

Environmental analysis of urban and peri-urban agriculture of Jessore district

Asma Sultana¹, Md. Shahadat Hossen¹, Md. Zakaria Ibne Baki^{2*}, Mahbuba Mustafa¹, Papri Hazra¹, Md. Rajib Hossain¹

¹Department of Environmental Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

²Scientific Officer, Agronomy Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh

ARTICLE INFO

Article history:

Received 3 April 2015

Accepted 30 April 2015

Available online 04 May 2015

Keywords:

Urban and peri-urban agriculture
Soil and water quality
Biodiversity index
Bangladesh

*Corresponding Author:

Md. Zakaria Ibne Baki
Email: rabbibau240@gmail.com

ABSTRACT

An investigation was carried out to study Hydrogen ion concentration (pH), Electrical conductivity (EC), Organic matter (OM), Nitrogen (N), Phosphorus (P), Potassium (K), Lead (Pb), Cadmium (Cd) and biodiversity index (D) contents in industrial site, road site and construction site area of Jessore district (urban) and Abhaynagar thana (peri-urban) in Bangladesh. Thirty soil and thirty water samples were collected from 6 different locations of Jessore district and Abhaynagar thana during August to October 2013 and biodiversity of particular sites were also observed at that time. All soil and water samples were highly 'acidic to neutral' in nature (pH = 4.08-7.29) and were problematic for crop production and health. The range of EC of soil samples was 105-435 μScm^{-1} and EC of water samples was 390-1329 μScm^{-1} which indicate that water samples were 'good to permissible' in quality for irrigating soils and crops. The average highest OM value of soil 1.856 % was found in road site peri-urban area and the average lowest value of soil 0.804 % was found in urban construction area which indicated that the soils were 'very low to medium' in quality of soil fertility. From the study it was found that urban and peri-urban (UPA) industrial, road and construction areas soil and water contained acceptable amount of N, P and K. The total Pb content of collected soil and water samples varied from 0.762-0.105 ppm and 0.099-0.014 ppm, respectively. The highest Pb concentration was found in urban contaminated industrial areas for both soil and water and the lowest Pb concentration was found in peri-urban construction site for both soil and water. The total Cd content of collected soil and water samples varied from 1.93-0.018 ppm and 0.979-0.001 ppm, respectively. The highest and lowest concentration of Cd also found similar to the Pb concentration. Consideration of all sites, higher biodiversity index was 0.495 for peri-urban industrial site and lower biodiversity index was 0.296 for urban industrial areas. The study also revealed that the area was significantly contaminated with toxic metals like Pb and Cd. High amount of these metals in surface soil and water caused health hazards to the surrounding environment.

INTRODUCTION

Urban and Peri-urban Agriculture (UPA) is referred to as agricultural practices within and around cities which compete for resources (soil, water, and energy, labour) that could also serve other purposes to satisfy the requirements of the urban population. UPA plays an important role as part of an environmental sustainability program. Physically, it increases green space, which reduces the urban heat island, storm water run-off and improves air quality, and because food is produced locally, urban agriculture also reduces energy consumption and pollution associated, with transportation. It also provides social benefit by providing inexpensive access to locally grown produce (Birley and Lock, 1999). It is a recent phenomenon although there is a long tradition of farming intensively within and at the edge of cities (UNDP, 1996).

The significance of urban and peri-urban agriculture (UPA) has emerged from the increasing population of urban poor in developing countries. The problem of food security has triggered people to find ways to feed themselves, like UPA. As an integral part of the urban landscape, UPA serves as a productive land use contributing significantly to the socio-economic development of cities. UPA is also competitive with rural farming in being close to urban markets and able to deliver fresher produce to the consumer. Therefore,

urban and peri-urban food system are crucial and can become sustainable if they reduce the cities needs to import resources to satisfy their production and consumption needs, and reduces the amount of waste leaving the city (Altieri and Catherine, 1999). Land and water are precious natural resources on which rely the sustainability of agriculture and the civilization of mankind. The pollution includes point sources such as emission, effluents and solid discharge from industries, vehicle exhaustion and metals from smelting and mining, and non-point sources such as soluble salts, use of agrochemicals, disposal of industrial and municipal wastes in agriculture and others (Nriagu and Pacyna, 1998; Schalscha and Ahumada, 1998; McGrath *et al.*, 2001; Zakir *et al.*, 2008). Each source of contamination has its own damaging effects to biodiversity such as plants, animals and ultimately to human health, but those that add heavy metals to soils and waters are of serious concern due to their persistence in the environment and carcinogenicity to human beings (Garbisu and Alkorta, 2001; Gisbert *et al.*, 2003).

Land and water pollution by heavy metals is a worldwide issue. All countries have been affected, though the area and severity of pollution vary enormously. In Western Europe, 1400000 sites were affected by heavy metals (McGrath *et al.*, 2001), of which, over 300000 were contaminated, and the estimated total number in Europe could be much larger, as pollution problems increasingly

occurred in Central and Eastern European countries (Gade, 2000). According to government statistics, more than 100000 ha of cropland, 55000 ha of pasture and 50000 ha of forest have been lost (Ragnarsdottir and Hawkins, 2005). Soil and water pollution is also severe in India, Pakistan and Bangladesh, where small industrial units are pouring their untreated effluents in the surface drains, which spread over near agricultural fields (Ntengwe, 2006).

In Bangladesh, there is a progressive increase in industrial wastes and due to the rapid industrialization such waste products have been causing severe contamination to the air, water and soils, thus polluting the environment. Heavy metals that have been identified in the polluted environment include As, Fe, Cu, Cd, Pb, Cr, Ni, Hg, Zn etc. These heavy metals enter into the environment through various industrial processes. Water resource, the prominent component of the environment is getting polluted over the years. Wastewater is mainly used for irrigation purpose, because this contains nutrients that enhance the growth of crop plants but it is also known to have significant contribution to the heavy metal content of soils. Soil contamination with heavy metals may also cause changes in the composition of soil microbial community, adversely affecting soil characteristics (Giller *et al.*, 1998;

Kozdroj and Elsas, 2001; Kurek and Bollag, 2004). Heavy metal pollution in the environment is quite relevant in the present scenario due to its deleterious effect on human health via food chain. Biosphere pollution by heavy metals has accelerated dramatically during the last few decades as a result of discharge of wastewaters from various industries and urban population. The consumption of plants grown in heavy metals rich soil, results in introduction of substantial amount of potentially toxic metals into the food chain (Pandey and Nautiyal, 2008; Agoramoorthy *et al.*, 2009; Naaz and Pandey, 2010). Application of sewage sludge and industrial waste substantially increased of trace metals in soil (Jones and Jarvis, 1981).

The increasing world population and limited natural resources led to the intensification of agricultural systems. As a result, the degradation of natural resources is of increasing concern in many ecosystems of different parts of the world. Land degradation, deterioration of water quality, water scarcity, biodiversity and habitat loss are of several deleterious impacts of intensive agricultural systems on the environment (Hardoy and Satterthwaite, 1989). Cultivable land is getting reduced alarmingly due to increasing population pressure leading to increasing demand for habitation in the urban area (Fraser, 2002). However, UPA, being an intensive agricultural system, dose adversely impact on environment. There is, therefore, a need to understand, analyze and predict the impacts of UPA on the environment to achieve sustainable agriculture (Haddad *et al.*, 1999).

