each consumed crop were > 1, indicating obvious risk of adverse health effect. Finally, the heavy metal levels in blood from a sample of local residents (n =16) were assessed along with blood chemistry tests. The levels of all heavy metals were within the normal ranges. Nevertheless, heavy metal contamination in both the environment and food crops raise concerns of health risks to the residents of this area.

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.

Yang *et al.* (2018) performed a study to evaluate the state of heavy metal contamination in soil and vegetables and assess the health risk of inhabitants in the mine-affected area and area far from the mine (reference area) in Daye, China. Methods: The heavy metal concentrations in soil and vegetable samples were detected by inductively coupled plasma mass spectrometry. The copper, lead, cadmium, and arsenic concentrations in soil and in vegetables were higher in the mine-affected area than in the reference area. The health risk of residents in the reference area was within the acceptable range (hazard index<1, carcinogenic risk<104). In the contaminated area, however, the mean hazard index was 2.25 for children and 3.00 for adults, and the mean carcinogen risk was 4.749104 for children and 0.587104 for adults. Conclusions: Potential health risks exist for inhabitants near the mine area. Cadmium and arsenic should be paid more attention as risk sources.

Delang (2018) reviewed the conditions of heavy metal contamination of China's soils. This results in high contamination of food, with 13.86 % of grain produced in China being affected by heavy metal contamination. Hunan Province represents the worst conditions: it is responsible for 32.1 % of China's cadmium (Cd) emissions, 20.6 % of its arsenic (As) emissions, 58.7 % of its mercury (Hg) emissions, and 24.6 % of its lead (Pb) emissions. While Hunan Province produces about 15 % of the total rice output of the country, according to official data, 13 % of the total area of the province has been contaminated with waste and heavy metals from mines. In many areas, especially those closer to mines, the agricultural production exceeds the official food safety standards.

Garba and Abubakar, (2018) presented in research work the level and distribution pattern of the metals: Pb, Cu, Cd, Cr, Zn, Mn, and Fe were determined in soil of Bauchi Metropolis. The results showed that, concentration of Pb ranged from 0.005 ± 0.003 to 0.051 ± 0.002 with highest level from the AMW whereas the lowest comes from the RA and it was not detected in BMP. Level of Cd ranges from 0.002 ± 0.001 to 0.004 ± 0.011, the highest level comes from the AMW, the lowest from the HW, it was not detected in RA and BMP. For Fe, the concentration ranged from 9.559 ± 0.211 to 10.630 ± 0.0231, the highest level was observed along the HW followed by the BMP, the lowest level however comes from the AMW. Cu was only observed in AMW with the level 0.007 ± 0.021. The level of Cr ranged from 0.009 ± 0.005 in the BMP to 0.026 ± 0.003 along the HW. The concentration of Mn ranges from 0.477 ± 0.0121 in the BMP to 0.980 ± 0.121 in the RA. The concentration of Zn ranges from 0.053±0.021 in BMP and RA to 0.252 ± 0.101 in the AMW. All measurements were in ppm. The metals were found randomly distributed within the Metropolis. Flooding coupled with gravity of the rain and the physiochemical property of the soil might have contributed to the level and distribution pattern of the metals within the Metropolis. The research also indicates that, anthropogenic activity is not the main source of the heavy metals but it is additive.

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. 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.

Tune *et al.*, (2016) conducted a review is to summarize the findings about heavy metals and their effects on animal organism and to describe a source of contamination and inputs of heavy metals into food chain. Furthermore, the comparison of the occurrence of selected heavy metals in different types of milk on the basis of previous studies has been made. Based on available information and according to level of contamination, we want to draw an attention to suitability of using milk for further processing in selected areas of the world.

Xie *et al.* (2016) investigated the accumulation of heavy metals in the Yellow River Delta (YRD) using 43 sampling sites to determine the concentrations and vertical distribution of heavy metals. The contamination factors and geo-accumulation index clearly indicated that the coastal ecosystems are still in their pristine state with respect to metal pollution. Factor loadings reveal that the first principal component was strongly and positively related to arsenic, chromium, copper, nickel, lead, and zinc, while the second showed highly positive factor loading on cadmium. The YRD could still be regarded as a ‘clean site’ because several typical heavy metals were found to have accumulated less in this region compared with other regions, e.g., the Pearl River Delta, which was heavily contaminated by heavy metals during the past decades. The findings of this study could contribute to wetland conservation and management in coastal YRD regions.

Jan *et al.* (2015) stated that heavy metals, which have widespread environmental distribution and originate from natural and anthropogenic sources, are common environmental pollutants. In recent decades, their contamination has increased dramatically because of continuous discharge in sewage and untreated industrial effluents. Because they are non-degradable, they persist in the environment; accordingly, they have received a great deal of attention owing to their potential health and environmental risks. Although the toxic effects of metals depend on the forms and routes of exposure, interruptions of intracellular homeostasis include damage to lipids, proteins, enzymes and DNA via the production of free radicals. Following exposure to heavy metals, their metabolism and subsequent excretion from the body depends on the presence of antioxidants (glutathione, α-tocopherol, ascorbate, etc.) associated with the quenching of free radicals by suspending the activity of enzymes (catalase, peroxidase, and superoxide dismutase). Therefore, this review was written to provide a deep understanding of the mechanisms involved in eliciting their toxicity in order to highlight the necessity for development of strategies to decrease exposure to these metals, as well as to identify substances that contribute significantly to overcome their hazardous effects within the body of living organisms.

According to Su *et al.* (2014) heavy metals in the soil refers to some significant heavy metals of biological toxicity, including mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr), and arsenic (As), etc. With the development of the global economy, both type and content of heavy metals in the soil caused by human activities have gradually increased in recent years, which have resulted in serious environment deterioration. In this study they compared and analyzed soil contamination of heavy metals in various cities/countries, and reviewed background, impact and remediation methods of soil heavy metal contamination worldwide.

Ahmad *et al.* (2010) investigated the spatial and temporal distribution of heavy metals in water, sediment and fish (dry weight basis) of Buriganga River, Bangladesh by atomic absorption spectrophotometer. In water concentration of Pb, Cd, Ni, Cu and Cr varied seasonally and spatially from 58.17to 72.45µg/L, 7.08 to 12.33µg/L, 7.15 to 10.32µg/L, 107.38 to 201.29µg/L and 489.27 to 645.26µg/L, respectively. Cr was the most abundant in the water of Balughat during pre-monsoon, whereas, Cd was the most scarce in the water of Shawaryghat during monsoon. The sediment also showed spatial and temporal variation of Pb, Cd, Ni, Cu and Cr ranged from 64.71 to 77.13 mgkg^{-1}, 2.36 to 4.25 mgkg^{-1}, 147.06 to 258.17 mgkg^{-1}, 21.75 to 32.54 mgkg^{-1} and 118.63 to 218.39 mgkg^{-1}, respectively. Among all the metals studied in sediment, Ni was the highest at Foridabad during pre-monsoon and Cd was the lowest at Shawaryghat during monsoon. In six species of fish studied, the concentration of Pb, Cd, Ni, Cu and Cr varied seasonally from 8.03 to 13.52 $mgkg^{-1}$, 0.73 to 1.25 $mgkg^{-1}$, 8.25 to 11.21 $mgkg^{-1}$, 3.36 to 6.34 $mgkg^{-1}$ and 5.27 to 7.38 $mgkg^{-1}$, respectively. Of the five metals studied Pb concentration was the highest in *Gudusiachapra* during monsoon, in contrast, Cd concentration was the lowest in *Cirrhinusreba* during post-monsoon. Some of the heavy metal concentrations are higher than the recommended value, which suggest that the Buriganga is to a certain extent a heavy metal polluted river and the water, sediment and fish are not completely safe for health.

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.

Agouborde and Navia (2009) found that zinc and copper removal from aqueous solutions using brine sediments (industrial residue), sawdust (agricultural residue) and the mixture of both materials has been researched through batch and column tests. The maximum zinc adsorption capacity was found to be 4.85, 2.58 and 5.59 mg/g using an adsorbent/solution ratio of 1/40, for brine sediments, sawdust and the mixture, respectively. For copper, the maximum adsorption capacity was found to be 4.69, 2.31 and 4.33 mg/g, using adsorbent/solution ratios of 1/40, for brine sediments, sawdust and the mixture, respectively. The main mechanism involved in the removal of both metals may be the ionic exchange between sodium and calcium ions present in brine sediments and H^+ present in functional groups of sawdust. The use of brine sediments, sawdust and their mixture, presents an interesting option both, for wastewater decontamination (as a possible non-conventional sorbent for the removal of heavy metals) and as a waste recycling option.

Venkateswaran *et al.* (2007) determined the residual and total metal contents in aqua regia digest. The extracts were analyzed for metals using inductively coupled plasma-atomic emission spectrometry. The major metal constitute in the samples is iron, the wastewater residue contains (12.3 and 7.4 g/Kg respectively on dry basis) and the sludge contains (31.5 and 41.6 g/Kg) respectively. Cr concentration is higher in wastewater residue of second electroplating industry. The descending order of the average total metal contents for these four samples were Fe > Cr > Sn > Zn > Cu > Ni > Mn > Pb > Cd > Ag. Based on the average of absolute values for the four samples the highest bioavailability order of metals is Cr (39 %) in wastewater residues and Zn (32 %) in sludge samples. Metal recovery was good, with < 10 % difference between the total metal recovered through the extractant steps and the total metal determined using aqua regia extract.

Islam *et al.* (2004) studied that the as status of five districts of Gangetic floodplains. Among the five districts, the soils of Pabna and Gopalganj districts had relatively lower levels of As compared to Rajbari, Faridpur and ChapaiNawabgonj districts.

