

# Development of technology for producing phosphorus fertilizers enriched in microelements

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**Abstract.** Literary and patent research was carried out on existing and developed new methods for producing phosphorus fertilizer enriched with microelements. Based on retrospective analyzes of known methods, a new universal technological scheme for the production of phosphorus fertilizers enriched with microelements - boron, molybdenum, manganese and other microelements - has been proposed. The developed technological scheme makes it possible to obtain phosphorus fertilizers enriched with microelements that meet the requirements of existing regulatory and technical standards and are distinguished by their versatility and environmental safety.

## 1 Introduction

High yields of agricultural crops are possible provided they are provided with complete and sufficient nutrition. The need of agricultural plants for nutrients depends on the type of plant and the form in which this substance is found [1].

Nutrient elements are divided into organogens (nitrogen, carbon, oxygen, hydrogen), ash (phosphorus, potassium, calcium, magnesium and sulfur), microelements (boron, manganese, molybdenum, zinc, etc.) and each of them performs its own functions in plant life functions [2]. In general, it has been determined that the composition of plants includes more than seventy chemical elements and it has been established that only sixteen of them are absolutely necessary for life: carbon, oxygen, hydrogen, nitrogen - so-called organic, phosphorus, potassium, calcium, magnesium, serazole elements and trace elements - boron, molybdenum, zinc, copper, cobalt, manganese, vanadium and others. Replacing one element with another is not possible, since each element performs its own function [3]. For example, manganese as a microelement is part of enzymes and participates in oxidation-reduction processes in plant organisms, affects the formation of chlorophyll, and promotes the synthesis of protein substances. When manganese is deficient in the soil, plant growth slows down; cereal crops, sugar beets, vegetable crops and cotton especially suffer from manganese deficiency.

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Many plants need boron throughout the growing season. It is necessary for the development of the meristem. Currently

time, in terms of its practical significance, molybdenum has been promoted to one of the first places among other microelements, especially in combination with boron [4].

Vanadium as a microelement attracts the attention of researchers, and in their opinion, it stimulates the fixation of atmospheric nitrogen, improves the growth of legumes and the intensity of the photosynthesis process [5].

Among phosphorus-containing fertilizers, the most common and fairly thoroughly studied are simple and double superphosphate. It should be noted that despite the fact that the content of the digestible form of phosphorus pentoxide in simple superphosphate is not high and is about twenty percent, it additionally contains calcium and the meso - element of sulfur. Therefore, in terms of their agrochemical value, simple and double superphosphate can be considered as a compound or complex fertilizer.

Even if the production of simple and double superphosphate is abandoned, it retains its value for producing microelement-containing, phosphorus-containing, as well as complex mixed fertilizers. It is also necessary to note that the most convenient and effective is the introduction of microelements into the composition of macrofertilizers, especially phosphorus-containing fertilizers.

## 2 Materials and methods

We have developed a number of methods for producing phosphorus-containing fertilizers enriched with various microelements, and some of them have been implemented on an industrial scale.

One of these methods for producing phosphorus-containing fertilizers [6] is based on the decomposition of phosphate raw materials with spent sulfuric acid and the introduction into the process of a waste solution of electric lamp production obtained by mixing apatite and a molybdenum-containing solution of electric lamp production at their mass ratio (2.0: 3.8) : 10 respectively.

In this case, the resulting phosphorus-containing fertilizer contains, in%:  $P_2O_5$ <sub>acv</sub> -19.70-19.87;  $P_2O_5$ <sub>free</sub> 4.91-5.00; molybdenum content is 0.12-0.13, which corresponds to the requirements of the regulatory and technical document [7].

According to another method [8], phosphorus-containing fertilizers with the addition of microelements - molybdenum and boron are obtained by introducing pandemite ( $2Ca \cdot B_2O_3 \cdot 3H_2O$ ) into the fertilizer composition and ammonium molybdenum is introduced into the fertilizer composition at the stage of the granulation process. This allows you to increase the mechanical strength of the granules and reduce the return of the technological process. Moreover, the best result is achieved by introducing pandemite, ammonium molybdenum and return into the process at their mass ratio (0.4-1.2) : (0.2-0.8) : (1.2-2.4), respectively.

