EFFECTS OF SLUMS ON ECOSYSTEM COMPONENTS

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Abstract

An *in vitro* study was conducted to assess the effects of slums on ecosystem services particularly soil, plant and water. The research findings indicated that, samples of soil, plant and water were contaminated with heavy metals, many of which were above permissible limits. The heavy metals exceeding the permissible limits pose serious threats to the surrounding plant and animal lives. Hence, there is a health risk associated with the consumption of the vegetables grown in the slums due to the fact that the heavy metals can bio-accumulate into human body through the food chain.

Key words: Slums, Ecosystem, Heavy metal, Bio-accumulation, Food chain

Introduction

Bangladesh is one of the most densely populated countries in the world with more than 160 million people living in a territory of around 56,977 sq. miles. One quarter of the population lives in urban areas, where population density is 200 times greater than the national figure and population growth is twice the national average (BBS 2011). Millions of slum-dwellers in Bangladesh live stressful lives among teaming rubbish because there is no or little waste disposal system. In these areas where wastes have been dumped without coverage, the soil will contain high amounts of pollutants. Industrial wastes originating from mining industries, chemical industries, metal processing industries etc. are major sources of soil contamination. These wastes include a variety of chemicals like heavy metals, phenols etc. (Babich and Stotzky 1977 and Mueller *et al*. 1989). Above certain concentrations and over a narrow range, the heavy metals turn into toxins (Babich *et al*. 1982). Moreover, the heavy metals deposited in the soil are bound preferentially to inter-aggregate soil materials and accumulation preferentially occurs in parts of the soil where plant roots are concentrated and in the forms that are easily accessible to plants (Wagner 1993). However, plants can absorb heavy metals in larger amounts than needed and the excessive amount will be stored in leaves and other edible parts. Through food consumption theses metals are then transferred to humans and animals. A high intake of heavy metals can damage organs and increase the risk of human cancer (Martin and Griswold 2009). Thus, the present study was conducted to assess the effects of slum areas on ecosystem components *viz.,* soil, plant and water.

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Materials and Methods

Soil, plant and water samples were collected from different slums in Dhaka city and were analyzed in the laboratory to find out the contents of nutrients and heavy metals.

Collection, preparation and processing of soil, plant and water samples

Soil Sampling: A total of eight soil samples was collected from four different slum areas of Dhaka city namely Kalyanpur, Gabtoli, Baunia and Sadek Khan. Table 1 shows the geographical coordinates of the sampling sites. The soils belong to Tejgaon series, which is mostly red, sticky, slightly acidic, clayey-loam having low to moderately low pH values (Hussain 1992). Soil samples representing 0–15 cm depth were collected by composite sampling method as suggested by the Soil Survey Staff of the USDA (1951). The collected soil samples were oven dried for 5 days. Visible roots and debris were removed. The samples were exposed to sunlight for speeding up the drying process. Ground samples were passed through a 2 mm sieve and mixed thoroughly. A portion ofthe soil samples (2 mm sieved) were further ground and screened to pass through a 0.5 mm sieve. The homogenized samples were used for physico-chemical analyses.

Table 1. Geographical coordinates of the sampling sites.

Sampling Site	Symbol	Latitude	Longitude
Kalyanpur	K	23º 47' 032''N - 23º47' 033"N	90º 21'432''E - 90º 21' 448"E
Gabtoli	G	23º 46'815''N - 23º 46' 921''N	90º 20' 405''E- 90º 20' 474''E
Baunia	B	23º 49' 093''N - 23º 49' 161''N	90º 22' 976''E - 90º 23' 000''E
Sadek Khan	SK	23º 44' 952"N - 23º 44' 969'' N	90º 21' 516"E - 90º 21' 543"E

Plant samples: A total of 28 plant samples was collected from three different slum areas namely Kalyanpur, Gabtoli, Baunia. The plant was uprooted and processed for laboratory analyses as suggested by Imamul Huq and Alam (2005). After collection, the whole plant was washed in tap water. Different plantparts were separated and were rewashed thrice with distilled water. These plant samples were first air-dried and then oven-dried (80 – 85º C), grounded and finally sieved through a 0.25mm sieve.