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

Elik (2003) analyzed the street dust samples of Sivas city, Yurkey analyzed that the mean concentration of Pb, Zn, Cu and Cd in soil were 197.0, 206.0, 68.0, 84.0 and 2.60 μgg$^{-1,}$ respectively.

Diaz–Valverde *et al.* (2003) collected soil samples which were sun shine soil, predominant vegetation, nearby roads, urban centers and 6 mines in Huelva, Spain.They found that average Pb and Cd contents in soil were 2.90 and 0.19 mgkg^{-1}, respectively. There was no such significant variation in heavy metal contents between samples.

Chowdhury (2003) detected that Fe, Mn, Zn, Cu and Pb from soils of various landuse practice from BAU 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.

Bibi *et al.* (2003) found that the detected heavy metal ranges in soil of different depthwere 3.60-26.20 ppm As, 89.0-117 ppm Cr, 8.0 - 48.0 ppm Cu, 19-24 ppm Pb, 127-177 ppm Sr, 41-143 ppm Zn and 109-212 ppm Zr.

Ahmed *et al.* (2003) collected 19 soil samples from Bhaluka region of Mymensingh.They investigated that the detected heavy metal ranges in soil were As

3.90-25.50 ppm, Cr 80-117 ppm, Cu 1.20-49 ppm, Mo 2.00-2.2 ppm, Ni 44-76 ppm, Pb 12-34 ppm, Sr 31.0-120.0 ppm, Th 12.0-26 ppm, U 1.60-5.8 ppm, V 134-273 ppm, Y 33-54 ppm, Zn 35-129 ppm and Zr 130-370 ppm.

Chowdhury *et al.* (2002) conducted an experiment on As affected area of Murshidabad in West Bengal, India. They reported that the mean concentrations of As, Pb, Cd, Cr, Fe, Cu, Ni, Zn, Mn, Se, V, Sb and Hg in the fallow land soils were5.31, 10.40, 0.37, 33.10, 674, 18.30, 18.80, 44.30, 342, 0.53, 44.60, 0.29, and 0.54,mg kg^{-1}, respectively.

Jahiruddin *et al*. (2002) investigated that soils of Gangetic alluvium contain more As than that of Brahmaputra alluvium and the former soils had more than 20 mgkg^{-1}As, whereas the later soils had As level below 20 mgkg^{-1} which was below maximum acceptable limit for agricultural soils. They also found that the mean concentration (mgkg^{-1}) in calcareous soil were Pb (22.80), Cd (0.25), Sb (0.74), Mo (0.31), Mn (457), Cu (29.20) and Zn (78.50), whereas in non-calcareous soils were Pb(24. 1), Cd (0.15), Sb (0.31), Mo (0.31), Mn (444), Cu (22.4) and Zn (66.4).

Peryea (2001) stated that heavy metals occur in many fertilizers and in some pesticides, purposefully included as micro nutritional or biocidal components, present as naturally occurring contaminants, or introduced when waste materials are used to formulate fertilizer products. Heavy metals may be of particular concern in tree fruit production because of the importance of foliar sprays, which deposit fertilizer and pesticide residues directly onto fruit. Furthermore, many orchards have histories of receiving high application rates of heavy metal-containing fertilizers and pesticides. Current issues concerning heavy metals and nutrient management include natural Cd and As enrichment in P fertilizers, anthropogenic heavy metal contamination of Zn fertilizers, Cu and As contamination of soil resulting from historical pesticide application, and effects of P fertilizer on soil As solubility and phyto availability. Disparate viewpoints regarding the significance of heavy metal contamination have resulted in varying regulatory approaches towards safeguarding human and environment health. Heavy metal concentrations in tree fruits are very low even when grown on contaminated soils. In contrast, the heavy metal contents of some orchard soils may be high enough to cause adverse effects in people, plants and the environment. Depending on land use, some type of remediation may be required in such soils. Avoiding future contamination of currently uncontaminated orchard soils will require modifying nutrient management practices to minimize importation of heavy metals.

Sattar and Blume (2000) carried out an experiment on total and available trace metals like Cr, Mn, Co, Zn, Pb, Cu, As, Mo, Ag, Cu, Sn, Sb, Ti, Hg and Ni contents were determined from the representative general soil types of Bangladesh at 0–15 depth. A variable available trace metals contents were recorded from the twenty soils and they are Pb (3.6–90 mgkg^{-1}), Cd (0.69–1.00 mgkg^{-1}), Cr (42–74 mgkg^{-1}) and Mn (26–716 mgkg^{-1}).

Sultana (2000) investigated isotope-aided studies on the effects of radiation processed sewage sludge application on crop yields and bio availability of heavy metal content of BAU soil. BAU soil contains 0.25, 14.0, 21.0 and 19.0 mgkg^{-1} aqua regia extracted heavy metal for Cd, Pb, Cu and Zn, respectively.

CHAPTER III

MATERIALS AND METHODS

This study was conducted during November, 2019 to January, 2020 to determine the status of heavy metals in some industrialized areas of Narayanganj district. The fine points of materials and methods for the study are presented in this chapter.

3.1 Location

Soil samples were collected from five specific industrial areas of Narayanganj district (Figure 1). Narayanganj is the oldest District of Bangladesh. It is also a center of business and industry, especially the jute trade and processing plants, and the textile sector of the country. It is called the 'Dundee of East'. The area of current Narayanganj district is about 684.37 sq. km. The district is bounded on the north by Narshingdi and Brahmanbaria districts, on the east by Comilla district, on the south by Munshiganj and Dhaka districts and on the west by the Dhaka district (Figure 1).

3.2 Climatic conditions

The weather is fairly moderate and the summer and winter are in the interval in the region. The difference between summer and winter average temperature of the district is 17.5° F. The amount of the annual average rainfall is 183 cm. The Geo position of the district is between 23°34' to 24°15' North Latitude and between 90°27' to 90°59' East Longitude (Narayanganj district official website).

3.3 Soil type

Narayanganj falls in AEZ-19 which is Old Meghna Estuarine Floodplain. Soil type is Non-Calcareous dark grey and grey floodplain soils. Soils are fertile, silty, gray to dark gray color, clayey or clayey loamy nature are low in lime or calcium (Narayanganj district official website). Organic content percentage is Medium and pH value is 5.5-6.6.

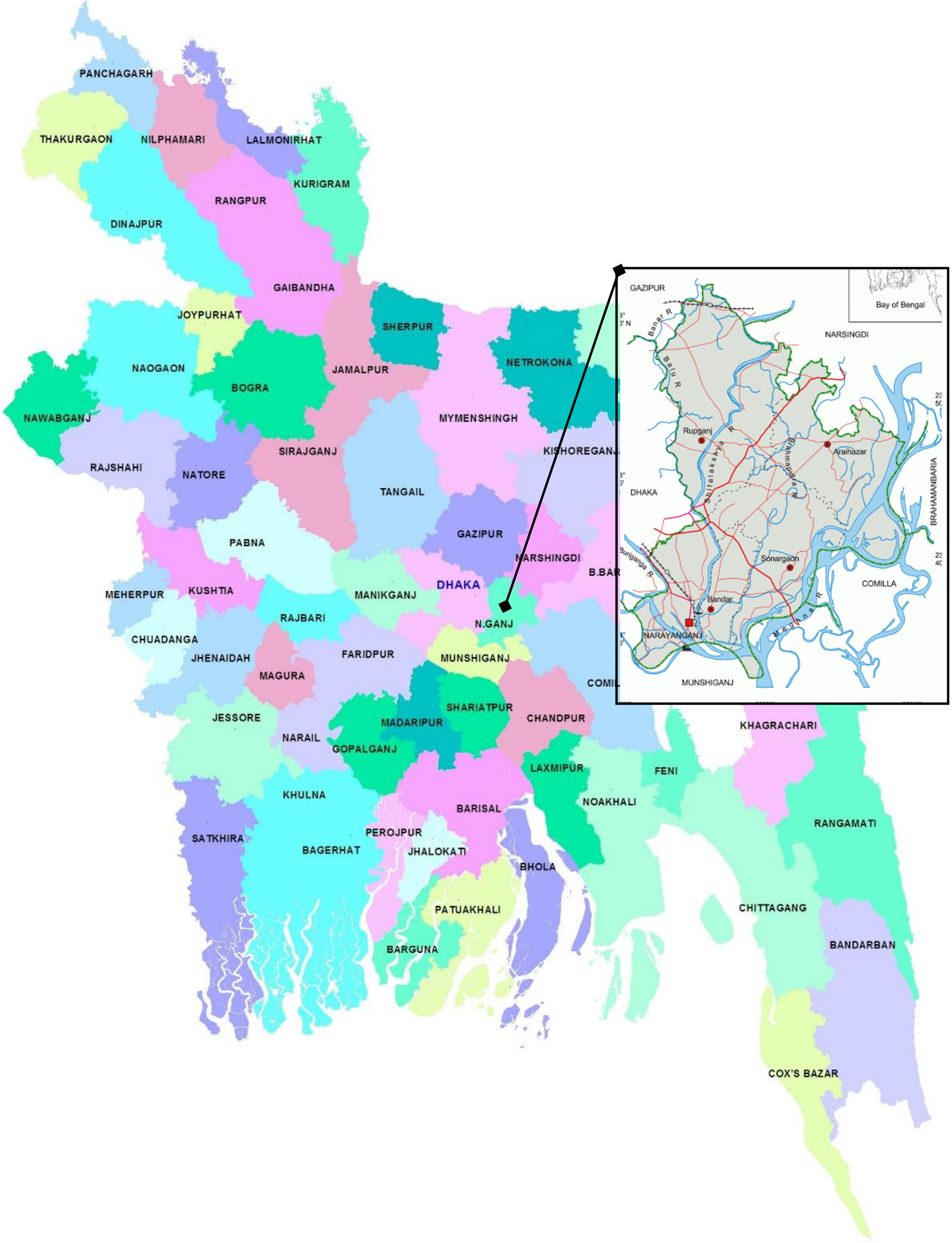

Figure 1: Showing Narayanganj district

3.4 Industries in Narayanganj district

Narayanganj is a highly industrialized district. The Dhakeswari Cotton Mill at Narayanganj, founded in 1926, was the first textile mill in the entire British district of Dhaka. Adamji, the world's largest jute mill, was established on 1951 on the east bank of the Shitalakshyan River in Narayanganj. According to the Bureau of Statistics, the total number of industrial units in Narayanganj is 2409. A short list of industry types in Narayanganj are presented below.

