# Obtaining Fertilized Precipitate On The Basis Of Mineralized Mass Without And With Separation Of An Insoluble Residue

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**Abstract :** The processes of obtaining fertilizer precipitates based on mineralized mass (MM) and hydrochloric acid without and with the separation of an insoluble residue are studied. The effects of acid concentration, amount and temperature of washing water on the qualitative parameters of precipitates are determined. The optimal amount and temperature of the wash water are established, where a fertilizer precipitate with the maximum content of $P_2O_5$ and the lowest content of calcium chloride is obtained. All acid concentrations, the ratio of MM : $H_2O$ = 1.0: 1.5; 1.0: 2.0 and a wash water temperature of 80-90°C are optimal. In this case, a fertilizer precipitate of the following contents is obtained: $P_2O_{5total}$ - 23.32-24.06%; $P_2O_5$ by citric acid - 20.52-21.29%; $CaO_{total}$ - 25.84-26.40%; $CaO_{assi.}$ by citric acid - 22.87-23.23%; $P_2O_{5water}$ = 2.02-2.21%; $CaO_{water}$ - 1.67-2.24%; Cl - 1.03-1.73% and the degree of washing off from $CaCl_2$ - 96.24-97.83% and $P_2O_{5total}$ –33.18-34.72%; $P_2O_{5assi.}$ by citric acid –29.20-30.89%; $CaO_{total}$ –34.51–35.55%; $CaO_{assi.}$ by citric acid –30.93-31.99%; $P_2O5_{water}$ 1.67-2.53%; $CaO_{water}$ -1.58-2.11%; Cl –1.07–1.23% and the degree of washing off from $CaCl_2$ –97.19–98.64%, respectively, without and with the separation of an insoluble residue.

**Keywords :** mineralized mass, hydrochloric acid, fertilizer precipitate, an insoluble residue, degree of washing.

## 1 INTRODUCTION.

The main actual tasks in the field of production of phosphorus fertilizers are: increasing production, expanding the range, involving low-grade raw materials in the processing and reducing the cost of production. Nowadays, the phosphorus industry is facing with a shortage of high-quality phosphate raw materials. In this regard, the search for methods to reduce the expense of their production, the involvement of substandard phosphorites in their production, increasing the concentration and effectiveness of phosphorus fertilizers is of great importance for agriculture of the republic. It is known that since 2017 in the Kyzylkum phosphorite complex (KPC) has been operating a new technological scheme for the thermochemical enrichment of phosphorite ores, where off-balance ore, the so-called mineralized mass, containing 12-14% $P_2O_5$ is formed at the sorting stage. It is stored separately until better times when an acceptable technology for its processing will be developed. Nowadays, it has been piled up about 13 million tons. When washing powdered phosphorite from chlorine, a huge amount of sludge phosphorite is formed with a content of 10-12% $P_2O_5$, which is discharged into the sludge field. In general terms, according to the enrichment scheme envisaged, from 1 million 875 thousand tons of phosphate ore (17.12% $P_2O_5$), 1158.4 thousand tons of off-balance ore are formed as tailings (average 11.63% $P_2O_5$). As a result, 42% of $P_2O_5$ is discarded as waste, for which no processing technology is yet available. These wastes and dusty sand formations clutter vast territories due to wind, which creates regional environmental problems (Navoi and Bukhara regions).


