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ASSESSMENT OF TOXIC HEAVY METAL CONTAMINATION IN CAULIFLOWER AND BRINJAL IRRIGATED WITH DRAVYAVATI RIVER WATER IN THE JAGATPURA REGION OF JAIPUR, RAJASTHAN

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ABSTRACT

Heavy metal contamination in agricultural environments is an important environmental concern because potentially toxic elements can persist in soils and accumulate in edible plant tissues. This research paper presents an analytical framework for investigating the distribution of lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu) and zinc (Zn) in irrigation water, agricultural soil, cauliflower (Brassica oleracea var. botrytis) and brinjal (Solanum melongena) in the Jagatpura region of Jaipur, Rajasthan. A sampling framework involving twelve agricultural locations is developed to demonstrate the collection and analysis of paired water, soil and vegetable samples. Model-Based concentration values are used to illustrate descriptive analysis and the interpretation of differences between vegetable species. In the example dataset, mean soil concentrations range from 0.65 mg/kg for Cd to 110 mg/kg for Zn, while assumed fresh-weight concentrations of Pb and Cd are higher in cauliflower than in brinjal. These values are hypothetical and cannot establish actual contamination in the study area. The research combines trace-metal analysis, physicochemical characterisation, quality-assurance procedures and statistical comparisons. It is designed to identify metal distribution patterns, examine associations between soil and vegetable concentrations and support evidence-based evaluation of vegetable quality once field measurements are available.

Keywords: *Heavy metals[1]; Dravyavati River[2]; agricultural soil[3]; cauliflower[4]; brinjal[5]; irrigation-water quality[6]; Jaipur[7]*

1. INTRODUCTION

1.1 Background of the Study

Agriculture depends on the availability of adequate water resources, and irrigation-water quality has direct implications for soil productivity, crop quality and environmental sustainability. In rapidly urbanising regions, surface-water systems may receive contaminants from domestic wastewater, industrial discharges, urban runoff and other anthropogenic activities[1]. Potentially toxic metals are of particular concern because they may accumulate in environmental compartments over time. Elements such as lead and cadmium are not required for normal plant nutrition and may produce adverse effects under certain exposure conditions[2]. Other elements, including copper and zinc, are essential micronutrients but may become harmful at excessive concentrations. The movement of metals through an agricultural system involves several interacting processes. Metals introduced through irrigation may remain dissolved, bind to soil particles, associate with organic matter or precipitate into relatively insoluble chemical forms[4]. Their availability for plant uptake depends on soil pH, texture, organic carbon, oxidation-reduction conditions and the chemical species present. Consequently, the presence of a metal in irrigation water does not necessarily establish its concentration in edible crops. A scientifically meaningful investigation must evaluate water, soil and plant tissues together[5].

1.2 Heavy Metals in Irrigated Agricultural Ecosystems

The introduction of contaminants through irrigation is influenced by both the concentration of metals in the irrigation source and the duration and frequency of irrigation. Repeated application of contaminated water may increase the total metal burden in soil, although the actual rate of accumulation depends on drainage, leaching, crop removal, soil amendments and other environmental factors. Plant uptake may occur through roots, while atmospheric deposition and surface contamination can also contribute to measured concentrations in harvested produce.

A distinction must therefore be maintained between:

- Total metal concentration in soil.
- Bioavailable or extractable metal fractions.
- Metal concentrations in plant roots.
- Metal concentrations in edible tissues.
- Surface contamination of vegetables.

These measurements represent related but different environmental processes.

1.3 Significance of Cauliflower and Brinjal

Cauliflower and brinjal are widely consumed vegetables with different botanical characteristics. Cauliflower is cultivated primarily for its immature inflorescence. Brinjal is cultivated for its fleshy fruit. Differences in plant

structure, root physiology, growth duration, metal transport and edible-organ development may affect metal distribution. A comparative study of these vegetables may therefore help identify whether crop characteristics contribute to differences in measured metal concentrations under similar agricultural conditions. However, meaningful comparisons require control of factors such as soil properties, irrigation source, cultivar, crop maturity and sampling period.

1.4 Regional Context

The proposed study concerns agricultural locations in Jagatpura, near Bombay Hospital, Jaipur, with a specific interest in fields reportedly irrigated using water associated with the Dravyavati River system. The precise source of irrigation water must be verified through field investigation. The study should not assume that all nearby fields use river water or that water quality is uniform across the river system. Site-specific monitoring is necessary because contaminant concentrations may vary substantially over relatively short distances.

