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Elevated levels of arsenic and trace metals in drinking water of Tehsil Mailsi, Punjab, Pakistan

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ABSTRACT

Trace metal contamination in drinking water poses severe threat to human health through long-term exposure. The present study highlighted the elevated arsenic (As) and trace metal concentrations in drinking water and associated potential health risk to local residents of Tehsil Mailsi (Punjab), Pakistan. Our results showed that concentrations of As, Cd, Fe, Cr and Pb exceeded the WHO limits in drinking water, whereas Cu, Mn, Co, Ni and Zn concentrations were below the safe limits. The calculated estimated daily intake (EDI) of metals from local drinking water had the order of Zn > As > Cu > Pb > Cd > Ni > Mn > Cr, and the consequent target hazard quotient (THQ) above 1 was observed for As and Cd, which employed high potential health risk to local residents. Spatial distribution of As and trace metals in drinking water were related to the local anthropogenic sources, due to intensive application of agrochemicals. The study area presents high potential health risk associated with As and trace metals pollution in drinking water. The local wells have never been tested for metal concentrations prior to use, and necessary processes should be taken to test the wells with respect to As and trace metals contamination.

1. Introduction

Trace metal pollution in water is one of the serious concerns worldwide due to their persistence, accumulation, and ecological toxicity in the aqueous environment (Yu et al., 2008; Qiao et al., 2013). Trace metals are present in various environmental compartments in broad concentrations ranging from ultra-trace (μg/L) to higher levels (mg/L), sometimes as a result of increasing anthropogenic inputs, thereby entering into soil and groundwater. The anthropogenic sources of trace metals include industrial waste discharges (Muhammad et al., 2010) and extensive use of agro-chemicals (Abbas et al., 2014). Other than anthropogenic sources, natural occurrences of trace metals as a result of chemical weathering of bed rocks and minerals also produce metal pollution in water (Khan et al., 2008; Krishna et al., 2009). Multivariate statistical analyses such as cluster analysis (CA), inter-metals correlation and principal component analysis (PCA) are usually helpful for source discrimination of trace metals in water (Wunderkind et al., 2001; Muhammad et al., 2011). Therefore, the demand has been increased to study the drinking water quality with respect to trace metal distribution, source, and exposure to health risk of trace metals.

It has been evidently reported that As consumption from drinking water has affected about 150 million people worldwide (Ravenscroft et al., 2009). As affected nations of the world include Bangladesh, India, China, Hungary, Pakistan, Argentina, Chile, Mexico, Taiwan, Vietnam and many parts of USA (Smedley et al., 2002). Additionally, >25 nations of the world are facing problem of As and trace metal pollution. These nations include China, India, Pakistan, Sri Lanka, Ghana, Ivory Coast, Senegal, Algeria, Kenya, Uganda, Tanzania, Ethiopia, Mexico and Argentina (Ravenscroft et al., 2009; Rahman et al., 2009; Smedley et al., 2002).

In Pakistan, As affected areas include Jamshoro, Sindh (Baig et al., 2009b), Manchar lake, Sindh (Arain et al., 2008, 2009), Lahore and Kasur, Punjab (Farooqi et al., 2007a), Muzaffargarh, Punjab (Nickson et al., 2005), D.G. Khan, Punjab (Malana and Khosa, 2011) and Tharparkar, Sindh (Brahman et al., 2013). In 2004, >40 people died in Hyderabad city due to the usage of drinking water contaminated with high level of As and other toxic metals (Arain et al., 2008). Similarly, trace metal pollution in water has been detected in many areas of Pakistan including Naranji (KPK) (Shah and Danishwar, 2003), Lahore and Kasur (Punjab) (Farooqi et al., 2007a, b), Nagar Parkar (Sindh) (Naseem et al., 2010), and Tharparkar (Sindh) (Brahman et al., 2013).

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Moreover, Pakistan Council for Research in Water Resources (PCRWR) has declared six cities as the most affected areas of Punjab with respect to elevated levels of trace metals, which include Multan, Bahawalpur, Sheikhopura, Vehari, Gujranwala, Kasur and Lahore (PCRWR, 2005).

Tehsil Mailsi is situated in the active flood plains of Sutlej River, Southern Punjab, Pakistan. Geographically, Tehsil Mailsi is surrounded by metal polluted areas of Vehari, Multan and Bahawalpur, and sharing the similar topography and geology. So far, little is known about anthropogenic or geochemical distribution of trace metals in local drinking water and associated health risk in Tehsil Mailsi. The anthropogenic contribution of trace metals has been resulted from extensive use of fertilizers, sewerage system, drainage system, solid waste management, and landfills/dumping sites (Abbas et al., 2014; Shah et al., 2010), whereas the geochemical contribution of metals is related to weathering and erosion of mafic and ultramafic rocks (Shah et al., 2010; Kavcar et al., 2009), which are affecting water quality of Tehsil Mailsi. Hence, the present study was designed to investigate As and trace metal distribution in drinking water of Tehsil Mailsi and consequent assessment of sources in regard of their potential health risks.

2. Materials and methods

2.1. Study area

Tehsil Mailsi (72°17′-72°19′E, 29°78′-29°92′N) is located in Southern Punjab, with an area of 1639 km^2 and a population of about 0.71 million (Fig. 1). The average annual precipitation is 243 mm and the mean temperature is 26 °C (DCR, 1998). Farming is the basic occupation of population with major cash crops including cotton, wheat, sugarcane, maize and rice. Mailsi is situated along river Sutlej, however, this river is dry in most part of the year and facing shortage of good quality drinking water. Additionally, groundwater accessed by either electric or hand pumps is the major source of drinking water in the study area.

