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THE ECOLOGICAL ASSESSMENT OF SOILS AROUND AGARAK TOWN

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Mining and smelting industry is developed in the area of the study. This economic sphere is one of the main sources of soil pollution with heavy metals which are considered as dangerous pollutants causing the desertification of soils. As a result of this study the appreciable qualitative changes in contents of some heavy metals were revealed.

Soil pollution – heavy metals – mining industry – recultivation of soils – hydroseeding method

Ուսումնասիրման տարածքում զարգացած են արդյունաբերության լեռնամետալուրգիական և լեռնաարդյունաբերական ճյուղերը: Արդյունաբերության այս ճյուղերը հանդիսանում են հողերի անապատացման պրոցեսին նպաստող վտանգավոր աղտոտիչներից՝ ծանր մետաղներով, աղտոտման հիմնական աղբյուրներից մեկը: Մեր կողմից կատարված ուսումնասիրություններով հայտնաբերվել են մի շարք ծանր մետաղների պարունակության նկատելի քանակական փոփոխություններ:

Հողերի աղտոտում – ծանր մետաղներ – լեռնարդյունաբերություն – հողերի ռեկուլտիվացում – հեղուկ սերմնացանի մեթոդ

В районе проводимых нами исследований (г.Агарак) развиты горнодобывающая и горнометаллургическая отрасли промышленности. Эти отрасли являются одним из основных источников загрязнения почв тяжелыми металлами – наиболее опасными загрязнителями, способствующими процессу опустынивания почв. Проведенными нами исследованиями выявлены заметные количественные изменения в содержании ряда тяжелых металлов.

Загрязнение почв – тяжелые металлы – горнодобывающая промышленность – рекультивация почв – метод гидропосева

Agarak town is situated in the south-east of Armenia. Mining and smelting industry is developed in this area. This economic sphere is one of the main sources of soil pollution with heavy metals (Pb, Cu, Ni, Cd, As, Mo, etc) which are considered as dangerous pollutants causing the desertification of soils [4, 5, 7, 8, 9, 10].

The lands of the studying area belong to the mountain forest brown soil type. In Armenia, this soil type is distributed at 500-1700 meters above sea level, and reaches up to 2400 meters in arid southern slopes. The topology of mountains with forest brown soils is characterized by various altitudes, such as mountains and dividing ridges, as well as fallings lowering to clefts and tributaries [1, 3].

Materials and methods. Experiments were carried out under field and laboratory conditions. Ten the most risky regions and one non-polluted region, as a control, were selected for field studies the sections were dug, and the samples were taken from the horizontal profile. The physicochemical parameters of soil samples were determined under laboratory conditions [2, 6].

Results and Discussion. Eleven sections were sorted into types and subtypes according to the results of field study.

The main soil types in studying objects were the mountain forest brown soil type and its 2 subtypes: (1) the brown carbonate soil of mountain forests, and (2) the brown typical soil of mountain forests.

Section descriptions and total properties determined during the field study are presented in tab. 1.

Tab. 1. Total characteristics of sampling areas

Sample number	Soil type and subtype	Basin	Surface gradient	Microrelief	Soil surface cover	Erosion degree (0-4)
1	brown typical of forest	Karchevan river	30°	smooth	herbage - 75%, naked soil - 20%, stones - 5%	2
2	brown typical of forest	Karchevan river	25°	smooth	herbage - 40%, naked soil - 30%, stones - 30%	2
3	brown typical of forest	Karchevan river	30°	small mounds	herbage - 40%, naked soil - 20%, stones - 40%	2
4	brown typical of forest	Karchevan river	35°	smooth	herbage - 70%, shrubs - 15%, naked soil - 10%, stones - 5%	2
5	brown typical of forest	Karchevan river	0°	smooth	herbage - 85%, shrubs - 12%, stones - 3%	0
6	brown carbonate of forest	Karchevan river	30°	mounds	herbage - 50%, naked soil - 10%, stones - 40%	2
7	brown carbonate of forest	Karchevan river	0°	smooth	herbage - 50%, naked soil - 50%	0
8	brown carbonate of forest	Karchevan river	10°	small mounds	herbage - 30%, naked soil - 20%, stones - 50%	2
9	brown carbonate of forest	Araks river	5°	small mounds	herbage - 20%, naked soil - 25%, stones - 55%	3
10	brown carbonate of forest	Araks river	10°	smooth	herbage - 30%, naked soil - 45%, stones - 25%	2
Control	brown carbonate of forest	Karchevan river	0°	smooth	herbage - 70%, naked soil - 25%, stones - 5%	1

According to tab. 1, the soil surface was 10-30% uncovered by plants, except the section 5, which was fully covered, and the sections 7 and 10, which were nearly half covered. The main vegetation was presented by herbage. Shrubs were observed only in the areas of sections 4 and 5. The studied soils were medium and highly eroded, except the 5, 7 and control sections, where erosion processes almost didn’t occur related to the well-developed vegetation and the smooth microrelief.