Water samples: The water samples were collected by Grab and Catch method from different sources of wells and ponds of the slum areas (Imamul Huq and Alam 2005).Few drops of concentrated HCl were added to the bottle in order to acidify the samples. Then the bottle was filled with water samples for chemical analyses following filtration.

Laboratory analysis of soil and plant samples: The quality control and quality assurance (QC/QA) of the analyses were done as described in Imamul Huq *et al.* (2008). Nitrogen in bothsoil and plant was determined by alkali distillation of the Kjeldahl digests (Imamul Huq and Alam 2005). Phosphorous was determined following colorimetric method using a spectrophotometer and potassium by a flame photometer (Jackson 1962). Organic carbon was determined by Walkley and Black's wet oxidation method (Imamul Huq and

Alam 2005) The heavy metals were analyzed by using Atomic Absorption Spectrophotometer (Varian AA 240) after digesting the samples with aqua-regia (for soil) and ternary acid mixture (for plants).

Data analysis: All data were statistically analyzed by using Microsoft Excel and MINITAB (version 17) package.

Results and Discussion

Nutritional status of soil and plant samples: Contents of nitrogen, phosphorous, potassium and organic matter in soil were determined (Figs. 1 to 3). The nitrogen of the soils was found to be insignificant as compared to the standard value (Fig. 1a). However, the available nitrogen was found to be higher compared to that of the standard value (Fig. 1b). The available phosphorous in the soil (Fig. 2b) was not significant except one sample (Sadek Khan) although the total phosphorous (Fig. 2a) was higher than the standard limit set for soil. The soils contained less potassium than the standard value for both soil and plant (Figs. 3a and 3b). The organic matter of the soils in the slums were mostly around 1% except the soil of Sadek Khan sampling site which possessed around 3.1% organic matter.
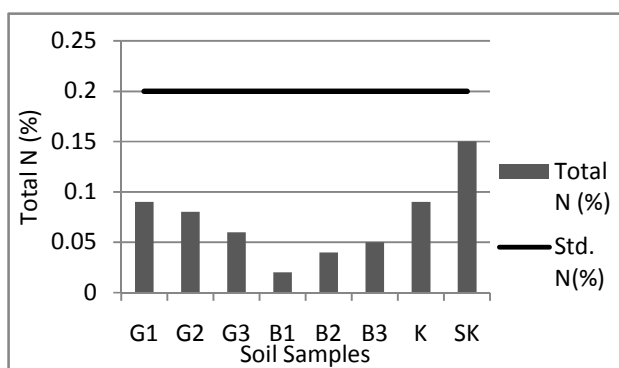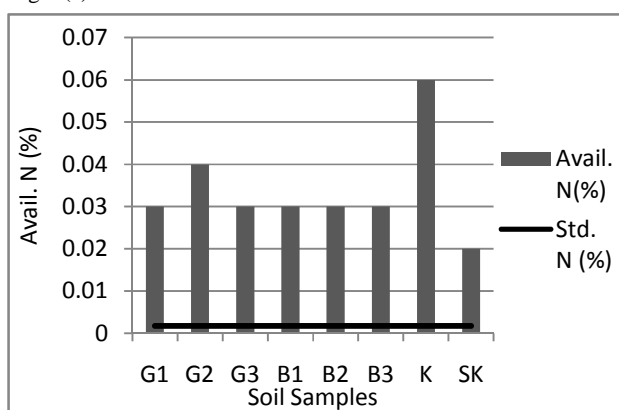

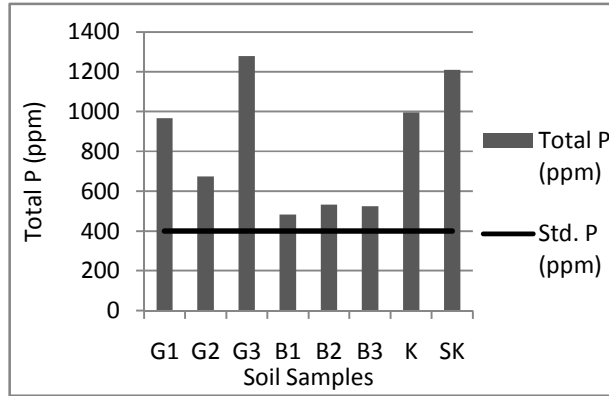Fig. 1(a). Total N in soils.

