ECOSYSTEMS FUNCTIONING FEATURES IN THE ZONE OF ANTHROPOGENIC IMPACT

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Abstract

As a result of increasing anthropogenic activities, the heavy metal pollution of atmosphere, soil and water is a growing environmental problem affecting crop quality and production and human health. Soil pollution by heavy metals is a serious and growing problem. Defining the criteria of ecological state of soil and vegetation in the area of oil and gas field (KOGCF) was carried out according to conventional techniques. Dominant plants were sampled (Artemisia and euphorbia) from the investigating area for studying the accumulation of heavy metals and establishing the nature of their impact on the morpho-physiological processes of the plant body. Data of the translocation factor and biological absorption coefficient are characteristic indicators of the accumulation of heavy metals by plants from the soil.

Key words: *Artemisia, euphorbia, biological absorption coefficient, translocation factor, heavy metals*

The production cycle is accompanied by the release of chemical elements into the environment, and it causes a serious problem of environmental pollution. Exploitation of oil fields leads to contamination and degradation, resulting in the loss of the land use of large areas of fertile land, reducing the productivity of field crops or environmental contamination.

Karachaganak field is one of the rapidly developing oil and gas regions of Kazakhstan, which is located in the west of Kazakhstan. The development of the oil industry does not exclude the possibility of its environmental impact and requires the development of methods and restoration technologies of disturbed lands. Protection and restoration of disturbed lands, as well as search for optimal and tailored to specific process conditions and recovery methods of technologically contaminated soil are very important. The resistance of natural systems depends on the interaction of several factors, among which are: physical and chemical, landscape-geochemical and biological. The basis for determining the resistance of the natural system laid geochemical principle of the migration process, man-made pollutants and their multifactorial [1, 2, 3].

The objective of this study was contaminants as the most powerful environmental factors have an impact on different processes in plant organisms. Excess and lack of many of macro - and trace elements can cause a number of negative processes, such as breathing problems, photosynthesis, fixation and assimilation of some important nutrients. It is well known that the migration of metals in the soil-plant system is determined by the type of soil and its hydrothermal mode, humus content, acidity, carbonate content and cation exchange capacity, the nature of soil-forming rocks, the specifics of the plant species, weather conditions and the nature of man-made pollution. It is known that knowledge of the gross of trace elements in the soil is not enough to determine the availability of any element in the plant. The total content of trace elements reflects their potential reserves, and the more objective indicator of plant security is the content of their mobile forms, depending on a number of above-mentioned factors [4].

Dispersion, accumulation and conversion of chemical elements in the soil are associated with a number of transformations, which are dependent on the nature of geochemical barriers.

Data of the translocation factor and biological absorption coefficient are characteristic indicators of the accumulation of heavy metals by plants from the soil (BAC).

Plants of different types are characterized by different resistance to the effects of different contaminants and their accumulation. Plants are biological indicators and they react and give an adequate response to the impact of factors. Sensitive indicators of plants bio indication can serve as separate processes in cell and organism (change of enzyme activity, changes in pigment complex) and morphological changes (change and shape and leaf size, chlorosis and necrosis). It is known that phenolic compounds may perform a protective function in plants. They accumulate in the bodies of plants under adverse conditions and provide stability of type.

Phenolic compounds are a good bio indication for Artemisiain the steppe areas, which explain the predominance of Artemisia in the investigated territory. The presence of phenolic compounds affects the color of the plant. A variety of colors flavonoid pigments in the plant kingdom due to a change in pH and the presence of heavy metal salts. The color change of various organs in adverse environmental conditions due to the increased intensity of the protective oxidation processes. Heavy metal ions are the determining factor in the course of oxidative processes in the cell, which are formed as a result of certain complexes, leading to restructuring oxohalide forms pigmented substances in the plant organism.

Participation level of a metal ion in these rearrangements depends on its basic physical and chemical properties. The accumulation of heavy metals is associated with their physicochemical properties (value of normal potential, electronegativity). The above-mentioned properties affect the formation of stable heavy metal compounds with a number of functional groups on the surface and inside the cells, especially the electronegativity may affect the ease of interacting with the metal protoplasm [5].

The values of the average contents of the same element in different plant species, which are growing in the same conditions, often fluctuate by 2-5 times.

