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Arsenicosis and its relationship with nutritional status in two arsenic affected areas of West Bengal, India

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ABSTRACT

Incidence of chronic arsenicosis in the lower Gangetic plain has led to intensive research on arsenic (As) contamination in groundwater and potential health crisis associated with exposure to groundwater As. Arsenic toxicity of local inhabitants and their nutritional status were investigated in two As affected villages (Nonaghata and Doulatpur) of West Bengal, India. Population-based case study on randomly selected subjects was used to assess chronic As exposure through medical evaluation and individual health survey. Groundwater As concentrations were found as high as 870 μg/L and 1752 μg/L in Nonaghata and Doulatpur respectively at a depth 50–100 ft. In Nonaghata, 26.7% of people (among 385 surveyed) showed dermatological manifestation and As skin lesions were dominant in age group of 15–30 and 30–45 years old. In both the age groups, cases of melanosis were higher (22.5% and 31.5%) compared to keratosis (15.4% and 12.5%). In Doulatpur 27.4% of people (among 440 surveyed) was found with dermatological manifestations and As skin lesions were dominant in age group of 15–30 and 30–45 years old. Cases of melanosis are higher (27.2% and 31.4%) compared to keratosis (10.8% and 30.7%) in these two age groups. Assessment on calories intake (mainly carbohydrate and protein) by local inhabitants showed that 67.5% and 66.8% people of these two villages belongs to poor nutrition. Assessment of odds ratios (OR) suggested that the stronger associations were with low nutrition which may increase susceptibility to arsenical skin lesions. Thus it is a matter of concern that nutritional status may be an important factor causing prevalence of As toxicity among local inhabitants.

1. Introduction

Arsenic (As) contamination in groundwater and its adverse impact on human health is a great concern in many countries around the world. Among the As affected regions, lower Gangetic plain is a well known hotspot of As crisis for severe As contamination, with large numbers of exposed individuals within the Bengal delta (Das et al., 2009; Kar et al., 2010). About 9.5 million people are at risk of consuming As >10 μg/L in nine districts of West Bengal, India (Chakraborty et al., 2002; Samal et al., 2011). Nadia and North 24 Pargana are the highly As affected districts (Nath et al., 2008; Maity et al., 2011, 2012) and more than 95% of the rural people in this area depend on groundwater for drinking purpose.

Arsenic pollution in groundwater and its deleterious effects on human health have been reported from many countries (Chowdhury et al., 2000; Chen et al., 2005; Kongkea et al., 2010). The risk associated with drinking of As-enriched groundwater in Bengal delta has been a matter of global concern (Bhattacharya et al., 2007). Most commonly observed symptoms of chronic As exposure are melanosis and hyperkeratosis. Previous studies demonstrated the risks of malignancies such as bladders, lungs, liver, kidney and skin cancers (Guha Mazumder et al., 1988; Chowdhury et al., 2000). In some regions, gangrene and peripheral vascular disease like blackfoot diseases have been reported as a severe consequence of drinking of As polluted well water (Lu, 1990). In addition, increased risks for diabetes and cardiovascular diseases have been linked to continued consumption of As-enriched groundwater (Guha Mazumder et al., 1988; Chowdhury et al., 2000; Berg et al., 2001; Ayotte et al., 2006). Dose–response relationship between As exposure and its adverse health impacts was studied through different biomarkers in different As affected region. In southwestern Taiwan, the bladder/lung cancer rates caused by As toxicity are higher among the areas with low levels of As (<150 μg/L) though cancer risks suggest a negative association with well water As levels (Lamm et al., 2013). Biomarkar study in Cambodia shows that As content in hair (0.27–57.2 μg/g) is significantly correlated ($r = 0.75$) with well water and average daily dose of As (Phan et al., 2011). The study also reported that arsenical skin lesions are mostly found in age group of 31–45 years old. Var-

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ious epidemiological studies on skin lesions in Bengal delta plain suggest that inhabitants with skin lesions had consumed water with As concentrations of >100 μg/L (Maity et al., 2012).