In urban agriculture, most of the contaminated river, canal and pond water was used for crop production. Therefore, it is necessary to know the status of urban agricultural soil and water for human safety consideration. Past research reported that urban area was contaminated mostly industrial wastes disposal on

environment and agricultural productivity which were highly polluted by heavy metals, using inorganic chemical fertilizers, intensive cropping pattern etc. (Bodiuzzaman, 2003; Anupom, 2010; Kohinoor, 2011; Taukir, 2011). Today, urban and peri-urban soil and water contamination have become a problem in Bangladesh. It rapidly degraded our soil quality as well as soil fertility and productivity but very limited research has so far been done in this field. Considering above views in mind, the present study was, therefore, undertaken with the aims to evaluate the impacts of UPA on soil and water quality and also on floristic biodiversity

MATERIALS AND METHODS

Selection of study location

Jessore is one of the greater districts of Khulna division, which is located in south west of Bangladesh. Jessore, is situated between 22°10' and 22°28' east longitudes and in between 89°16' and 89°64' north latitudes, is in directly proximity of Jessore Domestic Airport, and the area is nearly slope from north to south. The Jessore district encompasses of 2,606 km², 7m elevated from sea level and the Jessore town is situated on the bank of Bhairab river (Chowdhury, 2012).

It is characterized by intense urbanization and several industrial sites. It is also distinguished by a high distribution of agricultural areas, and is therefore classified as an urban agriculture area. Abhaynagar is situated between 23°07' and 23°15' north latitude and in between 89°18' and 89°34' east longitudes of Bangladesh, is predominantly agricultural, and is intermediate between urban and rural areas with no industrial sites or heavy urbanization, and was therefore, classified as a peri-urban agricultural area.

The chemical composition of agricultural field soil and surface water like pond, lake and river waters is a major factor in determining its quality and hence, the chemical analysis of soil & surface water samples is necessary to assess the concentration of water toxicity on human health, crops and livestock.

An attempt has been made to analyze soil & water samples collected from the entire Jessore & Abhaynagar (urban & peri-urban) area and the chemical analysis of soil and water samples included the concentration of Pb, Cd, N, P, K, OM, EC and pH of all collected samples.

Selection of sampling units

To perform the environmental analysis based on agricultural land use type basis, the Industrial area, High rise building area, High way road area which represents high urbanization were chosen.

These units are randomly selected from the urban and peri-urban area. In Jessore district and Abhaynagar thana, 3 sampling units were selected within each agricultural land use type, to evaluate soil and water quality. However, to study the floristic biodiversity, Jessore and Abhaynagar were chosen. Here, total 6 sites were selected, and collected in two consecutive seasons (3 sampling units each), one accounting for Kharif (2013) and the other for Rabi (2014) floristic diversity.

Selection and description of sampling sites

Once in the field, the sampling sites were chosen subjectively depending of accessibility, on ground agricultural field and the degree to which it represented the urban and peri-urban location. Fig.1 and Fig.2 illustrate the soil sampling sites in Jessore and Abhaynagar thana. Three urban area-sampling sites in each location, adjacent to industrial area, adjacent to high rise building and adjacent to highway road site were chosen. The natural area sampling sites were chosen with subjective judgment of moderate degradation.

Description of soil

Land Formation

The low-lying areas extend mainly towards fringe areas of the town characterized by swampy areas, currently used for agricultural purposes that are poorly drained and persistent water logging problems (Reiman, 1993).

Soil Type

Jessore district is formed entirely by the deltaic action of the Ganges which brought mud and lime stone from the Himalayas. The soil is to a great extent uniform in character and varies only greater or smaller admixture of sand, silt and clay. Naturally, the percentage of sand is greater along the riversides and smaller in those areas where deltaic action has ceased. The town fringes particularly are the marsh areas (Hassan, 1984). It is situated at AEZ 14. Gopalganj-Khulna Bils (224700 ha). The region occupies extensive low-lying areas between the Ganges River Floodplain and the Ganges Tidal Floodplain. Organic matter content is medium to high. They have low bearing capacity when wet, potentially strongly acid and low in P and Zn status. Fertility level is medium.

Collection of Soil and water samples

Composite samples were obtained using the random sampling method for field soil sampling (Ryan *et al.*, 1996) from each sampling site chosen in both locations; Jessore and Abhaynagar, within the three land use types. The samples were obtained from a depth of approximately 0-15cm (Richards *et al.*, 1998). This was performed to enable the differentiating between long-term and short-term effects of agricultural practices on soil quality to determine the magnitude of the impact on the environment. Adjacent areas demonstrate the soils ability to return to its baseline levels were in a short period of time relative to that of the urban and natural land use types. Therefore, from the each sampling sites in industrial area, high rise building area and high way road site in Jessore and Abhaynagar, total 60 samples (30 water & 30 soil samples) were obtained respectively with 5 replications in 6 urban and 6 peri-urban areas.

Preparation of soil samples for analysis

From the collected soil samples the stones, gravels, plant roots, leaves etc. were picked up and removed. The samples were brought to the 'Soil Science Laboratory' of Bangladesh Agricultural University, Mymensingh, where they were left to air-dry for 48 hours, after which they

were ground then screened to pass a 10 mm sieve. The soil samples were kept in clean labeled plastic containers before undergoing chemical analysis.

Preparation of water samples for analysis

The water samples were collected in 100mL plastic bottles. These bottles were cleaned with dilute hydrochloric acid (1:1) and then washed with tap water followed by distilled water. Before sampling bottles were rinsed again 3 to 4 times with water to be sampled. After collection the bottles containing samples were sealed immediately to avoid exposure to air. The samples were taken from the river, lake and pond few meters below the surface. To provide necessary information for each sample such as date of collection, location, source of water, depth etc. were recorded in note book and each sample collected in a plastic bottle, was labeled separately with a unique identification number. After collecting, all samples were filtered with Whatman No.1 filter paper to remove unwanted solid and suspended material before analysis. Then samples were transferred to 90mL of water samples into another 100mL bottle which contained 10mL 2M hydrochloric acid solution. Hydrochloric acid solution was protected water samples from any fungal and other pathogenic attack. After collection the samples were then carried to the 'Soil Science Laboratory' of Bangladesh Agricultural University, Mymensingh. In the laboratory the bottles were kept in a clean, cool and dry place.

Analytical Methods of soil & water analysis

Determination of pH

Soil and water pH was determined by glass electrode pH meter as described by Jackson (1985).

Electrical conductivity (EC)

The Electrical conduction of soil & water were measured form 1:5 soil water suspension using a glass electrode EC meter as described by Jackson (1962). The results were expressed in $\mu\text{S}/\text{cm}$.

Organic matter content

Organic matter content was determined using the Wet Combustion Method (Walkley and Black, 1934; Walkley, 1947; FAO, 1974). This procedure for measuring the organic matter content of the soil samples involves the reduction of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) by organic carbon compound and subsequently determining the unreduced dichromate by oxidation-reduction titration with ferrous sulfate (FeSO_4). For every soil sample collected, 10mL of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) solution and 20mL of concentrates sulfuric acid (H_2SO_4) was added to 2g of soil. After standing for 30 minutes 200mL of distilled water and 10mL of phosphoric acid (H_3PO_4) were added and left to cool. Using diphenylamine indicator, the mixture was titrated with ferrous ammonium sulfate solution until the color changed from violet-blue to green. The organic matter content was calculated by multiplying the content the organic carbon by Van Bemmelen factor 1.73 (Piper, 1950).

Major nutrient status in soil & water

Total nitrogen

Total nitrogen in the soil was determined by macro Kjeldahl method by digesting soil sample with concentrated 5mL H₂SO₄, 2 or 3mL H₂O₂ and catalyst mixture (K₂SO₄ : CuSO₄.5H₂O : Se = 10:1:0.1) requiring temperature 360°C for 1 hour. Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in boric acid with 0.1N H₂SO₄ (Page et al., 1989).

Available phosphorus

Available phosphorus was estimated by extracting the soil with 0.5M NaHCO₃ solution having pH 8.5 following the method of Olsen et al., (1954). In this colorimetric method SnCl₂ was used as a reductant and sodium bicarbonate (NaHCO₃, 0.5M) was the extractant. The P in the extract was then determined by developing a blue color by SnCl₂ reducing of phosphomolybdate complex and measuring the color calorimetrically at 660nm wave length comparing the color developed with a standard phosphate solution (Black, 1965). In case of water sample, 20mL sample was needed for analysis without extracting which was followed to same procedure of above soil analysis.

