THE BIOCONVERSION FACTOR OF SOME GREEN PLANTS GROWTH IN THE METALLURGIC INDUSTRIAL AREA

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Abstract
The bioconversion factor of plants is determinate, on the first hand by the species, but also by the metals content and pH of the soil. In this study, we analyzed by Inductively Coupled Plasma - Atomic Emission Spectrometry method (ICP-AES) the heavy metals concentration level for Ti, Mo, Ni and Pb, as in the plants growth in the metallurgic industrial area, as in the soil of these plants. The sampled species, Lolium perenne, Festuca pratensis, Stipa capillata, Agrostis alba, Cynodon dactylon, Luzula campestris and Agrostis tenuis, are an herbaceous plants, the base component of perennial meadow.
The soil reaction is between low acid and low basic, with values of pH range of 6.47 - 7.84 and represents, beside the species, an important parameter in plants' bioconversion factor appreciation. The bioconversion factor of studied species has values from 0.67 to 4.86 for titanium, 0 to 11.17 for molybdenum, 0.19 to 1.6 for nickel and 0 to 12.30 for lead. The species Cynodon dactylon and Lolium perenne shows the highest values of bioconversion factor and might be considered efficient in bioremediation of the soil infested with these metals.

Keywords: bioconversion factor, green plants, heavy metals

1. INTRODUCTION

In the industrial platform of Targoviste City, the metallurgic activities of the industrial units SC Mechel SA, SC Oțelinox SA and SC Erdemir SRL present a pollution risk by the deposit of the emitted substances reach in heavy metals on the leaves and on the soil, by the improper deposits of the rough material, by the careless handling of materials, by the infiltration of some noxious substances draw into the soil by the precipitation and by the waste waters emission caused by the sewerage system breakage [8].
The atmospheric emissions, emanated from the metallurgic activities, are found on soil up to some kilometers distance from the pollution sources. The level of these dusts emission depends on the final metallurgic product type. For example, for cast iron, steel, bronze and brass, the emitted dusts are about 8-12 Kg/tone of product, but, for the aluminum, these emissions increase up to 450 Kg/tone of product[9].
The metallic elements accumulation in plants represents the first step for toxically agents' insertion in the food chain, even in the human body. Some pollutants are not metabolized in the food chain, neither remove from the organisms and they are deposed in the consumer organisms, process that is named biological amplification [8]. If the pollutant is evenly distributed in plants, in them development season, the phenomena is named biological dilution [8]; in this way, if the seeds were treated or if the young plant is charging with some pollutants it will become toxic, but, by the biomass increasing, the concentration of toxically element in plant decrease under the maximum limits.
The bioconversion factor of metals in plants is influenced by many parameters like: nature and chemical form of the metallic element, biological species and the pH level in the soil [10]. In the present paper is studied the influence of the soil reaction and the plant species on the bioconversion factor for the analyzed heavy metals.

2. MATERIAL AND METHODS

To establish the bioconversion factor of Ti, Mo, Ni and Pb in some green plants, we choose to sample some species of foddering perenne grass, wild growth in the industrial area of Targoviste: *Lolium perenne, Festuca pratensis, Stipa capillata, Agrostis alba, Agrostis tenuis, Cynodon dactylon* and *Luzula campestris*.

These plants represent an important source of animals foddering, being the base component of perennial meadow [7]. Take into account the high range of these plants in meadow structure, the fact that vegetable mass obtained is a cheap fodder for the husbandry field, but also the risk of heavy metals infested plants consumption it is necessary to know the bioconversion factor of these metallic elements in green mass, comparing with the concentration in the soil.
For each plants species we sample the soil closer with the radicular part of the plant, down to the depth where the root can be founded. Both the sampling of plants and soil, and them processing were done with plastic, glass and pottery instruments to avoid any metal contacts which can influence the final results. To establish the heavy metals concentration in the analyzed plants and in the soil, the samples were dry out into an oven until the complete process and then grinding to a fine powder (conform SR ISO 11464). The estimation of metallic charge range of analyzed plants and them soil with heavy metals was done by the Inductively Coupled Plasma - Atomic Emission Spectrometry method (ICP-AES). For the analyzes with ICP-AES method, the biological samples (plants) were mineralized, in Berghof microwave digestor, by mixture with 10 ml of nitric acid concentrated 65% and 2 ml of hydrogen peroxide, and for the soil samples were done hot extractions with nitric acid 1:1.
In present paper, the samples analyzing was done with a 110 Liberty spectrometer type of Varian brand. To disintegrate the sample in constituents atoms or ions is used a plasma source, which will stir up them on superior energetic layer. They will revert to the initial form by the emission of characteristic energy photon, emission recorded by an optical spectrometer. The radiation intensity is proportional with each element concentration in the sample and is intern calculated by a couple of calibration curves to obtain directly the measured concentration.
The concentration resulted are given in mg of metal related with kg of dry soil or plants. The minimal detection limits of device range according the analyzed element and is 0,3 mg/kg for Ti and 0,6 mg/kg for Mo, Ni and Pb.
The soil reaction of the soil was established with a WTW 3110 pH-meter: 5 g of each soil sample were mixed with 50 ml of KCl 0.1N, F 1.000, Tt 0.0056 g/ml.

