

Temporal Changes in Salinity and Agrochemical Parameters of Light Sierozem Soils Near A 500 Kv Power Transmission Line in The Fergana Valley

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Abstract

This study examines changes in salinity and agrochemical parameters of light sierozem soils at experimental site No. 2 near a 500 kV power transmission line in the Fergana Valley. The site has a soil bonitet rating of 58. The aim was to assess changes in soil parameters during 2023–2025 and identify differences between the 0–20 and 20–40 cm layers. A comparative analysis was conducted of humus content, pH, phosphorus and potassium contents expressed as P_2O_5 and K_2O , and salinity. During the study period, salinity increased from 0.38 to 0.42% in the upper layer and from 0.43 to 0.47% in the lower layer. Humus content decreased from 1.10 to 1.05% and from 0.82 to 0.76%, respectively, while pH increased from 7.70 to 7.90 and from 7.90 to 8.10. P_2O_5 content decreased from 22 to 20 mg/kg in the 0–20 cm layer and from 16 to 14 mg/kg in the 20–40 cm layer; K_2O content decreased from 255 to 240 and from 225 to 210 mg/kg, respectively. Throughout the observation period, the lower layer had higher salinity and pH but lower humus, phosphorus and potassium contents. The findings show concurrent increases in salinity and pH and decreases in humus and nutrient contents. Establishing the contribution of electromagnetic exposure to these changes requires field measurements, comparison with a control site, and consideration of the water regime and agricultural management practices.

Keywords: Light sierozem soils, soil salinity, agrochemical parameters, 500 kV power transmission line, electromagnetic field, humus, pH, Fergana Valley.

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1. Introduction

Changes in soil salinity are a major concern for agricultural land use. The accumulation of soluble salts affects the availability of soil water to plants and may limit land productivity. Under irrigation, the direction of this process depends on irrigation water quality, irrigation management and drainage efficiency. Salinity

assessment should therefore consider not only the level measured at the time of sampling but also changes over time and its distribution with soil depth [1].

Soil salinity should be considered alongside indicators of soil fertility. Organic matter contributes to soil structure, water retention and conditions supporting soil organisms. Its content is associated with plant residue inputs and

tillage practices. Monitoring salinity and humus content together provides a more complete description of soil changes, although coincident temporal patterns do not, in themselves, establish a causal relationship between these processes [2].

Soil reaction, expressed as pH, is another important parameter. It is associated with nutrient transformations, microbial activity and mineral equilibria. According to Mosley et al., factors governing spatial differences in pH include carbonate content, climatic conditions, clay content and organic carbon content. The authors also emphasize that measured values depend on sample preparation and the analytical method. Assessing interannual changes in pH therefore requires comparable measurement conditions and should not substitute for an independent assessment of salinity [3].

Power-frequency electric and magnetic fields constitute an additional physical factor on land crossed by transmission lines. The electric field is associated with line voltage, whereas the magnetic field is associated with current. The nominal voltage therefore characterizes the source but does not uniquely determine the actual exposure at a particular point on the soil surface. Studies near transmission lines must consider measured field parameters and the positions of observation points relative to the line [4].

Potential changes in soils near high-voltage lines have been investigated in recent field studies. Baydilli et al. examined soils in a semi-arid agroecosystem in Türkiye by comparing samples collected directly near transmission lines with those from a control site 300 m away. They reported lower microbial biomass carbon and reduced activity of certain enzymes in soils near the line. These findings support the inclusion of biological indicators in studies near electricity infrastructure but do not directly explain temporal changes in salinity, humus or pH at another site [5].

Methodological approaches to investigating soils near transmission lines combine field observations and laboratory analyses [6]. For the light sierozem soils at site No. 2 in the Fergana Valley, the specific research

question is how changes in salinity over several years coincide with changes in humus, pH, phosphorus and potassium in two soil layers. Within this framework, describing the observed changes precedes assessing their possible causes. Separating these stages helps avoid attributing all observed changes to a single anthropogenic factor.