Exchangeable potassium

Exchangeable potassium was determined with the help of flame photometer following the method described by Jackson (1962). For soil extraction 10g soil was mixed with 50mL 1.0N ammonium acetate at pH 7.0. The mixture was shaken for 30 minutes with the help of mechanical shaker and the contents were filtered. The extraction was the passed through a tube into gas flame. The air pressure was fixed at 10 psi, and the percent emission was recorded at wave length of 768 nm (Ghosh et al., 1983).

Digestion of the sample

Determination of total Pb & Cd content in soil

The soil sample weighting 1.0g was transferred into a dry clean digestion vessel. Five mL nitric acid (HNO₃) and 3mL perchloric acid (HClO₄) were added to the vessel. The digestion vessel was placed then on a heating block and was heated at a temperature to 120°C for two hours and 180°C for one hour. The digest was cooled, filtered through Whatman No. # 42 filter paper and diluted to 50mL with deionized water into plastic bottle.

Determination of available Pb & Cd content in soil

The available Pb & Cd was determined by ammonium nitrate extraction methods where 4gm soil was treated with 20mL 1M ammonium nitrate solution. The samples were then shaken mechanically for two hours under 10-12 rpm, centrifuged for 5 minutes under 3000 rpm, and collected the supernatant extract in the plastic bottles. All soil extract samples were then filtered by using Whatman No. # 42 filters paper and diluted with deionized water into plastic bottle.

Determination of Pb & Cd content in soil environment

The total and available Pb content in soil environment were determined by using sensitive AAS (Atomic Absorption Spectrometer) adjusting wave length 283.3 and temperature 3000°C and available Cd content were determined by using sensitive AAS (Atomic Absorption Spectrometer) adjusting wave length 228.8 and temperature 3000°C.

General precaution

For collection and presentation of samples care was taken to obtain a sample that was truly representative of existing conditions and to handle it in such a way that it did not deteriorate or become uncontaminated before it reached the laboratory. Preservation techniques were applied to retard the chemical and biological changes that inevitably continue after the removed from the source. All materials coming into contact with the sample were glass or plastic and a sample container was thoroughly washed with distilled water.

Floristic biodiversity sampling

In Jessore & Abhaynagar 6 sampling total were selected, and collected in two consecutive seasons (3 sampling units such as within industrial area, surrounding building area, along roadsides), one accounting for *Kharif* (2013) and the other for *Rabi* (2014) floristic diversity. However, for the natural area sampling units, a random walk procedure (Coker and Kent, 1992), was adopted to collection the samples at 6 collection points. At each collection point, all the undesired weeding plants present within a 1m² transect were collected.

The samples were brought to the Bangladesh Agricultural University of Mymensingh Laboratories for identification to the specimen level. However, several plants were identified to the genus level due to the absence flowers or fruits. Taxonomic identification and nomenclature was based on the Flora of Bangladesh, (Post and Dinsmore, 1934), weeds of Bangladesh (Edgecombe, 1970).

Floristic biodiversity analysis

To determine the similarity between the different sampling sites and land use type in terms of plant species and insect-pests they contain. The biodiversity was calculated of selected area using the method of "Simpson Index of Diversity".

Therefore, the index of biodiversity:

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where,

D is the index we are calculating

n is the number of individuals of a given species

N is the total number of individuals present in sample

This index ranges from 0 (no diversity) to 1 (maximum diversity).

Statistical analysis

Statistical analysis of the data generated out of the chemical analyses of soils and water samples, were done

with the help of a scientific calculator (Casio Super Fx-100D) following the standard procedure as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Quality assessment of water and soil

Water samples were collected from different sources viz. Industrial site area, road site area and construction site area. Their quality was assessed in term of various chemical properties. The salient features of the experimental findings presented in this chapter and discussed under appropriate headings.

Hydrogen ion concentration (pH)

Total 30 water samples were collected from Bhoirob river, canal and pond at Jessore district area. In industrial areas, the pH values of soil samples were within the range of 6.02-4.08 in urban area over the sources and 5.26-6.64 in peri-urban urban area (Tables 4.1) which indicates that the water samples were acidic water. The mean value was 5.112-5.826. The pH values of water samples were within the range of 6.96-4.64 in urban area and 6.25-5.59 in peri-urban urban area which indicates that the water samples were acidic water. The mean

value of soil was 5.112 for urban area, 5.826 for peri-urban area and water was 5.8 for urban area and 5.976 for peri-urban area respectively.

In road site area, the range of soil pH was 6.8-5.2 for urban area and 6.75-5.9 for peri-urban area, the range of water pH was 7-6.17 in urban area and 7.29-6.18 in peri-urban area. The mean value of soil was 6.158 for urban area, 6.304 for peri-urban area and water was 6.582 for urban area 6.626 for peri-urban area respectively.

In construction site area, the range of soil pH was 6.86-6.14 in urban area and 6.73-5.96 in peri-urban area, the range of water pH were 6.01-6.78 in urban area and 6.89-5.99 in peri-urban area. The mean value of soil was 6.372 for urban area, 6.436 for peri-urban area and water was 6.386 for urban area, 6.34 for peri-urban area respectively.

The highest pH value found in road site area in peri-urban area that was 7.29 probably due to addition of basic materials in water system and the lowest pH value was 4.08 found at industrial site in urban area due to accumulation of acidic waste water effluents discharges from industrial sewage (Table 4.1). The pH levels three types of soil and water followed the order of construction site > road site > industrial site.

Table 1. pH and EC ($\mu\text{S}/\text{cm}$) of soil and water samples of selected sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area).

Quality	Samples (n=5)	Industrial site areas		Road site areas		Construction site areas	
		Urban	Peri-urban	Urban %	Peri-urban	Urban %	Peri-urban
pH	Soil	5.11±0.73	5.826±0.65	6.158±0.71	6.304±0.38	6.372±0.29	6.43±0.31
	Water	5.8±1.03	5.976±0.24	6.582±0.29	6.626±0.41	6.386±0.33	6.34±0.39
EC($\mu\text{S}/\text{cm}$)	Soil	142.66±21.44	257.40±96.65	207.72±94.84	176.82±42.34	272±109.73	169.66±50.78
	Water	898.8±56.84	661.8±222.33	913.2±66.86	816±261.49	979±223.10	1024±239.55

According to SRDI, 2009 (Appendix 1) showed that the highest value (7.29) which was neutral (6.6-7.3) in nature and lowest value (4.08) which was very acidic (>4.5) in nature. The normal pH range of water was 6.5-9.0 Thus, pH values of most of the water samples under test were within the normal range and these waters might not be harmful for crops, animals, fisheries and poultry, According to ADB (1994).

According to Ayers and Westcot (1985), the acceptable range of pH for irrigation water quality is from 6.0 to 8.5. On the basis of their comments, all the tested water samples were suitable for irrigating agricultural crops. Similar findings were reported by Basher (2005), that the pH value of pond, tubewell, river and canal water ranged from 6.88 to 7.88, 7.21 to 8.02, 7.24 to 7.38 and 6.90 to 7.70, respectively. Similar observation was also reported by Hossain (1998); Sarker (1997); Quayum (1995); Razzaque (1995). On the basis of water quality standard for aquaculture, the recommended pH ranges from 6.5 to 8.0 (Meade, 1989). According to this, all the water samples collected were suitable for aquaculture.

Electrical conductivity (EC)

Conductivity is the measure of the capacity of a solution to conduct electric current. The EC of water samples

collected from the different location of Bhoirob river, Canal and pond of Jessore district area. In industrial areas, the EC values of soil samples were within the range of 165.3-118 μScm^{-1} in urban area and 387-171.8 μScm^{-1} in peri-urban area (Tables 4.2). The EC values of water samples were within the range of 968-811 μScm^{-1} in urban area and 916-390 μScm^{-1} in peri-urban urban area which indicates that the water samples were acidic water. The mean value of soil was 142.66 μScm^{-1} for urban area and 257.4 μScm^{-1} for peri-urban area and water was 898.8 μScm^{-1} for urban area and 661.8 μScm^{-1} for peri-urban area respectively.

