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Heavy metal contamination in water and its impact on environment

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Abstract: A study was to conduct with an aim to investigate the contamination of water by heavy metal in the vicinity of rapidly growing urbanied and industrialied area around Iswardi in Bangladesh. Rapid and poorly planned urban growth, along with industrial expansion and insufficient waste management systems, significantly impact the physical environment and lead to increased accumulation of municipal waste. In developing countries like Bangladesh, one of the most critical challenges of urbanization is the effective management of solid, liquid, and hazardous waste. Many cities lack adequate regulations and proper facilities for disposing of dangerous waste, which can include toxic or even radioactive materials. Levels of heavy metals have been assessed against the drinking water standards established by the EU (1998) and WHO (1993, 2004). The levels of arsenic (<0.01 mg/l) and cadmium (<0.03 mg/l) in the water samples that were analyzed were found to be below the risk thresholds. The findings indicate that the mean concentrations of Pb (0.05±0.01 mg/l) and Cr (0.2±0.1 mg/l) in drinking water have increased. These levels are higher than the drinking water limits set by the WHO (2004, 1993) and the EU (1998) for Pb (0.01 mg/l) and Cr (0.05 mg/l), respectively, and may provide a modest health risk to humans. Certain heavy metals are classified as xenobiotics because they serve no beneficial purpose in biological systems and can be harmful even at very low concentrations. Toxic metals such as cadmium, beryllium, chromium, lead, and arsenic fall into this category. Elevated concentrations of these metal ions are extremely hazardous to both humans and animals, as well as to plants. Their ability to dissolve in water makes them a significant environmental concern.

Keywords: *Drinking water, Poverty, Heavy metal, Research, Rural.*

Introduction

Previous studies have indicated that individuals tend to consume less food when eating alone compared to when they dine with family or in groups (Nestle et al., 1998). 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 (Edelman & Menz, 1996; Sutherns et al., 2004). 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 (Sutherns et al., 2004).

The present study focuses on assessing heavy metal contamination in water sources near the rapidly urbanizing and industrializing region of Ishwardi, Bangladesh. Unplanned urban growth and industrial activities, along with insufficient waste management, have led to substantial environmental changes and a growing accumulation of municipal waste. Waste management—particularly of solid, liquid, and hazardous materials—remains a significant challenge in many developing countries, especially in Bangladesh. Several urban areas lack effective regulations and disposal infrastructure for toxic or even radioactive waste.

Due to challenges in waste disposal, industrial and municipal wastewater is often used for irrigating crops, particularly in peri-urban areas, because of its availability and the limited supply of fresh water. However, irrigation with such wastewater contributes significantly to the buildup of heavy metals in soil. The transfer of these metals from soil to crops is influenced by factors such as metal speciation, soil characteristics, and plant type. Heavy metals are highly persistent, non-biodegradable pollutants that pose long-term risks to both food safety and environmental health. In recent years, metal contamination of aquatic environments has garnered global concern due to the widespread occurrence, toxicity, and enduring nature of these pollutants. Due to global rapid growth of population as well as intensive domestic activities and delating agricultural and industrial production, a large amount of toxic chemical particles especially heavy metals like Lead (Pb), Arsenic (As) have been discharged vastly into seas and rivers worldwide. The objectives of this study are to assess the contamination levels of heavy metals in both water and sediment, to analyze metal enrichment in relation to their chemical speciation in sediments, and to evaluate the perceived health risks by the surrounding community.

Materials and Methods

This study is largely exploratory and partly descriptive in nature, necessitating a mixed-methods approach that incorporates both qualitative and quantitative data, as well as primary and secondary sources. The researcher aims to examine the environmental factors influencing the dietary status of rural women in Pabna, Bangladesh. Most of the people of the Pabna living in the rural area that is why researcher chose Pabna as a research area.

The water samples were collected from five sites within Ishwardi regions. Auto ricemill area, Bohorpur village of Dasuria union, fresh vegetable land of Sahapur village of Sahapur union, the riverside area of Ruppur village where the nuclear power plant is to be set up of Pakshi union, the Poultry area, Boroichara village of Silimpur union; the river collasing area, Mazdia village of Sara union; Ishwardi, Pabna are research fields of this environmental experiment.

