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DETERMINATION OF DIAGNOSTIC INDICATORS IN ALLUVIAL MEADOW-FOREST SOILS FORMED IN THE SHAMKIRCHAY RESERVOIR BASIN

R.A. SADIGOV^{1*}, G.S. MIRZAYEV¹, F.H. GURBANOVA² and D. MUHAMMAD³

¹Department of Engineering and Applied Sciences, UNEC-Azerbaijan State University of Economics, Baku, Azerbaijan

²Department of Public Administration and Social Innovation, UNEC-Azerbaijan State University of Economics, Baku, Azerbaijan

³Department of Soil and Environmental Sciences, University of Agriculture, Peshawar, Pakistan

*Corresponding author's email: ramil_sadiqov-1983@mail.ru

Email addresses of co-authors: garay_mirzayev@unec.edu.az, fidan.gurbanova@unec.edu.az, dost@aup.edu.pk

SUMMARY

The northeastern sector of the Lesser Caucasus, particularly the Shamkirchay reservoir basin in Western Azerbaijan, faces soil fertility degradation due to anthropogenic pressures and limited soil conservation efforts. In the region's foothills, the said area is strategically vital for agriculture yet contains fewer, however, important forest ecosystems, notably alluvial meadow-forest soils. These soils covering around 558.76 hectares were evidently crucial for ecological and agricultural stability. From 2018 to 2025, six representative soil profiles (Sections 85, 126, 127, 128, 143, and 144) entailed studies to determine their ecological conditions. The soils' morphological and chemical properties assessment included humus content, total nitrogen, available phosphorus and potassium, pH, calcium carbonate (CaCO₃), and granulometric composition (sand, silt, clay, and dust). The data, as statistically analyzed, determined the present fertility level as well as identified their degradation trends. The emerging results underscore the urgent need for targeted conservation measures to preserve these vulnerable soil systems and support sustainable agricultural practices in this fundamental region.

Keywords: Alluvial meadow-forest, soil profile, morphological description, granulometric composition, fertility, diagnostic parameters, basin

Key findings: In the Shamkirchay reservoir basin, the alluvial meadow-forest soils revealed medium to heavy clay textures with a high fine particle accumulation in surface horizons and elevated humus and nitrogen levels in the AU_{ca} (dark humus/organic-rich) layer, indicating active organic cycling. Consistent calcium carbonate presence supports buffering capacity, while neutral to slightly alkaline pH and the moderate phosphorus and potassium levels sustain fertility.

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INTRODUCTION

The lands within the Shamkirchay reservoir basin have played a critical role for several decades in crop production. However, extensive and often unregulated soil use has led to its significant decline in productivity, and some areas exhibited signs of degradation. Therefore, restoration and mitigation of ongoing degradation processes in these soils has become an urgent priority, particularly in the northeastern slope of the Lesser Caucasus, where degradation intensity is considerably high.

In the ecological evaluation of soils, one of the key components is the development of specialized assessment scales to classify varying degrees of soil fertility and degradation. As the ecological condition of an area basically correlates with the soil's state, therefore, it becomes imperative to develop a comprehensive system of criteria and various indicators. Such a type of system would facilitate the evaluation of ecosystem functionality and biogeocenotic dynamics. The complete analysis of the soil condition is also essential in identifying the individual factors that contribute to specific soil properties. Thereby, it will enable a more accurate soil assessment and the design of its effective protection, rehabilitation, and sustainable utilization measures (Sadigov, 2022a; Jafarova and Aliev, 2020).

Alluvial meadow-forest soils are typically prevalent in the estuarine regions of Azerbaijan's river system. Under xerophytic forest and shrub vegetation in a climatic regime, these soils develop that closely resemble the Mediterranean type. Such a climate is distinct with hot and dry summers, extended warm autumns, and relatively mild winters. The average annual air temperature ranges between 8.4 °C and 10.8 °C, while in the coldest months, the mean temperature varies from 1.7 °C to 3.8 °C. Snow cover is typically transient, and soil freezing is rare. The biologically inactive phase of soil formation is relatively brief, lasting approximately 30 days, usually from June to August.

Annual precipitation ranges from 250 to 400 mm, mostly falling in the spring and autumn. Active thermal conditions appeared favorable for soil development and vegetation growth, with atmospheric and soil temperatures exceeding 10 °C for approximately 3400–4000 and 3500–5000 hours per year, respectively (International Soil Classification System for Naming Soil and Creating Legends for Soil Maps, 2014; Babaev *et al.*, 2017; Sadigov, 2018).