The chronic arsenicosis has a story related with nutritional status is assumed but not well established. Mitra et al. (2004) investigated first such study whether nutritional levels may modulate the exposure of arsenic and related diseases in West Bengal, India. Several other studies have shown that poor nutritional status may increase the risk of As-induced health effects. Individuals with poor nutritional status in some villages of West Bengal, India have been shown an increase of 1.6-fold in the prevalence of keratoses (Guha Mazumder et al., 1998). This suggests malnutrition may increase the susceptibility for As toxicity. Milton et al. (2004) reported that the prevalence ratio (or risk) was 1.92 for poor nutritional status among the arsenicosis cases compared to the unexposed population. Arsenic exposed people of Taiwan and Chile were also reported to have a low socio-economic status and poor nutritional status (Tseng, 1977; Borgeno et al., 1977). Few studies in part of Taiwan reported inhabitants with low nutrition particularly low protein may have associated with prevalence of arsenic-induces diseases (Mitra et al., 2004). Many factors are likely to influence the toxicity of As including food quantity consumed per day, concentration of As in dietary and cooking water, socio economic condition and subsequent malnutrition. These are important factors which may accelerate the risk of As toxicity (Borgeno et al., 1977; Hsueh et al., 1995; Chowdhury et al., 2001; Roychowdhury et al., 2002). Earlier research revealed that the poor nutritional status may increase the risk of As related health effects (Milton et al., 2010, 2004; Islam et al., 2004; Guha Mazumder et al., 1998). The interactions between As and nutrition may include oxidative stress, which requires nutrient dependent defense systems as well as As metabolism (methylation) via 1-carbon metabolism. This requires methyl groups, folic acid, vitamin B-12, and betaine for the re-methylation of homocysteine to methionine (Vahter, 2007). The reduction and oxidation methylation reactions occur to form monomethyl arsonic acid (MMA) and dimethylarsinic acid (DMA) in liver (Kitchin, 2001). Glutathion is likely to act as a reducing agent for converting As (V) species into As (III), which can then accept a methyl group from S-Adenosylmethionine (SAM) to produce the methyl As (V) species (Cullen and Reimer, 1989). The diets containing low methionine, choline, or proteins have a decrease in As methylation and an increase in tissue retention of As, especially in the liver (Vahter and Marafante, 1987). The higher intakes of protein, methionine, and cysteine are associated with higher urinary As excretion, Heck et al. (2009). However, the role of nutritional factors on As metabolism and toxicity is not fully understood.

Bioaccumulation of As in human system is a complex process which is influenced by factors such as environmental quality, age, gender, nutrition, speciation and binding nature (Steinmaus et al., 2000). However, there are limited number of studies describing association of As toxicity and nutritional status in the affected population of the Bengal delta plain, particularly in Nadia and North 24 Pargana district, West Bengal. Previously we reported exposure of As through agricultural crops and vegetables in the As-affected populations in Nadia district, West Bengal (Samal et al., 2011). Current investigation is focused to examine the distribution of groundwater As pollution and the prevalence of As toxicity among affected population in the contaminated regions. Attempts are also taken to highlight the interconnectivity between As toxicity and nutritional status. To investigate this, a study was carried out to evaluate As toxicity in two As-affected villages in the Nadia and North 24 Pargana district, West Bengal, India. The potential health exposure was estimated through individual health survey.

2. Methodology

2.1. Study area and its geological setting

In the present investigation two As-affected villages (Nonaghata village in Haringhata block of Nadia district and Doulatpur village in Habra-II block of North 24 Pargana district, West Bengal, India) were selected (Fig. 1). Both the study areas are part of the lower Gangetic plain, which were formed primarily by the deposition of late Holocene to recent sediments borne by the Ganges River. The subsurface lithology of the area is of deltaic silt deposits. The Ganges Delta aquifers are generally multi-layered, varying from unconfined to leaky-confined (i.e. locally confined) in the shallow alluvial deposits and confined in the deeper alluvial deposits (Kar et al., 2010). In the study area, groundwater levels lie within a few meters below the ground surface and fluctuate with the annual dry and wet season conditions. Annual fluctuations in groundwater levels are controlled by the local hydrogeological conditions and withdrawal of groundwater for irrigation.

2.2. Groundwater sampling and analysis

Groundwater samples used for drinking purpose were collected from domestic tubewells as well as irrigation wells during post

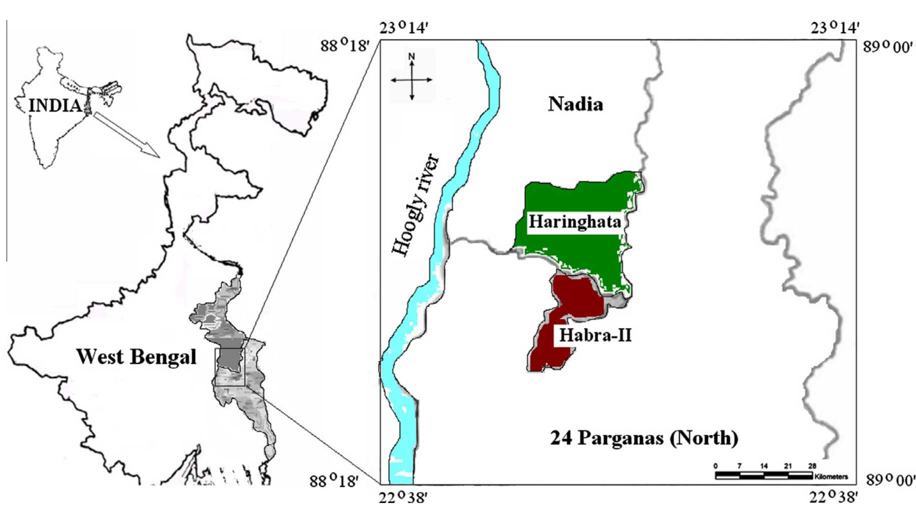

Fig. 1. Study area map showing two blocks Haringhata in Nadia district and Habra-II in North 24 Parganas district, West Bengal, India.