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Original Research Article

Assessment of trace metals in foodstuffs grown around the vicinity of industries in Bangladesh

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ABSTRACT

In the present study, we investigated the levels of chromium (Cr), nickel (Ni), copper (Cu), arsenic (As), cadmium (Cd) and lead (Pb) in eight groups of foods, namely, cereals, pulses, vegetables, fruit, fish, meat, eggs and milk. The range of Cr, Ni, Cu, As, Cd and Pb in the foodstuffs was 0.18–4.8, 0.008–10, 0.47–22, 0.003–0.98, 0.0003–0.85 and 0.005–3.7 mg/kg fw, respectively. The daily intakes (EDIs) of Cr, Ni, As, Cd and Pb were higher than the maximum tolerable daily intake (MTDI), indicating their potential sources from dietary intake. The combined metal hazard quotients ($\sum HQs$) from rice, fruit, vegetables and fish were higher than 1, meaning that metals may pose a considerable risk to local inhabitants due to consumption of these four food items. From the human health point of view, this study showed that the studied foods were not safe for the local inhabitants, and potential risk cannot be neglected for regular or excessive consumers.

1. Introduction

Metals and metalloids are ubiquitous in the environment, through either natural or anthropogenic intervention, and elevated concentrations in the environment result from waste disposal, smelter stacks, atmospheric deposition, application of fertilizer, pesticide and sewage sludge in the arable land (Cui et al., 2005; Zheng et al., 2007; Islam et al., 2014a). While they are essential for plant growth and/or human nutrition, some micronutrients (e.g. Cu, Cr and Ni) might be toxic at high concentrations (McLaughlin et al., 1999; Rahman et al., 2014). Other toxic trace elements such as As, Cd and Pb might also inadvertently enter the food chain and pose risks to human and animals (Sankar et al., 2006; Sharma et al., 2007; Bundschuh et al., 2012; Ji et al., 2013; Rahman et al., 2014). Trace metals such as Cr, Ni, As, Cd and Pb have been considered as the most toxic elements in the environment by the US Environment Protection Agency (EPA) (Lei et al., 2010; Islam et al., 2014a). Therefore, the risks associated with metal contamination in foodstuffs are of great concern.

Although the relative contribution of trace metals has not yet been clearly established, dietary intake is considered as the vital exposure pathway (Kachenko and Singh, 2006; Sharma et al., 2007). Fig. 1 shows those possible food chain pathways through which the Bangladeshi population is generally being exposed to metal toxicity. "soil–plant–human" and/or "plant–animal–human" and/or "soil–water–animal" could be the potential food chain pathways of metal accumulation in human populations. In this study we tried to trace food chain pathways in the natural ecosystem, by means of which metals may contaminate human foods so that we can assess the potentiality of these pathways in exposing trace metals to human.

Rice is the major staple food in many countries, particularly in Asian countries like Bangladesh, India, Thailand, China and

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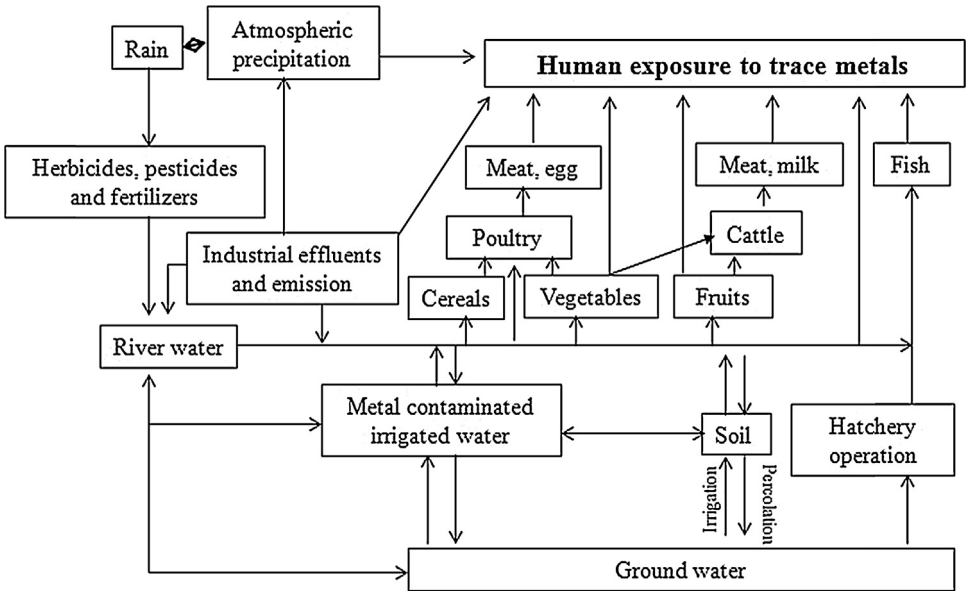

Fig. 1. Possible food chain pathways through which humans may be exposed to trace metals.
Modified after Rahman et al. (2008).

