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ARTICLE

Genesis and Migration of Salts in Irrigated Meadow Sazovs Soils

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Abstract

The study focuses on the Central Fergana region, which is characterized by an arid climate and low natural drainage capacity. It has been observed that even the salts accumulating at a slow rate in such soils eventually reach significant concentrations. In irrigated lands, an additional 1–1.5 g of salts per liter of irrigation water is continuously introduced, leading to an increased accumulation of soluble salts both quantitatively and qualitatively. Furthermore, it has been noted that mineralized groundwater located close to the surface also contributes to this process.

Keywords: sulfate, carbonate, phosphate, chloride, meadow sazovs soil.

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1 Introduction

The hydromorphic nature of Central Fergana soils has now been proven [5], and it has been noted that the soil profiles in the peripheral parts of the alluvial fans contain densely gypsified, prismatic-vertic layers.

According to the data of Pankov M.A. [4], salt accumulation in Central Fergana soils has mainly occurred due to Na_2SO_4 and gypsum. However, the author takes a one-sided approach, explaining that gypsum formation occurs solely due to the exchange reaction between calcium bicarbonate and sodium sulfate. In reality, the genesis of gypsum in these soils differs from others due to its halo-geochemical characteristics.

Our research has identified that such soils still exist in several districts, and samples have been collected. According to the data [1, 2], the soils of the Kuvasoy alluvial fan are also characterized by salinization, waterlogging, poor permeability, prismatic structure, and vertic properties.

In conducting this study, the chemical analysis of soil and water samples, as well as the determination of soil humus, exchangeable cation composition, gypsum, calcium, and magnesium carbonates, was carried out using the standardized methodologies of the Uzbek Cotton Research Institute and the "Guidelines for Chemical Soil Analysis."

The characterization of soils was performed by analyzing easily soluble salts using the aqueous extract method.

It has been recognized [3] that the water permeability of these soils is twice as low compared to soils without gypsum layers.

It should be specifically noted that prismatic and gypsiferous soils cover vast areas in Central Fergana. These soils exhibit several negative properties,

which are directly related to the composition, characteristics, thickness, and spatial distribution of the prismatic-vertic layers.

2 Materials and Methods

As the research object, the soils formed in Central Fergana were selected. The primary research method employed was V.V. Dokuchaev's morphogenetic and profile-based approach. The chemical and physical analyses of the collected soil samples were conducted following the guidelines outlined in the "Guidelines for Chemical Soil Analysis."

The mechanical composition of the soil was determined using the pipette method with sodium hexametaphosphate. The soil's salt composition, including anions and cations, was analyzed using the aqueous extract method. Carbonates (CO_2, Ca, Mg) were determined by the acidimetric method, while Ca and Mg were analyzed using the Trilon-B complexometric method.

3 Results and Discussion

In most cases, the prolonged decomposition, weathering, and dissolution of complex salts and minerals in the soil result in the formation of oxides such as SiO_2, Al_2O_3, Fe_2O_3, along with various simple and complex salts as final products. Initially, these complex salts mainly consist of aluminosilicates, silicates, ferrosilicates, and other related compounds.

The amount of newly formed simple salts is relatively low, as the influence of water on silicates and other complex salts is minimal.

In Central Fergana, which belongs to the arid climate zone and is characterized by a very low degree of natural drainage, even the slowly accumulating salts gradually concentrate over time, eventually reaching significant amounts. Particularly in irrigated lands, an additional 1–1.5 g of salts per liter of irrigation water continuously enters the soil, leading to an increased accumulation of water-soluble salts both quantitatively and qualitatively. Furthermore, mineralized groundwater located close to the surface also contributes to this process.

However, it is evident that water-soluble simple salts in the soil have a strong influence on soil energetics, the processes occurring within it, as well as its physical, chemical, and biological properties. The quality, quantity, and geoenergetic state of salts also play a significant role in shaping various soil characteristics and attributes.

The concentrations of sulfate, carbonate, phosphate, chloride, and other salts have been analyzed for the studied soils, as presented in Table 1.

According to the data in the table, newly irrigated shallow prismatic-vertic meadow-swamp soils are classified as slightly saline based on the dry residue content. The total salt accumulation in these soils varies within the range of 0.428–1.106%.

If the total salt content in the plow layer of the profile is 0.428%, while in the 32–55 cm prismatic-vertic layer it reaches 1.106%, this can be explained by the leaching process. During autumn and winter, when soil salinity is washed out, chloride-sulfate salts are more easily removed, while their movement out of the layer becomes relatively difficult. Consequently, these salts accumulate above prismatic-vertic layers, which have poorer water and air permeability.

