



PRODUCTION OF FERTILIZERS BASED ON OXIDIZED BROWN COAL AND PHOSPHATE RAW MATERIALS

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Abstract: Organomineral fertilizers were obtained based on the Central Kyzylkum phosphorite raw material. For the study, samples of oxidized coals of Angren brown coal were taken. The technical composition and humic acid content of the coal were determined using standard methods. During the co-grinding of phosphate ores with oxidized coal, brown coal significantly increases the content. An increase in the content of citric and water-soluble forms of phosphate was observed.

Keywords: Renewable energy sources, solar panels, solar panel output power, solar panel operation.

Introduction

Coal mining wastes—oxidized coals—represent a significant source of essential organic matter and are increasingly utilized to stabilize the humus status of soils [1]. In the Angren region, known for its brown coal deposits, there exist substantial reserves of oxidized coals rich in humic acids, with concentrations reaching up to 80%. This high humic acid content renders them highly promising for conversion into organomineral fertilizers.

In parallel, the Central Kyzylkum region is endowed with valuable mineral resources, among which phosphorites stand out as key agrochemical raw materials. However, the beneficiation of low-grade phosphate ores to extract useful components presents notable technological challenges. These include high operational costs and the resultant formation of waste concentrate stockpiles, which give rise to both economic and social concerns. Furthermore, the processing of such ores generates significant volumes of waste materials, contributing to environmental pollution [2].

Under current ecological and economic constraints, there is a pressing need to develop low-waste, environmentally sustainable approaches for processing both coal and phosphate raw materials. One such approach is the mechanical activation of oxidized brown coals in combination with phosphate materials. This method has demonstrated potential for enhancing the reactivity and



compatibility of raw materials, thus improving processing efficiency. The application of energy-efficient mechanical devices in this context further contributes to optimizing the technological process and reducing environmental impact [3].

Research Methods

The composition of humic acids extracted from brown coal samples obtained from the Angren deposits has been determined through technical and elemental analysis. The results are as follows (in %): moisture – 35.83; ash – 16.63; carbon – 51.11; hydrogen – 3.26; nitrogen – 3.76; oxygen and sulfur (combined) – 41.87. In addition, the content of key functional groups has been quantified: carboxyl groups ($-\text{COOH}$) at 5.02 mg-equiv/g and hydroxyl groups ($-\text{OH}$) at 4.64 mg-equiv/g.

These data highlight the chemical and structural potential of the oxidized coal for application in the production of organomineral fertilizers. The relatively high carbon content and the presence of active functional groups such as carboxyl and hydroxyl moieties suggest strong complexation and ion-exchange capabilities, which are critical for nutrient binding and gradual release in soils. The substantial moisture content and moderate ash levels are consistent with the properties of humic acids derived from low-rank brown coals.

Notably, compositional differences between coal samples taken from the upper and lower strata of the deposit were observed, particularly in terms of oxygen content, which plays a significant role in the formation and structure of humic acids. The studied coals are categorized as having an average humification level, indicating an intermediate stage in organic matter transformation.

Technological Evaluation and Fertilizer Production

A series of technological experiments were carried out to explore the potential of combining natural phosphate raw materials with oxidized brown coal for the production of organomineral fertilizers. The focus of the investigation was on assessing the influence of various operational parameters—particularly the coal-to-phosphorite ratio—on the solubility and availability of phosphorus (P_2O_5) in the final product.

The results indicated that the phosphate activation process is highly sensitive to the ratio of coal to phosphorite. Among the evaluated formulations, the ratio of coal to phosphorite ($k : f$) = 1:2 emerged as the most optimal. At this ratio, the quantity of phosphorus soluble in citric acid or lime—a key indicator of plant-available phosphorus—increased significantly. Specifically, the



availability of P_2O_5 reached up to 36.5%, nearly doubling compared to untreated phosphate material.

This enhanced solubility underscores the role of humic substances derived from oxidized coal in activating phosphate ores. These substances are known to possess functional groups (such as carboxyl and hydroxyl) capable of chelating metal ions and forming soluble organophosphate complexes. Notably, this activation occurs without the need for conventional chemical oxidation or acid treatments, making the method both cost-effective and environmentally sustainable.

Thus, the synergistic use of oxidized brown coal and low-grade phosphate raw materials presents a viable pathway for producing high-efficiency, low-waste organomineral fertilizers suitable for modern sustainable agriculture.

Results

The technological process for producing organomineral fertilizers is based on the mechanical blending of natural components—specifically, the grinding and homogenization of phosphate raw materials with oxidized brown coal. This method utilizes a low-energy, solid-phase approach that enhances the reactivity of both constituents without the need for aggressive chemical treatments.

The resulting product contains up to 9% of water-soluble substances, indicating a high degree of nutrient availability. The presence of humic acids from the coal matrix facilitates the mobilization of phosphorus and other micronutrients, improving their accessibility to plants. Preliminary agronomic evaluations and greenhouse trials have demonstrated a positive impact on plant growth and development, suggesting the effectiveness of the formulation.

Importantly, when applying the developed organomineral fertilizer in agricultural systems, it is necessary to compare and validate its performance against existing commercial organomineral fertilizers. Field trials are essential for determining its agronomic efficiency, nutrient release kinetics, and environmental safety under real-world conditions. These trials provide critical data to optimize application rates, assess soil-plant interactions, and ensure the long-term sustainability of fertilizer use.

Discussion

Experimental data indicate that the application of organomineral fertilizers significantly enhances plant productivity. In the case of radish cultivation, the dry biomass increased notably when organomineral fertilizers were applied at concentrations ranging from 32% to 34%. These values reflect a measurable improvement in biomass accumulation compared to the control group.



The control treatment involved seed priming with a 0.001% aqueous solution of sodium humate, applied at a rate of 0.6 kg/m². This served as a baseline to evaluate the effectiveness of the developed organomineral formulations.

In potato cultivation, the effect of organomineral fertilizer application varied depending on the dosage. The increase in yield ranged from 18.6% to 39.7%, with the most pronounced effect observed at a fertilizer application rate of 6 tons per hectare. This dosage was identified as the optimal rate, balancing both agronomic efficacy and economic viability. The findings suggest that organomineral fertilizers not only contribute to improved nutrient uptake but also stimulate physiological processes essential for crop development.

These results reinforce the potential of organomineral fertilizers derived from oxidized brown coal and phosphate raw materials as sustainable and effective soil amendments in modern agriculture.

Conclusions

The optimal regime for phosphorite activation was established through the joint dry grinding of oxidized brown coal and apatite concentrate at a mass ratio of 1:2. The mechanical activation process was conducted over a duration of 15 minutes, with a sample-to-grinding-body mass ratio of 1:15. Under these conditions, the solubility of phosphorus—measured as absorbable P₂O₅—reached 36.5%, indicating a significant enhancement in phosphate availability due to mechanical activation.

Based on the optimized processing conditions, an experimental batch of organomineral fertilizer was synthesized and subjected to field trials. The results demonstrated a substantial positive impact on agricultural productivity. Specifically, the application of the fertilizer led to a 34% increase in the dry mass yield of radish and a 39.7% increase in potato tuber yield. These outcomes confirm the efficacy of the developed organomineral fertilizer in enhancing crop growth and nutrient utilization under field conditions.

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