Studies Concerning the Immobilisation and Stabilization of the Mining Landfills

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In this work we studied the possibility of immobilisation and stabilization of the waste dumps from mining exploitations. Sterile samples studied from the metalliferous mining landfills of Moldova Noua, SC Moldomin S. A. From the accumulator/indicator plants ~~of~~ barley (Hordeum vulgare L) was determined the content of copper, molybdenum, manganese, arsenic, zinc and lead by X-ray fluorescence using spectrum analyzer by fluorescence of RX (FRX–NITON ANALYZERS). Studies were conducted to identify the best management practice for immobilisation metal in soil and interaction of these metal contaminants with associated plants. The research protocol comprises addition of soil, in sterile to accelerate physico-chemically driven sorption actions and growth of appropriate plant species to reduce physiologically driven uptake of metals. The study for sterile originated of mining exploitations was performed by leaching tests in order to store in specially landscaped; landfill sites inventory for dangerous metals. The results indicated that sterile corresponds with class non-hazardous waste and may be accepted for storage in specially designed waste.

Keyword: metals, inertare, stabilization, landfills mining

Activities of mining and ore processing activities are sources of metal pollution. Given the low value of the percentage of useful substances in gross minerals, the total amounts of residues after extraction of useful substances are large and contain significant amounts of metals [1]. Their storage on the soil determined, via hydrological flows and atmospheric contamination, of ecological systems at large distances from the source [2]. For this reason it is very important to find solutions to remedy the polluted areas taking action is the primary source or the secondary sources [3]. An environmentally friendly method is most effective and presents the widest scope. So the remedy is to reduce the mobility of pollutants [4] and thus are reduced and the effects of pollution, for that in this paper we will insist on this type of rehabilitation [5]. In Romania, the idea of environmental clean-up of the natural ecosystem (landscape) appeared in 1973, in a paper written by Academician N. Boscaiu. He used a term that is poorly today-environmental reconstruction. The same term was used in the same year by Soran. After this beginning, ecological restoration problems in Romania were reiterated by V. Soran, I. Puia, A. Ardelean and a few others to the seventh edition of the European Ecological Congress in Budapest. But important was the participation of Romanian ecologists Edition of the International Conference on Restoration Ecology and Sustainable Development, which was organized by the Society for Ecological Restoration, from May 27 to 29, 1996 in Zurich, Switzerland [6]. The mining industry in Romania, during its existence, has affected and still affects very serious all environmental factors, which is why today it pays great attention to their rehabilitation, so mining waste using various purposes how and by playing the economic cycle degraded lands [7]. Under the legislation, which is explicit, exact and categorical, national companies and corporations controlled the extraction activities and exploitation of useful mineral deposits. These companies will increase the future concerns for the protection and restoration of environmental factors affected [8, 9]. Active bio-accumulation of metals by plants was experienced in several case studies. Thus it was observed that specific plants growing on soils contaminated with metals, with time have adapted to conditions of pollution, assimilating into their body toxic elements [10, 11]. Some plants have proven to be good bioaccumulation concentrating metal ions 1000 mg per kg of dry matter [12]. This paper is a case study, which examines mining area Moldova Noua by proposing a model for bioaccumulation of metals in plants accumulator as barley (*Hordeum vulgare* L.). Research consists in proposing a solution for metal pollution bioremediation mining area Moldova Noua, studies on rehabilitation of soils polluted with heavy metals from mining areas, and testing of a type of solution bio-remediation (phytoremediation) for sterile from mining area Moldova Noua.

Experimental part

Order to establish waste materials class was carried out leaching test, according to Official Monitor no. 194 bis of 8 March 2005.

Leaching test

There have been harvested quantities defined sterile (100 g and 500 g) over which was added 1000 mL of water, so that to have the ratio L: S = 10:1, L: S = 2:1. Samples were homogenized for 24 h, then filtered and analyzed for metal content. The metal content was determined by atomic absorption spectrometry using VARIAN Spectr AA 280FS spectrophotometer.

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Studies on inertance and stabilization the mining landfills by phytoremediation

Samples sterile and soil were mixed in different proportions, placed in vegetation pots, using the accumulator plant *H. vulgare*. The samples thus obtained were dosed periodically with water. Following a period of 30 days the plants were separated (roots and stems) and dried at room temperature (20°C). The plants dried were separated into roots and stems, calcined, after which were analyzed for metal content by X-ray fluorescence, using spectrum analyzer by fluorescence of RX (FRX). The equipment is intended to be analyzed by fluorescence of X-ray qualitative and quantitative elemental (chemical composition) of accuracy (ppm level) in situ for environmental samples, geological, biological, of a different nature solid and liquid and various forms, without processing [13].

