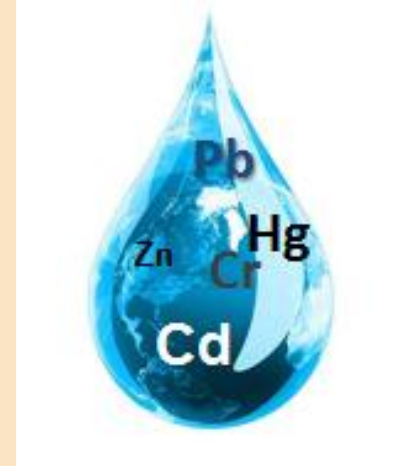

HUMAN HEALTH RISKS FROM HEAVY METALS VIA CONSUMPTION OF CONTAMINATED FOOD

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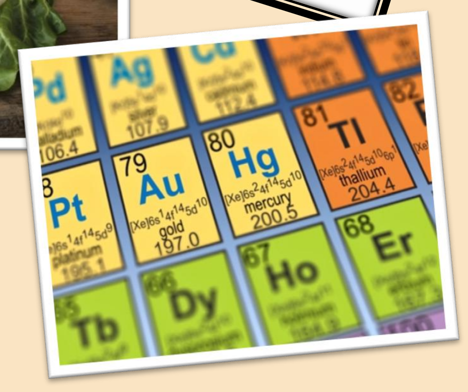


INTRODUCTION

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.

DIETARY INTAKE is the main route of exposure for most people, although *INHALATION* can play an important role in very contaminated sites. **THUS INFORMATION ABOUT HEAVY METAL CONCENTRATIONS IN FOOD PRODUCTS AND THEIR DIETARY INTAKE IS VERY IMPORTANT FOR ASSESSING THEIR RISK TO HUMAN HEALTH.**

GLOBAL PROBLEM

HUMAN HEALTH RISKS ASSESMENT

RISK ASSESSMENT: Risk of intake of metal-contaminated FOOD, characterized by:

HAZARD QUOTIENT (HQ) - ratio of determined dose to the reference dose (RD).

The population f will pose no risk if the ratio is **less than 1** and if the ratio is equal or **greater than 1** then population will experience health risk.

$$HQ = [W_{plant}] \times [M_{plant}] / R_fD \times B$$

$[W_{plant}]$ - dry weight of contaminated plant material consumed (mg/d)
$[M_{plant}]$ - Plant concentration of metal in vegetables (mg/kg),
RfD - food reference dose for the metal (mg/d)
B - body mass (kg)

DAILY INTAKE OF METALS (DIM):

$$DIM = C_{metal} \times C_{factor} \times D_{food\ intake} / B_{av.\ weight}$$

C_{metal} = heavy metals conctent in plants (mg/kg)
C_{factor} = conversion factor
$D_{food\ intake}$ = daily intake of vegetables.

DAILY DIETARY INDEX:

$$DDI = X \times Y \times Z / B$$

X = metal in vegetable
Y = dry weight of the vegetable
Z = approximate daily intake
B = average body mass of the consumers

HEALTH RISK INDEX (HRI):

$$HRI = DIM / R_fD$$

If the value of HRI IS LESS THAN 1 then the exposed population is said to be safe.

HEALTH EFFECTS

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.

CHROMIUM (VI) compounds are toxins and known human carcinogens, whereas Chromium (III) is an essential nutrient. Breathing high levels can cause irritation to the lining of the nose; nose ulcers; runny nose; and breathing problems, such as asthma, cough, shortness of breath, or wheezing.

Exposure to high levels **MERCURY** can permanently damage the brain, kidneys, and developing fetuses. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Short-term exposure to high levels of metallic mercury vapors may cause lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

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.

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.

