



Organic and inorganic colloids impacting total iodine behavior in groundwater from the Datong Basin, China



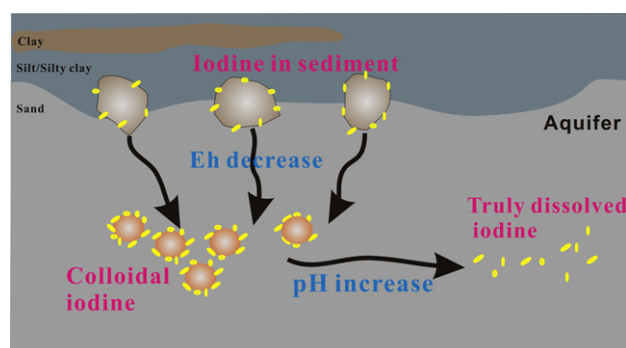
Kun Qian, Junxia Li, Xianjun Xie*, Yanxin Wang*

State Key Laboratory of Biogeology and Environmental Geology, School of Environmental Studies, China University of Geosciences, 430074 Wuhan, China

HIGHLIGHTS

- The effects of colloids on groundwater iodine mobilization were unraveled.
- Reducing conditions favored colloidal iodine release into groundwater.
- The increase of pH enhanced iodine desorption from colloids.
- Fe-OM colloids controlled iodine behavior in large grain size fractions.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 14 January 2017

Received in revised form 13 May 2017

Accepted 14 May 2017

Available online 30 May 2017

Editor: D. Barcelo

Keywords:

Colloids

Grain size fractionation

Iodine

Redox potential

Desorption

ABSTRACT

The geochemical behaviors of colloids in aquifers played an important role in determining the fate of iodine in groundwater system. To decipher the impact of colloids on iodine mobilization in aquifers, three successive pore-sized colloids filtration (0.45 μm , 30 kDa and 5 kDa) were conducted on in-situ during groundwater sampling. The results showed that the distribution ratios (f) of total iodine (I_T) and iron in the dissolved solution (i.e., 5 kDa ultrafiltered) were from 0.78 to 0.99 and from 0.56 to 0.94, respectively. Natural organic matter (NOM) in the colloidal fractions obtained the f values ranging from 0.14 to 1.00. The decreased Eh values from recharge area to discharge area indicated redox potential of groundwater system changed from oxidizing to reducing along groundwater flowpath, and interestingly, the corresponding iodine fractions in groundwater were decreasing in dissolved solution and increasing in colloidal fractions. Inverse correlation between Fe and DOC and positive correlation between iodine and DOC suggested the occurrence of reductive dissolution of iron oxyhydroxides and degradation of organic iodine in groundwater system. Iodine distribution increased in dissolved solution and decreased in colloids with pH increase. Moreover, as pH increased, f (Fe) and f (DOC) decreased in dissolved solution and increased in colloids. Relatively weak correlation of f (I_T) with f (Fe) and strong relationship between f (I_T) and f (DOC) in the large grain size fractions suggested the Fe-OM complexes controlled iodine distribution in groundwater, which depends on the presence of Fe bridges. Negligible association of iodine with Fe and NOM in the small grain size fractions might be attributed to the effects of abundant OH^- content in groundwater.

© 2017 Elsevier B.V. All rights reserved.

* Corresponding authors.

E-mail addresses: xjxie@cug.edu.cn (X. Xie), yx.wang@cug.edu.cn (Y. Wang).

1. Introduction

Iodine is necessary for the production of thyroid hormones and for the proper functioning of the thyroid gland. As an essential micronutrient in mammals, iodine deficiencies and excesses can lead to severe metabolic disorders, which have been a worldwide public health problem (Andersen et al., 2012; Laurberg, 2010). The presence of iodine in surface and groundwater has been widely reported. The relevant species including iodide, iodate and organically bound iodine, and their fate and behavior are totally different (Álvarez et al., 2015; Li et al., 2014; Xu et al., 2011a; Zhang et al., 2011). Togo et al. (2016) reported that high iodine groundwater (up to 34 mg/L) was found in the Pliocene Koetoi and late Miocene Wakkanai formations of the Horonobe area, northern Hokkaido, Japan and clarified the origin and migration of iodine in sedimentary rocks. In Denmark, high iodine groundwater was investigated and the spatial distribution patterns suggested that total iodine (I_T) higher than 40 $\mu\text{g/L}$ originated from postglacial marine and glacial meltwater sand and from Campanian - Maastrichtian aquifers (Voutchkova et al., 2014). A recent study conducted by Tang et al. (2013) found that the high iodine groundwater was distributed in arid/semi-arid inland areas of China with the average iodine concentration up to 1143 $\mu\text{g/L}$, exceeding the Chinese government recommended value of 150 $\mu\text{g/L}$ for iodine. The high iodine groundwater could be related to the unique topography, geomorphologic features and aquifer structures. They appointed the salinization, geological settings of the lacustrine and fluvial sediments as the reason for the high iodine concentration in the groundwater from the Taiyuan Basin (Tang et al., 2013). However, the investigation in the North China Plain found that the groundwater from the flood plain adjacent to the Yellow River, the Haihe River and the coastal plain around the Bohai bay had high-iodine concentration of up to 1901 $\mu\text{g/L}$, and the decomposition of organic matter within the aquifer system was the mechanism of iodine enrichment in groundwater (Zhang et al., 2013). The studies performed by Li et al. (2013, 2014) also suggested that elevated iodine concentration (as high as 1890 $\mu\text{g/L}$) observed in the Datong Basin, China could be contributed to the degradation of organic matter and reductive dissolution of iron oxyhydroxides.

