# CHARACTERIZATION OF HEAVY METALS CONTENTS IN VARIOUS PLANT FOODS FROM POLLUTED SITES

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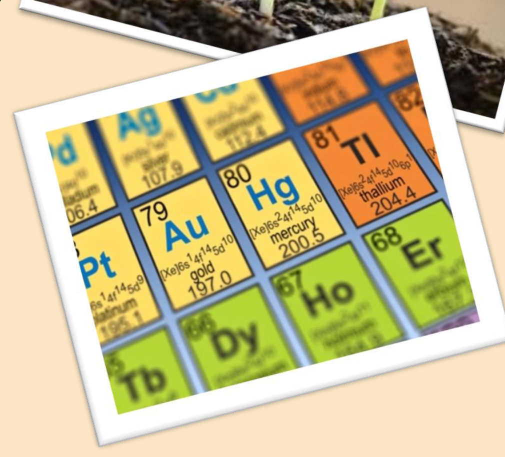

## INTRODUCTION

Mining and processing metal ore can be a significant source of **HEAVY METAL CONTAMINATION** of the environment. The environmental concern in mining areas is primarily related to physical disturbance of the surrounding landscape, spilled mine tailings, emitted dust and acid mine drainage transported into rivers. Excessive accumulation of heavy metals in agricultural soils around mining areas, resulting in elevated heavy metal uptake by plant food, is of great concern because of **POTENTIAL HEALTH RISK** to the local population.
The consumption of plants produced in contaminated areas, as well as ingestion or inhalation of contaminated particles is two principal factors contributing to **HUMAN EXPOSURE TO METALS**. Cultivation of crops for human or livestock consumption on contaminated soil can potentially lead to the uptake and accumulation of trace metals in the edible plant parts with a resulting risk to human health. Increasing evidence shows that heavy metal pollution of mined areas caused health damage to the local inhabitants.
**SERIOUS SYSTEMIC HEALTH PROBLEMS** can develop as a result of excessive dietary accumulation of heavy metals such as Cd, and Pb in the human body. Although Zn and Cu are essential elements, their excessive concentration in *PLANT FOOD* and *FEED PLANTS* are of great concern because of their toxicity to humans.

**GLOBAL PROBLEM**

**HUMAN HEALTH RISKS ASSESMENT**




Up to 50% of inhaled inorganic **LEAD** may be absorbed in the lungs. Adults take up 10–15% of lead in food, whereas children may absorb up to 50% *via the gastrointestinal tract.* ***Lead in blood is bound to erythrocytes, and elimination is slow and principally via urine.*** Lead is accumulated in the skeleton, and is only slowly released from this body compartment. Half-life of lead in blood is about 1 month and in the skeleton 20–30 years.

**Pb** and **Cd** are considered potential carcinogens and are associated with etiology of a number of diseases, especially cardiovascular, kidney, nervous system, blood as well as bone diseases.

**HEALTH EFFECTS**

**MANGANESE** has recently become a metal of global concern because of the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as a gasoline additive. Proponents of the use of MMT have claimed that the known link between occupational manganese exposure and the development of a Parkinson's disease-like syndrome of tremor, postural instability, gait disorder, and cognitive disorder has no implications for the relatively low levels of manganese exposure that would ensure from its use in gasoline.

**ALUMINUM** contributes to the brain dysfunction of patients with severe kidney disease who are undergoing dialysis. High levels of aluminum have been found in neurofibrillary tangles (characteristic brain lesions in patient's with Alzheimer's disease), as well as in the drinking water and soil of areas with an unusually high incidence of Alzheimer's disease.

