

DECOMPOSITION PROCESS OF CENTRAL KYZYLKUM PHOSPHORITE WITHOUT ACID IN THE PRESENCE OF A BIO-COMPONENT AND ANALYSIS OF ELEMENT SOLUBILITY

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Abstract: In this work, the possibility of converting Central Kyzylkum phosphorite (CKP) samples into a soluble form under acid-free and environmentally safe conditions through heat treatment in the presence of a bio-component was studied. The experiments were carried out with bio-component ratios of 1:1, 1:2, 1:3, and 1:4 at temperatures up to 100°C. The composition of the obtained products was analyzed using an Avio 200 (ICP-OES) optical emission spectrometer. The results showed that the concentrations of Ca, Sr, Mg, K, Fe, P, and other elements consistently increased with the amount of bio-component.

Keywords: Central Kyzylkum phosphorite, bio-component, acid-free decomposition, ICP-OES, solubility.

In recent years, due to the increasing demand for phosphorus fertilizers in agriculture, the development of efficient and environmentally safe methods for processing phosphorite raw materials has become an urgent issue.

In traditional production, sulfuric, phosphoric, or nitric acids are used for the decomposition of phosphorites; however, these processes generate large amounts of waste and cause environmental pollution [4]. Therefore, current research is being conducted in the direction of "green technologies" (green chemistry), aimed at activating phosphorites based on acid-free, bioactive, or organic components [1, 5].

It has been proven that composite fertilizers can be obtained through the acid-free processing of phosphorites using mechanochemical activation. In this method, organic compounds and bioactive additives are used instead of acidic reagents, ensuring environmental safety [1]. Similar approaches note that converting waste materials into organo-mineral fertilizers helps maintain the nutrient balance of the soil and reduce production costs [5].

Organo-mineral fertilizers have been shown to increase the microbiological activity of the soil and significantly improve the efficiency of phosphorus and nitrogen uptake by plants [2]. In the study by de Melo Benites, it was found that organo-mineral fertilizers contribute to the long-term preservation of total phosphorus (P) reserves in the soil and increase the solubility of natural phosphates [3].

Although the direct application efficiency of phosphate rocks is low, it has been proven that their treatment with biologically or organically active components transforms phosphorus into forms easily assimilated by plants [6]. In particular, the oxidative and complex-forming properties of bio-components increase the solubility of iron, calcium, and phosphorus compounds, which ensures high efficiency under acid-free conditions [7].

Several developments have also been made to ensure resource efficiency and environmental sustainability in phosphorite processing through the use of wastewater and bio-based components [8]. In this approach, phosphorus and microelements separated from waste are recycled and incorporated into the fertilizer composition.

In his research, Rickard analyzed the role of phosphoric acid and its salts as fertilizers and discussed the advantages of using natural phosphorus sources, presenting promising directions for their regeneration in bioactive forms [9]. At the same time, modern studies evaluate the

synthesis of organo-mineral fertilizers based on renewable organic materials as a promising and sustainable production strategy [10].

In general, the use of bio-components, organic solvents, and waste materials for acid-free decomposition of phosphorites is considered an effective, environmentally friendly, and economically feasible technology. When such approaches are applied to the processing of Central Kyzylkum phosphorites under local conditions, they create the possibility of producing plant-available forms of phosphorus and developing liquid organo-mineral fertilizers [1–10].

Materials and Methods

For the experiment, the Central Kyzylkum phosphorite (CKP) was ground for 2 hours using a ball mill. Then, the ground mass was sieved into fractions using the sieving method, and the finest fraction was selected for the experiment. From the ground mass, four samples of precisely measured amounts were weighed on an analytical balance, and treated with a bio-component in ratios of 1:1, 1:2, 1:3, and 1:4. The experiment was carried out in a three-neck flask. A condenser was attached to one neck of the flask, a thermometer was installed in another to monitor the temperature, and a stirrer was placed to ensure uniform mixing of the liquid mass. The process was performed at a temperature of 100°C. Each sample was maintained at a constant temperature until it turned reddish-brown, and the resulting solution was filtered using a vacuum filter. Each filtered solution was taken for analysis to determine the content of macro- and microelements.

