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ANALYSIS OF MOUNTAIN-FOREST CINNAMON SOIL TYPES IN THE BASIN OF THE NEW SHAMKIRCHAY RESERVOIR

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SUMMARY

The analysis of a soil-ecological base commenced on the existing mountain-forest cinnamon soils in the New Shamkirchay Reservoir Basin, which play a vital role in developing the agricultural economy in the Western region of the Republic of Azerbaijan. Thus, cleaning the area, increasing the fertility of mountain-brown soils, water-retaining capacity, and developing an action plan to ensure better productivity are among the most urgent processes to eliminate water shortages in areas with historical irrigation systems. The presented article discusses the research on the mountain-forest brown soils formed in the Shamkir region territory. This research area's formation comprised an area of 2,498.43 ha. The current analysis based on the morphological and chemical descriptions with diagnostic indicators of six soil profiles (Sections 26, 27, 28, 33, 34, and 54) progressed during 2018–2021 in the targeted areas. The prime diagnostic indicators studied were humus, total nitrogen, phosphorus, potassium, granulometric composition (for sand, dust, silt, and clay fractions), soil reaction (pH), carbonate content ($CaCO_3$), and their statistical analysis. Specifications for the six sections of the different soil profiles relied on modern tools through the determination of geographical coordinates. Determining geographical coordinates of soil samples employed the Garmin GPS map 62s. Based on the digital elevation model (DEM file), interpolating the elevation points obtained from topographic maps of previous years resulted in a new digital elevation model with low distortion. Likewise, the study has built a new relief model (in ArcGis 10.3).

Keywords: Mountain-forest cinnamon, fertility parameters, morphological descriptions, granulometric composition, soil hydrogen index, diagnostic parameters

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Key findings: Mountain-forest cinnamon is one of the widespread soil types in Azerbaijan. The vital factors of that soil are fertility parameters like humus (%), nitrogen (%), $CaCO_3$ (%), and the sum of absorbed bases (SUB, mg-ekv), which can sustain plant growth and optimize the crop yield in that specified soil. The soil also contains elementary particles of different sizes (1-0.25, 0.25-0.05, 0.05-0.01, 0.01-0.005, 0.005-0.001, <0.001, <0.01 mm, quantity in %). The granulometric composition's expression of the soil is the percentage of the weight of the arid soil.

INTRODUCTION

Mountain-forest cinnamon soils are prevalent in Azerbaijan, with formations in a lower zone than dry forests and shrubs. These lands occupy a large area in the middle and low mountain ranges of the Lesser Caucasus. The climate of xerophytic forests and shrubs, where mountain-forest cinnamon soils develop, is very close to the Mediterranean climate (Sadigov, 2013; Ministry of Agriculture of Azerbaijan State Land Management Project Institute, 2020). These areas are also characteristic of hot, dry summers, long, warm autumns, and mild winters. In this area, the average annual temperature was 8.4 °C to 10.8 °C; however, the temperature of the coldest months varies between 1.2 °C and 3.4 °C (Sadiq and Mammadov*,* 2018).

Snow cover is mostly unstable, and soils usually do not freeze. The dry phase of biological activity (soil formation) is relatively short (June-August), reaching an average of 30 days. The precipitation was 350–600 mm and falls mainly in spring and autumn. The active temperature of the atmosphere and soil (>100) was 3400–4000 and 3500–5000 hours, respectively (Babaev *et al.,* 2011). Approximately 60% of the leaning in this area fluctuates between 0°1.37° S, with 15% inclination in the range of 1.37° - 4.72°S. The slope of the remaining 20% is above 4.72° S; however, the maximum slope was between 25.19°–50.2° S in this area (Mammadov*,* 2007; Sadigov, 2018a, b).

Similarly, determining mountain-forest cinnamon soils revealed typical development under light oak-hornbeam forests, with well-developed and inadequately moistened litter and xerophilic grass covers. Dryer variants of these soils also occurred under arid light forests, consisting of pistachio-juniper formations and groups of friganoid and shiblak shrubs. In some cases, the total amount of phytochemicals in oak-hornbeam forests, where washed mountain-brown soils appear, reached 116.0–244.2 t/ha, and in shrub-cereal cenotes, 27.1 t/ha. In the grass cover of dry forests, the ash element contents were usually high (Alliprandini *et al*., 2009; Gargiulo *et al.,* 2014; Ghanbarian and Daigle, 2015; FAO, 2020).

Mountain-forest cinnamon soil type is prevalent in the basin of the Shamkirchay reservoir, which stands within 600–800 masl. The period of primary soil surveys in the basin dates back to the end of the 19th and the beginning of the 20th century when the reservoir did not yet exist. At that time, several Azerbaijani and Russian soil scientists conducted research, and an analysis of the scientific discussions of their works ensued. Some scientists even contributed substantially to studying mountain-forest cinnamon soils in the territory of the Republic of Azerbaijan. However, in the presented study and historical analysis, lately, analyzing new approaches in this area included identifying their differences and the regular conduct of monitoring (Sadigov, 2016, 2019).

The mountain-forest cinnamon soils of Azerbaijan have characteristics of a relatively thick humus layer, a clay layer under the humus horizon, good aggregation, distinct selection, and a carbonate-illuvial horizon. Depending on the degree of surface disintegration and the effect of relief conditions, the soil profile thickness also varies widely. Comparatively, based on southern and southeastern slopes, the profile thickness does not often exceed 50–60 cm. However, at the same time, the carbonate compounds were often visible in the soil's upper humus layer.

Based on the digital elevation model (DEM file) by interpolating elevation points obtained from topographic maps of previous

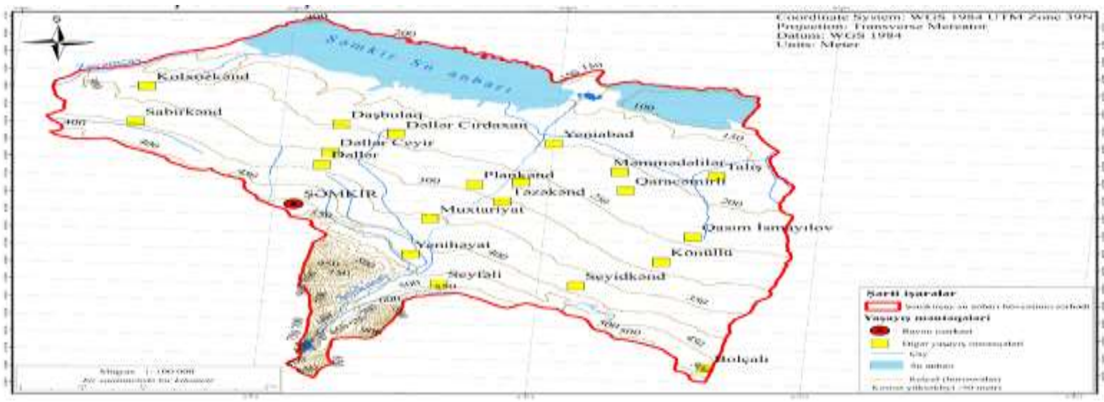

Figure 1. Relief map of the basin of the New Shamkirchay reservoir (Made by Sadigov R.A.).