This study focuses on light sierozem soils at experimental site No. 2 near a 500 kV transmission line, with a soil bonitet rating of 58. Data for 2023–2025 are examined for the 0–20 and 20–40 cm layers. Particular attention is given to concurrent temporal changes in salinity and agrochemical parameters and to whether differences between depths persist or change.

The aim of the study was to assess changes in salinity, humus content, pH, phosphorus and potassium in the light sierozem soils of site No. 2 during 2023–2025 and to characterize these changes in the 0–20 and 20–40 cm layers. The objectives were to compare annual values, calculate absolute and relative changes, and analyze differences between layers. The results provide a basis for further investigation of soil conditions near a 500 kV transmission line and assessment of the potential contribution of electromagnetic exposure.

2. Methods

The study examined light sierozem soils at experimental site No. 2 near a 500 kV power transmission line in the Fergana Valley. According to the site description, the soil bonitet rating is 58 and the transmission line protection zone is 30 m. The protection zone width was treated as a site characteristic; it does not specify the distance from the line to individual sampling points.

The analysis used soil data from 2023, 2024 and 2025 for two depth intervals: 0–20 and 20–40 cm. Each layer was analyzed separately, after which the parameters were compared between layers within each year. This approach characterized interannual changes and differences between the upper and lower portions of the sampled soil profile. The principal site characteristics are presented in Table 1.

Table 1. Characteristics of site No. 2 and the dataset analyzed

Characteristic	Description
Study area	Fergana Valley
Experimental site	No. 2

Characteristic	Description
Soil	Light sierozem soils
Soil bonitet rating	58
Transmission line voltage	500 kV
Protection zone reported in the site description	30 m
Observation years	2023, 2024, 2025
Sampling depths	0–20 and 20–40 cm
Parameters analyzed	Humus, pH, P ₂ O ₅ , K ₂ O, salinity

Soil condition was assessed using humus content, soil reaction (pH), phosphorus and potassium contents expressed as P₂O₅ and K₂O, and salinity. Humus content and salinity were reported as percentages, and phosphorus and potassium contents as milligrams per kilogram of soil. Parameter designations were retained as given in the source data. Pending clarification of the laboratory methods, P₂O₅ and K₂O were not assigned to specific chemical fractions, and salinity was not equated with electrical conductivity or the dry residue of a soil water extract.

Data processing included calculation of absolute and relative changes during 2023–2025. Absolute change was calculated as the difference between the 2025 and 2023 values. This difference was expressed in percentage points for humus and salinity, in mg/kg for P₂O₅ and K₂O, and in pH units for pH. Relative change was calculated by dividing the difference by the 2023 value and expressing the result as a percentage. Percentage changes in pH were not calculated.

Values were also compared for the 2023–2024 and 2024–2025 intervals to determine whether the direction of change persisted throughout the observation period and whether the magnitude differed between intervals. Differences with depth were assessed by comparing each parameter between the 0–20 and 20–40 cm layers within each year. Values were not averaged across the full 0–40

cm interval, and humus stocks were not calculated.

The study was observational, and data processing was restricted to descriptive analysis. The dataset contained one value for each parameter at each combination of year and depth; information on the number of independent samples and variability was unavailable. Statistical significance was therefore not assessed, and annual values were not treated as independent replicates of a single experiment.

Interpretation distinguished between soil changes near the transmission line and demonstrated effects of electromagnetic fields. The dataset did not include measured electric or magnetic field levels or data from a comparable control site. The contribution of electromagnetic fields was therefore not quantified. The observed changes were considered in light of the need for further information on irrigation, fertilizer application, crop types and sampling dates.

3. Results

During 2023–2025, salinity and pH increased in the light sierozem soils at site No. 2, while humus, phosphorus and potassium contents decreased. The direction of change was the same in the 0–20 and 20–40 cm layers. In every year, the lower layer had higher salinity and pH and lower humus, P₂O₅ and K₂O contents (Table 2).

