MINISTRY OF ECOLOGY AND NATURAL RESOURCES OF THE REPUBLIC OF AZERBAIJAN

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SPREAD OF THE HEAVY METALS IN THE SOIL OF SUMGAYIT INDUSTRIAL ZONE, INACTIVATION OF THE IMPACT OF THE LATTER AND RESTORATION METHODS OF SOIL FERTILITY

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SYNOPSIS

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General character of the work.

Relevance of the subject. Protection of soil resources, preserving of fertility, land re-cultivation and reuse of it are the most topical problems nowadays. The continuous growth of the world population and limited amount of productive lands make the efficiency of those lands even more relevant. The protection of the land resources is one of the global problems. Continuous industrial and agricultural development, increased energy demand can account to the growth of the problem. Consequently, humanity will be forced to form new sustainable landscapes that can provide it with oxygen, water, food, energy.

"The complex Measures Plan for 2006-2010 on ecological state improvement in the Republic of Azerbaijan" approved by the Decree of the President of the Republic of Azerbaijan (No.1697 of September 28, 2006) was adopted.

Waste, organic and non-organic pollutants entering the soil under different anthropogenic influences cause danger for ecology. Depending on kind and concentration of pollutants, soil has an ability to self-clean. As a result of the various anthropogenic activities, the industrial, production waste, chemical substances used in agriculture congregate in soil and cause the self-cleaning ability of soil radically diminish.

Heavy metals are very important in the lives of living organisms. However, it was proved that the intensive spread of the latter in biosphere, atmosphere and high concentration of them in soil cause danger for biota. Therefore, the quantitative research and impact of such spread on living organisms is crucial.

It is particularly difficult to collect heavy metals in soil, the process that is very important in the industrial zones, and in Sumgayit industrial zone in particular. The main problem of industrial zones is centralization of the industrial objects and population in one place. Pollution of soil with waste, for example gas, dust, carbon dioxide, produced by industrial enterprises, is more dangerous than soil degradation. From this point of view the Sumgayit industrial zone is one of the most urbanized regions with high population's density close to the industrial enterprises.

The soil is considered strong absorber of chemical elements, that are absorbed by upper fertile layer of soil. However, the land possesses buffer character and it can reduce the toxicity of pollutants by itself. However, self-cleaning process is slower than the industrial spread of heavy metals and it serves a reason of aggravation of soil and fertility loss.

The large-scale man-made impacts on our planet lead to the redistribution of chemical elements in the planet, resulting in localization of many heavy metals in major industrial centres.

Not taking account of the natural-ecological factors (prevailing winds and insufficiency of rainfalls), chemical industry in the Sumgayit administrative zone caused formation of the great ecological complications.

In the past, the neglect of natural and environmental factors (prevailing winds and insufficiency of rainfalls) in the chemical industry in the administrative area of Sumgait led to major environmental consequences. The ecological state was estimated as catastrophic.

Our country possesses limited land resources. Therefore, the protection of land resources is highlighted as an important problem in the paragraph 18 of "Soil Code".

Goals and objectives of the research: An objective of the research is to determine the level of the spread of heavy metals in the soil of industrial zone, to prepare ecologically grounded inactivation methods, to define fertility restoration methods and to determine the impact of such spread on plants.

The following tasks have been fulfilled to achieve this objective:

- Selection of the key plots to conduct the research work;
- Description of genetic layers according to International WRB system, taking soil samples from different layers and definition of physio-chemical and agrochemical peculiarities of soil;
- Establishing qranulometric structure of soil samples, a quantity of humus, nitrogen, absorbed bases, calcareous amount and pH;
- Establishing by GPS of geographical coordinates location on map-scheme in the zone where experiment was performed;

- Establishing of optimal norms and ratios of organic-mineral and mineral fertilizers under the beetroot and fir-tree in the grey-brown soil of the experimental area; establishing an absorber ability of soil in relation to heavy metals;

- Establishing of the level of an impact of organic and mineral fertilizers on heavy metals amount in grey-brown soils;

- Establishing the level of absorption heavy metals by the plants;

- Establishing the impact of inactivation methods of heavy metals on the productivity of agricultural plants;

- Establishing the level of the impact of heavy metals on an amount of soil microorganisms;

- Establishing the impact of the application of organic fertilizers on element content of plants under the condition of high concentration of heavy metals;

- Calculation of the economical rationality of inactivation methods of heavy metals.

Scientific innovation. The methods of biological prevention of the spread of heavy metals were tried out on beetroot and fir seedings for the first time in Sumgayit industrial zone. The research work demonstrates that the sanation (recovery) of the polluted soils processed with organic-mineral fertilizers is technically safe, economically rational and ecologically effective.

Practical significance of the work. The analysis of the change of the biological and physical characteristics of the soil as well as the influence of the latter on morphogenetic indicators of grey-brown soils under the impact of the spread of heavy metals is scientifically and practically significant. An application of organic and mineral fertilizers under the beetroot and fir plants, discovery inactivation methods of heavy metals and restoration of soils fertility and agroecological improvement of soils is of great practical importance.

Application. According to the results of the research, the pollution level of heavy metals was established for the purpose of preventing of the spread of heavy metals in soils, the complex agrotechnical and agroecological system of measures was prepared and application of those measures in the above-mentioned zone was recommended.

Approbation of the work. The results of the research were discussed in annual accounts (2014-2017) of the Department of Biodiversity Conservation and Specially Protected Natural Areas of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, also in the International scientific-practical Conferences.

Published works. 8 articles, 12 theses were published on this subject of this dissertation.

Structure and volume of the work. The dissertation consists of 175 computer writings, introduction, 5 chapters, conclusions and recommendations. 35 tables, 10 pictures, 1 map-scheme, 2 schemes, 155 references were used.

CONTENTS OF THE DISSERTATION

I chapter. Physio-geographical characteristics of "Absheron peninsula".