Table 1: Showing the industries in Narayanganj

Serial No	Type of Industry	Number
1	Garments	360
2	Textiles	175
3	Jute mills	16
4	Salt mills	70
5	Knitting factory	1895
6	Paper and packaging	40
7	Steel industry	48
8	Chemicals	17
9	Dying	188
10	Cement factory	8
11	Melamine Factory	3
12	Lime factory	35
13	Re-rolling factory	75
14	Cables factory	2
15	Hosiery factory	2075
16	Jamdani industry	1 (Loom- 40)
17	Soap factory	5
18	Fan factory	3
19	Light factory	1
20	Others	870

(Source: Narayanganj district official website)

3.5 Sampling sites

A total of fifty soil samples, ten from each of the five specific areas were collected from Narayanganj district (Bandar, Madanganj, Nabiganj, Shiddhirganj, Meghnaghat) that areas are highly covered with the industries like dying, textiles, cement, steel and two samples collected from each site from higher and farmable land as check sample to compare with those sample from industrial site. From the mentioned area of Narayanganj district soils were collected near from side of the industries, closely cultivation plot near industries, drains and road side.

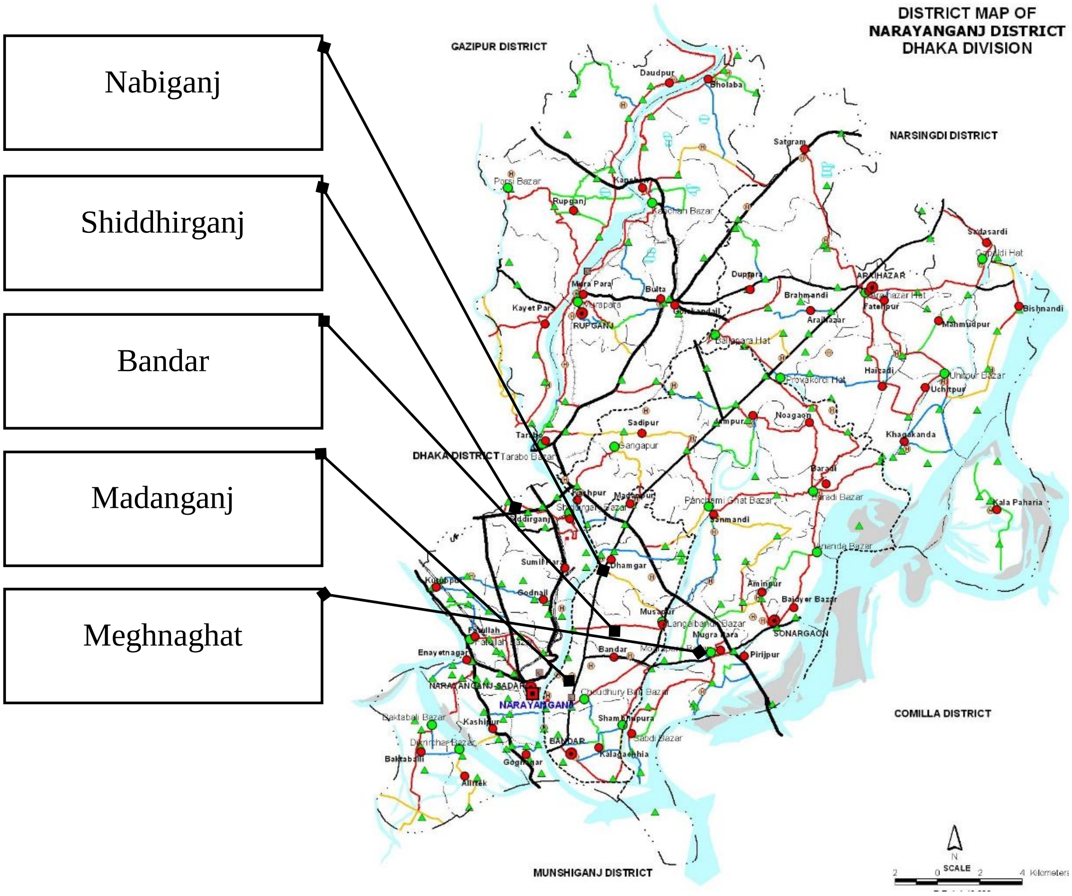

Figure 2: Sampling sites in Narayanganj

3.6 Collection of soil samples

Soil samples were collected randomly from the three layer at a depth of 0-15 cm, 15-30 cm and 30-50 cm from each location with an auger sampler method. The samples that were collected from different soil depth of 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. All the soil samples were put into the individual polythene bag with distinct marking, tagging and labeling, were brought to the Soil research Lab, Soil Resources Development Institute (SRDI), Regional Office, Farmgate, Dhaka for soil analysis.

3.7 Soil analysis

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

3.7.1 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).

3.7.2 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).

3.7.3 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 1.73 (Van Bemmelen factor). (Page *et al.*, 1989)

3.7.4 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.

3.7.5 Determination of total Cd, Pb, Ni and Cr

3.7.5.1 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).

3.7.5.2 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).

3.7.5.3 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).

3.7.5.4 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).

3.8 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to observe the heavy metal status in some industrialized areas of Narayanganj. Observed and analyzed founding’s are presented in this chapter.

4.1 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 Bandar, silt loam for Madanganj, clay loam for Nabiganj, silty clay for Shiddhirganj, and soil of Meghnaghat was clay loam. Soil particle percentage is presented in table 2. 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 soil from the sampling sites

Sampling sites	Sand (%)	Silt (%)	Clay (%)	Textural class
Bandar	40.2	36.7	23.1	Silty Clay
Madanganj	30.2	49.9	19.9	Silt Loam
Nabiganj	34.9	38.2	26.9	Clay Loam
Shiddhirganj	39.2	37.9	22.9	Silty Clay
Meghnaghat	34.7	38.6	26.7	Clay Loam

4.2 Chemical properties of soil sample

4.2.1 pH value of soil sample

The value of pH in the soil ranged from 5.7 to 7.2 (Table 3) in the sampling area. In the analysis the highest mean value of pH (6.98) was found in the cement industrial site. Also the lowest mean value of pH (6.04) was found in the site of dying industrial area.

The average value of pH ranged following the order as: Dying < Check < Steel < Textile < Cement. In Bandar pH range was 6.1-6.8, in Madanganj 7.2-7.0, in Nabiganj 6.1-7.2, in Shiddhirganj 5.7-7.1 and in Meghnaghat 6.1-6.8.

The desirable pH range for optimum plant growth varies among crops. While some crops grow best in 6.0-7.0, others grow well under slightly acidic condition. 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.

Table 3: pH level of soil from the sampling sites of Naranganj district

Sampling sites	Dying	Textile	Cement	Steel	Check
Bandar	6.1	6.8	6.8	6.3	6.2
Madanganj	6.2	6.6	7.0	6.7	6.4
Nabiganj	6.1	6.5	7.2	6.6	6.5
Shiddhirganj	5.7	6.2	7.1	6.5	5.9
Meghnaghat	6.1	6.7	6.8	6.3	6.1
Mean	6.04	6.56	6.98	6.48	6.22

4.2.2 Organic carbon content of the soil sample of Narayanganj district

Variation was found in organic carbon content of soil samples. The range of organic carbon was from 1.48% to 0.75% (Figure 3). The lowest amount of organic carbon was recorded from the cement industrial area (0.75%) and the highest amount of organic carbon was found from non-industrial area (1.48%). The variation occurred in soil organic carbon may be due to different types of waste at different sites. Usually huge amount of organic and inorganic chemical waste is dumped in industrial area. For this reason the different industrial sites contain different amount of organic matter. All the soil sampling areas of Narayanganj contain similar amount of organic carbon. In general, the organic matter content in soil of Bangladesh is quite low (BARC, 2005).

