Environmantal Risk Phytoaccumulation of Arsenic in *Spinacea Oleracea* L. and *Lactuca Sativa* L.

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Abstract: Pollution of the environment, particularly the soil, appears to be one of the major contemporary issues. In addition, many studies point to the involvement of ecological risk of heavy metals into the food chain through edible plants like *Spinacea oleracea* L. and *Lactuca sativa* L.. This paper presents the results of the “ex-situ” application of phytoaccumulation on the soils of contaminated terrain using the plant species of spinach (*Spinacea oleracea* L.) and lettuce (*Lactuca sativa* L.). Sequestration of arsen from the soil by these plant species was observed through phytoaccumulation factor—PF and limit values (mg/kg). The main task and objective of this research was to establish the level of accumulation of toxic element As from the soil by plants and to calculate the PF factor of transfer. The experiment was set up in the control conditions where the soil from eight contaminated locations was placed in the experimental containers. The AAS method was used to analyze heavy metal in plant material and soil. PF factor values ranged from 0.1 to 1.0 which indicates that the spinach and lettuce plants rechargeable moderate compared to arsenic.

Key words: Phytoaccumulation, *Spinacea oleracea* L., *Lactuca sativa* L., arsenic.

1. Introduction

The environment in general comprises everything that surrounds the people: soil, air, water and biodiversity etc.. Nowadays, pollution of environment and primarily of soil, poses one of the most pressing issues in Europe. The European commission has identified eight major threats to soil (Thematic Strategy for Soil Protection Communication COM/2006/231), which besides erosion, organic matter decline, flooding, landslides, salinization, compaction, loss of biodiversity and change of use, also include soil pollution.

States that polluted soil is a soil whose contents of harmful substances have increased due to human or natural activities to the levels which may be dangerous to humans as well as to the production of plants and animals [1]. The occurrence of polluted soil always brings a high environmental risk of heavy metals entering the food chain. According to Basic [2], the

dominant point of origin or the starting point of entry of heavy metals into the food chain is soil. It has been established that Cd, Hg, Pb, As, Cr and Tl are toxic to plants and dangerous to the health of consumers (heterotrophs), condition of biosphere and stability of the terrestrial and semi-terrestrial ecosystems [3].

Translocation of heavy metals into the plants is tracked through the translocation coefficient which varies in different plant species depending on the metal [4, 5]. In different sources, the accumulation factor is referred to as accumulation factor, enrichment coefficient, translocation coefficient, transfer factor, phytoaccumulation factor, soil-plant transfer coefficient, bioaccumulation factor or biological adsorption coefficient (BAC) [6-13].

According to Klope et al. [4], edible plants such as *Lactuca sativa* L. and *Spinacea oleracea* L. have a great ability to accumulate heavy metals (Table 1). Hence, they were selected for this experiment. These two species are widely used in nutrition in Bosnia and Herzegovina, for example, in the preparation of traditional dishes (“spinach pie”) and various salads.

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Table 1 Ability of some edible plants to accumulate heavy metals.

High	Medium	Low	Very low
<i>Lactuca sativa</i>	<i>Brassica o. acephala</i>	<i>Zea mays</i>	<i>Phaseolus sp.</i>
<i>Spinacia oleracea</i>	<i>Brassica ol. capitata</i>	<i>Brass. oler. italica</i>	<i>Pisum sativum</i>
<i>Beta vulg. v. cicla</i>	<i>Beta vulgaris rubra</i>	<i>Brass. oler. botrytis</i>	<i>Cucumis melo</i>
<i>Cichorium end. lepidium</i>	<i>Brassica rapa</i>	<i>Brass. ol. gemmifera</i>	<i>Lycopers. esc.</i>
<i>lapatif.</i>	<i>Raphanus sativus</i>	<i>Apium graveolens</i>	<i>Caps. annum</i>
<i>Daucus carota</i>	<i>Solanum tuberos.</i>	<i>Rubus sp. and Fragaria sp.</i>	<i>Solanum m.</i>

The legislation of BiH governs the allowed content of harmful and hazardous substances in soil as well as some contaminants in foodstuffs [14, 15].