In this chapter the detailed information based on sources of literature about geographical position, relief, geological and geomorphological structure, climate, plant and soil cover in the Absheron region was provided.

II chapter. Research object, method and agrochemical characteristics of soil of the experimental area.

The research was performed in the period of 2014-2017 in the grey-brown soil (under beetroot and fir plants) in the area was impacted by the spread of heavy metals in the base of "Azerchemistry" - Ethylene-Polyethylene factory in Sumgait. The main objective was to fulfil phytoremediation process, to optimize the norms of fertilizers, to study the impact of organic and mineral fertilizers on the productivity of beetroot and restoration of soil fertility.

The experiment was performed in 2 schemes, 5 options and 3 repetitions and fulfilled in the following scheme:

1.Control (unfertilized)

2.$N_{60}P_{60}$ K_{60} (background)

3.Background + 15t/ha of manure

4.Background+ 5,0t/ha vermicompost

5.Background + 2,5t/ha vermicompost + 30t/ha manure

A territory for each option was 56,0 m^2 (8,0x 7,0), the accounted area was 50,4 m^2 (7,2x7,0), 1 meter protective zone between each repetition was defined (3 repetitions in total).

In the experiment the ammonium saltpetre (affecting nitrogen -34% was used as nitrogen fertilizer, simple superphosphate (affecting phosphorus 18%) as phosphorus fertilizer, potassium chloride (affecting potassium 52%) as potassium fertilizer. As organic fertilizer half-rotten manure of the cattle with composition of 0,5% nitrogen, 0,3% phosphorus and 0,6% potassium, 65% humidity was used.

After the experimental area was selected 50% of the annual norm of organic fertilizers (manure, vermicompost) were applied under the plot, 50% of annual norm of mineral fertilizers were applied during ploughing in early spring, and the rest were divided into 2 parts and applied during 10-15 leaves formation and flowering period.

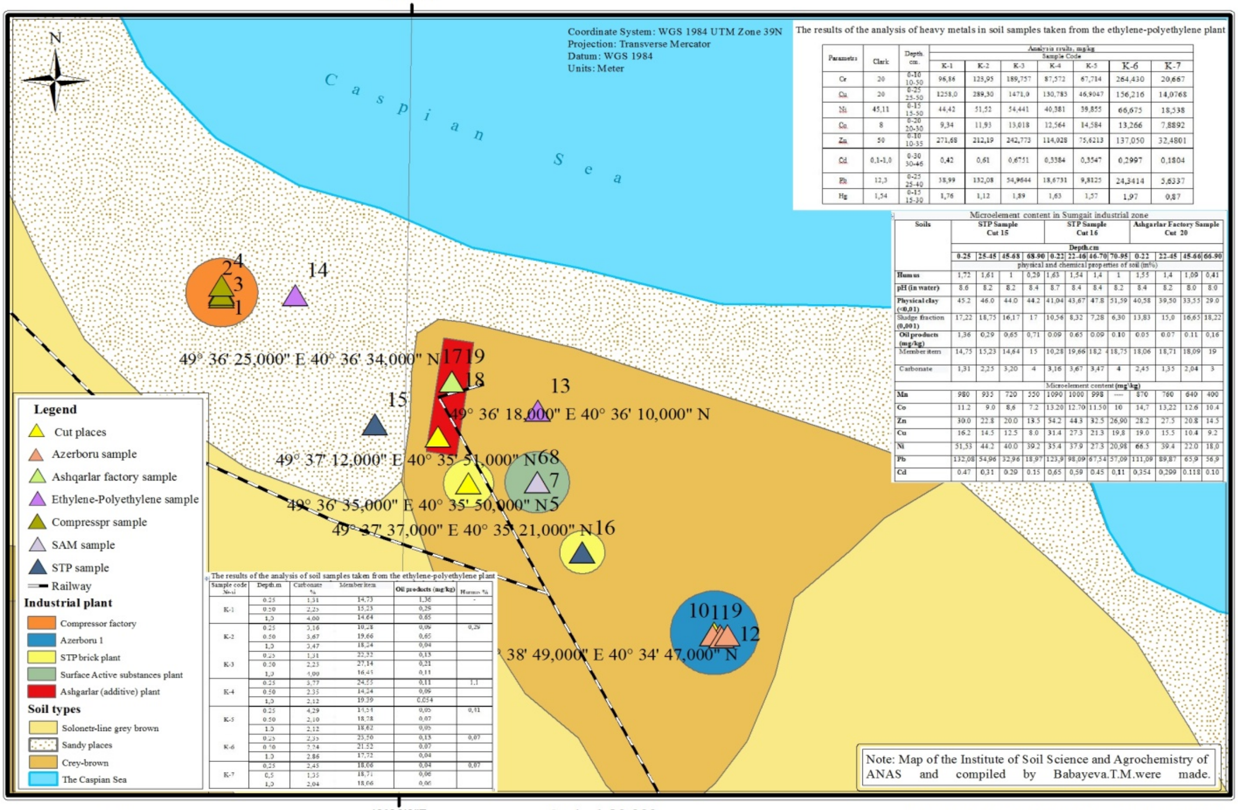
The strategic places were selected, and soil cuts were put in different depths, the soil samples were taken on genetic layers, the plant cover, the land relief, the location was recorded.

In order to estimate the current state of the selected zone the physical and chemical analysis of water from the same area were made.

