ASSESSMENT OF TRACE METALS IN THE ENVIRONMENTAL MEDIA AND FOODS FROM THREE RIVERS AND THEIR ADJACENT AREAS IN DHAKA CITY, BANGLADESH

バングラデシュ、ダッカ市の三つの河川とその周辺地域における環境媒体と食品に含まれる微量金属の評価

Abstract of thesis

Trace metal is a member of loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloids, lanthanides, and actinides. Trace metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities. They are stable and cannot be destroyed, and therefore tend to accumulate in the environment. In recent years, there has been a substantial concern over the extent of contamination of the environment with toxic elements and their involvement to public health. Therefore, the accumulation of trace metals in the environment cause a potential risk to human health due to their transfer, uptake by flora and fauna and subsequent introduction into the food chain.

In this thesis, trace metals like chromium, nickel, copper, arsenic, cadmium and lead were investigated in the environmental media and commonly consumed food composites around three riverine ecosystems in Dhaka City, Bangladesh. Dhaka is one of the ten mega-cities in the world. The population of Dhaka City is predicted to increase about 21 million by 2020 from the current population of 12 million. With the rapid development, this city is facing numerous environmental challenges. The distribution of trace metals in the terrestrial and aquatic environment, as well as their impact upon organisms and human health, are of great concern due to their persistent, non-biodegradable and toxic properties. To date, there have been a few studies on trace metal monitoring in Bangladesh and data on the distribution of trace metals in the urban riverine ecosystems are scarce. In addition, there have been no investigations on the chemical speciation of trace metals in soil and sediments. The principal aim of this thesis, however, was to investigate the levels of trace metals in the environment and assess human health risk due to metal exposure.

Wide-scale monitoring campaign of trace metals were undertaken simultaneously besides three riverine ecosystems between 21st February and 26th March 2012 (winter) and 4th August

and 8th September, 2012 (summer). Further monitoring was completed in the same study area at summer (10th August – 17th September, 2013) to analyze the seasonal variation of these contaminants. There were nine monitoring sites from three different rivers (Turag, Buriganga and Shitalakha) around Dhaka City, Bangladesh.

Considering the data from all sites of three rivers, total concentrations of metal in water were 31±32, 16±4.4, 22±8.3, 19±3.8, 0.29±0.07 and 4.7±2.0 µg/L in winter and 23±27, 22±7.4, 11±3.7, 11±3.0, 0.24±0.06 and 3.5±1.5 µg/L in summer for Cr, Ni, Cu, As, Cd and Pb, respectively. During winter season, total concentrations of metal in sediment were 844±638, 411±102, 251±93, 42±8.2, 19±4.7 and in summer 385±567 mg/kg dw and 547±581, 298±121, 130±52, 27±12, 16±6.1 and 327±560 mg/kg dw for Cr, Ni, Cu, As, Cd and Pb, respectively for all sites of three rivers. Elevated concentration of Cr was found at B1 site of Buriganga River (close to the tannery industry) and Pb was found at B2 site of Buriganga River (close to the lead smelting factory). Sequential extraction tests revealed that the studied metals were predominantly associated with the residual fraction, followed by the organically bound phase. The concentrations of these metals in water and sediment varied seasonally, where winter season showed higher than summer. Slightly higher levels of metals during winter might be attributed to the variation in water capacity of the river, where water input to the river is generally limited in winter, resulting in the precipitation of pollutants in water and sediment. The concentrations of Cr, Ni, Cu, As, Pb and Cd in eight different land use soils (total of 70 sampling sites) were in the range of 2.4–1258, 8.3–1044, 9.7–823, 8.7–277, 1.8–80 and 13–842 mg/kg, respectively which exceeded the environmental action level for soils. Among the land-use types, tannery waste disposal site (TW) appeared the most impacted with trace metals. The concentrations of metal were subsequently used to establish hazard quotients (HQs) for the group specific population through ingestion, dermal contact and inhalation pathways.

In this study, the levels of trace metals in eight categories of foods (n=173) were also investigated, namely, cereals, pulses, vegetables, fruits, fish, meat, egg and milk which were collected from study sites like agriculture field, household, adjacent river (Turag, Buriganga and Shitalakha) and local market in Dhaka City. The mean concentrations of Cr, Ni, Cu, As, Cd and Pb in cereals (1.8, 1.3, 2.3, 0.64, 0.075 and 0.17), pulses (1.9, 1.9, 4.0, 0.24, 0.018 and 0.35), vegetables (0.68, 3.2, 12, 0.083, 0.15 and 0.84), fruits (1.4, 1.2, 5.4, 0.38, 0.04 and 0.53), fish (2.4, 1.6, 3.7, 0.25, 0.035 and 1.0), meat (1.3, 0.60, 2.1, 0.037, 0.027 and 0.25), egg (1.4, 1.9, 4.0, 0.087,

0.022 and 0.24) and milk (1.6, 1.5, 2.3, 0.056, 0.029 and 0.20 mg/kg fresh weight). The mean concentration of Cr, Ni, As, Pb in most of the food samples were higher than the maximum allowable concentration (MAC), indicating these foods are contaminated by these metals. Trace metals in water, soil and foods were exceeded the international standard levels. It is assumed two possible ways for the relationship of metal transformation to food. Firstly, soils are contaminated by the inclusion of trace metals through the industrial waste. Consequently, the foods which are grown in these land area are highly contaminated by trace metals. Secondly, river water which is contaminated through the industrial effluents are using for irrigation in the adjacent agricultural land. This might have some relations for the metal contamination in foods that are grown in the study area.

In the study area, local people might expose trace metals through three possible exposure media such as foods, water and soil. The daily intake (EDI) of Cr, Ni, As, Cd and Pb through the exposure media were higher than the maximum tolerable daily intake (MTDI) indicating an obvious health risk. This study highlights the importance of site specific multipathway health risk of the urban people regarding trace metals exposure in the capital city of Bangladesh.