E3S Web of Conferences **587**, 04001 (2024) https://doi.org/10.1051/e3sconf/202458704001
GreenEnergy 2024

Regime of salt in alluvial soils irrigated in Bukhara region, Uzbekistan

T. Ortikov[2], *Otabek* Umarov[1*], *Zahro* Bafayeva[1] and *Javohir* Jumayev[1,3]

[1] Bukhara State University, Bukhara City 200100, Bukhara, Uzbekistan
[2] Samarkand State University, Samarkand, Uzbekistan
[3] Bukhara State Pedagogical Institute, Bukhara City 200100, Uzbekistan

Abstract. This article provides information on the regime of salts in alluvial soils irrigated in the Bukhara region, including the quantity of salts easily dissolved in water, their distribution types and levels, total exchangeable bases (NSO3), as well as the amounts of Cl and SO4 in soil composition and the quantities of major cations such as calcium, magnesium, sodium, and potassium. As a result of the increase in the quantity of these salts in the soil, significant information is presented on the weak, moderate, and strong leaching processes.

1 Introduction

The meliorative condition of irrigated lands, in the first place, depends on the proper functioning of existing collectors and drainage systems, as well as the level of groundwater and the amount of salts in the soil. The increase in leaching of irrigation waters in soils is a factor contributing to salinization, and the influence of human activity on the environment, namely the change in hydro-ecological conditions, is becoming increasingly significant [9,11.].

With the increase in the degree of soil salinity, the overall water consumption during the growth period of crops decreases. At the same time, the number of crops suitable for the area also decreases [5,10.].

The meliorative condition of irrigated soils in the Bukhara region cannot be considered satisfactory. Therefore, a complex study of the characteristics of these soils, taking into account the hydro meliorative and soil-climatic conditions of the region, and timely implementation of meliorative measures can improve their meliorative condition [2,3.].

To correctly form the water-salt balance of irrigated lands and achieve a positive change in the water-salt balance, it is necessary to reduce the amount of salts in the irrigation water and in the soil, which is brought out through collector-drainage networks [8].

The soils of the foothill territories and the delta part of the river are composed of various types of saline soils, which include undeveloped melkozem-saline (*soils with a fine texture, often characterized by a high proportion of silt and clay particles*) formations, as well as partially saline formations that have not yet been developed, which are mainly formed in alluvial plains, deltas of rivers and lakes, and aeolian (wind) deposits. In these areas, various

* Corresponding author: o.r.umarov@buxdu.uz

types of saline soils have developed and are developing, which are intensively leached and weathered, mainly composed of coarse sandy, sandy, and sandy loamy soils, saline deposits of coastal and delta lakes, and semi-humid soils formed in areas of excessive moisture. Some of these soils are saline-alkaline, saline, and saline-alluvial soils [4].

The main factor limiting soil fertility is considered to be soil salinity, and the degree of leaching is calculated. The rapid development of irrigated agriculture, on the other hand, activates salt accumulation processes, strengthens secondary salinization in the soil, and contributes to the operation of collector-drainage networks, which allows the disposal of currently mineralized drainage waters and ensures their discharge at a specified depth in the soil profile. Therefore, if rapid meliorative measures aimed at increasing secondary salinization processes and the factors causing them are not taken into account, the spread of salt manifestations is natural [1,6,7].

In managing the salt regime of leached soils, it is crucial to correctly select methods for reducing salt content. The leaching of soil is determined by the composition and quantity of salts dissolved in water. The most dangerous ions in this regard are considered to be carbonate, sodium, chloride, magnesium, and sulfate ions, therefore, this selected topic is considered relevant.

2 Materials and methods

The research object was represented by extensively leached alluvial soils irrigated in the Bukhara region.

Soil samples were collected from layers ranging from bottom to top based on the methods commonly accepted. These soil samples were analyzed in laboratory conditions using the following methods:

1. Drying oven method - to evaporate moisture from soil samples;
2. Calcium and magnesium cations - determined by complexometric method;
3. Sodium and potassium ions - determined by volumetric method;
4. Carbonate and bicarbonate ions or total exchangeable bases - neutralization with 0.01 N sulfuric acid using phenolphthalein and methyl orange indicators;
5. Sulfate ions - determined by gravimetric method;
6. Chloride ions - determined by argentometric method according to Mohr.

