Assessment of Heavy Metal Pollutionin Soils under Vegetable Growing areas of Pabna

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Abstract:

Soil contamination by heavy metals poses a significant threat to food safety, environmental health, and sustainable agriculture, particularly in densely populated and agrarian countries like Bangladesh. The rapid industrialization and urbanization in regions such as Ishwardi in Pabna have raised concerns about potential heavy metal accumulation in agricultural soils used for vegetable production. However, limited studies have comprehensively assessed the levels of toxic metals like lead (Pb), cadmium (Cd), chromium (Cr), and arsenic (As) in soils from these high-production zones. This study aims to evaluate the concentration of selected heavy metals in soils collected from five vegetable-growing sites across Ishwardi—namely Bohorpur, Ruppur, Sahapur, Boroichara, and Silimpur. Soil samples were prepared by standard air-drying and sieving procedures and subsequently analyzed for total Pb, Cd, Cr, and As concentrations using atomic absorption spectrophotometry (AAS) after acid digestion. The results indicated that the concentrations of all four metals were below international risk thresholds, with Cr showing the highest average concentration (20.7 mg/kg), followed by Pb (3.97 mg/kg), Cd (0.863 mg/kg), and As (0.232 mg/kg). Despite being within permissible limits (WHO, EU standards), the presence of these metals warrants regular monitoring due to their cumulative and long-term ecological effects. It is recommended that sustainable land-use practices, regular soil testing, and safe irrigation management be adopted to prevent future contamination in vegetable-growing regions of Pabna.

Keywords: Heavy metal,Soil, Sample, Pollution, Ecosystem.

Introduction:

Soil is a complex mixture of minerals, nutrients, organic matter and living organisms upon which all other terrestrial tropic systems are dependent. It is a vital resource for sustaining basic human needs such as food, fiber and shelter. It serves as the key supplier of heavy metals to the hydrosphere, atmosphere and living organisms, and therefore plays a crucial role in cycling of metals in nature (Sultana & Chowdhury, 2022). Heavy metals are non-biodegradable and abounding in nature due to severe different anthropogenic activities, such as industrial manufacturing process, domestic refuse, waste materials, etc. releasedinto the environmental sources .There presence effect many living being like human, plant, birds, amphibian and microbes at various level. The deposition of heavy metals in soil creates an unexpected disruption of terrestrial ecosystems. However at higher concentrations, all types of heavy metals are responsible for serious dangerous effects and are considered as

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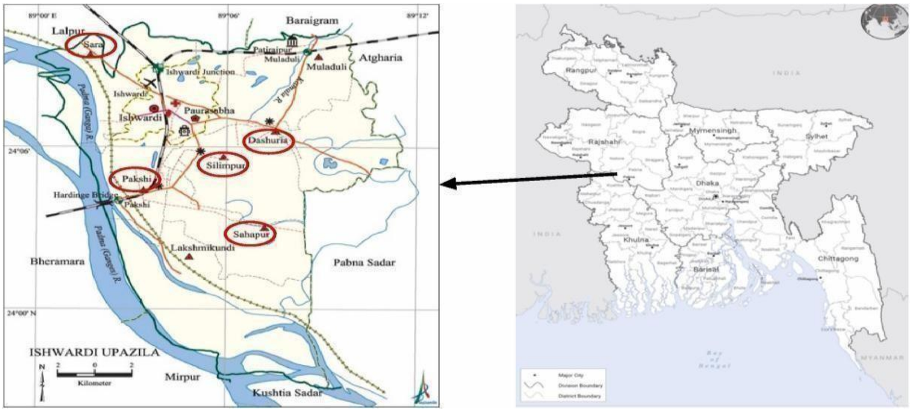
environmental pollutants. Bangladesh is one of the most densely populated countries with various case reports on deposition of heavy metal into ecosystem and its exposure increased in recent decades. The effluents from various industrial are channelized to river and soil leading misbalance in ecosphere (Chowdhury, 2020). Heavy metal pollution is released into the environment by various anthropogenic activities, such as industrial manufacturing processes, domestic refuse and waste materials. Excess concentrations of heavy metals in soils have caused the disruption of natural terrestrial ecosystems. When heavy metals are retained in the soil by repeated and uncontrolled additions, they interfere with these key biochemical processes which alter ecological balance (Sultana & Chowdhury, 2022). Pollution by heavy metal is introduced in the environment through human participations, including industrial works, household waste with other refuse. Elevated amount of heavy metals of soil is responsible for the disruption of terrestrial ecosystems of nature. At elevated quantities, heavy metals exhibit strong toxicity and cause environmental pollutants (Chowdhury et al., 2025). The soil from different areas of Bangladesh is affected by various heavy metals which lead to the resistant bacteria which make them extreme surviving (Mahmud et al., 2025). Previous studies have indicated that individuals tend to consume less food when eating alone compared to when they dine with family or in groups. People living in rural regions typically have lower life expectancies, yet they suffer from higher rates of disability, accidents, poisonings, and violence compared to urban populations. This situation disproportionately affects women, who not only are the primary users of healthcare services but are also traditionally responsible for maintaining family health. When access to nearby healthcare is limited, women often bear the burden of managing health-related responsibilities if family members must travel for treatment (Sheema et al., 2025). This current study was also conducted with an aim to investigate the heavy metal contamination of soil in the vicinity of rapidly growing urbanized and industrialized area around Ishwardi in Bangladesh. A significant adjudgment in physical environment and increasing rate of the accumulation of municipal waste are caused by the rapid and relative unorganized urban expansion, industrial developments coupled with inadequate waste management. Irrigation with wastewater is responsible significantly to the heavy metals content of soil. The bioavailability of soil metal to vegetable was controlled by soil metal speciation, soil properties and plant species. Some of these heavy metal ions are considered to be xenobiotic because these have no beneficial role in body functioning and are even very harmful in minor concentrations. Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb) and so forth are so called highly toxic metals. Higher levels of these metal ions are highly toxic to humans including plants, animals, soils and their solubility in water is premeditated to be one of the major environmental issues.The objectives of this study are to investigate the concentrations of Pb, Cd, As and Cr in soil within vegetable growing regions of Iswardi, Pabna, Bangladesh.