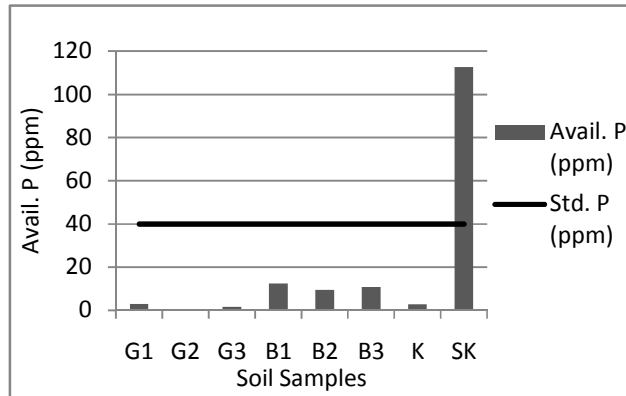Fig. 1(b). Available N in soils.

Fig. 2(a). Total P in soils.

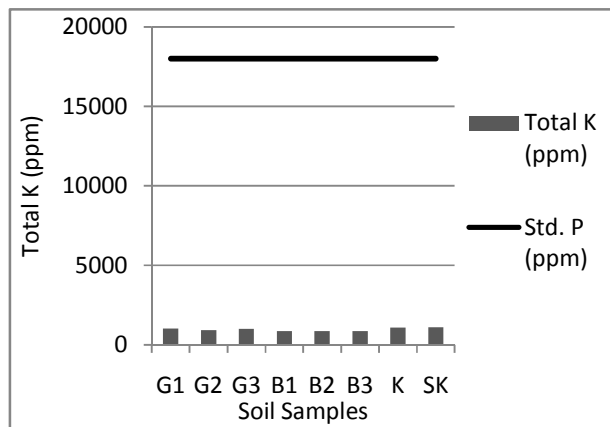Fig. 2(b). Available P in soils.

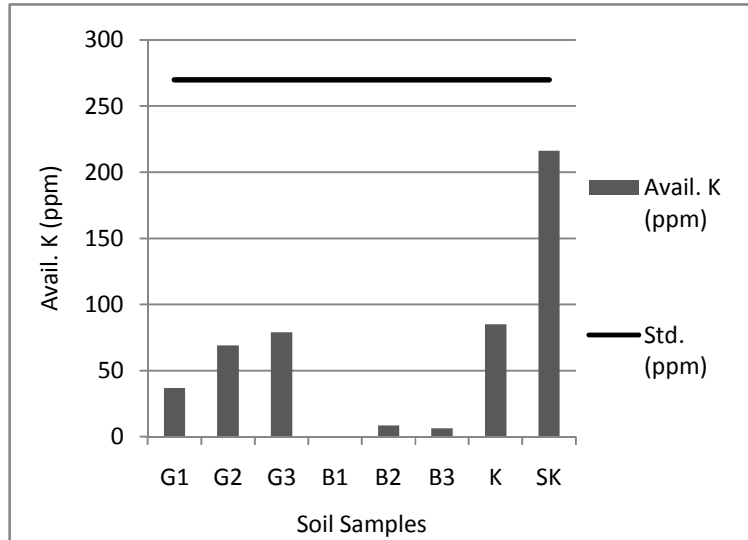Fig. 3(a). Total K in soils.

Fig. 3(b). Available K in soils.

Heavy metals in soils and plants: Contents of heavy metals (Pb, Cr, As, Zn, Mn and Al) recorded in soils and plants are presented in Figs. 4 to 9.
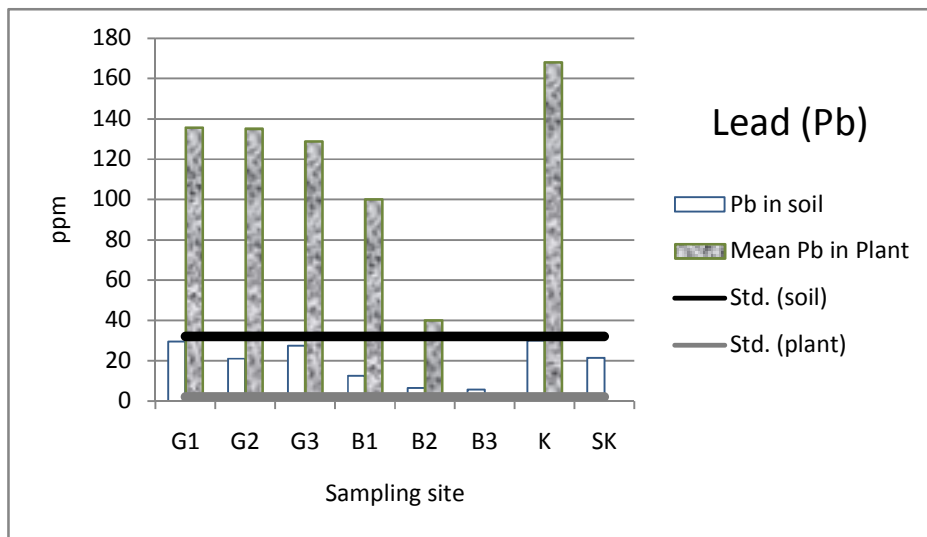