The topography of the basin is highly variable. The slope analysis revealed approximately 60% of the basin's terrain exhibited a slope gradient between 0° and 1.37°, while 15% falls within the 1.37°–4.72° range. The remaining 20% of the terrain comprised steeper slopes exceeding 4.72°, and the maximum gradients ranged between 25.19° and 50.2°. On slopes, these variations were particularly relevant to soil conservation, as erosion processes typically intensify on slopes greater than 2–3 degrees (Ghanbarian and Daigle, 2015; Sadigov *et al.*, 2024) (Figure 1).

Alluvial meadow-forest soils' characterization showed a relatively shallow humus layer overlaying a clay-rich subhorizon in this region. However, these soils enunciated better structural aggregation, distinct horizonation, and the presence of carbonate-illuvial layers. The total profile thickness considerably varied based on topographic position and erosion intensity. On gentle southern and southeastern slopes, profile thickness generally does not exceed 50–60 cm. Carbonate accumulations are frequently noticeable even within the upper humus horizons, reflecting both climatic influence and parent material characteristics. Generating a new digital elevation model (DEM) to support terrain analysis and soil conservation planning used interpolation techniques applied to elevation data derived from historical topographic maps. This refined DEM developed by using ArcGIS 10.3 served as the basis for constructing detailed slope and relief maps of the Shamkirchay reservoir basin (Figure 1). Mapping slope gradients is essential for identifying areas at risk of soil erosion and

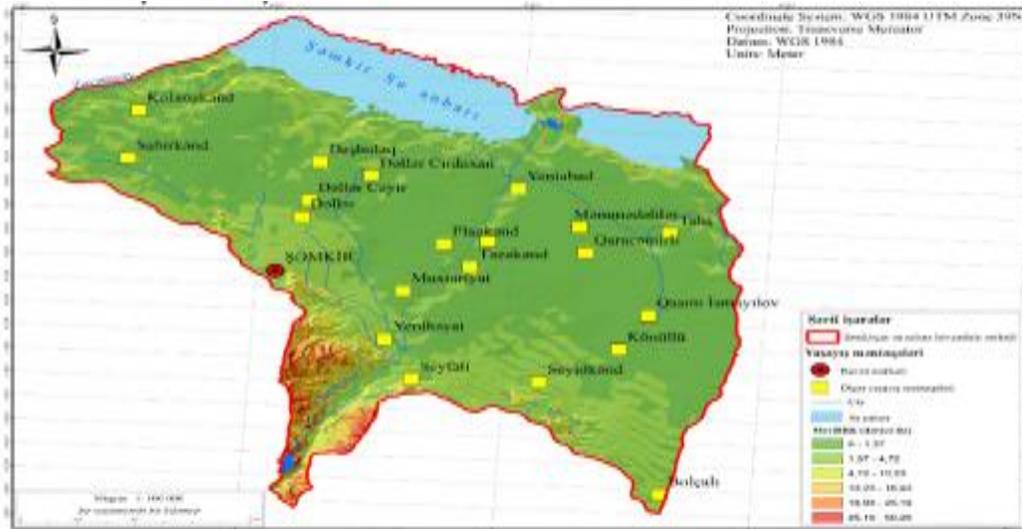


Figure 1. Slope-Aspect map of Shamkirchay reservoir basin (Prepared by Sadigov [2024]).

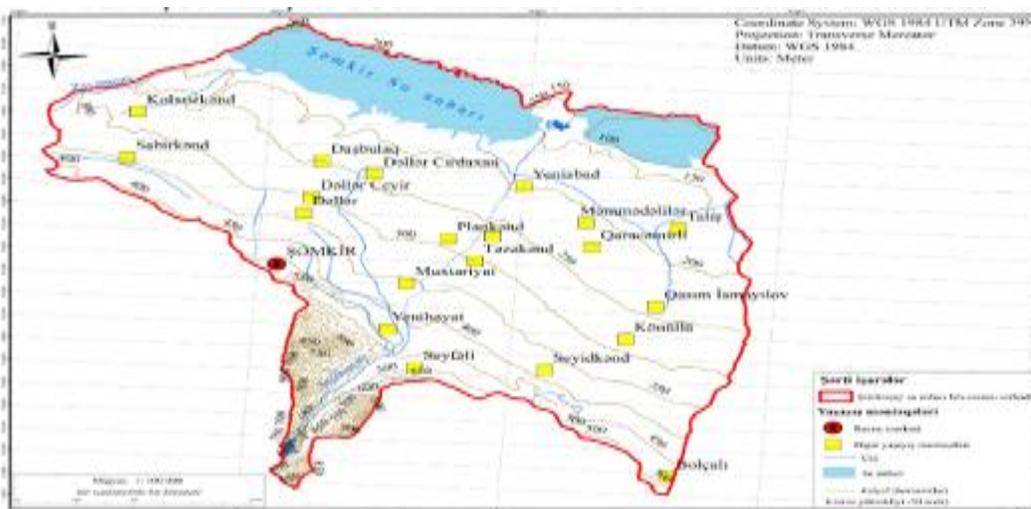


Figure 2. Relief map of the basin of the Shamkirchay reservoir (Prepared by Sadigov [2024]).