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In addition, a large-capacity by-product is formed in the caustic soda industry - hydrochloric acid, which has limited marketing, and it can become the cheapest and most affordable reagent in the processing of the above phosphorus-containing wastes. Recently, in our country, much attention has been paid to the processing of various types of phosphorites of the Central Kyzylkum (CK) into intermediate products and various types of fertilizers [1-6]. Besides, in the scientific and technical literature there is a lot of information about obtaining feed and fertilizer precipitates (dicalcium phosphate or calcium hydrogen phosphate) based on various types of phosphorites. In [7], the rheological properties of ammoniated mother liquors were studied, and the technology for processing low-grade phosphorites of the Central Kyzylkum by hydrochloric and nitric-sulfuric acid methods was developed and it was shown that the resulting suspensions were technologically advanced to produce complex phosphoric fertilizers and purified precipitate. Based on the results of the studies, material balances were compiled and a flow chart was developed for the hydrochloric and nitric sulfuric acid processing of phosphorites of the Central Kyzylkum with obtaining complex fertilizer and precipitate by two-stage ammonization of nitric sulfuric extract. The results of studying the incomplete decomposition of off-balance phosphorite ore of Central Kyzylkum with hydrochloric acid are presented and discussed in scientific work [8] and calcium-phosphorus fertilizers with various contents of assimilated forms of phosphorus and calcium are obtained. The patents [9, 10] describe methods for producing dicalcium phosphate from phosphoric acid and limestone, and also by processing low-grade phosphate ores with various acids (HCl, $HNO_3$ or a mixture of $HNO_3$ and $H_2SO_4$). The method allows to increase productivity by accelerating the filtering of the insoluble residue, removing impurities of iron and aluminum from the phosphoric acid solution, eliminating the stages of dilution and evaporation of the solution. Earlier [11–15], we studied the process of obtaining a fertilizer precipitate based on hydrochloric acid decomposition of the mineralized mass and powdered phosphorite from Kyzylkum phosphorites, as well as from washed calcined phosphoconcentrate. One of the disadvantages of fertilizer precipitates obtained according to

the above scientific works is a large amount of calcium chloride, due to which the fertilizer becomes hygroscopic. This study presents the results of determining the effect of acid concentration, amount and temperature of washing water on the qualitative indicators of fertilizer precipitates.

## 2 RESEARCH METHODS.

For laboratory experiments there has beed used the off-balance ore (mineralized mass-MM), containing, weight %: 14.60 $P_2O_5$, 43.99 CaO; 14.11 $CO_2$, 1.58 $SO_3$; 10.82 i.r.; CaO : $P_2O_5$ = 3.01. The concentration of hydrochloric acid ranged from 25 to 32%. The rate of hydrochloric acid was used to be 100% of stoichiometry on CaO in the feedstock. The norm of $Ca(OH)_2$ for the precipitation of $P_2O_5$ (in the form of $CaHPO_4$) was taken 100%. The degree of washing of the precipitate from $CaCl_2$ was calculated by the formula as follows:

$$\varphi = \left(1 - \frac{m_{pep.} \cdot \omega CaCl_2}{m_{feed} \cdot 1.982 \cdot \omega CaO_{total}}\right) \cdot 100\%$$

where $m_{feed}$ is the mass of the initial phosphorite, $\omega_{CaOtotal}$ - mass fraction of CaO in the initial phosphorite, $m_{prep.}$ is the mass of the obtained precipitate, $\omega_{CaCl2}$ is the mass fraction of $CaCl_2$ in the precipitate. 1.982 is the ratio of molar mass of $CaCl_2$ and CaO according to the reaction CaO + 2HCl = $CaCl_2$ + $H_2O$. The technique of laboratory experiments and the chemical analysis of the obtained precipitates are given in [11].