1.1 Arsenic in Soils and Plants

Arsenic (As) was first documented by the alchemist Albertus Magnus [16, 17]. It is an amphoteric metalloid in the Va group of the periodic table of elements, whose atomic mass is 74,9216 and atomic number 33. It is accounted among toxic elements [18]. According to Conti et al. [19], all heavy metals and metalloids in large amounts are toxic, and the boundary separating the essential from the toxic elements depends on the concentration of the element and the quantity taken in by food.

Arsenic is found in all environment media, while its largest reservoir is the lithosphere [20]. According to Fitz and Wenzel [21], the arsenic concentration levels in environmental media are usually below 10 mg/kg. Accessibility of As to plants depends on the levels of pH, as well as the contents of iron, aluminum and calcium [18]. Limit values for arsenic, depending on soil texture, are 10 mg/kg for sandy soils, 15 mg/kg for powdery-loamy soils and 20 mg/kg for clayey ones [14]. Permissible concentration of arsenic in vegetables is 0.30 mg/kg of moist matter [15].

2. Material and Methods

Soil taken from eight contaminated sites was transferred to the control containers and sown with *Lactuca sativa* and *Spinacea oleracea*. At the end of the vegetation period, plant material was sampled and samples were prepared for analysis. The analysis of the plant material was performed by AAS method in

the Federal Institute of Agriculture in Sarajevo, while soil analyses were made in the PAM Institute (Institute for Soil Science, Agrochemistry and Melioration) at the Faculty of Agricultural and Food Sciences in Sarajevo.

The phytoaccumulation factor is calculated according to the Eq. (1):

$$PF = \frac{C_{plant}}{C_{soil}} \quad (1)$$

Where,

C_{plant} is denotes concentration in plant residues at the end of the experiment (mg/kg);

C_{soil} is denotes concentration in soil prior to the experiment (mg/kg).

Levels of PF [7]:

High accumulator plants: PF 1-10;

Moderately accumulator plants: PF 0.1-1.0;

Low accumulator plants: PF 0.01-0.1;

Non accumulator plants: PF < 0.01.

3. Results

Total content of arsenic (As) in edible plants in relation to the limit values are shown in Figs. 1 and 2.

The content of As in the tested moist plant material at all sites was slightly above the limit values and ranged from 0.31 mg/kg to 0.35 mg/kg in *Lactuca sativa* L. and from 0.32 mg/kg to 0.38 mg/kg in *Spinacea oleracea* L..

The resulting values of phytoaccumulation factor—PF (Table 2) show that the selected edible plants of *Lactuca sativa* L. and *Spinacea oleracea* L. are low accumulator plants for arsenic. The PF values ranged between 0.01 and 0.05 (for *Lactuca sativa* L.) and between 0.02 and 0.05 (for *Spinacea oleracea* L.).

Fig.1 The total content As in *Lactuca sativa* L. in relation to the limit values.

Fig. 2 The total content As in *Spinacea oleracea* L. in relation to the limit values.

Table 2 Levels of PF coefficient for As in *Lactuca sativa* L. and *Spinacea oleracea* L..

Location	PF _{As} for <i>Lactuca sativa</i> L.	PF _{As} for <i>Spinacea oleracea</i> L.
Location 1	0.02	0.02
Location 2	0.02	0.02
Location 3	0.05	0.05
Location 4	0.02	0.02
Location 5	0.03	0.04
Location 6	0.02	0.04
Location 7	0.02	0.02
Location 8	0.01	0.04

4. Discussion and Conclusion

In Bosnia and Herzegovina, *Lactuca sativa* L. and *Spinacea oleracea* L. are used for human consumption in a variety of traditional dishes, such as “spinach pie”, as well as various salads. These edible plants can serve as an indicator in the assessment of potential environmental risk of phytoaccumulation of arsenic (As) in them. These plants also have a high ability to absorb heavy metals from the soil.

Given that the total content of arsenic (As) in edible plants of *Lactuca sativa* L. and *Spinacea oleracea* L. was only slightly above the permissible values, they have proven to be poor/low accumulator plants. Levels of PF ranged between 0.01 and 0.05 for *Lactuca sativa* L. and between 0.02 and 0.05 for *Spinacea oleracea* L..

Based on the obtained results, it can be stated that *Lactuca sativa* L. and *Spinacea oleracea* L. pose an insignificant environmental risk when it comes to the entry of arsenic in the food chain through these plants.

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