



DOI

10.66073/ReFocus-Conf/
0910171



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863–866

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IQTIBOS UCHUN

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Production of a complex
organomineral fertilizer based on local
raw materials // «O'zbekiston olimi
ayollarining mamlakat taraqqiyotiga
qo'shayotgan hissasi» mavzusidagi
xalqaro ilmiy-amaliy konferensiya
materiallari (Nukus, 2026-yil 9–10-
oktyabr). – Nukus, 2026. – B. 863–
866. – DOI: [https://doi.org/10.66073/
ReFocus-Conf/0910171](https://doi.org/10.66073/ReFocus-Conf/0910171)

PRODUCTION OF A COMPLEX ORGANOMINERAL FERTILIZER BASED ON LOCAL RAW MATERIALS

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Abstract: This study evaluates the chemical composition of Central Kyzylkum phosphorite, phosphogypsum, and sapropel as potential raw materials for complex organomineral fertilizer production. Sapropel contained 21.52% organic matter and 1.50% nitrogen, together with P, K, Ca, S, and Mg. Phosphorite contained 17.54% P_2O_5 and 47.75% CaO, while phosphogypsum contained 47.60% SO_3 and 32.61% CaO. The results demonstrate the complementary composition of these raw materials and provide a chemical basis for further development of an N-P-K-Ca-S containing organomineral fertilizer.

Keywords: organomineral fertilizer, Central Kyzylkum phosphorite, phosphogypsum, sapropel, chemical composition, local raw materials.

Introduction

The rational utilization of local mineral raw materials, recycling industrial by-products, and combining mineral and organic components into a single product are key scientific and practical focuses in developing more effective agricultural fertilizers. The scarcity of phosphate raw materials has especially heightened interest in processing low-grade phosphorites and in the comprehensive use of secondary phosphorus resources [1-3].

Central Kyzylkum phosphorites serve as a vital raw material source for phosphorus fertilizer production in Uzbekistan. Notably, these phosphorites contain significant quantities of calcium- and carbonate-containing compounds alongside phosphates. Studies have shown that different fractions and by-products of Central Kyzylkum phosphorites can be utilized for mineral fertilizer manufacturing, including the partial decomposition with mineral acids to enhance the amount of plant-accessible phosphorus forms [1, 2, 4].

Phosphogypsum is a major by-product of the phosphate fertilizer industry, mainly composed of calcium sulfate dihydrate. It is notably valuable as a secondary mineral resource rich in calcium and sulfur [5, 6]. However, its chemical makeup varies depending on the original phosphate raw material and processing methods, potentially including residual phosphorus- and fluorine-based compounds and other impurities. Therefore, analyzing its chemical composition is crucial before utilizing phosphogypsum as a fertilizer component [5, 6].



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«O'zbekiston olimi ayollarining
mamlakat taraqqiyotiga
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NUKUS, 9–10-OKTYABR 2026

Adding an organic component to a complex fertilizer enables the integration of mineral nutrients with organic matter within one system. In this context, sapropel stands out as a promising natural organomineral raw material. Its makeup varies depending on formation conditions and, besides organic and mineral matter, it can contain nitrogen, phosphorus, potassium, calcium, and other elements [7]. Consequently, accurately determining its chemical composition is crucial when assessing its suitability for fertilizer production.

Although Central Kyzylkum's phosphorite, phosphogypsum, and sapropel differ in origin and chemical makeup, their nutrient components can complement each other. Phosphorite mainly provides phosphorus and calcium, phosphogypsum supplies calcium and sulfur, and sapropel offers organic matter along with various macro- and micronutrients depending on its composition. Therefore, comparing their chemical compositions is a crucial first step in assessing the possibility of producing a comprehensive organomineral fertilizer from these materials.

This study aimed to analyze the chemical composition of Central Kyzylkum phosphorite, phosphogypsum, and sapropel, and to preliminarily evaluate their potential combined use as mineral and organic raw materials for producing a complex organomineral fertilizer.

Materials and methods

The study materials included Central Kyzylkum phosphorite, phosphogypsum, a byproduct of phosphate fertilizer production, and natural organomineral sapropel. These were chosen for their chemical composition and potential roles in creating a complex organomineral fertilizer. Phosphorite provides phosphorus and calcium, while phosphogypsum is a secondary mineral rich in calcium and sulfur. Sapropel, a natural substance, contains organic matter along with macro- and secondary nutrients important for plant growth.

In the initial phase of the study, the focus was on analyzing the chemical makeup of the raw materials. Sapropel was tested for organic matter, total nitrogen, phosphorus, potassium, calcium, sulfur, magnesium, carbonate content, ash, moisture, and pH. In phosphorite, the determined components included SiO_2 , Al_2O_3 , Fe_2O_3 , MgO , P_2O_5 , CaO , SO_3 , and CO_2 , while in phosphogypsum, measurements covered P_2O_5 , SO_3 , CaO , MgO , Al_2O_3 , Fe_2O_3 , SiO_2 , moisture, and pH. For comparison of agrochemical qualities, the elemental contents of P, K, Ca, S, and Mg in sapropel were also converted stoichiometrically into P_2O_5 , K_2O , CaO , SO_3 , and MgO equivalents.

