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GENERAL CHARACTERISTIC OF SOILS OF KAJARAN TOWN SURROUNDINGS

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Analyses of some physicochemical properties of soil samples from six of the most risky sites in mining territories around Kajaran Town and from unpolluted site as a control revealed that the studied soils were basically weakly eroded, and they were classified from moderately bad to good according to texture. In some soil samples much stoniness was observed. The root systems were comparatively well-developed almost in all soil samples and they were rated from medium to good. Experiments have led us to the assumption that the erosion processes in studied sites were conditioned by natural climatic conditions, high slope gradients and high anthropogenic impact.

Keywords: mining, desertification of soils, soil assessment, soil improvement.

Introduction. Currently the impact of human activities on natural landscapes has reached to such a level that it surely affects both their qualitative and quantitative characteristics. Modern industrial production results in toxic effects on biota that appears to be one of the main factors of man-caused ecological risk. Chemicals entered into the ecosystem circulation accumulate within different links of trophic chains, concentrate in air, water, soil and sediments, and get the property of long-term after-effects.

The contents of different substances in soil may originate from natural pedogeochemical properties, anthropogenic sources or a mixture of these two fractions. Ratios of these fractions vary widely depending on the type of substances, the type of soil and land use, the nature and extent of external impacts [1].

Developed mining and smelting industries are the main sources of soil pollution with heavy metals that are not biodegradable and have toxic effects on living organisms at certain level of concentration [2]. Contamination of soils by heavy metals is a significant problem, which leads to negative influence on soil characteristics and limitation of productive and environmental functions and eventually – to desertification of soils [3–5].

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Mining industry is the developed branch of economics in the Republic of Armenia. This economic sphere has been the mainstay of Armenian economy for over 20 years.

The aim of our studies was the assessment of soil condition of ecologically vulnerable mining territories around Kajaran Town and suggestion of ways for their improvement. The establishment of eventual correlation between soil pollution with heavy metals and soil condition will enable us subsequently to implement its improvement measures more effectively by reducing of toxic impact of heavy metals on the environment.

Material and Methods. Kajaran Town is situated in the South-East of the Republic of Armenia in Syunik Marz. Taking into consideration the location of the main sources of soil pollution with heavy metals six of the most risky sites in this area and an unpolluted site as a control were selected for the study:

1) the sites adjacent to Kajaran ore-dressing and processing enterprise (samples №№ 1–6);
2) recultivated tailing dam of Pkhrut (sample № 7);
3) recultivated tailing dam of Darazam (sample № 8);
4) recultivated tailing dam of Voghji (sample № 9);
5) surroundings of Artsvanik active tailing dam (samples №№ 10–12);
6) surroundings of open mine near Kajaran Town (samples №№ 13–18).

It should be noted, that the tailing dam of Artsvanik is rather far from Kajaran Town nevertheless this site was also chosen as far as it is now the only active tailing dam of the enterprise. The control section was done on distance 4 *km* from enterprise in a westerly direction (approximalely on distance 1 *km* westward from Kajaran village).

Taking into account all above-mentioned, 19 sections of only horizon A of soil (0–20 *cm*) were performed in selected sites. After homogenization and removal of unwanted content (stones, plant material, etc.) samples were air-dried at room temperature, ground, sieved to pass a 1 *mm* mesh and stored in an all-glass jar for analysis of their properties.

The physicochemical parameters of soil samples were determined under field and laboratory conditions [6]. Humus content in the soil was determined according to the method of I.V. Tyurin [7], the pH of the soil was potentiometrically measured with pH-meter ("Hanna, Checker"). Determination of soil texture was carried out by "Feel Method" [8].

The coordinates and the altitude of sampling sites territory above sea level having been recorded with GPS receiver as well as the landscape, relief, pattern of slopes, vegetation, stoniness, degree of erosion, soil types, structure of soils, soddy condition, content of carbonates, mechanical composition of soils have been described in registration book for general evaluation of soil condition.

