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GROUP AND FRACTIONAL COMPOSITION OF HUMUS IN THE SOILS OF THE LOWER AMU DARYA REGION

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Abstract: Humus is one of the key components of soil, determining its physical, chemical, and biological properties. The analysis of humus fractions in the soils of the Lower Amu Darya region is of great importance for improving soil fertility and ensuring ecosystem stability. Humus fractions are formed as a result of soil organic matter accumulation, its decomposition, and complex interactions among organic and mineral components.

The fractional composition of humus reflects its multifunctional nature and the ways it changes under different ecological conditions. Each fraction, characterized by specific chemical and physical properties, plays a distinct role in soil processes. For instance, heavy fractions are generally enriched with heavy metals, mineral components, and other nutrients, contributing to soil structural stability. In contrast, light fractions contain easily decomposable organic compounds and serve as a rapid source of nutrients for plants.

This article provides a detailed analysis of the group and qualitative composition of humus fractions in the soils of the Lower Amu Darya region. The influence of humus fractional composition on soil fertility, as well as recommendations for soil improvement, are discussed. The findings of this study are significant for the effective management of soil resources and the maintenance of agroecological sustainability.

Key words: meadow alluvial soils, depressed meadow alluvial soils, total humus content, humus quality composition, degree of humification, humic acid, fulvic acids.

Introduction: The composition of humus and its properties, the binding of humic acids with soil mineral components, and the diversity of their forms play an important role in determining the degree of soil cultivation and soil types. In this regard, identifying changes in the composition of soil organic matter is of significant importance.

The organic composition of soil varies in terms of quantity and quality, mainly due to the influence of various factors. The role of vegetation in the dynamics of humus formation is particularly substantial, and its strong influence has been confirmed by quantitative data. Therefore, studying the group and fractional composition of humus in irrigated soils is of great scientific and practical importance. Investigation of humus composition makes it possible to assess the intensity of humus formation processes and to develop measures aimed at enriching soils with organic matter.

Soil humus is not only an important morphogenetic indicator but also a key criterion of soil fertility. However, the accumulation of humus in soils, its transformation, and the formation of

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new generations of humus constitute a highly complex process that depends on a wide range of factors. Under natural soil-forming conditions, the development of the humus horizon and its subsequent evolution proceed primarily within the framework of natural environmental factors.

Humus is one of the most essential elements of soil fertility. Processes of soil structure formation, the state of soil water–air and thermal regimes, as well as the availability of nutrients, are closely related to the quantity and quality of humus. It is well known that different groups of soil humus (humic acids, fulvic acids, and humins) and their interactions with the mineral fraction of soil play a multifaceted role in plant nutrition and soil formation. From this perspective, the present study examines the qualitative and quantitative composition of humus in the main irrigated soils of selected massifs (Qamishariq, Bozatou, Shumanay, and Begjap) located in two districts (Chimboy and Shumanay) on the right and left banks of the Amu Darya delta, focusing on meadow-alluvial and takyr-like meadow soils.

Materials and Methods: The objects of the study are old-irrigated and newly irrigated meadow-alluvial and takyr-like meadow soils that are widely distributed in the Chimboy and Shumanay districts on the right and left banks of the Lower Amu Darya. The composition and group–fractional structure of humus substances in irrigated meadow soils were determined using the I. V. Tyurin method, modified by V. V. Ponomaryova and T. V. Plotnikova.

Under the conditions of the Republic of Karakalpakstan, a number of researchers have conducted studies on the composition and group–fractional structure of humus substances. Toshqo‘ziev M. M. carried out investigations on the left bank of the Lower Amu Darya and established that the humus composition is characterized as humate–fulvate, fulvate, and strongly fulvate types [1, pp. 97–110].

Studies on the composition and group–fractional structure of humus substances in the soils of Uzbekistan have also been conducted by several researchers. In particular, Toshqo‘ziev M. M. and Karimov X. X. investigated the fractional and group composition of humus in dark gray and typical gray soils distributed in the Tashkent oasis. Their results showed that humic acids accounted for 32.74–36.72% in irrigated dark gray soils and 35.74–40.14% in typical gray soils, while fulvic acids constituted 35.31–50.93% in non-irrigated dark gray soils and 44.12–48.54% in rainfed typical gray soils [2, pp. 70–77].