The type and subtype properties of the soil are presented in the paragraphs bellow.

The first subtype was the brown carbonate soil of mountain forests (sections – 6, 7, 8, 9, 10 and control). This subtype of soil was distributed 700-1000 meters above sea level, on the gradients of 0-30 degrees, the microrelief was mainly smooth, and the erosion degree was 0-3. This soil was mainly very rocky, and the carbonates were distributed from top to bottom. This subtype of soil was not fertile and useful for agricultural purposes, except the 7 and control samples.

The second subtype of the studied soil was the brown typical soil of mountain forests (sections – 1, 2, 3, 4, 5). The brown typical soil of mountain forests occupied intermediate place between the carbonate and limeless subtypes by their geographical position, morphological and physicochemical characteristics. This type of soil, compared to the carbonate type, had higher position above sea level, the gradient was 0-35 degrees, the microrelief was smooth, and the erosion degree was 0-2. The soil of this subtype was not fertile and useful for agricultural purposes, except the samples 4 and 5.

Data indicate that the soils of all areas were medium eroded, except the 5, 7 and control samples (tab. 1). The erosion processes were conditioned by natural climatic conditions, high slope gradients and high anthropogenic impact. Due to high anthropogenic pressure, related to economic activities and soil pollution (especially with heavy metals), the growth of vegetation and the formation of strong root system were partially pressed, and the soil became more vulnerable to erosion processes. General characteristic of studied soil is presented in tab. 2.

The best ratio of physical clay/physical sand was observed in soil samples 2, 4, 5, 7. These soil samples, according to texture classification, were characterized as good soil. The worst ratio of physical clay/physical sand was observed in soil samples 8, 9, 10, which were characterized as moderate bad soil according to the texture classification. Much rockiness was observed in soil samples 6, 8, 9. Comparatively well-developed root systems were observed in 4, 5 and control soil samples. The 2, 4, 5, 7 and control soil samples had favorable structural properties. The pH of studying soil samples was slightly alkaline and ranged from 7.43 to 7.75. The content of humus ranged from 1.73 to 4.52% in the upper A horizon. The highest content of humus was observed in section 5 (4.52%), where the soil was not eroded and was rich with vegetation. The lowest content of humus was observed in section 9, where incompletely formed, sandy loam, highly eroded, slight capacity soil types were distributed.

The content (mg/kg) of some metals (including heavy metals) and non-metals in studied soils is presented in tab. 3. As the content of metals and nonmetals in soil is specific and depends on the compound of rocks producing the soil, and the conditions of soil formation, for the determination of pollution level the obtained results were compared with control sample which was considered as a background. The study revealed significant changes in concentrations of following heavy metals: Mn (samples 4, 6 and 7), Co (1, 4), Ni (4, 8, 9), V (2, 4), Zn (6), Cr (8, 9), As (2, 3, 6, 7, 9), Cu, Mo, Ag, Cd, Pb (almost all samples). Compared to the control sample a significant difference (over 15 times) in the content of heavy metals such as copper and molybdenum was observed which was due to the high content of copper and molybdenum in ores. Soil samples 2, 3, 4, 6 and 9 were highly polluted, and the soil sample 10 was non-polluted. It is important to mention that such pollution of soil with heavy metals in studied area was conditioned by human activities, especially by mining and smelting industrial activities.