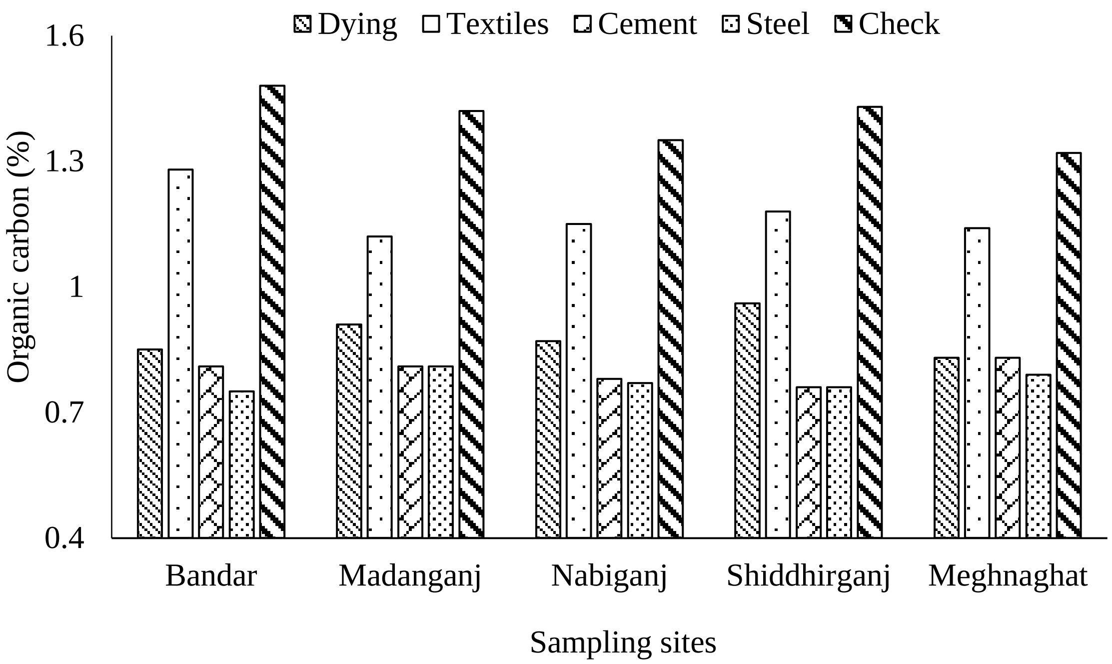

Figure 3: Organic carbon content of soil from the sampling sites

4.3 Heavy metal content of soil samples collected from Bandar, Narayanganj

The lead content of the soil sample collected from Bandar was in the range of 13.2-36.2 $mgkg^{-1}$ (Table 4). The highest concentration of lead (36.2 $mgkg^{-1}$) was observed in soil sample collected near the steel industry and the lowest lead concentration (13.2 $mgkg^{-1}$) was found in the soil collected from non-industrial area. The analyzed soil samples were in the following order: Check < Textile < Dying < Cement < Steel area.

The cadmium content of the soil sample collected from Bandar ranged 0.29-0.88 $mgkg^{-1}$ (Table 4). The cadmium value that was found analyzing the collected soil sample were highest in the soil that was collected from dying and cement industrial area (0.88 and 0.87 $mgkg^{-1}$ respectively) and the lowest value was in the soil of from non-industrial area (0.29 $mgkg^{-1}$). The value of these sample was in the following order Check < Textile < Steel < Cement < Dying area.

The chromium content of the soil sample collected from Bandar was in the range of 16.9-36.3 $mgkg^{-1}$ (Table 4). The highest concentration of chromium (36.3 $mgkg^{-1}$) was observed in soil sample collected from the steel industry area and the lowest chromium concentration (16.9 mg kg^{-1}) was found in the soil collected from non-industrial area. The analyzed soil sample were in the following order: Check < Textile < Dying < Cement < Steel area.

The nickel value of the soil sample collected from Bandar ranged from 12.8-29.1 $mgkg^{-1}$ (Table 4). For the nickel content the value that was found analyzing the collected soil sample were in the highest in the soil that was collected from dying industry area (29.1 $mgkg^{-1}$) and the lowest value was in the soil of non- industrial area (12.8 $mgkg^{-1}$). The value of these sample was in the following order: Check < Steel < Textile < Cement < Dying area.

Table 4: Heavy metal content of the soil samples collected from Bandar of Narayanganj district

Industry types	**Lead content** (mgkg^{-1})	**Cadmium content** (mgkg^{-1})	**Chromium content** (mgkg^{-1})	**Nickel content** (mgkg^{-1})
Dying	27.8	0.88	31.1	29.1
Textiles	24.7	0.44	23.7	24.7
Cement	31.9	0.87	26.8	25.9
Steel	36.2	0.72	36.3	16.1
Check	13.2	0.29	16.9	12.8
Mean	26.8	0.6	27.0	21.7
SD	7.8	0.2	6.6	6.2

SD: Standard Deviation

4.4 Heavy metal content of soil sample collected from Madanganj, Narayanganj district

The lead content of the soil sample collected from Madanganj was in the range of 12.4-32.1 mgkg^{-1} (Table 5). The highest concentration of lead (32.1 mgkg^{-1}) was observed in soil sample collected from the steel industry area and the lowest lead concentration (12.41 mgkg^{-1}) was found in the soil collected from sample far from industries. The analyzed soil samples were in the context of following order: Check < Textile < Dying < Cement < Steel area.

The cadmium content of the soil sample collected from Madanganj ranged 0.29-0.97 mgkg^{-1} (Table 5). The value that was found analyzing the collected soil sample were in the top most range in the soil that was collected from steel industrial area (0.97 mgkg^{-1}) and the lowest value was found in the soil of from non-industrial area (0.29 mgkg^{-1}). The analyzed samples were in the following order: Check < Textile < Dying < Cement < Steel area.

The chromium content of the soil sample collected from Madanganj was in the range of 22.7-37.1 mgkg^{-1} (Table 5). The highest concentration of chromium (37.1 mgkg^{-1}) was observed in soil sample collected from the steel industry area and the lowest chromium concentration (22.7 mgkg^{-1}) was found in the soil collected from non-industrial area. The analyzed soil samples were in the context of following chronological order: Check < Textile < Dying < Cement < Steel area.

The nickel content of the soil sample collected from Madanganj ranged, 11.1-21.7 mgkg^{-1} (Table 5). The highest nickel content was found from dying industry area (21.7 mgkg^{-1}) and the lowest value was found in the soil of non-industrial area (11.1 mgkg^{-1}). The value of these sample was in the following order: Check < Steel < Textile < Cement < Dying area.

Table 5: Heavy metal content of soil sample collected from Madanganj of Narayanganj district

Industry types	**Lead content** (mgkg^{-1})	**Cadmium content** (mgkg^{-1})	**Chromium content** (mgkg^{-1})	**Nickel content** (mgkg^{-1})
Dying	23.7	0.81	30.3	**21.7**
Textiles	21.8	0.51	29.6	14.9
Cement	27.3	0.89	31.5	18.3
Steel	**32.1**	**0.97**	**37.1**	14.2
Check	**12.41**	**0.27**	**22.7**	**11.1**
Mean	23.5	0.7	30.2	16.0
SD	6.5	0.3	4.6	3.6

SD: Standard Deviation

4.5 Heavy metal content of soil sample collected from Nabiganj, Narayanganj

The lead content in Nabiganj was in the range of 11.2-32.2 $mgkg^{-1}$ (Table 6). The highest concentration of lead (32.2 $mgkg^{-1}$) was observed in soil sample collected from the steel industry area and the lowest lead concentration (11.2 $mgkg^{-1}$) was found in the soil collected from non-industrial area. The analyzed soil sample were in the context of following chronological order: Check < Textile < Dying < Cement < Steel area.

The cadmium content of the soil sample collected from Nabiganj ranged 0.25-1.23 $mgkg^{-1}$ (Table 6). The content that was found analyzing the collected soil sample were highest in cement industrial area (1.23 $mgkg^{-1}$) and the lowest value was found in the soil from non-industrial area (0.25 $mgkg^{-1}$). The value of these sample was in the following order: Check < Textile < Dying < Steel < Cement area.

The chromium content of the soil sample collected from Nabiganj was in the range of 21.1- 42.5 $mgkg^{-1}$. The highest concentration of chromium (42.5 $mgkg^{-1}$) was observed in soil sample collected from the steel industry area and the lowest chromium concentration (21.1 $mgkg^{-1}$) was found in the soil collected from non-industrial area. The analyzed soil sample were in the following order as Check < Textile < Dying < Cement < Steel area.

The nickel content of the soil sample collected from Nabiganj ranged from 11.6 to 23.9 $mgkg^{-1}$ (Table 6). For the nickel content the value that was found analyzing the collected soil sample were the highest that was collected from dying industry area (23.9 $mgkg^{-1}$) and the lowest nickel value was in the soil of no industry area (11.6 $mgkg^{-1}$). The nickel value of these sample was in the following order: Check < Steel area < Textile < Cement < Dying.

Table 6: Heavy metal content of the soil sample collected from Nabiganj, Narayanganj district

Industry types	**Lead content** (mgkg^{-1})	**Cadmium content** (mgkg^{-1})	**Chromium content** (mgkg^{-1})	**Nickel content** (mgkg^{-1})
Dying	25.9	0.97	29.2	**23.9**
Textiles	23.5	0.51	28.3	15.8
Cement	28.4	**1.23**	34.4	19.4
Steel	**33.2**	1.06	**42.5**	12.7
Check	**11.2**	**0.25**	**21.1**	**11.6**
Mean	24.4	0.80	31.1	16.7
SD	7.4	0.4	7.1	4.5

SD: Standard Deviation

4.6 Heavy metal content of soil sample collected from Shiddhirganj, Narayanganj district

The lead content of the soil sample collected from Shiddhirganj was in the range of 16.1-49.2 mgkg^{-1} (Table 7). The highest concentration of lead (49.2 mgkg^{-1}) was observed in soil sample collected from the steel industry area and the lowest lead concentration (16.1 mgkg^{-1}) was found in the soil collected from non-industrial area. The analyzed soil sample were in the following chronological order: Check < Textile < Dying < Cement < Steel area.

The cadmium content of the soil sample collected from Shiddhirganj ranged from 0.28-1.7 mgkg^{-1} (Table 7). The cadmium value that was found analyzing the collected soil sample were the highest in the soil that was collected from steel industrial area (1.07 mgkg^{-1}) and the lowest value was in the soil of from non-industrial area (0.28 mgkg^{-1}). The value of these sample was in the following order: Check < Textile < Dying < Cement < Steel area.

The chromium content of the soil sample collected from Shiddhirganj was in the range of 23.1-47.4 mgkg^{-1} (Table 7). The highest concentration of chromium (47.4 mgkg^{-1}) was observed in soil sample collected from the steel industrial area and the lowest chromium concentration (23.1 mgkg^{-1}) was found in the soil collected from sample far from non-industrial area. The analyzed soil sample were in the following chronological order: Check < Textile < Dying < Cement < Steel area.

