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IMPROVEMENT OF THE AGROECOLOGICAL STATE OF POLLUTED SOILS BY THE PHYTOREMIDEATION METHOD

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Abstract:

Today, research is being carried out in the world on a number of priority areas for cleaning soil from toxic substances, including: determining the accumulation of residual amounts of pollutants along the trophic chain in the soil environment, creating new technologies aimed at cleaning toxic heavy metals in soil-water-plants, microorganisms , resistant to toxic elements - the acquisition and reproduction of destructor strains, and in addition, our studies have shown that the introduction of toxicants into the soil system causes nutritional stress.

Keywords: irrigated soils, waters and plants, nutrients, pesticides and heavy metals, ecological state of soils.

INTRODUCTION. Currently, more than 20 million hectares, including 3.2 million hectares of irrigated arable land, grow food for the needs of the population, the necessary raw materials for economic sectors.

Extensive agrotechnological, environmental and reclamation measures are being taken to meet the need for environmentally friendly products, rational use of irrigated lands, improve the agrochemical and reclamation state of the soil, maintain and systematically increase its productivity. As a result, the quality of agricultural products is improved by reducing the accumulation of toxic substances in the soil. Taking into account the presence of heavy metals in the soil-forming rock, the amount of heavy metals and residual pesticides, their effect on the processes occurring in the soil, the accumulation of toxicants in the soil layers, their effect on the agrochemical state of the soil, and the determination of the movement of residual organochlorine pesticides through seepage water, trophic the chain of toxic substances, i.e., the study of the dynamics of soil-water-plant movement, is an urgent task.

LITERATURE REVIEW. Scientists proposed a third hypothesis about limiting the influence of heavy metals and the biochemical activity of various types of humus and forest soil, which mask the negative influence of metals and enzyme activity [4; doi.org/10.1007/s11270-020-4450-0].

Heavy metals present in the soil have a negative effect on soil elements, adversely affect their chemical composition and lead to a stressful state.

Lead, cadmium and mercury are toxic metals that are not essential for nutrition. However, the toxic effects of these metals can be mediated or enhanced by the interaction or deficiency of metals necessary for nutrition [7; doi: 10.1093/ajcn/61.3.646S. PMID: 7879732].

The ability of plants to access heavy metals is highly dependent on the plant species as well as the chemical and physical properties of the soil. Different types of plants show different absorption capacity; some species can absorb high levels of cadmium, lead, chromium, while some species only absorb one or a few metals. Species resistance can be different in different periods of plant growth [5; With. 679-685].

When using phytoremediation methods of biological treatment, by reducing the content of heavy metal ions from the composition of the soil, the restoration of mobile forms of nutrients is achieved. Therefore, in our study, we conducted the following experiments.

The purpose of the study is to determine the amount of toxicants in irrigated soils, their impact on the soil environment, on the ecological and agrochemical state of soils, as well as to develop ways to increase the ability of soils to self-heal.

RESEARCH OBJECTIVES:

determine the amount of heavy metals and pesticides, as well as their impact on soil processes;

determine the effect of toxicants on the agrochemical state of soils;

to improve the technology of reducing the movement of toxic substances in soils and increasing the ability of soils to self-purify.

RESEARCH METHODS. The studies were carried out in field and laboratory conditions. They used "Methods of agrophysical research", "Methods for conducting field experiments". Humus was determined by the Tyurin method, nitrogen by Kjeldahl, total forms of phosphorus by the Ginzburg method, potassium by the Smith method, mobile forms of nitrate nitrogen by the ion selective method, ammonium nitrogen with the Nessler reagent, Phosphorus by the Machigin method, potassium by flame photometric chromatography, heavy metals by atomic -absorption method on the AAS apparatus, pesticides in liquid hexane medium on the Mass-chromatograph apparatus, micro-vegetation experiment "Miniature" was carried out by the Neubauer method in Golodkovskaya's modification. Statistical processing of the obtained data was carried out using the Microsoft Excel computer program, as well as by the method of N.A. Plokhinsky, A.V. Sokolov, G.F. Lakin and B.A. Dospekhov.

SCIENTIFIC NOVELTY OF THE RESEARCH. The dependence of toxically high amounts of heavy metals and pesticides on the humus state of soils has been determined.