Najimova Iroda reported that humic acids within the humus fractional composition are widely distributed in soils and can interact with soil minerals and clay components to form soil aggregates. Humic acids play an important role in improving soil structure, increasing water-holding capacity, and enhancing resistance to erosion [3, pp. 59–63].

Xodjimuratov N. R. noted that under conditions of long-term irrigation and agricultural use in both old-irrigated and newly irrigated soils, organic matter accumulates not only in the upper horizons but throughout the entire soil profile. Along with an increase in humus content, its quality also improves with longer irrigation periods. As the proportion of all fractions of humic and fulvic acids increases, the share of non-hydrolyzable residues in humus decreases [4, pp. 534–538].

Yuldashov G. and Abdaxmanov T. emphasized that the qualitative indicators of humus, as well as its fractional and group composition, vary among different soil types and subtypes, and therefore require differentiated characterization. The group composition of humus consists of humic acids, fulvic acids, and humin substances [5, p. 238].

According to Shadiyeva N. I., various groups of humus substances in soils, including humic and fulvic acids, actively interact with the mineral fraction of soils and play a significant role in

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plant physiological and biochemical processes, as well as in soil formation, highlighting their multifaceted importance [6, p. 27].

Studies conducted by Toshqo‘ziev M. M. and S. Q. Ochilov [7, pp. 129–152] on irrigated soils of the Kashkadarya basin showed that, in terms of the group composition of humus, humic acids predominate over fulvic acids in the organic matter–rich topsoil layer. This indicates a well-structured condition of the upper horizons. The content of humic acids decreases downward along the soil profile, whereas the proportion of fulvic acids increases with depth.

Based on the research results obtained by Toshqo‘ziev M. M. and Shadiyeva N. I., comprehensive scientific studies were conducted on the main properties, humus status, and group–fractional composition of humus in zonal soil types. These included rainfed and irrigated eroded light gray, typical gray, dark gray, and carbonate brown soils, with a focus on their fertility status and ways to improve soil productivity [8, pp. 78–81].

Toxirova Z. R. reported that fulvic acids represent the second major component of humus and belong to nitrogen-containing high-molecular-weight oxycarboxylic acids. Fulvic acids differ from humic acids by their lighter color, higher solubility in water and mineral acids, and greater susceptibility to acidic hydrolysis [9, pp. 1514–1518].

Qorabekov O. G. determined the fractional and group composition of humus in hydromorphic soils of the Tashkent oasis. His studies revealed a high content of calcium-bound humic and fulvic acids in the second fraction, leading to the conclusion that humic acids are predominantly incorporated into the humin fraction of soil organic matter [11, p. 95].

Results and Discussion: The conducted studies revealed that the group and fractional composition of humus varies depending on the distribution of soils within geomorphological zones, as well as on soil type and subtype. In the genetic horizons of the studied soils, the total humus content in the plow and subplow layers of meadow-alluvial soils ranged from 0.826 to 1.120% in the “Shumanay” massif, from 0.905 to 1.304% in the “Begjap” massif, and from 0.919 to 1.162% in the “Qamishariq” massif. Correspondingly, in the lower horizons of these massifs, humus content decreased to 0.479–0.531%, 0.495–0.850%, and 0.425–0.819%, respectively. In contrast, takyr-like meadow soils distributed in the “Bozatau” massif exhibited considerably lower values, with humus content of 0.570–0.719% in the plow and subplow layers, decreasing to 0.290–0.315% in the lower horizons (Table 1).

