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ELABORATION OF COMPLEX PURIFICATION METHOD OF SOILS CONTAMINATED WITH HEAVY METALS

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Abstract

The wrong strategy for the utilization of the huge amount of organic and inorganic waste generated every day has created significant problems. Pollution of the environment with heavy metals causes particularly serious consequences. There are many methods of cleaning the polluted environment caused by heavy metals. The ideal way is biological remediation, which is an effective method of managing and restoring the polluted environment. Works on biostimulation of local microorganisms necessary for the bioremediation of soils contaminated with heavy metals have been carried out. The results of the studies showed that local microorganisms are effective for the bioremediation of heavy metals. The use of a consortium of bacteria and microscopic fungi selected by us, which did not have a mutually antagonistic effect on each other, was especially effective.

Key words: *heavy metals, pollution, remediation, microorganisms.*

Introduction

Population growth, industrialization, urbanization, anthropogenic activities, and natural resources are causing environmental pollution on a global scale. The wrong strategy for the utilization of the huge amount of organic and inorganic waste generated every day has created significant problems.Pollution of the environment with heavy metals causes particularly serious consequences.

The term heavy metals is a general collective term used for metallic and non-metallic elements having high atomic mass. They are highly toxic even at low concentrations. Heavy metals belong to widespread pollutants, they are persistent and therefore non-degradable and pose serious threats to environment. These elements are released into the environment as a result of various production processes. Zn, Cu, Cd, Pb, Ni are considered as the most toxic pollutants. They accumulate in microorganisms, plants, animals and the human body and disturbance metabolic and physiological processes.

Scientific and technical processes have revealed new prospects for the methods of combating environmental pollutants. There are many methods of cleaning the polluted environment caused by heavy metals, which are divided into 2 main groups: abiotic, which includes physical and chemical methods, and biotic. The use of traditional removal methods of heavy metal in practice on a large scale is unprofitable due to the high cost. Also, this method is dangerous due to the negative consequences of constant monitoring and control.

Removing heavy metals in an eco-friendly way is important. The ideal way is biological remediation, which is an effective method of managing and restoring the polluted environment. Many metals, such as Zn, Cu, Cr, Ni, are essential and useful trace elements for the growth and development of organisms. Cd, Hg, Pb do not have a similar nature and their significance in physiological processes has not been established. It should be noted that even high concentrations of essential metals above the permissible level adversely affect the microbial community of soils and their functional activity. Microorganisms play an important role in removing heavy metals from the environment. They are known to have high potential for bioremediation of contaminated soils, as well as increasing yields at lower costs. Microorganisms carry out bioremediation by changing the oxidation state of heavy metals, which leads to a decrease in their toxicity. Secretions released as a result of the metabolic activity of microorganisms are able to dissolve, precipitate, biosorb and enzymatically transform heavy metals; as a result, these heavy metals undergo degradation, detoxification and transformation into more stable, inert, less dangerous and mobile forms [1].

Special soil treatment helps to modify soil in a form inaccessible to humans and animals and to remove dangerous substances, including radionuclides, from the soil. The basis of this method is that substances toxic to humans are not harmful to plants. Studying the binding of heavy metals by microorganisms in-situ is difficult. They can be bound by both microorganisms and their secretions, which change their mobility. Some microorganisms synthesize extracellular polymers of acidic nature capable of mobilizing heavy metals in soils.

The binding of heavy metals is possible through plant accumulators (sorrel, nettle), but it needs several years of treatment (sowing, mowing.). This prolongs the process and requires the safe disposal of this plant biomass. Some microorganisms are able to transform dangerous substances into insoluble forms to make them inaccessible and safe for plants. In such preserved form, heavy metals can settle in the soil for tens and hundreds of years and do not threaten living organisms.

Microorganisms have different abilities to break down heavy metals. It is based on the accumulation of heavy metal ions in the cells of microorganisms and the subsequent reduction of these ions into a non-toxic form

It should be noted that the soil is a multi-component dynamic system, the properties of which constantly change as a result of microbial, chemical, hydrological, and geological processes. Environmental factors such as temperature, pH, low-molecular organic acids, and humic acids affect the transformation and mobility of heavy metals in soils, their oxidation state, bioavailability to microorganisms, and the effectiveness of microorganisms in the bioremediation process of heavy metals. It is promising to use consortia of fungi and bacteria for this purpose [2].

Research results

Works on biostimulation of local microorganisms necessary for the bioremediation of soils contaminated with heavy metals have been carried out [3,4]. At this stage, various microorganisms, which almost have no antagonistic effect on each other activity have been selected and studied.

Cellulose-degrading bacteria and microscopic fungi were selected from the microorganisms isolated from the local soil. Their content is defined, accordingly, $5.5.10^3$ and $1.3.10^3$ (calculated on 1 g of dry soil), soil moisture was 7.9%.