developing the design of effective erosion control measures. The indicators of minimum and maximum values of slope utilized standardized map symbols. Therefore, it is important to mention that soil erosion processes typically initiate when slope gradients exceed 2–3 degrees, highlighting the need for targeted soil protection strategies in these vulnerable areas (Ministry of Agriculture of Azerbaijan State Land Management Project Institute, 2020; Mammadov *et al.*, 2025).

MATERIALS AND METHODS

The depicted research focused on alluvial meadow-forest soils located in the Yeni Shamkirchay reservoir basin, with an area of 558.76 hectares. These soils sit primarily in lower elevation zones of the basin and play a vital role in agricultural development and ecological stability. Following a detailed study plan, fieldwork conducted along pre-established transects took place from 2018 to

Table 1. Sections of geographic coordinates in soils of the alluvial meadow-forest type.

No.	Section number	X-coordinate (east longitude)	Y-coordinate (northern latitude)
1	Soil section 85	X.46 ° 17 ' 25 " E	Y.40 ° 54 ' 59 " N
2	Soil section 126	X.46 ° 13 ' 22 " E	Y.40 ° 55 ' 15 " N
3	Soil section 127	X.46 ° 13 ' 59 " E	Y.40 ° 54 ' 47 " N
4	Soil section 128	X.46 ° 15 ' 17 " E	Y.40 ° 54 ' 38 " N
5	Soil section 143	X.46 ° 04 ' 28 " E	Y.40 ° 44 ' 20 " N
6	Soil section 144	X.46 ° 03 ' 67 " E	Y.40 ° 42 ' 36 " N

the summer of 2025. Soil profiles incurred description and sampling from eight designated plots located in areas with mountain-forest brown (Dystric Cambisols-DVv) soils. The locations of the sampling sites succeeded in their determination using GPS coordinates obtained with a Garmin GPSMAP 62s device (Table 1). Soil profile layers reached classification, and the diagnostic features, such as color, texture, structure, compaction, and horizonation, obtained documentation (Gumbatov *et al.*, 2024; Sadigov *et al.*, 2024).

Laboratory analyses proceeded in certified laboratories at the Institute of Soil Science and Agrochemistry under the Ministry of Science and Education of Azerbaijan, as well as at the Azerbaijan State University of Economics (UNEC), Azerbaijan. All the conducted analyses employed recognized methodologies currently used in soil science research (Kashinsky, 1970; Kovda, 1973; *Dospekhov*, 1984; State Standard of the Republic of Azerbaijan, 2013; FAO, 2020).

In soil analyses, the study used the following different instruments with recommended methodologies: humus content (determined using the I.M. Tyurin wet oxidation method); total nitrogen — N (assessed by the Kjeldahl method); carbonate content — CaCO₃ (measured by calcimetry and titration); total phosphorus — P and potassium — K (quantified using ICP-MS — Agilent); granulometric composition (determined using the N.A. Kachinsky pipette method); cation exchange capacity CEC (assessed through D. Ivanov method — absorbed cations); hygroscopic moisture (determined thermally at 105 °C); and soil reaction pH (measured in a 1:5 soil-to-water suspension using a pH meter). The nitrogen forms studied were the absorbed ammonium (Kononov method), water-soluble ammonia (Nesler method), and

nitrate content—NO₃⁻ (Grandval-Lajoux method).

The studied soils bore classification according to the World Reference Base for Soil Resources (WRB) and correlation with the national soil classification system of Azerbaijan. Developing a comprehensive soil map used ArcGIS 10.3, integrating soil survey data with digital elevation data to illustrate the spatial distribution and variation of alluvial meadow-forest soils across the basin. The accuracy and consistency of the analytical results attained confirmation using mathematical-statistical analysis based on the methodology of *Dospekhov* (1984). This ensured the reliability of both field and laboratory data for further interpretation.

A new digital elevation model (DEM) with low distortion succeeded in its development by interpolating elevation data derived from historical topographic maps. Slope gradient maps' generation also ran in ArcGIS 10.3 to assess erosion risk zones and support land-use planning. Soil erosion processes entailed recording to initiate at the slope gradients of 2°–3°, making slope mapping critical for sustainable soil management. The spatial arrangement of the soil sampling plots and soil sections illustrations appear in Figure 3 (Sadigov *et al.*, 2025; Shukurov *et al.*, 2025).