The research conducted in the field and laboratory conditions was carried out based on widely used and standardized methods in the field of soil science. These methods were employed to study the composition and characteristics of the soils mentioned above.

3 Results and discussion

Research conducted on alluvial soil conditions in Bukhara province indicate that the non-irrigated alluvial soils are conducive for agricultural purposes, with the content of soluble salts in soil water within normal limits. Additionally, harmful salts are absent. For example, in non-irrigated alluvial soils in Bukhara province, at a depth of 0-31 cm, the content of dry residue is 0.098%, carbonates 0.008%, chloride ions 0.013%, sulfate ions 0.049%, calcium cations 0.013%, magnesium ions 0.009%, and the combined content of potassium and sodium is 0.003% (Table 1).

These indicators were also found to be comparable in the 31-63 cm and 63-94 cm horizons, with values of 0.086%, 0.007%, 0.011%, 0.045%, 0.012%, 0.008%, 0.002%, and 0.083%, 0.007%, 0.011%, 0.041%, 0.011%, 0.007%, 0.004%, respectively. Carbonate ions were not detected in the soil. The absence of chloride ions in non-irrigated alluvial soils indicates the beginning of the initial limit of chloride ion leaching. However, the content of sodium is significantly low compared to the limit of leaching. This contributes positively to soil improvement. Calcium cations constitute the main part of cations, which has a positive effect on soil fertility and improvement. The main salt content was found to be higher in the upper horizon.

When non-irrigated alluvial soils transition to irrigated ones, the total content of soluble salts in water increased from 0.098% to 0.183% in the upper horizon. Similar increases in the content of dry residue were observed in other horizons as well. The increase in dry residue content was related to chloride, sulfate, sodium, and potassium ions. Calcium and magnesium cations also increased slightly. The presence of chloride and sulfate ions in the content of leaching indicates a positive effect on soil fertility and improvement. In the 0-29 cm horizon of non-irrigated alluvial soil, the content of carbonate ions was 0.011%, chloride ions 0.024%, sulfate ions 0.096%, calcium cations 0.017%, magnesium cations 0.012%, and the combined content of potassium and sodium ions was 0.023%.

In moderately irrigated soils, the content of dry residue increased sharply. The increase in soluble salt content was associated with an increase in the content of all cations and anions. In particular, the content of chloride, sulfate, magnesium, and sodium ions was significantly higher compared to non-irrigated alluvial soils. For example, in moderately irrigated alluvial soils, the content of dry residue in the upper horizon reached 0.572%. In this case, the content of carbonates in the 0-26 cm horizon was 0.013%, chloride ions 0.133%, sulfate ions 0.224%, calcium cations 0.138%, magnesium ions 0.019%, and the combined content of sodium and potassium was 0.004% (Table 1). The content of soluble salts increased gradually from the upper to lower horizons according to the soil profile. However, sharp differences were not observed.

In strongly irrigated alluvial soils, the total content of soluble salts, namely the dry residue, increased significantly. This was observed across all horizons of the soil profile. The total content of soluble salts increased gradually from the upper to lower layers of the soil profile. The highest indicator of soluble salt content was found in the lower horizons of 79-108 cm and 108-138 cm. For instance, if the total content of soluble salts in the 0-25 cm depth horizon of strongly irrigated alluvial soil was 1.231%, then this indicator amounted to 1.135% in the 25-49 cm horizon, 1.438% in the 49-79 cm horizon, 1.724% in the 79-108 cm horizon, and 1.765% (Table 1) in the 108-138 cm horizon. The content of carbonates in strongly irrigated soils did not show significant changes compared to moderately irrigated alluvial soils. However, the content of chloride and sulfate ions increased sharply in strongly irrigated alluvial soils. This situation was observed across all horizons of the soil profile. The content of chlorides in the soil profile horizons ranged from 0.178% to 0.283%, while sulfate ions were higher, ranging from 0.559% to 0.880% (Table 1).