For the purpose of analysis, 200 mg of each sample was weighed on an analytical balance (FA220 4N) for mineralization. The mineralization process was carried out using a **MILESTONE Ethos Easy** (Italy) mineralization unit. For this, 200 mg of the sample, 6 ml of nitric acid (HNO₃) purified by distillation using an **infrared-based acid purification device (Distillacid BSB-939-IR)**, and 2 ml of hydrogen peroxide (H₂O₂) as an oxidizing agent were placed into the reaction tube of the unit. The mixture was mineralized at 180°C for 50 minutes.

After completion of the mineralization process, the resulting mixture in the tube was transferred into a separate conical volumetric flask and diluted with distilled water (BIOSAN, Latvia) up to a volume of 50 ml. The prepared solution was then poured into special tubes in the autosampler section and placed for analysis. The prepared samples were analyzed using an **Avio 200 ICP-OES Inductively Coupled Plasma Optical Emission Spectrometer** (Perkin Elmer, USA). The device provides high accuracy, allowing the detection of elements in the solution up to 10⁻⁹ g. The results of the analysis are presented in **Table 1**.

Table 1.

Concentration of elements in the samples (mg/100 ml)

№	Elements	Sample 1	Sample 2	Sample 3	Sample 4
1	Ca	433.64	3318.57	468.43	2058.10
2	Sr	2.29	9.63	3.92	13.12
3	Mg	16.60	31.24	16.52	21.23
4	Fe	2.33	12.54	0.33	47.18
5	K	231.00	228.71	144.42	22.75
6	P	229.128	231.730	235.821	262.621

As can be seen from the table, the contents of Ca, Sr, Fe, and P elements increased significantly from sample 1 to sample 4. In particular, the phosphorus content increased from 229.128 mg/100 ml in sample 1 to 262.621 mg/100 ml in sample 4, which indicates that phosphates have transformed into a soluble form under the influence of the bio-component.

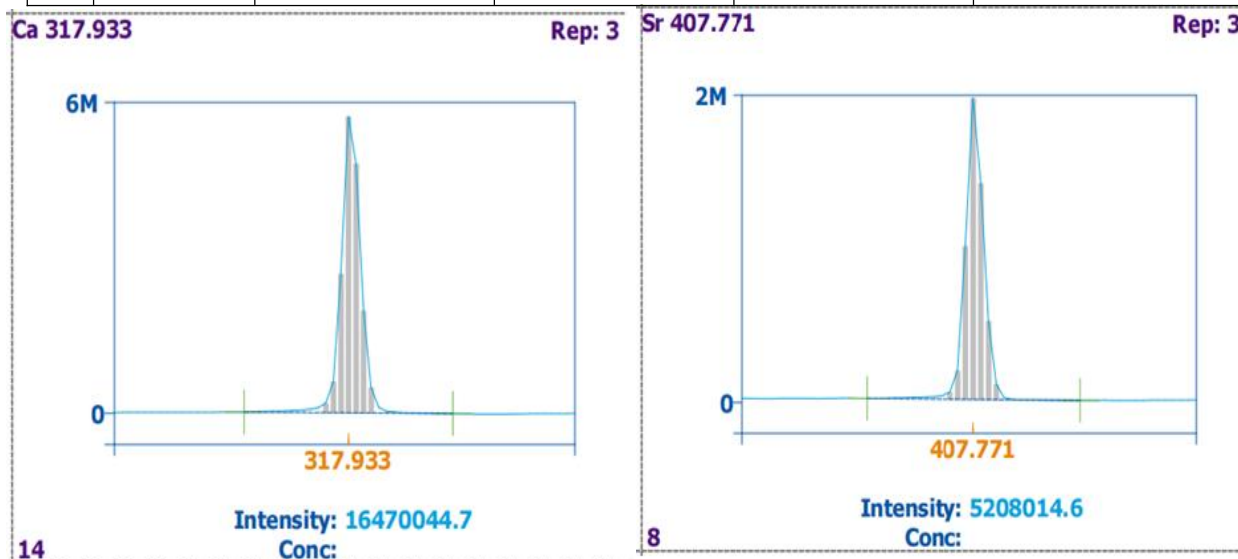
The increase in Ca and Sr → indicates that the degree of decomposition of calcium–strontium compounds has increased. The increase in Fe activity → shows that the bio-component had an oxidative effect. The sharp increase in P → demonstrates that the phosphate rock decomposed effectively without the use of acid. The K and Mg values remained relatively stable but retained beneficial levels for plant growth.

If the results of Table 1 are recalculated as percentage concentrations, the results will be as shown in Table 2.

Table 2.

