Supporting Information: Hydrogeochemical data for groundwater remediation systems in Bihar, India, 2018-2022

Data Identifier: 77700f8e-5da6-45ab-9c12-df1a7d20bc32

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Collection/generation methods:

Study area & sampling strategy

Water samples were collected in 2019 from remediation systems (n = 31) located in the State of Bihar in the Middle Gangetic Plain, India, within the following districts: Patna (n = 18); Buxar (n = 3); Gaya and Katihar (n = 2 each); and Aurangabad, East Champaran, Nawada, Munger and Vaishali (n = 1 each). Further samples collected from one system located in Ballia District (Uttar Pradesh) were also included in this study because of the proximity of the study site to Bihar and their co-existence in the Mid Ganga Plain.

Samples from remediation systems were collected opportunistically within the framework of a larger stratified random groundwater sampling campaign systematically encompassing all districts of Bihar (Richards et al., 2020). The wider groundwater sampling campaign involved sampling of ~300 tubewells distributed across Bihar (Richards et al., 2020) and the identified mitigation units reported in this current study are generally indicative of the frequency and types of mitigation systems encountered during random groundwater sampling (noting that more units were more commonly encountered in urban areas such as Patna). Upon arrival at a particular location the field team asked locally if there were any remediation systems present in the surrounding households or community. Sampling was then undertaken if remediation systems were identified and access was granted. Importantly this meant that all samples were collected under "spot check" conditions, under typical operating conditions for that particular system/setting, and where owners or overseers had no prior knowledge that sampling was to take place. In a limited number of cases in Buxar and Patna, sampling was carried out on remediation systems already known to exist by members of the research team. The higher proportion of samples collected in Patna district reflected both the higher density of groundwater sampling points in Patna as well as Patna being an urban area where household point of use water treatment systems are more prevalent.

We use the term "remediation" as a broad term to encompass multiple potential approaches for the mitigation of one of more groundwater contaminants to minimize risks for human health. This may include the implementation of point-of-use water treatment systems (as largely reported here) as well as other options, for example switching to a less-contaminated source (which potentially may not require any water treatment technology).

Remediation system sampling & characterization

For each remediation system identified, subsamples of (i) untreated groundwater sources used as the system feed/inlet and (ii) corresponding finished product/outlet water were sought to be collected. Some additional packaged water from local suppliers was also sampled, as packaged water supplies can also be considered a remediation approach, although the corresponding inlet groundwater was not possible to sample. Inlet water samples were typically collected either directly from corresponding handpumps, using methods previously published (Richards et al., 2020), or from household taps connected directly to the untreated groundwater source. Outlet water samples were collected directly from system outlets or from the nearest point of access (in some cases this was

from the outlet of a connected storage vessel). All samples were collected in plastic beakers which were thoroughly sample rinsed between samples.

Samples for subsequent laboratory analysis of major and trace cations and anions were filtered (0.45 μm cellulose/polypropylene syringe filers) upon collection and stored in glass bottles. Samples for cation and trace metal(loid) analysis were acidified (2% trace grade HNO3) after transport and arrival at the University of Manchester laboratories (Manchester Analytical Geochemistry Unit), due to HNO3 transport restrictions. Further sampling details are provided elsewhere (Richards et al., 2020).

Chemical analysis (laboratory)

Chemical analysis of major and trace elements was undertaken at the Manchester Analytical Geochemistry Unit (MAGU). Inductively coupled plasma mass spectrometry (ICP-MS, Agilent 7500cx) was used for the analysis of As, U and Zn. Inductively coupled plasma atomic emission spectrometry (ICP-AES, Perkin-Elmer Optima 5300 dual view) was used for the analysis of Fe, P, Ca, Mg, Mn, Na, K and Si. Further analytical method details and information on quality assurance/quality control are provided elsewhere (Richards et al., 2020).

Nature and Units of Recorded Values:

Included on datafile in column headers. For further information:

Short Column Name (on datafile)	Column	Further details	Units
System_ID	A	ID number of remediation system	Not applicable
As_Retention_%	B	Calculated arsenic retention, where arsenic retention (%) = $(1 - (C_{outlet,As}/C_{inlet,As}))*100$; where $C_{outlet,As}$ is outlet concentration of As and $C_{inlet,As}$ is inlet concentration of As	%
Tech_Type_Code	C	Identification of type of remediation technology; 1 = reverse osmosis or other membrane system; 2 = non reverse osmosis or other membrane system	Not applicable
Setting_User_Type_Code	D	Identification of type of setting/user; 3 = household (HH); 4 = non-household (non-HH)	Not applicable

Fe_Inlet_ppm	E	Measured Fe concentration in inlet water	ppm
P_Inlet_ppm	F	Measured P concentration in inlet water	ppm
As_Inlet_ppb	G	Measured As concentration in inlet water	ppb
Ca_Inlet_ppm	H	Measured Ca concentration in inlet water	ppm
Mg_Inlet_ppm	I	Measured Mg concentration in inlet water	ppm
Na_Inlet_ppm	J	Measured Na concentration in inlet water	ppm
Si_Inlet_ppm	K	Measured Si concentration in inlet water	ppm

Note this data relates to remediation samples only where paired inlet-outlet data are available (a full description is included in the associated full publication). Values below detection/non-detects have been input as 0.1 ppb for As (ICP-MS) and 0.001 for Fe and P (ICP-AES).

Details of data structure:

Spreadsheet containing data for 31 remediation systems in Bihar, India, including As retention, technology category, setting category, and water inlet composition (selected parameters Fe, P, As, Ca, Mg, Na and Ni). There are 11 columns of data.

Quality control:

Further details of quality control are described in Richards et al 2022.

References:

Richards, L.A.; Kumar, A.; Shankar, P.; Gaurav, A.; Ghosh, A.; Polya, D.A. (2020) Distribution and Geochemical Controls of Arsenic and Uranium in Groundwater-Derived Drinking Water in Bihar, India. Int. J. Environ. Res. Public Health 17, 2500. https://doi.org/10.3390/ijerph17072500

Richards, L.A.; Parashar, N.; Kumari, R.; Kumar, A.; Mondal, D.; Ghosh, A.; Polya, D.A. (2022) Household and community systems for groundwater remediation in Bihar, India: Arsenic and inorganic contaminant removal, controls and implications for remediation selection, Science of the Total Environment, Volume 830, 154580, https://doi.org/10.1016/j.scitotenv.2022.154580