## CONDUCTED INVESTIGATIONS/PERSPECTIVES

### Study area

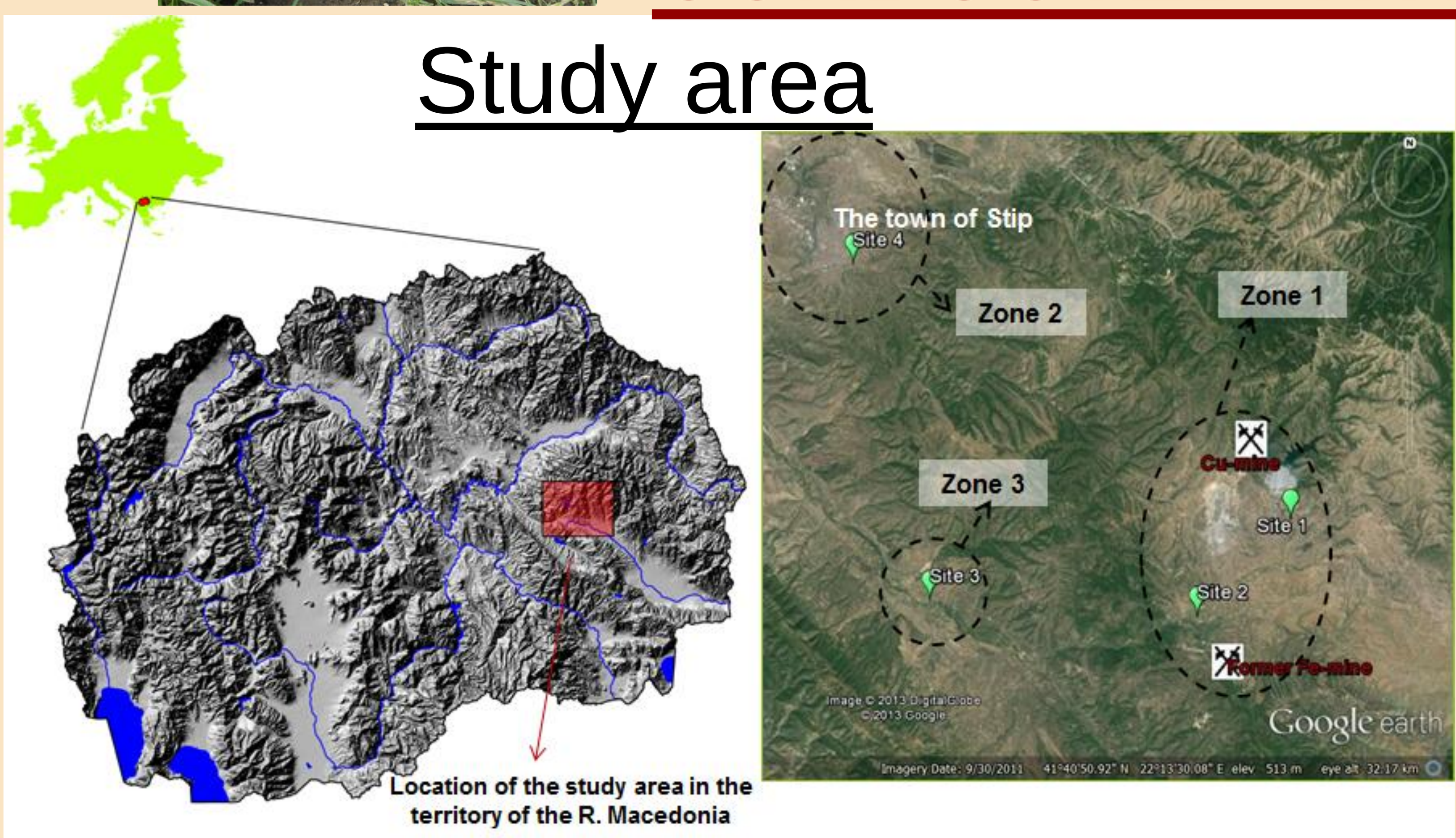


**Figure 1.** Locality of the study area in the territory of the R. Macedonia separated in zones (Zone 1 – polluted area; Zone 2 – urban area; Zone 3 – control area, not-contaminated area)

### Methodology

**SOIL PRETREATMENT -** Three methods were applied for the study of the plant-availability of the elements:**(1)** Extraction with deionized $H_2O$, that provides information on the actual availability of elements fromthe soil solution; **(2)** Extraction with 0.1 M HCl for 1 h and filtered with an acid-resistant filter, displacing potentially available forms that are not easily extracted. Total digestion was applied for determining of total elements contents. **(3)** Extraction of the soluble species of trace elements in a mixed buffered solution (pH = 7.3) of triethanolamine (0.1 mol $l^{-1}$ TEA) with $CaCl_2$ (0.01 mol $l^{-1}$) and diethylenetriaminepentaacetic acid (DTPA, 0.005 mol $l^{-1}$), that is often recommended for the extraction of toxic or biogenic metals. DTPA extracting solution was preparing in this way: 0.005 M DTPA (diethylenetriaminepentaacetic acid), 0.01 M $CaCl_2$ and 0.1 M TEA (triethanolamine) was adjusted to pH to 7.30± 0.05 with 1:1 HCl.

**PLANTS PRETREATMENT –** Plants samples were totally digested with application of closed wet digestion method using $HNO_3$ and $H_2O_2$ for total tissue digestion.