The research was completed using the following methods:

- granulometric composition and bulky mass by N.A.Kachinsky and mastersizer apparatus;
- humus and total nitrogen by I.V.Turin;
- the hygroscopic humidity –thermal method;
- natural moisture- weight method;
- pH in water suspension -pH meter;
- absorbed bases –Ca and Mg –D.I.Ivanova;
- Na-K.K. Hedroitsa; calcareous ($CaCO_3$) –calsimeter;
- nuclear –NVS-2;
- total nitrogen –kieldal method;
- gross phosphorus (P_2O_5) – B.P.Machigin;
- exchangeable potassium (K_2O) –P.V.Protasov;
- ammoniac solving in water –D.M.Konev;

MAP SCHEME OF THE RESEARCH OBJECTS IN THE SUMGAIT INDUSTRIAL ZONE



The results of the analysis of heavy metals in soil samples taken from the ethylene-polyethylene plant

Parametrs	Clark	Depth, cm.	Analysis results, mg/kg Sample Code K-1	K-2	K-3	K-4	K-5	K-6	K-7
Cr	20	0-10 10-50	96,86	123,95	189,757	87,572	67,714	264,430	20,667
Cu	20	0-25 25-50	1258,0	289,30	1471,0	130,783	46,9047	156,216	14,0768
Ni	45,11	0-15 15-50	44,42	51,52	54,441	40,381	39,855	66,675	18,538
Co	8	0-20 20-30	9,34	11,93	13,018	12,564	14,584	13,266	7,8892
Zn	50	0-10 10-35	271,68	212,19	242,773	114,028	75,6213	137,050	32,4801
Cd	0,1-1,0	0-30 30-46	0,42	0,61	0,6751	0,3384	0,3547	0,2997	0,1804
Pb	12,3	0-25 25-40	38,99	132,08	54,9644	18,6731	9,8125	24,3414	5,6337
Hg	1,54	0-15 15-30	1,76	1,12	1,89	1,63	1,57	1,97	0,87

Microelement content in Sumgait industrial zone

Soils	STP Sample Cut 15				STP Sample Cut 16				Ashgarlar Factory Sample Cut 20			
	Depth.cm											
	0-25	25-45	45-68	68-90	0-22	22-46	46-70	70-95	0-22	22-45	45-66	66-90
	physical and chemical properties of soil (in%)											
Humus	1,72	1,61	1	0,29	1,63	1,54	1,4	1	1,55	1,4	1,09	0,41
pH (in water)	8.6	8.2	8.2	8.4	8.7	8.4	8.4	8.2	8.4	8.2	8.0	8.0
Physical clay (<0,01)	45.2	46.0	44.0	44.2	41,04	43,67	47.8	51,59	40,58	39,50	33,55	29.0
Sludge fraction (0,001)	17,22	18,75	16,17	17	10,56	8,32	7,28	6,30	13,83	15,0	16,65	18,22
Oil products (mg/kg)	1,36	0,29	0,65	0,71	0.09	0.65	0.09	0.10	0.05	0.07	0.11	0,16
Member item	14,75	15,23	14,64	15	10,28	19,66	18,2	18,75	18,06	18,71	18,09	19
Carbonate	1,31	2,25	3,20	4	3,16	3,67	3,47	4	2,45	1,35	2,04	3
	Microelement content (mg\kg)											
Mn	980	935	720	550	1090	1000	998	---	870	760	640	400
Co	11.2	9.0	8,6	7.2	13.20	12.70	11.50	10	14,7	13,22	12.6	10.4
Zn	30.0	22.8	20.0	13.5	54.2	44.3	32.5	26,90	28.2	27.5	20.8	14.5
Cu	16.2	14.5	12.5	8.0	31.4	27.3	21.3	19,8	19.0	15.5	10.4	9.2
Ni	51,53	44.2	40.0	39.2	35.4	37.9	27.3	20,98	66.5	39.4	22.0	18,0
Pb	132,08	54,96	32,96	18,97	123,9	98,09	67,54	57,09	111,09	89,87	65,9	56,9
Cd	0.47	0,31	0.29	0.15	0,65	0,59	0.45	0,11	0,354	0,299	0.118	0.10

The results of the analysis of soil samples taken from the ethylene-polyethylene plant

Sample code №-si	Depth.m	Carbonate %	Member item	Oil products (mg/kg)	Humus %
K-1	0.25	1,31	14,73	1,36	-
	0.50	2,25	15,23	0,29	
	1,0	4,00	14.64	0,65	
K-2	0.25	3,16	10,28	0,09	0,29
	0.50	3,67	19.66	0,65	
	1,0	3,47	18,24	0,04	
K-3	0.25	1,31	22,32	0,13	
	0.50	2,23	27,14	0,21	
	1,0	4,00	16,45	0,11	
K-4	0.25	3,77	24,55	0,11	1,1
	0.50	2.35	14,24	0,09	
	1,0	2,12	19.39	0,054	
K-5	0.25	4,29	14,54	0,05	0,41
	0.50	2,10	18,28	0,07	
	1.0	2,12	18,62	0,05	
K-6	0.25	2,35	23,50	0,13	0,07
	0.50	2,24	21.52	0.07	
	1.0	2.86	17,72	0,04	
K-7	0,25	2,45	18,06	0,04	0,07
	0,5	1,35	18,71	0,06	
	1,0	2,04	18,06	0,06	

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Scientific leadersr: Quliyev.E.G., Mammadov.Q.M

- dry residue chlorine Cl ion – titrating silver with nitrate ($AgNO_3$);

- sulphate ion- (SO_4^{-2}) –precipitating like barium sulphate ($BaSO_4$);

- titrating normal and total alkalinity phenolphthalein by methyl orange indicators, 0,025n H_2SO_4;

- heavy metals control AA-700 atom absorption spectrometer apparatus;

- in soil microbiological analysis-by B.A.Dospekhova's planting method in petri agar solution.

The results of the field experiment, calculation of productivity, the accuracy of the experiment, correlative relations, math analysis were completed using methods and literature by B.A.Dospekhova, V.N.Peregudov and P.N.Konstantinov, economical rationality –by N.N Baranov. It is known from the results of the analysis that the experimental area possesses low and high alkaline character. Concentration of carbonates in the experimental area is 5,16-9,33%. This shows that the area is averagely calcareous. The saline with soda weren't found in the research areas. HCO_3 carbonates were detected in slight quantity. Concentration of chlorine - 0,184%, sulphate - 0,305%. The results demonstrate that the area is chlorine -sulphatic. In this chapter the agroecological and morphogenetic character of the soils in the area of "Azerchemistry" factory was provided.

