Occurrence and distribution of manganese in drinking water in India and implications for population health: preliminary results

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Introduction

- Manganese is a geogenic trace metal that can cause health concerns including neurologic issues when consumed at high concentrations in domestic and agricultural water, including drinking water.
- The WHO establishes a provisional guideline of 80 µg/L and the US EPA establishes a Secondary Maximum Contaminant Level (SMCL) of 50 µg/L.[1,2]
- India is the world's largest user of groundwater, which accounts for 80% of domestic usage. It is also the second largest country by population, with a population of 1.4 billion people in 2023.

Methods

- The Water Institute is conducting a systematic review of 3,500+ studies on waterborne toxic metals in low- and middle-income countries.
- This nested sub-review relied on 20 India-focused studies, yielding 63 individual drinking water samples and 83 aggregated observations.
- Data on manganese concentration, season of sample collection, water system type, population of study area, subnational location, and geographic coordinates were extracted from each study.
- Exceedance was calculated based on the WHO provisional guideline of 80 µg/L and the US EPA Secondary Maximum Contaminant Level (SMCL) of 50 µg/L. The 2023 projected population based on the 2011 Indian census was used for analysis.
- These data were analyzed using R statistical software with an alpha level of 0.05 and mapped with ArcGIS Pro.

Results

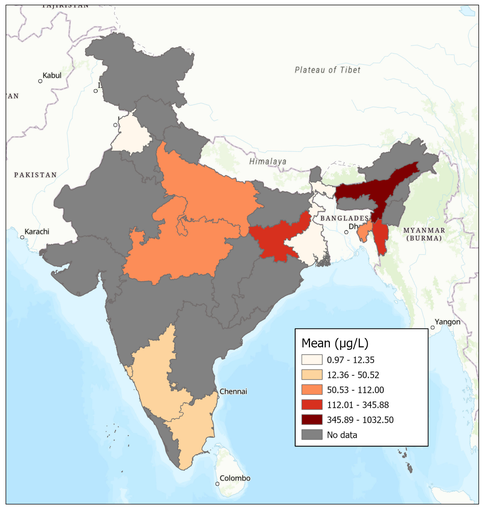

Figure 1: Mean Mn levels by states in India

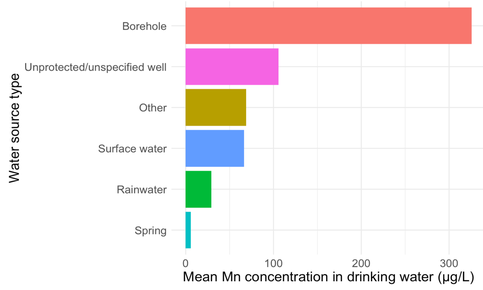

Figure 2: Mean Mn levels by water source type defined by the Joint Monitoring Programme[3]

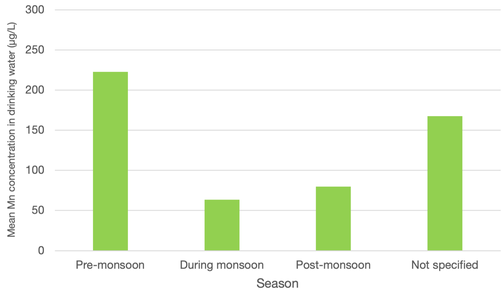

Figure 3: Mean Mn levels by time relating monsoon season

- For all water samples analyzed across India (**Figure 1**), the mean manganese concentration was 163.6 µg/L with a standard deviation of 314.4 µg/L.
- Measurements varied from 0.80 µg/L and 2733.6 µg/L.
- Boreholes and other groundwater sources have the highest average Mn concentrations.
- Averages in samples collected were highest before the monsoon.
- 11 out of 18 districts sampled had concentrations exceeding the WHO guideline, and 14 districts had concentrations exceeding the EPA SMCL (**Table 1**).
- Based on a two-sided t-test, boreholes, surface water, and unspecified/ unprotected wells were significantly associated with manganese levels ($p < 0.001$) (**Figure 2**).
- Monsoons were not associated with any change in contamination, based on an ANOVA test ($p = 0.19$) (**Figure 3**).

Table 1: Population of districts with at least one observation in current study

State	District	Population
Assam	Darrang	2,273,200
Chhattishgarh	Rajnandgaon	84,640,000
Goa	*NA*	3,172,500
Jharkhand	East Singhbhum	47,700,000
Karnataka	Bengaluru City	11,750,000
Madhya Pradesh	Singrauli	3,020,000
Mizoram	Kolasib	1,822,400
Odisha	Cuttack City	2,520,000
Punjab	Bathinda	3,260,000
	Muktsar	2,093,000
	Patiala	4,540,000
Tamil Nadu	Thoothukudi	1,940,000
Tripura	West Tripura	9,700,000
Uttar Pradesh	Aligarh	157,850,000
	Deoria	3,540,000
Uttarkhand	Pithoragarh	1,010,600
West Bengal	Murshidabad	25,830,000
	Nadia	5,790,000
Grand Total		**372,451,700**

Mean manganese concentration exceeding WHO or EPA guidelines

Conclusions

- Significant relationships between boreholes and other wells and high manganese contamination is likely caused by groundwater contamination.
- Manganese is a geogenic compound and therefore would not be greatly affected by monsoon weather, consistent with previous findings.
- 16 of the 20 studies were assumed to be conducted not based on known contamination. If manganese levels in other areas are similar to these results, its contamination in drinking water is a potential health concern in large portions of India's population.
- Through the Jal Jeevan Mission and expanding access to piped drinking water, it would be important to monitor Mn concentrations in new drinking water systems.[4]
- Major limitations included small sample size, inconsistent/unclean data, and data aggregation.

References

1. World Health Organization (2022). *Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda.*
2. United States Environmental Protection Agency (2004). *Drinking Water Health Advisory for Manganese.*
3. Joint Monitoring Programme (n.d.). Drinking water. https://washdata.org/monitoring/drinking-water
4. Jal Jeevan Mission. Accessed April 21, 2023. https://jaljeevanmission.gov.in/about_jjm