In road site area, the range of soil EC were 328-120.1 μScm^{-1} in urban area and 245-128 μScm^{-1} in peri-urban area, the range of water EC were 1023-855 μScm^{-1} in urban area and 1207-578 μScm^{-1} in peri-urban area with the mean value of soil was 207.72 μScm^{-1} for urban area and 176.82 μScm^{-1} for peri-urban area and water was 913.2 μScm^{-1} for urban area and 816 μScm^{-1} for peri-urban area respectively.

In construction site area, the range of soil EC were 435-165 μScm^{-1} in urban area and 228-105 μScm^{-1} in peri-urban area, the range of water EC were 1235-701 μScm^{-1} in urban area and 1329-780 μScm^{-1} in peri-urban area. The mean value of soil was 273 μScm^{-1} for urban area

and $169 \mu\text{Scm}^{-1}$ peri-urban area and water was $979 \mu\text{Scm}^{-1}$ for urban area and $1024 \mu\text{Scm}^{-1}$ for peri-urban area respectively.

The highest EC value found in construction site area in peri-urban water was $1329 \mu\text{Scm}^{-1}$ due to the huge quantities of salts, solid wastes and effluents of tannery industries (Costae et al., 2001) in water system and the lowest EC value of soil was $105 \mu\text{Scm}^{-1}$ found at construction site in peri-urban area due to near the crop fields of Pharmaceutical industrial areas (Table 4.2). The EC levels three types of soil and water followed the order of construction site > road site > industrial site. The high salt affected soils of contaminated sites account for the higher EC. The low EC of uncontaminated soils is related to comparatively low salinity contents.

On the basis of EC values, Wilcox (1955) the classified irrigation water into four group such as excellent salinity ($\text{EC} < 250 \mu\text{S/cm}$), good salinity ($\text{EC} = 250-750 \mu\text{S/cm}$), permissible salinity ($\text{EC} = 750-2000 \mu\text{S/cm}$), doubtful salinity ($2000-3000 \mu\text{S/cm}$) and unsuitable salinity (> 3000). Similar type of EC result was also reported by Costa et al. (1985); Raju and Goud (1990). Considering the suitability of water for irrigation, Wilcox (1955) categorized water into five groups (Appendix 2). According to the classification all water samples were "good to permissible" class. The EC content of these samples were similar to the findings to Salhea (2005) that the electrical conductivity (EC) varied from $256 \mu\text{Scm}^{-1}$ to $788 \mu\text{Scm}^{-1}$ in dry season and $247 \mu\text{Scm}^{-1}$ to $785 \mu\text{Scm}^{-1}$ in wet season.

Organic matter content

The organic matter content of contaminated soil has been presented in Fig. 1. In industrial areas, the organic matter content of soil ranged from 1.69-0.55 % in urban areas and 1.03-2.63 % in peri-urban areas. In road site areas, the organic matter content of soil ranged from 1.65-0.65 % in urban area and 2.65-0.62 % in peri-urban areas. In construction site areas, the organic matter content of soil ranged from 1.15-0.63 % in urban area and 1.99-0.95 % in peri-urban areas.

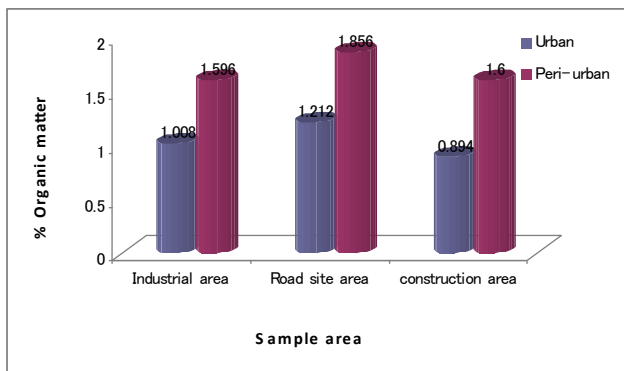


Figure 1. The comparison of organic matter content in different sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area).

The highest mean value was found 1.856 % at road site in peri-urban areas. This is primarily due to the presence of a thick vegetative cover and the undisturbed nature of these sites, allowing greater organic matter accumulation

on road site soil. The deposition and decomposition of huge quantities of solid wastes and sewage sludge responsible for the organic matter enrichment in this soil. Similar observation was also reported by Fjallborg et al. (2002). According to SRDI 2009 (Appendix 3), considering the classification of OM on the basis of soil fertility; this highest mean value (1.856 %) was medium (1.7-3.4 %) in nature for soil which was suitable for crop production.

The lowest mean value was found 0.894 % at industrial site in urban areas from crop field. This is due to the soil organic matter slow rate of loss from soil. This indicates that soil organic matter is an indicator of long-term agricultural impact on soil quality, similar to findings of soil pH. However, this is contrary to soil EC levels that increase rapidly with agricultural practices (i.e. cultivated areas), and return quickly to the baseline levels once agricultural practices have stopped (i.e. peri-urban areas).

According to SRDI 2009 (Appendix 3), considering the classification of OM on the basis of soil fertility; this lowest mean value (0.894 %) was lower (< 1.0 %) in nature for soil which was not suitable for crop production.

From the study, it was revealed that uncontaminated soils contained relatively more organic matter than contaminated soils. Here, the fluctuation of organic matter had observed in post-harvest soil by the application of different pesticides. This reason might be pre-manuring of respective field, decomposition of weeds, plants residues and organic component. Moreover, during the sample collection action of pesticides might be neutralized and no action of pesticide residues.

Major nutrient status in soil and water

Total nitrogen

The total nitrogen (N) content of contaminated soil has been presented in Table 4.3. In industrial areas, the total nitrogen of soil ranged from 0.229-0.14 % in urban area and 0.791-0.332 % in peri-urban areas with a mean value was 0.17 % for urban area and 0.518 % for peri-urban area respectively. According to SRDI, 2009 (Appendix 4), the urban soil contain low nitrogen (0.091-0.18 %) which was unsuitable for crop production and peri-urban soil contain very high nitrogen (> 0.45 %) which was suitable for crop production. The total nitrogen of water ranged from 9.55-1.4 ppm in urban area and 7.72-5.25 ppm in peri-urban areas with a mean value was 6.97 ppm for urban area and 6.966 ppm for peri-urban area respectively.

In road site areas, the total nitrogen of soil ranged from 0.265-0.119 % in urban area and 0.444-0.165 % in peri-urban areas with a mean value were 0.195 % for urban area and 0.328 % for peri-urban area respectively. According to SRDI, 2009 (Appendix 4), the urban soil contain medium nitrogen (0.181-0.27 %) and peri-urban soil contain standard nitrogen (0.271-0.36 %) which was suitable for crop production. The total nitrogen of water ranged from 5.92-2.95 ppm in urban area and 8.4-6.15 ppm in peri-urban areas with a mean value of 4.702 ppm

for urban area and 7.276 ppm for peri-urban area respectively.

In construction site areas, the total nitrogen of soil ranged from 0.521-0.175 % in urban area and 0.496-0.339 % in peri-urban areas with a mean value were 0.366 % for urban area and 0.419 % for peri-urban area respectively. According to SRDI, 2009 (Appendix 4), the urban soil

contain low nitrogen (0.271-0.36 %) and peri-urban soil contain high nitrogen (0.361-0.45 %) which was suitable for crop production. The total nitrogen of water ranged from 5.95-1.4 ppm in urban area and 8.18-6.19 ppm in peri-urban areas with a mean value was 4.05 ppm for urban area and 7.392 ppm for peri-urban area respectively.

