ISSN 0258-7122
Bangladesh J. Agril. Res. 37(1): 9-17, March 2012

HEAVY METAL POLLUTION OF SOIL AND VEGETABLE GROWN NEAR ROADSIDE AT GAZIPUR

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Abstract

Levels of lead, cadmium, and nickel in roadside soils and vegetables along a major highway in Gazipur, Bangladesh were investigated. Soil samples were collected at distances of 0, 50, 100, and 1000 m (meter) from the road. The concentrations of lead (Pb) and nickel (Ni) in soil and vegetables (bottle gourd and pumpkin) decreased with distance from the road, indicating their relation to traffic and automotive emissions. The concentration of cadmium (Cd) was found to be independent of distance from road. There were significant differences in the concentrations of lead, cadmium, and nickel for different plant species and soils at various distances. The heavy metals contents both in the soils and vegetables for every distance from the road was found in the order nickel>lead>cadmium.

Keywords: Pollution, heavy metal, roadside soil, vegetable.

1. Introduction

Emissions from heavy road traffic on the roads contain lead (Pb), cadmium (Cd), zinc (Zn), and nickel (Ni), which are present in fuel as anti-knock agents and this leads to contamination of air and soils on which vegetables are planted (Ikeda *et al*., 2000). Accumulation of heavy metal in agricultural land through traffic emission may result in soil contamination and elevated heavy metal uptake by crops, and thus affect food quality and safety (Ho and Tai, 1988; Garcia and Millan, 1998). Food chain contamination is one of the important pathways for the entry of these toxic pollutants into the human body (Ferner, 2001; Ma *et al.*, 2006).

Apart from lead, very little concern has been given to the likelihood of pollution by other heavy metals which can be originated from automobiles, tyre wear and motor oils. Lagerwerff and Speeht (1970) reported that the Cd content of three lubricating oils range from 0.20 to 0.26 ppm and that of three diesel oils from 0.07 to 0.10 ppm. The lead content of four tyres of different brands was also found to range from 20 to 90 ppm. Certain components of automotive engines, chasis and piping contain copper and manganese, while nickel and chromium are

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usually used in chrome plating. Some of the metals presumably derive from the wear of metallic automobile parts containing these metals (Voegborlo and Chirgawi, 2007). Moreover, release of Pb through vehicle emission, leading to Pb pollution to atmosphere, soil and crops (Pei and Chaolin, 2004).

With the rapid increase in number of motor vehicles on Bangladesh roads recently, and as a consequence of a boost in commercial and industrial activities, considerable amounts of some heavy metals are likely to be emitted regularly as long as the nearby sources remain active. Very imitated information is available in Bangladesh on the level of heavy metal accumulation in roadside soil and vegetable crops due to highway traffic. This article contains information of heavy metal contents in soils and in the edible parts of two vegetables collected at various distances from a major highway in Gazipur district.

2. Materials and Method

2.1. Study area

The area selected for the study was a dual carriage highway about 5 km north from Joydebpur centre (Road-round about of Joydebpur) and runs northward. It carries, on an average, 9,000 motor vehicles per day. The site was selected for this study because it links capital city (Dhaka) and it has a comparatively high traffic density. There are also no major road intersections to cause a significant decrease in the traffic density.

2.2. Sampling procedure

Edible parts (stem, leaf, and fruit) from two popular vegetables, namely bottle gourd (*Lagenaria vulgaris*) and pumpkin (*Cucurbita moschata*); and its associated soils were taken at distance of 0m, 50m, 100m, and 1000m (meter) from the edge of the road. Every distance replicated thrice as sample-1, sample-2, and sample-3. The 1000m site was used as the reference site. It was characterized by no traffic density. This site is sparsely populated and basically residential with no industrial activities.

Soil samples were taken at a distance of 0, 50, 100, and 1000 meter from the highway at selected sites. Three soil samples were taken from three points from each distance. Soil samples were taken from the upper soil layer of 0–5 cm. Each soil sample was air dried, and all clods and crumbs were removed and mixed uniformly by sampling. Soils were sieved through a 2-mm sieve to remove coarse particles before sub-sampling for chemical analysis. Three plant samples were taken from three points from each distance and samples were prepared for each distance. The plant materials were then packed into polythene bags and taken to the laboratory for analysis.

2.3. Preparation and preservation

After delivery to the laboratory, all vegetables were washed in fresh running water to eliminate dusts, dirties, possible parasites or their eggs and were finally washed with deionized water. The clean vegetable samples were air-dried and placed in an electric oven at 65 °C for 72–96 h depending on the sample size. The dry vegetable samples were homogenized by grinding using a ceramic coated grinder and used for metal analysis. All soil samples were spread on plastic trays and allowed to dry at ambient temperature for 8 days. The dry soil samples were ground with a ceramic coated grinder and sieved through a nylon sieve. The final samples were kept in labeled polypropylene containers at ambient temperature before analysis.

