Heavy metal contamination in water, soil, and vegetables of the industrial areas in Dhaka, Bangladesh

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Abstract Concentrations of Cu, Zn, Pb, Cr, Cd, Fe, and Ni have been estimated in soils and vegetables grown in and around an industrial area of Bangladesh. The order of metal contents was found to be Fe > Cu > Zn > Cr > Pb > Ni > Cd in contaminated irrigation water, and a similar pattern Fe > Zn > Ni > Cr > Pb > Cu > Cd was also observed in arable soils. Metal levels observed in different sources were compared with WHO, SEPA, and established permissible levels reported by different authors. Mean concentration of Cu, Fe, and Cd in irrigation water and Cd content in soil were much above the recommended level. Accumulation of the heavy metals in vegetables studied was lower than the recommended maximum tolerable levels proposed by the Joint FAO/WHO Expert Committee on Food Additives (1999), with the exception of Cd which exhibited elevated content. Uptake and translocation pattern of metal from soil to edible parts of vegetables were quite distinguished for almost all the elements examined.

Keywords Trace elements · Plant uptake · Bioconcentration factor · Wastewater irrigation

Introduction

Heavy metal pollution of agricultural soil and vegetables is one of the most severe ecological problems on a world scale and also in Bangladesh. The food chain contamination is the major pathway of heavy metal exposure for humans (Khan et al. 2008). Industrial or municipal wastewater irrigation is a common reality in three fourth of the cities in Asia, Africa, and Latin America (Gupta et al. 2008). Wastewater from industries or other sources carries an appreciable amount of toxic heavy metals which create a problem for safe rational utilization of agricultural soil (Yadav et al. 2002; Chen et al. 2005; Singh et al. 2004). Long-term use of industrial or municipal wastewater in irrigation is known to have significant contribution to trace elements such as Cd, Cu, Zn, Cr, Ni, Pb, and Mn in surface soil (Mapanda et al. 2005). Excessive accumulation of trace elements in agricultural soils through wastewater irrigation may not only result in soil contamination but also affect food quality and safety (Muchuweti et al. 2006; Sharma et al. 2007). Some trace elements...
are essential in plant nutrition, but plants growing in the nearby zone of industrial areas display increased concentration of heavy metals, serving in many cases as biomonitors of pollution loads (Mingorance et al. 2007). Vegetables cultivated in soils polluted with toxic metals due to industrial activities take up heavy metals and accumulate them in their edible and non-edible parts in quantities high enough to cause clinical problems both to animals and human beings consuming these metal-rich plants because there is no good mechanism for their elimination from the human body (Arora et al. 2008; Alam et al. 2003). Trace elements are very harmful because of their non-biodegradable nature, long biological half-lives, and their potential to accumulate in different body parts. High concentrations of trace elements (Cu, Cd, and Pb) in vegetables and fruits were related to high prevalence of upper gastrointestinal cancer (Turkdogan et al. 2002).

In Bangladesh, more than 90 vegetables and 60 fruits are being grown in the country (Alam et al. 2003). Major vegetable crops include brinjal (egg plant), chilli, lady’s finger, potato, tomato, etc. In an average Bengali home, the main meal would consist of boiled rice served with some sort of vegetables. There have been a number of studies which reported the deposition of heavy metals in soil, crops, and vegetables grown in the vicinity of industrial areas (Yang et al. 2004; Grytsyuk et al. 2006; Mingorance et al. 2007; Khan et al. 2008).

However, there are very few published reports from Bangladesh for heavy metal contamination in soil and irrigation water and its transfer to vegetable crops grown in the vicinity of industrial areas.

This paper investigates the level of Cu, Zn, Pb, Cr, Cd, Fe, and Ni in irrigation water, soils, and in vegetables from agricultural land near Dhaka Export Processing Zone, which is one of the largest industrial complexes located at Savar in Dhaka of Bangladesh. The aim of the work was to highlight the contamination status of heavy metals in edible portion of vegetables grown in industrially polluted soils in Bangladesh and to identify the interactions between soil and crops metal concentration. The concentrations of heavy metals in soil, vegetables, and water were compared with the established safe limit. This provides a basis for guiding further activities aimed at preventing exposure of humans through monitoring and control of irrigation water and/or amelioration of uptake to vegetables.

Materials and methods

Study area and sampling

The present study was carried out from January 2005 to February 2006 in and around Dhaka Export Processing Zone (DEPZ), which is a large industrial area comprised of a good number of local and foreign industries like fabric printing and dyeing, food processing, textiles, electric cables, pharmaceutical, chemical, etc., located at about 25 km away from the capital city Dhaka of Bangladesh. Most of the industries discharge their effluents without any prior treatment, through open drain and contaminates water, soil, and vegetables of the adjacent areas.

Different kinds of vegetables such as brinjal (egg plants) (Solanum melongena L.), chilli (Capsicum frutescens), radishes (Raphanus sativus), etc. are grown in the area throughout the year and are used for home consumption and mainly for selling to residential areas of Dhaka. Samples of soil and five vegetables [brinjal (egg plants), chilli, lady’s finger, tomatoes, and green cabbage] were collected randomly in triplicate from effluent-contaminated agricultural land located beside Dhalai beel (a lake in which all the complex industrial effluents from DEPZ are disposed).

For each plant sample, 10–15 vegetable plants of the same species were collected at random from the fields of the sampling sites by hand using vinyl gloves, carefully packed into polyethylene bags, and the whole plant body was brought to the laboratory. The cleaning (removal of soil) of vegetable plant samples was performed by shaking and also by means of a dry pre-cleaned vinyl brush. Then the whole vegetable plant bodies were divided into different parts and non-edible portions were removed as per normal household practices. The edible parts of the vegetable samples were washed with tap water several times and subsequently dipped in 0.01 N HCl acid for 5 min followed...