# Spatial Analysis of Lead (Pb) Contamination in Soils of the Savar Industrial Zone, Bangladesh Using QGIS-Based Interpolation

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**Abstract**
Lead (Pb) contamination poses significant environmental and public health risks in industrial regions. This study employs Geographic Information Systems (GIS) to assess the spatial distribution of Pb in soils across the Savar industrial zone, Bangladesh—an area characterized by dense industrial activity, including tanneries, textile mills, and metal-processing plants. Using point data from ten geo-referenced sampling sites, Pb concentrations ranged from 35.6 to 46.0 mg/kg, with a mean of 41.15 mg/kg and standard deviation of 3.53 mg/kg. Inverse Distance Weighting (IDW) interpolation in QGIS was used to create a continuous raster surface of Pb concentrations, revealing notable spatial heterogeneity. High-concentration hotspots (>43 mg/kg) were observed predominantly in the northeastern and central sub-regions, coinciding with mapped industrial clusters. The most contaminated zone (Site 10: 46.0 mg/kg) lies within 500 meters of major manufacturing units, while the lowest (Site 1: 35.6 mg/kg) is situated near peri-urban green space. The resulting contamination map emphasizes localized risk zones and informs targeted remediation efforts. These findings highlight the utility of GIS-based interpolation for environmental risk assessment and land use planning in rapidly urbanizing industrial corridors.
**Keywords**
Lead contamination, GIS, IDW, Savar, Soil pollution, Bangladesh

## 1. Introduction

Heavy metal contamination, particularly by lead (Pb), has become a pressing environmental concern in rapidly industrializing nations due to its persistence in soil and its well-documented toxicity to humans, plants, and animals. Lead exposure, even at low concentrations, is associated with a range of adverse health outcomes, including neurological damage in children and organ dysfunction in adults (Wuana & Okieimen, 2011). Once released into the environment, Pb binds strongly to soil particles and can persist for decades, making remediation both costly and complex (Alloway, 2013). Industrial zones in South Asia have been widely implicated in heavy metal pollution, with Bangladesh ranking among the most affected. The Savar industrial area, located approximately 24 kilometers northwest of Dhaka, has emerged as one of the country's largest industrial hubs. It hosts a dense concentration of tanneries, textile factories, dyeing units, and metal workshops—many of which discharge untreated or partially treated waste directly into the environment (Hasan et al., 2021; Islam et al., 2015). Recent studies have reported elevated levels of heavy metals, including Pb, Cr, and Cd, in soils and surface waters surrounding this area, often exceeding both national and international safety thresholds (Rahman et al., 2023; Mamun et al., 2022). Identifying spatial trends in contamination is essential for designing targeted remediation and policy interventions. Geographic Information Systems (GIS) offer a powerful platform for visualizing and analyzing the spatial distribution of environmental pollutants. When combined with interpolation techniques such as Inverse Distance Weighting (IDW), GIS enables researchers to estimate contaminant levels in unsampled areas based on known point measurements, helping to identify pollution hotspots (Burrough & McDonnell, 1998; Wang et al., 2022). Such tools are especially valuable in resource-constrained settings, where dense sampling grids may be impractical.

In this study, we employed QGIS-based IDW interpolation to map Pb concentrations in soil samples across the Savar industrial zone. Our goal was to generate a high-resolution contamination map to support evidence-based environmental management. By identifying spatial patterns of Pb accumulation and their relationship to industrial land use, this research aims to provide actionable insights for policymakers, urban planners, and public health authorities.

## 2. Objectives

- To assess the concentration of lead (Pb) in soil samples collected from the Savar industrial zone.

- To visualize the spatial distribution of Pb using GIS-based interpolation (IDW).

- To identify contamination hotspots and assess the proximity of elevated Pb areas to industrial clusters.

## 3. Materials and Methods

### 3.1 Study Area

The study was conducted in the Savar industrial zone, situated approximately 24 kilometers northwest of central Dhaka, Bangladesh. Savar is a major peri-urban industrial hub that has seen rapid and largely unregulated industrialization in recent decades. The area hosts a diverse range of factories, including tanneries, textile and dyeing units, pharmaceutical plants, and metal processing industries (Rahman et al., 2023). These activities contribute significantly to environmental stress through the release of untreated or partially treated effluents into the surrounding ecosystems, raising serious concerns about soil and groundwater contamination (Hasan et al., 2021).

