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Reducing Groundwater Pollution through Increased Humus Content and Soil Sorptive Capacity Using Angren Coal Dust

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Abstract

This study explores an innovative approach to mitigating groundwater pollution caused by nitrate and nitrite leaching from agricultural soils. By applying coal dust—a by-product of the Angren coal industry—onto cotton and wheat fields, we observed enhanced sorption of nitrogen compounds and improved soil quality. Results demonstrate a significant reduction in nitrate content in groundwater, as well as increased humus content and soil water retention. This method provides a sustainable solution to both environmental pollution and soil degradation in arid agricultural regions.

Keywords: Coal dust, nitrates, nitrites, groundwater pollution, humus, Angren, soil absorption capacity.

Introduction

The intensive use of nitrogen-based fertilizers in agriculture has led to a widespread problem of groundwater contamination, especially in regions with shallow water tables and insufficient rainfall. Nitrate (NO_3^-) and nitrite (NO_2^-) ions easily leach from the soil, eventually reaching aquifers and posing health hazards such as methemoglobinemia and long-term carcinogenic effects.

In Uzbekistan, cotton and wheat cultivation relies heavily on fertilizers, making the contamination of underground water a persistent issue. A promising solution lies in the use of industrial by-products such as Angren coal dust. With high surface area and strong adsorption properties, coal dust can serve as a dual-function additive: capturing harmful nitrogen compounds and enriching the soil's organic matter through carbon incorporation.

2. Materials and Methods

2.1 Study Site and Soil Characteristics

Field experiments were conducted on loamy and gray soils in the Tashkent region. Test plots were selected with similar crop rotation, irrigation practices, and fertilizer application schedules.

2.2 Experimental Design

Control plots received conventional nitrogen-based fertilizer (urea and ammonium nitrate) without additives. Experimental plots received the same fertilizers with the addition of Angren coal dust at a rate of 2.5 tons per hectare.

2.3 Data Collection

Groundwater samples were taken monthly from 3–5 meter deep wells and analyzed for nitrate/nitrite concentrations using spectrophotometric methods (APHA, 2017). Soil samples were tested before and after the growing season for humus content, pH, and soil organic carbon (SOC).

3. Results and Discussion

3.1 Nitrate and Nitrite Reduction in Groundwater Groundwater analysis showed a 45% average decrease in nitrate concentration in plots treated with coal dust. The reduction was most significant during peak irrigation months, confirming that coal dust effectively immobilizes nitrogen compounds during leaching events.

3.2 Humus and Soil Quality Improvement Humus content in experimental soils increased by 0.8–1.1% over six months. The coal dust contributed not only to nitrogen adsorption but also to long-term improvements in soil structure, water retention, and microbial activity.

3.3 Environmental and Economic Implications The use of coal dust provides an eco-friendly and cost-effective method to manage fertilizer runoff. It also utilizes an industrial waste product, minimizing environmental burden and promoting circular economy principles.

4. Conclusion

This study confirms the effectiveness of Angren coal dust as a soil additive that reduces groundwater contamination while enhancing soil fertility. Its dual function—nitrogen adsorption and humus enrichment—makes it a viable solution for sustainable agriculture in arid and semi-arid regions. Further research is recommended to explore long-term soil dynamics and the scalability of this method for broader agricultural application.

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