Vietnam, where soil and ground water pollution with high level of As and trace metals have been reported (Roychowdhury et al., 2003; Duxbury et al., 2003; Meharg and Rahman, 2003; Das et al., 2004; Rahman et al., 2013). Increased levels of trace metals in agricultural soils and their uptake in rice, vegetables and other food crops have become a serious health issue in this region (Meharg and Rahman, 2003; Williams et al., 2006; Islam et al., 2014b). While a significant number of studies have been focused on As in Bangladeshi rice and vegetables (Alam et al., 2003; Das et al., 2004; Karim et al., 2008; Rahman and Hasegawa, 2011), studies on other trace metals in other daily consumable foods are scarce (Alam et al., 2003; Rahman et al., 2013). Therefore, this study aimed to evaluate the levels of trace metals in foodstuffs that are generally consumed by the Bangladeshi population, and to assess health risk associated with dietary intake of metals.

2. Materials and methods

2.1. Study area and sample

Dhaka, with a metropolitan area of 815.8 km^2, is surrounded by the three major rivers Turag, Buriganga and Shitalakha, which are currently used for industrial waste disposal. Dhaka is one of the most densely populated cities in the world with 12 M people, of which fewer than 25% are served by sewage treatment facilities (Islam et al., 2014c). The basic information of the study areas is presented in Table S1 (Supplementary material). The most consumed foods for Bangladeshi people, i.e. cereals, pulses, vegetables, fruits, fish, meat, eggs and milk, were collected during February–March, 2012 and August–September, 2013. About 173 food samples were collected from three rivers and their adjacent areas around the Dhaka city metropolitan area, Bangladesh (Fig. 2). A composite sample for each

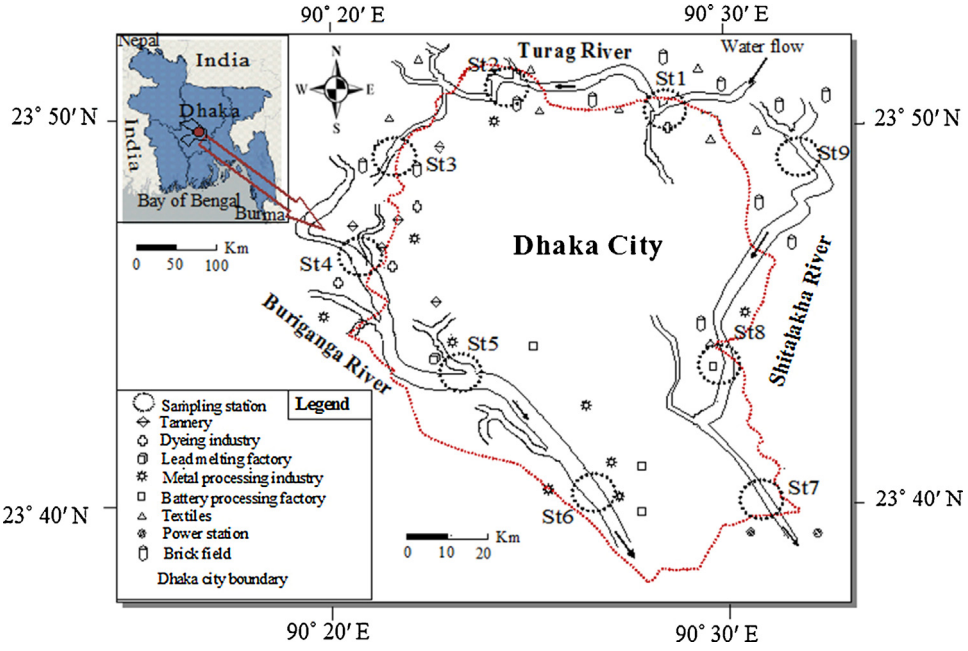

Fig. 2. Map of the study area around Dhaka City, Bangladesh.