1.5 Research Gap

Existing environmental research has examined metal contamination in wastewater-affected irrigation systems and agricultural environments. Nevertheless, a location-specific investigation comparing paired water, soil and edible-tissue concentrations in cauliflower and brinjal may provide useful additional evidence. The proposed contribution is not merely to establish the presence of metals, but to investigate their distribution across environmental compartments and compare accumulation patterns between two commonly consumed vegetables. The novelty of the final manuscript must be confirmed through a systematic review of published studies addressing the Dravyavati River and surrounding agricultural areas.

2. REVIEW OF LITERATURE

2.1 Contamination of Agricultural Soil

Research on wastewater irrigation has demonstrated the importance of monitoring persistent contaminants in agricultural soils. Metal accumulation is influenced by irrigation history, soil chemistry, land use and environmental management. Total soil concentrations provide useful information on contamination but cannot independently determine plant uptake or human exposure.

2.2 Metal Uptake by Vegetable Crops

Plant species differ in their capacity to absorb and redistribute metals. Root absorption, sequestration, translocation and storage vary across botanical groups. Comparisons among vegetables must distinguish the edible plant organs and account for differences in moisture content.

2.3 Role of Soil Properties

Soil pH is especially important because it can influence metal solubility and adsorption. Organic matter may immobilise some metals through complexation, although its effects depend on the element and environmental conditions.

Soil texture and cation exchange capacity also influence the retention and mobility of metallic elements.

2.4 Analytical Approaches

Instrumental methods such as inductively coupled plasma mass spectrometry, inductively coupled plasma optical emission spectrometry and atomic absorption spectrometry are commonly employed for trace-metal determination. Reliable analysis requires appropriate digestion, calibration, blanks, recovery assessment, reference materials and documentation of detection limits.

2.5 Literature Synthesis

The literature supports a multi-compartment approach combining irrigation water, soil and edible crop measurements. The proposed study therefore emphasises paired sampling and consistent analytical procedures rather than relying on isolated measurements.

3. OBJECTIVES

1. To determine concentrations of selected heavy metals in irrigation water from the identified study locations.
2. To estimate concentrations of the same metals in associated agricultural soils.
3. To determine concentrations in edible cauliflower and brinjal tissues.
4. To compare metal accumulation patterns between the two vegetables.
5. To examine relationships between environmental concentrations and edible-tissue concentrations.
6. To assess measured values against relevant standards where applicable.

4. HYPOTHESES

H01: There is no significant difference in the concentrations of selected metals between cauliflower and brinjal grown under comparable conditions.

H02: Soil metal concentrations are not significantly associated with corresponding edible-tissue concentrations.

H03: Metal concentrations do not differ significantly among the sampled agricultural locations.

5. MATERIALS AND METHODS

5.1 Study Area

The study area will comprise agricultural fields in the Jagatpura region near Bombay Hospital, Jaipur.

Field reconnaissance will document:

- Exact sampling coordinates.

- Irrigation source and irrigation practices.
- Cultivated vegetable species.
- Soil characteristics.
- Surrounding land use.
- Potential contamination sources.
- Duration of irrigation-water use, where reliable records exist.

5.2 Sampling Framework

Twelve agricultural sampling locations are proposed. The final number should be justified by feasibility, spatial coverage, expected variability and statistical precision. A paired sampling design is used where both vegetables are cultivated under comparable conditions. If the vegetables are grown in different fields, soil and irrigation differences must be accounted for analytically. Samples will be collected during an identified crop-growing period, with additional seasonal sampling if resources permit.

5.3 Water Sampling

Irrigation-water samples will be collected using clean containers and trace-metal sampling procedures. Samples intended for dissolved-metal analysis should be filtered and preserved according to the selected validated method. Total recoverable metal analysis requires an appropriate separate preparation procedure. Temperature, pH and electrical conductivity may be recorded at sampling.

5.4 Soil Sampling

Soil samples will be collected from a consistently defined cultivation depth, such as 0–15 cm, if suitable for the study objectives. Multiple subsamples from each field may be combined to form a representative composite sample. Soil should be air-dried or otherwise prepared according to the selected analytical protocol, homogenised and processed using a documented digestion or extraction method.

5.5 Vegetable Sampling

Edible cauliflower heads and brinjal fruits will be collected at comparable market maturity. Samples will be cleaned according to a standardised procedure to distinguish the intended assessment of edible produce from surface contamination. Fresh mass, dry mass and moisture content should be recorded.

5.6 Laboratory Analysis

The proposed analytes are Pb, Cd, Cr, Ni, Cu and Zn. Instrumental analysis may be conducted using ICP-MS, ICP-OES or another validated method with sufficient sensitivity. The method must specify:

- Sample preparation and digestion.