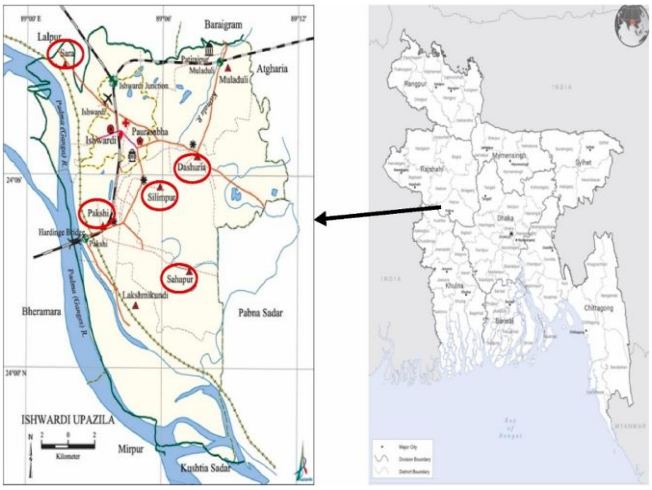

Fig: Study area

The water samples used for heavy metals investigation of the choosing site are collected from three different sources which are pond, tube-well and irrigation water.

Water Sampling

15 water samples were collected for this study from five different sites across five regions within Ishwardi. These samples were taken from three distinct water sources: ponds, tube wells, and irrigation channels. Unfiltered water samples were used for total metal analysis. Heavy metal concentrations were measured under specified operating conditions and parameters at the Central Science Laboratory in Rajshahi. A multi-element standard solution was used to create the calibration curve.

All testing batches followed a rigorous internal quality control protocol and were validated only if they met predefined quality standards. Each experimental run included a blank sample, certified reference materials, and duplicate samples to ensure the elimination of batch-specific errors. The measured values were compared against certified reference values, and in both cases, the results confirmed that the sample preparation methods and instrumental settings yielded accurate and precise measurements.

Results and Discussion

Heavy Metals Tracing on Water in the Study Area

The findings of this case study clearly indicate that leafy vegetables tend to accumulate higher levels of heavy metals compared to root vegetables. The common practice of irrigating field crops with wastewater was also examined to assess its impact on metal accumulation in these crops, which ultimately exposes humans to these contaminants. Additionally, the daily intake of heavy metals was calculated separately for both adults and children to evaluate potential health risks.

Table 3.1: Heavy metals concentration (As, Pb, Cr and Cd) in water sample (mg/L)

Union		**Sahapur**	**Dasuria**	**Pakshi**	**Sara**	**Silimpur**	**Standard**
Village		**Sahapur**	**Bohorpur**	**Ruppur**	**Mazdia**	**Boroichara**	**Value**
As	Tube-well	0.0042	0.0038	0.0038	0.0019	0.0052	0.05
	Pond	0.0034	0.0038	0.0015	0.0035	0.0018	2.0
	Irrigation	0.0056	0.0029	0.0019	0.0087	0.0056	0.05
Pb	Tube-well	0.0482	0.0562	0.0682	0.0602	0.0441	0.05
	Pond	0.0441	0.0763	0.0401	0.0642	0.0682	0.01
	Irrigation	0.0602	0.0722	0.0642	0.0682	0.0722	0.05
Cr	Tube-well	0.3849	0.468	1.0571	2.3878	0.0645	0.05
	Pond	0.1827	0.2169	1.1636	0.0596	0.042	0.5
	Irrigation	0.0391	2.1836	0.9868	0.1075	0.0606	1.0
Cd	Tube-well	0.0044	0.0151	0.0103	0.0142	0.0018	0.1
	Pond	0.0161	0.0096	0.009	0.0073	0.0099	0.05
	Irrigation	0.0136	0.0144	0.0131	0.0044	0.0051	0.01