Content of components in percentage concentration

№	Element	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)
1	Ca	10.84	82.96	11.71	51.45
2	Sr	0.06	0.24	0.10	0.33
3	Mg	0.42	0.78	0.41	0.53
4	Fe	0.06	0.31	0.01	1.18
5	K	5.78	5.72	3.61	0.57
6	P	5.73	5.79	5.90	6.57



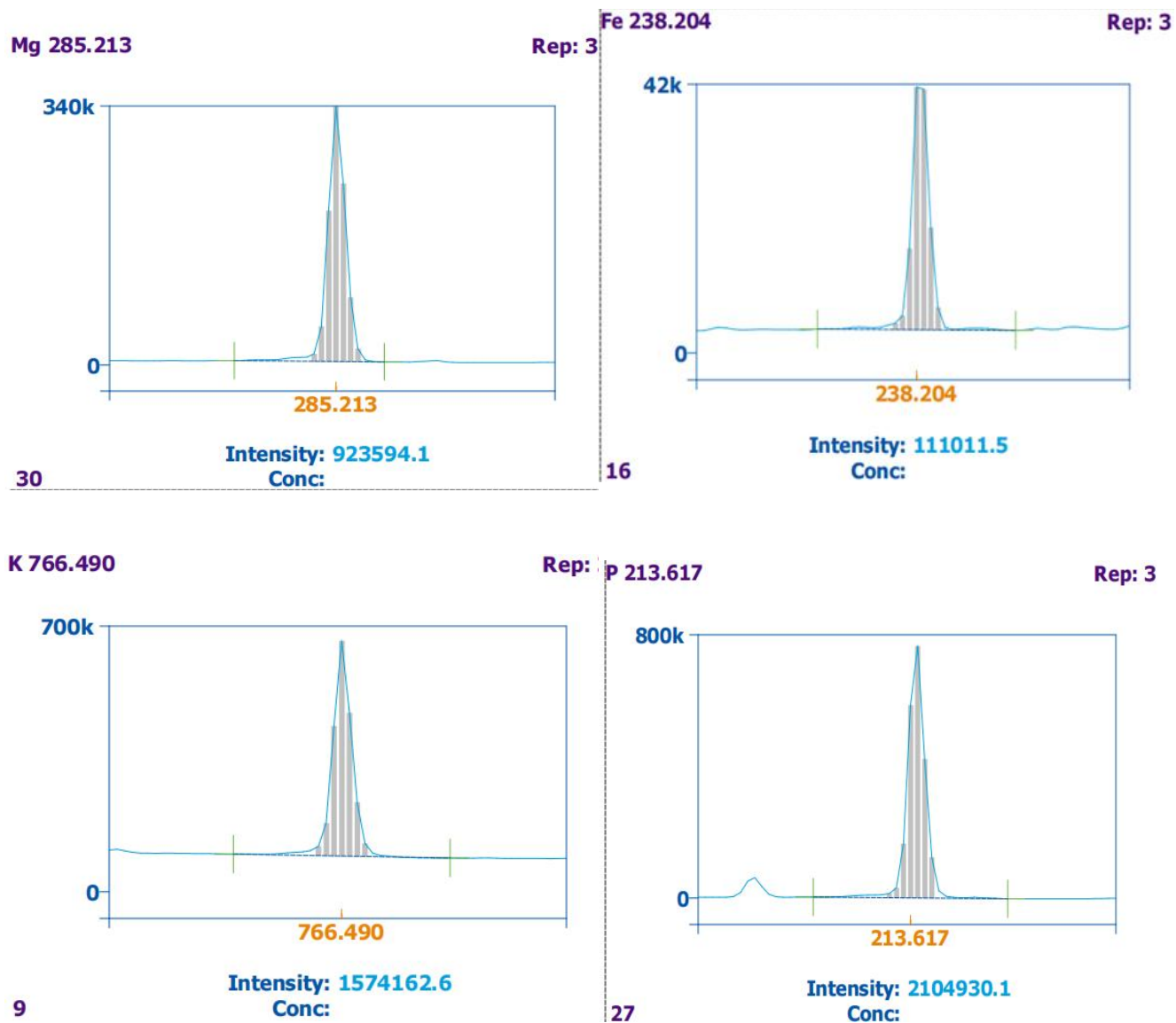


Figure-1. Spectral results obtained using the Avio 200 ICP–OES Inductively Coupled Plasma Optical Emission Spectrometer.