Table 1. Analysis of Waterlogged Alluvial Soils Irrigated in Bukhara Region

Horizon and Depth, cm	Solubility		Cl		SO_4		Ca		Mg		Anions	Cations	mg/equiv of K, Na ions	% of K, Na ions	Dry residue, %	Type
	Total SO3, %	Total SO3, mg/equiv	%	mg/equiv	%	mg/equiv	%	mg/equiv	%	mg/equiv						
Unsalted																
0-31	0.008	0.13	0.013	0.37	0.049	1.02	0.013	0.65	0.009	0.74	1.52	1.39	0.13	0.003	0.098	
31-63	0.007	0.12	0.011	0.31	0.045	0.94	0.012	0.60	0.008	0.66	1.36	1.26	0.10	0.002	0.086	
63-94	0.007	0.12	0.011	0.31	0.041	0.85	0.011	0.55	0.007	0.58	1.28	1.13	0.15	0.004	0.083	
4-113	.007	.12	.012	.34	.042	.87	.01	.50	.007	.58	.33	.08	.25	.006	.085	
13-148	.008	.13	.012	.34	.042	.87	.009	.45	.006	.49	.34	.94	.40	.009	.086	
Weakly salted																

-29	.011	.18	.024	.68	.096	.00	.017	.85	.012	.99	.86	.84	.02	.023	.183	-C
9-49	.007	.12	.015	.42	.069	.44	.012	.60	.008	.66	.97	.25	.72	.016	.127	-C
9-81	.009	.15	.016	.45	.071	.48	.016	.80	.009	.74	.08	.71	.54	.012	.133	-C
1-109	.010	.16	.02	.56	.073	.52	.011	.55	.008	.66	.25	.21	.04	.024	.146	-C
09-140	.007	.12	.012	.34	.068	.42	.015	.75	.008	.66	.87	.41	.46	.011	.121	-C
Moderately salted																
-26	.013	.21	.133	.75	.224	.66	.138	.89	.019	.56	.63	.45	.18	.004	.572	-C
6-47	.014	.23	.124	.50	.245	.10	.14	.99	.017	.40	.83	.39	.44	.010	.602	-C
7-80	.014	.23	.138	.89	.229	.77	.14	.99	.014	.15	.89	.14	.75	.017	.628	-C
0-105	.013	.21	.142	.01	.291	.06	.13	.49	.016	.32	0.28	.81	.47	.057	.649	-C
05-137	.013	.21	.140	.95	.201	.18	.124	.19	.012	.99	.35	.18	.17	.027	.652	-C
Strongly salted																
-25	.013	.21	.197	.56	.597	2.42	.09	.59	.078	.42	8.19	1.00	.19	.165	.231	-C
5-49	.012	.20	.178	.02	.559	1.63	.09	.44	.068	.60	6.85	0.03	.82	.157	.135	-C
9-79	.012	.20	.269	.59	.673	4.01	.08	.19	.088	.24	1.79	1.43	0.36	.238	.438	-C
9-108	.022	.36	.283	.98	.880	8.31	.18	.08	.119	.79	6.66	8.88	.78	.179	.724	-C
08-138	.013	.21	.189	.33	.803	6.71	.14	.94	.105	.64	2.26	5.58	.68	.154	.765	-C

The increase in the ratio of magnesium cations to calcium cations in strongly irrigated soils leads to an increase in the content of harmful and alkaline salts in soil water. This, in addition to increasing the content of sodium and potassium ions in soil water, leads to a sharp increase in salinity. Since the high content of sodium ions in the soil leaching complex negatively affects soil structure, fertility, and pH, it can even lead to the appearance of "black" soil patches. The increase in the alkalinity of the environment negatively affects the mobility of macro and micronutrients in the soil, reducing the availability of nutrients in a form that plants can absorb. The increase in magnesium content in the soil also contributes to soil salinisation. Therefore, the overall increase in the total content of soluble salts in strongly irrigated alluvial soils not only indicates a positive effect on soil fertility and improvement but also brings about specific challenges related to the increase in ions that affect soil properties.

The high content of chlorides in strongly irrigated alluvial soils also contributes to the manifestation of positive effects on soil fertility and improvement. The content of chloride ions in strongly irrigated alluvial soils exceeded that in non-irrigated soils, indicating a significantly positive effect on soil melioration and improvement.