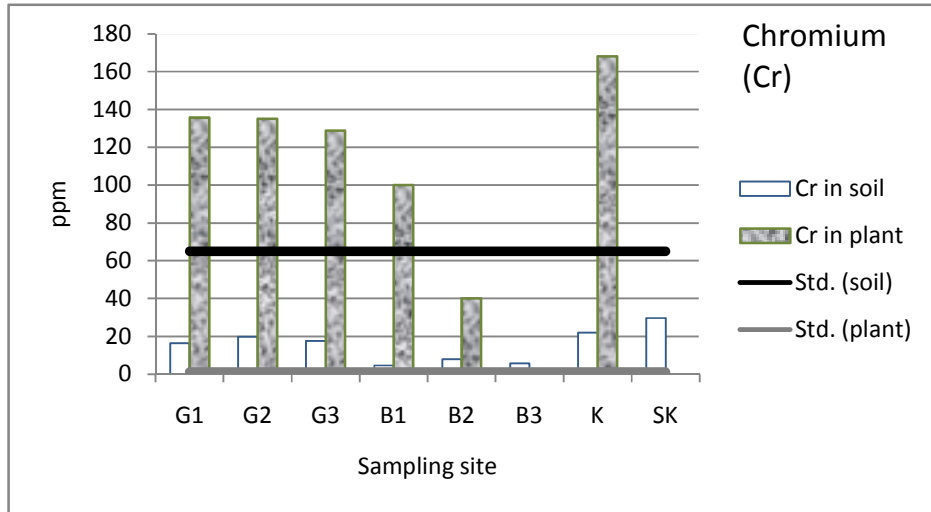Fig. 4. Concentration of lead (Pb) in soils and plants.

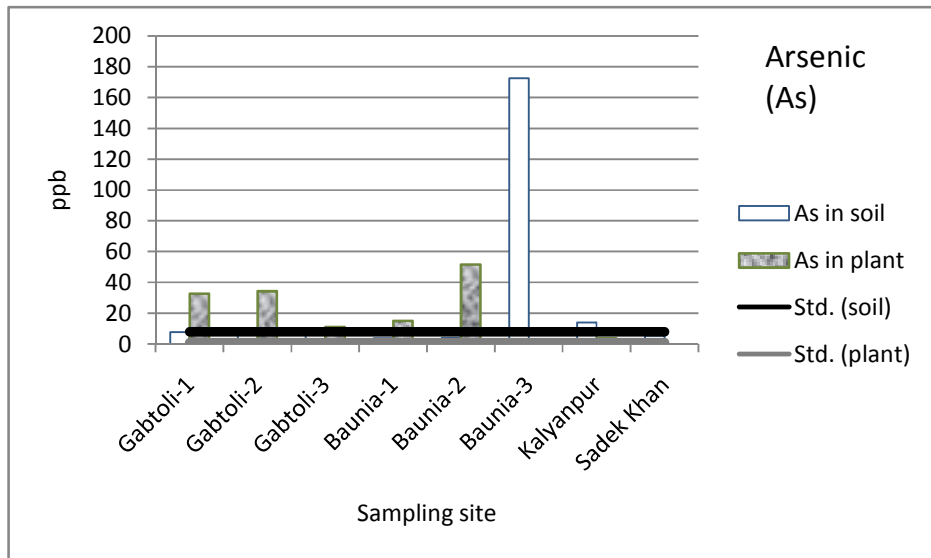Fig. 5. Concentration of chromium (Cr) in soils and plants.