Table 2: N (%), P (ppm), K (ppm) of soil and water samples of selected sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area).

Content	Sample (n=5)	ID	Industrial site areas		Road site areas		Construction site areas	
			Urban	Peri-urban	Urban %	Peri-urban	Urban %	Peri-urban
N (%)	Soil %		0.17±0.03	0.51±0.18	0.19±0.05	0.32±0.12	0.36±0.13	0.41±0.06
	Water(ppm)		6.97±3.28	6.96±1.07	4.70±1.14	7.27±0.92	4.05±2.14	7.39±0.75
P (ppm)	Soil (ppm)		14.98±2.13	13.76±4.52	8.47±1.64	12.68±2.45	8.58±1.99	12.77±2.35
	Water (ppm)		0.17±0.0	0.41±0.2	0.15±0.0	0.39±0.27	0.37±0.20	0.37±0.33
K (ppm)	Soil		132.18±32.50	166.99±48.20	163.90±61.73	147.80±36.57	143.14±18.63	186.32±45.62
	Water		4.59±1.10	5.36±1.78	4.01±0.71	3.50±1.49	5.38±1.19	6.52±0.92

Mean± SD * S = Soil; W = Water

The highest value of soil was found 0.791 % at industrial site in peri-urban areas and 9.55 ppm at industrial site in urban areas. It might be associated with the presence of high organic matter contents. This was in agreement with Stomberg *et al.* (1994). He stated that tannery waste increased the total-N, NH₄-H and NH₃-N concentrations at surface soils. Nuruzzaman *et al.* (1996) found high accumulation of total-N (up to 2.7%) below 120cm depth in tannery industries. Furthermore, the drains carrying the sewage sludge from tannery and other industrial sources also seen to contribute an increase in total-N in concentrated soils. Ahmed *et al.* (1996) showed that the total-N content in non-irradiated and irradiated sewage sludge were 0.87% and 0.97%, respectively.

The lowest value of soil (0-15cm) was found to be 0.119 % at road site in peri-urban areas and 1.40 ppm of water at industrial site in urban areas. These observations were very close to the findings of Chowdhury (1992). He stated that the total-N contents decreased with increasing depth of soil. Das (1997) reported that application of insecticides increased the content of available NH₄⁺ and NO₃ by influencing the nitrification of native soil nitrogen through the increased activity of micro-organism. Concentration of phosphorus (P)

Phosphorus (P) content of soil samples varied from 16.96-11.8 ppm for urban site and 21.65-10.95 ppm for peri-urban area and water was 0.252-0.044 ppm for urban site and 0.789-0.176 ppm for peri-urban area (Table 4.4), the highest value was obtained with peri-urban industrial site 21.65 ppm and the lowest value 10.95 ppm was for peri-urban industrial site. In the present study, the water P level from the four areas had exceeded the limit range. So, these values were not suitable for agricultural production. The maximum permissible limit of phosphorus is 2 mg L⁻¹ (WHO, 1971). The average concentration of Phosphorus (P) in industrial site of soil was 14.989 ppm for urban area, 13.76 ppm for peri-urban area and 0.17 ppm for urban area, 0.41 ppm for peri-urban area of water respectively.

In road site areas, the available P of soil ranged from 10.64-6.39 ppm in urban area and 16.55-10.32 ppm in peri-urban area with a mean value was 8.48 ppm for urban area and 12.69 ppm for peri-urban area respectively. The available P of water ranged from 0.223-0.079 ppm in urban area and 0.785-0.116 ppm in peri-urban areas with a mean value of 0.152 ppm for urban area and 0.397 ppm for peri-urban area respectively.

In construction site areas, the available P of soil ranged from 10.111-5.157 ppm in urban area and 16.35-10.11 ppm in peri-urban areas with a mean value was 8.58 ppm for urban area and 12.77 ppm for peri-urban area respectively. The available P of water ranged from 0.634-0.109 ppm in urban area and 0.965-0.191 ppm in peri-urban area with a mean value 0.37 ppm for urban area and 0.378 ppm for peri-urban area respectively.

The highest value of soil was found 21.65 ppm at industrial site in peri-urban areas and 0.965 ppm in water at construction site in peri-urban areas. Appendix 5. illustrates P levels recommended by FAO (1980). Comparing P levels from both urban and peri-urban agricultural lands to recommended levels, it may be deduced that available P is in moderate. These increases are attributed to P fertilizer application limited to the agricultural lands. Soils of Jessore being alkaline in nature reduce the availability of P in solution, decreasing its mobility leading to a lower risk of P leaching.

The lowest value of soil (0-15cm) was found to be 5.157 ppm at construction site in urban areas and 0.044 ppm of water at industrial site in urban areas which was mainly due to the clayey nature of the soils in Jessore. Other soil characteristics influence the availability of P in solution. Clayey soils, characteristics of Jessore, hold inorganic P more tightly reducing its availability in soluble forms (Olsen and Watanabe, 1957). Soil organic matter was also higher in Jessore, which allows gradual mineralization of P enhancing P use efficiency. These

two factors reduce the risk of leaching, and thus eutrophication. Bhuiyan (1988) reported that the available P content at different soil series of Bangladesh ranged from 2.2 to 140 $\mu\text{g g}^{-1}$ with the mean value of 21.2 $\mu\text{g g}^{-1}$. Sattar (1985) reported that pesticides can change the physical, chemical and biological characters of soil. He also reported that normal dose of a pesticides may increase the availability of some plant nutrients.

Concentration of Potassium (K)

The exchangeable (K) content of contaminated soil has been presented in Table 4.5. In industrial areas, the K of soil ranged from 175-106 ppm in urban area and 240-106 ppm in peri-urban areas with a mean value was 132.18 ppm for urban area and 166.99 ppm for peri-urban area respectively. The K of water ranged from 6.46-3.66 ppm in urban area and 7.5-2.55 ppm in peri-urban areas with a mean value was 4.59 ppm for urban area and 5.36 ppm for peri-urban area respectively.

In road site areas, the K of soil ranged from 249-110 ppm in urban area and 211.65-123.6 ppm in peri-urban areas with a mean value were 163.9 ppm for urban area and 147.8 ppm for peri-urban area respectively. The K of water ranged from 5.15-3.33 ppm in urban area and 5.12-1.06 ppm in peri-urban area with a mean value of 4.01 ppm for urban area and 3.50 ppm for peri-urban area respectively.

In construction site areas, the K of soil ranged from 173.7-123.8 ppm in urban area and 235-137.6 ppm in peri-urban areas with a mean value were 143.14 for urban area and 186.32 ppm for peri-urban area respectively. The K of water ranged from 6.8-4.14 ppm in urban area and 7.58-5.07 ppm in peri-urban areas with a mean value was 5.38 ppm for urban area and 6.52 ppm for peri-urban area respectively. The highest value of soil was found 249 ppm at road site in urban areas and 7.58 ppm of water at construction site in peri-urban areas. Different chemical waste which contains potassium acetate, potassium borate, potassium carbonate and potassium sodium tartrate used for industrial purpose may increase K concentration in surface water.

The lowest value of soil (0-15cm) was found 106.00 ppm at industrial site in peri-urban areas and 1.06 ppm of water at industrial site in urban areas. This might be due to the dumping of large quantities of city refuses, sewage sludge and municipal wastes. Thorne *et al.* (1975) reported that a typical sludge (dry weight basis) contained K on an average of 0.4 meq/100g ranging from 0.1-0.7 meq/100g. Ahmed *et al.* (1996) also reported that K content in non-irradiated sewage sludge was 0.61 meq/100g and in irradiated sewage sludge was 0.56 meq/100g. K content in monsoon season was higher than the winter season (in case of pond water). This might be due to run off of K bearing fertilizer from the adjacent crop field, leaching of domestic effluent and decomposition of organic matter, which contaminated the pond water. Similar information was also studied by Tapas *et al.* (2000). The presence of high amount of K in surface water might be due to the surface runoff of agricultural water, farm refuses, untreated sewage sludge etc.