Table 2. Salinity and agrochemical parameters of light sierozem soils at site No. 2 during 2023–2025

Parameter	Depth, cm	2023	2024	2025
Humus, %	0–20	1.10	1.07	1.05
Humus, %	20–40	0.82	0.79	0.76
pH	0–20	7.70	7.80	7.90
pH	20–40	7.90	8.00	8.10

Parameter	Depth, cm	2023	2024	2025
P ₂ O ₅ , mg/kg	0–20	22	21	20
P ₂ O ₅ , mg/kg	20–40	16	15	14
K ₂ O, mg/kg	0–20	255	248	240
K ₂ O, mg/kg	20–40	225	218	210
Salinity, %	0–20	0.38	0.40	0.42
Salinity, %	20–40	0.43	0.45	0.47

Salinity in the upper layer increased steadily from 0.38% in 2023 to 0.40% in 2024 and 0.42% in 2025. The corresponding values in the lower layer were 0.43, 0.45 and 0.47%. Thus, the annual increase at both depths was 0.02 percentage points, and the total increase over the observation period was 0.04 percentage points. Relative to the 2023 baseline, salinity increased by 10.53% in the 0–20 cm layer and by 9.30% in the 20–40 cm layer.

The difference in salinity between the lower and upper layers remained constant at 0.05 percentage points. Salinity therefore increased while the initial difference between depths was maintained. The higher relative increase in the upper layer reflects its lower initial value and does not indicate a greater absolute increase.

Soil pH increased alongside salinity, rising from 7.70 to 7.90 in the 0–20 cm layer and from 7.90 to 8.10 in the 20–40 cm layer. The annual increase was 0.10 units in both layers, giving a total increase of 0.20 pH units. Throughout the observation period, pH in the lower layer exceeded that in the upper layer by 0.20 units. These data indicate a shift toward more alkaline conditions but do not, by themselves, establish the salinity type or degree of sodicity.

Humus content in the 0–20 cm layer decreased from 1.10 to 1.05%, a decline of 0.05 percentage points or 4.55% of the initial value. In the 20–40 cm layer, it decreased by 0.06 percentage points, from 0.82 to 0.76%, equivalent to 7.32%. Unlike salinity and pH, the absolute change in humus content differed slightly between depths.

The interannual pattern of humus content also differed between layers. In the upper layer, the decrease was 0.03 percentage points between 2023 and 2024 and 0.02 percentage points between 2024 and 2025. In the lower layer, humus content decreased by 0.03 percentage points in each interval. The difference between layers was 0.28 percentage points in 2023 and 2024 and 0.29 percentage points in 2025. Without information on analytical uncertainty and replication, the significance of this small change in the difference between layers cannot be assessed.

P₂O₅ content decreased from 22 to 20 mg/kg in the upper layer and from 16 to 14 mg/kg in the lower layer. The annual decrease was 1 mg/kg at both depths. The total absolute decrease was 2 mg/kg, corresponding to relative decreases of 9.09% in the 0–20 cm layer and 12.50% in the 20–40 cm layer. In every year, P₂O₅ content in the upper layer exceeded that in the lower layer by 6 mg/kg.

K₂O content decreased from 255 to 240 mg/kg in the 0–20 cm layer and from 225 to 210 mg/kg in the 20–40 cm layer. The absolute decrease was 15 mg/kg in each layer, corresponding to 5.88 and 6.67% of the initial values, respectively. At both depths, K₂O content decreased by 7 mg/kg between 2023 and 2024 and by 8 mg/kg between 2024 and 2025. The difference between layers remained at 30 mg/kg.

The overall changes in the parameters examined are summarized in Table 3.