## 3 RESULTS.

The results of laboratory experiments are summarized in table 1. From the data of the table it is seen that at a HCl concentration of 25% and with a change in the weight ratio of MM : $H_2O$ from 1.0: 1.5 to 1.0: 2.0, that is with an increase in the amount of wash water to phosphorite, the $P_2O_5$ content in the samples of fertilizer precipitates increases from 23.75 to 24.26%, i.e. by 0.51%, and the amount of $CaO_{water}$ and Cl decreases from 2.16 to 1.50%, i.e. by 0.66% and from 1.58 to 0.96%, i.e. by 0.62%, respectively, in samples of fertilizer precipitates without removing of an insoluble residue. In the case of the separating of an insoluble residue at an HCl concentration of 25% and with a change in the weight ratio of MM : $H_2O$ from 1.0: 1.5 to 1.0: 2.0, i.e. with an increase in the amount of wash water to phosphorite, the content of the total form of $P_2O_5$ in the samples of fertilizer precipitates increases from 33.18 to 34.06%, i.e. by 0.88%, and the amount of $CaO_{water}$ and Cl decreases from 1.79 to 1.58%, i.e. by 0.21% and from 1.23 to 0.86%, i.e. 0.37%, respectively. This suggests that due to the removal of calcium chloride from the wet product, the quality of the precipitate improves. If we compare the results obtained without and with the release of insoluble residues, then in the case of the release of an insoluble residue, concentrated single phosphoric fertilizers are obtained containing at least 33% $P_2O_5$. In all indicators, these fertilizer samples are superior to fertilizers obtained without removing an insoluble residue. A similar pattern is observed when using other concentrations of acid. But at the same time, the quality of fertilizer precipitates is correspondingly slightly reduced due to incomplete washing of $CaCl_2$. When washing a moist fertilizer precipitate, in addition to the amount of wash water, its temperature also plays an important role. It is known that the solubility of calcium chloride in water is significantly dependent on temperature. For example, at 20°C the solubility of calcium chloride is 74.5 g per 100 g of water, at 100°C - 158g [16]. In this regard, the effect of washing water temperature on the quality of fertilizer precipitates was studied. When washing samples of wet precipitates, the water temperature was varied in the range of 20-90°C. The technique of laboratory experiments and the chemical analysis of the obtained fertilizer precipitates are identical to those described in [11], but the wet fertilizer precipitate was washed twice with water at various temperatures at a weight ratio of MM : $H_2O$ = 1.0: 1.5 and 1.0 : 2.0 in both cases. The acid concentration in all cases was 32%. The results of laboratory experiments are shown in table 2. The data in the table show that with a ratio of MM : $H_2O$ = 1.0 : 1.5 and an increase in the temperature of the wash water to be from 20 to 90°C, the content of $P_2O_{5total}$ increases slightly from 23.01 to 23.32%, the content of $P_2O_{5water}$ and $CaO_{water}$ decreases from 2.56 to 2.21%, from 2.74 to 2.24%, respectively, in the case without separation of an insoluble residue. The content of Cl is reduced from 2.20 to 1.73%, respectively. With a ratio of MM : $H_2O$ = 1.0 : 2.0 and an increase in the temperature of the wash water from 20 to 90 ° C, it contributes to a slight increase in the content of $P_2O_{5total}$ in samples of fertilizer precipitates from 23.67 to 24.06%, $CaO_{total}$ and Cl decreases from 27.44 to 26.40% and from 1.39 to 1.03%, respectively. But at the same time, the quality of precipitates is significantly improved by reducing the content of calcium chloride. It is also seen from the tabular data that in the case of the release of an insoluble residue, the qualitative parameters of fertilizer precipitates are significantly improved, and samples of concentrated phosphorus-containing fertilizers are obtained. For example, with a ratio of MM : $H_2O$ = 1.0 : 1.5 and an increase in the temperature of the wash water from 20 to 90°C, the content of $P_2O_{5total}$ increases slightly from 33.25 to 34.19%, the content of $P_2O_{5water}$ and $CaO_{water}$ decreases from 2.90 to 2.35%, from 2.41 to 2.11%, respectively. The content of Cl decreases 1.89 to 1.50%, respectively. With a ratio of MM : $H_2O$ = 1.0 : 2.0 and an increase in the temperature of the wash water from 20 to 90°C, it contributes to a slight increase in the content of $P_2O_{5total}$ in samples of fertilizer precipitates from 33.78 to 34.72%, $CaO_{total}$ and Cl decreases from 36.06 to 35.55% and from 1.35 to 1.00%, respectively. The data of table 2 clearly show that at washing water temperatures of 80 and 90°C the content of $CaO_{water}$ and Cl

***TABLE 1***

*THE EFFECT OF THE CONCENTRATION OF HYDROCHLORIC ACID AND THE RATIO OF MM : $H_2O$ ON THE CHEMICAL COMPOSITION OF PRECIPITATES*

