

Temporal Changes in Soil Physicochemical Properties Near A 110 kV Power Transmission Line in The Fergana Valley

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Abstract: This study examines temporal changes in soil physicochemical parameters at experimental site No. 1 near a 110 kV power transmission line in the Fergana Valley. The aim was to characterize changes in soil properties during 2023–2025 under long-term exposure to the electromagnetic field generated by the line. Humus content, pH, and phosphorus and potassium contents expressed as P_2O_5 and K_2O were compared between the 0–20 and 20–40 cm layers. During the study period, humus content decreased from 1.35 to 1.28% in the upper layer and from 1.05 to 0.98% in the lower layer. Over the same period, pH increased from 7.40 to 7.60 and from 7.60 to 7.80, respectively. P_2O_5 content decreased from 28 to 24 mg/kg in the 0–20 cm layer and from 20 to 16 mg/kg in the 20–40 cm layer, while K_2O content decreased from 300 to 280 and from 260 to 240 mg/kg, respectively. Both layers exhibited the same direction of change: declining humus, phosphorus and potassium contents accompanied by increasing pH. These findings characterize changes in soil at the study site; however, establishing the contribution of electromagnetic fields requires comparison with control soils, field measurements, and consideration of agricultural management and environmental factors.

Keywords: Soil, electromagnetic field, 110 kV power transmission line, humus, pH, phosphorus, potassium, Fergana Valley.

Introduction: Maintaining soil fertility requires an understanding of changes driven by environmental conditions, agricultural land use and anthropogenic factors. Organic matter content is a key indicator of soil condition because it is associated with soil structure, water retention, nutrient availability and soil organism activity. Monitoring humus content alongside other agrochemical parameters therefore helps identify the direction of soil change and provides a basis for assessing soil condition [1].

Electric and magnetic fields generated by power transmission lines are among the physical factors present near electricity infrastructure. Alternating-current transmission lines produce power-frequency fields within the non-ionizing region of the electromagnetic spectrum. The electric field is associated with voltage, whereas the magnetic field is associated with electric current. Consequently, the

nominal line voltage only partially characterizes the source and cannot replace direct field measurements at the study site. A continuously operating transmission line entails long-term exposure to a time-varying field, rather than exposure to a static field in the physical sense [2].

Investigating the potential effects of electromagnetic fields on soils requires a combination of field observations and laboratory analyses. Marupov et al. reviewed methodological approaches to studying soils near power transmission lines, including field and laboratory methods for assessing soil properties. Site-specific investigations extend this approach by enabling comparisons of soil parameters over time and with depth. A distinction must nevertheless be made between describing soil conditions near a transmission line and establishing a causal relationship between observed changes and electromagnetic exposure [3].

Water management and tillage practices are essential considerations when interpreting observations on agricultural land. In irrigated soils, salt accumulation depends on irrigation water quality, irrigation practices and drainage. Organic matter content is also linked to crop residue inputs and land management. Changes in soil parameters near transmission lines should therefore be evaluated in the context of these accompanying factors: proximity to a line alone does not establish that the observed changes are caused by electromagnetic fields [1, 4].

The present study is limited to an analysis of three-year changes in soil parameters at experimental site No. 1 near a 110 kV transmission line in the Fergana Valley. It examines humus content, soil reaction, and phosphorus and potassium contents expressed as P_2O_5 and K_2O in the 0–20 and 20–40 cm layers. This comparison identifies the direction and magnitude of interannual changes and assesses whether the upper and lower layers exhibit similar patterns.

The aim of the study was to characterize changes in soil physicochemical and agrochemical parameters at site No. 1 near a 110 kV transmission line during 2023–2025 and to identify differences between the 0–20 and 20–40 cm layers. The objectives were to compare annual values, calculate absolute and relative changes, and assess differences between the layers. The findings provide a basis for further investigation of a possible relationship between soil condition and electromagnetic exposure.

METHODS

The study analyzed changes in soil properties at experimental site No. 1, located near a 110 kV power transmission line in the Fergana Valley. The analysis used data for 2023–2025 describing soil conditions at depths of 0–20 and 20–40 cm.

The parameters examined were humus content, soil

reaction (pH), and phosphorus and potassium contents expressed as P_2O_5 and K_2O . Humus content was reported as a percentage, while phosphorus and potassium contents were reported in milligrams per kilogram of soil. Annual values were compared separately for each layer.

Data processing involved calculating absolute and relative changes over the study period by comparing the 2025 values with those recorded in 2023. Changes in humus content were expressed in percentage points and as percentages of the initial values; changes in phosphorus and potassium contents were expressed in mg/kg and as percentages. For pH, only the difference between the values was calculated. The 2024 data were used to assess the consistency of interannual changes.

Values for the upper and lower soil layers were also compared within each year. This comparison identified differences between depths and established whether the direction of change was consistent in the 0–20 and 20–40 cm layers.