➢ **Metal Concentration in Water**

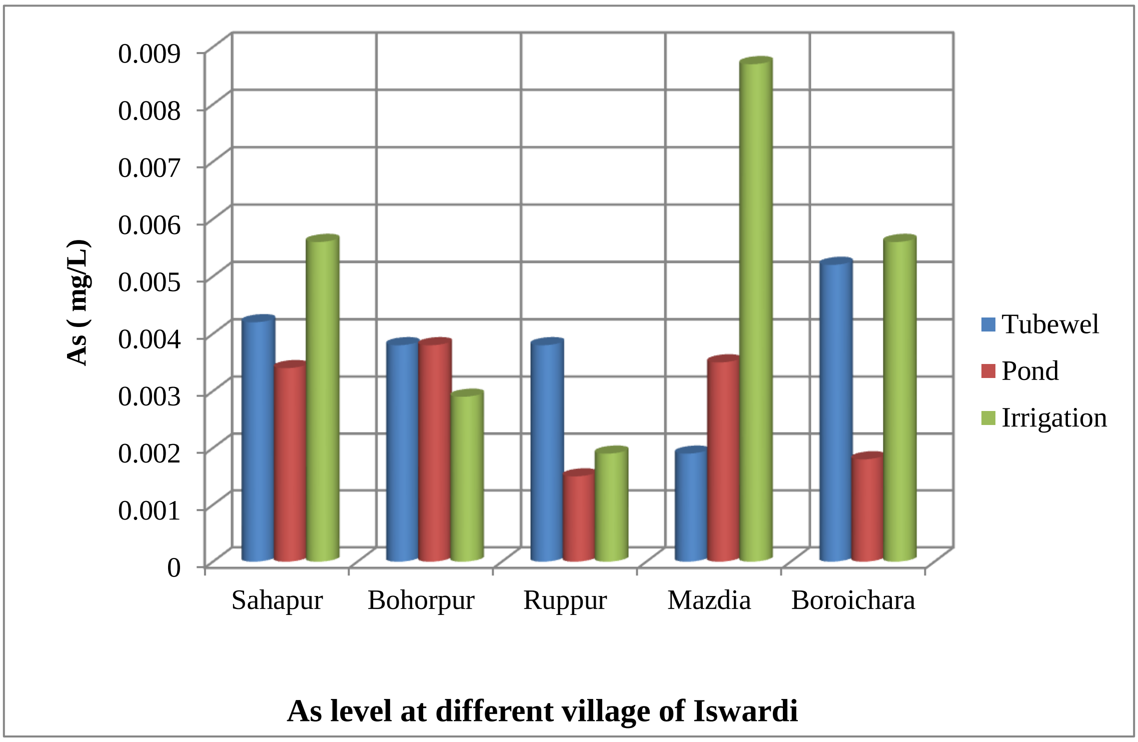

Figure 3.1: Arsenic (As) level at different village of Ishwardi

The concentration of As was observed 0.00384mg/L on average. The highest value of As was observed in Mazdia, Sara (0.0087mg/L) through irrigation system but lowest in tube-well section (0.0019mg/L). Again in Boroichara and Sahapur, the As value is same (0.0056mg/L). The lowest As value was got at site Ruppur Pakshi pond (0.0019 mg/L) in irrigation section and pond section (0.0015mg/L).