The calcination loss

Calcination plant tests had the purpose the removing of the organic portion thereof, for analysis in the future. The plant material weighed seated in crucible it heat until the carbonization, after that crucible is left to cool into desiccator and then crucible with ashes resulting after carbonization plant will be weighed again. The difference between initial mass and the mass remaining after calcination plant is losst at calcination. Statistical analysis was performed using *minimizing SSR in a Multiple Regression.*

Results and discussions

Phytoremediation is an environmentally agreeable and inexpensive procedure for landfills mining tailing rehabilitation that uses metallophyte plants. *H. vulgare* plants reduce the soil metal contents to environmentally agreeable levels by accumulating metals.

Metals represent important environmental pollutants, particularly in lands with rich anthropogenic stress. For soil-plant network, metal toxicity limit is highest permissible content in soil (total or bioavailable concentration) that does not pose any phytotoxic effects or a metal in edible parts of plants do not exceed food hygiene norms.

Additionally, interactions of soil-plant root-microbes have roles in regulating metal movement from soil to the edible parts of plants.

Plant species efficient of accumulating metals are of appreciable interest for phytoremediation and phytomining. Metals interfere with physiological activities of plants (photosynthesis), gaseous exchange, nutrient absorption; cause reductions in plant growth, dry matter accumulation and productivity. The mechanism of metals tolerance/ hyperaccumulate in *H. vulgare* L. is less known. Presumably, dangerous metals accumulation is dependent upon mechanism of proline transport in a glycinebetaine-plant· *accumulator as barley [14.*

A mass balance was imposed out to estimate resource removal mechanisms. Phytoremediation mostly due to phytoextraction significantly disclosed the metals removal. It is seen from data obtained that sterile derived by mining corresponds with class waste non-hazardous and may be accepted for storage in specially designed waste.

Leaching test

The experimental data on leaching test, to determine the class of waste, for acceptance of deposits specially designed is shown in table 1.

Studies on stabilized mining landfills by phytoremediation

Phytoremediation is feasible, innovative, and technical cost-effective for non-destructive remediation of metal contaminated soils.

Phytoremediation is a technique that produces inert metal.

Initial content of metals from sterile

The experimental data on the initial content of metals in sterile are given in table 2.

It is observed from experimental data that sterile has a high metal content which raises need application of methods of remediation.

Table 1
LEACHING TEST

Indicator	L/S=2:1		L/S=10:1	
	MAC [mg/kg d.m.]	Experimental value [mg/kg d.m.]	MAC [mg/kg d.m.]	Experimental value [mg/kg d.m.]
Arsenic	0.4	0.5	2	3.2
Cadmium	0.6	0.8	1	2.5
Total chromium	4	5.2	10	14.7
Copper	25	36.2	50	53.7
Mercury	0.05	0.13	0,2	0.35
Nickel	5	7.5	10	13.7
Lead	5	9.8	10	12.3
Zinc	25	32.7	50	65.7
Molybdenum	5	8.3	10	12.17
Chlorides	10.000	12.351	15.000	17.325
Sulphates	10.000	11.432	20.000	21.450

MAC–maximum acceptable (allowable) concentration

Metals	Maximum acceptable concentration (MAC) [mg/kg d.m.]	Metal Content in sterile, [mg/kg d.m.]
Copper	20	1772
Molybdenum	2	107
Nickel	20	51
Lead	20	88
Zinc	100	543
Arsenic	5	79
Manganese	900	401
MAC–maximum acceptable (allowable) concentration		

Table 2
INITIAL CONTENT OF METALS IN STERILE

Sample	Initial mass m_i, g	Final mass m_f, g	The loss at calcination		Predicted *Y*	Residual	Squared Residual
			Δm, g	η,%			
control sample (R)	0.4151	0.1499	0.2652	63.9	12.99	-12.99	168.64
control sample (S)	1.5683	0.2213	1.347	85.9	18.18	-18.18	330.57
sterile (R)	1.7085	0.7465	0.962	56.3	11.19	-11.19	125.24
sterile (S)	1.0302	0.2538	0.7764	75.4	15.70	-15.70	246.55
½ sterile+½soil (R)	0.5654	0.2627	0.3027	53.5	10.53	-10.53	110.88
½ sterile+½soil (S)	1.3597	0.1428	1.2169	89.5	19.03	-19.03	362.21
⅔sterile+⅓soil (R)	1.8355	0.9411	0.8944	48.7	9.40	-9.40	88.29
⅔sterile+⅓soil (S)	0.7255	0.2758	0.4497	61.9	12.51	-12.51	156.59
layer of steril+layer of soil (R)	2.4998	1.3536	1.1462	45.9	8.74	-8.74	76.30
layer of steril+layer of soil (S)	1.3881	0.2239	1.1642	83.9	17.71	-17.71	313.62
R–root; **T**–stem; Minimizing SSR in a Multiple Regression from η,% the loss at calcination							