Clear background concentrations of heavy metals in soils and plants has not set in the Republic, so, it is necessary, to make a data to compare the distribution of heavy metals in the region with the world's percentage abundance. Obviously, there is a mechanism that regulates the accumulation and distribution of heavy metals in herbal plants between the roots and above-ground organs. In this case, roots act as a barrier between the soil and above-ground plant bodies, preventing delivery of a large number of elements in the over ground parts.

In the area of oil and gas field (KOGCF) vegetable blanket is represented by the following associations: wheat grass, Artemisia sericea, absinthial, bitter Artemisia milfoil. The dominant plant species are white Artemisia, wheatgrass, tatarian lettuce, euphorbia, amaranth, quinoa, bindweed, yellow lucerne.

Defining the criteria of ecological state of soil and vegetation in the area of oil and gas field (KOGCF) was carried out according to conventional techniques. To identify the influence of deposits in the soil and vegetation of the region under study, experimental data on the total content of heavy metals at different distances from the source of pollution (in the field circuit and on the border of the sanitary protection zone) in four directions, taking into account the wind rose.

Dominant plants were sampled (Artemisia and euphorbia) from the investigating area for studying the accumulation of heavy metals and establishing the nature of their impact on the morpho-physiological processes of the plant body. Translocation factor of pollutant transfer in Artemisia and euphorbia were calculated using the basis of ratios of the heavy metal concentrations in plant and soil samples.

Accumulation of molybdenum and nickel in the investigated territory was established from the experimental data. Because of high mobility of Ni in the soil, it has a significant effect on its content in plants. It is well known from the literature that nickel easily passes into the plant from the soil, where the concentration may be even greater than in the soil in which they grow. Along with this, the accumulation of molybdenum in plants was observed in our studies, although its content in the soil is small. Apparently, enhanced absorption of molybdenum by plants is associated with its nutrient function. The analytical data of research are presented in the tables 1, 2.

Table 1. Heavy metal concentration in Artemisia (ppm)

№	Location	Cu ppm		Ni ppm		Pb ppm		Zn ppm	
		Contour	SPZ	Contour	SPZ	Contour	SPZ	Contour	SPZ
1	2	3	4	5	6	7	8	9	10
1	North	0,46	0,18	2,75	2,75	0,75	1,00	5,0	4,0
	Accumulation factor	1,2	1,2	2,5	1,2	2,3	1,2	2,0	1,5
	Translocation index	0,15	0,08	0,30	0,41	0,05	0,25	0,18	0,24
2	East	0,24	0,16	17,6	14,3	1,0	0,9	2,83	1,83
	Accumulation factor	1,9	1,4	2,1	1,2	1,1	1,5	1,2	1,2
	Translocation factor	0,12	0,10	2,91	2,93	0,16	0,25	0,18	0,10
3	West	0,86	0,17	6,8	6,8	0,9	0,75	0,88	5,34
	Accumulation factor	2,0	1,0	1,8	0,8	1,8	1,2	1,5	1,2
	Translocation factor	0,27	0,06	0,85	0,72	0,11	0,13	0,07	0,30
4	South	0,18	0,47	10,1	10,0	0,65	0,65	6,1	2,3
	Accumulation factor	1,7	1,0	1,7	1,8	1,8	1,6	1,2	1,1
	Translocation factor	0,06	0,31	1,5	1,54	0,11	0,11	0,64	0,92
5	Limits of metal content in herbs	5-25		-		-		21-45	

№	Location	Mn ppm		Mo ppm		Co ppm		Fe ppm	
		Contour	SPZ	Contour	SPZ	Contour	SPZ	Contour	SPZ
1	2	3	4	5	6	7	8	9	10
1	North	2,5	3,5	0,15	0,35	0,07	0,28	0,08	1,45
	Accumulation factor	2,3	1,5	2,4	1,8	1,2	1,1	1,8	1,2
	Translocation factor	0,26	0,24	0,83	3,9	0,04	0,2	0,08	2,1
2	East	4,5	3,8	0,42	0,46	0,05	0,28	0,05	0,15
	Accumulation factor	1,8	1,5	2,8	1,7	1,7	1,6	1,2	1,5
	Translocation factor	0,33	0,31	4,7	3,8	0,03	0,31	0,05	0,17
3	West	3,9	4,6	0,68	0,26	0,09	0,06	0,06	0,23
	Accumulation factor	2,1	1,0	2,2	1,9	1,1	1,3	1,2	1,4
1	2	3	4	5	6	7	8	9	10
	Translocation factor	0,46	0,55	5,67	2,6	0,05	0,04	0,05	0,27
4	South	4,4	3,2	0,60	0,43	0,07	0,16	0,34	0,5
	Accumulation factor	2,1	2,1	1,9	1,3	1,6	1,6	1,9	2,1
	Translocation factor	0,45	0,22	5,0	4,8	0,03	0,09	0,52	0,64
5	Limits of metal content in herbs	25-117		1,7-4,7		0,26-0,48		5	