RESULTS AND DISCUSSION

In the Shamkirchay reservoir basin, the formed soils have long been useful for agricultural purposes. In assessing their current state, a series of granulometric and morphological analyses continued on soil samples collected during the field study. The results provided

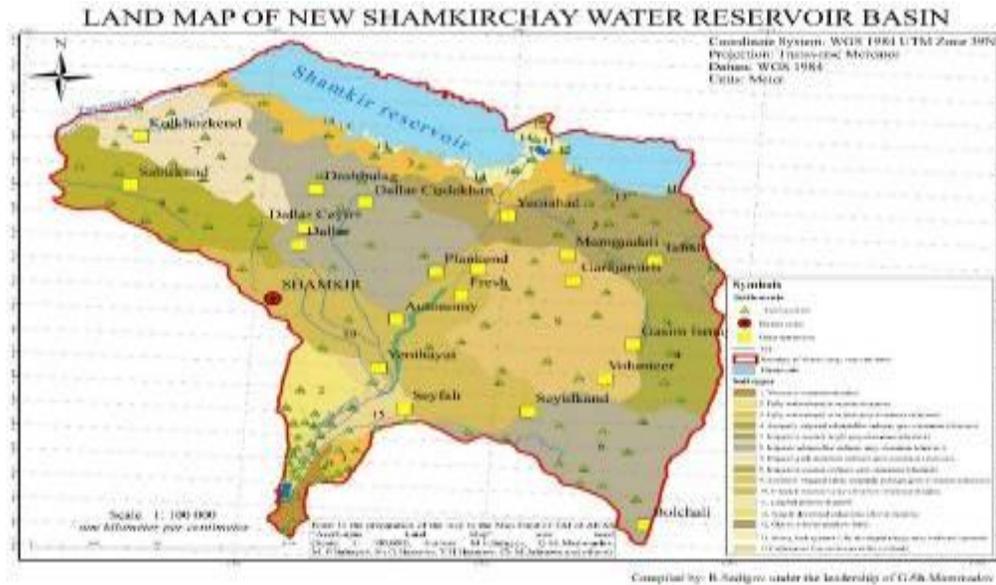


Figure 3. Land map of the Shamkirchay water reservoir basin (Prepared by Sadigov [2024]).

insights into the physical and morphological properties of the alluvial meadow-forest soils that achieved notable shaping by natural processes and anthropogenic impact (Jafarov and Aliev, 2020; Huseynov *et al.*, 2025).

The detection of the soil granulometric composition was successful in the absolutely dry soil samples collected at various sampling points across the basin. The alluvial meadow-forest soils fall within the category of medium to heavy clay soils (Table 2). The particle-size distribution supports their classification as fine-textured soils, which show typical association with reduced permeability and increased water retention capacity, with these factors found crucial for both agricultural productivity and erosion risk. These soils also received an anthropogenically modified alluvial meadow-forest soils category based on the World Reference Base for Soil Resources (WRB). The uppermost accumulative humus horizon (AUca) ranges from two to 18 cm in thickness, with characteristics of a light to dark brown shade and a fine granular structure. In this layer, the humus content ranges between 3.46% and 4.06%, indicating moderate fertility. In these profiles, the soil horizons with vertical development revealed the following sequence:

A₀ → AUca → A/Bca → B/Cgca → AUgca → Clgca → AU^h_{gca} → ClI_{gca}

Morphological analysis of profile section 85

The morphological analysis detailed the Soil Profile Section 85 in the depicted study site with coordinates X: 46°17'25" E, Y: 40°54'59" N. The said profile exhibited the distinct genetic horizons, described as follows:

A₀ (0–2 cm)—organic forest litter composed of decomposed leaf matter. AUca (2–17 cm)—dark brown, finely granular, humus-rich layer with high porosity and better air permeability. The structure was granular to weakly blocky; roots and rhizomes were abundant. It slightly effervesces with HCl, indicating the beginning of carbonate accumulation. A/Bca (17–31 cm)—transitional horizon, light brownish-gray in color, with a less distinct structure. Fewer plant roots were visible. Low moisture content and the weak effervescence under HCl indicate minimal carbonate presence.