III chapter. Analysis of the spread of heavy metals and microelements in the of grey-brown soil in Sumgait industrial zone. The main sources of anthropogenic pollution in the soil are discovered in this chapter. The pollutants in the soil affect its physical, chemical and biological consistency and are a reason for a change of soil parameters. The morphological-diagnostics and pollution level in soil was conducted by some scientists (G.Mammadova, A.Akhundova, A.Hasanova).

The main pollutants in soil samples taken from the factory zone were Cd, Cr, Zn, Pb. The pollution was mostly observed in the north part of the factory. Concentration of Cu, Cr, Zn, Pb, Ni microelements at the various depths was shown on Table 1. Cu - 30mg/kg, Cr - 25mg/kg, Zn - 62mg/kg. The results showed that the microelements concentration exceeded "Clark" index 10 times in the zone close to the factory.

Concentration of humus jumps 0,41-1,72% interval. The structure of the soil in the zone is weak, less sticky, and slightly polluted with oil products. The physio-chemical analysis of the water samples taken from the Caspian Sea and Sumgayit river passing from "Azerchemistry" factory show that pH is neutral, Cl^- and SO_2^{-4} ions dominate. But from heavy metals Cd-0,018 mkg/l, Ni-3,399 mkg/l, Cu-3,305 mkg/l, Pb-0,138mkg/l were discovered in Sumgayit river. Cd-0,18 mkg/l, Ni-8,993mkg/l, Cu-3,900 mkg/l, Pb-0,174 mkg/l in the Caspian Sea.

Table 1.

The consistency of microelements in grey-brown soil in Absheron peninsula (mg/kg)

№ .	**Depth. cm.**	**Cu**	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Co**
Clark		20	50	10	0,1-1,0	20	40	8
Sumgait industrial zone								
01	0-10 10-50	9,1 12,0	92 94	5 5	0,94 0,88	28 29	7 9	2,2 1,4
02	0-26 26-50	67,0 38,0	84 66	3 8	0,94 0,82	14 19	18 34	1,2 4,2
03	0-15 15-50	77,0 26,0	65 72	9 5	0,82 0,84	22 20	5 8	3,6 3,7
04	0-15 15-50	10,0 9,0	58 62	9 5	0,92 0,62	34 38	12 19	1,8 2,8
05	0-20 20-31	16,0 9,0	88 62	3 4	0,36 0,37	42 68	6 7	1,8 2,6
06	0-20 20-35	30 22	62 65	9 12	0,28 0,51	25 28	8 5	3,6 3,4
07	0-15 15-35	28 9	48 62	9 21	0,28 0,57	9 38	11 7	5,2 1,8
08	0-10 10-33	9 8	42 50	5 5	0,92 0,34	34 24	8 14	5,1 2,6
09	0-30 30-46	5 5	68 74	4 5	0,94 0,82	17 21	8 5	3,4 5,4
10	0-15 15-30	18 12	62 68	8 8	0,28 0,27	34 25	13 9	4,2 1,7

Table 2.

Parameters of physio-chemical analysis of the water samples taken from the Caspian Sea and Sumgayit river passing from "Azerchemistry" factory.

№	Parameters	Measurements	Results of the analysis	
			Sumgayit river	Caspian Sea
1.	pH		7,64	7,77
2.	Electrical conductivity	µS/cm	1110	1158
3.	Saltness	$^{0}/_{00}$	0,3	0,4
4.	Smell	mark	3	3
5.	Chlorine ion, Cl^-	mg/l	99,109	102,623
6.	Sulphate ion, SO_4^{2-}	mg/l	240,399	246,922
7.	Nitrate ion, NO_3^-	mg/l	2,612	2,706
8.	Dependent particles	mg/l	4211	4253
9.	Dry residue	mg/l	722	770
10.	Oil products and oil	mg/l	6,8	1,6
11.	Cd	mkg/l	<0.018	0.018
12.	Ni	mkg/l	3.399	8.993
13.	Cu	mkg/l	3.305	3.900
13.	Pb	mkg/l	0.138	0.174

IV Chapter. Selection of hyperaccumulator plants and impact of fertilizers on soil nutrient regime and productivity. rdinary beetroot and fir plant were used as hyperaccumulator plants in the research zone. It was discovered that the plants with more vitamin C better absorb heavy metals from soil and have an ability to self-clean. One of the most important agrotechnical measures for self-clean process is application of fertilizers by a green method in order to obtain abundant and qualitative product. The results of the research show that an application of organic fertilizers prevents spread pf heavy metals and forms good environment for the nutrient regulation. Application of phosphorus fertilizers in high doses decreases the toxicity impact of lead, copper, zinc and cadmium. Experience of some countries suggests that an application of organic and mineral fertilizers in high doses is recommended in order to undermine the toxicity of heavy metals. As it is seen from Table 3 ammoniac nitrogen and nitrate nitrogen at leaf formation stage (without fertilizer) option during traditional soil cultivation was 17,5-11,5 and 8,5-5,2 mg/kg at 0-10 and 10-50cm layers, phosphorus and potassium 15,3-8,6; 260,3-200,5 mg/kg , but in a rip stage it was 15,2-9,7; 7,2-4,1; 14,1-8,4; 200,5-170,2 mg/kg. As a result of application of organic and mineral fertilizers an amount of nutrient increased to an important level. Amount of ammoniac nitrogen and nitrate nitrogen under vermicompost 5t/h+$N_{60}P_{60}K_{60}$ option was 25,3-16,5; 10,8-6,3mg/kg, phosphorus and potassium was 22,6-11,5; 270,6-203,5 mg/kg at leaf formation stage, at 0-10 and 10-50 cm – layers, in rip stage fluctuated 20,5-12,6; 8,3-5,1; 18,7-10,6; 230,2-170,2mg/kg. An amount of ammoniac nitrogen and nitrate nitrogen absorbed under manure 15t/h+ $N_{60}P_{60}K_{60}$ option at shrubbery stage was 16,5-30,4; 15,8-8,7 mg/kg, phosphorus and potassium – 28,6-15,7; 275,7-207,6 mg/kg at 0-10 and 10-50cm-layers, in rip stage 25,2 -13,3; 10,6-6,3; 22,5-12,8; 235,3-172,6 mg/kg, phosphorus and potassium -28,6-15,7; 275,7-207,6 mg/kg, in rip stage 25,2-13,3; 10,6-6,3; 22,5-12,8; 235,3-172,6 mg/kg.