The nickel content of the soil sample collected from Shiddhirganj ranged from 12.6-33.4 mgkg^{-1} (Table 7). For the nickel content the value that was found the highest in the soil collected from cement industry area (33.4 mgkg^{-1}) and the lowest value was in the soil non-industry area (12.6 mgkg^{-1}). The nickel value of these sample was in the following order: Check < Steel < Textile < Dying < Cement area.

Table 7: Heavy metal content of the soil sample collected from Shiddhirganj of Narayanganj district

Industry types	**Lead content** (mgkg^{-1})	**Cadmium content** (mgkg^{-1})	**Chromium content** (mgkg^{-1})	**Nickel content** (mgkg^{-1})
Dying	38.9	0.87	37.2	28.9
Textiles	23.5	0.61	34.3	25.8
Cement	42.4	0.93	41.4	**33.4**
Steel	**49.2**	**1.07**	**47.4**	18.7
Check	**16.1**	**0.28**	**23.1**	**12.6**
Mean	34.0	0.8	36.7	23.9
SD	12.3	0.3	8.1	7.4

SD: Standard Deviation

4.7 Heavy metal content of the soil sample collected from Meghnaghat of Narayanganj district

The lead content of the soil sample collected from Meghnaghat was in the range of 13.7-35.2 mgkg^{-1} (Table 8). The highest concentration of lead (35.2 mgkg^{-1}) was observed in soil sample collected from the steel industry area and the lowest lead concentration (13.7 mgkg^{-1}) was found in the soil collected from non-industrial area. The analyzed soil sample were in the following order: Check < Textile < Dying < Cement < Steel area.

The cadmium content of the soil sample collected from Meghnaghat ranged from 0.35-1.45 mgkg^{-1} (Table 8). The cadmium content that was the highest in the soil that was collected from steel industrial area (1.45 mgkg^{-1}) and the lowest value was in the soil of from non-industrial area (0.35 mgkg^{-1}). The value of these sample was in the following order: Check < Textile < Dying < Cement < Steel area.

The chromium content of the soil sample collected from Meghnaghat was in the range of 20.2-35.2 mgkg^{-1} (Table 8). The highest concentration of chromium (35.2 mgkg^{-1}) was observed in soil sample that was collected from the steel industry area and the lowest chromium concentration (20.2 mgkg^{-1}) was found in the soil collected from non-industrial area. The analyzed soil sample were in the context of following order: Check < Textile < Dying < Cement < Steel area.

The nickel content of the soil sample collected from Meghnaghat ranged from 12.4-24.6 mgkg^{-1} (Table 8). For the nickel content of the soil sample was the highest in the soil that was collected from cement industry area (24.6 mgkg^{-1}) and the lowest value was in the soil of non-industrial area (12.4 mgkg^{-1}). The value of these sample was in the following order: Check < Steel < Textile < Cement < Dying area.

Table 8: Heavy metal content of soil sample collected from Meghnaghat of Narayanganj district

Industry types	**Lead content** (mgkg^{-1})	**Cadmium content** (mgkg^{-1})	**Chromium content** (mgkg^{-1})	**Nickel content** (mgkg^{-1})
Dying	33.4	0.85	26.4	**24.6**
Textiles	23.5	0.51	27.5	14.5
Cement	40.3	**1.45**	29.4	20.1
Steel	**35.2**	0.95	**35.2**	16.8
Check	**13.7**	**0.35**	**20.2**	**12.4**
Mean	29.2	0.8	27.7	17.7
SD	9.5	0.4	4.8	4.3

SD: Standard Deviation

4.8 Correlation among pH and heavy metal

All the heavy metal contents showed weak correlation with soil pH. Soil pH and lead was weakly correlated to each other (r = 0.1047) (Figure 9). Correlation between soil pH and Cadmium was very weak (r = 0.2144) (Figure 10). Correlation between soil pH and chromium was very weak (r = 0.2166) (Figure 11). Soil pH and Nickel was correlated to each other which was also weak (r = 0.2053) (Figure 12).