Table 2. Heavy metal concentrations in euphorbia

№	Location	Cu ppm		Ni ppm		Pb ppm		Zn ppm	
		Contour	SPZ	Contour	SPZ	Contour	SPZ	Contour	SPZ
1	2	3	4	5	6	7	8	9	10
1	North	0,01	0,05	10,5	9,7	0,4	0,35	5,6	4,3
	Accumulation factor	1,3	0,9	2,0	1,4	2,7	1,9	2,2	1,5
	Translocation factor	0,01	0,02	1,17	1,44	0,03	0,09	0,21	0,26
2	East	0,04	0,33	13,1	12,0	1,2	1,0	4,7	7,7
	Accumulation factor	1,4	1,3	1,1	1,5	3,1	3,6	1,8	2,3
	Translocation factor	0,02	0,2	2,16	2,5	0,19	0,28	0,3	0,39
3	West	0,26	0,02	8,3	7,5	0,8	0,8	4,9	5,9
	Accumulation factor	1,2	0,8	2,4	2,2	2,3	1,2	1,9	1,8
	Translocation index	0,08	0,01	1,03	0,80	0,09	0,14	0,37	0,33
4	South	0,40	0,14	10,1	0,7	0,7	0,65	5,8	2,8
	Accumulation factor	3,3	2,0	1,7	1,3	1,9	2,1	1,9	1,1
	Translocation factor	0,14	0,09	1,8	1,56	0,10	0,11	0,6	0,11
5	Limits of metal content in herbs	5-25		-		-		21-45	

№	Location	Mn ppm		Mo ppm		Co ppm		Fe ppm	
		outline	SPZ	outline	SPZ	outline	SPZ	outline	SPZ
1	2	3	4	5	6	7	8	9	10
1	North	4,8	4,3	0,57	0,11	0,1	0,41	0,07	0,16
	Accumulation factor	3,3	2,5	2,1	1,6	1,2	1,4	1,7	2,4
1	2	3	4	5	6	7	8	9	10
	Translocation factor	0,51	0,3	3,2	1,2	0,05	0,29	0,07	0,23
2	East	4,2	4,9	0,46	0,19	0,11	0,03	0,61	0,43
	Accumulation factor	1,6	1,8	2,3	0,9	3,5	2,7	1,7	1,3
	Translocation factor	0,31	0,4	5,1	1,58	0,07	0,03	0,66	0,48
3	West	4,45	4,79	0,21	0,21	0,08	0,06	0,17	0,04
	Accumulation factor	1,8	1,4	0,7	1,3	1,2	1,2	2,4	1,1
	Translocation index	0,53	0,44	1,75	2,1	0,04	0,04	0,13	0,05
4	South	3,3	4,7	0,39	0,33	0,48	0,33	0,11	0,24
	Accumulation factor	1,7	1,1	1,8	0,9	3,0	2,6	1,9	2,9
	Translocation factor	0,34	0,33	7,8	3,7	0,22	0,20	0,17	0,31
	Limits of metal content in herbs	25-117		1,7-4,7		0,26-0,48		5	

The biological absorption coefficient (BAC) was used to characterize the barrier functions of plants. The value BAC indicates the "biohpility" level of chemical elements, and its change - level of anthropogenic impact on the soil. The calculated data of BAC was analyzed and metals were classified into groups: Co, Mn, Cu, Ni, Mo - to a group of elements of the weak accumulation and medium capture; Pb - to a group of elements with a weak capture [6].

