



PROSPECTS FOR USING THE MINERAL
POLYHALITE AS A MULTI-COMPONENT MINERAL
FERTILIZER ON IRRIGATED SOILS IN
UZBEKISTAN

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ABSTRACT

This article analyzes the physicochemical properties, primary nutrient content, water solubility, and soil migration of the mineral polyhalite, as well as its impact on agricultural crop yields. The study is based on a synthesis of results from laboratory, soil column, and field experiments published in international scientific literature. Particular attention is paid to issues concerning soil salinity, the movement of salts with water, nutrient balance, and the efficient use of mineral fertilizers within the context of irrigated agriculture in Uzbekistan.

Preserving soil fertility, ensuring the rational use of irrigation water, and enhancing the efficiency of mineral fertilizers are key scientific and practical objectives in Uzbekistan's agriculture. In irrigated areas, factors such as soil salinity, rising groundwater levels, and the efficiency of drainage systems can influence the soil's salt balance. FAO literature also identifies the accumulation of salts introduced via irrigation water—and the conditions required to leach them from the root zone—as critical factors affecting crop productivity.

In this context, studying the mineral polyhalite, which contains several essential nutrients, is of particular importance. Polyhalite is a natural sulfate mineral with the chemical formula $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$, serving as a source of potassium, calcium, magnesium, and sulfur. Unlike conventional potassium fertilizers, polyhalite can supply these elements simultaneously. However, its practical effectiveness in Uzbekistan's soils is expected to depend on variables



such as the degree of soil salinity, soil texture, initial nutrient levels, and irrigation practices. Barbier et al. (2017) investigated the elemental composition, water solubility, salt index, and nutrient migration in various soils of natural polyhalite. Meanwhile, Mello et al. (2018) compared polyhalite with other potassium fertilizers in the context of tomato cultivation in Brazil. Although these studies do not provide ready-made agronomic guidelines for Uzbekistan, they establish a significant scientific basis for planning local experiments.

Table 1.

Composition of key nutrient elements in natural polyhalite

Element	Quantity , %
Potassium (K)	11,3 ± 0,2
Calcium (Ca)	11,0 ± 2,4
Magnesium (Mg)	3,81 ± 0,2
Sulfur (S)	18,5 ± 3,2

The values presented in the table were determined for specific samples of natural polyhalite; they cannot be assumed to represent a fixed composition applicable to any polyhalite sample found in Uzbekistan. The chemical and mineralogical composition of the mineral intended for local use must be determined through laboratory analysis.

The potassium contained in polyhalite plays a role in plant water relations, enzyme activity, and photosynthesis. Calcium is essential for the formation of cell walls and tissues, magnesium is a component of chlorophyll, and sulfur is vital for the synthesis of proteins and other organic compounds. Consequently, polyhalite is regarded as a mineral resource capable of supplying multiple nutrients simultaneously.

When evaluating the physicochemical properties of polyhalite, it is necessary to consider its solubility and salt index. A mean solubility value of 14.29 g/L was recorded during standard solubility testing of natural polyhalite. In this study, the salt index of polyhalite was found to be 68.5 ± 10.8 , which is lower than the values of 127.8 ± 6.0 and 102.8 ± 2.2 observed for potassium chloride and potassium sulfate, respectively.

