Heavy Metals Concentration in Irrigation Water, Soils and Fruit Vegetables in Coastal Area, Kota Bharu, Kelantan, Malaysia

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Abstract

This study was conducted to evaluate the levels of selected heavy metals namely Aluminium, Boron, Cadmium, Iron, Lead, Manganese and Zinc in irrigation water, soils and selected fruit vegetables (brinjal, chilli and lady's fingers) which were cultivated in Kampung Badang, Pantai Cahaya Bulan in Kota Bharu, Kelantan, Malaysia. The water used for irrigation in Kampung Badang, Pantai Cahaya Bulan had the highest concentration of Boron (3.5 ppm) followed by Manganese (1.105 ppm), Iron (0.233 ppm), Lead (0.22 ppm), Zinc (0.217 ppm), Aluminium (0.214 ppm) and Cadmium (0.0853 ppm). However, in general, the quality of the irrigation water complied with the Class IV, Interim National Water Quality Standard for Malaysia, INWQS, 1985 (standard for irrigation water) and Food and Agriculture Organization of the United Nations (FAO) Standard (1985) except Cadmium. The irrigation water results were also compared with the Indian Standard (Awashthi, 2000), where in general, all the measured parameters complied with the standards except Cadmium (0.01 ppm) and Plumbum (0.10 ppm). Meanwhile, the concentration of Aluminium, Iron, Boron, Zinc, Manganese, Lead and Cadmium in soils were ranged from 2.858 - 3.5ppm, 3.753 – 3.92 ppm, 3.753 – 3.92 ppm, 0.667 – 1.133 ppm, 0.253 – 0.653 ppm and 0.68 – 1.307 ppm, 0.072 – 0.181 ppm and 0.0283 – 0.0844 ppm respectively. The concentrations of heavy metals in soils were also complied with the Indian Standard (Awashthi, 2000) and the European Union (EU) Standards (2002). In addition, the concentration of Aluminium, Iron, Boron, Zinc, Manganese, Lead and Cadmium in vegetables ranged from 0.071 – 0.22 ppm, 1.28 – 2.76 ppm, 2.367 – 2.467 ppm, 0.273 – 0.32 ppm, 0.064 – 0.098 ppm, 0.0127 – 0.138 ppm and 0.0482 – 0.053 ppm respectively. All heavy metals analyzed in the vegetables also complied with the Indian Standard (Awashthi, 2000), World Health Organization (WHO)/FAO (2007) and EU Standards (2006).

*Keywords***:** fruit vegetables, heavy metal, soil, ferum, manganese

Introduction

Contamination of the environment with toxic heavy metals has become one of the major causes of concern for human kind. Heavy metals in surface water bodies, ground water and soils can be either from natural or anthropogenic sources. The two basic categories of pollution are organic and inorganic (Duke &Williams, 2008). Inorganic pollution is basically from heavy metals. Chemical substances such as heavy metals are one of the factors which contribute to environmental pollution, and it was believed that it can disrupt living ecosystem (Kabata-Pendias & Pendias, 2001). Currently, anthropogenic inputs of metals exceed natural inputs due to increased urbanization and industrialization. Industrial wastes, atmospheric deposition from crowded cities and other domestic wastes are among the major sources of heavy metals in the surface water, ground water and soils (Varalakshmi and Ganeshamurthy, 2010). On the other hand, heavy metals such as Cadmium, Copper, Plumbum, Nickel, Chromium, and Mercury may be present in soil from the parent materials during soil formations (Plaster, 2003). Soil is a supporting layer for all organisms in the world. The most important thing is soil acts as a medium for plant growth which can recycle the nutrient and resources needed by plants. Soil will absorb heavy metals in the polluted river as well as ground water and these will cause side effect for vegetable growth. As root grows in the soil, it will absorb water and nutrients in solution (Plaster, 2003). Heavy metals that are attached with soil water and soil particles will be absorbed by plant roots and accumulated in vegetables (Alirzaveya *et. al*. 2006). Another patch way for heavy metals to get into vegetables is via irrigation water which is contaminated by heavy metals.

This present study was aimed at finding out the levels of contamination of seven heavy metals viz. Aluminium (Al), Boron (B), Cadmium (Cd), Iron (Fe), Lead (Pb), Manganese (Mn) and Zinc (Zn) in irrigation water, soils and selected fruit vegetables in Kampung Badang, Pantai Cahaya Bulan in Kota Bharu, Kelantan, Malaysia. A number of studies had been conducted by researchers to identify the levels of heavy metals in vegetables from various sources. Anita *et. al*. (2010) stated that, waste water irrigation led to the accumulation of heavy metals in soil and consequently into the vegetables, while, Miclean *et. al*. (2000) found out that the metal accumulation in vegetables grown in the vicinity of industrial sites represents a potential risk for public health. Works by Garcia *et. al*. (1981) had shown that some common vegetables are capable of accumulating high levels of metals from the soils.

