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Effects of organic and inorganic colloids on iodine mobilization in groundwater of the Datong Basin, northern China

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Abstract

In order to identify the effects of groundwater colloids on iodine mobilization in aquifer system, nine groundwater samples were in-situ filtered through successive pore-sized membranes (0.45 μm, 30 kDa and 5 kDa) using filtration technique under N_2 atmosphere. Obvious decrease in groundwater iodine, Fe, Al and DOC was observed in the larger pore-sized fractions, indicating that groundwater iodine is closely associated with larger Fe-Al colloids. The analysis result of sample DT15-27 suggests that the extremely reducing condition could promote iodine dissolved in the truly dissolved phase. For low iodine groundwater, no good correlation between iodine and Fe, Al, DOC was observed for all sequential filtration steps, suggesting that groundwater iodine is trapped in the truly dissolved phase because of competitive adsorption of iron/aluminum.

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Keywords: Colloids; iodine; moblization; Datong.

1. Introduction

Iodine contamination has become a "hotspot" of environmental studies due to consumption of iodine contaminated groundwater can cause public health problems. Great efforts have been made to understand the mechanisms of iodine mobilization and enrichment in soil and aquatic systems. Currently, numerous studies focused on iodine in marine and/or radionuclide-contaminated areas and it is seldom to report the cases of high iodine groundwater from island areas such as the Datong Basin, northern China. Previous studies[1, 2] have characterized that the redox environment of groundwater system strongly control the iodine release from sediments into groundwater, and iodine mobilization in groundwater was related to the nature of dissolved organic matter in the Datong Basin. However, these opinions need more microcosmic evidences. Especially, the important contribution of colloids to

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groundwater iodine mobilization was lacked.

The Datong basin, a Cenozoic rift basin, is located in the northern semi-arid region of China with annual average rainfall of 300-400 mm and evaporation above 2000 mm. 75% to 85% of the rainfall occurs from July to August and the main surface water Sanggan River is ephemeral. It's surrounded by the Hengshan Mountain and Hongshou mountain ranges, the basin mainly includes Pliocene to Pleistocene unconsolidated sediments of various depths from 1500 m to 3500 m and the grain size of the sediment generally decreases from the margin to the center of the basin. Quaternary groundwater systems are mainly comprised of the alluvial–pluvial, lacustrine and alluvial–lacustrine aquifers and can be divided into three groups: upper (5–60 m), middle (60–160 m) and lower aquifers (>160 m).

2. Methodology

According to the spatial distribution of groundwater chemistry[2], nine groundwater samples from domestic and agricultural irrigation wells were collected in August, 2015. The well depth ranged from 20 to 130m, including 4 shallow wells (< 60m) and 5 middle-deep wells (> 60m). The in-situ parameters, including pH, temperature (T) and redox potential (Eh) were monitored after 20L water was pumped out from each well. Then groundwater samples were collected into several 1L glass bottles after being filtered through a 0.45 μm cellulose nitrate filter and successively nominal molecular weight cutoffs (MWCO) of 30 kDa (fraction "<30 kDa"), 5 kDa (fraction "<5 kDa") within 10 h, respectively. Elements in the fraction "<5 kDa" were assumed to be truly dissolution. The samples for cation and trace element analysis were acidified using ultra-purified HNO_3 to pH<2, and samples for anion analysis were collected directly after filtering. Samples for iodine species, dissolved organic carbon (DOC) analysis were collected in pre-cleaned amber glass sampler vials without headspace, and stored in the dark until analysis. Alkalinity was measured in the field within 24h by titration. All the chemistry analyses above were performed in the State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan).

3. Results and discussion

Table 1 and 2 and Fig. 1-3 show the results of samples with each filtration step. According to the variations of I_T, Fe, Al and DOC concentration, nine groundwater samples are divided into three groups: group 1 (G1: DT15-10, DT15-16 and DT15-17), group 2 (G2: DT15-27), and group 3 (G3: DT15-22, DT15-29, DT15-36, DT15-39 and DT15-43). Samples DT15-10, DT15-16, DT15-17 and DT15-27 have high iodine concentrations (> 150 μg/L) and are located in the center of Datong basin. Notable variations in I_T and DOC concentrations are observed between 0.45 μm and 5 kDa in DT15-10, DT15-16 and DT15-17, while for DT15-27, a sharp decrease in DOC concentration but unvaried I_T is observed in the higher pore-sized fractions (0.45 μm to 30 kDa). G3 samples generally have relative lower iodine concentrations (< 150 μg/L) from the margin area of Datong basin.

Table 1 Physio-chemical characteristics of studied groundwater (0.45μm filtrates) in the Datong Basin of Shanxi Province.

No.	Depth (m)	pH	Eh (mV)	T (°C)	HCO_3^- (mg/L)	I_T (μg/L)	DOC (mg/L)	Fe^{3+} (μg/L)	Al^{3+} (μg/L)
DT15-10	92	7.90	-170	12.6	968	1055	69.1	20.6	22.4
DT15-16	40	7.88	16.2	11.3	1087	419	80.9	52.2	185
DT15-17	20	7.63	-9.3	14.9	824	1065	36.0	175	27.7
DT15-22	130	7.70	49.2	15.9	311	11.19	0.914	226	0
DT15-27	85	7.83	-122	12.9	432	1067	70.3	85.8	2.96
DT15-29	60	7.79	-200	15.2	737	137	5.73	262	5.17
DT15-36	60	8.02	-97.0	12.8	408	183	4.86	96.1	15.4
DT15-39	120	8.13	-71.6	16.5	216	171	2.44	123	5.97
DT15-43	120	8.48	-216	16.4	341	179	3.02	99.8	1.96

For group one, obvious variation appears in concentrations of Fe, Al and DOC for 0.45 μm filtered and 5 kDa ultrafiltered samples apparently (Fig. 1a-c). A large amount of these components exists in 0.45 μm filtered samples in comparison with 5 kDa ultrafiltered samples, suggesting that part of them maintains as colloids in the groundwater (gain size between 5kDa and 0.45μm). Notable amount of DOC concentration retains in the colloids with the range from 21.8 mg/L to 38.3 mg/L, suggesting that more than 37% of NOM is associated with the fractions with colloids. In addition, similar trends are also observed for Fe and Al concentrations. The detained Fe and Al in 5 kDa ultrafiltered fractions account for 55.8-80.4% and 0-52.9% of that of 0.45μm filtrates, respectively. Interestingly, for Fe, Al and DOC, there is obvious drop of content in the larger pore-sized fractions (Fig. 1a-c). It