Table 3. Absolute and relative changes in soil parameters at site No. 2 during 2023–2025

Parameter	Depth, cm	Absolute change	Relative change, %
Humus	0–20	–0.05 pp	–4.55
Humus	20–40	–0.06 pp	–7.32
pH	0–20	+0.20 units	—

Parameter	Depth, cm	Absolute change	Relative change, %
pH	20–40	+0.20 units	—
P ₂ O ₅	0–20	–2 mg/kg	–9.09
P ₂ O ₅	20–40	–2 mg/kg	–12.50
K ₂ O	0–20	–15 mg/kg	–5.88
K ₂ O	20–40	–15 mg/kg	–6.67
Salinity	0–20	+0.04 pp	+10.53
Salinity	20–40	+0.04 pp	+9.30

Among the parameters that decreased, P₂O₅ showed the largest relative decline. Relative decreases in humus, P₂O₅ and K₂O were greater in the lower layer. For phosphorus and potassium, however, this difference was entirely attributable to lower initial values combined with identical absolute decreases. For humus, the lower layer also showed a slightly greater absolute decrease.

Overall, the three-year observations revealed concurrent increases in salinity and pH and decreases in humus, phosphorus and potassium contents. Most differences between layers remained virtually unchanged. These findings describe temporal changes in the light sierozem soils at site No. 2; identifying their causes requires comparison with water management practices, agricultural operations and measured electromagnetic field parameters.

4. Discussion

The principal feature of the observed changes in light sierozem soils at site No. 2 was the combination of increasing salinity and pH with declining humus, phosphorus and potassium contents. These changes occurred at both depths, but their concurrence does not establish a common cause. Interpretation requires a distinction between temporal changes, differences between layers, and potential factors governing soil condition.

The increase in salinity of 0.04 percentage points in both layers indicates a rise in the measured parameter within the sampled soil profile. Under irrigation, this pattern may be associated with salt inputs in irrigation water and leaching conditions. According to FAO guidance, salt accumulation depends on irrigation water quality, irrigation management and drainage [1]. For site No. 2, however, these explanations remain hypotheses because information on the water balance, irrigation water

composition and drainage conditions was unavailable.

The higher salinity of the 20–40 cm layer persisted throughout the three years. The difference between layers did not increase and remained at 0.05 percentage points. This distribution shows consistently higher salinity at the lower depth but does not identify the direction of salt movement. Inferring downward leaching or upward transport would require observations of soil moisture, groundwater and salt distribution deeper in the profile. The two sampled layers are also insufficient to locate the maximum salt accumulation within the entire soil profile.

Increasing pH accompanied increasing salinity, but these parameters represent different soil properties. A rise in salinity does not necessarily imply a proportional rise in pH. Mosley et al. demonstrated that soil reaction is associated with soil composition, including carbonate, clay and organic carbon contents, and that measured values also depend on measurement conditions [3]. The simultaneous increase in the two parameters at site No. 2 should therefore be interpreted as an observed association rather than a demonstrated causal relationship.

The pH of 8.10 recorded in the 20–40 cm layer in 2025 is not, by itself, sufficient to classify the soil as sodic. Similarly, the salinity value of 0.47% cannot support a definitive classification of salinity severity without clarification of the analytical method and salt composition. At this stage, the findings support an increase in salinity relative to baseline and a shift toward more alkaline conditions.

The decrease in humus content is a separate aspect of the observed changes. Organic matter is associated with soil structure, water retention and soil organism activity, making its monitoring important for fertility assessment [2]. However, the reported decrease in humus mass

fraction cannot automatically be equated with a loss of humus stocks per unit area. Such a calculation requires bulk density data and comparable soil masses. Changes in physical properties also require direct measurement.

The relative decrease in humus content was greater in the lower layer, at 7.32%, compared with 4.55% in the upper layer. However, the difference between the absolute decreases was only 0.01 percentage points. Without information on replication and analytical precision, it is not possible to determine whether this difference represents genuinely different changes with depth. It would therefore be premature to infer greater sensitivity of the lower layer to external exposure from these values.