Results and discussion

Chemical analysis of the starting raw materials showed that sapropel differs fundamentally from the mineral components. It contained 21.52% organic matter and 1.50% nitrogen. The measured elemental contents were 0.80% P, 3.18% K, 17.90% Ca, 0.94% S, and 0.11% Mg. For fertilizer-oriented presentation, these values correspond to 1.83% P_2O_5 , 3.83% K_2O , 25.05% CaO , 2.35% SO_3 , and 0.18% MgO , respectively. The pH was 8.31 and the ash content was 76.90%.

Table 1. Chemical composition of sapropel

No	Organic matter, %	N, %	P ₂ O ₅ , %*	K ₂ O, %*	CaO, %*	SO ₃ , %*	MgO, %*	CO ₂ , %	Ash, %	pH	Moisture, %
1	21.52	1.50	1.83	3.83	25.05	2.35	0.18	15.70	76.90	8.31	1.58

The presence of N, P, K, and organic matter suggests that sapropel is not just an organic filler but also a source of nutrients in the complex fertilizer. The potassium content stands out, as the other mineral components examined are not major potassium sources. Additionally, the high calcium-equivalent level points to a significant calcium-bearing mineral fraction in the sapropel.

The Central Kyzylkum phosphorite's chemical composition included 17.54% P₂O₅ and 47.75% CaO. The raw material also contained 16.50% CO₂, 4.06% SO₃, and 1.79% MgO, along with smaller quantities of SiO₂, Al₂O₃, and Fe₂O₃.

Table 2. Chemical composition of Central Kyzylkum phosphorite

No	SiO ₂ , %	Al ₂ O ₃ , %	Fe ₂ O ₃ , %	MgO, %	P ₂ O ₅ , %	CaO, %	SO ₃ , %	CO ₂ , %
1	1.24	0.95	0.73	1.79	17.54	47.75	4.06	16.50

The P₂O₅ content shows phosphorite as the main phosphorus source in the proposed fertilizer. Meanwhile, high levels of CaO and CO₂ are significant for the upcoming nitric acid processing stage. Since carbonate components react with nitric acid, both the P₂O₅ level and the carbonate fraction in the raw material should be taken into account when determining HNO₃ dosage in future studies.

Analysis of phosphogypsum revealed that its main constituents were SO₃ at 47.60% and CaO at 32.61%. It also included 1.62% P₂O₅, 0.22% MgO, and 2.08% SiO₂. The moisture content ranged from 18% to 20%, and the pH level varied between 4.5 and 5.3.

Table 3. Chemical composition of phosphogypsum

No	P ₂ O ₅ , %	SO ₃ , %	CaO, %	MgO, %	Al ₂ O ₃ , %	Fe ₂ O ₃ , %	SiO ₂ , %	Moisture, %	pH
1	1.62	47.60	32.61	0.22	0.71	0.14	2.08	18-20	4.5-5.3

The elevated levels of SO₃ and CaO suggest that phosphogypsum could serve as a source of sulfur and calcium for the suggested organomineral fertilizer. Additionally, remaining P₂O₅ might help balance the phosphorus content in the final product.

The combined evaluation of the three raw materials suggests they can work together functionally. Phosphorite supplies P and Ca; phosphogypsum provides Ca and S; and sapropel organic matter provides N and K, along with additional P, Ca, S, and Mg. In the next technological phase, nitric-acid activation of phosphorite could also add nitrate nitrogen. When this nitrate–phosphate compound is combined with

phosphogypsum and sapropel, it creates a foundation for developing a complex organomineral fertilizer that includes N-P-K-Ca-S and organic matter.

Chemical analysis indicates that Central Kyzylkum's phosphorite, phosphogypsum, and sapropel are complementary raw materials. Phosphorite contains 17.54% P_2O_5 and 47.75% CaO, highlighting its function as a source of phosphorus and calcium. Phosphogypsum's 47.60% SO_3 and 32.61% CaO suggest it could be a secondary source of sulfur and calcium. Meanwhile, sapropel differs from the mineral components by encompassing 21.52% organic matter, along with N, P, K, Ca, S, and Mg.

These findings provide a preliminary chemical basis for further research on combining these raw materials to develop a complex organomineral fertilizer that includes organic matter and N-P-K-Ca-S nutrients. Future studies will focus on the conditions for nitric-acid activation of phosphorite, the optimal ratios of phosphogypsum to sapropel, and the physicochemical and agrochemical characteristics of the resulting fertilizer.

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