The analysis was descriptive. As information on replication and variability was unavailable, the statistical significance of differences was not assessed. The observed changes characterize soil conditions at the study site. Establishing their relationship with electromagnetic exposure requires additional comparisons with field measurements and control-site data, together with consideration of irrigation and fertilizer management.

RESULTS

Comparison of the 2023–2025 data revealed changes in the same direction in both soil layers at site No. 1. Humus, phosphorus and potassium contents decreased consistently over the observation period, whereas pH increased. Differences between the 0–20 and 20–40 cm layers persisted throughout the three years (Table 1).

Table 1. Soil parameters at site No. 1 near a 110 kV transmission line during 2023–2025

Parameter	Depth, cm	2023	2024	2025
Humus, %	0–20	1.35	1.32	1.28
Humus, %	20–40	1.05	1.02	0.98
pH	0–20	7.40	7.50	7.60
pH	20–40	7.60	7.70	7.80
P_2O_5 , mg/kg	0–20	28	26	24
P_2O_5 , mg/kg	20–40	20	18	16
K_2O , mg/kg	0–20	300	290	280
K_2O , mg/kg	20–40	260	250	240
PO, %*	0–20	0.30	0.32	0.34

Parameter	Depth, cm	2023	2024	2025
PO, %*	20–40	0.35	0.37	0.39

In the 0–20 cm layer, humus content decreased from 1.35% in 2023 to 1.32% in 2024 and 1.28% in 2025. The total decrease was 0.07 percentage points, equivalent to 5.19% of the initial value. In the 20–40 cm layer, humus content decreased from 1.05 to 0.98% over the same period. The absolute decrease was also 0.07 percentage points, but the relative decrease was greater, at 6.67%, because of the lower initial humus content.

In both layers, humus content decreased by 0.03 percentage points between 2023 and 2024 and by 0.04 percentage points between 2024 and 2025. The difference between the upper and lower layers remained constant at 0.30 percentage points. Thus, despite the overall decline, humus content remained higher in the upper layer.

Soil pH increased consistently at both depths. It rose from 7.40 to 7.60 in the 0–20 cm layer and from 7.60 to 7.80 in the 20–40 cm layer. The annual increase was 0.10 units, giving a total increase of 0.20 pH units. In every year, pH in the lower layer exceeded that in the

upper layer by 0.20 units. The observed pattern therefore indicates a shift toward more alkaline conditions, with the difference between depths remaining unchanged.

P₂O₅ content decreased from 28 to 24 mg/kg in the 0–20 cm layer and from 20 to 16 mg/kg in the 20–40 cm layer. The annual decrease was 2 mg/kg at both depths. Over the entire period, the absolute decrease was 4 mg/kg, corresponding to relative decreases of 14.29% in the upper layer and 20.00% in the lower layer. The greater relative decrease at 20–40 cm reflects the lower initial value.

K₂O content also decreased consistently, from 300 to 280 mg/kg in the upper layer and from 260 to 240 mg/kg in the lower layer. The absolute decrease over the observation period was 20 mg/kg in each layer, corresponding to 6.67 and 7.69% of the respective 2023 values. Throughout the period, K₂O content in the 0–20 cm layer exceeded that in the 20–40 cm layer by 40 mg/kg. The calculated changes are summarized in Table 2.

Table 2. Changes in soil parameters at site No. 1 between 2023 and 2025 relative to the 2023 baseline

Parameter	Absolute change, 0–20 cm	Relative change, %	Absolute change, 20–40 cm	Relative change, %
Humus	–0.07 pp	–5.19	–0.07 pp	–6.67
pH	+0.20 units	—	+0.20 units	—
P ₂ O ₅	–4 mg/kg	–14.29	–4 mg/kg	–20.00
K ₂ O	–20 mg/kg	–6.67	–20 mg/kg	–7.69
PO*	+0.04 pp	+13.33	+0.04 pp	+11.43

Among the parameters that decreased, P₂O₅ exhibited the largest relative change, at 14.29–20.00%. The relative decreases in humus and K₂O contents were smaller. However, the absolute change in each parameter was identical in both layers. Differences in relative decreases therefore reflected the initial values rather than a larger absolute decrease in the lower layer.

The parameter designated as “PO” in the source data increased from 0.30 to 0.34% in the 0–20 cm layer and from 0.35 to 0.39% in the 20–40 cm layer. The absolute increase was 0.04 percentage points at both depths. Interpretation of this change requires clarification of the parameter’s full name and analytical method.

The data show consistent interannual patterns in the two soil layers. During 2023–2025, humus, P₂O₅ and K₂O contents decreased, while pH increased. These results describe changes at site No. 1 near a 110 kV transmission line; identifying their causes requires consideration of land management and electromagnetic exposure parameters.

