



DEGRADATION PROCESSES OF GYPSIFEROUS SALINE SOILS UNDER CLIMATE CHANGE CONDITIONS

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Annotatsiya. Ushbu maqolada iqlim o'zgarishi sharoitida gipsli sho'rlangan tuproqlarda kechayotgan degradatsiya jarayonlari tahlil qilingan. Asosiy e'tibor Orol dengizi qurib qolgan tubi hududlariga qaratilgan bo'lib, bu yerlarda iqlimning aridlashuvi, havo haroratining oshishi hamda deflyatsiya jarayonlarining kuchayishi natijasida tuproqlarning fizik, kimyoviy va biologik degradatsiyasi jadallashmoqda. Maqolada iqlim ko'rsatkichlari, tuproqlarning sho'rlanish darajasi va gips miqdori bo'yicha statistik ma'lumotlar keltirilgan. Shuningdek, degradatsiya jarayonlarini kamaytirish maqsadida kompleks meliorativ va biologik tadbirlarni qo'llash zarurligi ilmiy jihatdan asoslab berilgan.

Kalit so'zlar: gipsli tuproqlar, sho'rlanish, tuproq degradatsiyasi, iqlim o'zgarishi, Orol dengizi tubi, deflyatsiya.

Аннотация. В статье рассматриваются процессы деградации гипсованных засоленных почв в условиях изменения климата. Особое внимание уделено территориям дна Аральского моря, где под воздействием аридизации климата, повышения температуры воздуха и усиления дефляционных процессов происходит интенсификация физико-химической и биологической деградации почв. Приведены статистические данные по изменению климатических показателей, степени засоления и гипсованности почв. Обоснована необходимость комплексных мелиоративных и биологических мероприятий.

Ключевые слова: гипсованные почвы, засоление, деградация почв, изменение климата, дно Аральского моря, дефляция.



Abstract. *This article examines degradation processes of gypsiferous saline soils under climate change conditions. Special attention is given to the Aral Sea dry bottom areas, where climate aridization, increasing air temperature, and intensified deflation processes accelerate physical, chemical, and biological soil degradation. Statistical data on climate indicators, soil salinity, and gypsum content are presented. The necessity of integrated reclamation and biological measures is substantiated.*

Keywords: *gypsiferous soils, salinity, soil degradation, climate change, Aral Sea dry bottom, deflation.*

Climate change is currently considered one of the most serious global challenges for natural ecosystems. Over the past century, the average global air temperature has increased by approximately 1,1-1,3 °C, and these changes have had particularly negative impacts on the stability of soil cover in arid and semi-arid regions. According to international organizations, the global area of saline soils amounts to 850–950 million hectares, of which at least 35-40% are represented by gypsiferous soils or soils formed under the influence of gypsum. Central Asia, including the territory of Uzbekistan, is highly vulnerable to climate change, where 45–50% of irrigated lands are affected by salinity to varying degrees.

Gypsiferous saline soils are widely distributed in the Jizzakh, Navoi, Bukhara, and Khorezm regions of Uzbekistan, where in some soil massifs the gypsum content reaches 10-25%. These soils are predominantly enriched with calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and their formation is directly associated with high evaporation rates, low precipitation, and mineralized groundwater. Scientific observations indicate that in gypsiferous saline soils, the content of soluble salts ranges from 0,6 to 3,5%, electrical conductivity varies between 4 and 18 dS/m, and soil reaction commonly shifts from neutral toward alkaline conditions, with pH values between 7,6 and 8,4.

As a result of climate change, increasing air temperatures have significantly intensified evaporation from the soil surface. Over the past 30-40 years, the average



annual air temperature in Uzbekistan has increased by 0,9-1,2 °C, leading to a 15-25% increase in evaporation rates. Enhanced evaporation promotes the upward movement of groundwater and facilitates the capillary accumulation of salts and gypsum in the upper soil layers. Consequently, salt concentrations in the 0-30 cm soil layer have increased by 1,5-2 times in certain areas.

A decrease in precipitation also plays a crucial role in the degradation of gypsiferous saline soils. In recent decades, annual precipitation in the region has declined by 8-12%, which has limited natural leaching processes. As a result, salts and gypsum are retained within the soil profile and continue to accumulate. During dry years, a reduction in humus content by 0,2-0,4% has been recorded, leading to a decline in soil fertility.

One of the most significant regional factors intensifying degradation processes in gypsiferous saline soils is the impact of the dried bottom of the Aral Sea. Scientific data indicate that since the 1960 s, the water level of the Aral Sea has declined by more than 20 meters, and over 60,000 km² of its former seabed has transformed into an open saline desert known as Aralkum. Currently, approximately 75-100 million tons of salts and fine dust particles are emitted annually into the atmosphere from this area and are transported by wind over distances of 300-500 km.

The aerosols originating from the Aral Sea dry bottom contain sodium chloride, sodium sulfate, magnesium salts, as well as gypsum particles, which deposit on the soil surface of adjacent territories and accelerate secondary salinization and gypsum accumulation processes. Observations conducted in the Republic of Karakalpakstan and Khorezm region reveal that due to windborne salt deposition, the dry residue content in the upper soil layer has increased by 0,3-0,6% over the past 10–20 years. In some areas, electrical conductivity has increased by 2-3 dS/m.

Salt-laden dust from the Aralkum also exerts a negative influence on the physical properties of soils. Deposited salt and gypsum particles form surface crusts, reducing water infiltration by 25-35% and decreasing seed germination rates by 20-



30%. This effect is particularly pronounced in gypsiferous saline soils, where soil structure degradation and compaction processes are further intensified.

From a chemical perspective, the deposition of salts from the Aral Sea dry bottom leads to an increase in the proportion of exchangeable sodium ions in the soil adsorption complex of gypsiferous saline soils to 15-18%, while the calcium-to-sodium ratio declines to 1,2-1,4. This shift promotes soil alkalization and reduces the availability of essential nutrients for plants by 25-40%.

Biologically, salt aerosols originating from the Aral Sea dry bottom further suppress microbiological activity in gypsiferous soils. Scientific evidence indicates that in such areas, microbial populations are reduced by 40-60% compared to control sites, while enzymatic activity declines by 30-45%. As a result, humus formation processes slow down significantly, and the soil's natural self-restoration capacity becomes severely limited.

Overall, the combined effects of climate change and the ecological disaster of the Aral Sea synergistically intensify degradation processes in gypsiferous saline soils. Calculations show that a 1 °C increase in air temperature, together with the influence of salt-laden dust from the Aralkum, increases soil salinity levels by an average of 15-20%. Therefore, the protection of gypsiferous saline soils, limitation of wind erosion, restoration of vegetation cover, and implementation of scientifically grounded reclamation measures are of strategic importance in the Aral Sea region and adjacent territories.

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