Table 3.

Impact of organic and mineral fertilizers on change of nutrients in the soil under beetroot (mg/kg in soil) (according to 3-year indicators)

Options	Depth, cm	Leaf formation stage				Rip stage			
		absorbed N/NH_3	N/NO_3	phosphorus P_2O_5	Potassium ableK$_2$O	Absorbed N/NH_3	N/NO_3	phosphorus P_2O_5	potassium K_2O
Control (without fertilizer)	0-10	17,5	8,5	15,3	260,3	15,2	7,2	14,1	220,5
	10-50	11,5	5,2	8,6	200,5	9,7	4,1	8,4	170,2
Vermicompost 5 t/h+ background	0-10	25,3	10,8	22,6	270,6	20,5	8,3	18,7	230,2
	10-50	16,5	6,3	11,5	203,5	12,6	5,1	10,6	170,2
Manure 15 t/ha+ background	0-10	30,4	15,8	28,6	275,7	25,2	10,6	22,5	235,3
	10-50	18,5	8,7	15,7	207,6	13,3	6,3	12,8	172,6
manure 30 t/h+ 2,5t/ha vermicompost background	0-10	33,6	18,6	33,0	283,5	29,6	12,5	24,2	240,6
	10-50	20,7	10,3	20,5	210,2	15,2	7,4	15,5	175,5

Under manure 30 t/h+ 2,5t/h vermicompost $N_{60}P_{60}K_{60}$ option an amount of absorbed ammoniac nitrogen and nitrate nitrogen was 33,6-20.7,18,6-10,3 mg/kg at shrubbery stage at 0-10 10-50 cm layers, in rip stage 29,6-15,2,12,5-7,4, 24,2-15,5, 240,6 -175,5 mg/kg. Vegetation experiment started at the beginning of April 2014. The experiment was conducted in the base of “Azerchemistry” factory. Analysis results show that Cl, K, Ca, Fe, Hg, Mn, Mo accumulate in fir leaves. But Cl, Ti, Mn, Hg, Pb accumulate in beetroots. An amount of metals is superior in the root system of the beet. Results showed that plants absorbed toxic metals in the experimental area.

As it is shown in Table 4 mineral and organic fertilizers impacts the change of the total quantity of heavy metals under fir tree and beetroot in grey-brown soil of the research area. Pb control option - 56,24mg/kg. $N_{60}P_{60}K_{60}$+background option - 32mg/kg.

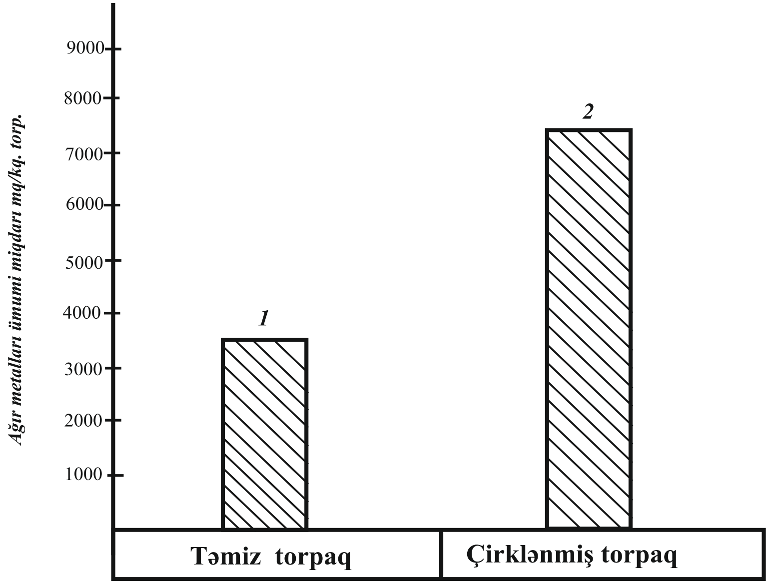
Table 4.

Impact of mineral and organic fertilizers (3-year indicators) on change of total quantity of heavy metals under fir tree and beetroot in grey-brown soils of the Sumgayit industrial zone (mg/kg dry mass).

s/s	Option	Cd	Pb	Ni	Hg	Cu	Cr	Co	Zn
1.	Control without fertilizer	0,58	56,24	47,86	1,82	112,93	125,23	21,76	128,17
2.	$N_{60}P_{60}K_{60}$+ background	0,47	32,71	30,97	1,47	98,76	98,17	19,87	98,27
3.	15 t/h of manure+ Background	0,35	20,63	23,64	1,08	72,45	79,26	17,42	93,72
	5,0 t/h vermicompost+ Background	0,32	15,78	19,27	0,93	68,15	71,23	15,63	89,24
4.	2,5 t/h vermicom-post+30 t/ha manure+ Background	0,23	11,45	13,75	0,63	42,63	42,63	13,42	73,63
5.	**BBG**	0,3	6,0	4,0	0,1	3,0	6,0	12,0	23,0

The highest result was noted under background+2,5 t/h vermicompost+ +30 t/h manure option. With the purpose of reducing the impact of heavy metals in grey-brown soil, improvement of soil and fertility restoration of the Sumgayit industrial zone, an application of 30 t/h manure and 2,5 t/h vermicompost in the part of organic fertilizer at background of $N_{60}P_{60}K_{60}$ mineral fertilizer was considered most effective.