CONDUCTING LABORATORY EXPERIMENTS. To eliminate the toxic effects of heavy metals on the soil, we carried out phytoremediation work. To do this, we used the microvegetation experience of Neubauer miniatures [6; With. 15.], modified by L.L. Golodkovsky [1; With. 56.]. In laboratory experiments, millet was sown three times during the growing season. Interesting experiments to reveal the physiological role of chromium in plant organisms were first staged in 1937 by D. Arnon.

In our studies, we studied the purification of harmful toxic (Cr, Ni) substances by the phytoremediation method on irrigated typical gray earth soils with a humus content of 0.85 and 1.70%, which are common in the Pastdargam district of the Samarkand region.

RESULTS. In soil samples taken from the plow horizon (0-30 cm) of a corn field (sample 1) with a humus content of 0.85%, the amount of chromium was 17 mg/kg, and in a soil sample from an apricot orchard (sample 2) with a humus content 1.70% amount of chromium was 32 mg/kg. In the 64-150 cm horizon, the lead content approaches the MPC, and nickel in the 0-32 cm horizon (1-section) is 23.3 mg/kg (Table 1).

The amount of nickel in the same soils in the 0-30 cm horizon was 23.3 and 20.3 mg/kg, respectively, which is lower (MAC). Therefore, these soils were artificially polluted with 5 times the maximum allowable concentration (MAC).

Table 1

Accumulation of heavy metals in soil horizons

№	**Place of soil sampling**	**Horizon, cm**	**General form, mg/kg**			
			Pb	**Cd**	**Cr**	**Ni**
1	Corn field with 0.85% humus	0-32	3,7	0,066	17	23,3
		32-44	3,5	0,092	11	18,2
		44-64	7,2	0,0103	17	16,3
		64-112	8,6	0,099	11	18,8
		112-150	8,3	0,087	16	12,8
		150-205	Not.def	0,049	Not.def	Not.def
2	Apricot orchard with 1.70% humus	0-37	7,3	0,482	32	20,3
		37-70	7,3	0,277	33	24,5
		70-100	8,9	0,328	33	23,6
		100-130	11,5	0,218	25	23,3
		130-160	3,6	0,123	22	22,8

As soil analyzes show, after harvesting seedlings growing at each time, in soils with an initial amount of humus of 0.85%, as a result of agricultural technologies, the amount of humus was, on average, 4.06%, and this is much higher than the amount of humus characteristic of these soil types.

To carry out the laboratory experiment given in Chapter 3, special vessels were prepared, with a capacity of 100 grams, 10 seeds of millet were sown in each vessel. To maintain a moisture content of 60% of the total field capacity, 20 ml of water was poured into low-humus soils, and 22 ml each into medium-humus soils. To maintain this moisture during the period of seed growth, the variants with low-humus soils were filled with water twice a day, 10 ml each, and the variants with medium-humus soils, twice 7-8 ml each, and the growth and development of plants was monitored.

In the second sowing period (07.05.08-04.06.08), the plants were photographed on June 1. In the soils of the contaminated control variant, yellowing of the leaves of plants was observed, their height was 6-7 cm, in the control variant with HCH the height was 6-8 cm, and in the variant with the use of heavy metal (chromium) it was 7-8 cm and in plants yellow spots were observed (Fig. 2). Plant height in soil variants with composted litter, in the 3rd repetition was 12-13 cm, in variant 5 - 15 cm, in the sixth variant - 13-14 cm. -14 cm, and in variants with the use of heavy metals - 9-12 cm.

In the third sowing period (17.06.08-14.07.08), in the 25th day of the growing season, in the variants with the use of toxicants (nickel and chromium), many spots were observed in the plant litter, the height of the plants in the nickel background was low. As a result of the data obtained, after a 3-fold sowing, the following state of the plants was established and the ability of plants to absorb heavy metals was considered. As a result, in plants grown on soil with a low content of humus, the amount of Cr was 16.2 mg/kg, Ni - 17.3 mg/kg, and in plants grown in soil with a high content of humus, the amount of Cr was 22 mg /kg, Ni - 7.6 mg/kg.