Materials and methods

The study sites covered the agriculture area around Kampung Badang, Pantai Cahaya Bulan, Kota Bharu, Kelantan, Malaysia (Figure 1). Kampung Badang, Pantai Cahaya Bulan, a suburban area located in the coastal area in the north west of Kota Bharu.

Figure 1: Study Area.

Samples of the edible fruity vegetables were randomly collected from 5 x 5 m area of two different fields. The fruit vegetables namely brinjal (*Solanum melongena),* chilli *(Capsicum anmum)* and lady's fingers (*Hibiscus esculentus*) were collected at fruiting stage or at least at 60 days after planting. Five fruits were collected for each type of vegetables. The collected samples were stored in polyethylene bags, each sample bag for each vegetable before taking them to the laboratory for the analysis. The soil that was used to grow the vegetables was randomly collected. Each location comprised three samples; one sample was taken from each type of vegetable soils. In addition, in each type of vegetable soils comprised three points, where these three point samples were mixed as one sample with a total weight of about 50 grams. Therefore, a total of three soil samples were collected for this study. A metal spade was used to collect the soil at 5 cm depth from the surface. The samples were then placed in plastic bags, each sample for each bag before taking them to the laboratory for analysis. The source of irrigation water for this cropland was tap water from Kelantan Water Berhad. Water samples used for irrigation were collected in a 500 ml washed polypropylene bottle and 1 ml of concentrated acid nitric (HNO_3) was added to the samples to avoid microbial activity. For heavy metal extraction, 1g ground wet sample of plant or soil was digested in 3 ml concentrated nitric acid (HNO_3) and 1 ml of concentrated hydrochloric acid (HCl) (3+1, (v/v)). The mixtures were oven heated for 3 hours at 40 ^{0}C. After that, the samples were removed from the oven and let them cool for a few minutes. Then they were diluted with 150 ml de-ionized water. The samples were then adjusted to pH 5 to 6 via acid base adjustment with hydrochloric acid and sodium hydroxide. Then, the samples were analyzed using Spectrophotometer DR5000. Meanwhile, irrigation water analysis followed USEPA Approve for wastewater analyses and adapted from Standard Methods for the Examination of Water and Wastewater (2005) via Spectrophotometer DR5000.

Results and discussion

The results obtained showed that in soil, the concentration of Aluminium ranged between 2.9 ppm and 3.5 ppm, where soil for growing chilli and brinjal recorded 3.5 ppm and soil for growing lady's fingers recorded 2.9 ppm. The concentration of Boron was between 0.67 ppm and 1.13 ppm and the highest recorded in soil for grow lady's fingers. Meanwhile, Cadmium concentration recorded between 0.028 ppm and 0.084 and the highest rercorded in soil for growing chilli. In addition, the concentration of Iron was between 3.75 ppm and 3.92 ppm where the highest concentration recorded in soil for growing brinjal. The concentration of Plumbum was between 0.072 ppm and 0.181 ppm where the highest recorded in soil for growing chilli. Manganese and Zinc were also measured for this study where the results showed that, the concentration of Manganese recorded was between 0.68 ppm and 1.31 ppm and Zinc recorded between 0.25 ppm and 0.65 ppm (Figure 2, 3 and 4). All Pb, Cd and Zn values complied with the Indian Standard (Awashthi 2000) and European Union Standards, EU (2002). Generally, concentration of Iron was the highest followed by Aluminium, Manganese, Boron, Zinc, Lead and Cadmium.

Among the heavy metals measured in three types of fruit vegetables, Boron concentration was the highest (2.37 ppm – 2.47 ppm), where the highest concentration was recorded in brinjal and Iron was the second highest (1.28 ppm – 2.76 ppm), and where the highest concentration was recorded in chilli. Meanwhile, the concentration of Cadmium ranged between 0.048 ppm and 0.053 ppm, where the highest concentration was recorded in brinjal. The concentration of Lead ranged between 0.013 ppm and 0.138 ppm with brinjal that recorded the highest concentration. In addition, the concentration of Zinc was ranged between 0.27 ppm and 0.32 ppm with the highest concentration recorded in brinjal (Figures 2, 3 and 4). All Pb, Cd and Zn values complied with the Indian Standard (Awashthi 2000), WHO/FAO (2007) and Commission Regulation, EU (2006).