Table 3
LOSS AT CALCINATION OF *H. VULGARE* PLANTS

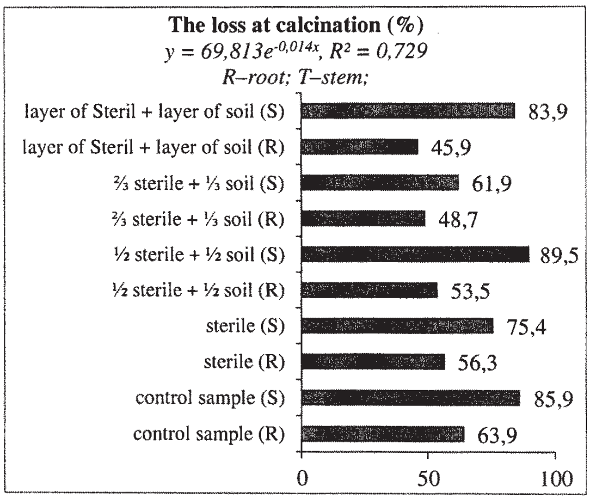

Fig. 1. The loss at calcination

It was observed that studied metals exceeding maximum concentration allowed by law, except manganese.

The loss calcination of *H. vulgare* plants is shown in table 3 and figure 1.

For series loss at calcination (to heat a substance so that it is oxidized/reduced/ loses water) trend line exponential equation are $y = 69.813e^{-0,014x}$, and squared value R_c = 0.729.

R-squared represents the percentage of the response variable variation that is explained by a linear model.

R-squared = Explained variation / Total variation.

R-squared is always between 0 (indicates that model explains none of variability of response data around its mean.) and 100% (indicates that model explains all variability of response data around its mean).

From experimental data is observed that the loss calcination is between H ≈ 40 and 80%.

Table 4
COPPER CONTENT FOLLOWING THE PROCESS OF BIOREMEDIATION

Sample	Cu^{2+} content [mg/kgd.m.] MAC	Cu^{2+} content [mg/kgd.m.] experimental value	Degree of extracting Cu^{2+} content [%]	Predicted Y	Residual	Squared Residual
control sample (R)	20	23	1.3	-1.80	1.80	3.23
control sample (S)		LOD	0	-2.11	2.11	4.43
sterile (R)		LOD	0	-2.11	2.11	4.43
sterile (S)		529	29.9	4.96	-4.96	24.57
½ sterile+½ soil (R)		448	25.3	3.87	-3.87	14.98
½ sterile+½ soil (S)		LOD	0	-2.11	2.11	4.43
⅔ sterile+⅓ soil (R)		140	7.9	-0.24	0.24	0.06
⅔ sterile+⅓ soil (S)		17	0.9	-1.89	1.89	3.58
layer of Steril+layer of soil (R)		498	28.1	4.53	-4.53	20.53
layer of Steril+layer of soil (S)		LOD	0	-2.11	2.11	4.43

R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from degree of extracting Cu^{2+} content [%]

These results were indicated and of Jakobs-Schönwandt and collaborators [13]

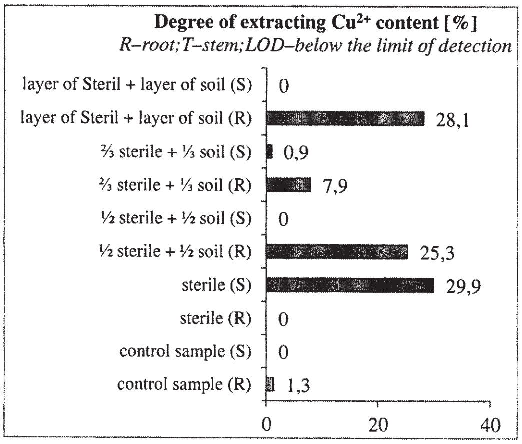

Fig. 2. The degree of extraction of copper after bioremediation sterile samples

We studied stabilization of waste dumps through bioremediation using *H. vulgare* plants.

Metal content following process of bioremediation

Recognizing a hyperaccumulator is a significant groundwork for phytoextraction of metal-contaminated soil.

H. vulgare appeared to be a model of the accumulator of metals in plants.

Copper content

The experimental data on the copper, respectively degree of extraction of thereof behind bioremediation samples of sterile mixed in different proportions with soil are shown in table 4 and figure 2.