In our work, against the background of soil with a low amount of humus (0.85%), with triple sowing of millet in the control variant, the amount of Cr in the plant increased to 16.2→23.7→23.8 mg/kg, and against a nickel background – up to 17.2 → 8.54 → 6.1 mg/kg in 1.70% in a humus background.

With a triple sowing in the soil + chromium variant, it was absorbed by the plant 109.1 mg/kg, and in the nickel background 127.5 mg/kg. The largest amount of nickel was absorbed during triple sowing of millet in the variant soil + Ni + earthworms + leaves + 30 t/ha of biohumus, which amounted to 382.6 mg/kg (Fig. 5.3.2). When organic fertilizers (leaves, earthworms, biohumus, manure) are applied to the soil with a high content of chromium and nickel, the accumulation of nickel by the plant increases, and chromium decreases (Fig. 5.3.1 and 5.3.2).

The background content of nickel in plants growing on ordinary soils is 0.2-2.0 mg/kg of dry matter. On soils rich in nickel (serpentines) - up to 50, in emissions from industrial enterprises processing nickel-containing ore, from 10 to 180 mg/kg, depending on the distance to the source [2; With. 489]).

Laboratory data show that in the variants with the introduction of 20 and 40 t/ha of manure, the accumulation of the amount of nickel increased, and with the introduction of 30 t/ha of manure, it decreased from 105 mg to 61.42 mg. In the variant with the introduction of 20 t/ha of biohumus, the amount of chromium in plants varies during the first sowing - up to 31.9 mg/kg, the second sowing up to 20.5 mg/kg and the third sowing - up to 22.0 mg/kg.

Liming, as well as the use of phosphorus and organic substances, significantly reduces the toxicity of chromium to plants on contaminated soils [2; With. 489]). In the soil + chromium variant without adding organics, the amount of chromium accumulated by the plant increased in the first and second sowings by 15.2-42.3 mg/kg. With a 1.70% humus background, it was 22.6-78.6 mg/l, and with the third sowing, its amount was 51.6↔85.3 mg/kg. In total, with three times sowing on a low-humus background, chromium was 109.1 mg/kg, with an average humus background - 186.3 mg/kg. This indicator in other variants was lower (Fig. 1).

Thus, experience shows that millet absorbs chromium and nickel better. To increase the assimilation of nickel into the soil, it is necessary to apply organic fertilizers and biohumus in the form of top dressing. The mechanism of this process has yet to be studied; it lies in the physiological adaptation of the plant (millet) to this metal.

It has been established that it is advisable to introduce earthworms and leaves + 30 t/ha of biohumus into soils contaminated with nickel, which increase the mobility of heavy metals and the accumulation of nickel in the organs of millet. Statistical analysis of laboratory studies of the experience of "miniatures" showed that in the soil, low-supplied with humus in the first sowing, in the variants contaminated with nickel, the obtained biomass had a degree of reliability of 99%, and in the variants contaminated with chromium, the degree of reliability of the biomass was not found, and at 2 -x and 3 crops of millet, the degree of reliability was 99%.

In plants on low-humus soils in the first sowing period, the amount of chromium was 23.6 mg/kg, and the amount of assimilable nickel in the third sowing period decreased from 8.54 mg/kg to 6.10 mg/kg.

In recent periods, the accumulation of nickel (Ni) in the composition of plants has decreased from top to bottom. For example, in soil with a biohumus background of 30 t/ha, in the first period, the amount of nickel was 152.37 mg, in the second period - 150.73 mg, and in the last period it decreased to 79.22 mg.

In biohumus variants in the composition of plants, a decrease in the amount of chromium from high rates is observed. In variants with organically fertilized backgrounds, a decrease in chromium and toxic substances is also observed. So, on fertilized backgrounds with a biohumus background of 20 t/ha, the amount of chromium in the first period was 31.86 mg/kg, in the second period - 20.48 mg/kg, and in the third period - 22.0 mg/kg . In the composition of plants of the control variant, an increase in the accumulation of chromium (from 15.21 to 42.30 mg/kg) is observed, and in the third period its amount was 51.60 mg/kg. Such indicators were not observed even in a fertilized background of 40 t/ha.

