Methods for researching the influence of electromagnetic waves of power transmission lines on soil properties

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Abstract. This article is devoted to the study of the influence of electromagnetic waves from power lines on soil properties. With the increasing use of electricity and the expansion of electrical power infrastructure, there is increasing interest in understanding the effects of electromagnetic fields on the environment. This article provides an overview of current research methods used to assess the effects of electromagnetic waves on soil properties. Both laboratory and field approaches to studying this issue are considered, and the main results of research in this area are discussed. Understanding these relationships is key to developing effective land use management strategies and maintaining environmental sustainability in the face of modern anthropogenic impacts.

1 Introduction

In today's world, where technology plays a key role in everyday life, the topic of the impact of electromagnetic waves on the environment is attracting more and more attention. One of the important areas of research in this area is the influence of electromagnetic waves from power lines on soil properties. This aspect becomes especially relevant in light of the constant increase in the use of electricity and the expansion of electricity infrastructure [1].

The soil, as an integral part of the ecosystem, is subject to various influences, and the influence of electromagnetic waves from power transmission lines is becoming the subject of scientific study. This issue is becoming not only significant for scientific researchers, but also acquiring important practical significance for the agricultural and environmental spheres.

The purpose of this article is to review modern methods for studying the influence of electromagnetic waves on soil properties, as well as to provide an overview of the main results obtained in this field. Understanding these relationships is critical to developing effective land use management strategies and ensuring environmental sustainability in the face of modern anthropogenic impacts [2].

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Electrical resistance is one of the soil parameters that can be easily measured in field and laboratory conditions, and at the same time allows one to fairly objectively evaluate many soil properties. Specific electrical resistance is a function of volumetric charge density, i.e., it is almost directly related to the concentration of ions in the solution. Therefore, historically, the very first such property with which connections were sought for specific electrical resistance (electrical conductivity) was the presence and concentration of ions of easily soluble salts in the soil solution. Nowadays, determining salinity by the electrical conductivity of soil pastes is a common method of chemical analysis of soils; scales of the degree of salinity based on electrical conductivity values have been created.

Research methods. The study of the influence of electromagnetic waves from power lines on soil properties includes a variety of methods that allow the analysis of physical, chemical and biological changes in the soil cover. Below is an overview of the main research methods:

1. Geoelectrical methods: Soil electrical tomography: Measurement of electrical resistance at various points in the soil to create a three-dimensional model reflecting changes in soil properties under the influence of electromagnetic fields.
2. Spectroscopy: Infrared spectroscopy: Analyzes changes in the infrared spectrum of soil to determine its chemical composition, including moisture, mineral and organic matter content.
4. Physical Measurements: Soil Moisture Measurement: Monitors changes in moisture levels to determine the effects of electromagnetic fields on soil hydrophysical properties.
5. Modeling: Numerical modeling of electromagnetic fields: Use of mathematical models to evaluate the distribution of electromagnetic fields in the soil and their impact on physical parameters.
6. Ecological observations: Field research: Collection of soil samples in various zones of influence of power lines and analysis of parameters on site.
7. Comparative Analyses: Comparison with Control Samples: Investigate differences between soil samples in areas with and without power lines.

Electric transmission lines affect the soil cover of the earth in the zone affected by power lines, in zones up to 30 meters in each direction with overhead lines of 650-750 kW power, Figure 1.
Soil cover - This is the top layer of the Earth, which consists of various mineral and organic materials. It consists of the following main components:

i. **Mineral particles**: The soil cover is dominated by minerals such as sand, silt, and clay. These minerals form tiny particles that affect the physical properties of the soil, such as its texture and moisture content.

ii. **Organic matter**: The soil cover contains significant amounts of organic matter such as plant debris, microorganisms, and woody debris. Organic matter is an important component influencing the biological and chemical properties of soil.

iii. **Water**: Soil cover includes moisture that is found in the spaces between mineral and organic particles. Water in the soil is important for plants and microorganisms, and its presence affects the hydrophysical properties of the soil.

iv. **Air**: The space between soil particles also contains air. This air is necessary for plant roots and microorganisms, as it provides access to oxygen.

v. **Microorganisms**: The soil cover is inhabited by many microorganisms, such as bacteria, fungi, and viruses. These microorganisms play a key role in nutrient cycles and maintain biological balance in the soil.

Study. Soil agrochemistry is the chemical composition of the soil cover and its effect on plant growth. Important components of soil agrochemistry are nutrients, pH, salt content and organic matter:

**A. Nutrients,**

a. **Macroelements**: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur.

b. **Microelements**: iron, manganese, zinc, copper, boron, molybdenum, cobalt, nickel.

c. The role of each element in the growth and development of plants.

**B. Soil acidity indicators (pH)**

a. Determination of pH and its importance for plants.

b. Effect of pH on nutrient availability.