2.4. Digestion and determination

One gram dry plant or soil sample was weighed into 50-ml volumetric flask, followed by the addition of 10 ml mixture of analytical grade acids HNO_3: $HClO_4$ in the ratio 5:1. The digestion was performed at a temperature of about 190 ºC for 1.5 h. After cooling, the solution was made up to a final volume with distilled water. The metal concentrations were determined by atomic absorption spectrometry using a VARIAN model AA2407 (USA) Atomic Absorption Spectrophotometer (AAS). Analysis of each sample was carried out four times to obtain representative results and the data reported in µg/g (on a dry matter basis). Statistical differences were performed by Tukey’s multiple comparisons test by using Excel Statistics version 4.0.

3. Results and Discussion

Heavy metals contents in soils at the same distance from the road was found in the following order: Ni>Pb>Cd. The same order of heavy metal contents was found in vegetables at the same sampling points. Concentrations of Pb in plant and soil samples collected from roadside appeared to be in the spatial pattern of distribution with the order of 0 m>50 m>100 m>1000 m. This shows that contamination of lead is caused by road traffic. Lead concentration in both plant and soil was found to decrease with increasing the sampling distance (Fig. 1–2 and 7–8).

There were significant differences between the distributions of Pb in the plant species and soils with various distances. It is seen that the mean Pb levels in bottle gourd and pumpkin were found to vary in the range of 1.71–3.43 and 1.65–4.76 µg/g, respectively (Table 1). Lead concentration was higher in pumpkin than in bottle gourd. This difference in Pb level may depend upon genotype, development stage, and growth rate of the plants, the depth and distribution of the root zone, the transpiration coefficient and the nutrient requirement (Naszradi *et al.,* 2004).

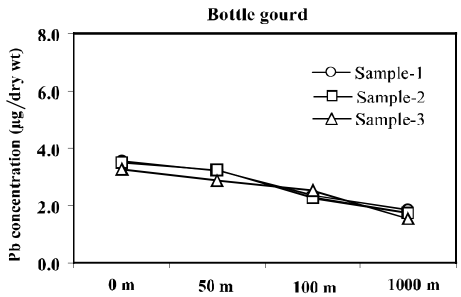

Fig. 1. Pattern of Pb concentration in plant at 0, 50, 100, and 1000 m away from highway.

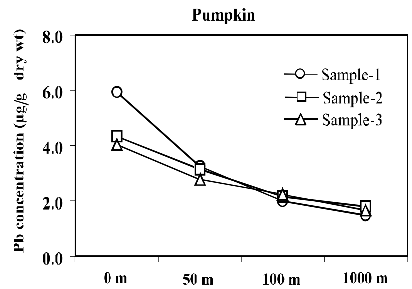

Fig. 2. Pattern of Pb concentra-tion in plant at 0, 50, 100, and 1000 m away from highway.

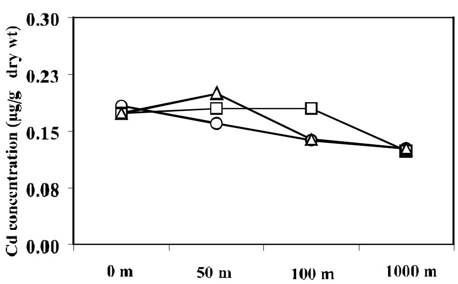

Fig. 3. Pattren of Cd concentration in plant at 0, 50, 100, and 1000 m away from highway.

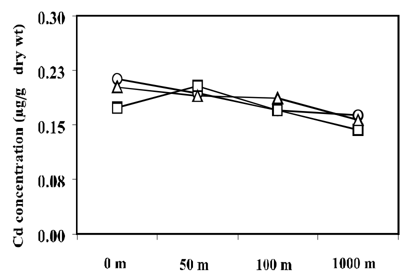

Fig. 4. Pattren of Cd concentra-tion in plant at 0, 50, 100, and 1000m away from highway.

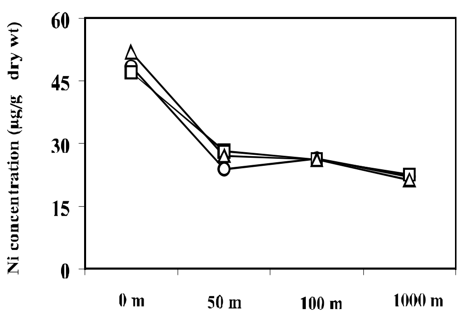

Fig. 5. Pattren of Ni concentration in plant at 0, 50, 100, and 1000m away from highway.

