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Effect of Waste Water on Heavy Metal Accumulation in Hamedan Province Vegetables

M. Cheraghi, B. Lorestani and N. Yousefi
Islamic Azad University, Hamedan Branch, Iran

Abstract: The objective of this research was to elucidate the effect of waste water on heavy metal concentration in vegetables. To this purpose a region fertilized with waste water (Najafi Boolvar, Hamedan, Iran) was chosen as a polluted area and a region without any waste water pollution (Heydareh, Hamedan, Iran) as a control area. Eight kinds of vegetables were collected from both areas, separately and after preparing, Pb, Zn, Cu and Mn concentrations of them, were measured by using the atomic absorption spectrophotometer. Present results showed that concentration of some heavy metals in vegetables grown in Najafi Boolvar was several times as high as that in Heydareh. According to the results of present study, waste water have special problems for vegetables and thus for human health, because of ability of accumulating heavy metals in soil and biological accumulation of these elements in food chain.

Key words: Heavy metal accumulation, pollution, vegetable, waste water

INTRODUCTION

The limitation of fertile fields has made human to increase the amount of production in the unit level. This action has been operated by exclusive using fossil energies, pesticides and chemical fertilizers. According to expensive use of chemical fertilizers in few recent decades, farmers tend to use waste water. The waste water is considered as low price fertilizer which is a rich source of nutrients elements for plants such as phosphor, nitrogen and low consuming elements such as iron, copper and zinc (Chaw and Reves, 2001).

Annually about 30 million tones of waste water was produced in the world which more than 70% of that used as an agricultural fertilizer. Also the waste water has a desired effect because of having high percents of organic matters for hydrologic conducting and ventilation, humidity and stability of soil particles. The waste water has a large amount of heavy metals such as cadmium, lead, nickel and the other poisonous metals. While the waste water is added to the soil, the plants absorb these elements. The long term using of waste water, makes these metals to accumulate in soil and increases the absorption and accumulation of them by the plant (Chaw *et al*., 2000).

Heavy metals are important as environmental pollutants and many of them are toxic even at very low concentrations (Nriagu, 1979). The necessity for study of heavy metals its kind and amount will be unavoidable, while there is the possibility of their entrance through several ways in to the human body. Consumption of agricultural products especially vegetables is one of heavy metals entrance ways to human body. In as much as farmers in Hamedan City use untreated waste water as a fertilizer, the possibility of pollution of vegetables by many kinds of pollutants such as heavy metals is not so improbable. In this research, entrance and accumulation of heavy metals in vegetables of this region have been studied.

MATERIALS AND METHODS

Plant species and sampling locations: Eight different kinds of vegetables were collected in the surrounding area of Najafi Boolvar (Hamedan, Iran), fertilized by untreated waste water, as a polluted area from January to June, 2007. Besides species located in close proximity to polluted site, vegetables were also collected from a control site, without any waste water, as controls, called Heydareh. The collected species are shown in Table 1.

The species studied consisted of 8 genera and 5 families (Table 1) of which 3 species belonged to Umbelliferae, forming the most dominant component in polluted site.

Plant sampling and analysis: Samples of different species were collected from the sites selected (polluted and control sites) (Table 1). The samples were thoroughly washed with running tap water and rinsed with deionized water to remove any soil particles attached to the plant surfaces. The vegetable tissues were then separated and oven dried (70°C) to constant weight. The dried tissues were weighed and ground into powder for metal concentration analysis. Metal contents

Corresponding Author: Cheraghi Mehrdad, Islamic Azad University, Hamedan Branch, Iran

Table 1: Vegetables composition in surrounding area of Najafi Boolvar

Plant species	Family
Spinaceae oleraceae	Chenopodiaceae
Artemisia dracunculus	Asteraceae
Petroselinum sativum	Umbelliferae
Coriandrum sativum	Umbelliferae
Mentha piperita	Lamiaceae
Anethum graveolens	Umbelliferae
Fumaria parviflora	Fumariaceae

(Pb, Zn, Cu and Mn) of the plant samples were extracted by acid digestion followed by measurement of total concentrations of all elements of interest using atomic absorption spectrophotometer (GBC Avanta, Australia) (Ward *et al*., 1975).