Heavy metals concentrations

The concentration of heavy metals Pb and Cd was always found maximum in water samples collected from Tannery areas. The maximum permissible limits for Pb and Cd in water were 5.0 and 0.10 mgL^{-1} , respectively (Ayers and Westcot, 1985). The concentrations of Pb and Cd in the studied water samples were within the range of 2.90 to 10.40 and 0.01 to 0.53 mg L^{-1} , respectively. So, all the waters under study were not suitable for agricultural production.

Available lead (Pb)

The heavy metals under study included Pb (Fig. 2 and Fig. 3). The total Pb content of collected soil samples were varied from 0.762-0.105 ppm. The soils from urban industrial contaminated areas had the highest (0.762 ppm) Pb content and the lowest (0.105 ppm) Pb content at peri-urban construction site (Fig. 2). Thus, all soils except soils contamination by pharmaceutical wastes were suitable for crop production.

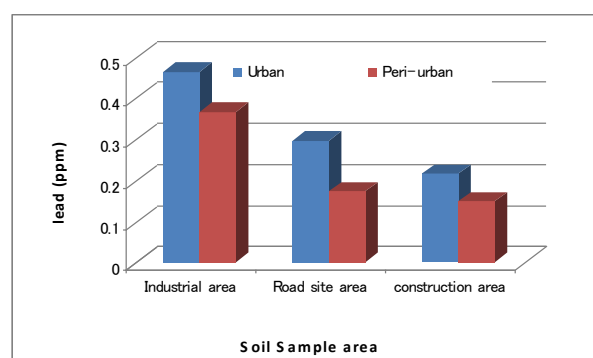


Figure 2. Average concentration of lead (Pb) content of soil in different sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

The total Pb content of collected water samples were varied from 0.099-0.014 ppm. The water from urban construction areas had the highest (0.099 ppm) Pb content and the lowest (0.014 ppm) Pb content at peri-urban industrial site (Fig. 3). Unlike others, the total Pb content of soils varied a little. It might be due to the accumulation of tannery wastes, effluents and use of heavy vehicles. This observation was very close of the findings of Duval *et al.* (1980).

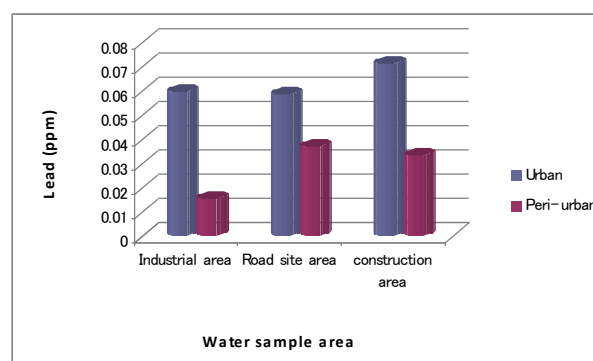


Figure 3. Average concentration of lead (Pb) content of water in different sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

Pb is one of the most important element in different industries dealing with mining, plumbing, gasoline, coal and water additive. Higher level Pb was found because lead piping and surface water contamination by or from industrial effluents, petrol, leaded paints, batteries, ceramics etc. Frisbie (2003) found that Pb (3 % of Bangladesh's area) concentration exceeded WHO health based guideline. The Pb concentration was 0.2524 ppm in Mohammadpur, Dhaka (Mazumder, 2006). This was probably due to the continuous use of waste water for irrigation purpose and discharge of industrial wastes and effluent. Similar observation also reported by Arora et al. (1985) and Thangavel et al. (2003).

The results indicated that contaminated soils contained relatively more Pb than uncontaminated soils. This was due to the deposition of large amount of industrial wastes and effluents. Jones and Jarvis (1981) reported that the trace elements content of the soils were substantially increased by the application of waste material such sewage sludge and industrial wastes. Similar observation was also reported by Cravo and Muraoka (1996) and Hooda et al. (1996).

Available Cadmium (Cd)

Cd concentration of soil samples was varied from 1.93-0.018 ppm. The soils from urban industrial contaminated areas had the highest (1.93 ppm) Cd content (Fig. 4) and the lowest (0.018 ppm) Cd content at peri-urban construction site. Thus, all soils except soils contamination by pharmaceutical wastes were suitable for crop production. This is due to higher levels of P fertilization in which Cd was found as an impurity (Williams and David, 1976; Rothbaum et al. 1986).

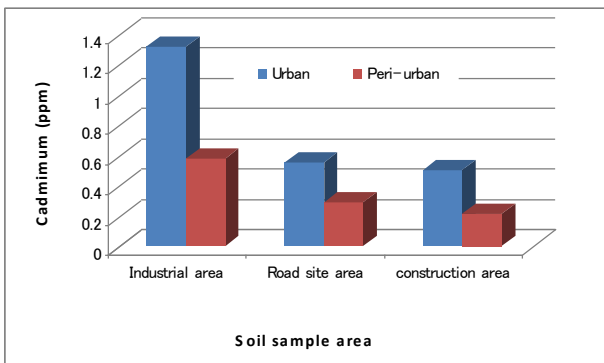


Figure 4. Average concentration of Cadmium (Cd) content of soil in different sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

Cd concentration of water samples were varied from 0.979-0.001 ppm. The water sample from urban industrial contaminated areas had the highest (0.979 ppm) Cd content and the lowest (0.001 ppm) Cd content at peri-urban construction site (Fig. 5). This can be attributed to several factors that enhance the availability of extractable Cd. Primarily, and similar to findings of Mellum et al., 1998, the Cd concentration is higher in loam to clay soils, that are characteristics of Jessore. Lower soil organic matter and pH also increase Cd in soil solution (Ndiokwere, 1984). Agricultural soils in industrial areas of Jessore (pH 4.08) have a significantly lower pH levels

compared to that of Abhaynagar (pH 5.26), and therefore, Cd in the soil solution is higher.

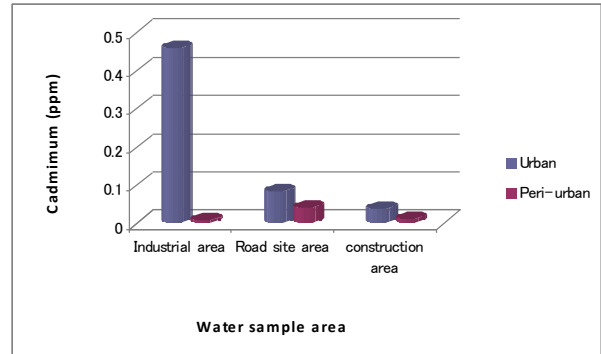


Figure 5. Average concentration of Cadmium (Cd) content of water in different sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

Cd uptake by plants in increased at lower pH levels, and is optimal at pH 4.5 to 5.5 (Ndiokwere, 1984). However, soil Cd levels in Tabarja and Choueifat has not exceeded the critical concentration for plant growth of 5-10 ppm (Naidu, et al., 1994). Low amount of Cd found in rocks, coal and petroleum and enters the surface water when dissolved by acidic waters. Cd contaminate water by or from industrial discharge, mining waste, metal plating, water pipes, batteries, paints and pigments, plastic stabilizers and landfill leachate. That's why industrial areas show higher concentration of Cd contamination in surface soil and water compare to industrial areas and construction areas. Present study showed higher concentration of Cd because water environment might be contaminated by huge amount of industrial waste and effluents.

Calculation of diversity with diversity indices

A total of 24 species were identified during the Rabi and Kharif season, as shown in Table 4.6. In industrial area, 11 species were identified (Table 4.7) in urban, 10 species were found in peri-urban area, the biodiversity index was (D = 0.495) for urban area and the biodiversity index was (D = 0.296) for peri-urban area which was indicated that biodiversity index was lower in urban area. It was due to access amount of agrochemicals use in urban areas.