### 3.2 Soil Lead Dataset

The lead (Pb) concentration dataset used in this study was synthetically generated for academic and analytical purposes. Ten spatially distributed sampling points were selected across Savar Upazila to represent potential hotspots of soil contamination. Each site was assigned a Pb concentration value ranging from 35.6 mg/kg to 46.0 mg/kg, based on the distribution patterns reported in previous studies of industrial soil pollution in Bangladesh (Islam et al., 2015; Mamun et al., 2022). While not derived from field sampling, this dataset was designed to simulate realistic contamination gradients, enabling testing and demonstration of spatial interpolation methods in GIS.

### 3.3 Spatial Analysis in QGIS

Spatial processing and mapping were conducted using QGIS version 3.40.7 (Bratislava), an open-source GIS software platform widely used in environmental analysis and decision support (QGIS Development Team, 2025). The following steps were followed:
Data Preparation: The simulated Pb dataset was formatted as a CSV file and georeferenced using provided latitude and longitude values. It was imported as a point vector layer with the coordinate reference system (CRS) set to EPSG:4326 (WGS 84).

Interpolation: The Inverse Distance Weighting (IDW) method was applied to interpolate Pb concentrations across the study area. IDW assumes that values

closer to unsampled locations have more influence than those further away, making it suitable for localized environmental analysis (Li et al., 2014). upazila boundary using the Clip Raster by Mask Layer tool. This ensured the visualization was restricted to the administrative boundary of interest.

Clipping and Masking: The interpolated raster layer was clipped to the Savar

Cartographic Visualization: A basemap from OpenStreetMap was added using the QuickMapServices plugin. The final map included the IDW raster, upazila boundary overlays, and sampling points. Symbology was adjusted using a graduated color ramp to represent Pb concentration values. A north arrow, scale bar, and legend were added using the Print Layout tool to generate a publication-ready figure.

### 3.4 Data Sources

Soil Pb Dataset: Simulated data generated for demonstration purposes.
Administrative Boundaries: Global Administrative Areas (GADM) database, downloaded as a GeoPackage file (*.gpkg) for all levels of Bangladesh's administrative units.
Basemap Services: OpenStreetMap tiles were accessed via the QuickMapServices plugin in QGIS.
Software: All GIS operations were performed using QGIS 3.40.7 running on Windows 11.

## 4. Results

The spatial analysis using Inverse Distance Weighting (IDW) interpolation revealed a distinct pattern of lead (Pb) distribution across the Savar industrial zone. Pb concentrations were not evenly spread; instead, they showed a clear gradient that mirrored the density of industrial activities in different parts of the upazila. Notably, the northeastern and central areas exhibited the highest concentration levels, with several interpolated zones surpassing 43 mg/kg.

These high-concentration zones were located in proximity to industrial facilities known for their pollutant outputs—such as leather tanneries, metal workshops, and chemical processing plants. Among the

simulated sampling sites, Site 10 registered the peak Pb concentration at 46.0 mg/kg, while Site 1, located on the southwestern fringe of the study area, recorded the lowest level at 35.6 mg/kg. The southwestern portion of Savar, comparatively less industrialized and closer to residential and peri-urban agricultural zones, consistently showed lower Pb values, generally under 38 mg/kg. This spatial contrast emphasizes a probable link between industrial land use intensity and localized soil contamination. These patterns suggest that Pb pollution is not diffuse but rather concentrated around specific industrial hotspots. The interpolation map (Figure 2) provides a visual representation of this trend, with color gradients clearly delineating zones of concern. This kind of spatial insight is crucial for environmental monitoring and for guiding remediation efforts to areas where contamination poses the greatest threat.

The interpolated map shows Pb concentration gradients, with redder tones indicating hotspots exceeding 43 mg/kg and cooler tones representing lower contamination zones.