| No | Ratio MM:$H_2O$ | $P_2O_{5tot.}$ | $P_2O_{5assi.}$ by 2% citric acid | $P_2O_{5wat.}$ | $CaO_{tot.}$ | $CaO_{assi.}$ by 2% citric acid | $CaO_{wat.}$ | Cl | Degree of washing off from $CaCl_2$, % |
|---|---|---|---|---|---|---|---|---|---|
| Hydrochloric acid concentration – 25% | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Without separation of insoluble residue | | | | | | | | | |
| 1 | 1,0:1,5 | 23,75 | 20,42 | 2,10 | 25,51 | 22,07 | 2,16 | 1,58 | 96,68 |
| 2 | 1,0:2,0 | 24,26 | 21,10 | 1,88 | 26,02 | 22,37 | 1,50 | 0,96 | 98,02 |
| With separation of insoluble residue | | | | | | | | | |
| 3 | 1,0:1,5 | 33,18 | 29,20 | 2,07 | 34,51 | 30,93 | 1,79 | 1,23 | 98,09 |
| 4 | 1,0:2,0 | 34,06 | 30,03 | 1,67 | 34,95 | 31,25 | 1,58 | 0,86 | 98,64 |
| Hydrochloric acid concentration – 30% | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 5 | 1,0:1,5 | 23,42 | 20,38 | 2,17 | 25,63 | 22,43 | 1,94 | 1,69 | 96,36 |
| 6 | 1,0:2,0 | 24,16 | 21,14 | 1,96 | 26,22 | 22,81 | 1,57 | 1,01 | 97,89 |
| With separation of insoluble residue | | | | | | | | | |
| 7 | 1,0:1,5 | 33,98 | 30,02 | 2,29 | 35,33 | 31,74 | 1,63 | 1,46 | 97,64 |
| 8 | 1,0:2,0 | 34,51 | 30,54 | 1,73 | 35,54 | 31,89 | 1,65 | 0,97 | 97,95 |
| Hydrochloric acid concentration – 32% | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 9 | 1,0:1,5 | 23,32 | 20,52 | 2,21 | 25,84 | 22,87 | 2,24 | 1,73 | 96,24 |
| 10 | 1,0:2,0 | 24,06 | 21,29 | 2,02 | 26,40 | 23,23 | 1,67 | 1,03 | 97,83 |
| With separation of insoluble residue | | | | | | | | | |
| 11 | 1,0:1,5 | 34,19 | 30,29 | 2,35 | 35,74 | 32,21 | 2,11 | 1,50 | 97,19 |
| 12 | 1,0:2,0 | 34,72 | 30,89 | 1,76 | 35,55 | 31,99 | 1,65 | 1,00 | 97,90 |

in products practically remain constant. This means that at a wash water temperature above 80°C, regardless of the ratio of MM : $H_2O$, the quality of fertilizer precipitates practically does not change in both cases and this is due to a slight change in the solubility of calcium chloride in the temperature range of 80-90°C. At a wash water temperature below 80°C, the content of calcium chloride in the composition of the obtained precipitate gradually increases.

***TABLE 2***

*THE INFLUENCE OF THE RATIO OF MM : H2O AND THE TEMPERATURE OF THE WASH WATER ON THE CHEMICAL COMPOSITION OF PRECIPITATES*