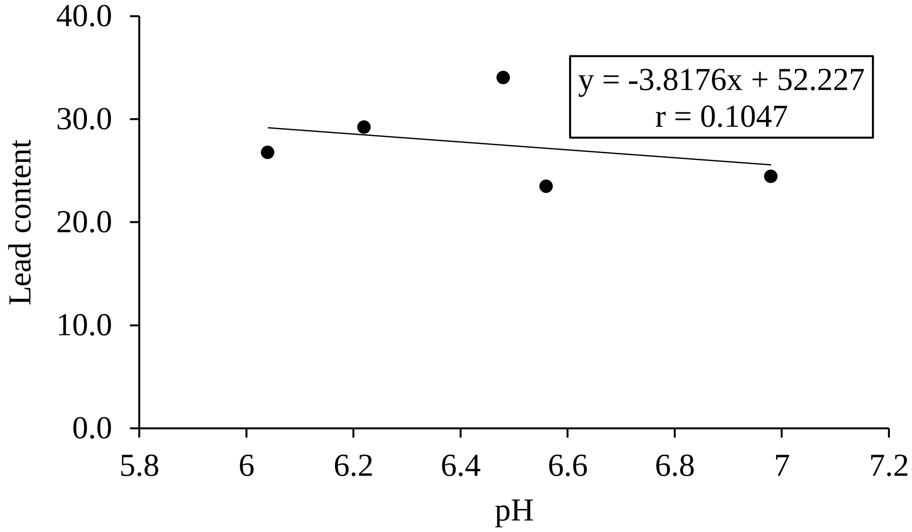

Figure 4: Correlation of soil pH with lead content

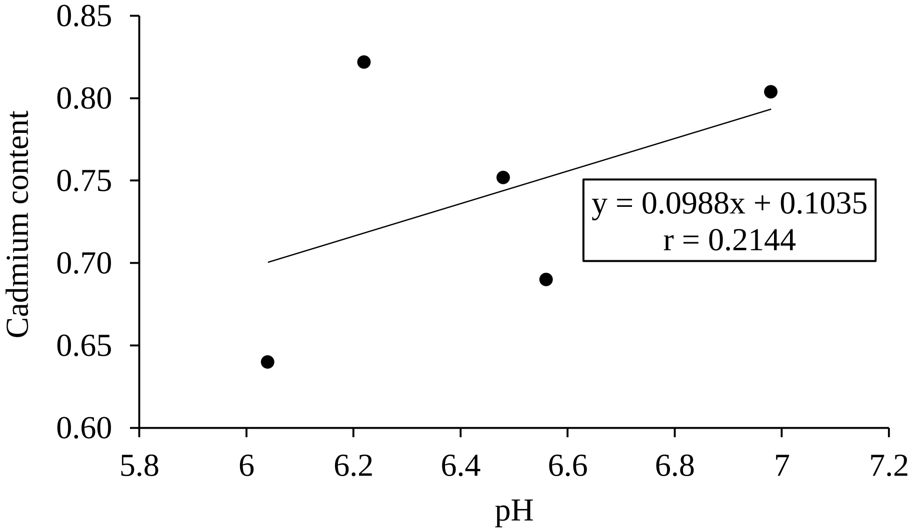

Figure 5: Correlation of soil pH with cadmium content

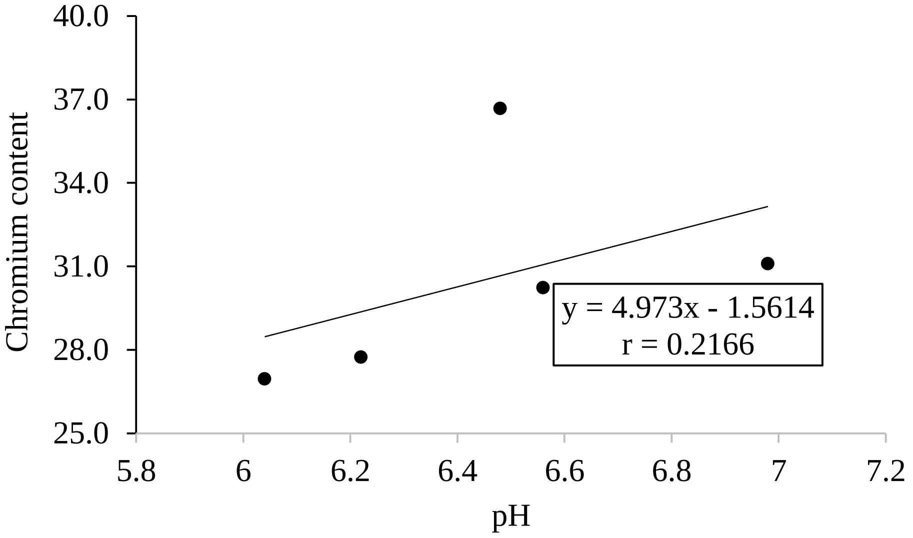

Figure 6: Correlation of soil pH with chromium content

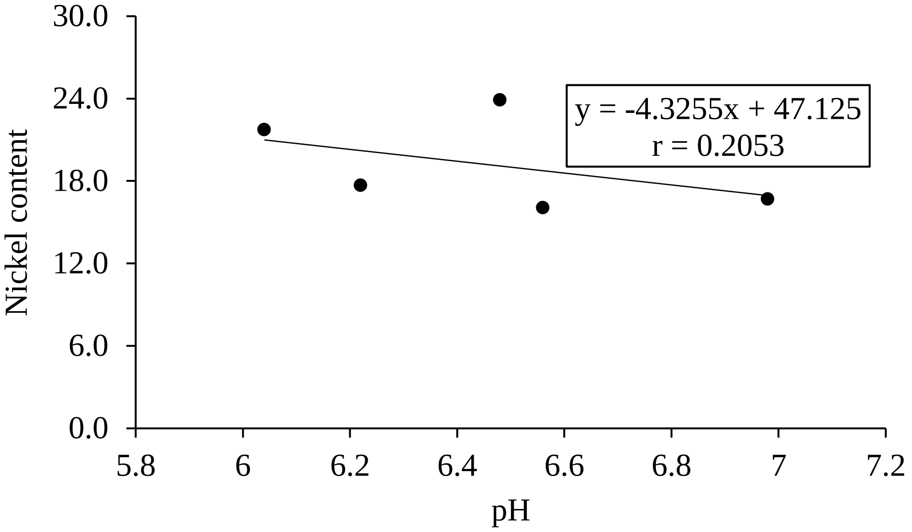

Figure 7: Correlation of soil pH with nickel content

4.9 Heavy metal concentration (mgkg^{-1}) in the collected soil samples compared with other research works

The average content of heavy metal viz. lead, cadmium, chromium and nickel were compared to better understand and justification of the outcome. Results were compared with six findings of other research works as, WHO (1996) from Ogundele *et al.*, 2015; Karim *et al*., 2014; Akter *et al.*, 2019; Zakir *et al.*, 2014 and Zakir *et al.,* 2015 performed in different areas of home and abroad. The comparison is presented in table 9. From the table mentioned below it is obvious that the concentration of Lead content in the study area is less than the prescribed value of WHO (1996). In case of Cadmium content, the value of study area almost exceeded the value of WHO (1996) recommendation in some case; that is an alarming sign for soil contamination. In case of Chromium content WHO (1996) recommended value is way higher than the value of studied area. For the Nickel content the WHO (1996) recommended value is higher than the value of studied area but the near future it must reach the ceiling if it gets increased at this alarming rate. From this comparison it is obvious that all the living beings are in threat because of heavy metal pollution in soil.

Table 9: Heavy metal concentrations (mgkg^{-1}) in the collected soil samples of different industrial areas of Narayanganj, Bangladesh compared with other research works

Heavy metals (mgkg^{-1})	**WHO (1996) from Ogundele *et al.*, (2015)**	**Matuail dumping Site (Karim *et al.*, 2014)**	**Khulna dumping site (Karim *et al.*, 2014)**	**Steel industry Narayanganj (Direct waste) (Akter *et al.*, 2019)**	**Dhaka city area (Zakir *et al.*, 2014)**	**Gazipur city area (Zakir *et al.*, 2015)**	**Study Area**
Lead	85	5.66 - 87.79	11.18 - 69.6	249 - 510	2.3 - 9.6	0.44 - 127.45	11.2 - 49.2
Cadmium	0.8	ND	ND	ND	1.23 - 6.95	0.08 - 1.60	0.25 - 1.45
Chromium	100	10.10 - 81.19	1.72 - 2.96	8 - 35	ND	0.00 - 80.78	16.9 - 47.4
Nickel	35	0.84 - 9.89	0.42 - 0.90	18 - 139	4.46 - 23.34	ND	11.6 - 28.9

ND: Not detected

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

Soil is one of the most important factors of environment. During the conduction of the study soil samples were collected from different selected area of Narayanganj district as Bandar, Madanganj, Nabiganj, Shiddhirganj and Meghnaghat to assess the impact of industrial waste that is discharged by the industries located in these region on environment and agricultural productivity and to compare the content with unpolluted areas to understand the environmental risk. A total number of 50 soil samples were collected from the target site (dying, textiles, cement, steel industries and non-polluted site) in the selected area. Later the collected samples were analyzed targeting the parameter like textural class, pH, Organic matter, Pb, Cd, 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 from 5.7-7.2. Organic content was also low for most of the samples.

In Bandar the content of lead was in the range between 13.2-36.2 mgkg^{-1}. The highest lead concentration of lead (36.2 mgkg^{-1}) was observed in soil from the steel industry. The analyzed soil samples followed the order: Check < Textile < Dying < Cement < Steel area. The cadmium content ranged between 0.29-0.88 mgkg^{-1}. The cadmium was high in the soil from dying and cement area (0.88 and 0.87 mgkg^{-1} respectively). The value of these samples followed the order: Check < Textile < Steel < Cement < Dying area. The chromium content was in the range between 16.9-36.3 mgkg^{-1}. The highest concentration of chromium (36.3 mgkg^{-1}) was observed from steel industry. The analyzed soil sample followed the order: Check < Textile < Dying < Cement < Steel area. The nickel content ranged from 12.8-29.1 mgkg^{-1}. The nickel content was the highest in the soil that was collected from dying industrial area (29.1 mgkg^{-1}) and the order: Check < Steel < Textile < Cement < Dying.

In Madanganj lead content was in the range between 12.41-32.1 mgkg^{-1}. The highest concentration of lead (32.1 mgkg^{-1}) was observed in soil from steel industry. The analyzed soil sample followed the order: Check < Textile < Dying < Cement < Steel area. The cadmium content ranged from 0.29-0.97 mgkg^{-1}. The highest cadmium was found in sample from steel industrial area (0.97 mgkg^{-1}) and samples followed the order Check < Textile < Dying < Cement < Steel area. The chromium content was in the range between 22.7-37.1 mgkg^{-1}. The highest concentration of chromium (37.1 mgkg^{-1}) was observed in sample from the steel industrial area and the samples followed the order: Check < Textile < Dying < Cement < Steel area. The nickel content ranged from 11.1-21.7 mgg^{-1}. The nickel content was the highest in the soil from dying industrial area (21.7 mgkg^{-1}) and the order was Check < Steel < Textile < Cement < Dying area.

In Nabiganj, the lead content was in the range from 11.2-32.2 mgkg^{-1}. The highest concentration of lead (32.2 mgkg^{-1}) was observed in sample collected from steel industry and the order: Check < Textile < Dying < Cement < Steel area. The cadmium value ranged from 0.25 - 1.23 mgkg^{-1}. Highest cadmium value was found from cement industrial area (1.23 mgkg^{-1}) and the order was Check < Textile < Dying < Steel < Cement area. The chromium content was in the range of 21.1-42.5 mgkg^{-1}. The highest concentration of chromium (42.5 mgkg^{-1}) was observed in soil sample from steel industry and the order: Check < Textile < Dying < Cement < Steel area. The nickel value ranged from 11.6-23.9 mgkg^{-1}. The nickel content was the highest in the sample collected from dying industrial area (23.9 mgkg^{-1}) and the samples followed order: Check < Steel < Textile < Cement < Dying area.

In Shiddhirganj, the lead content was in the range from 16.1-49.2 mgkg^{-1}. The highest concentration of lead (49.2 mgkg^{-1}) was observed in sample collected from the steel industrial and the order was Check < Textile < Dying < Cement < Steel area. The cadmium value ranged from 0.28-1.7 mgkg^{-1}. The highest cadmium was found from steel area (1.07 mgkg^{-1}) and the samples followed the order: Check < Textile < Dying < Cement < Steel area. The chromium content ranged from 23.1- 47.4 mgkg^{-1}. The highest concentration of chromium (47.4 mgkg^{-1}) was observed in the steel industry and the order: Check < Textile < Dying < Cement < Steel area. The nickel value ranged from 12.6-33.4 mgkg^{-1}. For the nickel content was the highest in the soil of cement industrial area (33.4 mgkg^{-1}) and the samples followed the order: Check < Steel < Textile < Dying < Cement area.

In Meghnaghat, the content was in the range of 13.7-35.2 mgkg^{-1}. The highest concentration of lead (35.2 mgkg^{-1}) was observed in the steel industry and the order: Check < Textile < Dying < Cement < Steel area. The cadmium content ranged from 0.35-1.45 mgkg^{-1}. The highest cadmium content was found from steel industrial area (1.45 mgkg^{-1}) and the samples followed the order: Check < Textile < Dying < Cement < Steel area. The chromium content was in the range from 20.2-35.2 mgkg^{-1}. The highest concentration of chromium (35.2 mgkg^{-1}) was observed in from steel industry and the order: Check < Textile < Dying < Cement < Steel area. The nickel content ranged from 12.4-24.6 mgkg^{-1}. For the nickel content was the highest in soil that was collected from cement industrial area (24.6 mgkg^{-1}) and samples followed the order: Check < Steel < Textile < Cement < Dying area.

CONCLUSION

Soils polluted with heavy metals have become common across the globe due to increase in geologic and anthropogenic activities. So the determination of heavy metal contents in soil has become the demand of time. The experiment was conducted and it is found that all soils were loamy type with almost neutral pH and lower content of organic matter. All the samples collected close to the industrial area contained noticeable amount of lead, cadmium, chromium and nickel. Though amount of heavy metal content was lower than the permissible amount by WHO, content was way higher than the sample collected from non-industrial area. There was negligible correlation between the heavy metals and the soil pH. The results also revealed that study area more or less equally contaminated with heavy metals like lead, cadmium, chromium, nickel etc. that are discharging with the byproduct of the industries. This is an indication of influence of industries on increasing heavy metal content of soil, which are causing uptake in plant through soil. Plants growing on these soils show a reduction in growth, performance, and yield. This may be the cycle of human health hazards that are ultimately causing by the industrial waste discharge in the adjacent environment.

REFERENCES

Agouborde, L. and Navia, R. (2009). Heavy metals retention capacity of a non-conventional sorbent developed from a mixture of industrial and agricultural wastes, *J. Hazard. Mater.* **167**(1-3): 536-544.