B/Cgca (31–52 cm)—silt-dominated, compact and heavy clay horizon, light brown, and low in organic content. It contains rust

Table 2. Granulometric composition of alluvial meadow-forest 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	1-0.25	0.005-0.001	<0.001	<0.01
1	2	3	4	5	6	7	8	9
85	AO 0-2	Forest floor						
	AU _{ca} 2-17	5.91	12.10	6.79	13.94	12.16	12.56	36.54
	A/B _{ca} 17-31	2.29	17.85	8.53	12.09	14.98	11.36	32.90
	B/Cgca 31 -52	4.73	10.72	7.24	10.78	12.44	13.20	24.13
	AUgca 52-83	5.17	7.42	11.46	8.49	17.28	11.16	39.02
	Clgca 83-127	3.44	13.49	9.28	14.82	22.16	8.79	28.02
	AU ^h _{gca} 127-159	4.77	4.32	4.68	11.09	14.69	19.37	41.08
	ClIlgca 159 -198	7.21	9.63	10.88	13.93	23.75	9.74	24.86
126	AO 0-2	Forest floor						
	AU _{ca} 2-16	4.25	7.1	6.5	5.6	5.9	16.44	54.21
	A/B _{ca} 16-30	3.75	5.18	4.25	3.1	4.9	15.35	63.47
	B/Cgca 30 -58	7.25	8.1	6.8	7.64	8	18.37	42.84
	AUgca 58-86	4.85	5.9	5.35	4.8	5.62	14.32	59.16
	Clgca 86-119	8.45	7.75	12.5	13.1	13.02	7.11	38.07
	AU ^h _{gca} 119-145	3.25	4.1	3.0	2.2	2.17	18.46	66.82
	ClIlgca 145 -169	8.9	7.4	11.5	13.00	11.54	9.78	37.88
127	AO 0-2	Forest floor						
	AU _{ca} 2-15	4.8	3.95	3.6	4.3	3.26	16.91	63.18
	A/B _{ca} 15-29	5.4	4.3	3.2	4.5	3.59	17.28	61.73
	B/Cgca 29 -51	7.15	8.52	4.28	5.15	4.99	10.17	59.69
	AUgca 51-78	6.75	5.8	4.4	5.6	4.4	15.73	57.32
	Clgca 78-116	8.27	9.13	7.55	8.75	6.36	11.73	48.21
	AU ^h _{gca} 116-139	3.7	4.2	2.1	2.3	1.85	18.67	67.18
	ClIlgca 139 -157	8.7	7.8	11.2	12.1	13.78	8.84	37.58
128	AO 0-2	Forest floor						
	AU _{ca} 2-17	5.1	3.8	4.2	5.5	4.69	18.34	58.37
	A/B _{ca} 17-32	4.7	3.85	3.9	4.0	4.41	19.51	59.63
	B/Cgca 32 -49	5.1	4.02	3.5	4.28	4.06	10.44	52.88
	AUgca 49-83	5.82	3.89	4.45	4.22	4.39	18.07	59.16
	Clgca 83-120	8.43	7.52	9.12	10.25	8.3	9.96	46.42
	AU ^h _{gca} 120-144	4.75	4.1	4.45	5.02	5.6	17.17	58.91
	ClIlgca 144 -172	8.55	7.75	9.40	11.2	7.21	10.41	45.48
143	AO 0-2	Forest floor						
	AU _{ca} 2-15	8.65	7.75	11.10	12.3	10.07	12.58	36.55
	A/B _{ca} 15-33	8.95	7.65	12.5	13.2	13.48	11.31	32.91
	B/Cgca 33 -58	9.1	8.32	14.2	15.38	15.6	13.25	24.15
	AUgca 58-89	8.35	7.75	11.25	12.00	10.47	11.13	39.05
	Clgca 89-124	9.45	8.3	15.1	15.0	15.37	8.77	28.01
	AU ^h _{gca} 124-156	7.35	8.19	7.5	8.25	8.31	19.35	41.05
	ClIlgca 156 -187	9.1	8.55	15.8	16.7	15.23	9.73	24.89
144	AO 0-2	Forest floor						
	AU _{ca} 2-18	4.85	5.3	6.2	6.5	6.47	16.45	54.23
	A/B _{ca} 18-32	4.65	4.85	3.9	4.15	3.66	15.38	63.41
	B/Cgca 32 -54	7.4	8.2	7.8	7.7	7.75	18.33	42.82
	AUgca 54-85	6.48	5.2	4.3	5.12	5.48	14.31	59.11
	Clgca 85-121	8.7	7.6	12.0	13.5	12.99	7.15	38.05
	AU ^h _{gca} 121-145	3.64	3.85	2.9	2.66	1.63	18.49	66.83
	ClIlgca 145 -166	8.45	7.55	11.5	12.3	12.62	9.75	37.83

mottling and signs of moisture fluctuation. Effervesces slightly with HCl, indicating deeper carbonate accumulation. AUgca (52–83 cm)—interface with parental material, composed of clay with embedded stones and pebbles covered with carbonate coatings. The structure was hard, compact, and weakly effervescent in reaction with HCl. Clgca (83–127 cm)—hard, loess-like, gypsum-bearing fine sediments mixed with soil-forming rocks. Low moisture, indistinct structure, and weak effervescence with HCl confirm the carbonate presence in deeper substrata.