In the “Shumanay” massif (Profile 5), newly irrigated meadow-alluvial soils showed an organic carbon content of 0.479–0.650% in the plow and subplow layers and 0.278–0.308% in the lower horizons. According to the fractional composition of humus substances, the calcium-bound second fraction accounted for approximately 10.23–12.93%. The first fraction of humic acids, consisting of free forms and those associated with mobile sesquioxides, comprised 5.76–6.37%. In this profile, the third fraction, strongly bound with clay particles and sesquioxides, ranged from 10.44 to 12.47%, with an increase observed in the deeper 107–131 cm layer (12.32%).

The content of fulvic acids in the second fraction increased from the upper to the lower horizons, ranging from 5.64 to 14.04%, while the third fraction varied between 7.24 and 13.78%. The first fraction of fulvic acids accounted for 4.16–9.88%. In the analyzed soil samples, the portion associated with aggressive fulvic acids (fraction 1a) constituted 5.23–8.92%. A comparison between the second fractions of humic and fulvic acids showed that humic acids predominated in the plow and subplow layers, whereas the second fraction of fulvic acids became dominant in the deeper horizons.

The content of hydrolyzable substances in newly irrigated meadow-alluvial soils ranged from 54.80 to 71.14%, while the proportion of non-hydrolyzable residues was 0.70–1.37 times higher. Accordingly, the upper horizons of these soils can be classified as humate–fulvate and fulvate types, whereas the lower horizons predominantly belong to the fulvate type [10].

In the “Begjap” massif (Profile 2), newly irrigated meadow-alluvial soils exhibited organic carbon content in the plow and subplow layers ranging from 0.525 to 0.756%, decreasing to 0.287–0.493% in the lower horizons. The second fraction of humic acids accounted for 9.34–10.84% in the plow and subplow layers, while in the lower horizons it ranged from 8.49 to 8.71%. The third fraction contained lower amounts compared to the second fraction, ranging from 5.48 to 7.24%. The first fraction, consisting of free humic acids and those bound with mobile sesquioxides, was relatively low, at 4.53–6.29%.

In the same profile, the second fraction of fulvic acids ranged from 12.07 to 20.19% in the plow and subplow layers and 11.68–21.60% in the lower horizons. The third fraction, strongly bound with clay particles and sesquioxides, increased from 6.88–9.91% in the upper horizons to 12.10–13.24% in the lower horizons. The first fraction of fulvic acids varied between 3.04 and 5.92%. Comparison of the second fractions of humic and fulvic acids showed that fulvic acids were more predominant. The content of aggressive fulvic acids (1a fraction) ranged from 3.57 to 4.84%. Hydrolyzable substances ranged from 48.90 to 64.13%, while the proportion of non-hydrolyzable residues was 0.42–0.68, classifying the soils as highly fulvate to fulvate types.

In the “Qamishariq” massif of the Chimboy district, old-irrigated meadow-alluvial soils (Profile 6) exhibited organic carbon contents of 0.674% in the plow layer and 0.533% in the subplow layer, decreasing to 0.247–0.475% in the lower horizons. In the calcium-bound second fraction of humic acids, the plow and subplow layers contained 6.19–7.05%, middle horizons 6.11–6.68%, and lower horizons 5.48–5.84%. The third fraction ranged from 4.87 to 6.38%. The first fraction, comprising free and mobile sesquioxide-bound humic acids, varied between 2.60–4.88% in the upper horizons and 2.63–4.46% in the lower horizons.

Fulvic acid content increased from the upper to lower horizons in the second fraction, with values of 17.14–21.39% in the upper, 24.21–24.42% in the middle, and 23.33–25.42% in the lower horizons. In the third fraction, strongly bound with clay and sesquioxides, the middle horizons had higher contents (15.86–16.42%) compared to the upper (11.57–13.88%) and lower (12.57–15.82%) horizons. The first fraction was very low, ranging from 2.60 to 5.43%. Consequently, the second fraction of fulvic acids was 3.2–3.6 times higher than that of humic acids. The aggressive fulvic acid (1a fraction) ranged from 4.38 to 6.90%, showing low to medium levels. Hydrolyzable substances ranged from 54.09 to 69.40%, and the proportion of non-hydrolyzable residues varied from 0.35 to 0.53, classifying these soils as highly fulvate to fulvate types.