| No | Ratio MM:$H_2O$ | $P_2O_{5tot.}$ | $P_2O_{5assi.}$ by 2% citric acid | $P_2O_{5wat.}$ | $CaO_{tot.}$ | $CaO_{assi.}$ by 2% citric acid | $CaO_{wat.}$ | Cl | Degree of washing off from $CaCl_2$, % |
|---|---|---|---|---|---|---|---|---|---|
| Wash water temperature = 20°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 1 | 1,0:1,5 | 23,01 | 20,43 | 2,56 | 27,08 | 24,41 | 2,74 | 2,20 | 94,51 |
| 2 | 1,0:2,0 | 23,67 | 21,18 | 2,34 | 27,44 | 24,58 | 2,02 | 1,39 | 95,85 |
| With separation of insoluble residue | | | | | | | | | |
| 3 | 1,0:1,5 | 33,25 | 29,72 | 2,90 | 36,24 | 32,96 | 2,41 | 1,89 | 94,76 |
| 4 | 1,0:2,0 | 33,78 | 30,35 | 2,05 | 36,06 | 32,66 | 1,96 | 1,35 | 95,90 |
| Wash water temperature = 30°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 5 | 1:1,5 | 23,05 | 20,44 | 2,53 | 26,90 | 24,17 | 2,70 | 2,16 | 94,62 |
| 6 | 1:2,0 | 23,70 | 21,19 | 2,31 | 27,24 | 24,33 | 1,97 | 1,35 | 95,96 |
| With separation of insoluble residue | | | | | | | | | |
| 7 | 1:1,5 | 33,40 | 29,83 | 2,86 | 36,17 | 32,88 | 2,38 | 1,85 | 94,80 |
| 8 | 1:2,0 | 33,89 | 30,38 | 2,02 | 35,99 | 32,57 | 1,93 | 1,31 | 96,05 |
| Wash water temperature = 40°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 1,0:1,5 | 23,09 | 20,45 | 2,49 | 26,71 | 23,93 | 2,65 | 2,12 | 94,71 |
| 10 | 1,0:2,0 | 23,74 | 21,21 | 2,27 | 27,05 | 24,09 | 1,93 | 1,31 | 96,19 |
| With separation of insoluble residue | | | | | | | | | |
| 11 | 1,0:1,5 | 33,51 | 29,89 | 2,81 | 36,10 | 32,79 | 2,35 | 1,81 | 94,81 |
| 12 | 1,0:2,0 | 34,01 | 30,43 | 1,99 | 35,92 | 32,49 | 1,90 | 1,25 | 96,30 |
| Wash water temperature = 50°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 13 | 1,0:1,5 | 23,13 | 20,46 | 2,45 | 26,53 | 23,71 | 2,60 | 2,07 | 95,01 |
| 14 | 1,0:2,0 | 23,80 | 21,22 | 2,23 | 26,89 | 23,89 | 1,86 | 1,25 | 96,48 |
| With separation of insoluble residue | | | | | | | | | |
| 15 | 1,0:1,5 | 33,62 | 29,96 | 2,76 | 36,05 | 32,70 | 2,31 | 1,76 | 95,32 |
| 16 | 1,0:2,0 | 34,12 | 30,50 | 2,01 | 35,86 | 32,41 | 1,82 | 1,18 | 96,64 |
| Wash water temperature = 60°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 17 | 1,0:1,5 | 23,17 | 20,48 | 2,41 | 26,35 | 23,49 | 2,51 | 1,98 | 95,42 |
| 18 | 1,0:2,0 | 23,85 | 21,24 | 2,19 | 26,71 | 23,68 | 1,79 | 1,18 | 96,87 |
| With separation of insoluble residue | | | | | | | | | |
| 19 | 1,0:1,5 | 33,78 | 30,06 | 2,70 | 35,97 | 32,54 | 2,26 | 1,71 | 96,22 |
| 20 | 1,0:2,0 | 34,24 | 30,57 | 1,96 | 35,79 | 32,31 | 1,76 | 1,12 | 97,12 |
| Wash water temperature = 70°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 21 | 1,0:1,5 | 23,21 | 20,49 | 2,35 | 26,17 | 23,28 | 2,42 | 1,90 | 95,82 |
| 22 | 1,0:2,0 | 23,93 | 21,26 | 2,14 | 26,56 | 23,49 | 1,73 | 1,12 | 97,42 |
| With separation of insoluble residue | | | | | | | | | |
| 23 | 1,0:1,5 | 33,89 | 30,12 | 2,62 | 35,91 | 32,44 | 2,21 | 1,65 | 96,82 |
| 24 | 1,0:2,0 | 34,37 | 30,65 | 1,91 | 35,70 | 32,19 | 1,77 | 1,09 | 97,62 |
| Wash water temperature = 80°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 25 | 1,0:1,5 | 23,26 | 20,51 | 2,28 | 26,00 | 23,08 | 2,33 | 1,81 | 96,02 |
| 26 | 1,0:2,0 | 24,01 | 21,27 | 2,08 | 26,41 | 23,31 | 1,70 | 1,06 | 97,64 |
| With separation of insoluble residue | | | | | | | | | |
| 27 | 1,0:1,5 | 34,02 | 30,21 | 2,53 | 35,79 | 32,29 | 2,14 | 1,55 | 97,12 |
| 28 | 1,0:2,0 | 34,53 | 30,77 | 1,85 | 35,61 | 32,09 | 1,68 | 1,02 | 97,84 |
| Wash water temperature = 90°C | | | | | | | | | |
| Without separation of insoluble residue | | | | | | | | | |
| 29 | 1,0:1,5 | 23,32 | 20,52 | 2,21 | 25,84 | 22,87 | 2,24 | 1,73 | 96,24 |
| 30 | 1,0:2,0 | 24,06 | 21,29 | 2,02 | 26,40 | 23,23 | 1,67 | 1,03 | 97,83 |
| With separation of insoluble residue | | | | | | | | | |
| 31 | 1,0:1,5 | 34,19 | 30,29 | 2,35 | 35,74 | 32,21 | 2,11 | 1,50 | 97,19 |
| 32 | 1,0:2,0 | 34,72 | 30,89 | 1,76 | 35,55 | 31,99 | 1,65 | 1,00 | 97,90 |