3. RESULTS AND DISCUSSIONS

In the industrial area, where the concentration of Ti, Mo, Ni and Pb in soil outrun, in many cases, the alert limits, the concentration level of these metals in plants increase up to a range risky for health of living organisms. This is because of the high tolerance of some plants species for heavy metals which they accumulate in root and shoots, by vacuoles or metals chelation [5]. Also, plants with a high level of accumulation show a great capacity of metals absorption from the soil and of metals transfer to root and shoots.
In some previous studies about the heavy metals in green plants, Ni shows a range of concentration about 0.84-2.1 mg/kg [4] and Pb range between 0.67-2.5 mg/kg [4,1]. Mo and Ti are usually nutrient constituents of the green plants, but in a high range of concentration they become toxics. Molybdenum deficiency caused reduction in growth, uniform yellowing of leaf blades and severe symptoms of nitrate toxicity [6].
The present study concerns the plants growth in the industrial area. The analyzed foddering grass develops a big vegetable mass, in a relative short time and they are known as well tolerant for heavy metals. Another advantage of this perennial grass is the high content of dry matter: *Lolium perenne* 41%, *Festuca pratensis* 33%, *Stipa capillata* 43%, *Agrostis alba* 42%, *Cynodon dactylon* 40%, *Luzula campestris* 50% and *Agrostis tenuis* 46%, comparing with other plants species like *Papaver rhoeas, Cirsium arvense* or *Artemisia vulgaris,* which has a percent of dry matter range from 12 to 36%.
Heavy metals concentrations in these plants are different from one species to another and vary according the metals concentration in the environment. Near these two parameters, the metals concentration level in plants depends on plant's age, meteorological conditions, field

topography and synergic and antagonist effects between the elements in the soil [3].

3.1. Heavy Metals Concentration in Perennial Grasses

Titanium concentrations in the analyzed perennial grasses vary in a large range of values, from one species to another (fig. 1). The lower concentration was founded for *Luzula campestris*, 17.59 mg/kg of dry matter and increase up to 92.71 mg/kg for *Agrostis alba* species. Also good accumulators are *Festuca pratensis, Stipa capillata* and *Cynodon dactylon* which show a Ti concentration range of 55.28 – 67.96 mg/kg of dry matter.