In these soils, except for sodium carbonate and sodium sulfate, the concentration of other salts gradually decreases upward from the groundwater. This indicates that these salts slowly rise toward the prismatic-vertic layer, where they accumulate beneath it, forming a double-sided or bipolar pedogeochemical barrier. Among the highly soluble salts, sodium sulfate exhibits the highest concentration within the prismatic-vertic layer, while in other layers, its amount is relatively lower and remains almost unchanged.

When analyzing the geochemical spectrum of the mentioned salts, the following pattern emerges:

According to spectral data, the highest total salt accumulation occurs in the shallow prismatic-vertic layer (32–55 cm depth). The proportions of both harmful and harmless salts follow a similar trend. Among the water-soluble salts, $MgSO_4$ is the most abundant, followed by $CaSO_4$, Na_2SO_4, $Ca(HCO_3)_2$, NaCl, and Na_2CO_3 in descending order.

Table 1. Salt composition and content (%) of irrigated, saline meadow-swamp soils with prismatic-vertic layers.

Profile №	Depth, cm	Na_2CO_3	$Ca(HCO_3)_2$	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCl	Total salts	Of which		Relative to total salts, %	
									Harm-ful	Harm-less	Harm-ful	Harm-less
	Newly reclaimed shallow prismatic-vertic soils (n=6)											
6A	0-18	No	0,012	0,195	0,187	0,020	0,014	0,428	0,221	0,207	51,6	49,4
	18-32	No	0,016	0,201	0,203	0,022	0,015	0,462	0,240	0,217	53,0	47,0
	32-55	0,023	0,045	0,427	0,531	0,058	0,045	1,106	0,657	0,472	59,1	40,9
	55-80	No	0,015	0,301	0,217	0,017	0,022	0,572	0,256	0,316	44,7	55,3
	80-140	No	0,018	0,353	0,251	0,020	0,021	0,663	0,292	0,371	44,0	56,0
	140-200	No	0,021	0,361	0,303	0,019	0,023	0,727	0,345	0,382	47,4	52,6
	Groundwater, g/L	0,310	0,148	3,160	2,320	0,903	0,720	7,251	4,253	3,308	58,7	41,3

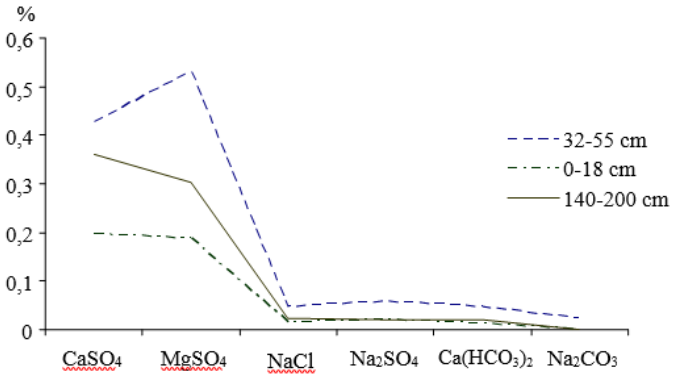

Figure 1. Geochemical Spectrum of Salts in Soil Layers

Such soils are also characterized by the fact that a small amount of soda (Na_2CO_3) has formed in the argic-calcic layer of the studied soils, amounting to 0.023%. The reason for this is the presence of organic matter, albeit in small quantities. Due to the lack of air above the argic-calcic layers, desulfurizing bacteria utilize the energy of organic matter and oxidize it, resulting in the formation of Na_2CO_3 and H_2S.

The distribution spectrum of these salts, namely water-soluble salts, in the studied cemented argic-calcic layers is as follows.

6A 32-55 cm. $MgSO_4 > CaSO_4 > Na_2SO_4 > Ca(HCO_3)_2 > NaCl > Na_2CO_3$

The distribution of salts in this manner is influenced by their water solubility, mechanical composition of the soil, mineralization and composition of groundwater, as well as evaporation processes and bidirectional geochemical barriers.

The groundwater of the studied soils is also mineralized, with a mineralization level of 7.251 g/L.

4 Conclusions

The accumulation of easily soluble salts on the upper layer of the argic-horizon of the studied soils negatively affects the growth and development of agricultural crops, ultimately leading to a decrease in yield.

To prevent this issue, deep loosening of the soil (up to 60-80 cm), breaking the argic-horizon, and implementing leaching measures can yield positive results.

The groundwater of these soils contains 0.310 g/L of soda (Na_2CO_3) and has a chloride-sulfate composition, meaning it is rich in sulfates. This characteristic is typical of the groundwater of Central Fergana soils.

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