## RESULTS

**Table 1.** Basic statistics for elements contents in shoots and roots of plant species (contents are given in mg $kg^{-1}$ on dried mass) [1]

| | *Rumex acetosa* | | | | *Urtica dioica* | | | |
|---|---|---|---|---|---|---|---|---|
| | Shoot | | Root | | Shoot | | Root | |
| | Range | Med | Range | Med | Range | Med | Range | Med |
| **Ag** | 0.01-0.47 | 0.15 | 0.005-0.11 | 0.037 | 0.011-0.35 | 0.091 | 0.029-0.17 | 0.058 |
| **Al** | 18.8-293 | 55.8 | 174-406 | 328 | 76.0-386 | 223 | 214-1396 | 494 |
| **As** | <0.25-0.94 | <0.25 | <0.25-1.18 | 0.76 | <0.25-0.90 | <0.25 | 0.53-0.94 | 0.89 |
| **Cd** | 0.03-0.07 | 0.039 | 0.05-0.09 | 0.053 | 0.01-0.03 | 0.01 | 0.02-0.11 | 0.08 |
| **Cr** | 0.13-0.60 | 0.22 | 0.41-0.74 | 0.66 | 0.22-0.78 | 0.40 | 0.73-2.29 | 1.01 |
| **Cu** | 6.54-11.4 | 8.07 | 6.33-23.6 | 12.9 | 10.6-32.4 | 15.3 | 7.1-24.0 | 10.0 |
| **Fe** | 56.0-218 | 79.2 | 211-424 | 238 | 80.1-240 | 154 | 204-892 | 459 |
| **Mn** | 11.3-30.3 | 17.7 | 6.89-16.5 | 11.5 | 16.5-77.7 | 23.8 | 18.1-48.4 | 31.4 |
| **Mo** | 0.33-1.24 | 0.76 | 0.27-1.65 | 0.57 | 0.54-2.05 | 1.26 | 0.03-0.50 | 0.09 |
| **Ni** | 0.51-1.93 | 0.77 | 0.49-3.10 | 1.55 | 1.45-1.67 | 1.51 | 0.89-3.78 | 3.32 |
| **Pb** | 0.56-0.96 | 0.70 | 0.32-1.83 | 0.65 | 0.40-0.98 | 0.65 | 0.86-1.69 | 1.24 |
| **Zn** | 18.6-29.3 | 23.3 | 15.0-31.8 | 23.7 | 12.9-36.2 | 15.4 | 12.4-167 | 20.9 |

| | *Spinacia oleracea* | | | |
|---|---|---|---|---|
| | Shoot | | Root | |
| | Range | Med | Range | Med |
| **Ag** | 0.01-0.16 | 0.08 | 0.01-1.17 | 0.04 |
| **Al** | 93.3-259 | 172 | 163-466 | 308 |
| **As** | <0.25-0.76 | 0.44 | <0.25-0.40 | <0.25 |
| **Cd** | 0.06-0.26 | 0.13 | 0.09-0.34 | 0.17 |
| **Cr** | 0.27-0.88 | 0.49 | 0.38-1.63 | 0.83 |
| **Cu** | 6.41-9.66 | 7.74 | 3.80-7.48 | 6.45 |
| **Fe** | 102-253 | 133 | 142-368 | 272 |
| **Mn** | 12.0-70.1 | 23.3 | 10.8-33.9 | 19.9 |
| **Mo** | 0.089-0.84 | 0.51 | 0.03-0.37 | 0.15 |
| **Ni** | 0.64-3.09 | 1.45 | 0.85-3.06 | 1.84 |
| **Pb** | 0.59-0.97 | 0.68 | 0.45-0.83 | 0.76 |
| **Zn** | 39.7-66.5 | 56.8 | 26.2-32.3 | 28.6 |