From the experimental data it was found that highest degree of extraction of copper is found in plant roots of *H. vulgare* batteries in sample: layer of sterile layer of soil; as in sample: sterile 1/2: 1/2 soil. Copper is a fundamental microelement required for plant growth and development.

But, excess copper may inactivate and disturb protein structure as a result of implacable binding to proteins. The physiological, genetic, and epigenetic answers of *H. vulgare* seedlings to surplus copper, establishing that supply of sterile in medium containing a large quantity of copper ions [15, 16], could improve plant tolerance potential to excess copper toxicity through attenuating copper-induced noxious effects at diverse levels.

These results were also indicated of Jakobs-Schönwandt and collaborators [13].

In the rest of the samples studied the degree of extraction is significantly lower. Copper was not absorbed in the stems as it is a metal with a tendency to accumulate in the roots preferably, according supported by Lin and collaborators [17].

Molybdenum content

Experimental data on the contents of molybdenum respectively the degree of extracting thereof after bioremediation sterile samples mixed in various proportions with the soil are presented in table 5 and figure 3.

From the experimental data is observed that in all cases studied the degree of extracting of molybdenum is elevated, there is even the control sample and sterile.

The higher extraction is encountered in plant roots accumulators *H. vulgare*, except that from molybdenum tailings sample have been removed more stems of *H. vulgare* accumulators plants.

Sample	Mo^{2+} content [mg/kg d.m.]		Degree of extracting Mo^{2+} content [%]	Predicted *Y*	Residual	Squared Residual
	MAC	experimental value				
control sample (R)	2	8	7.5	-0.33	0.33	0.11
control sample (S)		4	3.7	-1.23	1.23	1.52
sterile (R)		3	2.8	-1.44	1.44	2.08
sterile (S)		8	7.5	-0.33	0.33	0.11
½ sterile + ½ soil (R)		7	6.5	-0.57	0.57	0.32
½ sterile + ½ soil (S)		4	3.7	-1.23	1.23	1.52
⅔ sterile + ⅓ soil (R)		8	7.5	-0.33	0.33	0.11
⅔ sterile + ⅓ soil (S)		6	5.6	-0.78	0.78	0.61
layer of Steril + layer of soil (R)		7	6.5	-0.57	0.57	0.32
layer of Steril + layer of soil (S)		4	3.7	-1.23	1.23	1.52

R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from Degree of extracting Mo^{2+} content [%]

Table 5
MOLYBDENUM CONTENT IN THE PLANT AFTER THE PROCESS OF BIOREMEDIATION

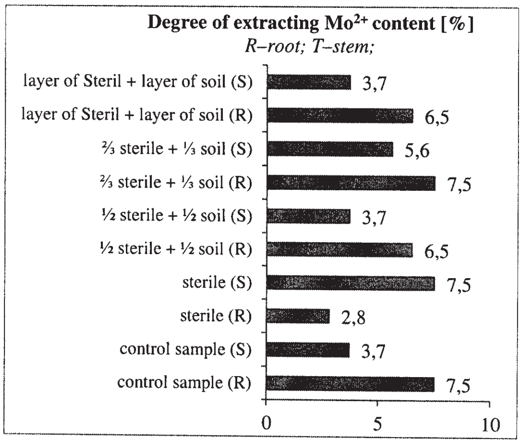

Fig. 3. The degree of extracting of molybdenum after bioremediation sterile samples mixed in different proportions with the solis

The element molybdenum is of vital importance for (nearly) all plants and animals systems. It needs to be complexed by a special cofactor in order to gain catalytic activity.

Molibdennitrogenase enzyme is involved in biological nitrogen fixation, a prokaryotic metabolic process that determines the global biogeochemical cycles of nitrogen and carbon as shown by Hernandez and collaborators [18].

Molybdenum and phosphorus are crucial for nitrogenase reaction; which catalyzes N_2 conversion to ammonia; and cell growth [19].

This concept may explain shifts in sterile and in soil fertility and implies that fixation depends on molybdenum and phosphorus in ways that are more complex than thought.

Manganese content

Experimental data on manganese content respectively its degree of extracting after bioremediation sterile samples mixed in different proportions with soil are shown in table 6 and figure 4.