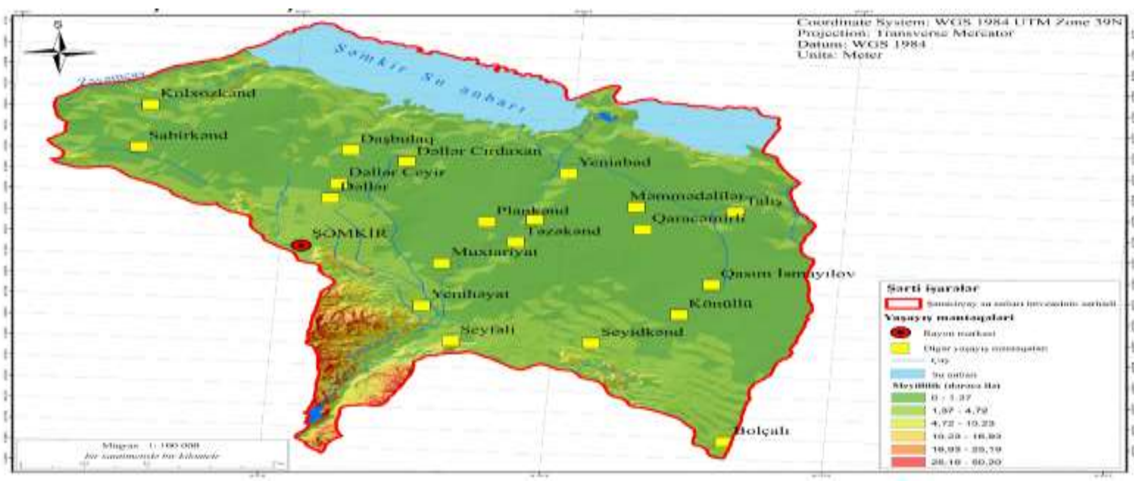

Figure 2. Slope-Aspect map of New Shamkirchay reservoir basin (Made by Sadigov R.A.).

years, a new digital elevation model with low distortion resulted, building a new elevation model in ArcGis 10.3, cutting height of 50 meters (Figure 1) (Barrett and Schaetzl, 1998; Sadigov, 2018a, b; Vogel and Conedera, 2020; Dai *et al.,* 2021). Based on the digital elevation model (DEM) of the new Shamkirchay reservoir basin, the proclivity map's development was in degrees. The study and mapping of the slope were also crucial to protect the soil from leaching and take measures to combat erosion. In the said area, the lowest and highest inclination rates bore labels in the conventional symbols section of the map. Notably also, soil washing begins where the slope is 2–3 degrees (Figure 2).

MATERIAL AND METHODS

The paper analyzes and summarizes the results of long-term research in the Shamkirchay Reservoir Basin since 2015. In practice, the selected plots' analysis focused on modern methods used. The Mountain-Forest Cinnamon (DV_v) soils discussed in the article gained adaptation to International Soil Names (WRB) and a compilation of the soil map using the ArcCIS program (Jaboil *et al.*, 2013). The study indexed soil horizons, with the soil's genetic characteristics adjusted to the correlation of the WRB system with the primary parameters of Azerbaijan's land classification.

Table 1. Sections of geographic coordinates in soils of the mountain-forest-cinnamon type.

No.	Mountain-forest-cinnamon soils		
	Number of section	X coordinate (east length)	Y coordinate (north width)
1	Section 26	X.46° 2′ 49.431″ E	Y.40° 44′ 28.922″N
2	Section 27	X.46° 1′ 59.110″ E	Y.40° 44′ 33.185″N
3	Section 28	X.46° 2′ 26.520″ E	Y.40° 44′ 35.287″N
4	Section 33	X.46° 2′ 49.088″ E	Y.40° 44′ 57.959″N
5	Section 34	X.46° 1′ 38.303″ E	Y.40° 45′ 10.860″N
6	Section 54	X.46° 2′ 8.298″ E	Y.40° 45′ 57.008″N

The pertinent study aimed to analyze the current situation in the mountain-forest cinnamon soils formed in the New Shamkirchay reservoir basin to conduct field research, determine diagnostic indicators, and perform a morphogenetic assessment (State Standard of the Republic of Azerbaijan, Soil quality, 2013; Kulhánek *et al.,* 2019).

Mountain-forest cinnamon soils cover an area of 2498.43 hectares in the New Shamkirchay reservoir basin. The presented article analyzes the plots of land in the adjacent area and on the predetermined routes for 2018–2021. The sections' specifications referred to modern methods engaging geographical coordinates (Gargiulo *et al.,* 2014; Mtyobile *et al*., 2020). Determining the geographic coordinates of soil samples used a Garmin GPS map 62s (Table 1). The article analyzes six plots of land on mountain-forest cinnamon soil, determining soil layers based on the profile. The diagnostic variables helped determine the granulometric composition, soil color, structure, hardness, and the number of morphological features. The necessary procedures relied on the methods presented in the laboratory at the Institute of Soil Science and Agrochemistry, National Academy of Soil Science of Azerbaijan.

In the soil field research, knowing the total humus content followed the I.M.Tyurin method, with the total nitrogen studied through the Kjeldahl method and carbonates estimated using a calcimetric device. Employing the method of vibration in the form of $CaCO_3$, total phosphorus (P), and total potassium (K) on an ICP-MS instrument (Agilent), the particle size distribution analysis engaged the N.A. Kaczynski approach. The succeeding steps include the techniques applied: 1) Absorbed cations to determine the absorption capacity of the soil by the D. Ivanov method, 2) hygroscopic moisture by the thermal process (drying the soil at a temperature of ×05 degrees), and 3) the reaction of the soil environment on a pH meter (ratio 1:5) in an aqueous solution of ammonia absorbed from nitrogen forms, soluble in water Ammonia Nesler, with nitrates analyzed by the method of Grandal-lyau (Neugschwandtner *et al.,* 2014; Zhang *et al.,* 2015; Sadigov, 2018a, b; Moitzi *et al.,* 2020). The recorded data's reliability underwent statistical analysis for confirmation (Dospekhov, 1984), with the sections located in targeted areas also analyzed (Figure 3).