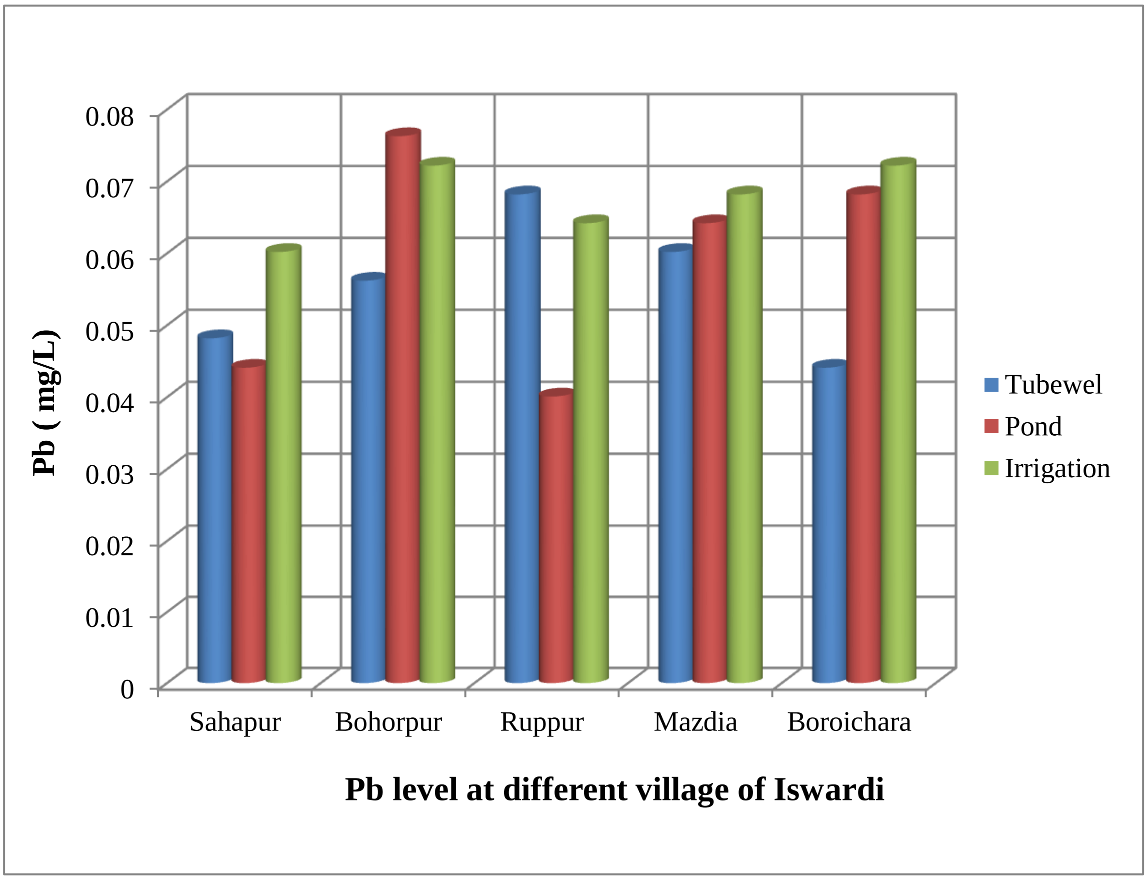

Figure 3.2: Lead (Pb) level at different village of Ishwardi

The standard level of WHO for drinking water contains mean concentration of Pb in water (2 mg/L). The averaged concentration of Pb was observed 0.0185375mg/L. The Pb highest value was available at Boroichara Silimpur irrigation site and Bohorpur Dasuria irrigation site (0.0722 mg/L). The Pb lowest value was observed at site Ruppur Pakshi pond.