Soil sampling and analysis: Soils were sampled from the same sites and location points, as well as the plants. The top 20 cm soil from among the plant roots was collected, air-dried for 2 weeks and then sieved through a 2 mm mesh. Samples were then analyzed for total metals (Pb, Zn, Cu and Mn). Total metal contents were extracted by acid digestion (Sposito, 1989). Metal contents were measured by atomic absorption spectrophotometer (GBC Avanta, Australia).

RESULTS AND DISCUSSION

Metal concentrations in soil: A major environmental concern due to dispersal of industrial and urban wastes generated by human activities is contamination of soil. Controlled and uncontrolled disposal of waste, accidental and process spoilage mining and smelting of metalliferous ores, sewage sludge application to agricultural soils are responsible for the migration of contaminations in to non-contaminated sites as dust or leachate and contribute towards contamination of our ecosystem. A wide range of inorganic and organic compounds cause contamination, these include heavy metals, combustible and putrescible substances, hazardous wastes, explosive and petroleum products. Major component of inorganic contaminants are heavy metals (Adriano, 1986; Alloway, 1990). Although heavy metals are essential for normal plant growth, elevated concentrations of both essential and non-essential metals can result in growth inhibition and toxicity symptoms (Hall, 2002). All metals at high concentrations have strong toxic effects and are regarded as environmental pollutants (Nedelkoska and Dorna, 2000). Although plants adapt rather readily to chemical stress, they also may be very sensitive to an excess of particular trace element. Visible symptoms of toxicity vary for each plant species and even for individual plants, but most common and non specific symptoms are inactivation of biomolecules by either blocking essential functional groups or by displacing essentialmetal ions (Goyer, 1997), changes in permeability of the cell membrane, reactions of thiol groups with cations and damage to photosynthesis apparatus (Kabata- Pendias and Pendias, 2000).

Table 2: Heavy metal standard concentrations (ppm) in soil and vegetables

Heavy metals	Soil	Vegetable
Cu	10.0	17.5
Zn	181.0	88.0
Pb	67.0	7.5
Mn	397.5	165.0

Kabata-Pendias and Pendias (1984)

Table 3: Mean of heavy metal concentrations in Najafi Boolvar and Heydareh*

Heavy metals	Najafi Boolvar	Heydareh
Cu	56	8.0
Zn	212	111.0
Pb	109	56.5
Mn	393	384.0

*Each data represent means of 8 samples

Untreated waste water can increase heavy metal absorption by vegetables fertilized with it (Chaw *et al*., 2000).

As shown in Fig. 1, Table 2 and 3, it is clear that the amount of heavy metals, expect Mn, in Najafi Boolvar, fertilized by waste water, is higher than standard concentrations and than in Heydareh soils, without any waste water. In case of Mn, concentration of this element in Najafi Boolvar dose not have significant difference with Heydareh.

Najafi Boolvar as a polluted region is predominantly contaminated with Cu, Zn and Pb; 56, 212 and 109 ppm, respectively.

Metal concentrations in vegetables: Metal concentrations in vegetables vary with plant species (Alloway *et al*., 1990). Plant uptake of heavy metals from soil occurs either passively with the mass flow of water in to the roots, or through active transport crosses the plasma membrane of root epidermal cell. Under normal growing conditions, plants can potentially accumulate certain metal ions an order of magnitude grater that the surrounding medium (Kim *et al*., 2003).