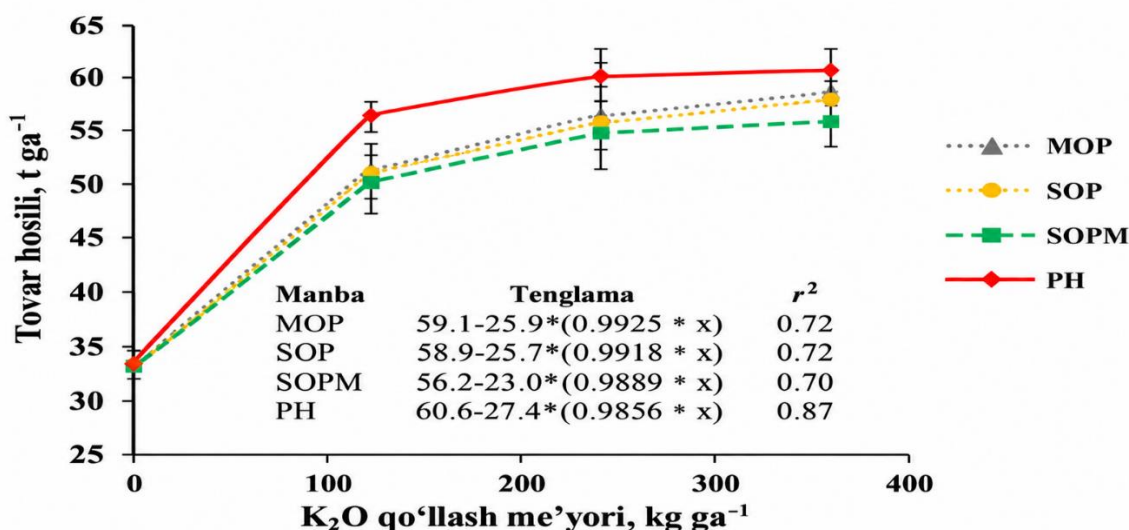


Table 2.

Some characteristics of polyhalite and traditional potassium fertilizers

Type of fertilizer	Water solubility, g/L	Salt index
Polyhalite	In a standard test, 14.29 — the average of natural samples.	68,5 ± 10,8
Potassium chloride (MOP)	344	127,8 ± 6,0
Potassium sulfate (SOP)	120	102,8 ± 2,2
Potassium-magnesium sulfate (SOPM)	240	49,1 ± 3,1

The relatively low salt index of polyhalite is one of its key characteristics as a fertilizer. However, under the conditions found in Uzbekistan, this factor cannot be equated with the prevention or reduction of soil salinity. The total salt content in the soil also depends on irrigation water quality, groundwater, drainage conditions, evaporation, and irrigation practices. Therefore, the use of polyhalite on saline soils should be evaluated by measuring electrical conductivity, water-soluble salts, and the ionic composition of the soil solution.

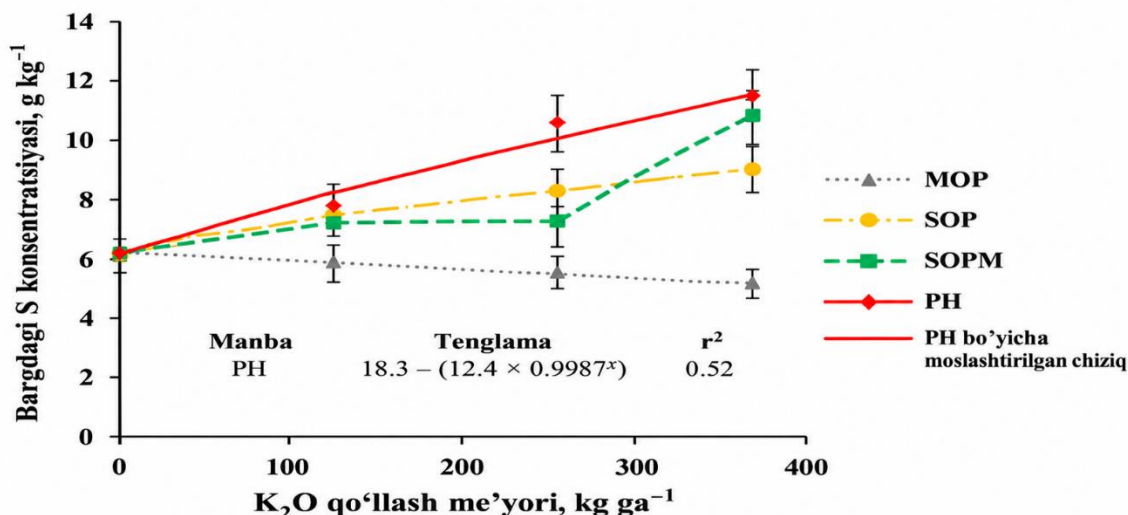


The dissolution of polyhalite is not determined solely by its solubility in water. Granulated polyhalite dissolved by approximately 87 percent after 15 minutes of stirring and fully dissolved within 120 minutes. While this result reflects specific experimental conditions and does not directly equate to the dissolution rate in soil, it demonstrates that the physical form of the polyhalite and environmental conditions influence dissolution dynamics.