Results and Discussion. The data of field studies indicate that the 19 sections of soil can be classified into types and subtypes. The main soil type in studied territory was the mountain cambisol with its subtypes:

1. a) mountain cambisol, decalcified, rubbly-stony, with weak capacity, weakly eroded in some places (samples №№ 1–3, 13, 17 and the control);

b) mountain cambisol, decalcified, with medium capacity, weakly eroded (samples №№ 4–6, 8, 14–16, 18);

2. mountain cambisol, calcareous, steppificated (samples №№ 7, 9–12).

Properties of studied objects as well as of type and subtypes are described hereinafter (Tab. 1). Decalcified mountain cambisol is the first subtype with its two variations. Decalcified mountain cambisol is distributed in comparatively high sites on northern and north-western slopes. This subtype of soils in studied territories is distributed 1760–2141 *m* above sea level (a.s.l.), on the gradients of 0–50 degrees. The microrelief is mainly constituted from small mounds, except the sample № 8, which being the recultivated territory is smooth, and the sample № 3, where there are mounds.

Table 1

Total characteristic of sampling areas

Sample №	Soil type and subtype	Basin*	Sampling coordinates N/E	Altitude, *m* a.s.l.	Surface gradient	Microrelief	Soil surface Cover – %	Erosion degree (0–4)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Ctrl	Decalcified mountain cambisol	V	39º 09′25.2′′ 46º 06′50.1′′	1979	50º	Small mounds	Herbage – 75, shrubs – 5, naked soil – 15, stones – 5	2
1	Decalcified mountain cambisol	V	39º 09′ 5.3′′ 46º 09′14.1′′	1918	40º	Small mounds	Herbage – 70, shrubs – 15, naked soil – 5, stones – 10	2
2	Decalcified mountain cambisol	V	39º 09′14.5′′ 46º 09′01.0′′	1929	45º	Small mounds	Herbage – 55, shrubs – 20, naked soil – 10, stones – 15	2
3	Decalcified mountain cambisol	V	39º 09′13.2′′ 46º 08′47.7′′	1911	45º	Mounds	Herbage – 60, shrubs – 15, naked soil – 15, stones – 10	2
4	Decalcified mountain cambisol	V	39º 08′54.3′′ 46º 09′08.3′′	1896	30º	Small mounds	Trees – 75, shrubs – 20, herbage – 5	1
5	Decalcified mountain cambisol	V	39º 08′ 6.6′′ 46º 08′50.9′′	1864	35º	Small mounds	Trees – 70, shrubs – 20, herbage – 10	1
6	Decalcified mountain cambisol	V	39º 09′01.1′′ 46º 08′42.3′′	1841	40º	Small mounds	Trees – 80, shrubs – 15, herbage – 5	1
7	Calcareous mountain cambisol	V	39º 09′17.1′′ 46º 12′31.9′′	1620	0º	Smooth	Herbage – 90, naked soil – 5, stones – 5	1
8	Decalcified mountain cambisol	V	39º 08′45.3′′ 46º 10′09.7′′	1760	0º	Smooth	Herbage – 80, naked soil – 20	1
9	Calcareous mountain cambisol	V	39º 10′34.0′′ 46º 13′59.8′′	1396	15º	Smooth	Herbage – 80, naked soil – 15, stones – 5	1
10	Calcareous mountain cambisol	K	39º 15′20.5′′ 46º 27′07.2′′	910	15º	Small mounds	Trees – 40, shrubs – 20, herbage – 35, naked soil – 5	1