In the “Bozatau” massif (Profile 4) on the right bank of the Lower Amu Darya, takyr-like meadow soils exhibited very low organic carbon content, ranging from 0.168 to 0.417%. In the calcium-bound second fraction of humic acids, values decreased from the plow and subplow layers to the lower horizons, ranging between 9.93 and 13.43%. The third fraction ranged from 10.59–11.27% in the upper horizons and decreased to 8.88–9.53% in the lower horizons. The first fraction, compared to the other two fractions, was lower, fluctuating between 8.36 and 10.07%.

For fulvic acids, the second fraction associated with calcium ranged from 10.28–15.59% in the plow and subplow layers and 3.20–4.54% in the lower horizons, with minimal differences observed between layers. The third fraction, strongly bound with clay particles and sesquioxides, ranged from 11.51 to 16.64%, while the first fraction varied between 3.36 and 14.07%. The

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aggressive fulvic acid (1a fraction) accounted for 5.67–8.17%, indicating a medium level. Hydrolyzable substances ranged from 65.80 to 76.00%, while the proportion of non-hydrolyzable residues was 0.69–0.94, classifying these soils as fulvate and humate–fulvate types.

Based on the research results, in the Shumanay ("Shumanay" and "Begjap" massifs) and Chimboy ("Qamishariq" and "Bozatau" massifs) districts, the group and fractional composition of humus in meadow-alluvial and takyr-like meadow soils showed that the second and third fractions of humic and fulvic acids predominated, depending on the soil's genetic horizon and type. Organic carbon content was lower in takyr-like meadow soils compared to meadow-alluvial soils. Overall, the studied soils were classified as fulvate and humate–fulvate, with some horizons belonging to the highly fulvate type.

In hydromorphic soils of the Tashkent oasis, the fractional and group composition of humus was also determined. Studies revealed that calcium-bound second fractions of humic and fulvic acids were predominant, with humic acids mainly incorporated into the humin fraction of soil organic matter

Table 1

Group and Fractional Composition (%) of Selected Soils Distributed on the Right and Left Banks of the Lower Amu Darya

Propile №	Horizon, sm	Humus, %	Organic Carbon Content in Humus (%)	Cgk			Total	Cfk				Total	Cgk+Cfk	Cgk / Cfk	Non-hydrolyzable Residue, % (Cum − (Cgk + Cfk)))
								a							

5	0-43	,120	0,650	,31	2,93	2,47	31,71	,23	,16	,47	,24	23,09	54,80	,37	45,20
	43-65	,826	0,479	,05	0,23	0,85	27,24	,89	,31	,64	3,78	33,61	60,84	,81	39,16
	65-87	,541	0,314	,37	2,43	1,79	30,67	,92	,88	,56	2,11	40,47	71,14	,76	28,86
Shumanay Massif Meadow-Alluvial Soil	87-107	,531	0,308	,17	0,39	1,69	28,32	,49	,44	2,34	0,39	37,66	65,98	,75	34,02
	107-131	,490	0,284	,98	1,61	2,32	29,98	,69	,74	,85	1,26	35,54	65,51	,84	34,49
	131-170	,479	0,278	,76	1,16	0,44	27,42	,48	,28	4,04	0,44	39,23	66,65	,70	33,35

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

2	0 -35	,30 4	0 ,756	,0 2	0, 84	,69	2 1,68	,5 7	,0 4	8, 51	,8 8	3 2,00	5 3,67	,6 8	46 ,33
Begjap Massif Meadow-Alluvial Soil	3 5-54	,90 5	0 ,525	,2 9	,3 4	,24	2 2,95	,3 8	,1 9	0, 19	,9 1	3 8,67	6 1,62	,5 9	38 ,38
	5 4-81	,81 2	0 ,471	,6 8	,5 3	,48	2 0,76	,2 6	,9 6	2, 07	1, 76	3 2,05	5 2,81	,6 5	47 ,19
	8 1-115	,85 0	0 ,493	,8 8	,4 9	,73	1 9,18	,4 6	,6 1	1, 68	,9 8	2 9,73	4 8,90	,6 5	51 ,10
	1 15-141	,57 0	0 ,331	,0 5	,0 7	,75	2 0,92	,8 4	,1 4	8, 75	2, 10	4 0,83	6 1,75	,5 1	38 ,25
	1 41-191	,49 5	0 ,287	,5 3	,7 1	,57	1 8,85	,5 3	,9 2	1, 60	3, 24	4 5,28	6 4,13	,4 2	35 ,87