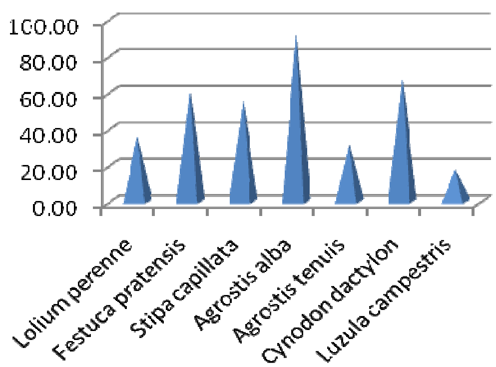

Figure 1 Titanium concentration in some green perennial grasses

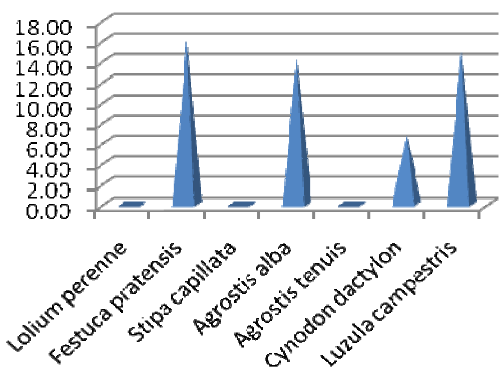

Figure 2 Molybdenum concentrations in some green perennial grasses

The molybdenum was detected only in four species of perennial grasses (fig. 4), *Lolium perenne, Stipa capillata* and *Agrostis tenuis* showing a molybdenum concentration under the detection limit of method (0.6 mg/kg of dry matter). The best accumulators of these metals are *Festuca pratensis, Agrostis alba* and *Luzula campestris* which have comparable values of Mo concentration, between 14.38 and 16.11 mg/kg dry matter.

The concentration of Ni in the analyzed green plants are different from one species to another (fig. 3), the lowest values showing *Agrostis tenuis*, 3.88 mg/kg of dry matter, and the highest concentration of Ni is in *Agrostis alba* species, which accumulate 60.22 mg/kg of dry matter. The other species shows comparable values of Ni concentration accumulated in plants, which range from 15.88 mg/kg of dry matter in *Lolium perenne* to 28.60 mg/kg of dry matter in *Cynodon dactylon*.

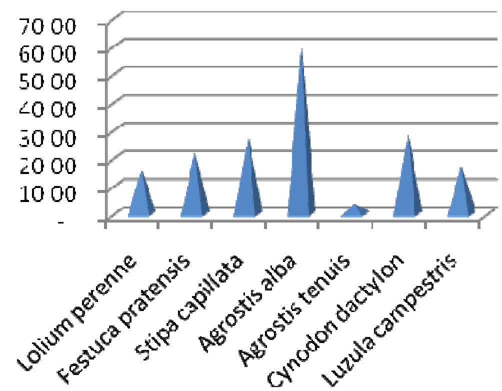

Figure 3 Nickel concentrations in some green perennial grasses

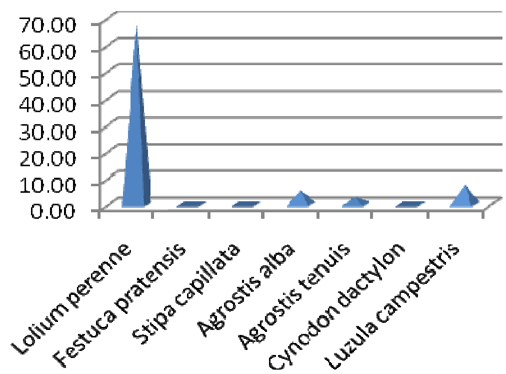

Figure 4 Lead concentrations in some green perennial grasses

The lead is another heavy metal which is not absorbed by all of the analyzed plants species. *Festuca pratensis, Stipa capillata* and *Cynodon dactylon* shows values of lead concentration under the detection limit of the method (fig. 4). *Agrostis alba, A. tenuis* and *Luzula campestris* indicate comparable low values of Pb concentration range of 2.72 – 7.38 mg/kg of dry matter, which are also higher than normal values mentioned in the references. But, the more surprising value of Pb concentration shows *Lolium perenne*, over 60 mg Pb per kg of dry matter.

From the analyzed species of perennial grasses, *Agrostis alba* shows the most important values of concentration for the majority of studied heavy metals, against *Stipa capillata* species which has a weak accumulation for Mo and Pb and a mediocre values of concentration for Ni and Ti.

3.2. The Bioconversion Factor of Perennial Grasses

The bioconversion factor represents the pollutant concentration in plant comparing with the environment concentration (in soil) [5]. Majority of plants have a bioconversion factor less than 1. The study of metals bioconversion has importance in the appreciation of species that shows a risk of pollutant accumulation dangerous for health of living organisms, but also for the appreciation of the species with a high capacity of pollutant absorption useful in the bioremediation process of infested soils. So as plants species to be used in soils phytoremediation, they need a high bioconversion factor, above 5. As the biomass of respectively species is bigger and the accumulation level is higher, as the species efficiency in phytoremediation process is remarkable. So, to reduce by 50% the contamination of a soil, in 10 crops, is necessary that plant has a bioconversion factor more than 20 [5].