CONDUCTED INVESTIGATIONS/PERSPECTIVES

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*				*Spinacia oleracea*			
	Shoot		**Root**		**Shoot**		**Root**		**Shoot**		**Root**	
	Range	**Med**	**Range**	**Med**	**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	0.01-0.16	0.08	0.01-1.17	0.04
Al	18.8-293	55.8	174-406	328	76.0-386	223	214-1396	494	93.3-259	172	163-466	308
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	<0.25-0.76	0.44	<0.25-0.40	<0.25
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	0.06-0.26	0.13	0.09-0.34	0.17
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	0.27-0.88	0.49	0.38-1.63	0.83
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	6.41-9.66	7.74	3.80-7.48	6.45
Fe	56.0-218	79.2	211-424	238	80.1-240	154	204-892	459	102-253	133	142-368	272
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	12.0-70.1	23.3	10.8-33.9	19.9
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	0.089-0.84	0.51	0.03-0.37	0.15
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	0.64-3.09	1.45	0.85-3.06	1.84
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	0.59-0.97	0.68	0.45-0.83	0.76
Zn	18.6-29.3	23.3	15.0-31.8	23.7	12.9-36.2	15.4	12.4-167	20.9	39.7-66.5	56.8	26.2-32.3	28.6

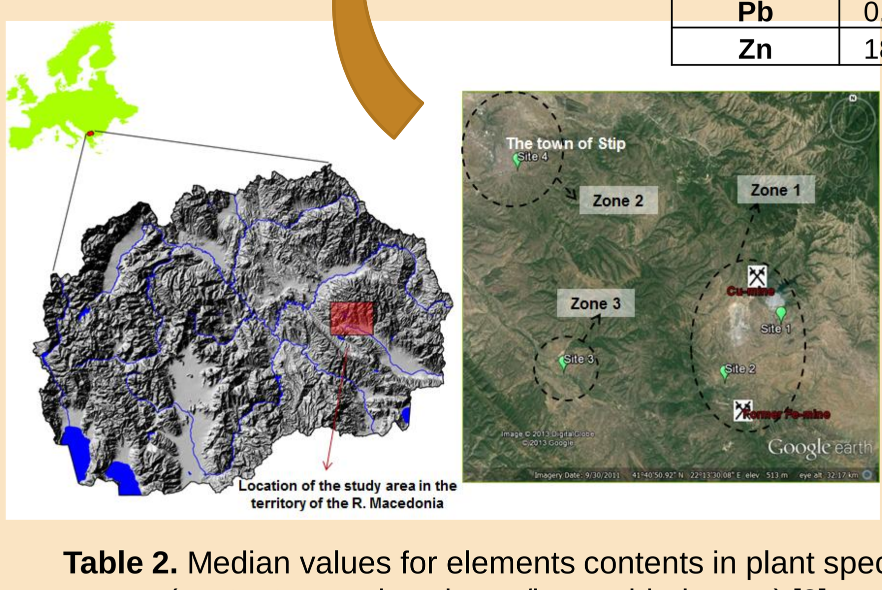
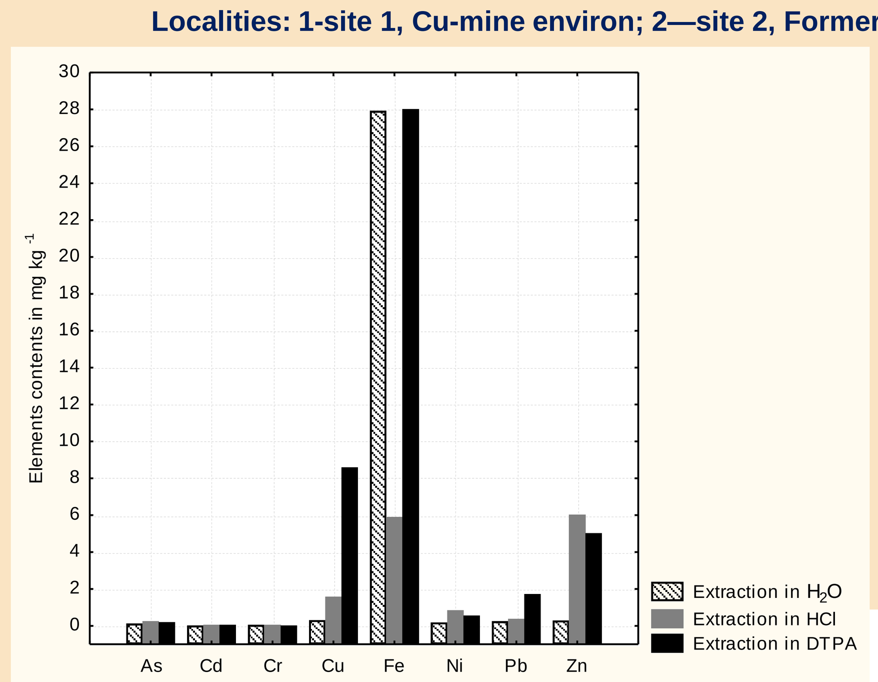