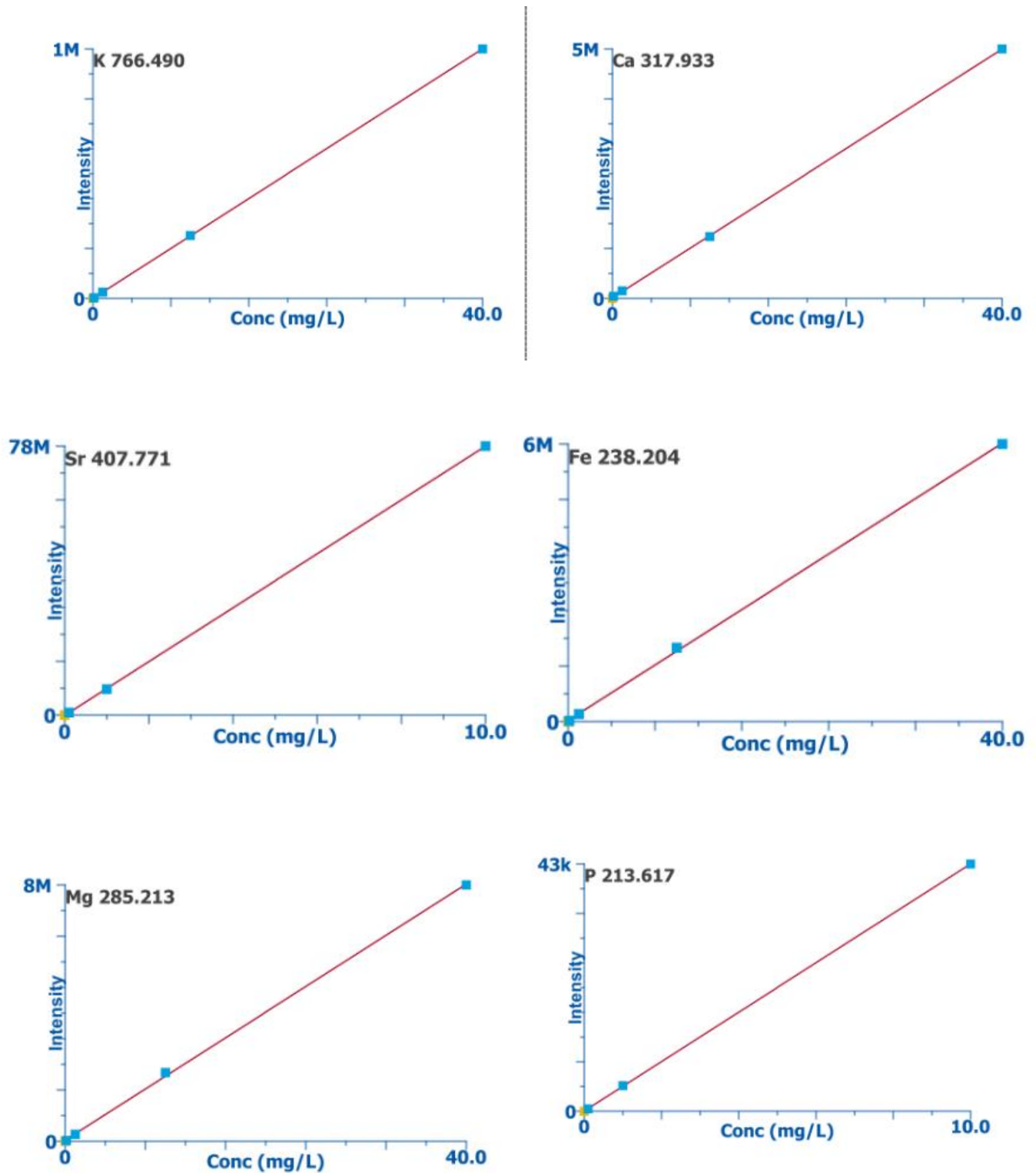


Figure-2. Calibration

In addition, the analysis results revealed the presence of small amounts of Al, Si, Mn, Na, and S in the solution.

The experimental results show that the treatment of Central Kyzylkum phosphorite (CQF)

with a bio component at 100 °C increases the solubility of phosphorus, calcium, strontium, and iron compounds under acid-free conditions.

This method is environmentally safe, waste-free, and resource-efficient, and can be effectively applied in the production of liquid organo-mineral fertilizers.

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