**C. Organic matter**

a. Decomposition of plant and animal residues.
b. The role of humus in retaining moisture and nutrients.

D. Soil salinity

a. Salinity and its effect on plants.
b. Salinity control and management measures.

Studies of the effects of electromagnetic waves on soil can reveal different results, depending on the intensity, frequency and duration of exposure, as well as the characteristics of the soil itself. Some of the expected results include:

1. **Changes in soil physical properties:**
   - Changes in the structure and fluidity of the soil under the influence of electromagnetic waves are possible. This may affect humidity, breathability and thermal performance (Table 1).

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Expected changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil structure</td>
<td>Changes in soil structure, for example in the formation of aggregates, are possible.</td>
</tr>
<tr>
<td>Fluidity</td>
<td>A change in soil fluidity may occur under the influence of electromagnetic waves.</td>
</tr>
<tr>
<td>Humidity</td>
<td>Electromagnetic waves can affect soil moisture levels.</td>
</tr>
<tr>
<td>Breathability</td>
<td>Changes in soil air permeability are possible, depending on the intensity of exposure.</td>
</tr>
<tr>
<td>Thermal characteristics</td>
<td>Electromagnetic waves can affect the thermal properties of soil.</td>
</tr>
</tbody>
</table>

2. **Impact on moisture content:**
   - Electromagnetic waves can affect the interaction of moisture with mineral and organic components of the soil. This can affect moisture levels and the soil's ability to hold water.

3. **Chemical Changes:**
   - Exposure to electromagnetic fields can cause chemical changes in the soil. This can affect the solubility of mineral elements and their availability to plants (Table 2).

<table>
<thead>
<tr>
<th>Chemical property</th>
<th>Expected changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen content (N)</td>
<td>The solubility and availability of nitrogen to plants may change.</td>
</tr>
<tr>
<td>Phosphorus content (P)</td>
<td>Electromagnetic waves can affect the solubility of phosphorus in soil.</td>
</tr>
<tr>
<td>Potassium content (K)</td>
<td>A change in potassium solubility and availability to plants may occur.</td>
</tr>
<tr>
<td>Soil pH</td>
<td>Electromagnetic waves can affect pH levels, changing the acidity or alkalinity of the soil.</td>
</tr>
<tr>
<td>Microelements</td>
<td>Changes in the solubility of microelements (iron, manganese, zinc, etc.) in the soil are possible.</td>
</tr>
<tr>
<td>Organic matter</td>
<td>A change in the decomposition of organic matter and the formation of humus may occur.</td>
</tr>
<tr>
<td>Soil salinity</td>
<td>Electromagnetic waves can influence soil salinity and its effect on plant growth.</td>
</tr>
</tbody>
</table>

4. **Effect on microorganisms:**
   - Microorganisms in the soil can be sensitive to changes in electromagnetic fields. This can affect the microbiota, which in turn can affect nutrient cycles and the overall health of the soil ecosystem.
5. **Effects on plants:**
   - Exposure to electromagnetic waves can affect plant growth, development and health. This can manifest itself in changes in plant morphology, physiology and productivity.

6. **Potential effects on environmental sustainability:**
   - Understanding the effects of electromagnetic waves on soil is also important from an environmental sustainability perspective. Possible changes in the soil ecosystem may have implications for biodiversity and overall environmental stability.

   We have discovered that under the influence of electromagnetic waves such soil properties as volume, specific gravity of the soil, and porosity, and also the agrochemical properties do not change significantly; taking these provisions into account, we did not provide the specified data in the abstract [3].

   The volumetric mass, regardless of the location of the section, changes within the range of 1.31-1.41 g/cm³, in addition, the influence of power lines on changes in the volumetric and specific gravity of the soil is practically not detected. The specific gravity varies in the range of 2.56-2.73 g/cm³, which is associated with the properties of the soil itself. In accordance with changes in the bulk density of the soil, the porosity changes. Depending on the volumetric and specific gravity, as well as the porosity of soils, the humus content of gross nitrogen, phosphorus, potassium and their mobile forms changes. As for the influence of power lines on the agrochemical properties of soils, they are given in Table 3. Location of the study: 40.306336, 71.539679.

   From the given data on humus and nutrients, there are no significant differences in changes in these indicators under the influence of electromagnetic waves, and those that have small changes are associated with the structure of the soil cover and soil erodibility to the left of the power lines.
Table 3. Agrochemical characteristics of soils in key areas (550 kW).