The accumulation in plants of the main part of the heavy metals that are in the composition of the soil are given in the works of many researchers [3; With. 9-15]). When composting 30 t/ha with vermicompost, in comparison with organic fertilizer, an increase in the mobility of heavy metals is achieved, the expediency of using vermicompost at a rate of 30 t/ha to increase the accumulation of nickel in the composition of millet has been established. When studying the accumulation of HCH in the composition of plants at all sowing dates, the following elements were studied: γ-HCH isomers in the control variant without fertilizers were assimilated in the amount of 0.45 mg/kg, and α-HCH isomers - 0.02 mg/kg, with an increase fertilizer norms, an increase in the digestibility of the α-HCH metabolite in the composition of plants is observed. Other pesticide metabolites, namely DDT, DDE, DDD, DDE, were not detected during the analyzes.

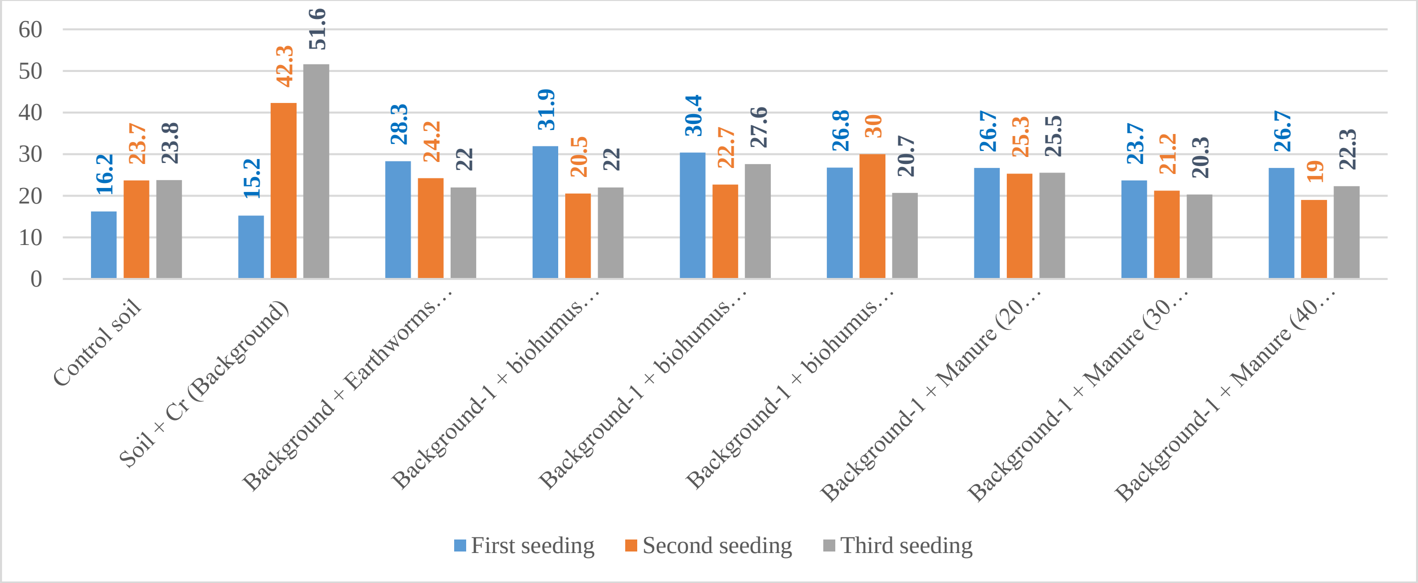

Figure 1. Dynamics of assimilation of chromium from the soil (0.85% humus)