Therefore, it is advisable to wash the wet residue at temperatures of 80°C and 90°C. In figure 1 shows the effect of the concentration of hydrochloric acid and the amount of washing water (MM : $H_2O$) on the content of $P_2O_{5total}$ in samples of fertilizer precipitates. From these data it is seen that with an increase in the concentration of acid, the content

of $P_2O_{5total}$ in samples of fertilizer precipitates, if an insoluble residue is obtained without isolation, it decreases slightly and this is due to the filtration rate precipitating suspensions, and with increasing amount of water the content of $P_2O_{5\ total}$ in samples of fertilizer precipitates increases slightly in both cases. In figure 2 shows the effect of the amount and temperature of the water on the degree of washing of the precipitate from $CaCl_2$ upon receipt of fertilizer precipitates with and without separation of an insoluble residue. From the data in the figure it can be seen that with an increase in the amount of water from 1.5 to 2.0 and the temperature of the wash water from 20 to 90°C, the content of calcium chloride in the precipitates significantly decreases.

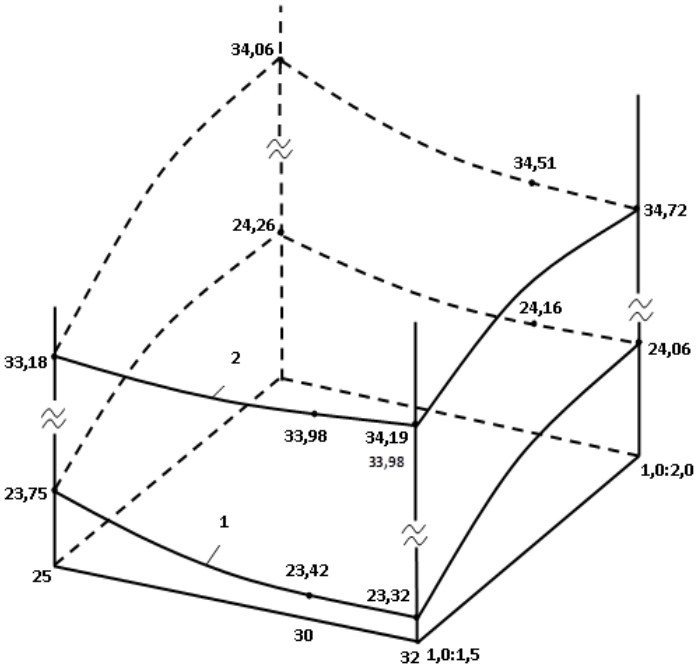


***Fig. 1**. Dependence of the change in the content of $P_2O_{5total}$ in precipitates on the concentration of HCl and the ratio of MM : $H_2O$.*
1-without separation of an insoluble residue; and 2-with separation of an insoluble residue.

With a ratio equal to MM : $H_2O$ = 1.0 : 1.5 with an increase in the temperature of washing water from 20 to 90°C, the degree of washing of calcium chloride increases from 94.76 to 97.19%, and with a ratio of MM : $H_2O$ = 1.0 : 2,0 in the indicated temperature ranges, the degree of washing of calcium chloride increases from 95.90 to 97.90%.

