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Heavy metals in wheat grain: Assessment of potential health risk for inhabitants in Kunshan, China

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ABSTRACT

Heavy metals (HMs) may cause deleterious effects on human health due to the ingestion of food grain grown in contaminated soils. Concentrations of HMs (Hg, As, Cr, Cu, Ni, Pb, Zn and Cd) in wheat grains were investigated in different areas of a developed industry city in Southeast China (Kunshan city), and their potential risk to health of inhabitants was estimated. The results showed that concentrations of HMs in the top soil (0–15 cm) were in this order: Zn>Cr>Ni>Pb>Cu>As>Hg>Cd. The Zn, Cr, Ni Cd and Hg concentrations of several soil samples exceeded the permissible limits of China standard. In addition, concentrations of HMs in wheat grain decreased in the order of Zn>Cu>Pb>Cr>Ni>Cd>As>Hg. There were 1, 6 and 10 wheat samples whose Zn, Pb and Cd concentrations were above the permissible limits of China standard, respectively. In relation to non-carcinogenic risks, Hazard Quotient (HQ) of individual metal presented values inside the safe interval. However, health risk due to the added effects of eight HMs was significant for rural children and rural adults, but not for urban adults and urban children. HQ (individual risk) and HI (Hazard Index of aggregate risk) to different inhabitants due to HMs followed the same sequence of: country children>country adults>urban children>urban adults. Amongst the HMs, potential health hazards due to As, Cu, Cd and Pb were great, and that due to Cr was the minimum. It was suggested to pay more attention on the potential added threat of HMs to the health of country inhabitants (both children and adults) through consumption of wheat in Kunshan.

1. Introduction

Heavy metals (HMs) are the most dangerous contaminants for environment and human beings (Bradl, 2005). Once excessive HMs enter in the soil, water or air, it may cause hazards to human health through consumption of food crops cultivated in these contaminated environments (Zhao et al., 2002; Wang et al., 2003). Ingestion of contaminated food is one of the main routs through which HMs enter the human body (Lacatusu et al., 1996; Järup, 2003; Grasmück and Scholz, 2005).

For human body, certain HMs are essential for the biological systems as structural and catalytic components of proteins and enzymes like zinc (Zn) and copper (Cu), and others are contaminants such as cadmium (Cd), arsenic (As), mercury (Hg), lead (Pb), chromium (Cr), nickel (Ni) and so on (Somers, 1974; Mushtakova et al., 2005). However, excessive retention of either kind of HMs in the environment imposes health risk to human. For instance, HMs induce toxic effect on human blood neutrophils (Mushtakova et al., 2005), As, Cd, Pb and Hg are endocrine-disrupting chemicals (Dyer, 2007). HMs of relevance to human health induces genomic instability (Coen et al., 2001).

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Both Pb and Hg are neurotoxic and there is a risk of developmental problems following exposure (Myers et al., 1997). Study showed that the most affected group of inhabitants by HMs is children (Lacatusu et al., 1996). Therefore, Food and Agriculture Organization (FAO) and Word Health Organization (WHO), United States Environment Protection Agency (US EPA) and other regulatory bodies of other countries strictly regulate the allowable concentrations or maximum permitted concentrations of toxic HMs in foodstuffs (FAO/ WHO, 1984; US EPA, 2000).

Potential health risk due to HMs can be assessed by carcinogenic or non-carcinogenic assessing methods. Non-cancer risk assessment methods based on Hazard Quotient (HQ) and Hazard Index (HI) are set by United States Environmental Protection Agency (US EPA, 1989). These methods have recently been used and proved to be valid and useful (Chien et al., 2002; Wang et al., 2005; Zheng et al., 2007), so it is also applied in this study. In general, potential food exposure routes of HMs include ingestion of fish and shellfish, meat and game, dairy, eggs and vegetables (US EPA, 1989), but little attention was paid on the consumption of grain crop (Chien et al., 2002; Nadal et al., 2004; Wang et al., 2005; Zheng et al., 2007; Chary et al., 2008). In fact, however, grain crop is almost the maximum ingestion food in one's daily diet all around the world (Caussy et al., 2003), and also one kind of lifetime consumption (Nadal et al., 2004).