RESULTS AND DISCUSSION

The lands of the Yeni Shamkirchay reservoir have long served for cultivation. The granulometric composition of the first soil studied used different soil samples collected from the targeted site and in arid soils, with the percentages determined. The results of the analysis on these soils are in Table 2. The mountain-forest brown soils belong to medium- and heavy-clay soils, and according to the international classification, these soils belong to the class of anthropogenically modified soils (System WRB-The World Reference Base for Soil Resources) (Jaboil *et al.,* 2013; Kultassov *et al*., 2023). In these soils, the thickness of the accumulative layer of AUvz varies, ranging from zero to 30 cm. The color is dark brown, with a fine-grained structure, and the humus layer formed in the upper layers within the range of 4.50%–6.00%. In these soils, the different layers, viz.,

Figure 3. Land map of the New Shamkirchay water reservoir basin (Made by Sadigov R.A.).

Table 2. Granulometric composition of mountain-forest-cinnamon soils (in % of the absolute dryness of the soil).

Section	Depth (cm)	Particle size (mm), quantity (%)						
		1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
26	AU_{vz} 0-24	9.78	20.13	6.91	26.02	12.45	63.18	24.71
	AU_{z} 24-43	5.91	22.01	6.79	23.94	17.16	65.29	24.19
	Bca 43-71	1.26	23.24	11.5	22.09	14.98	64.00	26.93
	B/Cgca 71-92	1.06	22.68	13.13	12.89	20.79	62.93	29.25
	CcaL 92-119	6.28	19.54	3.34	24.48	12.89	60.84	24.47
27	AU_{vz} 0-16	8.37	15.15	13.24	7.57	27.98	63.24	27.69
	AU_{z} 16-31	2.89	18.12	16.5	.1.89	26.26	62.49	27.05
	Bca 31-59	7.18	17.12	11.57	14.57	19.84	64.13	29.72
	B/Cgca 59-87	1.35	20.49	12.22	32.36	9.15	65.94	24.43
	CcaL 87-116	9.09	10.97	18.71	22.15	10.51	61.23	28.57
28	AU_{vz} 0-28	4.8	19.29	18.52	4.97	24.43	57.39	27.99
	AU_{z} 28-42	9.62	13.79	17.26	16.18	16.67	59.33	26.48
	Bca 42-73	5.57	15.42	20.91	9.88	22.78	58.10	25.44
	B/Cgca 73-97	6.98	17.50	13.78	20.33	16.85	61.74	24.56
	CcaL 97-115	7.65	24.45	7.07	12.45	20.40	60.83	25.98
33	AU_{vz} 0-22	1.06	26.98	11.68	24.55	6.92	59.08	27.18
	AU_{z} 22-41	6.51	26.16	7.05	21.82	12.04	60.28	26.42
	Bca 41-67	8.31	22.14	11.08	16.41	12.64	58.47	29.36
	B/Cgca 67-89	8.56	17.86	15.93	16.87	13.13	57.65	27.65
	CcaL 89-123	7.31	25.16	7.65	13.75	12.95	59.88	27.18
34	AU_{vz} 0-26	8.28	27.72	5.78	19.44	11.46	61.22	30.32
	AU_{z} 26-43	5.82	10.02	16.65	22.8	16.82	67.51	27.60
	Bca 43-65	8.09	33.16	6.79	29.47	8.12	64.75	27.16
	B/Cgca 65-87	3.56	22.46	8.12	14.73	21.95	65.86	29.18
	CcaL 87-101	7.69	19.99	2.7	25.14	17.81	69.62	26.67
54	AU_{vz} 0-15	10.52	25.65	1.68	1.68	7.81	62.15	30.96
	AU_{z} 15-34	6.55	24.18	2.33	2.33	13.05	66.94	29.17
	Bca 34-56	8.29	11.07	15.01	15.01	16.73	65.63	26.41
	B/Cgca 56-78	8.60	15.75	7.81	7.81	16.12	67.84	27.16
	CcaL 78-104	7.41	14.16	14.42	14.42	11.85	64.01	29.18

AUvz, AUz, Bca, B/Cgca, and CcaL were also visible at depth. The present results were contrary to past findings' classifications that the new methodology (AUvz, AUz, Bca, B/Cgca, and CcaL) and the humus layer's formation in the upper layers ranged within 4.12%–5.68% (Babaev *et al*., 2011; Sadigov, 2018a, b; Amangaliev *et al*., 2023).

The field characterization of the soil profile of Section 26, located in the targeted area, commenced to characterize the morphological properties of mountain-forest cinnamon soils. AUvz (0–24 cm) appeared with the density and hardness of the gazh layer. The thickest layer and richness of humus were also available. The color was dark-cinnamon and porous, and the air permeability was also good. It has a small heap-like structure. It was heavy, clayey-moist, and rich in root and rootlets of plants, and the insect ways activate air and water conductivity. The soil fissures were distinct. It was transitional, and it boils under the influence of HCl. The depth of the carbonate layer was slightly evident. Comparing the results from scientists who have conducted research in this field showed similar numbers. It was apparent that there are differences of 3–4 cm in soil profile layers, humus thickness, good air-water permeability, and under the influence of HCl, it decreases from high to low levels from severe boiling to medium boiling. Carbonate indicated local distribution in soil layers (Babaev *et al*., 2011; Kunypiyaeva *et al*., 2023).