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

6	0 -28	,16 2	0 ,674	,4 5	,0 5	,19	1 8,78	,0 1	,6 0	7, 14	1, 57	3 5,31	5 4,09	,5 3	45 ,91
Kamisharik Massif Meadow-Alluvial Soil	2 8-38	,91 9	0 ,533	,1 9	,1 9	,38	1 8,83	,8 8	,8 8	1, 39	3, 88	4 5,03	6 3,85	,4 2	36 ,15
	3 8-59	,82 6	0 ,479	,0 5	,6 8	,64	1 8,43	,3 8	,4 3	4, 21	5, 86	4 9,89	6 8,31	,3 7	31 ,69
	5 9-75	,81 9	0 ,475	,8 9	,1 1	,63	1 6,68	,4 2	,9 5	4, 42	6, 42	4 8,21	6 4,89	,3 5	35 ,11
	7 5-102	,59 0	0 ,342	,3 1	,8 4	,43	1 9,62	,9 7	,6 3	5, 42	2, 57	4 5,59	6 5,21	,4 3	34 ,79
	1 02-160	,42 5	0 ,247	,5 2	,4 8	,87	1 8,89	,9 0	,4 6	3, 33	5, 82	5 0,51	6 9,40	,3 7	30 ,60

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

4	0-24	,719	0,417	0,07	3,43	1,27	34,87	,71	,36	5,59	1,51	37,17	72,04	,94	27,96
Bozatau Massif Takyr-Like Meadow Soil	24-49	,570	0,331	,38	3,31	1,19	33,96	,17	,96	0,28	6,64	42,04	76,00	,81	24,00
	49-61	,456	0,264	,45	2,86	0,59	32,96	,94	,45	,89	5,12	41,40	74,36	,80	25,64
	61-75	,315	0,183	,14	2,05	,97	31,21	,23	2,05	,32	4,54	36,14	67,36	,86	32,64
	75-100	,280	0,162	,07	1,34	,53	29,99	,90	4,07	,54	4,07	38,57	68,56	,78	31,44
	100-131	,250	0,145	,36	0,84	,36	29,60	,67	3,55	,20	3,79	36,21	65,80	,82	34,20

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	1 31-200	(,290	0 ,168	,36	,93	,88	2 7,20	,75	,93	0,45	3,06	3 9,18	6 6,39	,69	33 ,61

Conclusion: In the second fraction of Profile 5, humic acids predominated over fulvic acids, whereas in the remaining profiles, fulvic acids were more dominant. The humus status in meadow soils is closely related to their degree of cultivation. Higher contents of humus and organic carbon were observed in old- and newly irrigated meadow-alluvial soils, while old-irrigated takyr-like meadow soils exhibited lower total humus and organic carbon levels.

The humus content of meadow-alluvial soils also depends on their mechanical composition. As the mechanical composition becomes heavier, not only does the humus content increase, but the quality of humus improves as well. Specifically, the proportion of humic acids rises, and the fractions bound to calcium and free or mobile sesquioxides increase. The mechanical composition of meadow-alluvial soils shows higher variability across genetic horizons compared to other soil types and subtypes. Variations in mechanical composition within a single soil profile influence both the quantity and quality of humus. In genetic horizons with light mechanical composition, the proportion of mobile fractions of humic and fulvic acids is higher, which can lead to leaching and lower accumulation of humus substances.

Research findings also indicated that, in the first fraction (1), associated with free and mobile sesquioxides, the contents of humic and fulvic acids were lower compared to other fractions. However, within this fraction, humic acids were more prevalent relative to fulvic acids.

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