AU^hgca (127–159 cm)—light brownish-gray, granular, heavy clay with occasional large roots and gypsum specks. Weakly effervescent under HCl and low in organic matter and moisture. Clgca (159–198 cm)—basal horizon composed of compact loess-like and gypsum-rich parental material. It contains small and large stones, indistinct in structure, and weakly effervescent under HCl, consistent with secondary carbonate and gypsum accumulation.

The main diagnostic parameters of alluvial meadow-forest soils across six sampled sections (Sections 85, 126, 127, 128, 143, and 144) are available in Table 3. The soil parameters analyzed include humus content (%), total nitrogen (%), carbonate content (CaCO₃, %), total absorbed bases (TAB, mg-eq), hygroscopic moisture (%), soil reaction (pH), mobile phosphorus (mg/kg), and exchangeable potassium (mg/kg). Humus content showed an obvious decline with depth across all the sampled profiles. However, the maximum values recorded resulted in the surface AUca horizon, ranging from 4.06% to 3.46%. These values progressively decreased in deeper horizons: A/Bca: 2.61%–1.45%, B/Cgca: 1.18%–0.98%, AUgca: 4.41%–2.09%, Clgca: 1.13%–0.81%, AUhgca: 3.18%–2.34%, and Clhgca: 0.89%–0.79%.

These results suggested moderate to better humus accumulation in surface and upper subsoil layers, contributing positively to soil fertility and biological activity. A comparative analysis with data from other studies conducted in the same region indicates the highest humus content was consistently evident in the surface AUca horizon, ranging

from 5.13% to 3.79% (Hasanov, 2015). These findings reflect the typical vertical distribution of organic matter in alluvial meadow-forest soils and underscore the limited humus accumulation in subsoil layers (Hasanov, 2018).

Total nitrogen content exhibited a distribution pattern similar to that of humus, with the highest concentration found in the AUca horizon (0.289%–0.251%), and recording a steady decrease was gradual with the depths A/Bca: 0.198%–0.125%, B/Cgca: 0.109%–0.096%, and AUgca: 0.311%–0.166%. However, no analysis of the nitrogen contents transpired in the Clgca, AUhgca, and Clhgca layers. The results highlighted the organic-rich upper horizons as the primary source of nitrogen for plant uptake.

The distribution of total nitrogen content closely mirrors that of humus, with the optimum concentration recorded in the surface AUca horizon (0.289%–0.251%), and a gradual decline prevailed in deeper layers. Specifically, in the A/Bca horizon, the nitrogen levels ranged from 0.198% to 0.125%; in B/Cgca, 0.109% to 0.096%; and in Augca, 0.311% to 0.166%. Additional analysis in three horizons, Clgca, AUhgca, and Clhgca, revealed the values of 0.112%–0.096%, 0.244%–0.213%, and 0.105%–0.087%, respectively. These findings confirmed the organic-rich upper horizons serve as the principal nitrogen reservoirs, which are crucial in supporting plant nutrition in alluvial meadow-forest soils (Hasanov, 2015, 2018).

The calcium carbonate (CaCO₃) content slightly varied among the horizons; however, it remained consistently high, reflecting the calcareous nature of these soils. The maximum CaCO₃ content appeared in the AUca horizon (6.94%–5.63%), with comparable values in the lower horizons, i.e., A/Bca (6.55%–5.34%), B/Cgca (6.43%–5.83%), AUgca (6.48%–5.54%), Clgca (6.31%–5.31%), AUhgca (6.48%–5.74%), and Clhgca (6.37%–5.51%). The highest CaCO₃ content resulted in the surface AUca horizon (7.16%–5.89%), with relatively consistent values across the lower soil horizons. Specifically, CaCO₃ content ranged from 7.52% to 5.11% in the A/Bca horizon, 6.71% to

Table 3. Main diagnostic indicators of clearings of existing alluvial meadow-forest soils in the basin of the Shamkirchay reservoir.