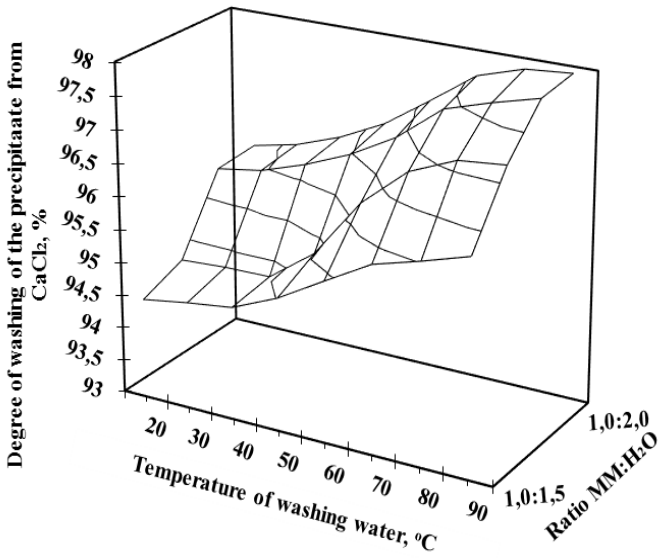


***Fig. 2**. Effect of amount and temperature of water on rate washing precipitate from $CaCl_2$*

Based on the results of laboratory studies, it was found that the acid concentration practically does not affect the quality of the obtained precipitates, by of the obtained precipitates. It was established that the ratio MM : $H_2O$ = 1.0 : (1.5 - 2.0) and the temperature of the wash water 80-90°C are optimal in both cases. In this case, the obtained precipitate samples have the following compositions,% mass: $P_2O_{5total}$ 23.26-24.26; $P_2O_{5assi.}$ by 2% citric acid 20.42-21.29; $CaO_{total}$ 25.51-26.41; $CaO_{assi.}$by 2% citric acid 22.07-23.31; $P_2O_{5water}$ 1.88-2.28; $CaO_{water}$ 1.50-2.33; Cl 0.96-1.81 and the degree of washing 96.02-98.02% in the case without separation of the insoluble residue and $P_2O_{5total}$ 33.18-34.72; $P_2O_{5assi.}$ 2% citric acid 29.20-30.89; $CaO_{water}$ 34.51-35.79; $CaO_{assi.}$ by 2% citric acid 30.93-32.29; $P_2O_5$ water 1.67-2.53; $CaO_{water}$ 1.58-2.14; Cl 0.86-1.55 and a degree of washing of 97.12-98.64% with the release of an insoluble residue. Next, we studied the chemical composition of insoluble residues separated under optimal conditions established by laboratory experiments. The data obtained are summarized in table 3.

***TABLE 3***
*THE CHEMICAL COMPOSITION OF SOLID RESIDUES*

| No | Ratio MM:$H_2O$ | $P_2O_{5tot.}$ | $CaO_{tot.}$ | $CaO_{wat.}$ | Cl | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | $SO_3$ | Igni-tation loss |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash water temperature = 80°C | | | | | | | | | | |
| 1 | 1,0:1,5 | 5,30 | 12,18 | 2,55 | 3,24 | 45,06 | 6,50 | 5,56 | 7,90 | 11,71 |
| 2 | 1,0:2,0 | 5,20 | 12,10 | 2,24 | 2,84 | 47,02 | 6,72 | 5,78 | 8,18 | 9,92 |
| Wash water temperature = 90°C | | | | | | | | | | |
| 3 | 1,0:1,5 | 5,24 | 12,09 | 2,55 | 3,20 | 45,64 | 6,70 | 5,61 | 8,02 | 10,95 |
| 4 | 1,0:2,0 | 5,16 | 12,04 | 2,21 | 2,80 | 47,32 | 6,81 | 5,82 | 8,20 | 9,64 |
| * - ignition loss | | | | | | | | | | |

From the data of table 3 it is obviously seen that with an increase in the amount and temperature of water, the main components of insoluble residues do not change significantly. These data are consistent with the data in table 2. The data in table 3 clearly show that at a temperature of washing water of 80 and 90°C, the content of $CaO_{water}$ in them. and Cl practically remains constant. This fact once again confirms

that the washing of the wet precipitate must be carried out with washing water at 80 and 90°C.

## 4 CONCLUSIONS.

1. For the first time, the possibilities of utilizing phosphate wastes and hydrochloric acid with the production of single phosphorus-containing fertilizers, which contribute to solving the environmental problems of the region, are shown.
2. The effect of the concentration of hydrochloric acid, the amount and temperature of washing water on the quality indicators of fertilizer precipitates was studied. The optimal parameters for obtaining fertilizer precipitates are determined.
3. For the first time, methods for producing concentrated phosphorus-containing fertilizers with the release of an insoluble residue are shown. The material composition of the insoluble residue was studied.

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