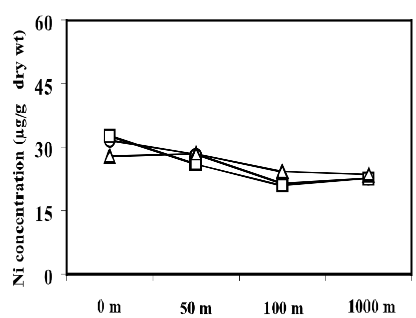

Fig. 6. Pattren of Ni concentra-tion in plant at 0, 50, 100, and 1000 m away from highway.

Table 1. Mean Pb, Cd and Ni concentration in µg/g (±, standard deviation) of vegetables from 0, 50, 100, and 1000 m away from road.

Distance from highway	Bottle gourd			Pumpkin		
	Pb	Cd	Ni	Pb	Cd	Ni
0 m	3.43±0.15c	0.18±0.01b	49.0±2.49b	4.76±1.03c	0.20±0.02b	30.7±2.56b
50 m	3.10±0.21c	0.18±0.02b	26.3±2.23a	3.06±0.25b	0.20±0.01b	27.6±1.33ab
100 m	2.38±0.13b	0.15±0.02ab	26.2±0.16a	2.13±0.12ab	0.18±0.01ab	22.3±1.74a
1000 m	1.71±0.16a	0.13±0.01a	21.9±0.61a	1.65±0.16a	0.15±0.03a	22.9±0.59a

Values within the same column with a common letter do not differ significantly (P <0.01)

Cadmium levels in roadside plant decreased with distance from the main road as similar to lead (Figs. 3–4), but for soil, the pattern was irregular for soil (Figs. 9–10). It is observed that the overall concentration of Cd in soil was found to be independent of distance from road. This indicates that Cd contamination in soil of this region is not due to road traffic. Average Cd levels in roadside plant and soil samples taken from four different sampling points are represented in Table 1 & 2. There were significant differences in the plant Cd contents, but in soil it was not, except for pumpkin between 0m and 1000m distance. The Cd contents in plant and soil varied between 0.18–0.20 and 0.29–0.32 µg/g, respectively, for road edge (0 m), and 0.13–0.15 and 0.20–0.23 µg/g dry wt for 1000m distance.

The concentrations of Ni showed a decreasing trend as the distance increased from the road edge in both plant and soil (Figs. 5–6 and 11–12). This decrease in the Ni levels with distance from the road indicated that vehicular emission played a significant role in the levels of Ni on the roadside plant and soil. Word *et al.* (1977) who reported that motor vehicle traffic is responsible for the build up of Cd and Ni in soils and vegetations along a motorway in New Zealand. The mean Ni content in the plant and soil varied significantly from site to site (Table 1 & 2). Nickel content in plant and soil ranged from 21.9 – 49.0 µg/g, and from 24.1 – 39.1 µg/g, respectively. The mean Ni levels in bottle gourd and pumpkin varied in the range of 21.9–49.0 and 22.3–30.7 µg/g, respectively.

Similar results have been reported by others where concentration of heavy metals in plants and soils increased nearer to the roadside and decreased with distance from roadside (Word *et al.,* 1977; Fergussion, 1991; Sithole *et al.*, 1993). Rodriguez *et al*. (1982) reported that accumulation of Pb and Cd above tolerable levels takes place up to a distance of approximately 33m. This suggests that edible crops for human or animal consumption should be restricted within strips of this width on both sides of heavily traveled roads. Motto *et al*. (1970) also found that most of the effects of Pb discharge from automobiles is confined within a zone 33m wide, measured from the road edge. Ward *et al*. (1975) however, suggested a more conservative value of 100m on either side of road edges. Chambers and Sidle (1991) found that plant metal levels highly vary when related to soil metal levels. In this study, plant Ni levels were found higher in bottle gourd plant at 0 m sites compared to soil Ni levels. This indicates that the high Ni content in plant appears to be due to a direct deposition and foliar absorption more than the translocation from roots to the upper part of the plants. In most sampling points, Pb, Cd, and Ni concentrations in four different sites of road at the same distance were not found close to each other (Fig. 1–12) because of differences in directions and strength of winds in these regions.

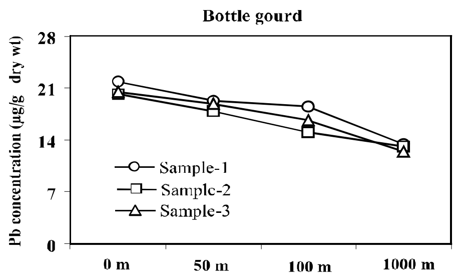

Fig. 7. Pattern of Pb concentration in soil at 0, 50, 100, and 1000 m away from highway.