In this study a total of 8 vegetables of 8 species are collected from 2 locations. Concentrations of Cu, Pb, Zn and Mn in soils and vegetable biomass are shown in Table 3. Metal concentrations in vegetables grown in uncontaminated soils (Heydareh) are 8.1-17 ppm for Cu, 4.3-7.3 ppm for Pb, 44.7-85.5 ppm for Zn and 109.2-165 ppm for Mn, whereas the highest metal concentrations in vegetables grown in contaminated soils are 9-36.5, 8.5-30.2, 48.1-181 and 109.1-183 for Cu, Pb, Zn and Mn, respectively (Fig. 1). According to Fig. 1, the

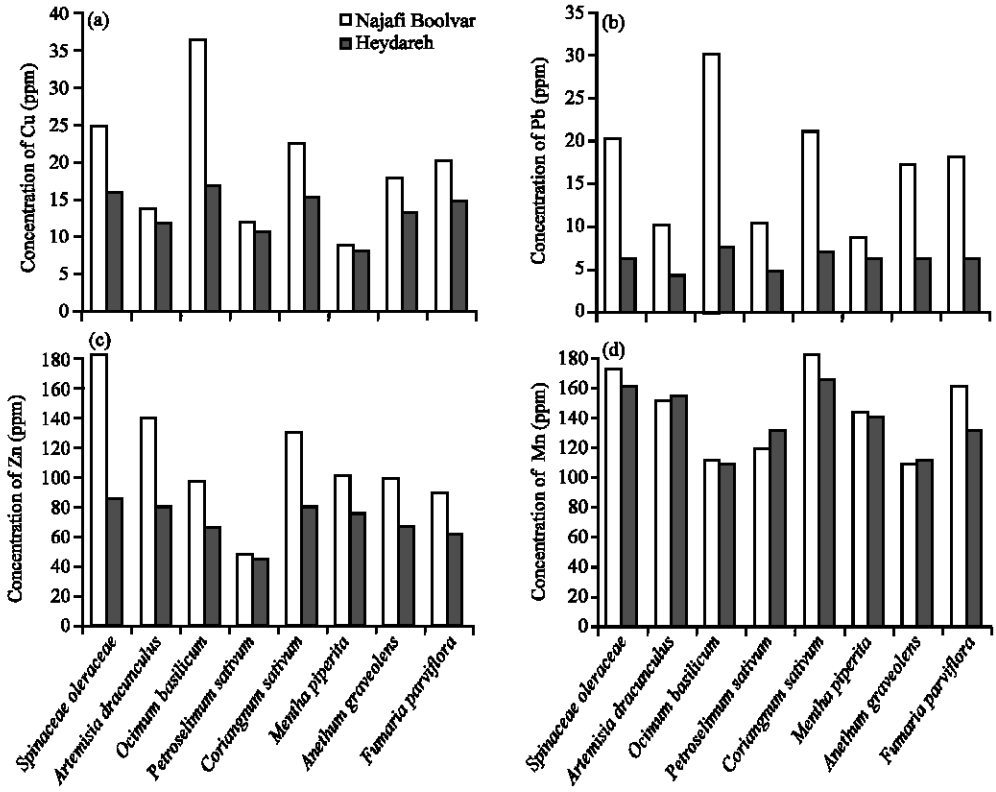

Fig. 1: Metal concentrations of (a) Cu, (b) Pb, (c) Zn and (d) Mn in vegetables of Najafi Boolvar and Heydareh

maximum of total Cu and Pb concentration in *Ocimium bacilicum*, maximum of total Zn in *Spinaceae oleraceae* and maximum of total Mn in *Coriandrum sativum* are found. Present results showed that the concentrations of Cu, Pb and Zn in all of the vegetables grown in Najafi Boolvar, are as high as those in Heydareh. About Mn, concentration of this element in *Spinaceae oleraceae*, *Ocimum basilicum*, *Coriandrum sativum*, *Mentha piperita* and *Fumaria parviflora* grown in Najafi Boolvar is higher than those of in Heydareh.

According to afford mentioned subject at present, it is concluded that heavy metals have special problems for vegetables and thus for human health, because of ability of accumulating heavy metals in soil and their biological accumulation in food chain, it is necessary to be careful about their poisonous and hazardous effect continuously.

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