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
11	Calcareous mountain cambisol	K	39º 14′27.3′′ 46º 27′49.8′′	899	15º	Smooth	Herbage – 85, naked soil – 15	0
12	Calcareous mountain cambisol	K	39º 14′37.6′′ 46º 27′54.8′′	912	15º	Small mounds	Trees – 10, shrubs – 10, herbage – 75, naked soil – 5	0
13	Decalcified mountain cambisol	V	39º 08′01.6′′ 46º 08′ 02.8′′	2131	50º	Small mounds	Trees – 10,, shrubs – 10, herbage – 55, naked soil – 15, stones – 10	2
14	Decalcified mountain cambisol	V	39º 08′02.9′′ 46º 08′12.1′′	2141	20º	Small mounds	Trees – 40, shrubs – 5, herbage – 50, naked soil – 5	1
15	Decalcified mountain cambisol	V	39º 08′12.7′′ 46º 07′58.6′′	2130	15º	Small mounds	Trees – 30, shrubs – 5, herbage – 60, naked soil – 5	1
16	Decalcified mountain cambisol	V	39º 08′14.9′′ 46º 09′04.9′′	2092	20º	Small mounds	Trees – 25, shrubs – 5, herbage – 60, naked soil – 10	1
17	Decalcified mountain cambisol	V	39º 08′29.4′′ 46º 09′16.8′′	2058	20º	Small mounds	Trees – 30, shrubs – 5, herbage – 45, naked soil – 20	1
18	Decalcified mountain cambisol	V	39º 09′17.3′′ 46º 07′54.7′′	1899	10º	Small mounds	Herbage – 90, naked soil – 10,	1

* V– Voghji River; K – Khalaj River.

Calcareous mountain cambisol is the second subtype. This subtype of soils in studied territories is 899–1620 *m* a.s.l., on the gradients of 0–15 degrees, microrelief is smooth or there are small mounds.

The description of each section and their general properties clarified during field studies are presented in Tab. 1. According to data of studies, the soil surface is well covered by plants and the naked soils generally make 0–15% in all except the sections № 8 and 17, where the 20% of surface is uncovered. The main vegetation in surroundings of sections №№ 1–3, 7–9, 11–18 and control is presented by herbage, and nearby the sections №№ 4–6, 10 – by trees and shrubs. It should be noted that near the sections №№ 12–17 the trees and shrubs are rather developed and they have great importance for soil conservation. The studied soils are basically weakly eroded except the sections № 11 and 12, where due to good mechanical composition of soil, sufficient vegetation and small surface gradient the erosion processes are not developed. The samples №№ 1–3, 13 and the control section in contrast to already mentioned are medium eroded.

Natural climatic conditions, steep gradient of slopes (from 40º up to 50º), with rather poor vegetation, texture and stoniness of soils as well as huge anthropogenic load (except the territory of control sampling) caused erosion processes. As a result of human activities due to operation of technique and soil pollution (particularly by heavy metals) the growth of vegetation and formation of strong root system are partially reduced and the soil became more vulnerable to erosion processes.

Table 2

General characteristic of studied soils

Sample №	Mechanical composition, %		Texture	Texture classification	Stones, *mm* (composition, %)	Q-ty of roots	Structure, *mm* (composition, %)	pH	Humus content, %
	physical clay (< 0.01 *mm*)	physical sand (> 0.01 *mm*)							
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Ctrl	23	77	Loam	Medium	2–5 (70) 5–20 (30)	Medium	Granular weak 1–2	7.60	3.79
1	18	82	Sandy loam	Moderately bad	2–5 (60) 5–20 (30) > 20 (10)	Medium	Granular weak 1–2	7.64	3.89
2	20	80	Sandy loam	Moderately bad	2–5 (60) 5–20 (30) > 20 (10)	Medium	Granular weak 1–2	7.72	3.54
3	20	80	Sandy loam	Moderately bad	2–5 (50) 5–20 (35) > 20 (15)	Medium	Granular weak 1–2	7.78	3.39
4	40	60	Clay loam	Good	Basically 2–5	Ample	Granular weak 1–2	6.84	6.09
5	37	63	Clay loam	Good	Basically 2–5	Ample	Granular weak 1–2	7.11	5.36
6	35	65	Clay loam	Good	Basically 2–5	Ample	Granular weak 1–2	6.90	6.31
7	33	67	Sandy clay loam	Moderately bad	2–5 (60) 5–20 (40)	Medium	Granular mild 1–2 (40) 2–5 (40) > 5 (20)	7.68	3.68
8	40	60	Silty clay loam	Good	Basically 2–5	Medium	Granular mild 1–2 (60) 2–5 (40)	7.58	3.94
9	50	50	Silty clay	Good	2–5 (50) 5–20 (40) > 20 (10)	Medium	Granular weak 1–2 (90) 2–5 (10)	7.71	3.71
10	38	62	Clay loam	Good	2–5 (80) 5–20 (20)	Medium	Granular cloddy 1–2 (30) 2–5 (30) > 5 (40)	7.45	7.51