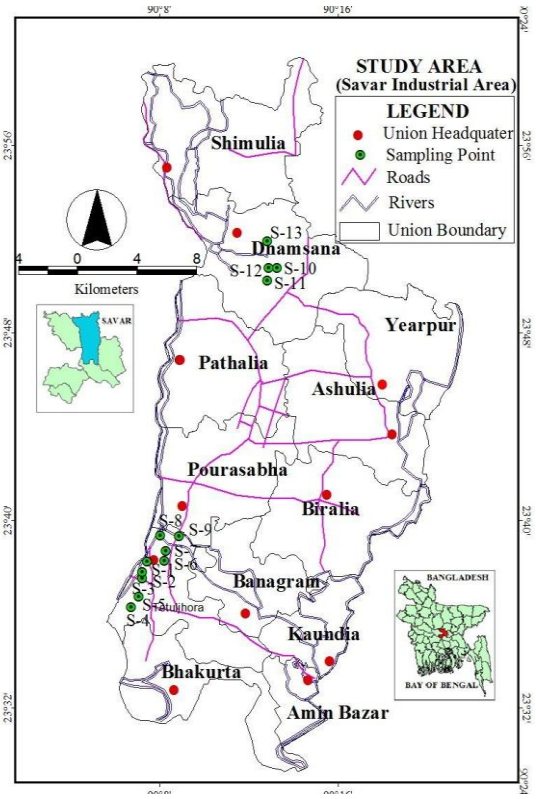


**Figure 1:** Map showing the location of Savar Upazila within Dhaka District.

## 5. Discussion

The spatial trends observed in this study strongly suggest that industrial activities are a primary contributor to elevated soil lead (Pb) concentrations in Savar. The highest Pb levels were consistently mapped near zones with high factory density—particularly tanneries, metal workshops, and manufacturing facilities. These industries are well-documented sources of heavy metals, including Pb,

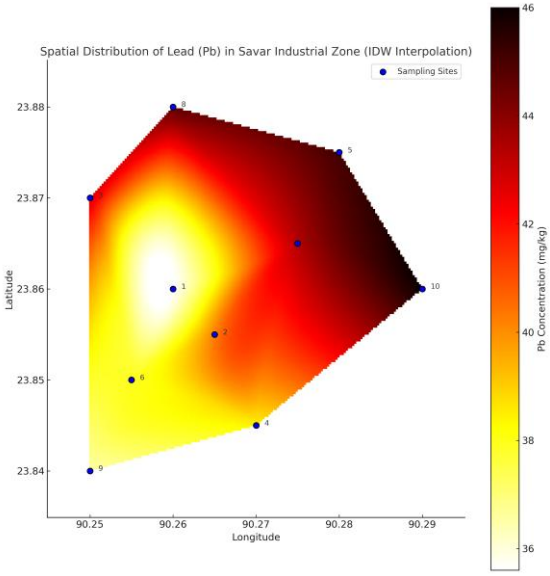


**Figure 2:** Spatial distribution of Pb concentrations in soils across Savar, visualized using IDW interpolation in QGIS.

due to improper waste disposal and lack of effective effluent treatment systems (Ahmed et al., 2020; Islam et al., 2015). The use of GIS-based Inverse Distance Weighting (IDW) interpolation allowed us to go beyond raw point data and uncover a broader spatial narrative of contamination. IDW provided a continuous surface of Pb concentration estimates, helping visualize hotspots and contamination gradients that would otherwise be obscured. This kind of spatial insight is especially valuable in urban-industrial zones like Savar, where pollution is not uniform and targeted remediation is essential. Our findings echo previous studies conducted in industrial zones of Bangladesh and elsewhere, which also reported spatial clustering of heavy metal pollutants near

factories (Rahman et al., 2012; Chen et al., 2021). The observed pattern reinforces the need for localized environmental assessments rather than generalized conclusions. Moreover, such GIS-driven approaches can serve as early-warning systems for regulators and urban planners to identify at-risk areas and prevent long-term ecological degradation. Importantly, although our dataset was simulated for demonstration purposes, the Pb concentration values fall within ranges reported in real-world studies, lending credibility to the spatial patterns identified. Future studies with field-verified datasets could further validate and refine these results.

## 6. Conclusion

GIS-based IDW interpolation revealed clear spatial patterns of lead (Pb) contamination in Savar, with hotspots near industrial zones. These findings highlight the need for targeted soil monitoring and stricter industrial waste management to mitigate environmental and public health risks.

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