The concentrations of Aluminium, Boron, Cadmium, Iron, Lead, Manganese and Zinc in irrigation water that was collected were 0.214 ppm, 3.5 ppm, 0.085 ppm, 0.233 ppm, 0.22 ppm, 1.105 ppm and 0.217 ppm respectively. Pb, and Zn values complied with the Indian Standard (Awashthi 2000), FAO (1985), and Class IV, Interim National Water Quality Standard for Malaysia (INWQS 1985) but not Cd. The concentration of Cd in irrigation water recorded 0.0853 ppm exceeded the safe limits standard (0.01 ppm). The concentration of heavy metals in irrigation water in sequence were B>Mn>Fe> Pb>Zn>Al>Cd.

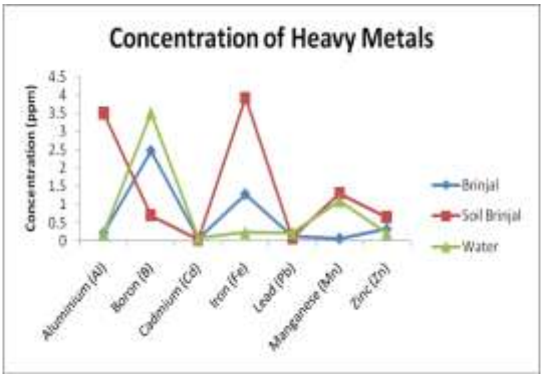

Figure 2: Concentration of heavy metals in brinjal, soil for brinjal and irrigation water.

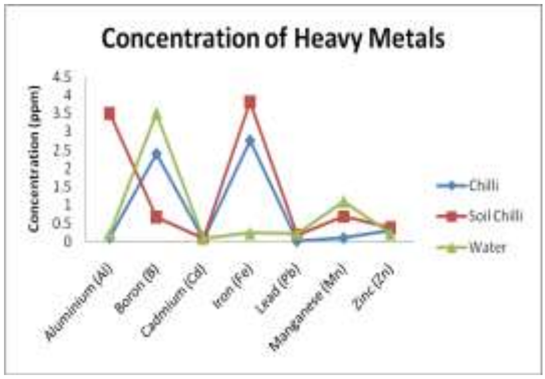

Figure 3: Concentration of heavy metals in chilli, soil for chilli and irrigation water.

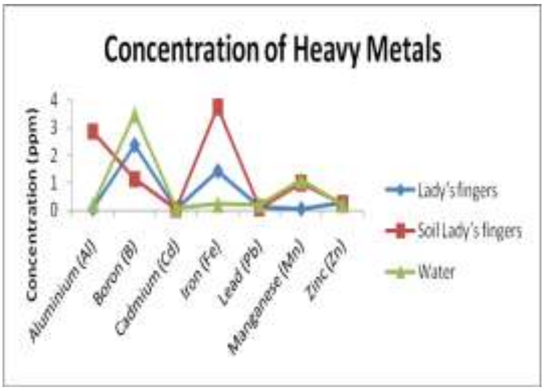

Figure 4: Concentration of heavy metals in lady's fingers, soil for lady's fingers and irrigation water.

The results showed that, the trend of heavy metal concentrations in vegetables was similar (positive correlation) with the trend of heavy metals concentrations in irrigation water. On the other hand, the trend of heavy metal concentrations in soil was also similar with the concentrations in vegetables and irrigation water except for Aluminium (negative correlation). Meanwhile, high concentrations of iron and manganese in soil was believed to be due to salt water intrusion (Figure 2,3 &4).

Conclusions

High concentrations of heavy metals in soil and irrigation water led to the accumulation of heavy metals in vegetables. Heavy metal concentrations varied among the test vegetables, which reflected the differences in their uptake capabilities and their further translocation to edible portion of the plants. The trend revealed that, high concentrations of Cd, Pb and Zn in soil and water led to high concentrations in vegetables, even though the concentrations in all vegetables were below the national and international permissible limits. Irrigation water was a dominant factor to determine the concentrations of heavy metals in vegetables compared to soil because irrigation water normally led to the accumulation of heavy metals in soil and consequently into the vegetables. Based on the results, it showed that, Boron was found to be the highest in irrigation water as well as in vegetables but not in soil. The lower concentrations of heavy metals in vegetables were believed to be due to the good quality of irrigation water and absence of pollution in soil in the study area. It could be suggested that fruit vegetables in Kampung Badang, Pantai Cahaya Bulan were safe for consumption.

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