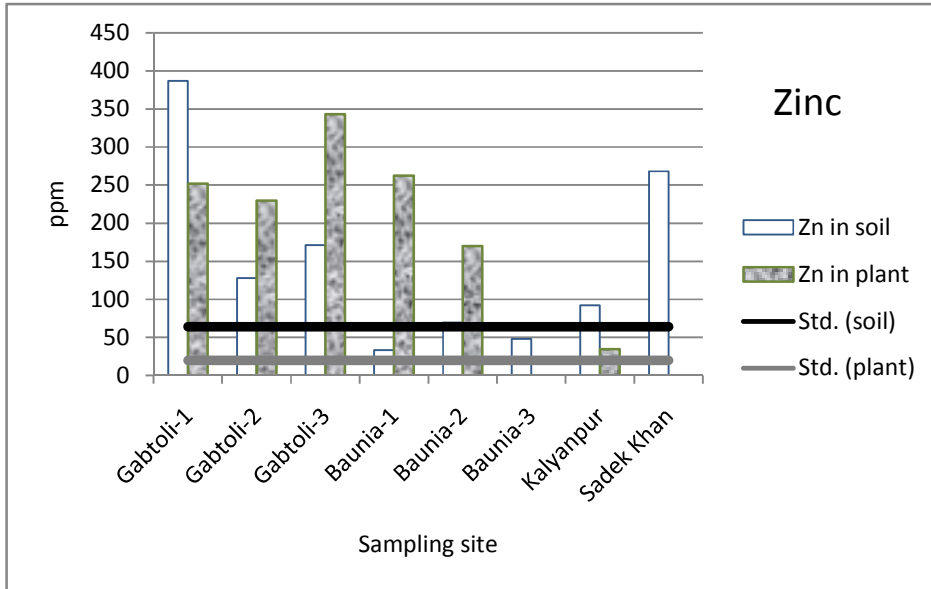Fig. 6. Concentration of arsenic (As) in soils and plants.

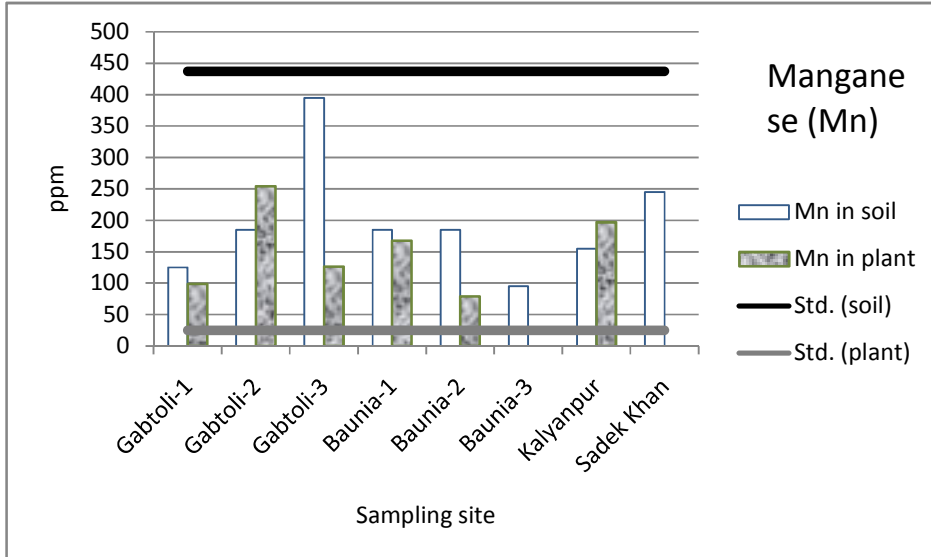Fig.7. Concentration of zinc (Zn) in soils and plants.