The plants that accumulate high concentration of metallic elements are named hyperaccumulators and can take 50-100 times more metals than a normal plant [2]. The phenomenon of hyperaccumulation is intensified if the environment has a high concentration of heavy metals. So far, were established about 400 species with hyperaccumulation capacity for heavy metals, and the level of metal concentrations in plants range up to 10000 mg/kg for Zn and Mn, 1000 mg/kg for Co, Cu, Ni and As, 100 mg/kg for Cd, respectively [6].

In table 1 are presented the bioconversion factors of ti, Mo, Ni and Pb for the analyzed specie of perennial grasses. The most representative species are *Cynodon dactylon* and *Luzula campestris* which shows the biggest bioconversion factors for Mo and Pb, respectively. At these values of the bioconversion factor we can say that these two species are hyperaccumulators for the respectively metals, and represent an efficient option for the phytoremediation technology of infested soils.

Table 1. The mean bioconversion factor for some perennial grasses

Specia	Bioconversion factor			
	Ti	Mo	Ni	Pb
Lolium perenne	4.86	0.00	0.19	0.35
Festuca pratensis	2.78	2.15	0.31	0.00
Stipa capillata	3.02	0.00	0.56	0.00
Agrostis alba	3.32	3.18	1.62	0.12
Agrostis tenuis	1.41	0.00	0.24	4.54
Cynodon dactylon	1.40	11.17	1.27	0.00
Luzula campestris	0.67	0.66	1.26	12.30

The bioconversion factor depends first on the species, on plants physiological parameters, but also on the soil characteristics, metals concentration, organic matter and pH. The soil reaction has influence on the metals ions meaning: as the pH of the soil is higher, as the binding of ions is stronger. For a pH of 6-7 the binding is maximum for Cu, Zn, Cd and Pb [10], which means that the absorption of these metals by plants are reduce, so, the bioconversion factor for some metals is lower for the plants growth on the soil with these values of the pH. These can be observed in some of the graphics below which represent the influence of soil pH on the bioconversion factor of Ti, Mo, Ni and Pb in some green plants from 7 species of perennial grasses.