**Localities: 1-site 1, Cu-mine environ; 2—site 2, Former Fe-mine; 3-site 3, referent area; 4-site 4, urban area**

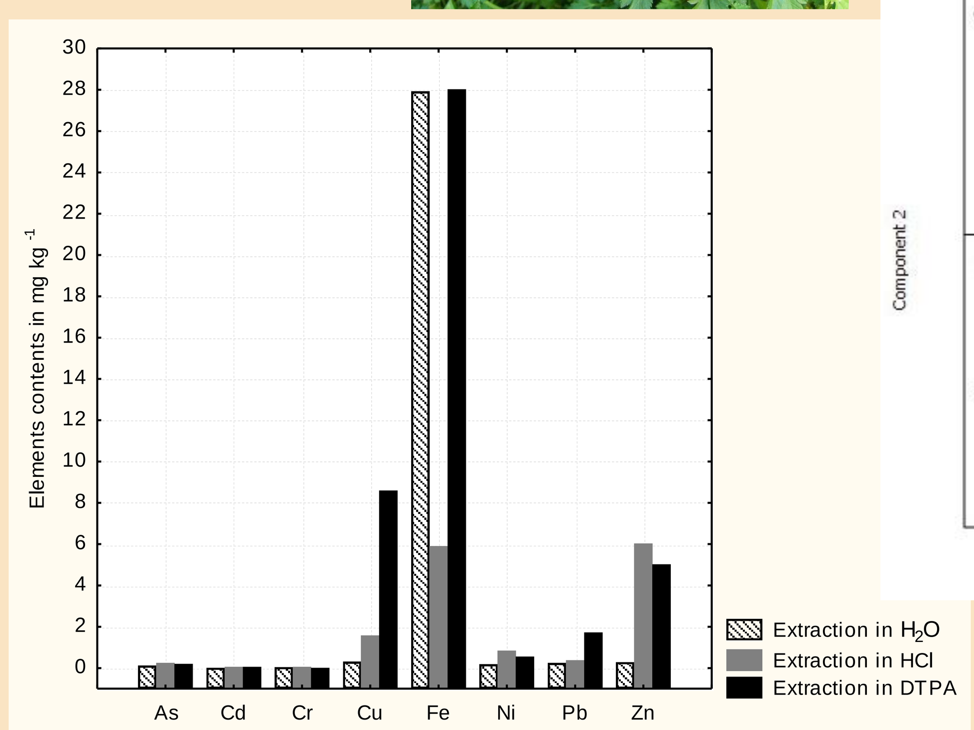


**Figure 2.** Bar plots for available forms - extracted elements contents in three different extracts solutions [2]
($H_2O$, 0.1 M HCl and DTPA–$CaCl_2$–TEA)

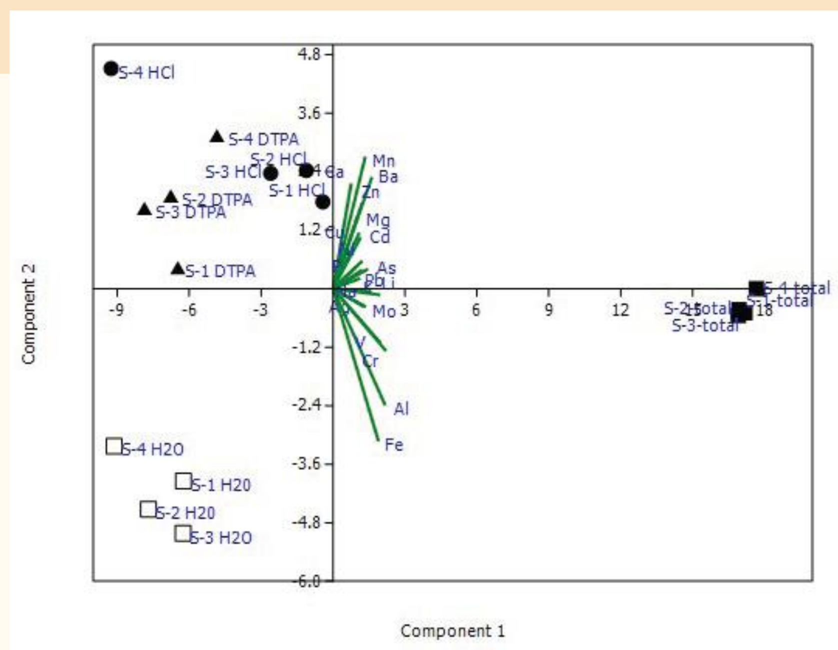


**Figure 3.** Biplot for PCA-soil model for dependence of elements contents from different sampling location, and different soil extraction solution