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
11	40	60	Silty clay loam	Good	Basically 2–5	Ample	Granular cloddy 1–2 (30) 2–5 (50) > 5 (20)	7.48	7.66
12	37	63	Clay loam	Good	Basically 2–5	Ample	Granular mild 1–2 (60) 2–5 (30) > 5 (10)	7.52	6.84
13	20	80	Sandy loam	Moderately bad	2–5 (40) 5–20 (30) > 20 (30)	Ample	Granular mild 1–2 (60) 2–5 (40)	7.27	5.42
14	25	75	Loam	Medium	Basically 2–5	Ample	Granular mild 1–2 (70) 2–5 (30)	7.12	6.04
15	35	65	Clay loam	Good	Basically 2–5	Ample	Granular weak 1–2	7.60	3.59
16	27	73	Loam	Medium	Basically 2–5	Ample	Granular weak 1–2 (90) 2–5 (10)	7.38	4.01
17	18	82	Sandy loam	Moderately bad	2–5 (75) 5–20 (25)	Medium	Granular weak 1–2 (90) 2–5 (10)	7.54	3.62
18	40	60	Silty clay loam	Good	Basically 2–5	Ample	Granular cloddy 1–2 (35) 2–5 (40) > 5 (25)	6.88	6.62

General characteristic of studied soils is presented in Tab. 2. The best ratio of physical clay/physical sand was observed in soil samples №№ 4–6, 8–12, 15 and 18. Comparatively worse ratio was observed in soil samples №№ 1–3, 13, 17. The soil samples of first row according to texture classification are characterized as good soils while the soils of second range as well as the soil sample № 7 are characterized as moderately bad soils. Much stoniness has been observed in samples №№ 1–3, 7, 9, 13 and in control. Comparatively well-developed root systems have been observed almost in all soil samples and they were rated from medium to good. Soil samples №№ 7, 8, 10–14 and 18 had favorable structural properties. The pH of studied soil samples was from slightly acidic to slightly alkaline and ranged from 6.84 to 7.78. The content of humus ranged from 3.39 to 7.66% in the upper A horizon. The highest content of humus was observed in section № 11 (7.66%). The lowest content of humus was in section № 3, where the medium degree of erosion and comparatively badly developed vegetation were observed.

Experiments have led us to the assumption that the erosion processes in studied territory were conditioned by natural climatic conditions, high slope gradients and high anthropogenic pressure, related to economic activities, especially to mining and smelting industry.

Conclusion and Suggestions. Assessment of soil condition enabled us to suggest the ways of its improvement. Taking into consideration all above-mentioned it is necessary to implement recultivation activities in the areas around Kajaran Town that constitute the main source of pollution by heavy metals. 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. Biological recultivation results in formation of a landscape with satisfactory biodiversity on disturbed and polluted areas.

It is also desirable to add appropriate plant hormones and microorganisms to specific mixture using during the implementation of hydroseeding method for increasing the germination ability of seeds, as well as for shortening of disease incidence and the acceleration of plants growth. In 2–3 *h* 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 growing of plants, the mulch material fibers are decomposed enriching the soil by organic matter.

On slopes with steep gradient it is desirable to implement the terracing activities for enhancement of efficiency of recultivation implementing by hydroseeding method.

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