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Research of transport effects of heavy metals in plants of *Opuntia Vulgaris Mill*grown in the technogenic contaminated soils

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Abstract

In this work, it was carried out the study of transport effect of a number of heavy metals from technogenic contaminated soil to the plants of *Opuntia Vulgaris Mill*. For the conducting research it was selected two sites for each plant from the technogenic contaminated zone in the village of Cala, Absheron Peninsula of Azerbaijan. It was used transportable roentgen-fluorescence XRF spectrometer X Omega Roentgen Pluorescence Spectrometer фирмы İnnov – Xfor the measurement of plants of heavy metals in contaminated soil and plants. Seedlings of these plants were moved from ecologically clean areas to contaminated areas. Before planting, the concentration of a number of heavy metals was measured in the soil at depths of (0-5); (10-15); (15-20) cm. Measurement of concentration of heavy metals in the samples were carried out after 6 month of planting. It was revealed that, there is “Transport effect” of a number of heavy metals from technogenic contaminated soil to the above-mentioned plants.

For *Opuntia Vulgaris Mill* – Cd (2,27-1,86): Pb (9,58-5,59);Zn (60,28-46,40);Ni(31,76-22,32); Co (4,60-2,46); Mn (39,76-16,57) (unit of measuring concentration - mg/kg; in the brackets, in the first place there is concentration in soil, in the second place there is transported concentration in plants taking into account background measurement before planting.

Key words: heavy metals, concentration, plants, soil, technogenic contaminated zone

Introduction

Phytoremediation is a new technology that uses plants and their associated rhizosphere microorganisms to remove contaminants from technogenic contaminated soils. In recent years this technology has been recognized as a cheap, effective and economically clean technology. But here we must note that, the effectiveness of this technology depends on many factors, for example properties of different soils and plants, physical and chemical processes occurring in soil, microbial properties and bioavailability of metals, the ability of different plant adsorption, accumulate and neutralize metals in technogenic contaminated soils. Despite some advantages, phytoremediation has not yet become commercially available technology. Progress in this area is hampered by lack of understanding of complex interactions in the rhizosphere of plants and mechanism that enable translocation of metals and their accumulation in plants. For further increase of effectiveness of phytoremediation, there is a necessity to improve the knowledge about the processes, such as the presence of pollution, especially rhizosphere layer, absorption of contaminants, translocation, poisoning, degradation and evaporation [1-3]. On the other hand, many research shows that a number of plants have the genetic potential to remove many toxic metals from soil [4].

The most basic kind of family of cacti is Opuntia (Opuntia) due to the fact that this plant has no system leaves, it evaporates very small amount of water and this ability allows it to survive in very rigorous environments. The unique properties of the plant of Opuntia are that it can collect in their internal organs of water from the environment and this property allows it to act as a biological indicator which determines the degree of deviation from the ecological balance of the environment. With this plant we can determine the degree of purification from contaminants of soil, water and air. At the same time the plant of Opuntia (Opuntia) has the property of absorbing and neutralizing contaminants [4,5].

Description of the Experiment

For conducting study, it was selected technogenic contaminated zone in the village of Cala, Absheron Peninsula of Azerbaijan. A separate section in the size of 10m×10mwas selected for *Opuntia Vulgaris Mill*. The distance between sites was equal to 25-30 meters. Certain parts of our view will allow investigating the effect of transport of heavy metals from technogenic contaminated soil to both plants in more optimal way. On the other hand, in comparison with the size of selected technogenic contaminated area, both sites were selected as close as possible to each other, in order both parts of the soil climatic conditions to be practically the same. It should be noted that, dry climate of moderately warm temperate semi-desert and dry steppe is characterized for the AbsheronPeninsula. The total solar radiation is 130-135 kcal / cm^2 per year. The main part of the total radiation (86-90 kcal / cm^2) is applied during the warm half of the year. The average annual temperature is 13,5-13,7 ˚C.

A characteristic feature of the selected area (village Cala, AbsheronPeninsula) is that, except technologically-anthropogenic effects on soil, there is contaminated sediments of oilfield wastewater and weak oil pollution. Some characteristics of the soil of the zone are shown in Table 1.

Table 1. Some indicators of contaminated soils

The depth taken from the soil sample (cm)	Hygroscopic moisture (%)	pH	CO_2 (%)
0-10	2,85	7,9	10,13
10-31	3,78	8,6	9,56
31-51	3,6	8,7	8,54
51-88	3,75	8,6	7,92
88-150	4,01	8,5	7,97

It was seen from Table 1 that, the characteristic feature of oil-contaminated soils is also a high pH in the upper soil horizons 8,8-9,4. These high indicators of pH in contaminated sections are not reduced in entire soil profile. Such strong basic conditions are explained by the presence of oil and alkalinity of drilling water, impregnating the whole soil profile. Acidity of pure soil varies within 7,9-8,2.

It is pertinent to note that the mobility of heavy metals in soil and their flow into the plant is very variable and depends on many factors: the type of plant, soil and climatic conditions. The concentration of heavy metals in plants depends on the age of the plants and strongly varies in different organs.

Soil shows its buffering properties, by transferring the water-soluble metal compounds to sparingly soluble form and sparingly soluble to more mobile, e.i. traced convergence of included compounds of elements and their conversion to compounds, characteristic of soil of particular composition and properties. However, the buffering capacity of the soil is not unlimited, and the amount of those compounds in which they enter the soil and then into plants is gradually increased with increasing exogenous concentrations of metal.