**Table 2.** Median values for elements contents in plant species (contents are given in mg/kg on dried mass) [2]

| Elements | *Allium sativum* | | *Allium cepa* | | *Petroselinum crispum* | |
|---|---|---|---|---|---|---|
| | **shoot** | **root** | **shoot** | **root** | **shoot** | **root** |
| | med | med | med | med | med | med |
| **As** | <0.1 | 1.28 | <0.1 | 0.40 | **0.54** | 0.62 |
| **Cd** | 0.03 | 0.14 | 0.03 | 0.15 | **0.04** | 0.06 |
| **Cr** | 0.19 | 1.60 | 0.16 | 1.30 | **0.34** | 1.11 |
| **Cu** | 3.71 | 10.1 | 3.3 | 14.6 | **6.84** | 9.75 |
| **Fe** | 44.2 | 736 | 46 | 648 | **134** | 350 |
| **Ni** | 0.15 | 2.36 | 1.26 | 2.12 | **2.43** | 1.58 |
| **Pb** | 0.35 | 1.86 | 0.73 | 1.14 | **0.88** | 1.03 |
| **Zn** | 11.3 | 30.4 | 14.9 | 42.7 | **23.8** | 16.9 |

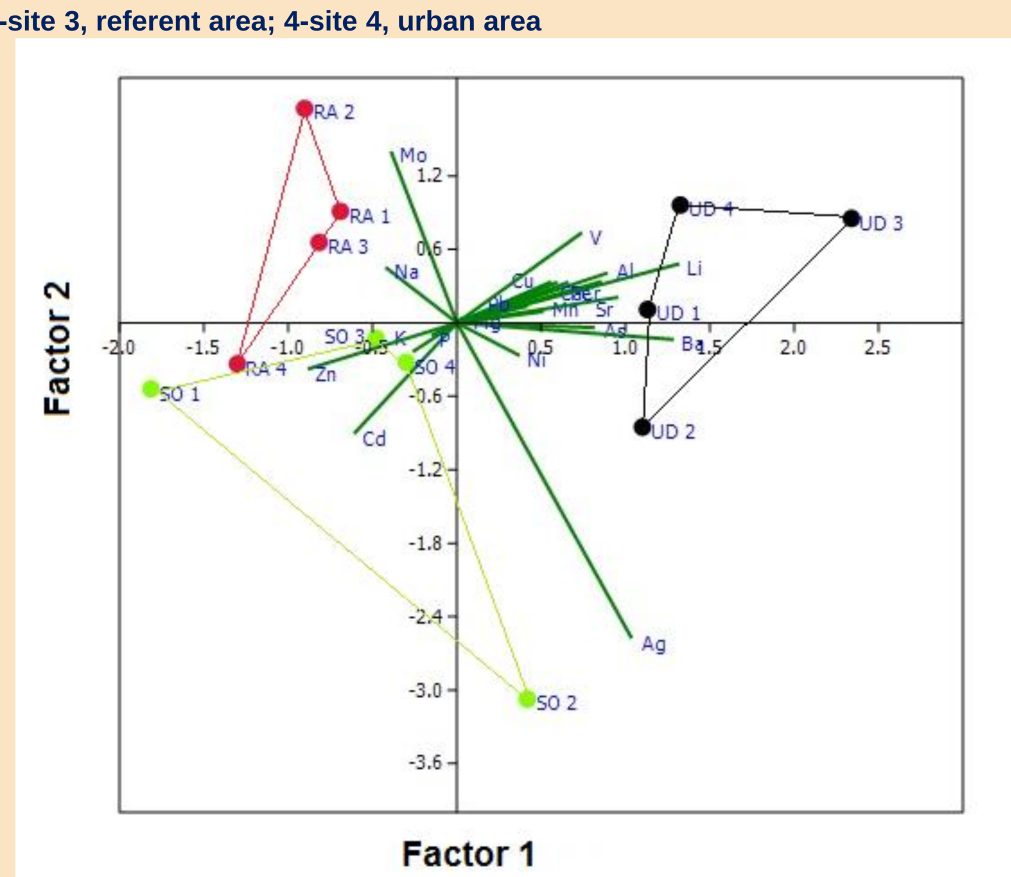


**Figure 4.** Principle components for type's vegetable species and its elements contents [1]
RA-*Rumex acetosa;* UD- *Urtica dioica;* SO- *Spinacia oleracea;* Site 1 and 2 – polluted area; Site 4 – urban area; Site 3 – control area