V Chapter. The impact of heavy metals on the sustainability of soil microorganisms in the technogenically polluted grey-brown soil. n impact of spread of heavy metals on microorganisms was researched. The soil samples were taken from around the Sumgayit industrial enterprises and laboratorial analysis was performed to study an impact of heavy metals on quantity of microorganisms in soil. A total number of bacteria and species composition of fungus in soil samples taken from polluted and natural non-polluted areas (in 0-10 depth) in the zone of Sumgayit Industrial zone. It is important to analyse an amount of heavy metals in control (clean) and polluted areas before analysing the factors including the biological circulation (microorganisms, agrotechnology) in active state (gross forms).



Picture 2. *Total amount of heavy metals in clean and technogenically polluted areas of grey-brown soils. Clean area; 2) Polluted area.*

The quantity indicates that the quantity of microorganisms is closely related to the amount of heavy metals in soil in Picture 2. The amount of heavy metals is 3500 mg/kg in the clean area, and 7500 mg/kg in technogenically polluted areas. The heavy metals accumulated less in the clean areas than in technogenically polluted areas. During the research an impact of heavy metals on microorganisms in soil was determined. The laboratorial analysis showed that the number of bacteria was 85000 in the soil samples taken at the distance of 50 meters in the base of “Azerchemistry” factory, but it increased at the distance of 100 meters to 105000. As a result of this discovery the following sentence would be valid: the number of bacteria reduces the higher the pollution. As Table 5 shows, the number of bacteria on the upper part of soil at 50 meters was 90000; at 100 meters 110000 in the factory zone. The waste affected on a quantity of bacteria as well. The number of bacteria at the distance of 50 meters was 60000, but the distance of 100 meters its quantity increased twice to 120000 in grey-brown soil of the factory. A total quantity of microorganisms was 570000 in the researched soil.

Table 5.

Change of the number of microorganisms in the soil polluted with heavy metals (thousands/1gram of soil)

Microorganisms (groups)	Superphosphate		Surface active substances		Ethylene Polyethylene		Microorganisms (groups)
	Distance, by meter		Distance, by meter		Distance, by meter		
	50	100	50	100	50	100	
Bacteria	85	105	90	110	60	120	570
Actinomycetes	16	85	51	102	48	103	405
Microscopic fungus	11	47	18	61	16	52	205
Total:							1274
Number of nitrogen-bacteria colonies on the plates							
Nitrogen-bacteria	1	2	2,5	4	1,5	3,5	14,5

Number of microscopic fungus and nitrogen-bacteria was established in soil and these changes were visible in all the researched soils depending on the level of pollution.

CONCLUSIONS

1. Titan (Ti) - 0,022-0,54 %, vanadium (V) - 0.016-0,1%; chrome (Cr) -0,009-0,28%; manganese (Mn) – 0,015 – 0,44%; copper (Cu) - 0,0023-0,057; arsenium (Ar) – 0,22 – 0,073%; iron (Fe) - 0,007-25,98% were found in soil samples taken from the zones close to factories in the Sumgayit Industrial zone (Compressor, Azerboru-Prokat and Surface Active Substances).The above-mentioned elements do not pass the BBG norms.

2. In the Compressor factory zone (section 1) Cu – 0,01675 or 167mg/kg, (section 2) - 0,0188% or 188 mg/kg; (section 3) - 0,0577% or 577 mg/kg. “Azerboru-Prokat” factory (section 6) - 0,009% or 90mg/kg they pass maximum permissible limit norm.
3. In the Compressor factory zone (section 2) chrome quantity was 0,0211% or 211 mg/kg, Surface Active Substances factory (section 5) - 0,0198%, (section 6) - 0,0521% or 521 mg/kg; (section 7) - 0,2191 % or 2191 mg/kg; “Azerboru-Prokat” factory (section 6) - 0,0108% or 108 mg/kg; (section 9) - 0,0120% or 120 mg/kg exceeded permissible limit norm.
4. It was determined that an amount of mercury in soil samples of the Ethylene-Polyethylene factory zone in the Sumgayit Industrial zone was near the BBG norm, but other metals exceeded permissible limit norm.
5. An impact of mineral and organic fertilizers on nutrient regime of grey-brown soils was established. Improvement of nutrient regime was observed in the options where an amount of absorbed ammoniac – (N/NH_4); nitrate nitrogen (N/NH_3); phosphorus (P_2O_5) and potassium (K_2O) was 17,5; 8,5; 15,3 and 260,3 mg/kg at a phase of the leaves formation of the beetroot at 0-10 cm depth in the control option (without fertilizer). An amount of N/NH_4, N/NO_3, P_2O_5 and K_2O increased till 20,7; 10,3; 20,5 and 210,2 mg/kg that positively affected the soil nutrient regime in the option where 30 t/ha manure +2,5 t/ha vermicompost was applied at background of $N_{60}P_{60}K_{60}$ mineral fertilizers.
6. With applied mineral fertilizers background in control option amount of Cd, Pb, Ni, Hg gross forms was 0,38; 12,28; 44,37, and 1,49 mg/kg in the leave formation phase of 7-8 leaves of the beetroot. These indicators were Cd-0,31; Pb-11,14; Ni-41,76; Hg-1,29 mg/kg at a phase of the leaves bending.
7. Bigger number of microelements was detected in the options where fertilizers are applied in comparison with the control option. Analysis of the samples taken from the leaves and one-

year sprouts of the fir-tree was made by applying of 2,5 t/ha vermicompost and 30t/ha manure of organic fertilizers at mineral fertilizers background under the condition of heavy metals increase in the soil.