Ahmad, J.U. and Goni M.A. (2009). Heavy Metal Contamination in Water, Soil, and Vegetables of the Industrial Areas in Dhaka, *Env. Monit. Assess.*,**166**(1-4): 347-57.

Ahmad, M.K., Islam, S., Rahman, S. Haque, M.R. and Islam, M.M. (2010). Heavy Metals in Water, Sediment and Some Fishes of Buriganga River, Bangladesh, *Intl. J. Env. Res.*, **4(2):** 321-332.

Ahmed, F., Katita, M., Satter, M.A., Ishiga, H., Rahman, M.M. and Bibi, M.H. (2003). Arsenic and other thirteen heavy metals contamination of Madhupur tract soil layers. *Bangladesh J. of Env. Sci.* **9:** 76-81.

Ahmed, M.K., Baki, M.A., Kundu, G.K., Islam, M.S., Islam, M.M. and Hossain, M.M. (2016). Human health risks from heavy metals in fish of Buriganga river, Bangladesh. Springerplus, p.5.

Akter, S., Khatun, R., Ahasan, M.M., Uddin, M.F., Jamil, H.M., Monika, A.N., Rahman, M.A., Rahman, M., Das, R.P. and Sharmin, R. A. (2019). Heavy Metals Content in Soil Sample Collected from Narayanganj Industrial Area, Bangladesh Using Proton Induced X-ray Emission. *American J. Env. Engineering*, **9(1):** 8-11.

Aldayel, O., Hefne, J., Alharbi, K.N. and Al-Ajyan T. (2018). Heavy Metals Concentration in Facial Cosmetics, *Nat. Pro. Chem. Res.*, **6(1):** 2329-6836.

Ali, M.M., Ali, M.L., Islam, M.S. and Rahman, M.Z. (2016). Preliminary assessment of heavy metals in water and sediment of Karnaphuli River, Bangladesh. *Env. Nanotech. Moni. Mang.* 5: 27–35.

Baghaie, A.H. and Fereydoni, M. (2019). The potential risk of heavy metals on human health due to the daily consumption of vegetables, *Env. Health Engin. Manage. J.*, **6(1):** 11–16.

Banu, Z., Chowdhury, M.S.A., Hossain, M.D. and Nakagami, K.I. (2013). Contamination and Ecological Risk Assessment of Heavy Metal in the Sediment of Turag River, Bangladesh: An Index Analysis Approach. *J. Water Resour. Prot.* **5:** 239–248.

Bibi, M.H., Ahmed, F., Satter, M.A., Ishiga, H. and Reza, M. M. (2003). Heavy metals pollution at different soil depths at Chadpur. *Bangladesh J. of Env. Sci*. **9:** 169-175.

Bouyocos, G.J. (1926). Hydrometer method improved for making particle size analysis of soils. *J. Agron*. **54:** 4661-4665.

Brevik, E.C. and Burgess, L.C. (2012). Soils and Human Health; CRC Press: Boca Raton, FL, USA.

Brown, S., Rufus, L., Chaney, J., Hallfrisch, G. and Xue Q. (2003). Heavy Metals in the Environment, *Journal of Env. Qual.* **32:** 100-108.

Butt, M.S., Sharif, K., Bajwa, E.B and Aziz. A. (2005). Hazardous effects of sewage water on the environment Focus on heavy metals and chemical composition of soil and vegetables Management of Environmental Quality. *An Intl. J.* **16(4):** 338-346.

Chen, Y., Wang, C.X. and Wang, Z.J. (2005). Residues and source identification of persistent organic pollutants in farmland soils irrigated by effluents from biological treatment plants. *Env. Int*. **31:** 778-783.

Chowdhury, M.K. (2003). Allocation of heavy metals in soils from different land use practice. MS. Thesis. Dept. of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Chowdhury, T.R., Uchino, T., Tokunaga, H. and Ando, M. (2002). Survey of arsenic in food composites from an arsenic affected area of Bengal, India, *Food Chem. Toxicol.,* **40(11):** 1611-1621.

Das, M., Ahmed, M.K., Islam, M.S., Islam, M.M. and Akter, M.S. (2011). Heavy Metals in Industrial Effluents (Tannery and Textile) and Adjacent Rivers of Dhaka City, Bangladesh. Global Science Books. *Terres. Aqua. Env. Toxicol.* **5(1):** 8-13.

Delang, C.O. (2018). Heavy metal contamination of soils in China: standards, geographic distribution, and food safety considerations. A review, *J. Geograph. Soci. Berlin,* **149(4):** 261-268.

Diaz-Valverde, A., Moreno-Rojas, R., Gordillo-Otero, J., Moreno-Arroyo, B., Jarello-Gonzalez, T. and Barba- Capote, C. J. (2003). Heavy metals in gurmelo (*Amanita ponderosa*). *Agriculture, Revista Agropecuaria*. **72(850):** 276-280.

Di-Maio, V.J.M. (2001). Forensic Pathology (2nd ed.). CRC Press.

DoE, (Department of Environment) (2007). Bangladesh State of the Environment, Department Environ and Ministry of Environ and Forest Pub. UNEP. P O Box-4 Klone, Luang. Pathaumthani, 12120. Thailand PP. 17-26.

Dolly, H. and Ford, M. (2001). The fate of metals in soil and water, UN. PP 1-74.

Elahi, A.M. (2008). Study on water quality of turag and its impact on Health. M.S. Thesis, Department of DVM, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Elik, A. (2003). Heavy metal accumulation in lane dust samples in Sivas. Department of Chemistry, Cumhuriyet University, Sivas, Turkey.

Garba, S.T. and Abubakar, M.A. (2018). Source and Distribution of The Heavy Metals: Pb, Cd, Cu, Zn, Fe, Cr, and Mn in Soils of Bauchi Metropolis, Nigeria, *American J. Engin. Res.,* **7(2):** 13-23.

Harvey, P.J., Handley, H.K. and Taylor, M.P. (2015). "Identification of the sources of metal (lead) contamination in drinking waters in north-eastern Tasmania using lead isotopic compositions". *Env. Sci. Pollut. Res*., **22(16):** 12276-12288.

Hasan, I., Rajia, S., Kabir, K.A. and Latifa, G.A. (2009). Comparative Study on the Water Quality Parameters in Two Rural and Urban Rivers Emphasizing on the Pollution Level. *Glob. J. Env*. *Res.* **3:** 218-222.

Hasan, M.M., Hosain, S. and Poddar, P. (2019). Heavy metal toxicity from the leather industry in Bangladesh: a case study of human exposure in Dhaka industrial area, *Env. Monitor. Ass.,* **191:** 530.

Havorak, O., Friesl, W. and Zwerger, I. (2006). Heavy metal contamination in the surroundings of a former Pb/ Zn smelter in Arnoldstein (Austria) Monitoring of bio available metal fractions in soils, Trace elements in the food chain. Proceedings of an international symposium on trace elements in the food chain, Budapest, Hungary PP: 191-195.

Hoque, M.E. (2003). Arsenic and other heavy metal status in soils and vegetables in Chapai Nawabganj. MS. Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hutton, M. and Symon, C. (2005). The quantities of Cd, Pb and Hg entering the UK environment from human activities. *J. Env. Sci,* **57:** 128-150.

Huy, N.Q., Luyen, T.V., Phe, T.M. and Mai, N.V. (2003). Toxic elements and heavy metals in sediments in Tham Luong Canal. Ho Chi Minh City, Vitenam. *Env. Eco.* **43(7):** 836-841.

Islam, M.R., Jahiruddin, M. and Islam, M.A. (2004). Assessment of arsenic in the water- soil- plant systems in Gangetic floodplains of Bangladesh. *Asian J. of Plant Sci***. 3(4):** 480-483.

Islam, F., Rahman, M., Khan, S.S.A., Ahmed, B., Bakar, A. and Halder, M. (2013). Heavy metals in water, sediment and some fishes of Karnafuly river, Bangladesh. *Int. J. Environ. Res*. **4:** 321-332.

Islam, M.S., Ahmed M.K., Raknuzzaman M., Mamun M.H. and Kundud G.K. (2017). Heavy metals in the industrial sludge and their ecological risk: A case study for a developing country, *J. Geochem. Explor*. **172:** 41-49.

Jackson, M.L. (1962). Soil Chemical Analysis. Prentice Hall. Inc. Englewood Chiffs. NY, USA. p. 7.

Jahiruddin, M., Harada, H., Hatanaka, T. and Islam. M.R. (2002). Status of trace elements in agricultural soils of Bangladesh and relationship with soil properties. *Soil Sci. Plant Nutri.,* **46(4):** 963-968.

Jan, A.T., Azam, M., Siddiqui, K., Ali, A., Choi, I. and Haq Q.M.R. (2015). Heavy Metals and Human Health: Mechanistic Insight into Toxicity and Counter Defense System of Antioxidants, *Intl. J. of Molecul. Sci.*, **16:** 29592-29630.

Jarup, L. (2003). Hazards of heavy metal contamination, *British Medical Bulletin*, **68(1):** 167-182.

Karim, M.R., Kuraoka, M., Higuchi, T., Sekine, M. and Imai, T. (2014). Assessment of heavy metal contamination from municipal solid waste open dumping sites in Bangladesh. *J. of Hydrol. Environ. Res.,* **2(1):** 41-49.

Kashem, M.A. and Singh, B.R. (1999). Heavy metal contamination of soil and vegetation in the vicinity of industries in Bangladesh. *Water, air, & soil Pollut.* **115:** 347-361.

Khan, H.R. (2008). Assessment of SPWAC (Soil-Plant-Water-Air Containment) Quality within and around Dhaka City Report Submitted to the Doctor of the Centre for Advanced Studies and Research in Biotechnological Sciences University of Dhaka, Bangladesh.