From the experimental data it was found that the highest degree of extracting of manganese found in the plant roots accumulators *H. vulgare* of the sample: layer of rock and layer of soil and in the sample: sterile 1/2: 1/2 soils. Manganese excess depressed growth of seedlings (but not germination) and stimulated oxidative stress (reactive oxygen species and lipid peroxidation) in plants and

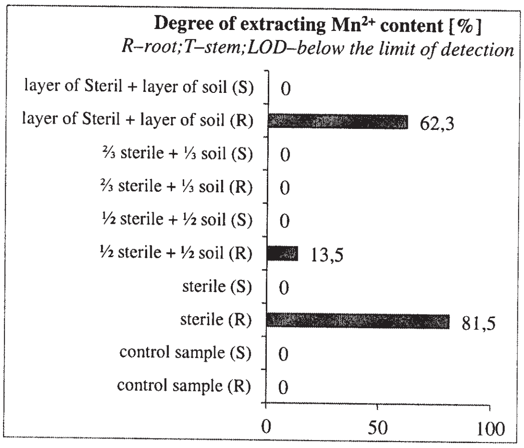

Fig. 4. The degree of extracting of manganese after bioremediation sterile samples Moldomin mixed in different proportions with soil

Table 6
MANGANESE CONTENT IN THE PLANT AFTER THE PROCESS OF BIOREMEDIATION

Sample	Mn^{2+} content [mg/kg d.m.]		Degree of extracting Mn^{2+} content [%]	Predicted *Y*	Residual	Squared Residual
	MAC	experimental value				
control sample (R)	900	LOD	0	-2.11	2.11	4.43
control sample (S)		LOD	0	-2.11	2.11	4.43
sterile (R)		327	81.5	17.14	-17.14	293.87
sterile (S)		LOD	0	-2.11	2.11	4.43
½ sterile + ½ soil (R)		54	13.5	1.08	-1.08	1.17
½ sterile + ½ soil (S)		LOD	0	-2.11	2.11	4.43
⅔ sterile + ⅓ soil (R)		LOD	0	-2.11	2.11	4.43
⅔ sterile + ⅓ soil (S)		LOD	0	-2.11	2.11	4.43
layer of Steril + layer of soil (R)		250	62.3	12.61	-12.61	158.97
layer of Steril + layer of soil (S)		LOD	0	-2.11	2.11	4.43

R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from Degree of extracting Mn^{2+} content [%]

Table 7
ARSENIC CONTENT IN THE PLANT AFTER THE PROCESS OF BIOREMEDIATION

Sample	As^{2+} content [mg/kg d.m.]		Degree of extracting As^{2+} content [%]	Predicted *Y*	Residual	Squared Residual
	MAC	experimental value				
control sample (R)	5	LOD	0	-2.11	2.11	4.43
control sample (S)		LOD	0	-2.11	2.11	4.43
sterile (R)		40	50.6	9.85	-9.85	96.92
sterile (S)		LOD	0	-2.11	2.11	4.43
½ sterile+½ soil (R)		24	30.4	5.07	-5.07	25.75
½ sterile+½ soil (S)		LOD	0	-2.11	2.11	4.43
⅔ sterile+⅓ soil (R)		18	22.8	3.28	-3.28	10.76
⅔ sterile+⅓ soil (S)		3	3.8	-1.21	1.21	1.46
layer of Steril+layer of soil (R)		31	39.2	7.15	-7.15	51.16
layer of Steril+layer of soil (S)		LOD	0	-2.11	2.11	4.43

R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from degree of extracting As^{2+} content [%]

seedlings [20]. In the remaining the samples studied the degree of extraction is significantly lower as shown Ishimaru and collaborators [21].

Manganese accumulates in stems and roots. In the experiments as a result of short time growing season, molybdenum stopped the roots of the plants accumulators *H. vulgare*.

Manganese is a vital nutrient required for plant growth, especially in the process of photosynthesis.

Plant prestidigitation is determined by multivarious environmental stresses including contrasting temperatures, light or nutrient deficiencies.

The molecular responses of *H. vulgare* plants exposed to such stress factors in combination are largely unknown.

This study was conducted to further investigate manganese-tolerance strategies of *H. vulgare* plant.

The *H. vulgare* plant is resistant to manganese and moderately resistant to manganese [22], especially thanks to its ability to sequestrate metals by chelation in vacuole.

Excess of manganese causes any specific toxicity symptoms in plants, but main target of their toxicity seems to be photosynthetic process.

Arsenic content

Experimental data on arsenic content respectively its degree of extracting after bioremediation sterile samples mixed in various proportions with soil are presented in table 7 and figure 5.

From the experimental data is observed that the degree of extracting of arsenic is greater in roots, regardless of the studied mixture.