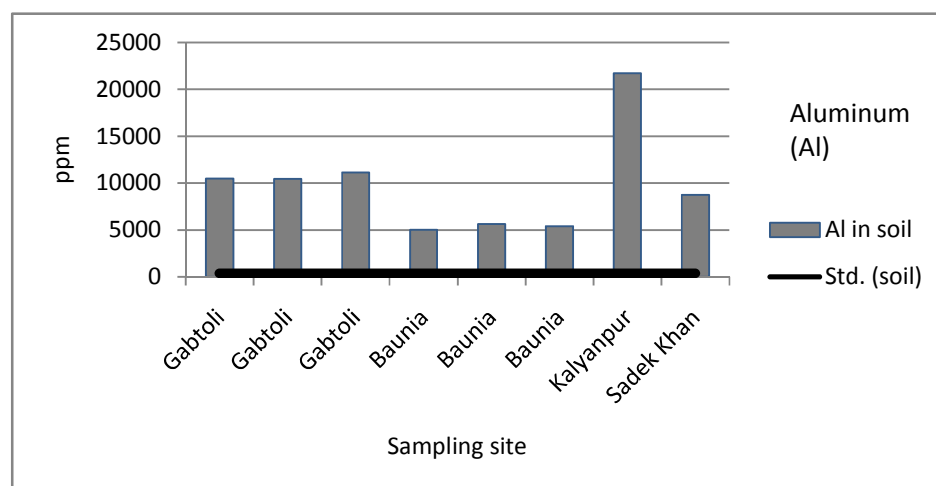Fig. 8. Concentration of manganese (Mn) in soils and plants.

Fig. 9. Concentration of aluminum (Al) in soils and plants.

Table 3 shows that heavy metals *viz.,* Cd, Al, As and Fe in water bodies were present in excessive amounts as compared to the standard limits for irrigation purpose. Manganese (Mn) was present in moderate level. However, Cr and Zn were found below the standard limits. This indicates that there is a possibility for plants to uptake heavy metals from the water used for irrigation purpose, which would further aggravate the situation.

Table 3. Total heavy metals contents in irrigation water.

Water samples	Zn*	Mn*	Pb*	Cd*	Cr*	Al*	As*	Fe*
Gabtoliwater sample	BDL	0.25	0.42	0.07	0.07	33.79	0.00614	126.84
Bauniawater sample	BDL	0.22	0.35	0.09	0.06	34.34	0.00581	79.63
Kalyanpurwater sample	BDL	0.17	0.73	0.06	0.09	35.69	0.00536	78.27

*values are in mg/L; BDL= Below Detection Level

It is apparent from the Figs. 4 to 9 that plants grown in slum areas contained more heavy metals compared to that of the corresponding soils. However, there was an excessive amount of aluminum (Al) in soils which might initiate soil acidity if the pH drops below 5.2 (Brady and Weil 2002).Almost all of the plant biomasses contained very high amounts of lead (Pb), which was present in the edible parts (fruit, leaf and shoot) and thus could be transferred through food chain in human body. The highest concentrations were found in soils and plants of Kalyanpur area (Fig. 4).

All of the plants contained chromium (Cr) much higher than the Maximum Allowable Concentration (MAC) and cannot be considered safe. The highest concentration of Cr was found in soils of Kalyanpur site and plants of Sadek Khan site (Fig. 5).Soils of

Baunia-3 site showed extremely high concentration of As and no plants were found to grow in this site. However, plants growing in Gabtoli-1, Gabtoli-2 and Baunia-2 contained As in amounts exceeding the upper limit, making it impossible to consume these plants (Fig. 6).

Nutritional status of plant samples: The plants contained sufficient amount of N and K (Table 2). But the phosphorous content of the plants was found to be below the standard level i.e. 2000 ppm (Imamul Huq and Alam 2005). This may happen partly because the soils contained lower amounts of available phosphorous.

Table 2. Total N, P, K contents in plants.