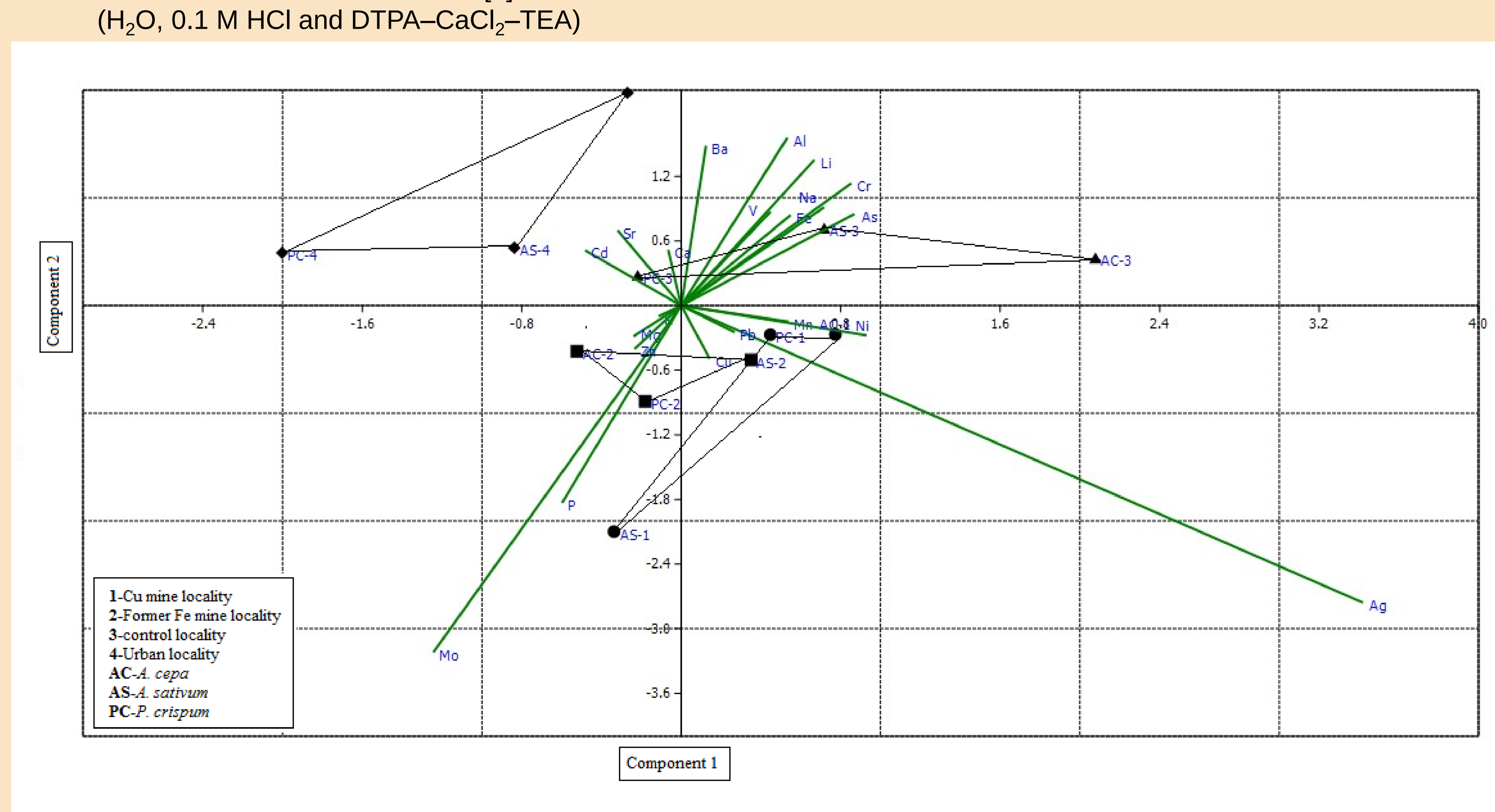


**Figure 5.** Principle components for type's vegetable species and its elements contents; Site 1 and 2 – polluted area; Site 4 – urban area; Site 3 – control area

## CONCLUSION

**Determination of heavy metals concentration in vegetables and food products is important for health risk assessment during food consumption. This kind of study can be used as a tool for the farmers so that they may adopt such strategies which lead them to save the population by minimizing the problems related to metal toxicities. Such assessment for the contaminants is required for the well-being of the population.**

**References**
[1] B. Balabanova, T. Stafilov, K. Bačeva, (2015) Bioavailability and bioaccumulation characterization of essential and heavy metals contents in R. acetosa, S. olearacea, and U. diuoica form copper polluted and referent areas. Journal of Environmental Health Science and Engineering 13(2):1-13.
[2] B. Balabanova, T. Stafilov, K. Bačeva (2015) Application of principal component analysis in the assessment of essential and toxic metals in vegetable and soil from polluted and referent areas. Bulgarian Journal of Agriculture Science, 21(3):536-544.

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