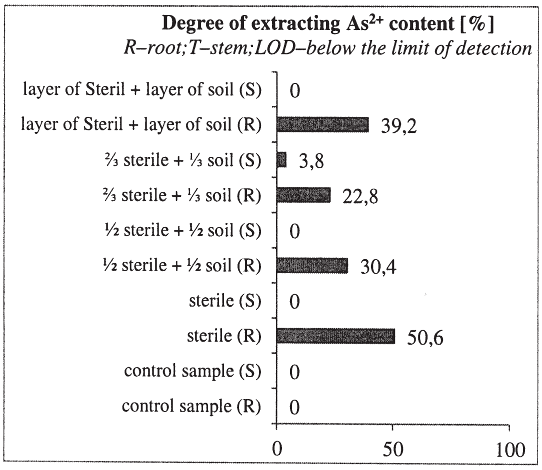

Fig. 5. The degree of extracting of arsenic after bioremediation sterile samples Moldomin mixed in different proportions with soil

Arsenic, being a toxic element's and is because there are large amount initially sterile as it supported by the Mateos and collaborators in 2006, metal uptake by plant species depends on many distinct environmental factors; soil *p*H is one of the factors due to its combined effect on chemical and biological processes, according to Mirza and collaborators in 2014 [23, 24].

Plants self-defend using inorganic arsenic species efflux systems and production of phytochelatins to complex inorganic arsenic species.

The phosphorus and sulphur may influence arsenic mobility and bioavailability, as well as the *H. vulgare* plant tolerance to arsenic [25], phytoremediation techniques employed to clean-up arsenic-contaminated areas should consider the interaction between arsenic and these elements.

Zinc content

Experimental data on content of zinc respectively its degree of extracting from samples sterile bioremediation mixed in different proportions to ground are shown in table 8 and figure 6.

Zinc is one of the essential metals required for best plant growth.

Plants of *H. vulgare* contain the promiscuous antifungal proteins and are capable to convey zinc tolerance [26].

Increasing zinc concentrations was established as helpful for increasing the enzyme activities of *H. vulgare* genotypes, these results are supported by Liu and collaborators in 2014 [27], zinc showing a high affinity for uptake in the plant roots accumulators *H. vulgare*.

So, it may be assimilated in the stems of the plants accumulators *H. vulgare*.

Interactions between zinc and phosphate nutrition in *H. vulgare* plants have long been recognized, but

Table 8

ZINC CONTENT IN THE PLANT AFTER THE PROCESS OF BIOREMEDIATION

Sample	Zn^{2+} content [mg/kg d.m.]		Degree of extracting Zn^{2+} content [%]	Predicted Y	Residual	Squared Residual
	MAC	experimental value				
control sample (R)	100	83	15.3	1.51	-1.51	2.28
control sample (S)		197	36.3	6.47	-6.47	41.83
sterile (R)		259	47.7	9.16	-9.16	83.91
sterile (S)		167	30.8	5.17	-5.17	26.72
½ sterile+½ soil (R)		217	40	7.34	-7.34	53.90
½ sterile+½ soil (S)		120	22.1	3.11	-3.11	9.70
⅔ sterile+⅓ soil (R)		151	27.8	4.46	-4.46	19.90
⅔ sterile+⅓ soil (S)		168	30.9	5.19	-5.19	26.96
layer of Steril+layer of soil (R)		274	50.5	9.82	-9.82	96.46
layer of Steril+layer of soil (S)		139	25.6	3.94	-3.94	15.53
R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from Degree of extracting Zn^{2+} content [%]						

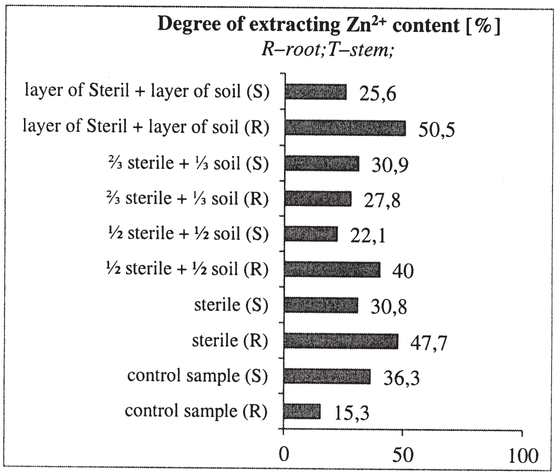

Fig. 6. The degree of extracting of zinc after bioremediation sterile samples Moldomin mixed in different proportions with soil

Table 9
LEAD CONTENT IN THE PLANT AFTER THE PROCESS OF BIOREMEDIATION

Sample	Pb^{2+} content [mg/kg d.m.]		Degree of extracting Pb^{2+} content [%]	Predicted Y	Residual	Squared Residual
	MAC	experimental value				
control sample (R)	20	LOD	0	-2.11	2.11	4.43
control sample (S)		LOD	0	-2.11	2.11	4.43
sterile (R)		LOD	0	-2.11	2.11	4.43
sterile (S)		LOD	0	-2.11	2.11	4.43
½ sterile+½ soil (R)		LOD	0	-2.11	2.11	4.43
½ sterile+½ soil (S)		LOD	0	-2.11	2.11	4.43
⅔ sterile+⅓ soil (R)		LOD	0	-2.11	2.11	4.43
⅔ sterile+⅓ soil (S)		LOD	0	-2.11	2.11	4.43
layer of Steril+layer of soil (R)		15	17	1.91	-1.91	3.65
layer of Steril+layer of soil (S)		LOD	0	-2.11	2.11	4.43
R–root; T–stem; and LOD–below limit of detection. Minimizing SSR in a Multiple Regression from degree of extracting Pb^{2+} content [%]						

indistinguishable information is available on their molecular bases and biological significance.