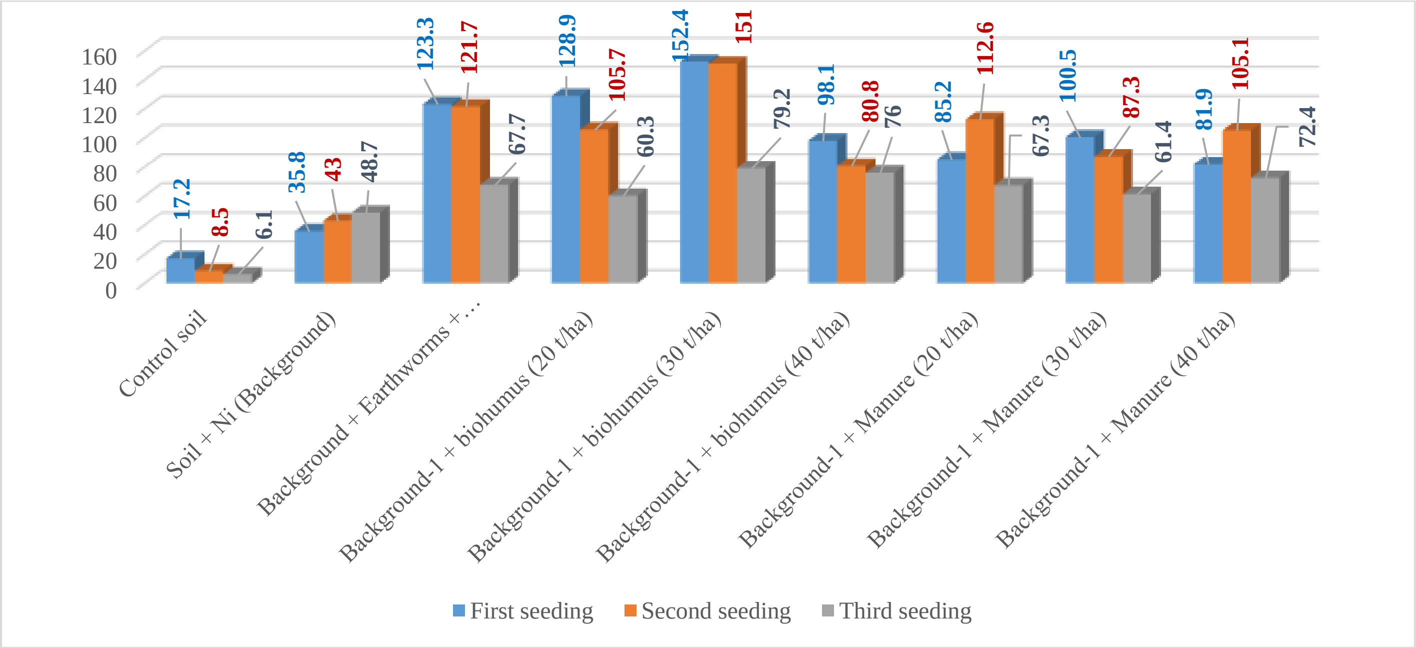

Figure 2. Dynamics of nickel uptake from soil (0.85% humus)

When carrying out mathematical processing of the data obtained from laboratory experiments "Miniatures" only in the obtained crops from low-humus soils contaminated with nickel, at the first sowing period, the degree of reliability is 99%, and in the variants with the use of chromium and pesticides, the degree of reliability in the crops was not found.

When analyzing plants sown in the second and third terms in soils with a humus content of 0.85%, the absorption of toxicants by plants was established, the degree of reliability of these analyzes was 99%.

In soils with 1.70% humus, on the variants contaminated with HCH, the degree of reliability of the yield obtained was 95%, and on the variants contaminated with nickel and chromium - 99%. This shows that the amount of humus in the composition of soils can reduce the degree of pollution.

The correlation between humus and yield obtained from irrigated typical gray soils with a humus content of 0.85% contaminated with HCH in the first period was r=0.72; against the background of chromium r = 0.78; nickel background r=0.88; in soils with 1.70% humus, these indicators, respectively, were equal to 0.65; 0.74; 0.76. In plants sown in the third period in soils 0.85% humus contaminated with HCH, the correlation dependence was equal to r=0.78, in the chromium background r=0.70, in the background of nickel r=0.79, in all toxic areas decrease in the correlation between humus and yield.

In conclusion, it should be noted that in order to reduce soil toxicity, find ways to improve the ecological state of the environment surrounding the plant, as well as various impacts on the soil, they must obey the law of minimum, replenishment of the element or factor that occurs in the least amount. Reducing the toxic effects of chemical compounds and heavy metals, as well as reducing their migration into water and the trophic chain, can be achieved by using organic fertilizers and leaf litter, but their doses must be strictly regulated, because against the background of high standards of organic substances, the toxicity of pollutants to the environment increases. When cleaning polluted soils, the sowing of millet, barley and oats gives a good result.