In road site area, 7 species were identified (Table 4.7) in urban, 15 species were found in peri-urban area, the biodiversity index was (D = 0.313) for urban area and the biodiversity index was (D = 0.322) for peri-urban area which was indicated that biodiversity index was lower in urban area. It was due to access amount of agrochemicals use in urban areas.

In construction area, 11 species were identified (Table 4.7) in urban, 9 species were found in peri-urban area, the biodiversity index was (D = 0.452) for urban area and the biodiversity index was (D = 0.409) for peri-urban area which was indicated that biodiversity index was lower in peri-urban area. It was due to access amount of agrochemicals use in peri-urban areas.

Consideration of all sites, higher biodiversity index was (D = 0.495) for peri-urban industrial site and lower biodiversity index was (D = 0.296) for urban industrial

areas because of high contamination of toxic and heavy metals from industrial sewage sludge, excessive use of agrochemicals and intensive cultivation which had residual effects on soil and water. Among these results, the biodiversity index of construction site areas and road site areas were comparatively low. The biodiversity index of three types of areas followed the order of road site > construction site > industrial site areas.

Similar observations were found by Prian and Piniero, 1994. These home gardens, considered as UPA, varied widely in species composition that ranges from 4 to 35 species and are maintained and harvested annually (Medina et al., 1996). In the case of Panama (Marigiotta, 1997), urban agriculture serves to ease the pressures of traditional agriculture on forestland.

Table 3: Weed and pest species observed in selected sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

Local name of Species (Scientific name)	Number of individuals					
	Industrial site areas		Road site areas		Construction site areas	
	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban
A. Amrul (<i>Oxalis europaea</i>)	1	0	1	4	0	0
B. Durba (<i>Cynodon dactylon</i>)	6	3	4	6	6	0
C. Kanaibashi (<i>Cyanotis bengalensis</i>)	1	0	0	0	0	0
D. Mutha (<i>Cyperus rotundus</i>)	9	5	6	6	5	0
E. Anguligash (<i>Digitaria sanguinalis</i>)	0	1	0	1	0	0
F. Carpetgash (<i>Axonopus compressus</i>)	3	2	9	2	2	0
G. Ulugash (<i>Imperata cylindrica</i>)	0	0	0	0	1	4
H. Shetdrone (<i>Leonurus sibiricas</i>)	0	0	2	4	0	1
I. Rice ear catterpillar (<i>Mythimna separata</i>)	0	0	0	0	0	1
J. Mealy bug (<i>Brevennia rahi</i>)	0	0	0	1	0	0
K. Green stink bug (<i>Nezara viridula</i>)	1	0	0	0	0	0
L. Brown plant hopper (<i>Nilaparvata lugens</i>)	1	2	2	2	3	0
M. Rice leaf folder (<i>Cnaphalocrocis medinalis</i>)	0	0	0	1	0	0
N. Yellow stem borer (<i>Stirpophaga incertulas</i>)	2	2	0	2	2	2
O. Rice hispa (<i>Dicladispa armigera</i>)	0	0	0	0	0	0
P. Green leaf hopper (<i>Nephotettix cincticeps</i>)	1	3	3	1	2	2
Q. Rice case worm (<i>Nymphula depunctalis</i>)	0	1	0	1	2	0
R. Biskatali (<i>Polygonum hydropiper</i>)	2	1	0	0	1	2
S. Topapana (<i>Pistia stratiotes</i> L.)	2	0	0	3	0	0
T. Kachu (<i>Colocasia esculenta</i>)	0	1	0	5	0	3
U. Malancha (<i>Alternanthera philoxeroides</i>)	0	0	0	0	1	0
V. Helencha (<i>Jussiaea repens</i> L.)	0	0	0	0	3	0
W. Shama (<i>Echinochloa crusgalli</i> L.)	0	0	0	2	0	3
X. Nunia (<i>Portulaca oleracea</i>)	0	0	0	0	0	1
Total N	29	21	27	41	28	19

Table 4: Calculation of biodiversity with diversity indices in selected sites of Jessore district (urban area) and Abahaynagar upazila (peri-urban area)

Category	Number of selected sites						
	Industrial site areas		Road site areas		Construction site areas		
	Urban n (no. of individual) n (n-1)	Peri-urban n (no. of individual) n (n-1)	Urban n (no. of individual) n (n-1)	Peri-urban n (no. of individual) n (n-1)	Urban n (no. of individual) n (n-1)	Peri-urban n (no. of individual) n (n-1)	
Category (weed)	1	24 (552)	13 (156)	22 (462)	33 (1056)	19 (342)	14 (182)
Category (Insect & pest)	2	5 (20)	8 (56)	5 (20)	8 (56)	9 (72)	5 (20)
Total N		29 (572)	21	27 (482)	41 (1112)	8 (414)	19 (202)
Index of bio-diversity, D		0.296	0.495	0.313	0.322	0.452	0.409

Biological variations within agricultural fields are great. Andreassen (1991) evaluated different soil properties to show why populations of 37 different weed species varied across fields in Denmark. The seed bank dynamics, microclimatic condition at the soil surface, crop stand and soil characteristics across a field are primary factor affecting the spatial distribution of weed populations (Hatfield, 2000). Johnson (1995) also found that the location of velvetleaf (*Abutilon theophrasti*)

remained constant across years but the density of weeds within an area varied among years. Temporal variation patterns reflect interactions among soil, meteorological condition, crop canopy and growth characteristic- s of the specific weed.

CONCLUSION

From the study it was found that urban and peri-urban (UPA) industrial, road and construction areas soil and

water contained acceptable amount of N, P and K where the peri-urban area was more suitable than urban area due to less contamination of toxic chemicals, organic farming, low residual impact of insecticides and pesticides. All the soil and water samples of Jessore district can safely be used for specific purpose after proper treatment. Routine research work with wide public awareness, government participation and government regulations can save the water of river, canal and ponds water of Jessore area and thus a safe and sound environment can be made for future generations.

