Groundwater arsenic contamination in Brahmaputra river basin: a water quality assessment in Golaghat (Assam), India

Mridul Chetia · Soumya Chatterjee · Saumen Banerjee · Manash J. Nath · Lokendra Singh · Ravi B. Srivastava · Hari P. Sarma

Received: 30 July 2009 / Accepted: 11 February 2010 / Published online: 12 March 2010 © Springer Science+Business Media B.V. 2010

Abstract Distribution of arsenic (As) and its compound and related toxicology are serious concerns nowadays. Millions of individuals worldwide are suffering from arsenic toxic effect due to drinking of As-contaminated groundwater. The Bengal delta plain, which is formed by the Ganga–Padma–Meghna–Brahmaputra river basin, covering several districts of West Bengal, India, and Bangladesh is considered as the worst As-affected alluvial basin. The present study was carried out to examine As contamination in the state of Assam, an adjoining region of the West Bengal and Bangladesh borders. Two hundred twenty-two groundwater samples were collected from shallow and deep tubewells of six blocks of Golaghat district (Assam). Along with total As, examination of concentration levels of other key parameters, viz., Fe, Mn, Ca, Na, K, and Mg with pH, total hardness, and SO$_4^{2-}$, was also carried out. In respect to the permissible limit formulated by the World Health Organization (WHO; As 0.01 ppm, Fe 1.0 ppm, and Mn 0.3 ppm for potable water), the present study showed that out of the 222 groundwater samples, 67%, 76.4%, and 28.5% were found contaminated with higher metal contents (for total As, Fe, and Mn, respectively). The most badly affected area was the Gamariguri block, where 100% of the samples had As and Fe concentrations above the WHO drinking water guideline values. In this block, the highest As and Fe concentrations were recorded 0.128 and 5.9 ppm, respectively. Tubewell water of depth 180 ± 10 ft found to be more contaminated by As and Fe with 78% and 83% of the samples were tainted with higher concentration of such toxic metals, respectively. A strong significant correlation was observed between As and Fe (0.697 at p < 0.01), suggesting a possible reductive dissolution of As–Fe-bearing minerals for the mobilization of As in the groundwater of the region.

Keywords Arsenic · Groundwater · Alluvium · Brahmaputra river basin
Introduction

Natural potable water resource is becoming exceedingly a limited reserve for the human race throughout the world. Furthermore, presence of varied numbers of pollutants including heavy metals in the water through natural and/or anthropogenic interventions imparts toxic and harmful effects to the environment and the individual (Chatterjee et al. 2008; Vaclavikova et al. 2008). Among the pollutants, arsenic is considered a high-priority toxic metal because it acts as a human carcinogen (Jie and Waalkes 2008; Das et al. 2009; Henke 2009). The introduction of a redox-sensitive element like arsenic (standard reduction potential $E^\circ = 0.56$ V and standard oxidation potential $E^\circ = -0.67$ V) in the environment may take place through several ways. Eroded sediments and varied inputs of human activities like mining, pesticides, pharmaceuticals, etc. are thought to be the common sources of arsenic (Bunnell et al. 2007). Chronic arsenic exposure is detrimental to human health being associated with cancer of the skin, lung, liver, urinary bladder, and kidney (Tchounwou et al. 2003; Bunnell et al. 2007; Jie and Waalkes 2008) and other diseases, including cardiovascular and peripheral vascular diseases, diabetes, peripheral neuropathies, portal fibrosis, and adverse birth outcomes (Xia et al. 2009). The arsenic contamination of drinking water is among the most awesome environmental health challenges nowadays, threatening the well-being and livelihood of more than a hundred million people worldwide (Bhattacharya et al. 2007). The presence of arsenic in groundwater has been reported extensively in recent years from different parts of the world, including countries in North America and Latin America (viz., USA, Canada, Mexico, Argentina, Bolivia, Brazil, and Nicaragua), Australia, and Southeast Asia (viz., Bangladesh, China, Nepal, Vietnam, Cambodia, and India; Smedley and Kinniburgh 2002; Bhattacharya et al. 2006; Mukherjee et al. 2006; Acharyya and Shah 2007; Das et al. 2009). However, the environmental problem of arsenic toxicity in groundwater of the entire Bengal delta of the Ganga–Padma–Meghna–Brahmaputra (GPMB) river plain, covering several districts of West Bengal and Bangladesh, creates apprehension toward the scientific community and considered as the worst arsenic-affected alluvial basin (Smith et al. 2000; Das et al. 2009). The magnitude of the severity in respect with arsenic toxicity in the region, where subsurface water is primarily used as a source of drinking water, is very high. In Bangladesh, 28–77 million people drink arsenic-contaminated water without having alternative resources. Chronic consumption of such toxic water, in the future, may lead to, according to the estimate of the World Health Organization (WHO), 1 in every 10 adult deaths caused by arsenic-related cancer (Ahmad et al. 2003; Halem et al. 2009, SOS-Arsenic, downloaded from http://www.sos-arsenic.net on 28 Feb 2010). Again, the permissible limit for As in drinking water, according to the WHO, is 0.01 ppm, which is similar to the specification laid down by the Bureau of Indian Standards (BIS; BIS 1991; WHO 1993; Nickson et al. 2007); however, in India, according to the BIS (1991), the maximum permissible limit in the absence of an alternate source is 0.05 ppm.

The Bengal delta plain is formed by the Ganga–Brahmaputra river system, the 13th largest modern delta in the world. The average annual sediment transport by the Ganga-Brahmaputra river system is about 1,800 tons/km$^2$ and a suspended load around 540–1,157 million tons per year (with dissolved particulates 173 million tons and suspended solids 1,060 million tons approximately), along with several trace elements channeling toward the Bay of Bengal (Singh 2006; Stephane and Charlet 2007). Arsenic in groundwater is often associated with geologic sources, but in some cases, anthropogenic inputs can be extremely important (Dey et al. 2005; Bhattacharya et al. 2007). However, a specific source of arsenic is yet to be identified in the region, but researchers envisaged few potential minor sources of arsenic, which are located in the Ganges catchment areas including the Himalayas and peninsular India (Acharyya and Shah 2007). The arsenic problem in groundwater in West Bengal, India, was first recognized in the early 1980s (Garai et al. 1984), and the health effects are now reasonably well documented. In fact, more than 50 million people are undoubtedly at risk in the Bengal delta plain (Sharma et al. 2006; Das et al. 2009). More recently, the