BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

EFFECTS OF SANDSTORMS ON SOIL SALINITY LEVELS

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https://doi.org/10.5281/zenodo.21786073

Abstract. This study provides a scientific analysis of the effects of sandstorms on soil salinization processes in the Surkhandarya Region, particularly in the Termez District of Uzbekistan. The relationship between salt particles transported by sand and dust, erosion processes, wind intensity, and soil structure is examined. Furthermore, changes in soil electrical conductivity (EC), the Sodium Adsorption Ratio (SAR), and water-soluble salts are evaluated within the scope of the study.

Keywords: Ecology, wind, salt, soil salinization, erosion, sand, dust, desertification, rivers, climate change.

Introduction. Southern Uzbekistan, particularly the Surkhandarya Region, is geographically located near desert and steppe zones, where wind erosion, sand movement, and sandstorms occur frequently. The Termez District is situated close to the Amu Darya River basin, and its soil characteristics, prevailing wind directions, low precipitation, and high temperatures contribute to the intensification of soil salinization processes.

Sandstorms generally originate from extensive desert areas and transport salt particles containing carbonates, chlorides, and sulfates. These salts are deposited on the soil surface and gradually increase soil salinity over time. This phenomenon is particularly evident along the Termez–Sherabad corridor, where wind intensity is relatively high.

The relevance of this study lies in the fact that soil salinization reduces plant growth, decreases agricultural productivity, lowers irrigation efficiency, and deteriorates the soil's reclamation status. Therefore, investigating the impact of sandstorms on soil salinization is of great importance for sustainable agriculture, environmental protection, and land reclamation management in the region.

Factors Influencing the Occurrence of Sandstorms

The occurrence and formation of sandstorms in the Termez District are influenced by the following factors:

Geographical Factors

The Amu Darya delta region contains numerous sources of sand and dust.
Southwestern winds intensify erosion processes in sandy areas.
Wind speeds are relatively high in foothill regions.

Climatic Factors

Annual precipitation is low (120–150 mm).
High temperatures in summer (~45 °C) and low humidity contribute to dry conditions.
Wind intensity increases in areas with sparse vegetation cover.

Anthropogenic Factors

Improper irrigation practices in irrigated areas;
Poor drainage conditions;
Leaving agricultural fields uncovered;

- Deterioration of the reclamation status of sandy areas.

Composition of Sandstorms and Their Effects on Soil

As determined by research, the chemical composition of storm particles indicates that dust aerosols in the Termez region contain the following components:

- Sodium chloride (NaCl);
- Calcium and magnesium sulfates ($CaSO_4$, $MgSO_4$);
- Carbonates ($CaCO_3$, $MgCO_3$);
- Fine sand particles (sand fractions of 0.05–1 mm);
- Residues of organic matter.

The deposition of these substances into the soil leads to changes in its chemical balance. The mechanism of soil salinization caused by sandstorms occurs in three stages:

1. Deposition of saline dust on the soil surface – during a sandstorm, 50–200 mg of salts may be deposited per 1 m² of soil area.

Table 1.

	Level of Soil Salinity	**Sulfate–chloride type saline soil**		**Chloride–sulfate type saline soil**	
		Chloride (Cl^-)	**Total soluble salts.**	**Chloride ion (Cl^-)**	**Total soluble salts.**
	Saline	Less than 0.01	Less than 0.25	Less than 0.01	Less than 0.3
	Slightly saline	0,01-0,04	0,25-0,50	0,01-0,04	0,30-1,0
	Moderately saline	0,04-0,20	0,50-1,0	0,04-0,20	1,0-2,0
	Highly saline and solonchak (salt-affected soils)	>0,2	>1,0	>0,2	>0,2

2. Under the influence of irrigation or rainfall, salts infiltrate into the upper soil layers.
3. Increased water evaporation – as a result, salts migrate back to the soil surface and accumulate. Therefore, in some agricultural areas of Termez, the EC value reaches 5–12 dS/m, indicating moderate soil salinity.

Soil Salinity Levels and the Effects of Sandstorms in the Termez District

The soil characteristics of the study area: The following soil types are widely distributed in the Termez District:

- Meadow-gray soils
- Irrigated gray soils
- Sandy and loamy soils
- Solonchak (salt-affected) areas

Their physicochemical properties contribute to the retention of storm dust particles and increase soil susceptibility to salinization.

Field Observations: Based on data from local meteorological stations and field observations, dust haze events are recorded up to 20–25 times during the dry season. Soil samples collected after sandstorms showed an increase of 8–15% in ion concentrations. The EC values are consistently higher in areas with strong wind activity.

Wind Erosion and Redistribution of Salts: As a result of sandstorms:

- Fine particles are carried away, leading to a reduction in soil nutrient content.
- Salts accumulate along prevailing wind directions, forming "salt pathways."
- Enhanced capillary rise increases the upward movement of salts, resulting in greater salt accumulation on the soil surface.

Changes Observed Under the Influence of Sandstorms

Physical Properties

- Soil bulk density increases;
- Soil structure deteriorates;
- Fine particle fractions decrease;
- Water infiltration capacity deteriorates.

Chemical Properties of Soil

- EC increases (up to 4–10 dS/m).
- The concentrations of Na^+, Cl^-, and SO_4^{2-} ions increase.
- The Sodium Adsorption Ratio (SAR) may increase to 8–18 units.
- The pH value slightly increases (up to 8.0–8.6).

Biological Indicators

- Microbial activity decreases;
- Nitrogen cycling slows down;
- Plant root biomass decreases.

Effects of Sandstorms on Agriculture and the Environment

Effects on Crop Yield in Salinized Areas

- Cotton yield decreases by 20–35%;
- Alfalfa growth is slowed down;
- Vegetable crops experience significant stress.

Effects on Irrigation Systems Due to the Deposition of Saline Dust in Canals:

- Increases water mineralization;
- Causes clogging of pipelines.

Environmental Impact: Concentrations of PM10 and PM2.5 particulate matter in the air increase, creating risks to human health, including respiratory diseases. Salt crystal deposition also causes leaf scorching and damage to plants.

Recommendations for Reducing Soil Salinization Processes

- Expansion of drip irrigation systems;
- Cultivation of salt-tolerant crop varieties (e.g., hybrid cotton and alfalfa);
- Soil gypsum application ($CaSO_4$) to replace exchangeable sodium and reduce sodicity.







Wind Protection Measures:

- Establishment of windbreaks using trees such as elm, poplar, and oleaster;
- Creation of dense protective shelterbelts in irrigated areas.

Soil Improvement Measures:

- Application of organic fertilizers to increase humus content;
- Mulching of agricultural fields;
- Restoration and improvement of drainage systems.

Conclusion. The conducted scientific analyses and data obtained from the study of the Termez District demonstrate that sandstorms are among the most important natural factors contributing to soil salinization processes. They not only transport salts into the soil but also intensify salinization through erosion, capillary rise, and disruption of the water balance. As a result, adverse effects occur on agricultural productivity, land reclamation conditions, and the ecological state of the region.

Therefore, combating wind erosion, implementing appropriate reclamation measures, and monitoring soil salt content are considered important and urgent tasks for the Termez region.

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