On the basis of translocation factor and comparison with the data of biological absorption coefficients, it was established that copper, nickel, manganese, molybdenum and cobalt penetrates into the plant cells easily. Assimilation of the above mentioned metals by plant organisms is associated with the fundamental characteristics of these metals, such as electronegativity and electrode potential. Due to which they are involved in redox processes in cells. Artemisia and euphorbia taken as dominant plants, the protective mechanism against the accumulation of zinc, copper and cobalt in the body is manifested as research objects. The amount of copper transferred from the soil to the plant is less than the amount of zinc.

Table 3. Accumulation of heavy metals in Artemisia

Characteristics	Cu	Ni	Pb	Zn	Mn	Mo	Co	Fe
Translocation factor	0,14	1,39	0,14	0,32	0,35	3,91	0,09	0,48
Biological absorption coefficient	20-0,1	20-0,1	0,2-0,01	1-20	20-0,1	20-0,1	20-0,1	0,1
The ratio of the biological absorption coefficient to translocation factor	0,71	0,07	0,7	3,12	0,28	0,02	1,11	0,2

Table 4. Accumulation of heavy metals in euphorbia

Characteristics	Cu	Ni	Pb	Zn	Mn	Mo	Co	Fe
Translocation factor	0,07	1,55	0,23	0,32	0,39	3,30	0,11	0,26
Biological absorption coefficient	20-0,1	20-0,1	0,2-0,01	1-20	20-0,1	20-0,1	20-0,1	0,1
The ratio of the biological absorption coefficient to translocation factor	1,42	0,06	0,04	3,12	0,25	0,03	0,9	0,38

Based on the results, the accumulation of heavy metals in the aboveground and root biomass of all the investigated territories can be clearly shown for Artemisia: Mo> Ni>Mn> Zn> Fe>Pb> Co> Cu.

An indirect proof of the existence of the protective reaction of plant organisms is the accumulation of phenolic compounds. A high content of phenolic compounds in Artemisia was observed both in the leaves and roots in the field circuit in the direction of north, east, west and on the border of the sanitary protection zone to the south. In euphorbia, clearly defined patterns have not been identified (Figure 1, 2).