The presence of natural organic matter (NOM) can significantly affect the geochemical behavior of iodine in the earth surface environment. The iodine in soils or sediments was thought to be bound predominantly to organic matter through formation covalent aromatic C—I bond (Xu et al., 2011a; Xu et al., 2011b). Some amount of the organic matter in the soils and sediments could be readily dispersible under some environmental conditions and presumably release iodine as the organic-iodine colloidal form (Xu et al., 2011b). Xu et al. (2012) also inferred that iodine dominated bound with humic acids (HAs), fulvic acids (FAs) and water extractable colloids (WEC). The WEC was dominated by organic colloidal fraction obtained from soil resuspension experiments and might be released during groundwater exfiltration, storm water or surface runoff. However, the laboratory modeling study usually underscored the importance of organic matter in soil as a sink (irreversible covalent binding) or a source (colloidal- and organic-iodine mobile species) for subsurface iodine (Chang et al., 2014).

Recently, it has been confirmed that a large number of iodine was linked with NOM and Fe (hydr)oxides in aquifer sediments (Dai et al., 2009). Under reducing conditions, biodegradation of I-bound NOM and reductive dissolution of Fe (hydr)oxides likely liberates considerable amounts of iodine into groundwater (Li et al., 2014; Pi et al., 2015). Therefore, it seemed that NOM and Fe jointly controlled the behavior of iodine within aquifer system to some degree. Tipping et al. (2002) reported Fe complexation capacities for natural waters ranging from 0.1 to 30 $\text{mmol Fe} (\text{mol C})^{-1}$. Bauer and Blodau (2009) proposed a high affinity of organic matter on Fe-(oxy)hydroxides surfaces (sorption capacity ranging from 15 to 66 $\mu\text{mol C} (\text{mmol Fe})^{-1}$). Pokrovsky et al. (2005) found that dissolved organic matter stabilized Al/Fe

colloids, indicating the presence of mixed organo-mineral colloids, and enhanced the effects of organo-mineral colloids on the trace elements transport in soil solutions.

High iodine groundwater has been reported in the Datong Basin, China with the I_T (total iodine) concentration up to 1890 $\mu\text{g/L}$ (Li et al., 2013). It is interesting to note that high iodine groundwater usually contained the relative high concentration of dissolved organic matter (ranging from <0.01 to 92.1 mg/L) and iron (ranging from <0.01 to 5.49 mg/L) (Li et al., 2014). In addition, the sediment samples from the borehole located at high iodine concentration area demonstrated that both shallow (depths: 15 to 20 m) and deep (depths: 85 to 90 m) aquifers contained high iodine contents (Li et al., 2013). The sediment bulk geochemical results also showed that high NOM and Fe_2O_3 samples were dominantly distributed at the depths of 15 to 20 m (shallow aquifer, TOC content 5.22%, Fe_2O_3 content 5.25%) and 85 to 90 m (deep aquifer, TOC content 2.13%, Fe_2O_3 content 5.73%). However, there is a very little information available in the literature on the possible formation of iodine-bearing colloids in groundwater (Xu et al., 2011b). Especially for the inland high iodine groundwater, it is essential to understand the mechanisms of colloids controlling iodine distribution and mobility in these areas.

Therefore, the objectives of this study are mainly to investigate the dissolved and colloidal (organic or inorganic) particles controlling iodine behavior in groundwater of the Datong Basin, China. The samples (ultra)filtered on site were analyzed to characterize the distribution of iodine and other organic/inorganic elements and subsequently elucidate the factors responsible for iodine mobility.

2. Study area

The Datong basin, one of the typical Cenozoic rift basins, is located in the semi-arid region of northwestern China (Fig. 1). Groundwater is the most important source for water supply at Datong Basin, which was over extracted up to 0.46 billion m^3/a (Xie et al., 2008). The area has an annual average rainfall of 225–400 mm and evaporation above

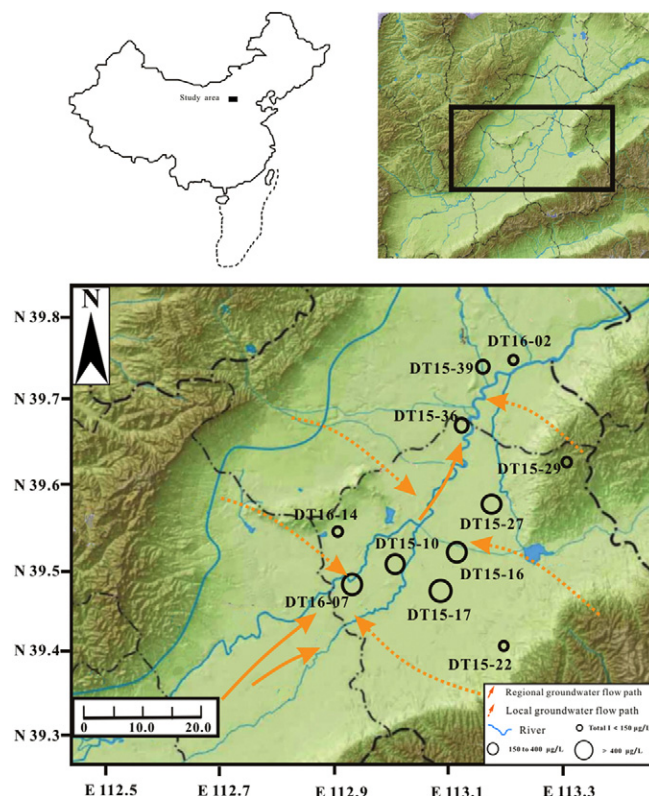


Fig. 1. Location of study area and sampling sites from the Datong basin, China.

Download English Version:

<https://daneshyari.com/en/article/5750397>

Download Persian Version:

<https://daneshyari.com/article/5750397>

[Daneshyari.com](https://daneshyari.com)