Sampling Site/ Plant Sample	TotalN (%)	Total P (ppm)	Total K (ppm)
Kalyanpur site			
Papaya (*Carica papaya*) (Leaf)	2.39	1468.15	17840.0
Sweet potato (*Ipomoea batatas*)	1.74	1567.92	14140.0
Gourd (*Lagenaria siceraria*)	3.36	1640.83	15940.0
Bean (*Phaseolus vulgaris*)	2.58	1721.41	13540.0
Tomato (*Solanum lycopersicum*)	1.21	1429.78	15440.0
Arum	1.43	1778.97	16840.0
Gabtoli site-1			
Red amaranth (*Amaranthus gangeticus*) (Leaf)	1.71	1295.47	13140.0
Red amaranth (*Amaranthus gangeticus*) (Shoot)		1541.06	25940.0
Tomato (*Solanum lycopersicum*) (Leaf)	3.13	1729.09	14540.0
Tomato (*Solanum lycopersicum*) (Root)		1587.11	9740.0
Tomato (*Solanum lycopersicum*) (Shoot + Fruit)		1706.06	18940.0
Bean (*Phaseolus vulgaris*) (Shoot + Leaf)	3.00	1276.29	11440.0
Gourd (*Lagenaria siceraria*) (Shoot)	4.27	1495.01	22940.0
Gourd (*Lagenaria siceraria*) (Leaf)		1345.36	14940.0
Gabtoli site-2			
Red amaranth (*Amaranthus gangeticus*) (Leaf + Root)	2.85	1552.57	25640.0
Green amaranth (*Amaranthus viridis*) (Leaf + Shoot)	2.70	1775.13	15040.0
Tomato (*Solanum lycopersicum*) (Leaf + Root)	1.92	1175.13	8640.0
Gabtoli site-3			
Indian spinach (*Basella alba*)(Leaf + Shoot)	0.57	1844.21	9340.0
Gourd (*Lagenaria siceraria*) (Shoot + Leaf)	2.28	1717.58	18040.0
Green amaranth (*Amaranthus viridis*) (Shoot + Root)	3.84	2055.23	13340.0
Green amaranth (*Amaranthus viridis*) (Leaf)		1544.90	15540.0
Baunia site-1			
Indian spinach (*Basella alba*)	1.21	1782.81	17240.0
Gourd (*Lagenaria siceraria*) (Leaf)	1.71	1890.25	11440.0
Gourd (*Lagenaria siceraria*) (Shoot)		1778.97	17140.0
Bean (*Phaseolus vulgaris*) (Leaf + Shoot)	2.56	1932.46	11240.0
Baunia site-2			
Red amaranth (*Amaranthus gangeticus*) (Leaf + Root)	4.00	1610.13	16040.0
Red amaranth (*Amaranthus gangeticus*) (Stem)		1425.94	20840.0
Green amaranth(*Amaranthus viridis*) (Shoot + Root)	3.84	2055.23	13340.0
Green amaranth (*Amaranthus viridis*) (Leaf)		1544.90	15540.0

The amounts of zinc (Zn) and manganese (Mn) in plants were found in amounts higher than the standard value. Fig. 8 shows that the highest concentration of Mn was found in the soils of Gabtoli-3 and plants of Gabtoli 2. However, the maximum concentration of Zn was found in the soils of Gabtoli 1 and plants of Gabtoli 3.

The pH values of the top soils were between 5.22 and 6.70, which might make the heavy metals available for the growing plants. Figs. 4 to 9 illustrate that the soils contained smaller concentration of heavy metals than plants alone did. This indicates that, there might be another source of heavy metals from which plants are taking them up. It could be water with which the soils were irrigated or the fertilizers which were applied to the soils to meet the nutritional deficiencies. However, if the pH decreases in soil, more metals are expected to be released and become available for plant uptake as the soil buffers the acidity.

It is observed from Figs. 4 to 9 that the soils in the slum areas contained heavy metals in varying concentrations; some of them were present at toxic levels. In case of plants, the scenario was quite different. These figures illustrate that almost all the plants grown in slums contained excessive amounts of heavy metals. Pb, As, Cr, Zn and Mn were present in all kinds of plant biomass (edible parts) at a toxic concentration which, if consumed for long period may contribute to carcinogenic diseases in human body.

Adverse effects of slums on the ecosystem are one of the burning questions of today's modern world. The present study provided a precise idea about the contents of nutrient elements and heavy metals present in soil, plant and water of different slum areas. The results confirmed that both the soils and plants in all slum areas contained high concentration of heavy metals exceeding the permissible limits that ultimately led to decreased agricultural crop production. The high concentration of heavy metals in soil might become readily available to the plants that could aggravate health risks of the slum dwellers. In addition, nitrogen, phosphorous and potassium contents were found to be less compared to those of the standard values. Water collected from various sources of slum areas did not meet the acceptable limit for irrigation. Thus, it is pertinent to assess the pollution level of soil, plant and water present in and around the slum areas. Further detailed study is needed regarding the type and magnitude of the treatments for these polluted components of ecosystem.

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