Declining P_2O_5 and K_2O contents should be considered in the context of plant nutrition and agricultural management at the site. Assessing their causes requires information on fertilizer application, crop types and nutrient removal in harvested crops. Interpretation of laboratory values also depends on the phosphorus and potassium fractions measured. Until the extraction methods are clarified, the data indicate decreases in the corresponding analytical parameters but do not establish changes in total nutrient stocks or plant nutrient deficiencies.

The potential contribution of electromagnetic exposure requires separate investigation. Baydilli et al., studying a semi-arid agroecosystem in Türkiye, found differences in microbiological and biochemical parameters between soils near high-voltage lines and a control site [5]. They also reported lower pH near the lines, whereas pH at site No. 2 increased over time. Direct comparison is limited by differences in study design: spatial comparisons with a control and interannual observations at a single site address different questions. Their publication supports the relevance of investigating soils near transmission lines but does not demonstrate that the increases in salinity and pH observed here were electromagnetic in origin.

The 500 kV line voltage and reported 30 m protection zone characterize the electricity infrastructure but do not replace exposure measurements at sampling points. The electric field is associated with voltage and the magnetic field with current [4]. Assessing relationships between soil parameters and electromagnetic fields therefore requires actual measurements of both field components. The available data also do not justify treating the protection zone boundary as the boundary of soil changes.

The soil bonitet rating of 58 was used as a baseline site characteristic. As no repeat bonitet assessment was available for 2023–2025, changes in individual parameters cannot be expressed as a demonstrated decline in the bonitet rating. Similarly, the absence of crop yield data prevents quantification of the consequences of the observed changes for crop productivity.

The practical significance of the findings lies in identifying priorities for further monitoring. At site No. 2, observations of salinity, pH, humus, phosphorus and potassium should continue at comparable sampling times and be supplemented with replicate samples, irrigation water characterization and electromagnetic field measurements. Including a control site with similar soil conditions and agricultural management would help test the persistence of the observed trends and distinguish the effects of the water regime, agricultural land use and electromagnetic exposure more reliably.

5. Conclusions

In the light sierozem soils at site No. 2 near a 500 kV transmission line, salinity and pH increased consistently during 2023–2025, while humus, P_2O_5 and K_2O contents decreased. The direction of change was the same in the 0–20 and 20–40 cm layers.

Salinity increased from 0.38 to 0.42% in the upper layer and from 0.43 to 0.47% in the lower layer. The absolute increase was 0.04 percentage points at both depths, and the relative increases were 10.53 and 9.30%, respectively. Salinity in the lower layer consistently exceeded that in the upper layer by 0.05 percentage points.

Soil pH increased from 7.70 to 7.90 in the 0–20 cm layer and from 7.90 to 8.10 in the 20–40 cm layer. The total increase was 0.20 units at both depths. The observed pattern indicates a shift toward more alkaline conditions but does not, by itself, establish the development of sodicity.

Humus content decreased from 1.10 to 1.05% in the upper layer and from 0.82 to 0.76% in the lower layer. The absolute decreases were 0.05 and 0.06 percentage points, respectively, and the relative decreases were 4.55 and 7.32%. Assessing the significance of differences between layers requires information on replication and analytical uncertainty.

P_2O_5 content decreased from 22 to 20 mg/kg at 0–20 cm

and from 16 to 14 mg/kg at 20–40 cm, corresponding to decreases of 9.09 and 12.50%, respectively. K₂O content decreased from 255 to 240 and from 225 to 210 mg/kg, equivalent to decreases of 5.88 and 6.67%. For both parameters, the absolute decrease was identical in the two layers.

Throughout the observation period, the lower layer had higher salinity and pH but lower humus, phosphorus and potassium contents. Differences between layers in salinity, pH, P₂O₅ and K₂O remained unchanged. Thus, the observed vertical distribution of these parameters was maintained despite interannual changes.

The findings describe soil changes at a specific site near a 500 kV transmission line but do not isolate the contribution of electromagnetic exposure. Investigating the causes of these changes requires measurements of electric and magnetic fields, repeated observations at a comparable control site, and consideration of irrigation, fertilizer inputs and nutrient removal in harvested crops.

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