Availability of zinc to *H. vulgare* plant is hampered by its immobile nature and adverse soil conditions. Root-shoot barrier, representing a considerable controller of zinc transport in *H. vulgare* plant is exceedingly affected by modifications in anatomical structure of managing tissue and adverse soil regimes like *p*H, clay content, calcium carbonate content, etc.

Exceedingly high metal concentrations in metal accumulator/indicator plants can be an elemental defence against herbivores.

The combined results have been found and studies using comparative approaches are relatively few.

Lead content

Experimental data on lead content respectively its degree of extracting from samples bioremediation sterile soil mixed in different proportions are presented in table 9.

It is observed that in the case of lead, which has affinity for uptake in plants, it is not only in the roots accumulated sample: sterile layer: layer of soil (17%) [28, 29]. Reduced seedling growth observed in presence of lead was probably due to decrease in activities of amylases and invertases in cotyledons and growing tissues respectively [30, 30].

Further biosynthetic capacity of roots and shoots was down regulated in *H. vulgare* seedlings due to reduced efficiency of pentose phosphate pathway under lead toxicity. This can be explained by the short growing period and the fact that lead is a metal tending to build up to the ends of the plant, in this study, insufficiently developed.

Conclusions

In this work we studied the possibility of stabilization sterile heaps from mining exploitations. Sterile samples taken in the study come of mining nemetalifer Moldova Noua–S.C. Moldomin S.A. For sterile derived from mining operations were conducted leaching tests for storage in dedicated facilities. Determining the initial content of metals in sterile was found that the sterile has a high metal content, which raises the need for robust methods of remediation. It was observed that all studied metals exceeding the maximum concentration are admitted by law, except manganese. We studied the stabilization of dumps sterile by bioremediation using as plant accumulators *H. vulgare*. The samples sterile and soil have been mixed in different proportions are seated in vegetation pots, using the plant accumulators *H. vulgare*. The samples thus obtained were watered regularly with water. After a period of 30 days the plants were separated and dried at room temperature (20°C).

The dried plants were separated into roots and stems, calcined for 6 h at a temperature of 550°C, the loss on ignition is between 40 and 80%. The metal content was analyzed by X-ray fluorescence, using spectrum analyzer by fluorescence of RX (FRX).

Experimental measurements established the following:

-the highest degree of extraction of metals was found in the roots of plants, especially in the sample: layer of rock and layer of soil and in the sample: sterile 1/2: 1/2 soils;

-according to the literature, in plants the tendency of accumulation is as follows: the metals assimilation is made at the extremities and to the end of vegetation season, and as the molecular weight of metal is high, it is accumulated even in the root.

Metal pollution is a major environmental problem of sterile land. Identifying out the tolerant plants, which may adapt to local climate and soil conditions, is premise of vegetation restoration.

In conclusion, it has been found that the stabilization of the dump of sterile of S.C. Moldoimin S.A. and also the accumulation of metal in the remediation of accumulator plants has led to good results, and can be widely applied, but this method requires cultivation elevated minimum 2 consecutive years. Our results provide evident evidence that, due to plant-plant facilitation, species productiveness positively affects the removal of metals from landfills mining soil through phytoremediation and provides further data on variety conservation and environmental remediation in a landfills mining environment.