When studying the solubility of polyhalite and the mobility of its nutrients under the conditions of Uzbekistan, it is advisable to include sandy, loamy, and heavy-textured soils, as well as areas with varying degrees of salinity. Such experiments make it possible to assess the



rate at which polyhalite releases potassium, calcium, magnesium, and sulfate ions into the soil solution, as well as their movement during irrigation.



This issue is of particular importance in Uzbekistan's irrigated agricultural regions. Irrigation water mobilizes ions within the soil solution, yet their leaching from the root zone depends on drainage and water dynamics. Therefore, the effectiveness of polyhalite application must be evaluated not only based on the nutrient content of the fertilizer but also on the duration for which these nutrients remain in a form accessible to plants. These results demonstrate the positive impact of applying polyhalite to potassium-deficient soil. However, these figures cannot be taken as representative of expected crop yields under the specific conditions of Uzbekistan, where factors such as soil salinity, irrigation water quality, climate, crop varieties, fertilization systems, and agronomic practices may differ.

Table 4.

Tomato yield in field trials in Uzbekistan

Option	Total yield, t/ga	Marketable yield, t/ha
Control	37	33
Potassium chloride (MOP)	59	54
Potassium sulfate (SOP)	59	54
Potassium-magnesium sulfate (SOPM)	59	54
Polyhalite (PH)	63	59

In the study, the marketable yield of the variant treated with polyhalite exceeded that of the control by 26 t/ha. The difference compared to variants using other potassium fertilizers was 5 t/ha. However, regarding total yield, the differences between the potassium sources were not statistically significant. Thus, the superiority of polyhalite was not evident across all parameters.



The authors noted the potential influence of secondary nutrients present in polyhalite, particularly calcium.

In the context of Uzbekistan, polyhalite can initially be studied experimentally on crops such as cotton, cereals, tomatoes, and other vegetables. However, determining which crop yields the greatest benefit requires soil analysis and field trials. In these experiments, polyhalite should be compared with traditional potassium fertilizers; nitrogen and phosphorus supply levels must be kept constant, and fertilizer application rates balanced based on active nutrient content.

Another important area of research under local conditions involves studying polyhalite in conjunction with irrigation regimes. This entails measuring initial and final soil electrical conductivity, water-soluble salt content, pH, and levels of exchangeable potassium, calcium, magnesium, and sulfate-sulfur. Crop productivity, produce quality, and nutrient uptake by the plants are also evaluated. Such an approach helps determine polyhalite's impact not only on yield but also on the soil's salt regime and nutrient balance.

Additionally, the processing of polyhalite using mineral acids constitutes a distinct area of research. The two key articles reviewed examined the mineral's water solubility and its agronomic properties in soil, but the kinetics of its dissolution in nitric or other mineral acids were not directly determined. If the use of polyhalite for local mineral fertilizer production is planned, specific laboratory experiments are required to determine parameters such as acid concentration, temperature, duration, stirring speed, liquid-to-solid ratio, and the quantity of elements released into the solution.

In conclusion, polyhalite is a multi-component mineral resource worth investigating as a source of potassium, calcium, magnesium, and sulfur for irrigated agriculture in Uzbekistan. International studies confirm its physicochemical properties and its potential to positively impact crop yields in potassium-deficient soils. However, controlled laboratory and field experiments on Uzbek soils are necessary to establish local application rates, determine its effects under saline conditions, and evaluate its economic viability.

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