Plant analyzes after four sowings against the background of HCH and chromium show a decrease in soil humus content, but the amount of humus remains in an elevated state. The introduction of leaves into soils, as well as the addition of 20-30 t / ha of biohumus to them, contributes to an increase in the amount humus in soils in the range of 4.34-4.61%, after sowing millet, the impact of toxic substances on the agrochemical properties of soils was minimized, only it is possible to determine their trends. Against the background of 20-30 t/ha of manure and 40 t/ha of biohumus in the experimental variants, the amount of humus was in the range of 5.35-5.61. In the experimental variants, the C:N ratio varies within 6.6-13.8 (Tables 2-4).

Table 2

Change in the amount of nutrients after 3-fold sowing of millet on HCH-contaminated low-humus (0.85%) soils

№	**Options**	**Humus, 0.85%**	**Total content, %**				**Mobile forms, mg/kg**		
			C:N	N-NO_3	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Soil + moisture + friability (control)	0,90	8,0	0,065	0,29	1,82	89,1	17,60	68
2	Soil + 5 MPC HCH	0,92	7,5	0,071	0,26	1,84	87,1	16,27	63
3	Soil + Earthworms +fallen leaves+ HCH (5 MPC)	4,46	8,9	0,29	0,36	2,5	70,8	38,53	100
4	Soil + Earthworms +fallen leaves+ vermicompost (20 t/ha) + 5 MPC HCH	4,34	9,0	0,28	0,40	1,37	31,6	40,52	80
5	Soil + Earthworms +fallen leaves+ vermicompost (30 t/ha) + 5 MAC HCH	4,61	9,6	0,28	0,27	2,2	61,7	50,95	213
6	Soil + Earthworms +fallen leaves+ vermicompost (40t/ha) + HCH 5 MPC	5,40	11,2	0,28	0,26	1,2	61,7	39,20	128
7	Soil + Earthworms +fallen leaves+ manure (20 t/per) + 5 MPC HCH	5,40	11,6	0,27	0,24	1,63	89,1	59,0	240
8	Soil + Earthworms +fallen leaves+ manure (30 t/ha) + 5 MAC HCH	5,47	13,8	0,23	0,25	2,1	79,4	56,80	130
9	Soil + Earthworms +fallen leaves+ manure (40 t/per) + 5 MPC HCH	5,57	10,1	0,32	0,64	2,37	45,7	81,33	123

The highest C:N ratio in the variants with the use of biohumus and manure was found in the variants contaminated with chromium, where it was equal to 9.0. With an increase in the amount of manure and biohumus, the ratio of carbon to nitrogen expands, there is no clear pattern in the negative impact of toxic chemical compounds (Tables 2-4).

The effect of pollutants on the nutrients absorbed by plants is clearly seen in the variants with the use of manure and biohumus. Nickel has the most toxic effect, which reduces the amount of assimilable forms of nitrates, phosphates and exchangeable potassium in all options, except for options with the use of organic additives and earthworms

Table 3
Change in the amount of nutrients after 3-fold sowing of millet on Cr-contaminated low-humus (0.85%) soils

№	Options	Humus, 0.85%	Total content, %				Mobile forms, mg/kg		
			C:N	N-NO_3	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Soil + moisture + friability (control)	0,90	8,0	0,065	0,29	1,82	89,1	17,60	68
2	Soil + 5 MPC Cr	0,87	8,9	0,057	0,12	1,80	58,9	15,60	67
3	Soil + Earthworms +fallen leaves+ Cr (5 MPC)	4,49	9,0	0,29	0,16	1,62	55,0	35,20	128
4	Soil + Earthworms +fallen leaves+ vermicompost (20 t/ha) + 5 MPC Cr	4,34	9,7	0,26	0,27	1,5	61,7	37,86	130
5	Soil + Earthworms +fallen leaves+ vermicompost (30 t/ha) + 5 MAC Cr	4,56	9,8	0,27	0,28	1,37	58,9	38,53	128
6	Soil + Earthworms +fallen leaves+ vermicompost (40t/ha) + Cr 5 MPC	5,42	10,1	0,31	0,40	1,37	50,1	50,19	172
7	Soil + Earthworms +fallen leaves+ manure (20 t/per) + 5 MPC Cr	5,45	12,6	0,25	0,40	1,0	70,8	50,95	172
8	Soil + Earthworms +fallen leaves+ manure (30 t/ha) + 5 MAC Cr	5,35	11,9	0,26	0,39	1,63	55,0	53,85	103
9	Soil + Earthworms +fallen leaves+ manure (40 t / per) + 5 MPC Cr	5,64	12,6	0,26	0,54	2,0	31,6	64,33	176