AUz (24–43 cm) contained a light mountain-brown grayish lizard, granular structure, heavy clay, few plant roots and rhizomes, small tree roots, and semi-permanent plant remains. Also, its structure was not clear; however, it was gradual. Sometimes, it was possible to come across worm routes. It does not boil under the influence of HCL, with low humidity, gradual transition, and low boiling under the HCL. The Bca (43–71 cm) emanated lilac, light brown, indistinguishable structure, heavy clayey, hard, rust spots, carbonate mold, single woody and large plant roots, dense, low humidity, gradually changing, and low boiling under the action of HCL. The subsoil layer was light brown, heavy clay, with a calcareous structure, many roots, small stones, and pebbles, with the rocks covered with calcareous carbonate, carbonaceous, fine-grained, dry, and pure transition. Compared with the regional project implemented by the Ministry of Agriculture of Azerbaijan (in the northeastern slopes of the Lesser Caucasus), one can observe the similarity of the results obtained in this type of land. Accordingly, the depth of the profile layers of the soil is 27–42 cm in the AUz layer and 42–69 cm in the Bca layer. These layers had formations of medium clayey, carbonated, large, and dense plant roots and stony and gravelly soils (Ministry of Agriculture of Azerbaijan State Land Management Project Institute., 2020).

The B/Cgca (71–92 cm) has access from the subsoil layer to the bedrock layer. The horizon consists of various small and large stones covered with calcareous carbonate. It has a light brown, indistinguishable structure, heavy clay, hard, dense, low humidity, and gradually transitioning, and it weakly boils under the influence of HCL. Carbonate is in the form of mites and dots. Meanwhile, Cgca (92–119 cm) is brownish, indistinguishable in structure, with heavy clay, hard, dense, low humidity, and gradually transitioning. It also contains small and large stones, soil-forming rocks, soft loess-like gypsum fine sediments, and weakly boils under the influence of HCL. The morphological effects of the said soil section showed that in the field, the color of the soil gradually changed from top to bottom, from dark brown to lilac, brownish brown, a broken structure, and even in the lower layers, the structure was not distinct, and the subsoil was very hard. Also, the soil, which has served crop planting for a long time, did not erode; the color of the soil has gradually changed from top to bottom, the structure destroyed, and the subsoil has become very hard. The soil hardening in the lower part impairs water permeability during precipitation, resulting in surface runoff, with favorable conditions created for forming surface erosion.

Other researchers also got the same results when comparing the study results with past outcomes. The lightening of the color of the soil gets off by the profiles. Under the influence of HCl, the boiling decreases, and weak boiling is evident. Disruption of the structure is simultaneous with the weakening of soil layers' permeability, stiffness, and hardness. Heavy clay soils cause soil-water permeability (Sadiq and Mammadov, 2018).

In section 26 (X coordinate X.46° 2′ 49,431″ E, Y coordinate Y.40° 44′ 28,922″N), based on depth, 1–0.25 mm particles of particle size distribution at maximum AUvz depth 0–24 cm, while minimum particles were visible in the range of 71–92 cm B/Cgca. Particles with a size of 0.25–0.05 mm emerged in the Bca 43-71 profile, while the highest number of particles was 23.24%, and the smallest number of particles was 19.54% in the CcaL profile (92–119 cm). Accordingly, the B/Cgca profile layer, with the most formed granulometric particles with a range of 0.05–0.01 mm, was prominent at a depth of 71–92 cm, 13.13%, and the minimum particles were in the range of CcaL 92–119 cm, attained at 3.34%.

Carbonate and non-carbonate soils are the most vital elements for soil profiles. Most carbonation concentrate in the upper layers, sometimes in the middle layers, but rarely in the lower layers. Looking at the results obtained by the researchers, a decrease in carbonation toward the lower layers occurred. At the same time, carbonate-rich layers are more noticeable in the upper soil profiles (Babaev *et al*., 2011; Sadiq and Mammadov, 2018).

Accordingly, in particles, the maximum limit with a size of 0.01–0.005 mm was 26.02% in the range of AU_{vz} (0–24 cm), and the minimum of particles emerged in the B/Crca (71–92 cm) in the range of 12.89%. As shown from the 0.005–0.001 mm in Table 2, the B/Cgca maximum was 20.79% at 71–92 cm, while the particle minimum occurred at 12.89% in the CcaL range (92–119 cm). Particle count <0.01 mm provided 24.19% in soil profile at a minimum depth of AUz (24–43 cm).

Determination of granulometric compositions of soils is one of the most crucial factors. The change of silt and clay particles along the profile gives different results in different layers. In this research, the minimum particles appeared in the B/Crca layer, but compared with other researchers, the minimum layer was in the Bca layer, and the maximum particles were similar to our results (Babaev *et al*., 2011; Sadiq and Mammadov, 2018).

The maximum particle size of B/Cgca was noticeable at 29.25% at a depth of 71–92 cm. Particles with <0.001 mm manifested at a maximum depth of AUz 24–43 cm, 65.29%, with the minimum particle size of CcaL determined at 92–119 cm, 60.84%. At soil site 26, the said analysis also showed that these soils were heavy clay soils with a granulometric composition. Explanations about the other soil sections are also available in Table 2.

The main diagnostic parameters of logging in the existing mountain forest brown (MLS) soils of the New Shamkirchay reservoir basin appear in Table 3. The table shows humus, total nitrogen, $CaCO_3$, total absorbed bases (TAN, mg-eq), soil hygroscopic moisture (in mg-eq), pH, available phosphorus (mg/kg), and exchangeable potassium (mg/kg) under current laboratory conditions (Figure 4). The territory of the basin of the Shamkirchay reservoir was an ancient agricultural land. There is a sufficient amount of newly irrigated areas. Before, in these areas, livestock raising developed (Babaev *et al*., 2011).

Determining the amount of humus in the different sections (26, 27, 28, 33, 34, and 54) of the profile, viz., AUvz, AUz, Bca, B/Cgca, and CcaL was in percentage (Table 3). The thickness of the humus layer has the range of 5.56%–4.74% for the AUvz layer, 4.78%–3.47% (Auz), 3.67%–2.18% (Bca), 2.94%–0.87% (B/Cgca), and 1% for the CcaL profile (Table 3). In support of Table 3, the detailed description of the humus layer, along with soil profiles and sections, is also visible in Figure 5. In addition to humus, determining the nitrogen (%) also ensued in the soil profile layers of the AUvz, AUz, Bca, B/Cgca, and CcaL sections. The nitrogen (%)ranges were 0.383%–0.331% (AUvz), 0.334%–0.252% (AUz), 0.264%–0.171% (Bca), 0.221%–0.117% (B/Cgca), and for the CcaL (KC); however, these figures had no analysis in most of the sections. Aside from Table 3, the percentage of nitrogen in profiles and sections also occurs in Figure 6. The thickness of the