4 Summary

In the Bukhara region, various degrees of salinisation in alluvial soils have been observed. The irrigated soils show higher concentrations of salts in soil water, with an increased content of harmful and alkaline salts. As the salinization level increases, the concentration of harmful and alkaline salts, as well as sodium, magnesium, and chloride salts, also increases, while the ratio of calcium to sodium and calcium to magnesium ions decreases, leading to unfavourable conditions for soil fertility from all perspectives.

Alluvial soils that have been affected to different degrees by salinization exhibit sharp differences in their salt regime and composition of soil water. There isn't a significant difference in the composition of soil water and the amount of dry residue between nonaffected and slightly affected alluvial soils. However, moderate and heavily affected alluvial soils show distinct differences in the composition of soil water and salt regimes. The most alarming situation in terms of salt regime is observed in moderately affected alluvial soils, especially in heavily affected ones.

References

1. H. Salimova, H. Artikova, E3S Web of Conferences **549,** 03027 (2024)
2. Hamroyev, H. Jumayeva, E3S Web of Conferences **420,** 10007 (2023)
3. I. Rakhmatov, E3S Web of Conferences **497,** 03038 (2024)
4. I. Rakhmatov, E3S Web of Conferences **497,** 03043 (2024)
5. Kuldoshev R., Rahimova M., E3S Web of Conferences **549,** 09028 (2024).
6. M. Axmedov and O. Sharipov, BIO Web of Conferences **113,** 01003 (2024)
7. M. Khayrullayev and G. Rajabova, BIO Web of Conferences **116,** 01022 (2024)
8. M. Shirinova et al., E3S Web of Conferences **538,** 05016 (2024)
9. N. Khakimova, E3S Web of Conferences **497,** 03005 (2024)
10. B. Mamurov et al., E3S Web of Conferences **538,** 02025 (2024)
11. B. Mamurov et al., E3S Web of Conferences **538,** 05031 (2024)
12. Dilova N. et al., E3S Web of Conferences **538,** 05001 (2024).
13. F. Jumayev, E3S Web of Conferences **549,** 03021 (2024)
14. G. Akramova et al., E3S Web of Conferences **538,** 05034 (2024)
15. N. Hakimova, Kh. Abdukhakimova, G. Sotiboldieva, E3S Web of Conferences **549,** 03020 (2024)
16. O. Umarov, Z. Bafayeva, D. Bo`riyeva, E3S Web of Conferences **549,** 03019 (2024)
17. O. Umarov, Z. Bafayeva, M. Alimov, E3S Web of Conferences **549,** 03016 (2024)
18. O. Umarov, Z. Bafayeva, T. Avezov, E3S Web of Conferences **549,** 03018 (2024)
19. O. Umarov, Z. Bafayeva, Z. Atayeva, E3S Web of Conferences **549,** 03017 (2024)
20. O. Umarov, Z. Bafayeva, J. Ravshanov, E3S Web of Conferences **549,** 03024 (2024)
21. O. Umarov, Z. Bafayeva, E. Qodirov, E3S Web of Conferences **549**, 03023 (2024)
22. Qo'ldoshev R., Dilova N., Hakimova N., BIO Web of Conferences **120,** 01049 (2024).
23. R. Kuldoshev et al., E3S Web of Conferences **371,** 05069 (2023)
24. R. Qo'ldoshev et al., E3S Web of Conferences **538,** 05017 (2024)
25. R. Qo'ldoshev et al., E3S Web of Conferences **538,** 05042 (2024)
26. R. Yunusov, F. Ganiyeva, BIO Web of Conferences **116,** 01023 (2024)
27. R. Yunusov, F.A. Ganiyeva, BIO Web of Conferences **116,** 01005 (2024)
28. S. Nazarova, E3S Web of Conferences **549,** 03022 (2024)
29. S. Siddiqov, D. Razoqova, E3S Web of Conferences **549,** 03025 (2024)
30. Sh. Nafetdinov, BIO Web of Conferences **116,** 01020 (2024)
31. T. Ortikov, B. Shoniyozov , A. Makhmatmurodov, M. Mashrabov, E3S Web of Conferences **462,** 02017 (2023)
32. U. Khayitov et al., E3S Web of Conferences **538**, 05022 (2024)