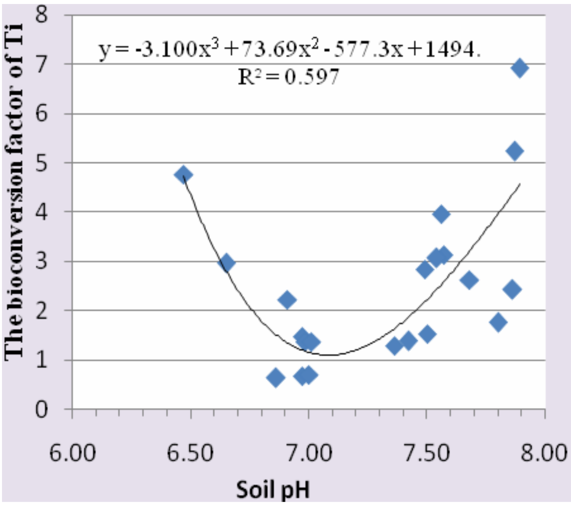

Figure 5 The correlation between the soil pH and the bioconversion factor of Ti

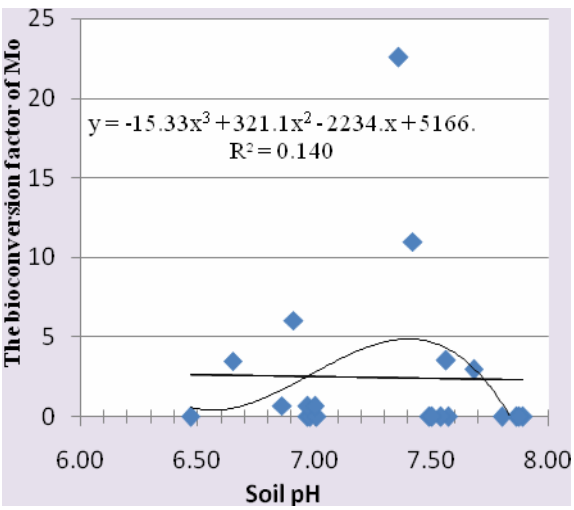

Figure 6 The correlation between the soil pH and the bioconversion factor of Mo

The bioconversion factor of titanium for the analyzed species of plants is influenced by the pH of the soil (fig. 5), but not only by this. The species has also an important function. The bioconversion factor of titanium decrease when the pH of soil is higher, up to 7. Between the values of pH 7…7.5 to 8, the bioconversion factor of titanium increase up to 7, which is an important value in the phytoremediation process of the infested soil.
The bioconversion factor of molybdenum is 0 for the majority of the analyzed samples, but the other examples shows that this factor is not influenced at all by the pH of the soil (fig. 6). The bioconversion factor of Mo is dependent on the species and on the physiological parameters of the analyzed examples.
For Ni and its bioconversion factor in the perennial grasses, the pH of the soil has the greater importance (fig. 7), the species being the second important parameter of the bioconversion factor. The analyzed examples have a value of pH range of 6.5 to 8, and, on this interval of soil reaction, the bioconversion factor of Ni decreases when the pH of the soil increases. The higher value of bioconversion factor, 2.26, is for a value of pH of 6.47.
The pH of the soil represents a parameter of the bioconversion factor of lead, but also the species is important for the level of accumulation of this metal in plants.

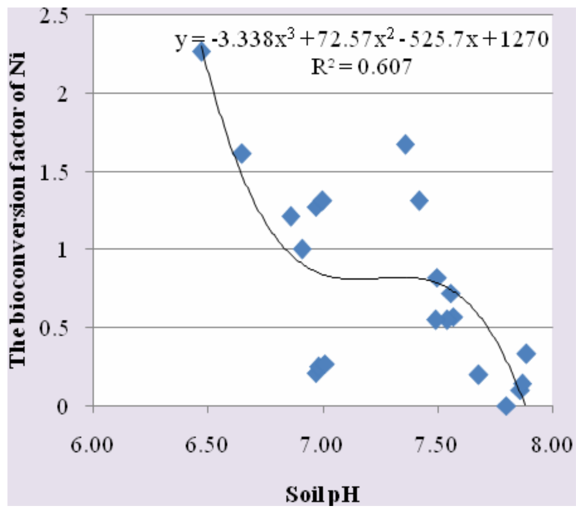

Figure 7 The correlation between the soil pH and the bioconversion factor of Ni

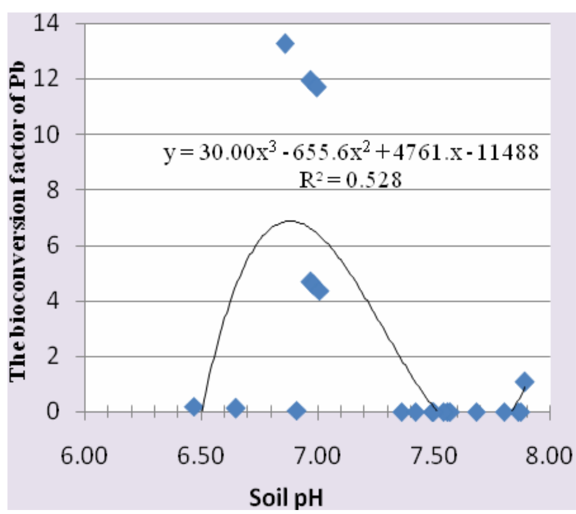

Figure 8 The correlation between the soil pH and the bioconversion factor of Pb

The highest values of bioconversion factor for lead are for a weak acid soil reaction, with a pH close to 7.

For Ti, Ni and Pd, the bioconversion factor of perennial grasses is determinate as by the species, as by the soil reaction with the best values of bioconversion factor for the plants growth on a soil with pH of 6.5-7 for Ni and Pb and up to 8 for Ti.

4. CONCLUSIONS

- *Lolium perenne* concentrate the highest quantity of lead;
- *Agrostis alba* concentrate the most important quantity of Ti, Ni and Mo;
- *Stipa capillata* has the lowest content for the studied metallic elements;
- The best accumulators of the analyzed heavy metals are *Cynodon dactylon* for Mo and *Luzula campestris* for Pb;
- The bioconversion factor of Ti, Ni and Pb is determinate by the species and soil reaction in the same time, and for Mo accumulation, the important parameter is represented by the species;
- The highest values of bioconversion factor for Ni and Pb are in a weak acid soil (6.5 – 7) and for Ti in an alkaline soil (up to 8).

5. REFERENCES

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