According to the method [9], in order to reduce the chamber ripening time and increase the mechanical strength of the granule, while simultaneously enriching the phosphorus fertilizer with microelements, copper containing mine water is used in a mixture with a boron-containing substance - tourmaline. At the same time, phosphorus fertilizer has standard properties and contains microelements - Cu, Zn, Mn, Co, Ni.

Theoretical and experimental research shows the possibility of obtaining phosphorus fertilizers of various compositions based on microelements

containing waste. These include the production of microelement phosphorus fertilizer based on powdered superphosphate [10]. This fertilizer contains manganese and vanadium as microelements, and as microelement raw materials, spent vanadium contact mass and manganese-containing sludge-waste from the production of manganese dioxide electrolysis.

tincal concentrate was used as a boron raw material in a mixture of serpentinite [11]. This allows the production of new phosphorus fertilizer containing meso elements and microelements.

When producing phosphorus fertilizer by decomposing phosphate raw materials with sulfuric acid, it is proposed to introduce datolite concentrate into the decomposition process, and add a molybdenum-containing solution to the granulation process. At the same time, the process of decomposition of phosphorus raw materials is intensified, and at the same time the product is enriched with microelements [12]. Considering the high cost and scarcity of microelement raw materials, to obtain phosphorus fertilizer with microelements, either the granulation process is carried out with sea water [13], or boron-containing minerals are treated with molybdenum-containing waste from electric lamp production and the metalworking industry, with subsequent introduction of fertilizers into the production process.

In order to increase the mechanical strength of phosphorus-containing fertilizer granules, mixtures of crushed shells and peat ash are used at their mass ratio of 2: (0.6-1.2) and the mass of fertilizers (0.2-32): 10, respectively [14].

Work has been carried out to increase the yield of granules of phosphorus-containing fertilizers with a size of 1-4 mm and the mechanical strength of the granule, while simultaneously enriching it with microelements, in particular manganese, [15] which slags from the metallurgical industry are introduced into the process in the form of phosphate-manganese pulp.

When producing phosphorus fertilizer, apatite concentrate and other phosphorites, which contain fluorine, are usually used as raw materials. Some of it is released into the gas phase, while some remains in the fertilizer, which is undesirable.

To reduce fluorine content in the product, the mineral danburite is used in a mixture with bone meal [16], which allows enrichment with the microelement boron.

The use of organic acids as an additive in the production of phosphorus fertilizers [17] allows one to intensify the technological process, reduce the chamber ripening time, and increase the content of assimilable  $P_2O_5$  in the product.

Another way to obtain phosphorus fertilizer [18] is to intensify the process by introducing the macronutrient potassium into the fertilizer composition.

Among microelements for plant life, zinc plays an important role, as it forms chlorophyll and participates in photosynthesis.

In [19], the possibility of obtaining zinc-containing phosphorus fertilizers was studied. For this purpose, dust from cleaning furnace gas from copper-zinc production is used. In this case, zinc-containing dust is introduced into the fertilizer composition during the first shoveling of phosphorus fertilizers (0.4-0.8): 1 parts by mass, respectively.

In phosphorus-containing fertilizers, the fluorine content is about one percent, which is not desirable, since fluorine accumulates in the soil and negatively affects the soil humus. Therefore, it is necessary to reduce its content to a minimum, especially when producing phosphorus-containing fertilizers from microelements.