Materials and Methods:

Soil samples have been collected from 5 choosen sites (Bohorpur, Ruppur, Sahapur, Boroichara and Silimpur) within five regions across Ishwardi in Pabna, Bangladesh (Figure 1).

Figure 1. Study area



Determination of As:
For arsenic (As) determination, 1.0 g of sieved soil was digested using a mixture of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) in a 3:1 ratio, following the method described by McGrath and Cunliffe (1985). The digest was filtered and diluted with deionized water to a fixed volume. The total arsenic concentration was then determined using Atomic Absorption Spectrophotometry (AAS) (Smith et al., 1990). Blanks and certified reference materials were analyzed alongside samples for quality control. All measurements were conducted in triplicate, and appropriate standard calibration curves were prepared for quantification.

Determination of Cd:
1.0 g of each soil sample was digested using a tri-acid mixture consisting of concentrated nitric acid (HNO_3), perchloric acid ($HClO_4$), and sulfuric acid (H_2SO_4) in a ratio of 5:1:1, following the procedure described by Lindsay and Norvell (1978) and modified by the USEPA (1996). After complete digestion, the samples were filtered and diluted to a fixed volume with deionized water. The concentration of Cd in the digest was measured using Atomic Absorption Spectrophotometry (AAS), using a graphite furnace for enhanced sensitivity. Reagent blanks and certified reference materials were included to ensure quality control. Each sample was analyzed in triplicate to ensure accuracy and reproducibility.

Determination of Pb:
For the determination of total lead (Pb), 1.0 g of sieved soil was digested with a mixture of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) in a 3:1 ratio following the method described by McGrath and Cunliffe (1985). The digests were filtered and diluted with deionized water to a known volume. The concentration of Pb in the extracts was analyzed using Atomic Absorption Spectrophotometry (AAS) equipped with a graphite furnace, which provides high sensitivity for trace metal detection (USEPA, 1996). Calibration standards were prepared using certified lead solutions, and all analyses were carried out in triplicate to ensure precision. Reagent blanks and certified reference materials were included for quality assurance and control.

Determination of Cr:
For total chromium (Cr) determination, 1.0 g of each soil sample was digested using a mixture of concentrated nitric acid (HNO_3), perchloric acid ($HClO_4$), and sulfuric acid

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(H_2SO_4) in a 5:1:1 ratio, following the method described by Lindsay and Norvell (1978) and adapted by the USEPA (1996). The digested samples were filtered through Whatman No. 42 filter paper and diluted with deionized water to a known volume. Chromium concentrations in the extracts were determined using Atomic Absorption Spectrophotometry (AAS) for higher sensitivity. Certified reference materials, blanks, and calibration standards were used to ensure quality control and analytical accuracy. All measurements were performed in triplicate.

Results and Discussion

The database of total metals concentration and chemical parameters of sediments are given in Table 1. The average value of pH in sediment is 6.5 near about neutral. A wide range of values for metals concentration was observed among the sampling sites. Factors such as salinity, geomorphologic setup and land runoff might have played a crucial role in the variationof metals. Concentrations of heavy metals at sites were much higher than other sites because of the fact that these sites are located at the downstream of the river and extensive discharging of urban waste. The average concentration of heavy metals in sediments wereinthe decreasingorder of Cr >Pb> Cd>As.

Chromium concentration in sediment was higher than other metals as a consequence of direct discharging untreated wastes from tanneries and textile industries. Cr concentration in sediment was found as 20.699 mg/kg and 8.422 mg/kg respectively which is the highest at Bohorpur Dasuria and lowest value at Sahapur. Cd concentration in sediment was found as 0.315 mg/kg and 0.863 mg/kg respectively which is the highest and lowest value. Pb concentration in sediment was found as 3.965 mg/kgand 2.768mg/kg respectively which is the highest and lowest value. In Boroichara Silimpur the concentration of Cd and Pb is maximum and in Bohorpur Dasuria the concentration of Cd and Pb is minimum.