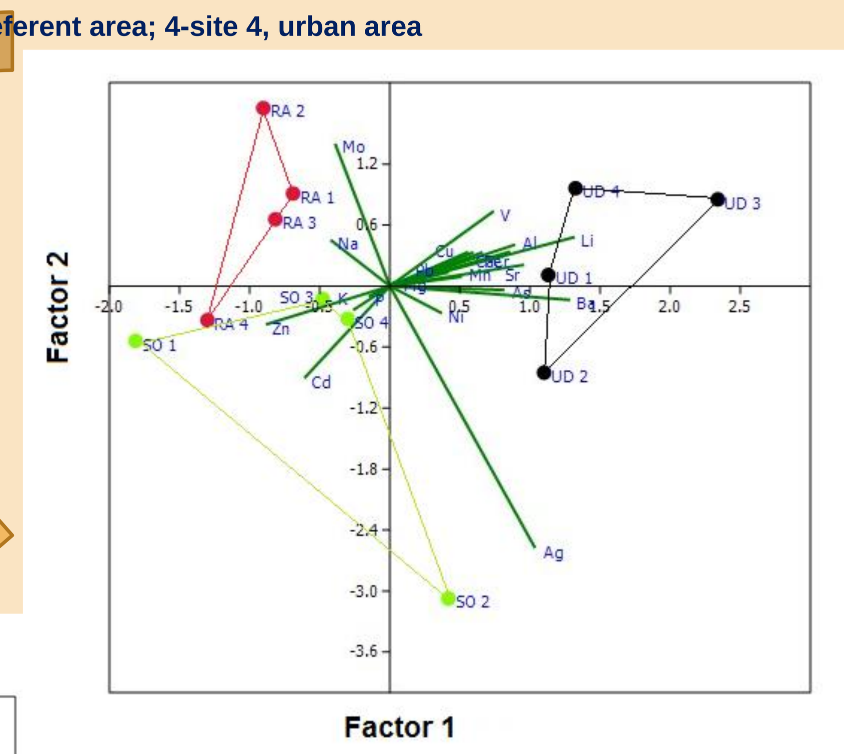
Table 2. Median values for elements contents in plant species (contents are given in mg/kg on dried mass) [2]

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

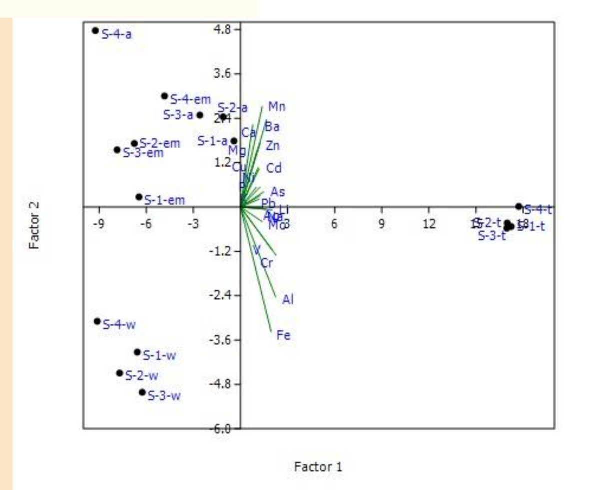
Localities: 1-site 1, Cu-mine environ; 2—site 2, Former Fe-mine; 3-site 3, referent area; 4-site 4, urban area



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)



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, not-contaminated area



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

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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