Natural cenoses $3,6 \cdot 10^4$ min/g.soil, under beetroot (control option) - $4,1 \cdot 10^4$ min/g.soil, under beetroot (application of fertilizer)- $4,4 \cdot 10^4$ min/g.soil, under fir plant (without fertilizer) $3,8 \cdot 10^4$ min/g. soil, in the option where fertilizers are applied $4,2 \cdot 10^4$ min/g.soil.

8. The different species of Bacillus, Micrococcus, Pseudomonas and Leptothrix, from bacteria. Aspergillus, Penicillium, Fusarium and Alternaria species from fungus were revealed in the options where fertilizers were applied in comparison with the control options.
9. While the beetroot productivity is 294 c/ha in traditional soil cultivation (3 year on average), it is 318 c/ha in $N_{60}P_{60}K_{60}$ option. Increase is 24c/ha or 8,1%-compared to control option. The highest productivity was taken in the option - background+2,5 t/ha vermicompost+30 t/ha manure. 400c/ha increase or two and more times higher than 58c/ha or 36,05% index was detected. If we compare the soil cultivation - the higher number of crops was taken in traditional cultivation in comparison with the minimum cultivation.
10. Results from the controlled sample taken from the leaves of the beetroots: Cd – 0,16, Pb – 0,79, Ni – 0,88, Hd – 0,34, Cu – 1,92 Cr – 1,70, Co – 0,8, Zn – 13,23 mg/kg. Samples with organic fertilizers demonstrated comparatively higher level of accumulation: Cd –0,34, Pb –1,82, Ni –4.15, Hd – 1,48, Cu – 5,92, Cr – 5,80, Co –4,10, Zn –21,05 mg/kg. Results from sample taken from the roots of the beetroots where accumulation was comparatively low: 0,27, 1,5, 3,05, 1,39, 5,80, 4,90, 3,0, 17,48 mg/kg.
11. It was established that the most effective option is: 30t/h manure + 2,5t/h vermicompost as an organic fertilizer at $N_{60}P_{60}K_{60}$ mineral fertilizers background in ordinary beetroot

and firtree for the purpose of soil improvement and fertility restoration, inactivation of spread of heavy metals in grey-brown soil in the Sumgayit Industrial zone.

Proposals for production:

1.To plant hyperaccumulator plants in the soil of Sumgayit Industrial zone.
2. To apply 30 tons of manure and 2,5 tons of vermicompost per hectare besides nitrogen, phosphorus and potassium for improvement of the industrial zone.
3. To carry out reclamation activities.

The contents of dissertation were reflected in the following articles:

1.“The Impact of the Sumgayit chemistry enterprises on environment’. Actual problems of Ecology and soil science in the XXI century”. III Republic Scientific Conference, Baku, 2014, p.95-99.
2. “Research of the slag waste in the Sumgayit “Boru Prokat” factory on ecosystem”. The VIII Traditional International Scientific Conference, dedicated to” Industry year” on protection of the Ecology and life activity Sumgayit, 2014, p. 262-263.
3.“Ecological evaluation of the Sumgayit Industrial zone”. Actual problems of Ecology and soil Science in the XXI century, the V Republic Scientific Conference, Baku, 2016, p. 13-15.
4.“Collection of heavy metals in the soils of the Sumgayit Industrial zone and methods of decrease of their toxic influence”. Materials of the XX republic Scientific Conference of Doctoral Students and Young Researchers, Baku, p.240-242.
5. ”The pollution of the Caspian sea”. Materials of the İnternational forum ”Caspian sea - the sea of friendship and hopes”, devoted to the 85 anniversary Dagestan state university, Makhachkala,2016, p.108-109.

6. ”İnvestigation of heavy metals contamination in the Sumgayit İndustrial zone”. The International Scientific Conference, Ganja, 2016, p. 235.
7. ”Ecological approach the multiculturalism worldwide”. Materials of the Republic scientific-theoretic Conference in a theme of social-philosophical and cultural Bases of Multiculturalism Conception. Baku, 2016, p. 294- 298
8. ”The Reasons of Desertification in Sumgayit’s İndustrial Gray-Brown Soils”. International scientific-technical Conference Natural Disasters and Human Life Safety, Baku, 2017, p 225-227.
9.”Ecological situation and restoration of soils fertility in agricultural and industrial”. Soil resources in Siberia Challenge of the XXI century, Russia, 2017, p. 86-89.
10.”Collection of heavy metals in the soils of the Sumgayit Industrial zone and methods of decrease of their toxic”. Scientific News, Sumgayit-2017, Vol.17, №2, p.46-49.
11. ”Ecological situation of the soils contaminated with heavy metals for the purpose of chemical industrial development in Sumgayit of the Azerbaijan Republic”. Bulletin of Science and Practice, 2017, №9 Scientific Journal, p.74-80.
12. ”Rationality of vermicompost and mineral fertilizers application in inactivation of heavy metals of the contaminated grey-brown soils in the Sumgayit Industrial”. Ecology and water economy, Scientific, technical and production journal, Baku, 2017, №3, p.3-7.
13.” Ecological assessment of the soils in the Sumgayit Industrial zone”. Ganja section of ANAS, News collection, №1(67),2017, p.61-66.
14.”General character of the grey-brown soils contamination in the Sumgayit Industrial zone”. Azerbaijan Agrarian Science, Scientific Theoretical journal of the Ministry of Agriculture of the Azerbaijan Republic, Baku 2017, p.124-127.
15. ”Ecological situation of technogenic-violated soils in the Sumgayit massive of the Absheron”. Expertise of the industrial