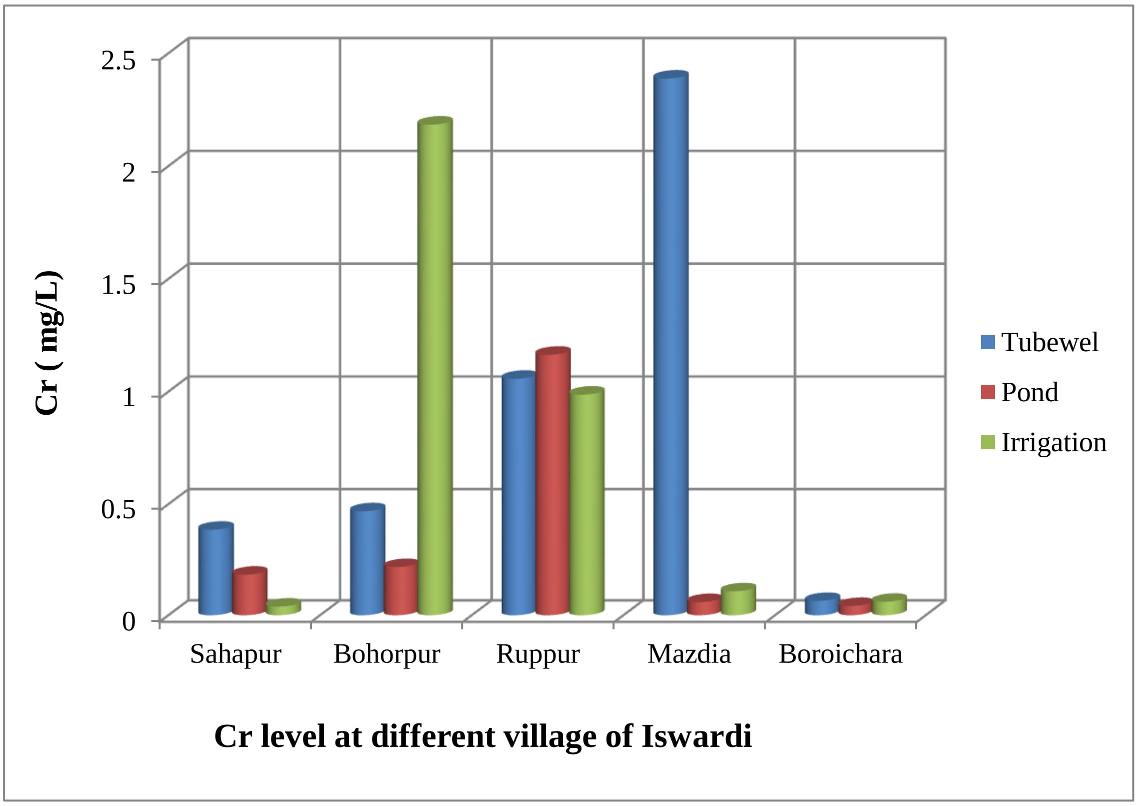

Figure 3.3: Chromium (Cr) level at different village of Ishwardi

The average concentration of chromium (Cr) in the water samples was found to be 0.621 mg/L. The highest concentration was detected in tube-well water from Mazdia in Sara (2.3828 mg/L), which may be attributed to contamination from domestic sewage and runoff from intensively farmed areas. In contrast, Cr levels in irrigation water were relatively low. The lowest Cr concentration was recorded in pond water from Boroichara in Silimpur, at 0.042 mg/L.

The heavy metal concentrations in surface water, as presented in Table 3.1, showed significant variation across different sampling sites ($p < 0.05$). The average concentrations of the analyzed metals in water followed the descending order: Cr > Pb > Cd > As. According to WHO guidelines, the acceptable mean concentration of Cr in drinking water is 0.15 mg/L.