The regional hydrology of Punjab including Mailsi has been described previously (Greenman et al., 1967). The aquifer of the study area is under alluvial plains with >340 m thick layer of Holocene and Pleistocene sediments transported by the River Sutlej (Greenman et al., 1967), originating from southern slopes of Kailash mountains near the lake of Mansarovarand, which flows parallel to the Himalayas. High percentage of silt, clay, fine sand and low organic matter is present in these sediments. The study area consists of a thickened sequence of unconsolidated flood plain deposits and Aeolian deposits of Pleistocene to present age. Calcium carbonate concretions of irregular shape, but of regular size and distribution are associated with these sediments (Farooq et al., 2007). The study area towards southwestern part of Bari Doab (area between the two rivers, Sutlej and Chenab) contains relatively older alluvial deposits, which tend to coincide with zones of highly mineralized groundwater (Greenman et al., 1967). The geologic features influencing the permeability and transmissibility of water are lateral lithological changes, disparity in sand thickness, and grain size distribution (Farooq et al., 2007). The older Quaternary (i.e., Pleistocene) deposits are more widely distributed in the western sedimentary basin, thereby promoting more aerobic aquifer conditions in the study area over other locations (Mahmood et al., 1998; Tasneem, 1999).

2.2. Sampling and analysis

Two sites (Mailsi and Sargana) were selected for water sampling (Fig. 1). Sampling was conducted in December 2013 following the standard procedures of Khan et al. (2012). Initially, survey was conducted about the health hazards associated with drinking water, which revealed 14% hepatitis, 29% stomach pain, 20% kidney pain, 18% typhoid, 7% lung cancer, 9% liver cancer and 3% other common diseases in local

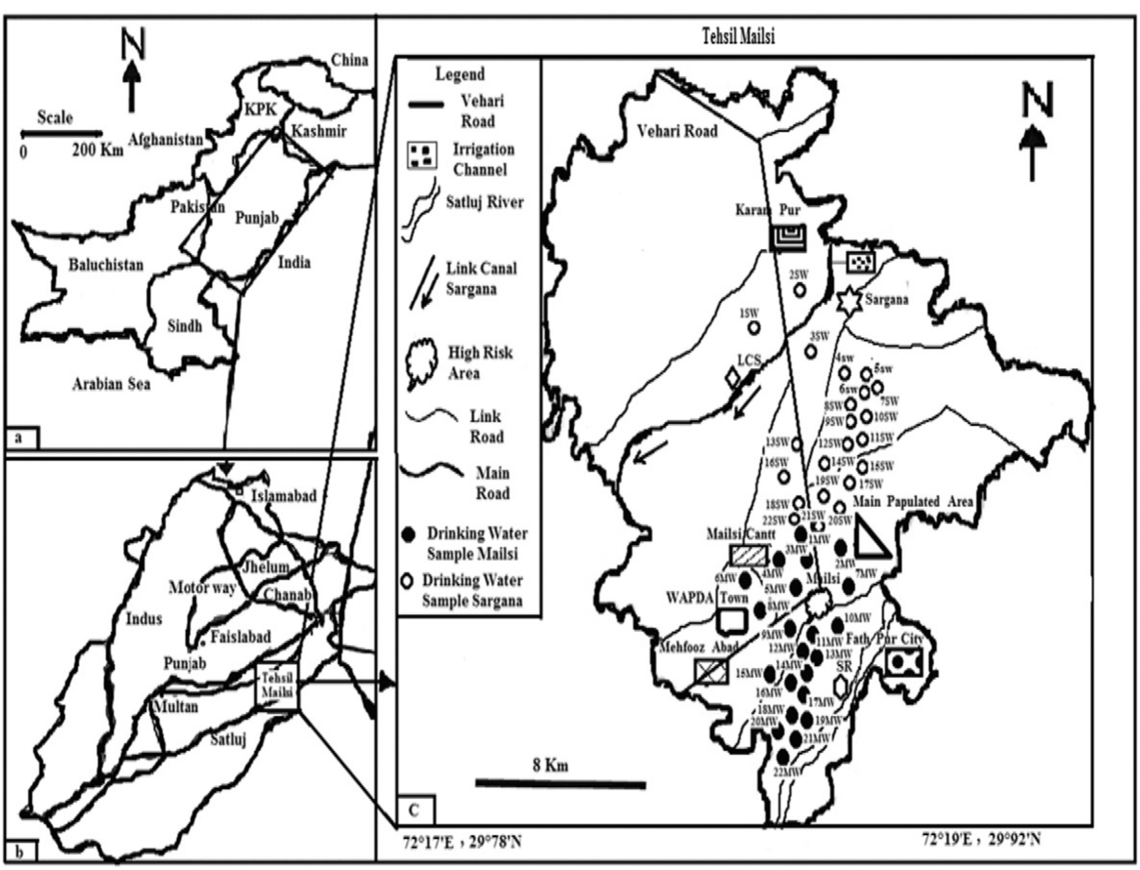

Fig. 1. Location maps showing the sampling points of drinking water from Sargana and Mailsi sites.