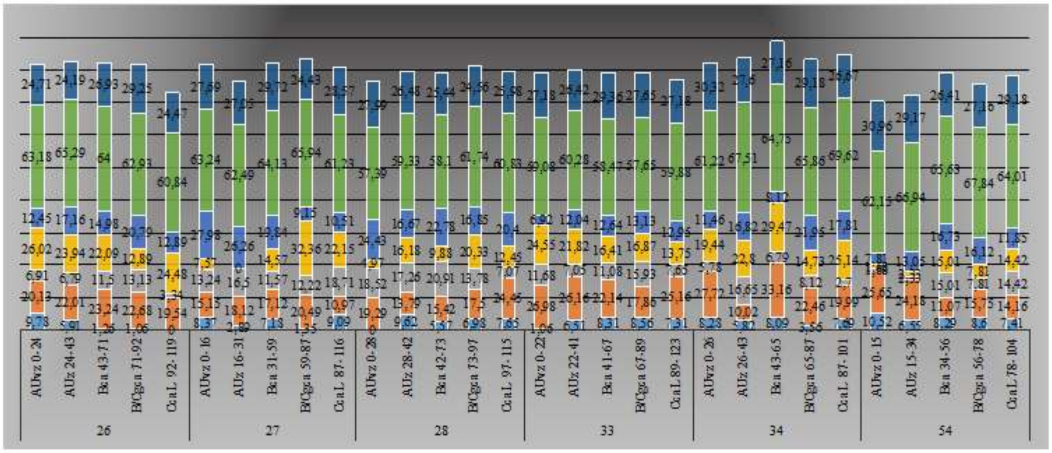

Figure 4. Graphical description of granulometric composition of mountain-forest-cinnamon soils (Series 1: 1-0.25 mm, Series 2: 0.25-0.05 mm, Series 3: 0.05-0.01 mm, Series 4: 0.01-0.005 mm, Series 5: 0.005-0.001 mm, Series 6: <0.001 mm, and Series 7: <0.01 mm).

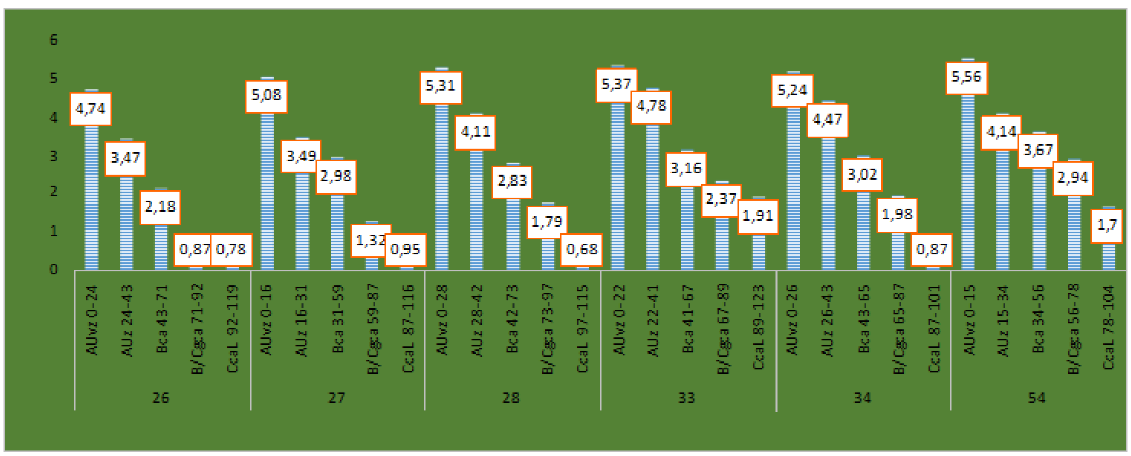

Figure 5. Determination of the amount of humus layer along the profiles (%).

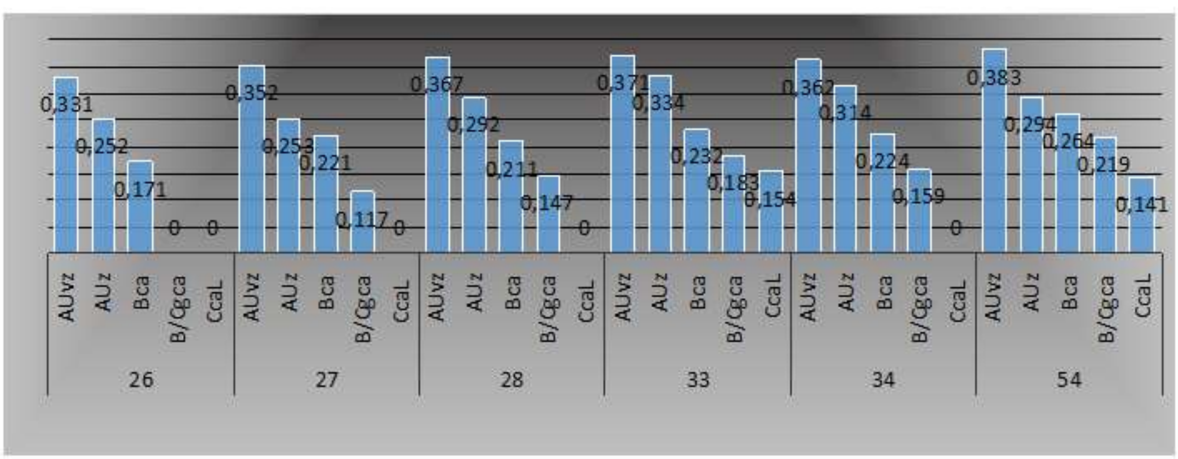

Figure 6. Determination of the amount of nitrogen layer along the profiles (%).

