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Occurrence and Tissue-Specific Distribution of Arsenic and Other Potentially Toxic Elements in Retail Meats: Implications for Dietary Risk Assessment

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INTRODUCTION & AIM

Potentially toxic elements (PTEs) can enter the food chain through contaminated soil, water, feed, and atmospheric deposition, creating a public health concern in meat-producing regions.

In Pakistan, evidence on tissue-specific and species-specific contamination of retail meat remains limited, especially across multiple cities and both liver and muscle tissues.

To quantify arsenic (As) and seven other PTEs in chicken, mutton, and beef, compare accumulation patterns across tissue types and cities, and assess dietary exposure and non-carcinogenic health risk using EDI, THQ, and HI.

METHOD

- Ninety-two paired liver and muscle samples were collected from retail markets and slaughter sources in Peshawar, Islamabad, Gujrat, and Lahore during 2022–2023.
- Samples were dried, digested, and analyzed using ICP-MS for Cd, As, Cr, Ni, Pb, Mn, Cu, and Zn. Statistical analysis included normality testing, group comparisons, Spearman correlation, and PCA to examine tissue-specific, species-specific, and city-specific patterns.
- Dietary exposure was estimated using conservative low- and high-consumption scenarios, and non-carcinogenic risk was evaluated with THQ and HI.

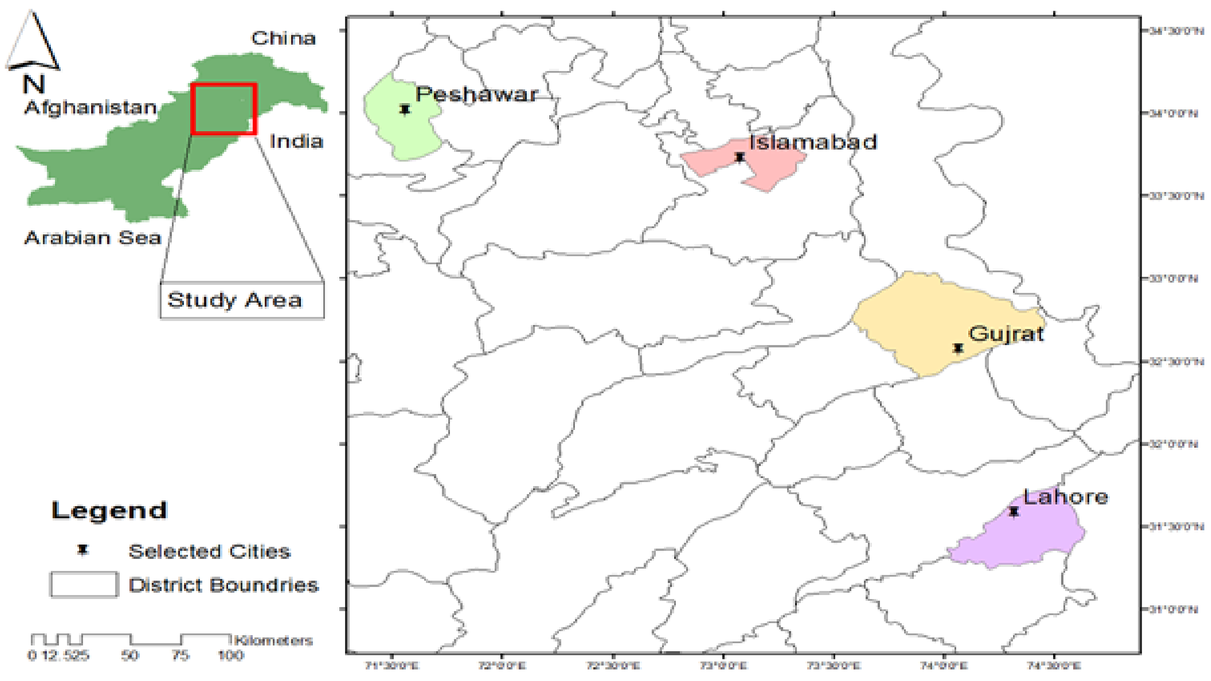

Figure 1. Geographical location of the study area in Pakistan, showing the four selected sampling cities (Peshawar, Islamabad, Gujrat, and Lahore) highlighted in different colors.

RESULTS & DISCUSSION

- Overall, the concentration trend in both liver and muscle was **Zn > Cu > Mn > Cr > Ni > Pb > As > Cd**.
- Beef liver showed the highest contamination burden, with elevated levels of Pb, Cu, and Cd in many samples.
- Liver generally accumulated more Cu, Mn, Cd, and Pb, while muscle often showed higher As, Ni, Zn, and Cr.
- Among species, beef samples showed the most pronounced contamination, while chicken was generally lower except for elevated Cr in some muscle samples.
- City-wise variation suggested different contamination patterns across Lahore, Islamabad, Gujrat, and Peshawar.
- Correlation and PCA indicated three likely co-variation patterns: geogenic groundwater influence for As, Cr, and Ni; atmospheric/ industrial dust for Pb, Cd, and Mn; and feed-related inputs for Zn and Cu, particularly in poultry.
- Risk assessment showed that high-consumption scenarios produced THQ values above 1 for As, Cr, Cu, and Zn in selected meat types.
- The cumulative hazard index exceeded 1 in all high-consumption scenarios, suggesting potential combined non-carcinogenic risk.
- These findings indicate that frequent consumption of beef, especially liver and muscle, may contribute to chronic dietary exposure.

CONCLUSION

- ✓ Retail meats from the studied cities contain measurable levels of PTEs, with clear tissue-specific and species-specific accumulation patterns.
- ✓ Beef, especially liver, appears to be the most important contributor to chronic exposure risk, while chicken muscle was generally less contaminated except for Cr.
- ✓ The results support the need for routine monitoring, improved feed and water quality control, and targeted risk mitigation in livestock production systems.

FUTURE WORK

- Future studies should include arsenic speciation, fresh-weight reporting, and broader environmental sampling to better confirm contamination sources.
- Additional data on animal age, sex, breed, and farming data would improve interpretation of accumulation patterns.
- Future studies should include more locations to assess spatial variability in meat contamination.