Section	Depth (cm)	Humus (%)	Nitrogen (%)	CaCO ₃ (%)	TAB (mg-eq)	Hyg. Humidity (%)	pH	P ₂ O ₅ (mg/kg)	K (mg/kg)
1	2	3	4	5	6	7	8	9	10
85	AO 0-2	Forest floor							
	AU _{ca} 2-17	3.74	0.269	5.63	30.16	5.63	7.2	30.15	462
	A/B _{ca} 17-31	1.47	0.127	5.34	25.31	5.34	7.7	35.26	423
	B/Cgca 31 -52	1.18	0.109	6.19	23.72	6.19	7.9	27.75	371
	AUgca 52-83	2.09	0.166	6.30	31.01	6.30	7.3	25.66	330
	Clgca 83-127	0.87	Not anal.	5.37	18.47	5.37	7.9	17.28	293
	AU ^h _g ca 127-159	3.05	-----	6.48	28.67	6.48	7.4	15.69	287
	ClIlgca 159 -198	0.79	-----	5.77	19.34	5.77	8.2	14.38	264
126	AO 0-2	Forest floor							
	AU _{ca} 2-16	3.46	0.251	6.15	31.32	6.15	7.2	32.44	449
	A/B _{ca} 16-30	1.94	0.156	6.47	29.78	6.47	7.2	23.66	431
	B/Cgca 30 -58	1.02	0.098	6.22	25.37	6.22	7.6	18.47	402
	AUgca 58-86	2.73	0.268	5.54	26.44	5.54	6.7	16.31	396
	Clgca 86-119	0.97	Not anal.	6.29	13.86	6.29	7.4	14.98	347
	AU ^h _g ca 119-145	3.14	-----	6.18	24.04	6.18	6.9	12.37	379
	ClIlgca 145 -169	0.89	-----	5.52	17.59	5.52	7.3	11.44	327
127	AO 0-2	Forest floor							
	AU _{ca} 2-15	3.84	0.275	6.94	33.42	6.94	7.5	32.66	378
	A/B _{ca} 15-29	1.93	0.156	6.51	31.93	6.51	7.5	29.37	359
	B/Cgca 29 -51	0.98	0.096	6.43	27.11	6.43	7.7	17.79	324
	AUgca 51-78	3.42	0.249	6.41	23.53	6.41	7.4	15.74	301
	Clgca 78-116	0.95	Not anal.	5.71	15.06	5.71	7.8	13.93	358
	AU ^h _g ca 116-139	2.34	-----	5.74	26.17	5.74	7.5	10.84	328
	ClIlgca 139 -157	0.79	-----	6.37	16.15	6.37	7.9	9.46	282
128	AO 0-2	Forest floor							
	AU _{ca} 2-17	4.06	0.289	5.99	32.91	5.99	7.1	32.58	358
	A/B _{ca} 17-32	2.61	0.198	6.16	30.05	6.16	7.3	29.63	347
	B/Cgca 32 -49	1.19	0.109	5.83	31.52	5.83	7.3	26.43	302
	AUgca 49-83	4.41	0.311	6.48	27.44	6.48	6.8	24.43	296
	Clgca 83-120	1.13	Not anal.	6.31	14.84	6.31	7.0	21.96	257
	AU ^h _g ca 120-144	3.02	-----	6.43	24.04	6.43	6.8	18.78	243
	ClIlgca 144 -172	0.88	-----	5.92	15.59	5.92	7.1	16.27	238
143	AO 0-2	Forest floor							
	AU _{ca} 2-15	3.75	0.269	5.68	30.12	5.68	7.2	30.15	468
	A/B _{ca} 15-33	1.45	0.125	5.41	25.34	5.41	7.8	35.28	421
	B/Cgca 33 -58	1.14	0.106	6.23	23.77	6.23	7.9	27.81	377
	AUgca 58-89	2.11	0.166	6.28	31.05	6.28	7.3	25.54	335
	Clgca 89-124	0.81	Not anal.	5.31	18.48	5.31	7.9	17.31	298
	AU ^h _g ca 124-156	3.07	-----	6.45	28.69	6.45	7.3	15.61	288
	ClIlgca 156 -187	0.83	-----	5.78	19.32	5.78	8.3	14.35	261
144	AO 0-2	Forest floor							
	AU _{ca} 2-18	3.48	0.252	6.17	31.38	6.17	7.3	32.45	443
	A/B _{ca} 18-32	1.91	0.154	6.55	29.75	6.55	7.3	23.61	431
	B/Cgca 32 -54	1.05	0.100	6.21	25.31	6.21	7.8	18.48	403
	AUgca 54-85	2.78	0.208	5.58	26.48	5.58	6.8	16.33	398
	Clgca 85-121	0.93	Not anal.	6.27	13.87	6.27	7.5	14.98	345
	AU ^h _g ca 121-145	3.18	-----	6.15	24.05	6.15	6.5	12.31	378
	ClIlgca 145 -166	0.87	-----	5.51	17.55	5.51	7.4	11.15	325

5.17% in the B/Cgca, 6.04% to 5.54% in the Augca, 7.66% to 6.02% in the Clgca, 7.45% to 5.98% in the AUhgca, and 6.77% to 5.82% in the Cllgca. The results revealed a uniform vertical distribution of carbonate content throughout the soil profile, suggesting stable geochemical conditions and effective buffering capacity within the alluvial meadow-forest soils of the Shamkirchay reservoir basin (Sadigov 2022; Sadigov *et al.*, 2024; Mustafayev *et al.*, 2025).