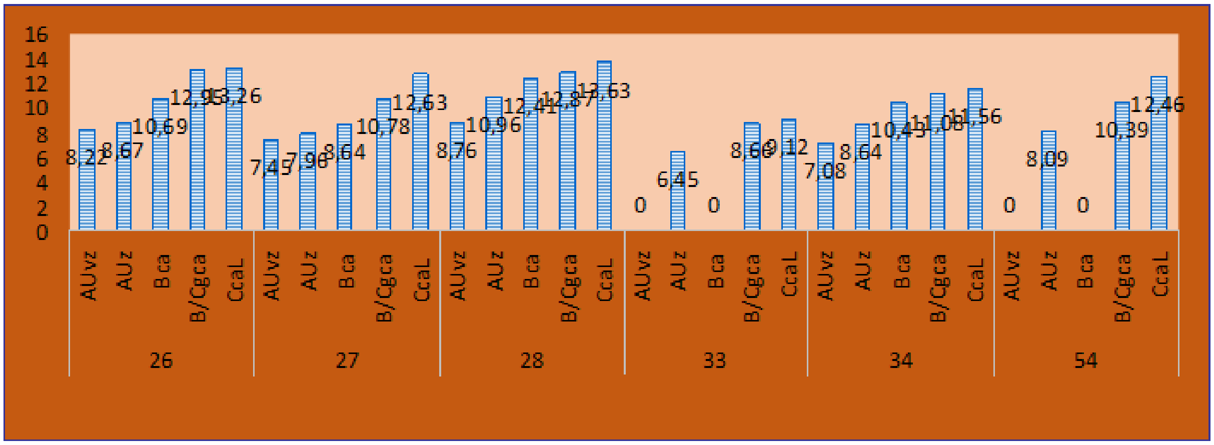

Figure 7. Determination of the amount of $CaCO_3$ along the profiles.

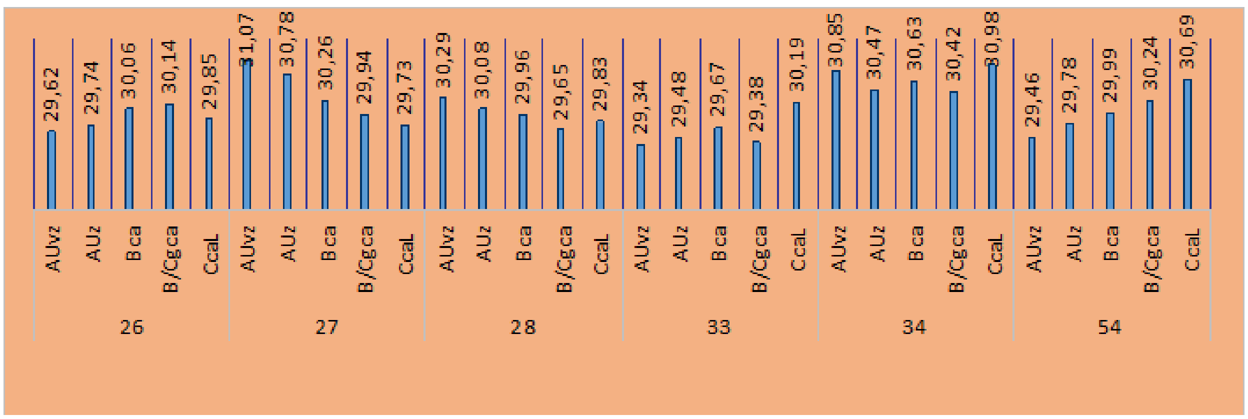

Figure 8. Determination of the amount of SAB layer along the profiles (mq-ekv).

humus layer was in the range of 5.02%–4.47% for AUvz layer, 4.43%–3.58% (Auz), 3.98%–2.62% (Bca), 3.09%–1.12% (B/Cgca), with the nitrogen (%)ranging at 0.349%–0.314% (AUvz), 0.312%–0.259% (AUz), 0.288%–0.199% (Bca), and 0.199%–0.105% (B/Cgca) (Babaev *et al*., 2011).

Along with the determination of humus and nitrogen, taking the percentage of $CaCO_3$ also continued in the profile layers, i.e., AUvz, AUz, Bca, B/Cgca, and CcaL, in the six sections (26, 27, 28, 33, 34, and 54) (Table 3). Soil carbonate in the AUv layer has a range of 8.76%–7.08%, with 10.96%–6.45% (AUz), 12.41%–8.64% (Bca), 12.95%–8.66% (B/Cgca), and 6.3%–9.12% (CcaL) (Table 3). A graphical representation of $CaCO_3$ also arises in Figure 7, supporting Table 3. Along with other fertility parameters, the AUvz, AUz, Bca, B/Cgca, and CcaL profile layers and the sum of absorbed bases (mg-ekv) ranges also resulted. These figures for the AUz profile were in the range of 30.78–29.48 mg-ekv, Bca profile (30.63–29.67 mg-ekv), B/Cgca profile (30.42–29.38 mg-ekv), and CcaL (30.98–29.73 mg-ekv) (Table 3). The graphical representation of SUB is also available in Figure 8. Other researchers have given the results of their studies consistent with this study. Soil carbonate in the AUv layer gave the range of 10.47%–8.62%, 11.33%–7.49% (AUz), 12.29%–8.06% (Bca), 12.22%–8.41% (B/Cgca), and 8.64%–10.44% (CcaL) (Babaev *et al*., 2011; Sadiq and Mammadov, 2018).

Table 3. Main diagnostic indicators of clearings of existing mountain-forest-cinnamon soils in the basin of the New Shamkirchay reservoir.