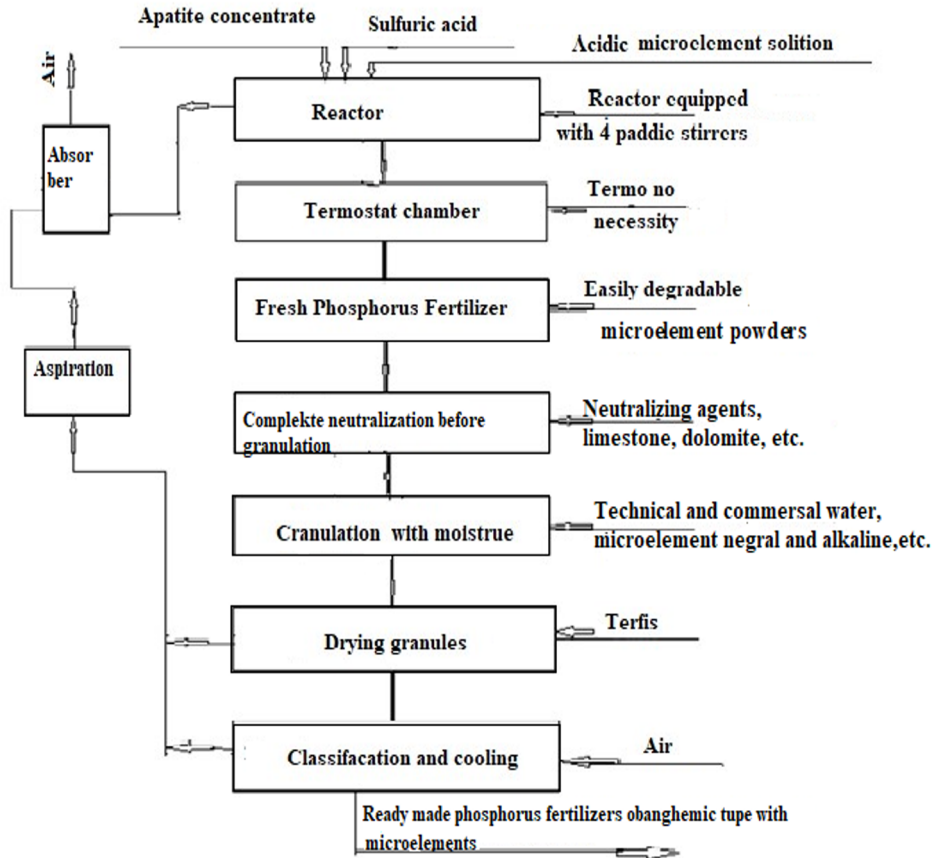
Taking this into account, in order to obtain phosphorus-containing fertilizers with manganese additives, it was proposed [20] to introduce manganese additives with perphyllite in the form of a pulp of 0.15-0.30 parts by mass per 100 parts by mass of fertilizers.

### 3 Results and Discussion

We have developed a composition of phosphorus-containing fertilizers [21] consisting of 2.0-3.0 parts by mass of spent vanadium contact mass, 1.0-1.5 parts by mass of manganese sludge, 0.5-0.75 parts of phosphate rock, 0.5 -0.75 parts cement dust, 1.0 parts acid

manganese resin, 0.4-0.8 parts montmorillonite, the rest is part superphosphate. Agrochemical testing shows that this composition of phosphorus fertilizer, compared to other fertilizers, increases the yield of winter wheat by 13.0%, corn by 14.5%, and alfalfa by 5.3%.

The above methods we have developed for obtaining phosphorus fertilizers with microelements allowed us to develop the below universal technological scheme (Figure 1).



**Fig. 1.** Principal (universal) technological scheme for producing phosphorus fertilizer enriched with microelements.

The description of this technological process is as follows: apatite concentrate [23] and sulfuric acid [24] are introduced into a reactor equipped with paddle mixers according to stoichiometric standards [22] (part of the sulfuric acid can be replaced with an acidic microelement containing, for example, molybdenum-containing acidic solution of electric lamp production) solution in the calculated amount to obtain phosphorus-containing pulp, which then enters the thermostat chamber, formation of structures in the form of a pie occurs. The resulting fertilizer is unloaded from the chamber and easily decomposed powder-like substances are introduced into it, for example, datolite concentrate, the mineral apatite, in the calculated amount. If necessary, the content of free  $P_2O_5$  of the reaction mass is neutralized to a content of 1.5-2.5% and subjected to the granulation process in a drum granulator with moistening of microelement containing liquids (sea water, solution of microelement absorption by mine water, and other aqueous microelement containing solution), drying, classification and cooling according to generally accepted methods [25].

When mixing the components in the reactor, the process of drying, classification and cooling, fluoride compounds and dust are released, respectively, and enter the aeration and absorption units [26].

All calculations of microelement-containing substances introduced into the process must take into account that the content of microelements in the finished product complied with the requirements of the regulatory technical document [7].

## 4 Conclusion

Thus, the developed universal technological scheme allows us to obtain phosphorus fertilizers enriched with microelements. Moreover, the processes can be carried out on the basis of existing technological equipment for the production of phosphate fertilizers, in particular for the production of simple and double superphosphate with minor changes.

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