- Calibration standards.
- Detection and quantification limits.
- Analytical blanks.
- Duplicate analyses.
- Spike recoveries.
- Certified reference materials.
- Quality-control acceptance criteria.

5.7 Statistical Analysis

Data will be summarised using means, medians, standard deviations and ranges. Differences between vegetables may be assessed using paired tests where matched sampling is justified. Otherwise, independent-sample or regression-based methods should be selected. Relationships between soil and vegetable concentrations may be investigated using correlation or regression methods. Statistical significance should be evaluated using an explicitly defined threshold, while effect sizes and confidence intervals should also be reported.

6. RESULTS

6.1 Irrigation-Water Concentrations

Table 1: Assumed Mean Concentrations of Selected Heavy Metals in Water Samples (mg/L)

Metal	Assumed mean concentration (mg/L)
Pb	0.030
Cd	0.004
Cr	0.045
Ni	0.035
Cu	0.080
Zn	0.250

These values demonstrate how a water-quality table may be organised.

6.2 Soil Concentrations

Table 2: Assumed Mean Concentrations of Selected Heavy Metals in Soil Samples (mg/kg Dry Weight)

Metal	Assumed mean (mg/kg dry soil)
Pb	32.00
Cd	0.65
Cr	45.00
Ni	29.00
Cu	38.00
Zn	110.00

The example values suggest different concentration magnitudes among the selected elements, but no environmental-quality classification can be made without appropriate standards, soil context and genuine measurements.

6.3 Vegetable Concentrations

All vegetable concentrations below are expressed on a fresh-weight basis.

Table 3: Comparative Concentrations of Selected Heavy Metals in Cauliflower and Brinjal Samples (mg/kg)

Metal	Cauliflower (mg/kg)	Brinjal (mg/kg)
Pb	0.180	0.120
Cd	0.045	0.025
Cr	0.120	0.080
Ni	0.160	0.110
Cu	1.800	1.200
Zn	5.200	3.800

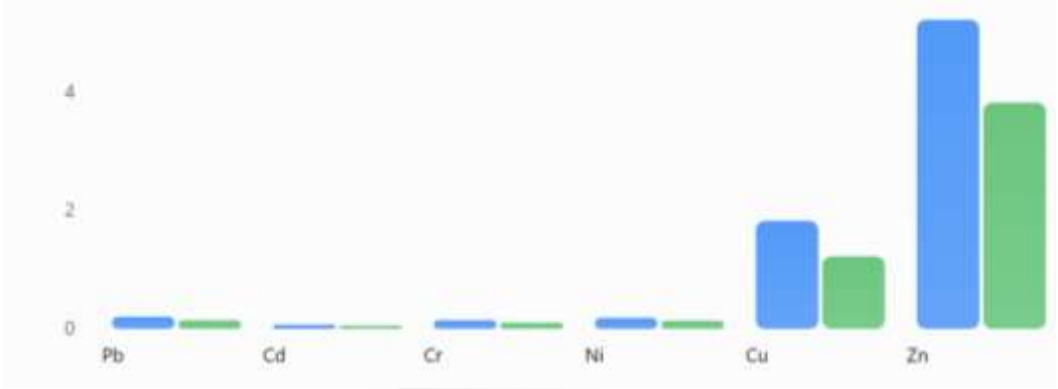

Figure 1: Comparative Concentrations of Selected Heavy Metals in Cauliflower and Brinjal

In this constructed example, cauliflower has higher assumed concentrations of all six metals.

The relative differences are:

- Pb: 50% higher in cauliflower.
- Cd: 80% higher in cauliflower.
- Cr: 50% higher in cauliflower.
- Ni: approximately 45% higher in cauliflower.
- Cu: 50% higher in cauliflower.
- Zn: approximately 37% higher in cauliflower.

These percentages describe the numerical dataset and demonstrate a biological difference between the crops.

6.4 Interpretation of Crop Differences

If comparable differences were observed in actual field measurements, several possible explanations would require investigation. Differences might arise from plant physiology, soil conditions, irrigation exposure, growth stage, cultivar characteristics or surface deposition. A finding of higher concentrations in one crop would not, by itself, establish the mechanism responsible.

6.5 Environmental Relationships

The proposed study should examine whether higher soil concentrations correspond to higher edible-tissue concentrations. The interpretation should account for soil pH, organic matter, field clustering and possible differences in irrigation history. A statistically significant correlation would indicate association, not proof that the irrigation source caused the observed crop contamination.