Section	Depth (cm)	Humus (%)	Nitrogen (%)	$CaCO_3$ (%)	Sum of absorbed bases (mg-ekv)	Hygroscopical Humidity (%)	pH	P_2O_5 (mg/kg)	K (mg/kg)
1	2	3	4	5	6	7	8	9	10
26	AU_{vz} 0-24	4.74	0.331	8.22	29.62	6.84	7.4	24.45	359
	AU_z 24-43	3.47	0.252	8.67	29.74	6.92	7.4	23.57	328
	Bca 43-71	2.18	0.171	10.69	30.06	6.79	7.5	22.16	305
	B/Cgca 71-92	0.87	Not.an	12.95	30.14	6.55	7.5	20.68	274
	CcaL 92-119	0.78	----	13.26	29.85	6.38	7.5	18.66	252
27	AU_{vz} 0-16	5.08	0.352	7.45	31.07	6.38	7.4	29.72	381
	AU_z 16-31	3.49	0.253	7.96	30.78	6.94	7.5	27.67	356
	Bca 31-59	2.98	0.221	8.64	30.26	7.22	7.5	25.95	317
	B/Cgca 59-87	1.32	0.117	10.78	29.94	7.54	7.4	22.14	283
	CcaL 87-116	0.95	Not.an	12.63	29.73	7.67	7.4	20.74	258
28	AU_{vz} 0-28	5.31	0.367	8.76	30.29	8.21	7.3	24.15	398
	AU_z 28-42	4.11	0.292	10.96	30.08	8.36	7.5	22.97	364
	Bca 42-73	2.83	0.211	12.41	29.96	7.94	7.5	20.93	328
	B/Cgca 73-97	1.79	0.147	12.87	29.65	7.69	7.2	18.70	294
	CcaL 97-115	0.68	Not.an	13.63	29.83	7.72	7.3	16.15	275
33	AU_{vz} 0-22	5.37	0.371	Not.an	29.34	7.82	7.4	26.25	365
	AU_z 22-41	4.78	0.334	6.45	29.48	8.12	7.5	24.06	321
	Bca 41-67	3.16	0.232	Not.an	29.67	8.28	7.5	22.91	296
	B/Cgca 67-89	2.37	0.183	8.66	29.38	8.01	7.4	22.04	270
	CcaL 89-123	1.91	0.154	9.12	30.19	7.93	7.4	20.48	248
34	AU_{vz} 0-26	5.24	0.362	7.08	30.85	7.04	7.5	23.17	298
	AU_z 26-43	4.47	0.314	8.64	30.47	7.20	7.4	21.39	267
	Bca 43-65	3.02	0.224	10.43	30.63	7.83	7.5	19.56	235
	B/Cgca 65-87	1.98	0.159	11.08	30.42	7.89	7.0	17.61	202
	CcaL 87-101	0.87	Not.an	11.56	30.98	6.76	7.2	15.22	195
54	AU_{vz} 0-15	5.56	0.383	Not.an	29.46	5.69	7.3	25.51	312
	AU_z 15-34	4.14	0.294	8.09	29.78	6.84	7.2	23.96	285
	Bca 34-56	3.67	0.264	Not.an	29.99	6.44	7.3	21.18	261
	B/Cgca 56-78	2.94	0.219	10.39	30.24	5.91	7.3	18.60	226
	CcaL 78-104	1.70	0.141	12.46	30.69	5.68	7.2	17.49	199

Table 3 further shows the percentage of hygroscopic moisture in the layers. Hygroscopic humidity in the AUvz layer was 8.21%–5.69%, 8.36%–6.84% (AUz), 8.28%–6.44% (Bca), 8.01%–5.91 % (B/Crca), and 7.93%–5.68% (SkaL) (Table 3). Along with Table 3, a graphical representation of hygroscopic moisture emerges in Figure 9. The said table also reflects the analysis of the soil environment by layers, and pH in the AUvz layer was 7.5–7.3, with 7.5–7.2 (AUz), 7.5–7.3 (Bca), 7.5–7.0 (B/Cgca), and 7.5–7.2 in the layer (Table 3). Figure 10 also describes graphically the soil environment. On other fertility indicators, the amount of mobile phosphorus (mg/kg) incurred evaluation for the profile layers, viz., AUvz, AUz, Bca, B/Cgca, and CcaL (Table 3). The total phosphorus had ranges of 29.72–23.17 mg/kg (AUvz), 27.67–21.39 mg/kg (Auz), 25.95–19.56 mg/kg (Bca), and 22.14–17.61 mg/kg (B/Cgca) (Table 3). Similarly, a graphical representation of the mobile phosphorus in the soil profile also occurs in Figure 11.

In comparing this study results, those obtained by Babayev and other researchers are as follows: Hygroscopic humidity in the AUvz layer was 8.83%–5.42%, 8.49%–6.96% (AUz), 8.22%–6.65% (Bca), 8.16%–6.23% (B/Crca), and 8.44%–5.67% (SkaL); pH in the AUvz layer was 7.6–7.4, 7.6–7.5 (AUz), 7.5–7.4 (Bca), 7.4–7.2 (B/Cgca), and 7.6–7.2 in the layer; and the total phosphorus had the ranges of 30.94–25.42 mg/kg (AUvz), 28.32–

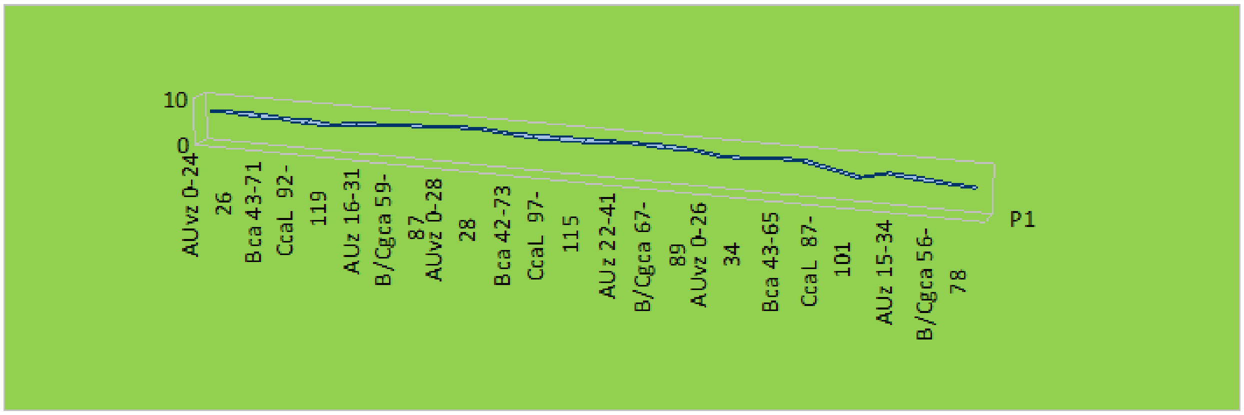

Figure 9. Determination of the amount of hygroscopic humidity layer along the profiles (%).

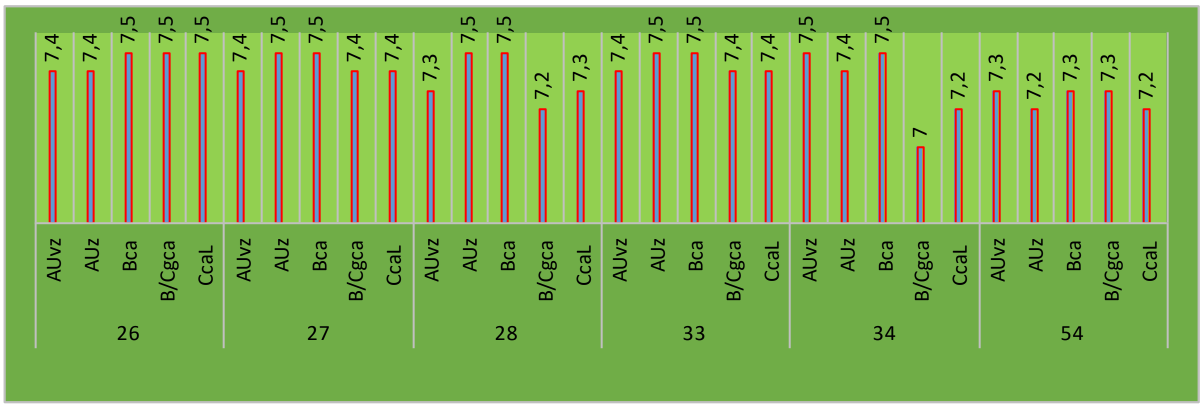

Figure 10. Determination of the amount of pH layer along the profiles.