DISCUSSION

Soil changes at site No. 1 were characterized by concurrent decreases in humus, P₂O₅ and K₂O contents and an increase in pH. This combination warrants attention in assessments of agricultural soil condition. Nevertheless, coincident changes over time do not establish a common underlying mechanism.

Interpretation requires consideration of both potential electromagnetic exposure and agricultural management at the site.

Humus content decreased in both layers. Organic matter contributes to soil structure, water retention and conditions supporting soil organisms. Its decline may therefore be relevant to the maintenance of soil fertility. However, the available data do not establish whether declining humus content was accompanied by changes in water-holding capacity or soil structure, since the corresponding physical parameters were not reported [1].

The identical absolute decrease in humus content at both depths, amounting to 0.07 percentage points, deserves particular attention. The larger relative decrease in the 20–40 cm layer is explained by its lower initial value. This result alone therefore does not indicate a stronger effect of the factor under investigation on the lower layer. The persistence of the difference between layers over three years indicates that the observed vertical pattern of humus content was maintained within the sampled soil profile.

The increase of 0.20 pH units in each layer indicates a shift toward more alkaline conditions. However, increasing pH should not be equated with demonstrated development of sodicity or accumulation of particular salts. Such an assessment requires additional information on soil solution composition and exchangeable cations. Under irrigation, water quality, salt inputs and leaching efficiency are important considerations; the site's water regime must therefore be taken into account when discussing the observed changes [4].

P₂O₅ showed the greatest relative decrease among the parameters that declined during the observation period. However, its concurrence with increasing pH does not establish that the change in soil reaction directly caused the decrease in measured phosphorus content. Testing this relationship requires information on the laboratory extraction method, the phosphorus fraction measured, fertilizer inputs and nutrient removal in harvested crops. Similarly, the decrease in K₂O content should be considered in relation to the balance between potassium inputs and uptake. Without this information, attributing the changes solely to electromagnetic fields would be premature.

Assessment of potential electromagnetic effects requires a distinction between the characteristics of the transmission line and actual conditions at the sampling location. The 110 kV rating specifies the voltage class of the line but does not quantify soil exposure. Electric and magnetic fields arise from different electrical characteristics: the former is

associated with voltage and the latter with current. Relating soil changes to electromagnetic fields therefore requires measurements of both field components directly at the study site [2].

This study contributes to field investigations of soils near electricity infrastructure, for which methodological approaches were presented by Marupov et al. [3]. The three-year dataset describes temporal changes at a specific site. The next step in testing the hypothesis of electromagnetic effects should be to compare these changes with those at a control site with similar soil conditions and agricultural management, while simultaneously recording field parameters.

A limitation of the present analysis is the lack of information on replication, analytical uncertainty and spatial variability. Consequently, it is not possible to determine the extent to which the observed interannual differences exceed natural variability and measurement uncertainty. Three annual observations are also insufficient for reliable prediction of future changes. The results should therefore be interpreted as a description of changes over a specific period, without extrapolating the observed rates to subsequent years.

The practical value of the study lies in identifying parameters that require continued monitoring at site No. 1. Further observations of humus content, soil reaction, and phosphorus and potassium status will help establish whether the identified trends persist. Supplementing these observations with information on agricultural practices, irrigation water quality and electromagnetic field levels will provide a basis for distinguishing potential causes and assessing soil condition more reliably.

CONCLUSIONS

At experimental site No. 1 near a 110 kV transmission line, humus, P₂O₅ and K₂O contents decreased consistently during 2023–2025, while pH increased. The direction of change was the same in the 0–20 and 20–40 cm layers.

Humus content decreased from 1.35 to 1.28% in the 0–20 cm layer and from 1.05 to 0.98% in the 20–40 cm layer. The absolute decrease was 0.07 percentage points at both depths, while the relative decreases were 5.19 and 6.67%, respectively. The larger relative decrease in the lower layer reflects its lower initial humus content.

Soil pH increased from 7.40 to 7.60 in the upper layer and from 7.60 to 7.80 in the lower layer. The increase of 0.20 units at both depths indicates a shift toward more alkaline conditions.

P₂O₅ content decreased by 4 mg/kg in each layer, from

28 to 24 mg/kg at 0–20 cm and from 20 to 16 mg/kg at 20–40 cm. The relative decreases were 14.29 and 20.00%. K₂O content decreased from 300 to 280 and from 260 to 240 mg/kg, respectively, corresponding to decreases of 6.67 and 7.69%.

Differences between the soil layers persisted throughout the observation period: the upper layer had higher humus, P₂O₅ and K₂O contents, whereas the lower layer had higher pH. The absolute differences between layers remained unchanged for these parameters.

The findings characterize changes in soil parameters near a transmission line but do not allow the contribution of electromagnetic exposure to be quantified. Testing this relationship requires repeated observations at the study site and a comparable control site, measurements of electric and magnetic fields, and consideration of irrigation, fertilizer inputs and nutrient removal in harvested crops.

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