Table 1: Heavymetals (Pb, Cr , Cd and As) in collectedsoil sample

Sl No.	Name of heavy metal	Soil sample (mg/kg)					
		S-1	S-2	S-3	S-4	S-5	Standard
1	Pb	2.768	3.022	3.012	3.206	3.965	10
2	Cr	20.7	8.422	8.894	10.71	9.747	60
3	Cd	0.315	0.728	0.797	0.536	0.863	1.1
4	As	0.183	0.232	0.181	0.132	0.158	0.5

According to European Union, 2002; FAO/WHO, codex general standard for contaminants and toxins in foods, 1996; World Health Organization, 2000; World Health organization, 2004; the standard value of the concentration of heavy metals in soil are given in table 1. We observed that concentration of all heavy metals in soil was found lower than in toxic level.

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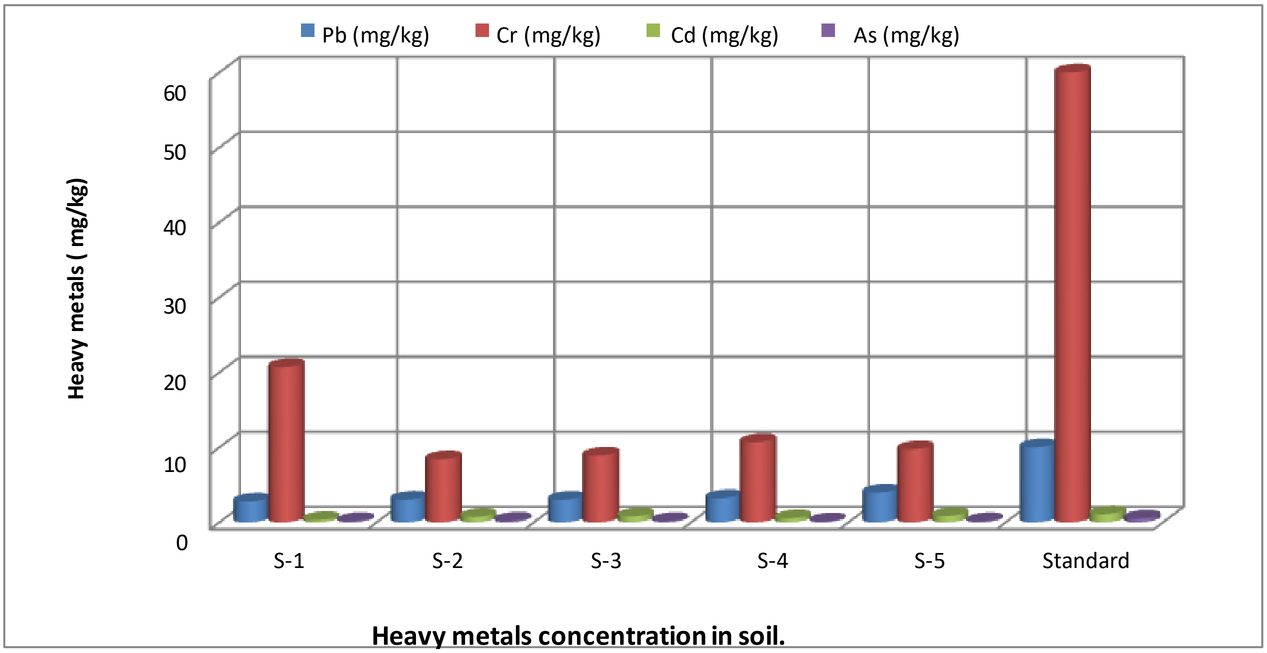

Figure 2: Heavymetalsconcentrationin soil

The heavy metal levels were compared with those of WHO (2004, 1993) and E U (1998) soil standards. According to the results (figure 2) cadmium (<1.1 mg/kg), Pb (<10 mg/kg), Cr (<60 mg/kg) and arsenic (<0.5 mg/kg) levels in soil samples analysed were below the risk limits.

Conclusion

The present study assessed the concentrations of selected heavy metals (Pb, Cd, Cr, and As) in soils from major vegetable-growing areas of Ishwardi, Pabna, Bangladesh. The results revealed that all detected levels of heavy metals were below the permissible limits set by WHO and E U standards. Among the analyzed metals, chromium was found in the highest concentrations, while arsenic remained the lowest across all sampling sites. The presence of these metals, though within safe thresholds, indicates potential contamination sources such as industrial effluents, wastewater irrigation, and urban waste disposal. Continuous monitoring is essential to prevent long-term accumulation that could pose serious threats to human health, crop productivity, and environmental sustainability. Based on the findings, it is recommended that local agricultural practices be aligned with environmental safety protocols, including regular soil testing, use of clean irrigation water, and controlled use of fertilizers and pesticides. Implementing these measures can help ensure the long-term safety of food crops and protect the health of the surrounding ecosystem.

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