Table 4
Change in the amount of nutrients after 4-fold sowing of millet on Ni-contaminated low-humus (0.85%) soils

№	Options	Humus, 0.85%	Total content, %				Mobile forms, mg/kg		
			C:N	N-NO_3	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Soil + moisture + friability (control)	0,90	8,0	0,065	0,29	1,82	89,1	17,60	68
2	Soil + 5 MPC Ni	0,88	9,2	0,055	0,16	1,82	63,1	15,3	66
3	Soil + Earthworms +fallen leaves+ Ni (5 MPC)	4,58	8,9	0,30	0,21	225	50,1	31,86	70
4	Soil + Earthworms +fallen leaves+ vermicompost (20 t/ha) + 5 MPC Ni	4,41	10,2	0,25	0,26	1,85	75,1	40,86	82
5	Soil + Earthworms +fallen leaves+ vermicompost (30 t/ha) + 5 MAC Ni	4,54	11,5	0,23	0,37	1,63	57,5	36,53	45
6	Soil + Earthworms +fallen leaves+ vermicompost (40t/ha) + Ni 5 MPC	5,35	12,4	0,25	0,30	1,37	45,7	47,39	47
7	Soil + Earthworms +fallen leaves+ manure (20 t/per) + 5 MPC Ni	5,38	12,5	0,25	0,28	1,73	60,1	53,40	117
8	Soil + Earthworms +fallen leaves+ manure (30 t/ha) + 5 MAC Ni	5,47	11,8	0,274	0,09	1,62	46,8	58,25	145
9	Soil + Earthworms +fallen leaves+ manure (40 t / per) + 5 MPC Ni	5,54	10,7	0,30	0,49	2,2	46,8	79,65	200

Based on the factual material obtained, it can be said that in order to restore the ecological function of soils and provide plants with nutrients, after sowing millet, it is necessary to apply the initial rate (50-60 kg/ha) of potash fertilizers for the main types of crops.