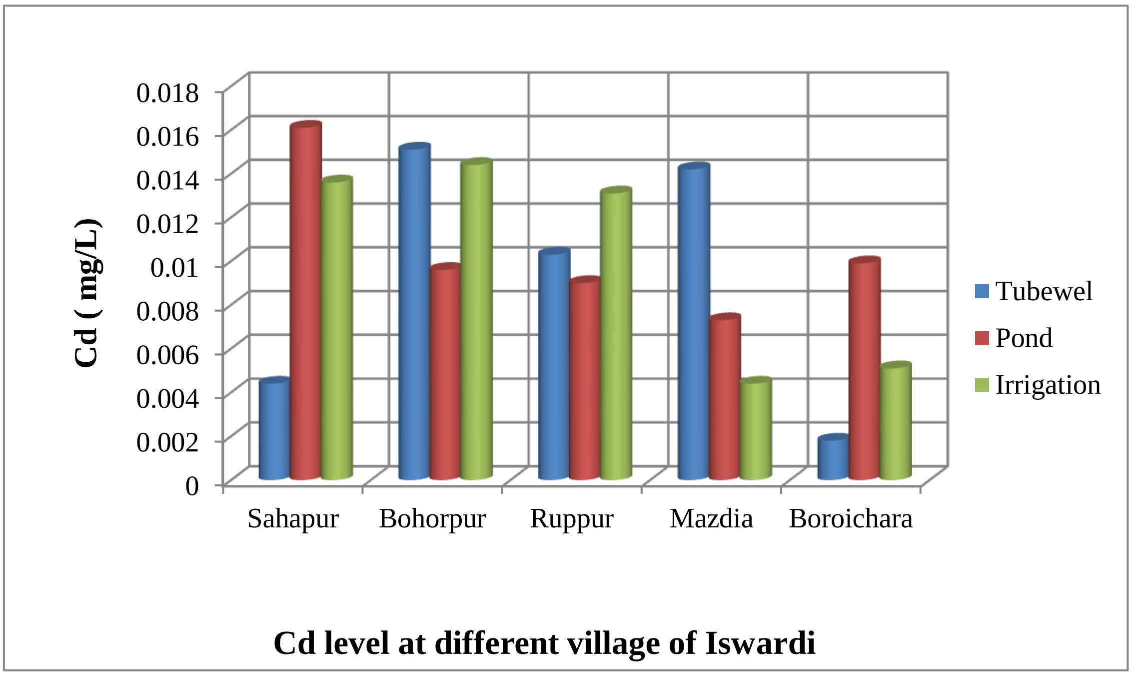

Figure 3.4: Cadmium (Cd) level at different village of Ishwardi

According to WHO standards, the permissible mean concentration of cadmium (Cd) in drinking water is 0.01 mg/L. In this study, the average concentration of Cd was found to be 0.0185 mg/L, exceeding the recommended limit. The highest Cd concentration was recorded at the Sahapur pond site (0.0161 mg/L), while the lowest was observed in tube-well water from Boroichara, Silimpur (0.0018 mg/L).

The statistical data for four heavy metals in water samples are presented in Table 3.1. This study focuses on analyzing heavy metal contamination in water within Ishwardi Thana. Water samples were collected from five different sites, covering three sources: ponds, tube wells, and irrigation channels. In addition to measuring contamination levels, the study aimed to link the potential health risks associated with these sites to the knowledge, attitudes, and perceptions of residents in Ishwardi Upazila.

The observed concentrations of heavy metals were compared against WHO (1993, 2004) and EU (1998) drinking water standards. The results revealed that the concentrations of cadmium (<0.03 mg/L) and arsenic (<0.01 mg/L) in the water samples remained below the respective risk thresholds. However, elevated levels of lead (Pb) and chromium (Cr) were recorded, with mean concentrations of Pb at 0.05 ± 0.01 mg/L and Cr at 0.2 ± 0.1 mg/L. These values exceed the WHO and EU guideline limits of 0.01 mg/L for Pb and 0.05 mg/L for Cr, indicating a potential health risk for human populations exposed to these sources.

The environmental implications of heavy metal contamination in water bodies are of significant concern. These metals can enter aquatic environments through industrial effluents, improper waste disposal, and surface runoff from urban and agricultural areas. Once introduced, heavy metals pose multiple threats:

- **Toxicity to Aquatic Life**: Elements such as Cr, Cd, Pb, As, Hg, Ni, and Cu are highly toxic to aquatic organisms even at low concentrations.
- **Bioaccumulation and Biomagnification**: Heavy metals can accumulate in aquatic organisms, progressing through the food chain and potentially harming wildlife and humans who consume contaminated fish and shellfish.
- **Water Quality Degradation**: The presence of heavy metals adversely affects key water quality parameters such as pH, turbidity, and temperature, thereby destabilizing aquatic ecosystems.
- **Human Health Risks**: Long-term exposure to contaminated water may cause severe health issues, including liver and kidney damage, cancers (gastric and skin), neurological disorders, and reproductive health problems

To address these challenges, regular water quality monitoring and the implementation of eco-friendly remediation strategies are essential. Biological methods, in particular, are recognized as cost-effective and sustainable solutions for the removal of heavy metals from contaminated water sources.

Conclusion

To determine the concentrations of lead (Pb), cadmium (Cd), arsenic (As), and chromium (Cr), we collected information from respondents regarding their eating habits and nutritional background, including the frequency and type of meals consumed daily. Additionally, heavy metal levels in drinking water were verified based on these behavioral insights. Data on the socioeconomic and environmental conditions of rural women were also gathered, alongside comparisons of their housing materials and lifestyles in relation to income and education levels. This study therefore offers a rich combination of exploratory and detailed quantitative and qualitative descriptions that shed light on the nutritional status of rural women in the area.

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