The total absorbed bases also decreased with depth, showing the highest values in the AUca horizon (33.48–30.12 mg-eq) and the lowest in the deep horizon Cllgca (18.48–13.86 mg-eq). Other values were A/Bca: 31.93–25.31, B/Cgca: 31.54–23.72, AUgca: 31.05–23.53, Clgca: 6.66–5.31, and AUhgca: 6.48–5.74 mg-eq. Hygroscopic moisture values, reflecting the water-retention capacity of the soils, followed a pattern similar to carbonate content: AUca: 7.15%–5.63%, A/Bca: 7.01%–5.34%, B/Cgca: 6.84%–5.83%, AUgca: 6.73%–5.54%, Clgca: 6.66%–5.31%, AUhgca: 6.48%–5.74%, and Cllgca: 6.96%–5.51%. The pH values ranged from slightly neutral to moderately alkaline across the profile: AUca: 7.8–7.1, A/Bca: 7.8–7.4, B/Cgca: 7.9–7.3, AUgca: 7.4–6.7, Clgca: 7.9–7.0, AUhgca: 7.5–6.5, and Cllgca: 8.3–7.1. Mobile phosphorus levels (mg-eq) also showed significant decreases with depth, i.e., AUca: 35.59–30.15, A/Bca: 35.28–23.61, B/Cgca: 27.81–17.49, AUgca: 25.66–15.73, Clgca: 21.96–13.93, AUhgca: 18.78–10.81, and Cllgca: 16.27–9.41. Exchangeable potassium values (mg-eq) were the highest in surface horizons and gradually declined with depth, i.e., AUca: 468–354, A/Bca: 431–344, B/Cgca: 403–302, AUgca: 398–296, Clgca: 358–255, AUhgca: 379–243, and Cllgca: 327–231.

In comparison, the results obtained by Babaev *et al.* (2011, 2017) were as follows. In the AUvz layer, the hygroscopic humidity ranged from 8.83% to 5.42%, 8.49%–6.96% in AUz, 8.22%–6.65% in Bca, 8.16%–6.23% in B/Crca, and 8.44%–5.67% in SkaL. The pH in the AUvz layer had a range of 7.6–7.4, 7.6–7.5 in AUz, 7.5–7.4 in Bca, 7.4–7.2 in B/Cgca, and 7.6–7.2 in the layer. The total phosphorus ranges from 30.94 to 25.42 mg/kg (AUvz),

28.32 to 22.71 mg/kg (Auz), 26.16 to 21.47 mg/kg (Bca), and 20.62 to 19.08 mg/kg (B/Cgca).

The latest study presents the results of extensive soil-ecological investigations conducted on the alluvial meadow-forest soils of the Shamkirchay reservoir basin from 2018 to 2025. Using modern sampling and analytical techniques, the soil's key physicochemical properties and nutrient contents underwent examination. The granulometric composition across the genetic profiles of the alluvial meadow-forest soils obtained a thorough characterization, revealing a range of texture classes primarily within medium to heavy clay categories. Morphogenetic analysis ensued to better understand the soil formation processes and horizon differentiation. A detailed morphological description was available for a representative soil-profile section (Section 85), located in the characteristic area of the studied basin (Sadigov and Macnunlu, 2023).

The soil horizons described include A₀, AUca, A/Bca, B/Cgca, AUgca, Clgca, AUhgca, and Cllgca, with their physical and structural characteristics recorded in the field. Diagnostic parameters critical to soil classification and fertility, such as humus content, total nitrogen, calcium carbonate (CaCO₃), total absorbed bases (TAB, mg-eq), soil hygroscopic moisture, pH, mobile phosphorus, and exchangeable potassium, also attained quantification in the laboratory using recognized methods. The accuracy and reliability of the results obtained validation statistically using the methodology of Dospekhov (1984). These results provide a comprehensive overview of the soil quality and fertility status within the Shamkirchay reservoir basin, forming a solid base for further soil management and conservation efforts in the region.

CONCLUSIONS

In alluvial meadow-forest soils of the Shamkirchay reservoir basin, the analyses of eight soil profiles showed moderate fertility in surface layers, with structural degradation and nutrient depletion in deeper horizons. These medium-to-heavy clay soils exhibited poor

aeration and water permeability, with compacted A_Ugca and C_lgca layers, limiting infiltration and increasing erosion risk. Humus content and essential nutrients like nitrogen, phosphorus, and potassium considerably declined with depth, reflecting limited organic input and the effect of prolonged agricultural practices. Despite stable carbonate levels maintaining slightly alkaline pH, the reduction in exchangeable bases highlights ongoing fertility loss.

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