In recent decades, with the rapid development of industry, agriculture, traffic and transportation, and mining industries, HM contamination is becoming serious in some regions, especially in developing countries (Jung and Thornton, 1997; Spiegel, 2002; Muchuweti et al., 2006). In China, the geological background levels of HMs are low, but with the activity of humans, soil, water, air, and plants were polluted by HMs in some cases and even affect human health through the food chain (Cheng, 2003). Human health risk from consuming crops grown in contaminated environment was widely present in the environment due to natural and anthropogenic emissions (Cui et al., 2005).

HMs in soil in the rapid economic development regions of south Jiangsu province have attracted extensive attention of many researchers. Pan et al. (1999) studied the available forms of HMs in soil environment in the south of Jiangsu province. Sun et al. (2004) assessed the concentration of HMs in the soil of the basic farmland of Kunshan. Recent study (Wan et al., 2005) showed that some of the concentrations of HMs (Hg, As, Cr, Cu, Ni, Pb, Zn and Cd) in soil were higher than their background values set by State Environmental Protection Administration of China (1995). Little attention is given, however, to concentrations of HMs in grain crops and their possible deleterious effects on human health in Kunshan. So, in this study, wheat grain samples in different locations of Kunshan were collected, to analyze concentrations of HMs (Hg, As, Cr, Cu, Ni, Pb, Zn and Cd) in wheat grain and to estimate the risk of adverse health effects of HMs through ingestion of wheat in Kunshan.

2. Materials and methods

2.1. *Study site and sampling*

Kunshan, which is in the southeast of Jiangsu province, belong to Yangzi River Delta which is the most developed area in China (Fig. 1). Kunshan is only 50 km far away from Shanghai municipality which is the biggest city in China. The total area of Kunshan is 927 km^2, and the population 600 thousand. Kunshan is a traditional agriculture area experienced in a

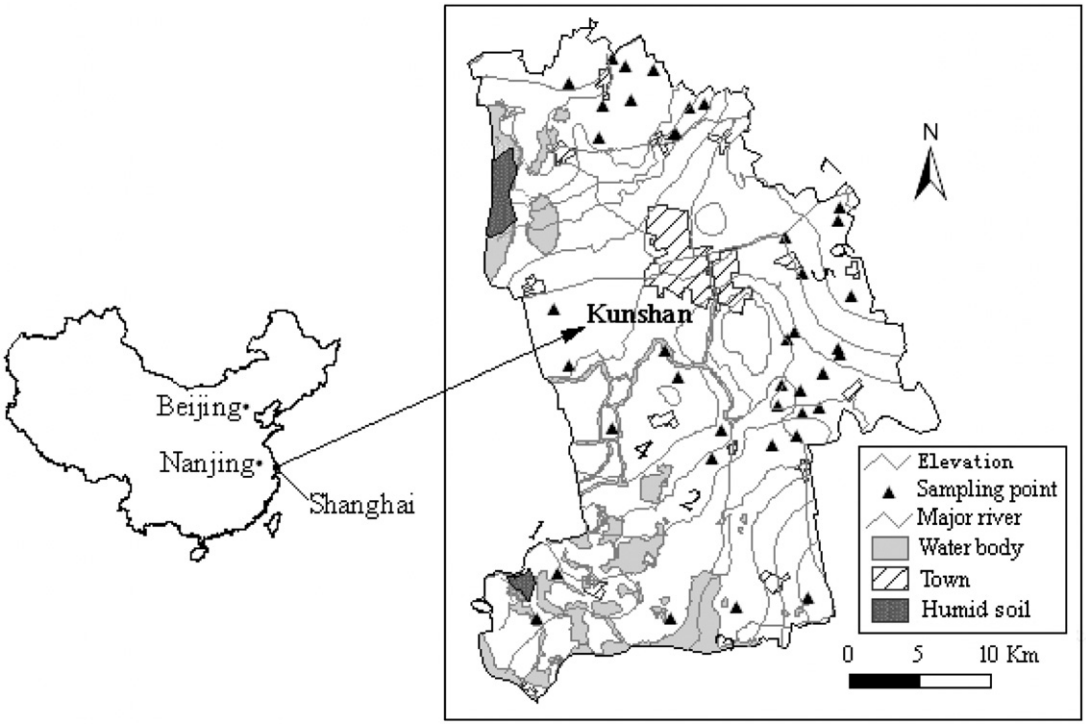

Fig. 1 – Sampling points of wheat grain on paddy soil (▲) in Kunshan.