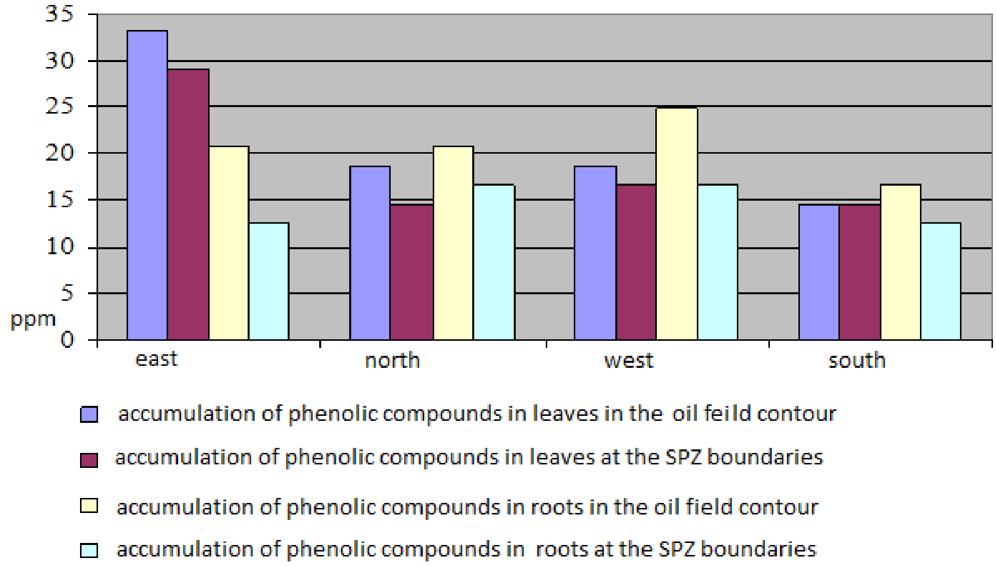

Figure 1. Accumulation of phenolic compounds in Artemisia

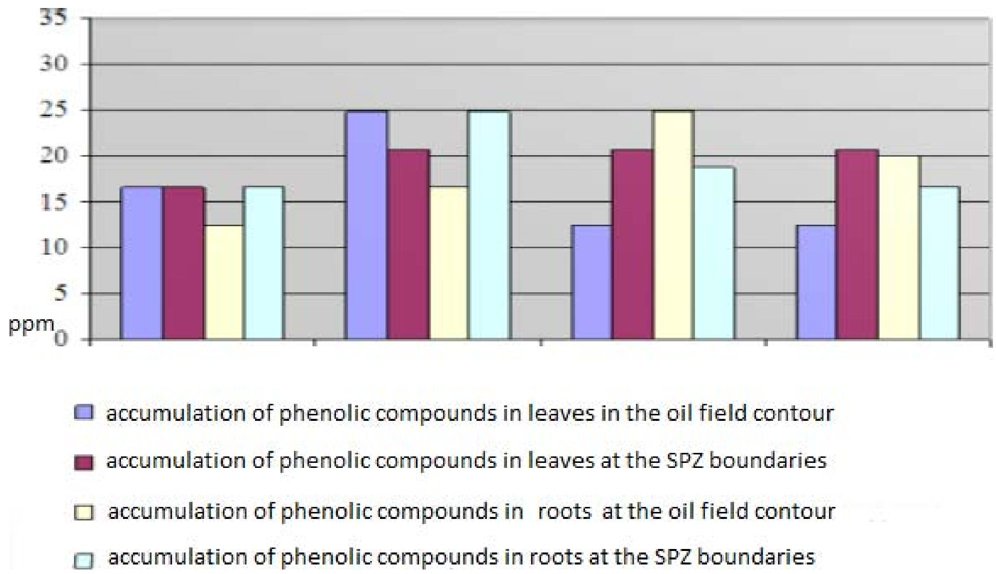

Figure 2. Accumulation of phenolic compounds in euphorbia

Experimental data allowed to establish diagnostic indicators of bio indication: translocation factor and biological absorption coefficient. Translocation factor of elements falls within the limits of the range of variability of biological absorption groups. The concentration of heavy metals in soil and their accumulation in plants correspond to the norm. Plants are characterized by some level of resistance in terms of the accumulation of heavy metal ions.

The soil of the study area contains high concentrations of nickel, lead, zinc. High concentration of nickel in soils due to the fact that this element accompanies with the gas-oil-bearing strata and the content of lead and zinc is due to anthropogenic influence.

High mobility of Ni in soil has a significant effect on its content in plants, as it is known from the literature that nickel easily converts from the soil into a plant, where the concentration may be even greater than in soil in which they grow. In addition, during our research accumulation of molybdenum in plants was observed, although its concentration in soil is low. Apparently, the enhanced absorption of molybdenum by plants is connected with its nutrient function.

Based on the data of biological absorption coefficients, it was established that copper, nickel, manganese, molybdenum and cobalt are the most easily penetrated into plant cells. The assimilation of above mentioned metals by plant organisms are associated with the fundamental characteristics of these metals, such as electronegativity and electrode potential. Due to they are involved with redox processes in cells. Artemisia and euphorbia are taken as main objects of research, defense mechanism against the accumulation of zinc, copper and cobalt was observed in the body of these plants.

As can be seen from the results of the study the accumulation of heavy metals is especially pronounced for artemisia. The concentration of heavy metals in the aboveground and root phytomass of all the study areas was the same: Mo> Ni>Mn> Zn> Fe>Pb> Co> Cu and within the variability range of the biological absorption group.

The content of metals in plants is a reliable indicator of the mobility of metals in soil. To estimate the existence of plant barrier mechanisms with respect to contaminants is possible in the presence of metal distribution in plant bodies (BAC and TF). To characterize the barrier function of plants the biological absorption coefficient was used (BAC), which is the division of the amount of a chemical element in plant ash on its content in the soil. The value BAC indicates the level of the "biophillity" of chemical elements, and its change - degree of anthropogenic impact on the soil. Accumulation factor (AF) is a more objective criterion in the assessment of the barrier function of the metal, which reflects the migration ability of mobile forms of metal [7].

Roots carry out the main barrier function to reduce the inflow of HM in plants. When metal penetrates into the roots of plants, chelation occurs and, as a consequence, a decrease in mobility [8, 9.10]. There is a specific mechanism for regulating the accumulation and distribution of heavy metals in plants between the roots and above-ground organs. The smaller the clark content of microelements in the soil, the higher their accumulation in soil and in plants. Heavy metals, as trace elements are involved in the small circulation of substances in ecosystems. The nature of accumulation and distribution of heavy metals depend on its clark content and the biological absorption coefficient in the soil-plant system.

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