Tab. 2. General characteristics of studied soils

Sample number	Mechanical consistency		Texture	Texture classi-fication	Stones	Quantity of roots	Structure	pH	Humus content, %
	Physical clay < 0.01, %	Physical sand >0.01, %							
1	30	70	sandy clay loam	moderate bad	basically 2-5 mm	few	granular weak 1-2 mm	7.53	2.87
2	40	60	silty clay loam	good	basically 2-5 mm	few	granular mild 1-2 mm - 20%, 2-5 mm - 60%, > 5 mm - 20%	7.75	1.83
3	20	80	sandy loam	moderate bad	2-5 mm - 60%, 5-20 mm - 40%	very few	granular weak 1-2 mm	7.68	2.14
4	40	60	silty clay loam	good	basically 2-5 mm	moderate	granular mild 1-2 mm - 70%, 2-5 mm - 30%	7.59	3.12
5	40	60	silty clay loam	good	basically 2-5 mm	many	granular mild 1-2 mm - 20%, 2-5 mm - 70%, > 5 mm - 10%	7.43	4.52
6	25	75	sandy clay loam	moderate bad	2-5 mm - 35%, 5-20 mm - 40%. > 20 mm - 25%	few	granular weak 1-2 mm	7.62	2.42
7	40	60	silty clay loam	good	basically 2-5 mm	few	granular mild 1-2 mm - 60%, 2-5 mm - 40%	7.48	3.34
8	15	85	sandy loam	moderate bad	2-5 mm - 30%, 5-20 mm - 40%, > 20 mm - 30%	very few	dusty up to 1mm	7.74	1.85
9	13	87	sandy loam	moderate bad	2-5 mm - 15%, 5-20 mm - 50%, > 20 mm - 35%	very few	dusty up to 1mm	7.75	1.73
10	10	90	sandy loam	moderate bad	2-5 mm - 50%, 5-20 mm - 40%, > 20 mm - 10%	very few	granular weak 1-2 mm	7.69	1.90
Control	30	70	silty clay loam	medium	2-5 mm - 70%, 5-20 mm - 30%		granular mild 1-2 mm - 50% 2-5 mm - 50%	7.45	3.59

Tab. 3. The content (mg/kg) of some metals (including heavy metals) in studied soils

Sample number	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	As	Mo	Pb	Cd
1	12.5	1.4	2841.5	54.3	2.1	1.3	53.3	4.9	0.6	5.2	1.1	0.03
2	16.3	0.6	3672.0	61.5	1.6	2.3	145.5	10.4	1.5	13.2	2.3	0.06
3	11.9	0.7	3242.0	32.3	1.3	0.7	123.5	7.1	1.0	8.5	3.9	0.04
4	14.1	3.8	3747.8	99.9	2.1	4.1	23.4	11.7	0.8	1.2	1.5	0.05
5	7.5	2.7	2299.7	70.0	1.3	2.2	25.3	7.7	0.4	1.5	1.7	0.03
6	11.2	2.0	3043.4	184.5	1.6	1.7	56.2	19.2	1.6	4.2	6.4	0.22
7	8.9	1.3	2974.3	113.0	1.4	1.0	81.2	10.8	1.0	6.2	3.5	0.04
8	9.5	6.8	2576.2	50.9	1.6	4.1	35.4	6.6	0.8	1.2	1.2	0.04
9	9.2	6.0	2592.9	49.0	1.4	3.7	39.7	6.5	0.9	0.9	1.4	0.05
10	8.2	2.8	2256.7	39.2	1.2	1.7	17.4	4.4	0.7	0.6	0.6	0.01
Control	7.5	2.6	2250.4	56.4	1.3	2.0	9.5	8.0	0.6	0.5	0.8	0.02

Taking into consideration all above-mentioned it is necessary to implement recultivation activities in the areas around Agarak town as the source of eroded, heavy metal polluted soils. The recultivation works are advisable to implement by the method of hydroseeding which is considered as a subtype of biological recultivation. The main goal of biological recultivation is the recovery of soil formation natural process, the stimulation of soil self-purification properties and biocenosis self-recovery process. A biological recultivation results in formation of a landscape with satisfactory biodiversity on disturbed and polluted areas.

It is also desirable to add some plant hormones and microorganisms to specific mixture used during the implementation of hydroseeding method for the increasing of germination ability of seeds, as well as for the shortening of disease incidence and the acceleration of the growth of plants. In 2-3 hours after the sowing of hydroseeding mixture the mulch material forms a specific cover on the soil which provides satisfactory humidity for the soil as well as prevents the erosion of the soil and the movement of seeds by wind and water. After the growing of plants, the mulch material fibers are decomposed enriching the soil by organic matters.

As the area of our studies was polluted especially with heavy metals it is also desirable to add to seed mixture used in hydroseeding method the seeds of plants which have ability to remove selectively from the soil some heavy metals making the process of recultivation more effective.

It is also suggested to use meliorants especially the mixture of organic fertilizers (manure, biohumus) and natural meliorants for utilization of heavy metals or at least for reducing of their toxic impact on the environment. It is proved scientifically that it is possible to improve the condition of soils polluted with heavy metals and to decrease the content of mobile forms of these elements by joint use of natural meliorants and organic fertilizers.

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