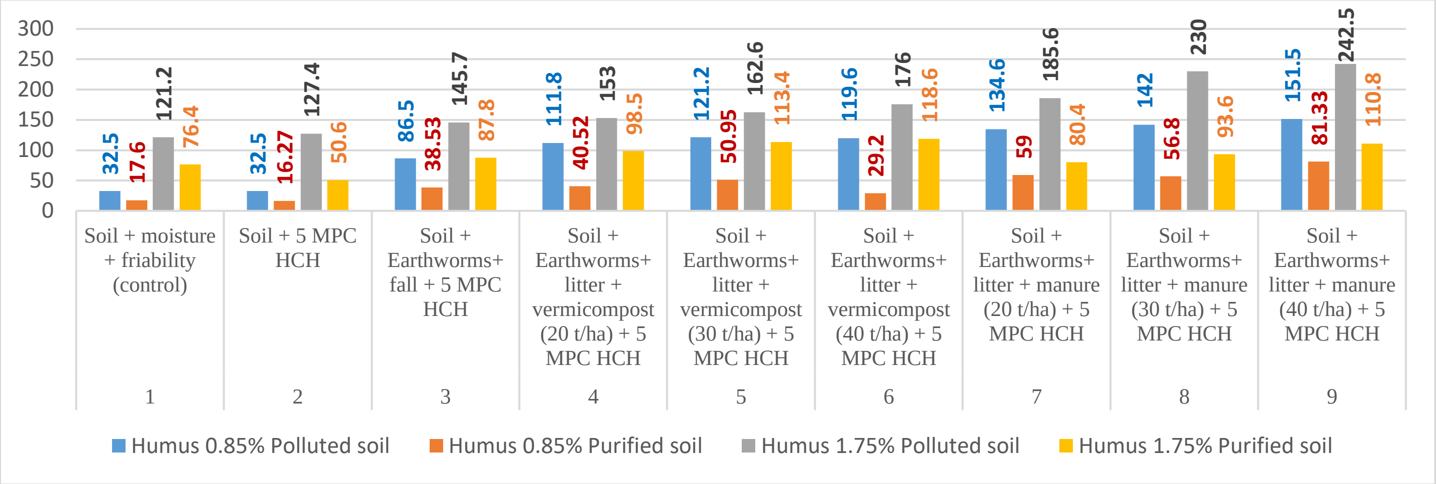

Figure 5. Effect of organochlorine pesticides on the content of available phosphorus, mg/kg

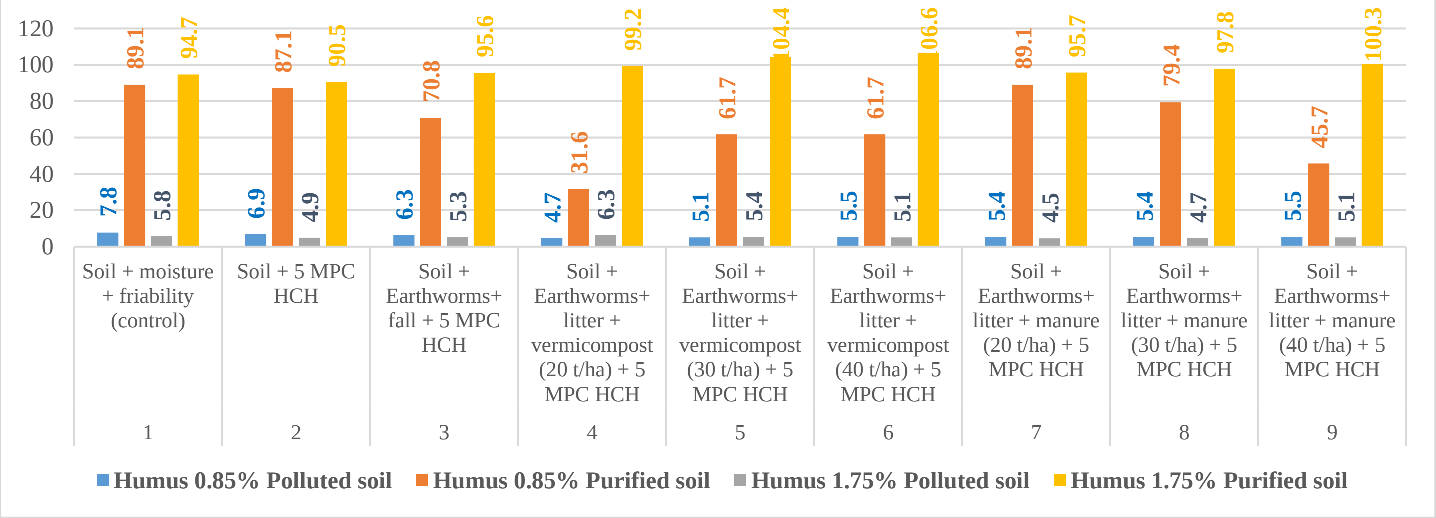

Figure 5. Effect of organochlorine pesticides on the content of available phosphorus, mg/kg

Thus, the agrochemical properties of nutrient-poor and toxic-pressed soils can be improved by keeping them in a state of fallow, maintaining moisture and air exchange in them, introducing at times 15-20 t/ha of fallen leaves and earthworms. By introducing manure at a rate of 20 t/ha and biohumus at a rate of 20-30 t/ha into soils, it is possible to reduce the toxic effects of residual amounts of organochlorine pesticides and heavy metals. Against the background of organic fertilizers, the ratio of carbon to nitrogen expands, and the quality of humus improves.

To restore waste lands with low fertility and tense environmental conditions, which have been withdrawn from agricultural use, it is necessary to use biological remediation methods. To restore the ecological state of polluted lands, increase their fertility, it is necessary to keep these lands in a state of fallow during 2 growing seasons, as well as constantly maintain moisture and looseness in them.

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