In the specific soil and climatic conditions of the region and the presence of certain type of vegetation of availability of heavy metals is determined by the properties of soil, a change that can significantly affect the accumulation of heavy metals in plant products. Heavy metals are the most mobile in the humus-poor acid soils of light granulometric composition with a low capacity of cation exchange and low buffer.

For the measurement of concentration of heavy metals in soil of both sites, locations of two sections were randomly selected. Sections were made up to a depth of 20 cm. With the help of transportable roentgen-fluorescence XRF spectrometer the concentration of heavy metals were measured in the vertical direction of three points: at a depth of 0-5sm; 10-15 cm; 15-20cm. The results of measurement are shown in Table 2 (the data are averaged over two sections of each site).

Table 2. The concentration of heavy metals in soil

Sections / Heavy metals	Concentration (mg/kg)					
	Section № 1			Section № 2		
	Depth (cm)			Depth (cm)		
	(0-5)	(10-15)	(15-20)	(0-5)	(10-15)	(15-20)
Cd	2,27	1,35	1,12	2,36	1,22	0,97
Pb	9,58	8,12	7,61	9,31	8,07	8,11
Zn	60,28	52,26	50,05	58,17	51,17	49,11
Ni	31,76	28,63	27,54	29,61	28,62	28,08
Co	4,60	5,42	5,53	4,71	5,46	5,62
Mn	39,76	43,65	45,84	37,15	42,37	46,57

*) It should be noted that, Cd- includes in I risk group; Pb- includes in II risk group; Zn and Ni include in III risk group; Co and Mn include in the groups of less danger.

10 *Opuntia Vulgaris Mill* was transferred from ecologically clean areas to these contaminated sites and was planted. The concentration of heavy metals was measured with the help of roentgen-fluorescent spectrometer of XRF samples of plants before planting them in contaminated areas. Results of control measurements are given in Table 3. Observation of the plants lasted for 6 months. During this period, the survival of plants was analyzed in technogenic contaminated sites. From planted *Opuntia Vulgaris Mill* plant survived only 6 plants (60% survival). This fact demonstrates the stability of the *Opuntia Vulgaris Mill* plant to technogenic contaminants. Exactly 6 months after planting, it was measured the concentration of heavy metals of surviving samples of these plants. For this purpose, three samples were taken from 6 surviving *Opuntia Vulgaris Mill* and the results of measurement of the concentrations of heavy metals were averaged over three samples for plant. Technology of manufacturing plant samples was as follows: plants were separated neat way from soils with root systems, then the root systems of plants have been thoroughly washed and dried. Then the plants with their roots were grinded and transferred to a separate vessel until homogenous properties (see. Table 3).

Table 3.The concentration of heavy metals in plant samples

Heavy metals / Plants	The concentration of heavy metals in plant samples (mg / kg)											
	Cd		Pb		Zn		Ni		Co		Mn	
	1	2	1	2	1	2	1	2	1	2	1	2
Opuntia Vulgaris Mill	<LOD	1,86	<LOD	5,69	4,21	50,61	6,37	28,69	0,28	2,74	9,33	27,65

Note: 1- control measurement; 2-measurement in the samples, after 6 months

Results and their Discussion

Observation of planted plants in the technogenic contaminated sites has shown that "survival effect" (resistance to technogenic contaminants in *Opuntia Vulgaris Mill* plants). This is explained by the fact that the plant has a catchment Opuntia property and very resistant to aridity, high temperature and salinity. This is explained by the fact that the plant of Opuntia has a catchment property and it is very resistant to aridity, high temperature and salinity.

The concentration and distribution of selected heavy metals at depth is almost the same for two contaminated sites. This fact is explained by that in order to achieve identity of external influencing factors, two contaminated sites were chosen optimally close to each other (the distance between the two sites is equal to 25-30 m). The optimal distance between two technologically contaminated sites is conditioned by the fact that it is possible to trace the effect of transport of heavy metals from contaminated soil to both plants independently.

As seen from Table 2 the concentration of Cd, Pb, Zn, Ni, Co changed in the direction of decreasing from top to bottom along the vertical direction. Only Mn concentration increased with the increase of depth. Comparative analysis of table 2 and 3 has showed that the effect of transport of Cd which includes in I risk group for *Opuntia Vulgaris Mill* plant was 81,94%. The effect of transport of heavy metal to the plant is calculated by the following formula:

$$EFTR = \left[\frac{C_{cd}^{Op} - C_{cd}^{(Op)}}{C_{cd}^{(1)}} \right] * 100\% (1)$$

Where EF_{TR} - effect of transport of heavy metals from contaminated soil to the plant measured in percentages, $C_{cd}^{(1)}$ - Cd concentration in the contaminated soil measured in units of mg / kg at depth of (0-5 cm), $C_{cd}^{(op)}$-The concentration of Cd in samples of plants of *Opuntia Vulgaris Mill* after 6 months of planting, $C_{o,cd}^{(op)}$ –The concentration of Cd in samples of plants of *Opuntia Vulgaris Mill* before planting the plants (control measurement)

"The effect of transport" for other heavy metals from contaminated soil to plants has been calculated using the same formula. The results of calculations of «the effect of transport» of heavy metal are demonstrated in Table 4.

Table 4.The effect of transport» of heavy metal

«Effect of transport» / Plant	"The effect of transport" of heavy metals from contaminated soil to plants calculated in percentages (%)					
	Cd	Pb	Zn	Ni	Co	Mn
Opuntia Vulgaris Mill	81,94	58,35	76,97	70,27	53,48	41,68

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