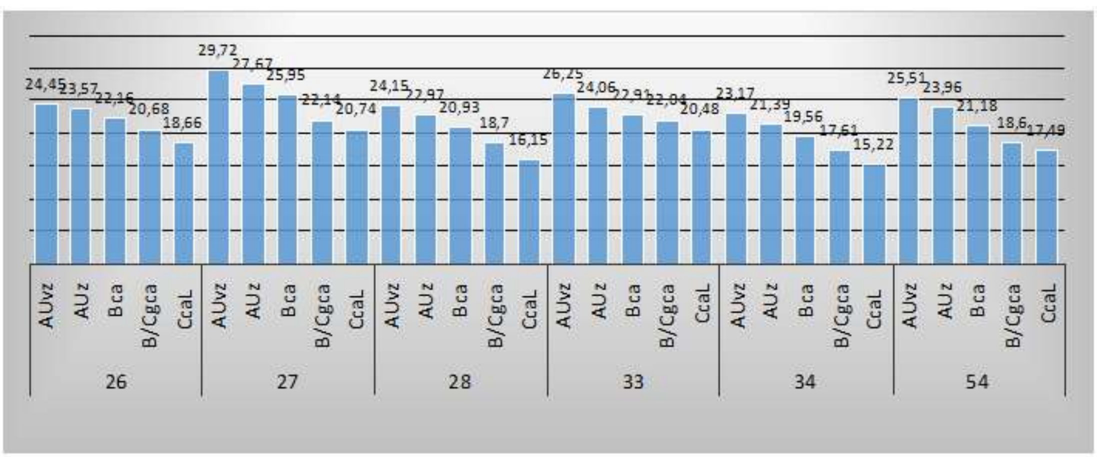

Figure 11. Determination of the amount of phosporium layer along the profiles (mg/kg).

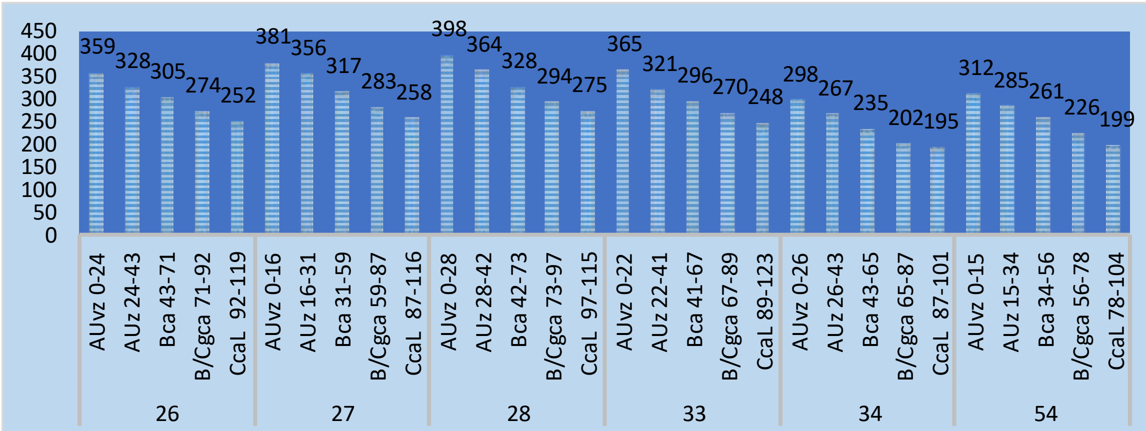

Figure 12. Determination of the amount of exchangeable potassium layer along the profiles (mg/kg).

22.71 mg/kg (Auz), 26.16–21.47 mg/kg (Bca), and 20.62–19.08 mg/kg (B/Cgca) (Babaev *et al*., 2011; Sadiq and Mammadov, 2018).

The amount of exchangeable potassium in sections (26, 27, 28, 33, 34, and 54) for profile layers, i.e., AUvz, AUz, Bca, B/Cgca, and CcaL also attained scrutiny (Table 3). The total amount of exchangeable potassium in the layer of AHC in the soils laid down varies between 398–298 mg/kg. However, these figures for the AUz profile had ranges of 321–267 mg/kg, Bca profile (328–235 mg/kg), B/Cgca (294–202 mg/kg), and CcaL profile (275–195 mg/kg) (Table 3). Adding to Table 3, a description of the exchangeable potassium in the profiles' layers and sections appeared in Figure 12. In comparison, the layer of AHC in the soils laid down varies between 384–290 mg/kg. However, these figures for AUz profile had ranges of 318–258 mg/kg, Bca profile (342–263 mg/kg), B/Cgca (276–229 mg/kg), and CcaL profile (306–186 mg/kg) (Babaev *et al*., 2011; Sadiq and Mammadov, 2018).

CONCLUSIONS

The article reflects the results of large-scale soil-ecological studies conducted in 2018–2021 on the mountain-forest cinnamon (DV_v) soils of the New Shamkirchay reservoir basin. In characterizing the morphological properties of these soils, only one of the soil-profile sections (section 26), located in the targeted area, attained a field description and a morphological depiction as determined according to profiles, i.e., AUvz, AUz, Bca, B/Cgca, and Cgca. The ratios of humus, total nitrogen, $CaCO_3$, total absorbed bases (TAB, mg-ekv), soil hygroscopic moisture (in mg-ekv), pH, available phosphorus (mg/kg), and exchangeable potassium (mg/kg) have also achieved determining under laboratory conditions. Based on field soil-chamber laboratory studies and morphological description of different soil plots in the study area, the AUvz - thickness of the humus layer in various forms of microrelief and farms, nitrogen (%), formation, depth of difference in hardness, their structural aggregates, particle size distribution, hygroscopic humidity, and other morpho-diagnostic features received successful study.

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