REFERENCES

- Asian Development Bank (ADB). 1994. Training manual for Environmental Monitoring. Engineering Science, INC., USA, pp. 2-16.
- Agoramoorthy, G., F.A. Chen, V. Venkatesalu and P.C. Shea., 2009. Bioconcentration of heavy metals in selected medicinal plants of India. *Journal of Environmental Biology*, 30: 175-178.
- Ahmed, C., 2002. Changing landscapes, shifting Values: land use dynamics at the rural-urban interface in Calveras County, California. *Emerging Issues: Along Urban-Rural Interfaces III, Linking Science and Society*, Atlanta.
- Ahmed, S., M. S. Rahman, M. I. Ali, M. B. Hossain and T. Alam. 1996. Isotope-aided studies on the effects of radiation processed sewage sludge application on crop yields and bio-availability of heavy metals in Bangladesh soils. A report of Bangladesh Institute of Nuclear Agriculture (BINA)/ Soil Sci/ 63/ FAO/ IAEA Res. contact No. 8477/RO/RB. pp. 1-9.
- Altieri M. A., G. K. Catherine. 1999. The greening of the "barrios": Urban agriculture for food security in Cuba, and Human Agriculture Values, *N*. 16: 131-140.
- Anupom, M. 2011. Current status of river, canal and pond and drain water contamination of Rajshahi metropolitan city, Bangladesh. M.S. Thesis, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh.
- Birley, M.H. and K. Lock. 1999. *The Health Impact of Peri-urban Natural Resource Development*. Cromwell Press: Trowbridge, UK.
- Black, C. A. 1965. *Methods of Soil Analysis*, part 2. Am. Soc. Agron. Inc. Madi, Wis., USA. p. 67.
- Bodiuazzaman, M. 2003. Trace metal (Pb, Cu, Zn, Fe, Mn As) contamination in sewage water of Dhaka metropolitan city, Bangladesh. M.S. Thesis, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 1-10.
- Chowdhury, M. H. 2012. Bangladesh Population Census, 2001, Bangladesh Bureau of Statistics; Cultural Survey Report of Abhaynagar Upazila, Copyright Bangla-pedia.
- Coker, C. H. and Kent, 1992. Pollution Indicators in Gaborone Industrial Effluent. *Journal of Applied Sciences* 5(1): 147-150.
- Edgecombe, R. G. 1970. The relationship between adsorption of trace metals, organic matter and p^H in temperature soils. *J. Environ. Qual.*, 15: 197-204.
- Food and Agriculture Organization of the United Nations (FAO), 1974. Control of water pollution from agriculture). Drainage and Irrigation Paper 43. FAO: Rome, Italy.
- Fraser, E. D. G. 2002. Urban ecology in Bangkok, Thailand: Community participation, urban agriculture and forestry. *Environments*, 30: 37-50.
- Gade, L.H. 2000. Highly polar metal-metal bonds in "early-late" heterodimetallic complexes. *Angewandte Chemie International Edition*, 39(15): 2658-2678. doi: 10.1002/1521-3773(20000804)39:15<265898>.
- Garbisu C. and I. Alkorta. 2001. Phytoextraction: A cost effective plant-based technology for the removal of metals from the environment. *Bioresearch Technology*, 77(3): 229-236.
- Ghosh, A. B., Bajaj, J. C. Hassan, R. and Singh, D. 1983. *Indian Soil and Water testing methods (Laboratory manual)*. Ind. Agric. Res. Inst. New Delhi, India. pp. 6-8.
- Giller, K.E., E. Witter and S.P. McGrath. 1998. Toxicity of heavy metals to microorganism and microbial processes in agricultural soils: A review. *Soil Biology and Biochemistry*, 30(10-11): 1389-1414.
- Gisbert, C., R. Ros, H.A. de, D.J. Walker, B.M. Pilar, R. Serrano and J.N. Avino. 2003. A plant genetically modified that accumulates Pb is especially promising for phytoremediation. *Biochemistry & Biophysics Research Communication*, 303(2): 440-445.
- Gomez, M. A. and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*. 2nd eds. International Rice Research Institute. Book. A Wiley Interscience Publication, New York. p. 28.
- Haddad, L. M. Ruel and J. Garrett. 1999. "Are Urban Poverty and Under nutrition growing? Some Newly Assembled Evidence." in *World Development* Vol. 27, No. 11.
- Hardoy, J. E. and D. Satterthwaite. 1989. *Environmental Problems of Third World Cities: a Global Issue Ignored*, IIED. London.
- Hassan, R.N. 1984. Metal contamination of surface soils of industrial city Saikot, Pakistan: a multivariate and GIS approach. *Journal of Environmental Geochemistry and Health*, 32: 179-191.
- Jackson, M. L. 1962. *Soil Chemical Analysis*. Prentice Hall. Inc. Englewood Cliffs. NY, USA. p. 73.
- Jackson, M. L. 1985. *Soil Chemical Analysis Oaretic Hall of India Private Ltd*. New Delhi, India.
- Jones, L. H. P. and Jarvis, S. C. 1981. The fate of heavy metals. In: *The chemistry of soils process*. Eds., D. J. Greenland and H. B. Hayers, pp. 593-620. Wiley, New York.
- Kohinoor, M. 2011. Assessment of heavy metal contamination in some soils and waters of Bogra city, Bangladesh. M.S. Thesis, Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh.
- Kozdroj, J. and J. D. van Elsas. 2001. Structural diversity of microbial communities in arable soils of a heavily industrialized area determined by PCR-DGGE finger printing and FAME profiling. *Applied Soil Ecology*, 17(1): 31-42. doi: 10.1016/S0929-1393(00) 00130-X.
- Kurek, E. and J. M. Bollag. 2004. Microbial immobilization of cadmium released from Cd in the soil. *Biogeochemistry*, 69(2): 227-239. doi:10.1023/B:BI0G31046.40036. pdf.
- McGrath, S.P., F.J. Zhao and E. Lombi. 2001. Plant and rhizosphere process involved phytoremediation of metal-contaminated soils. *Plant and Soil*, 232(1/2): 207-214.
- Nriagu, J.O. and J.M. Pacyna. 1988. Quantitative assessment of worldwide contamination of air water and soils by trace metals. *Nature*, 333(6169): 134-139.
- Ntengwe, F.W. 2006. Pollutant loads and water quality in stream of heavily populated and industrialized towns. *Physics and Chemistry of the Earth*, 31: 832-839.
- Nuruzzaman, M., Islam, A., Ullah, S. M. and Rashid, M. H. 1996. Contaminants in the soil environment by the tannery industries. 1st. Int. conf. contaminants and the soil environment (Extended Abstracts), Adelaide, Australia. pp. 257-258.
- Olsen, S. R., Cole, C. V., Watanabe, F. S and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S Dept. Agril. Circ.*, p. 929.
- Page, A. L., Miller, R. H. and Kenny, D. R. 1989. *Methods of Soil Analysis, Part 2*, 2nd edn. Amer. Soc. Agron. Inc. Wisconsin, USA. p. 1203.
- Pandey, S.N. and B.D. Nautiyal. 2008. Electroplating effluents and its irrigational impact on seedling growth of pigeon pea and maize. *Journal of Industrial Botanical Society*, 87: 1-6.
- Piper, C.S. 1950. *Soil and Plant Analysis*. Adelaide University, Hassel Press, Australia. p. 78.
- Ragnarsdottir, K.V. and D. Hawkins. 2005. Trace metals in soils and their relationship with scrapie occurrence. *Geochimica et Cosmochimica Acta*, 69(10): 196-199.
- Reiman, M. W. and S. Dinsmore, 1993. Effects of Cd²⁺ and DTPA on young sugar beets (*Beta vulgaris*), I. Cd²⁺ uptake and sugar accumulation. *Plant Physiologist*. 66: 69-74.

- Richards, I. R., C.J. Clayton, A. J. K. Reeve. 1998. Effects of long-term fertilizer phosphorus application on soil and crop phosphorus and Cadmium contents. *Journal of Agricultural Science*. 131: 187-195.
- Ryan, S., Anamika, T. Chauhan, L. K. S. Dinesh, K. and Gupta, S. K. 1996. Ecotoxicological evaluation of municipal sludge. *Alternatives to Laboratory Animals*. 33(1): 21-27.
- Schalscha, E. and I. Ahumada. 1998. Heavy metals in rivers and soils of central Chile. *Water Science Technology*, 37(8): 251-255.
- Stomberg, A. L., D. D. Hemphil, and V. V. Volk, 1994. Yield and elemental conc. of sweet corn grown on tannery waste-amended soil. *J. Environ. Qual.*, 13 (1): 162-166.
- Taukir, H. 2011. Impact of industrial waste disposal on environment and agricultural productivity around Gazipur District of Bangladesh. M.S. Thesis, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh.
- United Nations Development Program (UNDP). 1996. *Urban Agriculture: food, jobs and sustainable cities*. UNDP: New York, USA.
- Walkley, J. K., A. D. Mackay, M. W. Brown, and L. D. Currie. 1947. Chemical and physical characteristics of phosphate rock material of varying reactivity. *Journal of Science of Food and Agriculture*. 87: 1057-1064.
- Walkley, M. G. and Black, D. M. 1934. Toxic elements and heavy metals in sediments in Tham Luong Canal, Ho Chi Minh City, Vietnam. *Environ. Ecol.* 43(7): 836-841.
- Zakir, H. M., N. Shikazono and K. Otomo. 2008. Geochemical distribution of trace metals and assessment of anthropogenic pollution in sediments of Old Nakagawa River, Tokyo, Japan. *American Journal of Environmental Sciences*, 4: 654- 665.