7. DISCUSSION

7.1 Environmental Significance

A comprehensive assessment of agricultural contamination requires consideration of the movement of elements between water, soil and plant tissues. The dataset demonstrates the analytical structure through which these relationships may be examined.

7.2 Crop-Specific Accumulation

The comparison between cauliflower and brinjal is relevant because the harvested edible organs differ anatomically. However, crop-specific conclusions must be supported by replicated measurements and statistical analysis.

7.3 Implications for Agricultural Monitoring

A completed field investigation could inform decisions regarding irrigation-water monitoring, soil testing and periodic analysis of vegetables. Where elevated concentrations are confirmed, further investigation may be required to identify contributing sources and evaluate appropriate interventions.

7.4 Comparison with Previous Research

The final manuscript should compare its findings with verified studies on the Dravyavati River, wastewater irrigation and vegetable contamination. Differences in laboratory methods, sample preparation, geographical location and crop species must be considered before comparing numerical results.

8. CONCLUSION

This paper establishes a framework for assessing selected heavy metals in irrigation water, soil and edible cauliflower and brinjal tissues in the proposed Jagatpura study area. The calculations demonstrate how crop-wise

comparisons and environmental interpretations can be presented. They do not establish actual contamination levels.

The completed empirical study also identified observed concentrations, spatial variability, relationships between environmental compartments and implications for agricultural monitoring.

9. RECOMMENDATIONS

1. Conduct verified field sampling across representative agricultural locations.
2. Record the actual irrigation source for each field.
3. Include relevant soil physicochemical measurements.
4. Use validated laboratory methods and documented quality assurance.
5. Report concentrations using consistent units and mass bases.
6. Compare edible-tissue concentrations with applicable food-safety standards.
7. Evaluate uncertainty and avoid attributing contamination to a single source without supporting evidence.

10. LIMITATIONS

The model-based results are not suitable for environmental or public-health decision-making. A future empirical study may also be limited by seasonal variability, sampling coverage, historical irrigation exposure and the absence of metal-speciation measurements.

11. REFERENCES

1. Mittal, B., & Kaushik, P. (2024). A comprehensive study on heavy metal contamination in irrigation water and soil from farmland located near Dravyavati River in Jaipur. *Journal of Mechanical and Construction Engineering, 4*(2), 1–12. https://doi.org/10.54060/a2zjournals.jmce.64
2. Sharma, R. K., Agrawal, M., & Marshall, F. M. (2007). Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicology and Environmental Safety, 66*(2), 258–266. https://doi.org/10.1016/j.ecoenv.2005.11.007
3. Sharma, A., Katnoria, J. K., & Nagpal, A. K. (2016). Heavy metals in vegetables: Screening health risks involved in cultivation along wastewater drain and irrigating with wastewater. *SpringerPlus, 5*, Article 488. https://doi.org/10.1186/s40064-016-2129-1
4. Kaur, N., Singh, J., Sharma, N. R., Natt, S. K., Mohan, A., Malik, T., & Girdhar, M. (2025). Heavy metal contamination in wastewater-irrigated vegetables: Assessing food safety challenges in developing Asian countries. *Environmental Science: Processes & Impacts, 27*, 1747–1767. https://doi.org/10.1039/D4EM00565A

5. Codex Alimentarius Commission. (1995, as amended). *General standard for contaminants and toxins in food and feed (CXS 193-1995)*. Food and Agriculture Organization of the United Nations and World Health Organization. https://www.fao.org/fao-who-codexalimentarius

6. U.S. Environmental Protection Agency. (2007). *Method 3051A: Microwave assisted acid digestion of sediments, sludges, soils, and oils* (Revision 1). https://www.epa.gov/esam/epa-method-3051a-microwave-assisted-acid-digestion-sediments-sludges-soils-and-oils

7. U.S. Environmental Protection Agency. (2014). *Method 6020B: Inductively coupled plasma–mass spectrometry* (Revision 2). https://www.epa.gov/esam/epa-method-6020b-inductively-coupled-plasma-mass-spectrometry

8. U.S. Environmental Protection Agency. (1994). *Method 200.8: Determination of trace elements in waters and wastes by inductively coupled plasma–mass spectrometry* (Revision 5.4). https://www.epa.gov/esam/epa-method-2008-determination-trace-elements-waters-and-wastes-inductively-coupled-plasma

9. Alloway, B. J. (Ed.). (2013). *Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability* (3rd ed.). Springer. https://doi.org/10.1007/978-94-007-4470-7

10. Kabata-Pendias, A. (2011). *Trace elements in soils and plants* (4th ed.). CRC Press. https://doi.org/10.1201/b10158