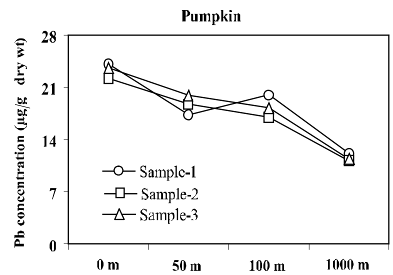

Fig. 8. Pattern of Pb concentra-tion in soil at 0, 50, 100, and 1000 m away from highway.

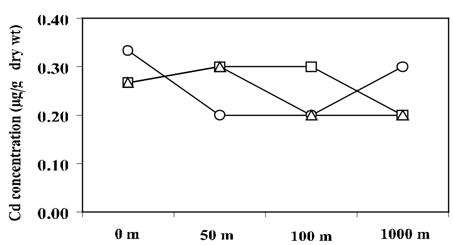

Fig. 9. Pattren of Cd concentration in soil at 0, 50, 100, and 1000 m away from highway.

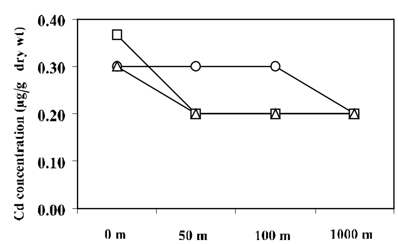

Fig. 10. Pattren of Cd concentra-tion in soil at 0, 50, 100, and 1000 m away from highway.

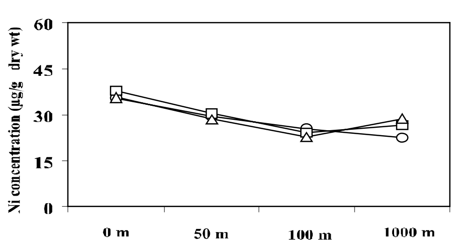

Fig. 11. Pattren of Ni concentration in soil at 0, 50, 100, and 1000 m away from highway.

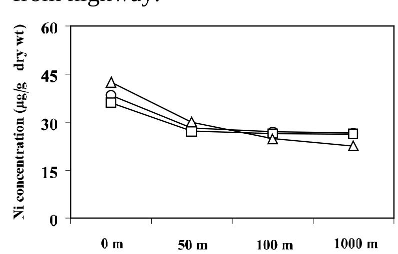

Fig. 12. Pattren of Ni concentra-tion in soil at 0, 50, 100, and 1000 m away from highway.

Table 2. Mean Pb, Cd, and Ni concentration in µg/g (±, standard deviation) of soils from 0, 50, 100, and 1000 m away from road.

Distance from highway	Bottle gourd			Pumpkin		
	Pb	Cd	Ni	Pb	Cd	Ni
0 m	20.8±0.91c	0.29±0.04a	36.3±1.31c	23.3±0.98c	0.32±0.04b	39.1±3.24b
50 m	18.6±0.72bc	0.27±0.06a	29.4±0.90b	18.6±1.30b	0.23±0.06ab	28.5±1.47a
100 m	16.7±1.73b	0.23±0.04a	24.1±1.40a	18.4±1.51b	0.23±0.06ab	26.2±1.14a
1000 m	13.0±0.51a	0.23±0.02a	25.9±3.14ab	11.6±0.47a	0.20±0.03a	25.2±2.20a

Values within the same column with a common letter do not differ significantly ($P < 0.01$)

The quality guidelines for plant and soil heavy metal concentrations developed in certain countries indicate wide variations. The level of heavy metals found in different sources of the present study were compared with the prescribed safe limit provided by WHO (1996), SEPA (2005), and other authors. The extent of Pb and Cd concentrations observed in plant of the different sampling distances was below the permissible levels reported by WHO (1996) and SEPA (2005). Nickel values obtained in the present study substantially exceeded the acceptable tolerance levels of WHO (1996) and SEPA (2005). In this study Pb and Cd content in soils ranged from 11.6 – 23.3 µg/g and 0.20 – 0.32 µg/g, respectively. Lead and Cd concentrations in soil from different sampling distance examined in the present study were below the permissible levels as recommended by India (Awashthi, 2000), China (SEPA 2005-except Cd), Kabata-Pendias and Pendias (1992), Bowen (1966), and Temmerman *et al.* (1984- except Cd). The concentration of Ni from different sampling distances (ranged, 24.1 – 39.1 µg/g) exceeded the acceptable tolerance level of Bowen (1966) and Kabata-Pendias and Pendias (1992).

4. Conclusion

The heavy metal contents at the same distance from the road was found in the following order: Ni>Pb>Cd. The same order of heavy metal contamination (Ni> Pb>Cd) was also observed for vegetables. With regard to the distances from road the order of heavy metal contents was 0 m>50 m>100 m>1000 m. 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. The concentration of Cd was found to be independent of distance from road showing that Cd contamination in this region is not due to road traffic. The greater concentrations of Ni and Pb in soils near the highway could result in represent long-term contamination of heavy metals from transport in a roadside environment.

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