References

1. CHO, Y.C., PAN, J.Y., Scientific World J., 2013, p. 704
2. MORAN, A.R., HETTIARACHCHI, H., Int. J. Environ. Res. Public. Health. **8**, no. 7, 2011, p. 2640
3. SINGER, M.B., AALTO, R., JAMES, L.A., KILHAM, N.E., HIGSON, J.L., GHOSHAL, S., Proc. Natl. Acad. Sci. U. S. A., **110**, no. 46, 2013, p.18436
4.ANWAR, M.N., Springerplus., **2**, 2013, p. 595
5.WANG, Y., FENG, Q., CHEN, L., YU, T., Environ Manage., **52**, no. 1, 2013, p. 209
6.CRISTESCU, R.H., BANKS, P.B., CARRICK, F.N., FRČRE, C., PLoS One. **8**, no. 11, 2013, e80469
7.CZIBULA, G., BOCICOR, M.I., CZIBULA, I.G., Evol Bioinform Online., **8**, 2012, p. 181
8.FRENTIU, T., PINTICAN, B.P., BUTACIU, S., MIHALTAN, A.I., PONTA, M., FRENTIU, M., Chem. Cent. J., 7, no. 1, 2013, p. 178
9.FODOR, D., BAICAN, G., Impactul industriei miniere asupra mediului, Editura Infomin, Deva, 2001, p. 17-25
10.NEAG, G., Depoluarea solurilor şi apelor subterane, Editura “Casa Cărţii de Ştiinţă”, Cluj-Napoca, 1997, p. 127-135
11.SHAN, J., SÁEZ, A.E., ELA, W.P., J. Environ. Eng. (New York), **136**, no. 2, 2010, p. 238
12.SAMFIRA, I., BUTNARIU, M., RODINO, S., BUTU, M., Dig. J. Nanomater. Bios., **8**, no. 4, 2013, p 1679
13.HUANG, L., BAUMGARTL, T., MULLIGAN, D., Ann Bot., **110**, no. 2, 2012, p. 223
14.BOSTAN, C., BUTNARIU, M., BUTU, M., ORTAN, A., BUTU, A., RODINO, S., PARVU, C., Rom. Biotech. Lett., **18**, no. 2, 2013, p. 8190
15.JAKOBS-SCHÖNWANDT, D., MATHIES, H., ABRAHAM, W.R., PRITZKOW, W., STEPHAN, I., NOLL, M., Appl. Environ. Microbiol., **76**, no. 24, 2010, p. 8076
16.BUTNARIU, M., Ann. Agric. Environ. Med., **21**, no. 1, 2014, p 11
17.LIN, C.Y., TRINH, N.N., FU, S.F., HSIUNG, Y.C., CHIA, L.C., LIN, C.W., HUANG, H.J., Plant. Mol. Biol., **81**, no. 4-5, 2013, p. 507
18.HERNANDEZ, J.A., GEORGE, S.J., RUBIO, L.M., Biochemistry. **48**, no. 41, 2009, p. 9711
19.BUTNARIU, M., CAUNII, A., Ann. Agric. Environ. Med., **20**, no. 4, 2014, p. 736
20.BUTU, M., RODINO, S., BUTU, A., BUTNARIU, M., Dig. J. Nanomater Bios., **9**, no. 2, 2014, p. 519
21.ISHIMARU, Y., BASHIR, K., NAKANISHI, H., NISHIZAWA, N.K. Plant Signal Behav., **7**, no. 7, 2012, p. 763
22.IANCULOV, I., PALICICA, R., BUTNARIU, M., DUMBRAVA, D., GERGEN, I., Rev. Chim. (Bucharest), **56**, no. 4, 2005, p. 441
23.MATEOS, L.M., ORDÓ EZ, E., LETEK, M., GIL, J.A., Int. Microbiol. **9**, no, 3, 2006, p. 207 Review
24.MIRZA, N., MAHMOOD, Q., MAROOF SHAH, M., PERVEZ, A., SULTAN, S., Scientific World J. 2014:921581. 2014
25.BUTNARIU, M., STOIN, D., CHET, C, COTUNA, O, PAIAN, C, Book Series: Actual Tasks on Agricultural Engineering–Zagreb. 37, 2009, p. 421
26.LIU, H., CHANG, L.H., SUN, Y., LU, X., STUBBS, L., Genome Biol. Evol., **6**, no. 3, 2014, p. 510
27.BUTNARIU, M., SMULEAC, A., DEHELEAN, C., CHIRITA, R., SARATEAN, V., Rev. Chim. (Bucharest), **57**, no.11, 2006, p. 1138
28.CARVALHO, M.T., AMARAL, D.C., GUILHERME, L.R., AARTS, M.G., Front Plant Sci., **4**, 2013, p. 180
29.BUTU, M., RODINO, S., PENTEA, M., NEGREA, A., PETRACHE, P., BUTNARIU M. Dig J Nanomater Bios., **9**, no. 4, 2014, p. 1317
30.DEVI, R., MUNJRAL, N., GUPTA, A.K., KAUR, N., Physiol. Mol. Biol. Plants., **19**, no. 1, 2013, p. 81
31.BUTNARIU, M., RODINO, S., PETRACHE, P., NEGOESCU, C., BUTU M. Dig J Nanomater Bios., **9**, no. 2, 2014, p. 745
32.CAUNII, A., BUTU, M., RODINO, S., MOTOC, M., NEGREA, A., SAMFIRA, I., BUTNARIU, M.,Rev. Chim. (Bucharest), **66**, no. 4, p. 472

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