Since these microorganisms do not exhibit antagonistic action towards each other, they were also co-inoculated and solutions contaminated with heavy metal ions were introduced. Both individual cultures and their consortium have been incubated in appropriate liquid nutrient medium for 24 hours. After that, we added aqueous solutions of nickel, cadmium and lead salts (1600 mg/l) to the mentioned microbial inoculants, waited for 96 hours under constant stirring conditions at 28°C. All experiments were done twice. After 96 hours, the microbial biomass was centrifuged and filtered. The separated microbial biomass was treated with distilled water and dried in hot air at 65°C ± 5 for 24 hours. The existing heavy metals were separated from the microbial biomass by treating it with nitric acid and perchloric acid (3:1 ratio). Samples were taken on the first day of inoculation (0 h for initial residual levels), and repeated every 24 h. The initial and final residual content of heavy metals in inoculant and biomass is determined.

In order to study the bioremediation capacity of microorganisms, cellulose-degrading bacteria *Myxococcus* and a representative of the microscopic fungi, genus *Rhizopus* were isolated and selected from local soil. The effects of bacteria and fungi on the bioremediation of heavy metals, as well as the possible impact of their joint consortium on the reduction of the amount of Pb, Cd, and Ni ions in a liquid nutrition medium, are investigated. The content of heavy metals after 96 h indicates a decrease in their content in the nutrient area as a result of absorption by these microorganisms.

Table 1. Accumulation of heavy metals by Cellulose-degrading bacteria (*Myxococcus*)

Heavy metals ions	Amount of heavy metals in liquid nutrient medium (mg/ml)					Amount of heavy metals in cell of bacteria (mg/g)				
	0 h	24 h	48 h	72 h	96 h	0 h	24 h	48 h	72 h	96 h
Ni	1.60	1.40	1.20	0.90	0.80	0	0.1	0.30	0.55	0.65
Pb	1.90	1.60	1.40	1.20	1.00	0	0.25	0.3	0.45	0.80
Cd	1.50	1.40	1.25	1.10	0.85	0	0.05	0.25	0.35	0.6

Table 2. Accumulation of heavy metals by microscopic fungi *(Rhizopus)*

Heavy metals ions	Amount of heavy metals in liquid nutrient medium (mg/ml)					Amount of heavy metals in cell of *Rhizopus* (mg/g)				
	0 h	24 h	48 h	72 h	96 h	0 h	24 h	48 h	72 h	96 h
Ni	1.60	1.30	1.10	0.85	0.75	0	0.20	0.35	0.60	0.70
Pb	1.90	1.50	1.35	1.10	1.00	0	0.3	0.55	0.60	0.85
Cd	1.50	1.30	1.10	1.00	0.80	0	0.15	0.25	0.45	0.55

Table 3. Accumulation of heavy metals by consortiums of Cellulose-degrading bacteria (*Myxococcus*) and microscopic fungi *(Rhizopus)*

Heavy metals ions	Amount of heavy metals in liquid nutrient medium (mg/ml)					Amount of heavy metals in consortiums (mg/g)				
	0 h	24 h	48 h	72 h	96 h	0 h	24 h	48 h	72 h	96 h
Ni	1.60	1.25	1.00	0.75	0.60	0	0.35	0.50	0.80	0.95
Pb	1.90	1.35	1.2	1.0	0.85	0	0.40	0.60	0.75	1.10
Cd	1.50	1.10	0.95	0.75	0.60	0	0.20	0.35	0.55	0.75

The results of the studies (Table 1, 2 and 3) showed that local microorganisms are effective for the bioremediation of heavy metals. The use of a consortium of bacteria and microscopic fungi selected by us, which did not have a mutually antagonistic effect on each other, was especially effective.

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მძიმე მეტალებით დაბინძურებული ნიადაგების გაწმენდის კომპლექსური მეთოდის შემუშავება

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აბსტრაქტი

ყოველდღიურად წარმოქმნილი უზარმაზარი რაოდენობის ორგანული და არაორგანული ნარჩენების უტილიზაციის არასწორმა სტრატეგიამ შექმნა მნიშვნელოვანი პრობლემები. განსაკუთრებით მძიმე შედეგს წარმოადგენს გარემოს მძიმე მეტალებით დაბინძურება. არსებობს მძიმე მეტალებით გამოწვეული დაბინძურებული გარემოს გასუფთავების მრავალი მეთოდი. გასუფთვების იდეალურ გზას წარმოადგენს ბიოლოგიური რემედიაცია, რომელიც დაბინძურებული გარემოს მართვისა და აღდგენის ეფექტურ მეთოდს წარმოადგენს. სამუშაოები განხორციელდა მძიმე მეტალებით დაბინძურებული ნიადაგების ბიორემედიაციისათვის საჭირო ადგილობრივი მიკროორგანიზმების ბიოსტიმულირების მიმართულებით.კვლევის შედეგებმა გვიჩვენა, რომ ადგილობრივი მიკროორგანიზმები ეფექტურია მძიმე მეტალების ბიორემედიაციისათვის. განსაკუთრებით, ეფექტიანი აღმოჩნდა ჩვენს მიერ შერჩეული ბაქტერიისა და მიკროსკოპული სოკოს კონსორციუმის გამოყენება, რომელთაც ერთმანეთის მიმართ ურთიერთანტაგონისტური ზემოქმედება არ გამოავლინეს.

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