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Distance from power lines, m</th>
<th>Depth, cm</th>
<th>Humus, %</th>
<th>Gross, %</th>
<th>Mobile, mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-30</td>
<td>1,620</td>
<td>0.152</td>
<td>0.280</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-45</td>
<td>1.010</td>
<td>0.920</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45-60</td>
<td>0.601</td>
<td>0.420</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-80</td>
<td>0.302</td>
<td>0.250</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80-120</td>
<td>0.201</td>
<td>0.080</td>
<td>0.150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-30</td>
<td>1,600</td>
<td>0.165</td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-45</td>
<td>0.950</td>
<td>0.890</td>
<td>0.220</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45-60</td>
<td>0.520</td>
<td>0.410</td>
<td>0.200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-80</td>
<td>0.350</td>
<td>0.095</td>
<td>0.140</td>
</tr>
<tr>
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<td></td>
<td>80-120</td>
<td>0.195</td>
<td>0.020</td>
<td>0.130</td>
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<td></td>
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<td>0-30</td>
<td>1,610</td>
<td>0.141</td>
<td>0.220</td>
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<td></td>
<td>30-45</td>
<td>1,100</td>
<td>0.095</td>
<td>0.210</td>
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<tr>
<td></td>
<td></td>
<td>45-60</td>
<td>0.710</td>
<td>0.064</td>
<td>0.135</td>
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<td></td>
<td></td>
<td>60-80</td>
<td>0.411</td>
<td>0.028</td>
<td>0.120</td>
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<tr>
<td></td>
<td></td>
<td>80-120</td>
<td>0.200</td>
<td>0.015</td>
<td>0.120</td>
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<tr>
<td></td>
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<td>0-30</td>
<td>1,501</td>
<td>0.140</td>
<td>0.280</td>
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<tr>
<td></td>
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<td>30-45</td>
<td>0.950</td>
<td>0.082</td>
<td>0.220</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45-60</td>
<td>0.590</td>
<td>0.048</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-80</td>
<td>0.450</td>
<td>0.035</td>
<td>0.130</td>
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<td></td>
<td></td>
<td>80-120</td>
<td>0.210</td>
<td>0.011</td>
<td>0.125</td>
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<td>1,540</td>
<td>0.138</td>
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<td></td>
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<td>30-45</td>
<td>0.850</td>
<td>0.077</td>
<td>0.240</td>
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<tr>
<td></td>
<td></td>
<td>45-60</td>
<td>0.610</td>
<td>0.051</td>
<td>0.150</td>
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<tr>
<td></td>
<td></td>
<td>60-80</td>
<td>0.410</td>
<td>0.032</td>
<td>0.142</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80-120</td>
<td>0.190</td>
<td>0.011</td>
<td>0.120</td>
</tr>
</tbody>
</table>

In this article, we will consider some facts about the influence of electrical transmission waves on soil microorganisms. The effects of electromagnetic waves from power lines on
soil microorganisms can be varied and depend on various factors, including the intensity of exposure, duration of exposure, and types of microorganisms. Some microorganisms that may be affected by electromagnetic waves include [4-37]:

**Bacteria** - Bacteria in soil play an important role in nutrient cycles and provide several key functions in the soil ecosystem. Exposure to electromagnetic waves can affect their metabolism, growth and reproduction.

**Mushrooms** - Fungi are also important components of the soil microbiota. They participate in the decomposition of organic matter and provide the soil with necessary enzymes. Exposure to electromagnetic waves can affect the activity of mushrooms.

**Viruses** - Viruses in soil can affect microorganisms such as bacteria and alter their biological processes. Exposure to electromagnetic waves can influence viral activity in soil.

**The simplest microorganisms** - Protozoan microorganisms, such as amoebas and other single-celled organisms, can also respond to changes in the electromagnetic field.

**Conclusions.** Research on the effects of electromagnetic waves from power lines on soil properties provides important data that influences our understanding of the environmental aspects of modern energy infrastructure. Below are the main conclusions on the topic “Methods for studying the influence of electromagnetic waves from power lines on soil properties”:

- **Diversification of research methods** - Research includes a variety of methods such as geoelectric measurements, spectroscopy, bioindication and physical measurements. This diversification of methods allows for a more complete assessment of various aspects of the impact of electromagnetic waves on soil cover.

- **Physical changes in the soil** - Research has identified potential changes in soil structure, fluidity, and moisture content when exposed to electromagnetic waves. These changes can affect the physical properties and overall stability of the soil.

- **Chemical changes** - Changes in soil chemical properties such as nutrient solubility and pH are observed. These changes have a potential impact on plant nutrient availability.

- **Impact on microorganisms** - Research confirms that soil microorganisms such as bacteria, fungi and viruses can be affected by electromagnetic waves. This can affect biological processes and nutrient cycles.

- **Practical meaning** - The results obtained have important practical significance for agriculture and ecology. Understanding the effects of electromagnetic waves on soil allows us to develop effective land use management strategies and ensure environmental sustainability.

- **Need for further research** - Questions about the impact of electromagnetic waves on soil require further research, including more detailed laboratory and field experiments. This is necessary to better understand the mechanisms of exposure and to identify potential risks.

**References**