Kladsomboon, S., Jaiyen, C., Choprathumma, C., Tusai, T. and Apilux, A. (2019). Heavy metals contamination in soil, surface water, crops, and resident blood in Uthai District, Phra Nakhon Si Ayutthaya, Thailand, *Env. Geochem. Health,* **42(2):** 545-561.

Lenetech, G.S. (2004). Effects of Cd^{2+} and DTPA on young sugar beets (*Beta vegans*), I. Cd^{2+} uptake and sugar accumulation. *Plant Physiol.,* **3:** 66- 69-74.

Li, C., Zhou, K., Qin, W., Tian, C., Qi M., Yan, X. and Han, W. (2019). A Review on Heavy Metals Contamination in Soil: Effects, Sources, and Remediation Techniques, *Soil and Sediment Contamination: Intl. J.,* **28(4):** 380-394.

Lovei, M. (1998). Phasing Out Lead from Gasoline: Worldwide Experience and Policy Implications. World Bank Technical Paper, The World Bank 397.

Mahamudul, M. H., S. Hosain, P. Poddar, A. A. Chowdhury, Estiner W. Katengeza and U. Kumar Roy (2019). Heavy metal toxicity from the leather industry in Bangladesh: a case study of human exposure in Dhaka industrial area. *Sci. Ind. Res.,* **191:** 530.

Malik, R.N., Jadoon, W.A. and Husain, S.Z. (2010). Metal contamination of surface soils of industrial city Sialkot, Pakistan: a multivariate and GIS approach. *Environ. Geochem. Health,* **32:** 179-191.

Marshall, T.J. (1998). Mechanical composition of soils in relation to field description of texture. Commonwealth Aust. Council. *Sci. Ind. Res.* Melbourne, Australia, Bull. 224. p. 20.

Mohuya, F.A., Bhuiyan R.H., Hoque S. (2010). Heavy metal contamination in Gulshan- Baridhara lake, Dhaka, *Int. J. Bangladesh Academy Sci.*, **19(1):** 53-61.

Mondol, M.N., Chamon A.S., Faiz B. and Elahi S.F. (2011). Seasonal variation of heavy metal concentrations in Water and plant samples around Tejgaon industrial Area of Bangladesh, *J. Bangladesh academy sci.,* **35 (1):** 19-41.

Mottalib, A., Hossain, S.S., Shaikh, A.A. and Islam, S. (2016). Heavy metal concentrations in contaminated soil and vegetables of tannery area in Dhaka, Bangladesh. *Intl. J. Current Res.*, **8(05):** 30369-30373.

Naser, H. M., Sultana, S., Gomes, R. and Noor, S. (2012). Heavy metal pollution of soil and vegetable grown near roadside at Gazipur, *Bangladesh J. Agril. Res.* **37(1):** 9-17.

Ogundele, D.T., Adio, A.A., Oludele, O.E. (2015). Heavy Metal Concentrations in Plants and Soil along Heavy Traffic Roads in North Central Nigeria. *J. Environ. Anal. Toxicol.* **5:** 334

Page, A.I., Miller, R.H. and Keeray, D.R. (1989). Methods of soil analysis. Part 2, 2nd ed. American Soc. Agron. Inc. Madiwis. USA.

Perry, J. and Vanderklein, E.L. (1996). Water Quality: Management of a Natural Resource. Blackwell Science.

Peryea, F.J. (2001). Heavy Metal Contamination in Deciduos Tree Fruit Orchards: Implication for Mineral Nutrient Managemant. *Acta Hortic.,* **564:** 31-39.

Proshad, R., Islam M.S., Kormoker T., Bhuyan, M.S., Hanif M.A., Hossain, N., Roy R. and Sharma, A.C. (2019). Contamination of Heavy Metals in Agricultural Soils: Ecological and Health Risk Assessment, *SF J. Nanochem. Nanotechnol.*, **2(1):** 1012.

Qureshi, S., Richards, B.K., McBride, M.B., Baveye, P. and Steenhuis, T.S. (2003). "Temperature and Microbial Activity Effects on Trace Element Leaching from Metalliferous Peats". *J. of Environ. Qual*. **32 (6):** 2067.

Rahman, S.H., Khanam, D., Adyel, T.M., Islam, M.S., Ahsan, M.A. and Akbor, M.A. (2012). Assessment of Heavy Metal Contamination of Agricultural Soil around Dhaka Export Processing Zone (DEPZ), Bangladesh: Implication of Seasonal Variation and Indices. *Appl. Sci. Basel*. **2:** 584-601.

Rakib, M.A., Ali, M., Akter, M.S. and Bhuiyan, M.A.H. (2014). Assessment of Heavy Metal (Pb, Zn, Cr and Cu) content in Roadside Dust of Dhaka Metropolitan City, Bangladesh. International Research Journal of Environment Sciences. **3(1):** 1-5.

Sattar, M.A. And Blume, H.P. (1998). Trace metal contamination in Bangladesh soils. *Bangladesh J. of Env. Sci*. **4:** 1-12.

Sattar, M.A. and Blume, H.P. (1999). Lead contamination of road dust of Bangladesh. Ecohazard. Otsu city, Shiga, Japan.

Sattar, M.A. and Blume, H.P. (2000). Trace metal contamination in Bangladesh soils. *Bangladesh J. of Soil Sci*. **26:** 15-21.

Shakery, A., Moor, F. and Razikormahalleh, L. (2010). Distribution of soil heavy metal contamination around industrial complex zone, Shiraz, Iran. 19th World Congress of Soil Science, Soil Solutions for a changing World, 1-6 August 2010, Brisbane, Australia.

Su, C., Jiang, L. and Zhang, W. (2014). A review on heavy metal contamination in the soil worldwide: Situation, impact and remediation techniques, *Env. Skeptics and Critics*, **3(2):** 24-38.

Sultana, T. (2000). Effect of intensive fertilizer on heavy metal concentration in soils and plants. M.S. Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Suruchi, K. and Khanna P. (2011). Assessment of Heavy Metal Contamination in Different Vegetables Grown in and Around Urban Areas, *Research Journal of Env. Toxicol.*, **5(3):** 162-179.

Suryawansh, P.V., Rajaram, B.S., Bhanarkar, A.D., Chalapati, R.C.V. (2016). Determining heavy metal contamination of road dust in Delhi, India, *Atmósfera*, **29(3):** 221-234.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K. and Sutton, D.J. (2012). Heavy metal toxicity and the environment. *Mol. Clin. Environ. Toxicol*. pp 101- 133.

Tune. M., Toman, R. and Tancin, V. (2016). Heavy metals Environmental contaminants and their occurrence in different types of milk, *Slovak Journal Animal Sci.,* **49(3):** 122-131.

Uddin, M.N., Hasan M.K. and Dhar, P.K. (2019). Contamination Status of Heavy Metals in Vegetables and Soil in Satkhira, Bangladesh, *Journal of Materials and Env. Sci.* **10(6):** 543-552.

Venkateswaran, P., Vellaichamy, S. and Palanivelu S. (2007). Speciation of heavy metals in electroplating industry sludge and wastewater residue using inductively coupled plasma, *International J. Environ. Sci. Technol.*, **4(4):** 497-504.

Villini, S.W. and Khalek, H. (1992). Effect of toxic heavy metals (Cd, Pb) from tannery on growth and mineral nutrition of breech (*Fagus sylvatica* L). *Vegetation* **101:** 43-53.

Walkley, A. and Black, D. R. (1935). An examination of the digestion method for determining, soil organic matter and proposed modification of the chronic acid titration method. *Soil Sci*., **37:** 29-38.

Wang, S.W. and Shi, X.L. (2001). Molecular mechanisms of metal toxicity and carcinogenesis. *Mol. Cell Biochem.* **222:** 3-9.

WHO (1996). Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization), Switzerland.

Xie, Z., Zhang, H., Zhao, X, Du, Z., Xiang, L. and Wang, W. (2016). Assessment of Heavy Metal Contamination and Wetland Management in a Newly Created Coastal Natural Reserve, China. *J. Coastal Res.,* **32(2):** 374-386.

Yang, J., Ma, S., Zhou, J., Song, Y. and Li, F. (2018). Heavy metal contamination in soils and vegetables and health risk assessment of inhabitants in Daye, China. *J. Intl. Medic. Res.,* **46(8):** 3374-3387.

Zakir, H.A., Sharmin, S. Mohiuddin, K.M. and Kaysar, S, (2015). Heavy metal contamination in surface soils of some industrial areas of Gazipur, Bangladesh. Bangladesh. *J. Chem. Bio. Phy. Sci.* **5:** 2191-2206.

Zakir, H.M. Sultana, N. and Akter, M., (2014). Heavy metal contamination in roadside soils and grasses: a case study from Dhaka city, Bangladesh. *J. Chem. Bio. Phy. Sci.,* **4(2)**: 1661-1673.

Zakir, H.M., Sharmin, S. and Shikazono, N. (2006). Heavy metal pollution assessment in water and sediments of Turag River at Tongi area in Bangladesh. *Int. J. Lakes Rivers,* **1:** 85-96.

Zhang, Q., Ruoyun, Y., Songling, F., Zemin, W., Han, Y. H.C. and Liu, H. (2019). Spatial heterogeneity of heavy metal contamination in soils and plants in Hefei, China, *Sci. Agric. Pp.*76-81

APPENDICES

Appendix 1. Ranges of Maximum Allowable Concentrations (MAC) for Trace Metals in Agricultural Soils and plant by WHO

Elements	**Target value of soil ($mgkg^{-1}$)**	**Permissible value of plant ($mgkg^{-1}$)**
Pb	85	2
Cd	0.8	0.02
Cr	100	1.30
Ni	35	10

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

Plate 1: Collection of soil sample

Plate 2: Some of the collected soil samples