safety and diagnostics of dangerous industrial objects, 2018, p.100-104.
16. ”Influence of the heavy metals quantity on stability of soil microorganisms in the technogenic contaminated grey-brown soils. Soil Science and Agrochemistry of ANAS, Vol-23, №1-2, Baku, 2018, p. 395-398.
17. ”Amelioration of violated”. Contemporary problems of Biology, Materials of Republic Scientific Conference, Sumgayit, 2018, p.111-113.
18. ”Ecological crisis of the Absheron peninsula”. International scientific-practical Conference. ”Ecology and oil-gas complex”, dedicated to the academican’s 85th anniversary of the National Academy of Kazakhstan Republic, doctor of geologo-mineralogical science, professor Diarov Muphtakha Diarovich, Atyrau, Kazakhistan, 2018, p.170-174.
19. ”Research of the soil cover of objects contaminated with heavy metals in Sumgayit massive of Absheron ”. Bulletin of Science and Practice Scientific Journal,2019, Volume5, Issue 1 , p. 151-156.
20. ”Clearance of the soil contaminated with heavy metals by the Phyto melioration method”. Bulletin of Science and Practice Scientific Journal, 2019,5(9), p.234-238.

БАБАЕВА ТУНЗАЛА МАМЕД

РАСПРОСТРАНЕНИЕ ТЯЖЕЛЫХ МЕТАЛЛОВ В ПОЧВЕ СУМГАИТСКОЙ ПРОМЫШЛЕННОЙ ЗОНЫ, ИНАКТИВАЦИЯ ИХ ВОЗДЕИСТВИЯ И МЕТОДЫ ВОССТАНОВЛЕНИЯ ПЛОДОРОДИЯ В ПОЧВЕ

РЕЗЮМЕ

Представленная диссертация имеет большое значение для защиты плодородия, рекультивации, очищения от загрязнения почв промышленной зоны города Сумгаита. В результате всестороннего исследования серо-бурых почв промышленной зоны, установлен уровень загрязнения тяжелыми металлами, предложены экологически обоснованные инактивационные методы. Пробы были поставлены на подверженные тяжелыми металлами серо-бурые почвы под свеклой и хвойными растениями на территории базы "Азерхимия" в 2014-2017 годах. По результатам исследования на серо-бурых почвах на территории базы были обнаружены: гумус 0,63-1,61%, азот 0,36-0,159%. По пробам выяснялось, что северная часть базы более подвержена загрязнению. Концентрация микроэлементов на различных глубинах составила: Cu – 30мг/кг, Cr-25мг/кг, Zn-62мг/кг. Концентрация микроэлементов на территории близко к базе более чем в десять раз превышала показатель "Klark". В условиях распространения тяжелых металлов в почве, на фоне минеральных удобрений, при внедрении 25т/га вермокомпоста и 30т/га навоза, были взяты образцы с листьев и однолетних отростков еловых растений. В результате было выявлено, что в сопоставлении с контрольным вариантом, в варианте с органическими удобрениями происходит наибольшая аккумуляция микроэлементов. Пробы сняти с листьев свеклы в контрольном варианте: Cd-0,16; Pb-0,79; Ni-0,88; Hg-0,34; Cu-1,92; Cr-1,70; Co-0,8; Zn-13,23мг/кг. Показатели проб с органическими удобрениями сравнительно намного выше: 0,34; 1,82; 4,15; 1,48; 5,92; 5,80; 4,10; 21,05мг/кг. Показатели проб с корнеплодов свеклы показывает относительно низкую акумуляцию: 0,27; 1,5; 3,05; 1,39; 5,80; 4,90; 3,0; 17,48мг/кг. В образцах были также изучены микроорганизмы. На основе полученных результатов, был проведен сравнительный анализ количественных показателей микроорганизмов подпахотных почв.

BABAYEVA TUNZALA MAMMAD

SPREAD OF THE HEAVY METALS IN THE SOIL OF SUMGAYIT INDUSTRIAL ZONE, INACTIVATION OF THE IMPACT OF THE LATTER AND RESTORATION METHODS OF SOIL FERTILITY

ABSTRACT

The presented dissertation has a great importance for the protection of fertility, re-cultivation, purification of soil from pollutants in the industrial zone. As a result of the comprehensive study of the grey-brown soil of the industrial zone in Sumgayit the level of spread of heavy metals was established, the ecologically based inactivation methods were suggested. The study was performed on the grey-brown soil under the beetroot and fir plants on the territory of "Azerchemistry" factory in the period 2014-2017.

The results demonstrated the level of the spread of heavy metals in the grey-brown soil in the territory of the factory: humus - 0,63-1,61%, nitrogen - 0,36-0,159%. It was established that the north part of the factory is more exposed to pollution. Analysis of the different depths of the soil demonstrated the level of concentration of microelements: Cu - 30 mg/kg, Cr 25 mg/kg, Zn 62 mg/kg. The microelements concentration exceeded "Clark" index 10 times in the zone close to the factory. In the process of spread of heavy metals (mineral fertilizers amidst) in soil the organic fertilizers were applied in the soil: 25 t/h vermicompost and 30 t/h manure. After analysis of the samples of the leaves and one-year old sprout of fir tree it was established that the level of accumulation of microelements is higher in the sample with organic fertilizers if to compare to the controlled sample.

Results from the controlled sample taken from the leaves of the beetroots: Cd – 0,16, Pb – 0,79, Ni – 0,88, Hd – 0,34, Cu – 1,92 Cr – 1,70, Co – 0,8, Zn – 13,23 mg/kg. Samples with organic fertilizers demonstrated comparatively higher level of accumulation: Cd –0,34, Pb – 1,82, Ni –4.15, Hd – 1,48, Cu – 5,92, Cr – 5,80, Co –4,10, Zn –21,05 mg/kg. Results from sample taken from the roots of the beetroots where accumulation was comparatively low: 0,27, 1,5, 3,05, 1,39, 5,80, 4,90, 3,0, 17,48 mg/kg.

Microorganisms were also researched in the soil samples. As the result of this sampling the comparative analysis of quantitative indicators of microorganisms in subsoils was performed.

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