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A WAY TO REDUCE THE NEGATIVE IMPACT OF POTASH ORE WASTE ON THE NATURAL ECOSYSTEM

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Abstract

The efficiency of the use of the terrain and the external space of the Tyubegatan potash deposit (Republic of Uzbekistan) has been studied and solutions for the placement of salt waste on the dump and in the tailings storage have been developed. The technology and parameters of anti-filtration protection of the salt dump and brine collector No. 1 are recommended, which allows reducing the negative impact on the environment and groundwater. A chemical method and technological parameters for fixing salt waste from potash deposits with the selection of a sodium silicate solution and hardeners have been developed.

Key words: Tyubegatan potash deposit, rock salt, salt dump, salt waste, Dehkanabad potash fertilizer plant, anti-filtration protection, tailings storage, negative impact on the environment and groundwater.

INTRODUCTION

The relevance of the work. A lot of research has been devoted to the development of theories of an open method of mining in the Republic of Uzbekistan [1-23], but environmental problems have not been sufficiently studied.

In the world, potash fertilizers are obtained from natural-type silvinite ore and they allow farmers to get high yields, making up for the lack of potassium in plants. The Verkhnekamskoye potash-magnesium salt deposit (OJSC Uralkali and OJSC Silvinit, Russia) and the Saskatchewan Salt Basin (Canada), which account for 82.2% of the world's recorded K_2O reserves, as well as the potash salt deposits in Germany, the Starobinskoye potash salt deposit (Belarus), are the largest in terms of reserves of potash ores being developed. During the development of potash ore deposits, a number of problems were identified, the most important of which are the violation of the geological and structural structure of the mined area when using the mine mining method and the formation of significant waste masses formed as a result of salt enrichment and represented by water-soluble compounds [9].

To date, scientific research is being conducted to reduce the negative impact of potash ore waste on the environment, reduce salinization of natural ecosystems and the earth's surface, prevent salinization and minimize the environmental impact of salt waste of potash ores, develop a method to reduce the negative impact of potash ore waste on the environment. In this regard, it is necessary to develop scientific foundations for the effective use of the terrain and the external space of potash deposits, search for solutions for the placement of salt waste on the dump and in the tailings dump, develop a method, technology, recipe and project for the use of a chemical method for fixing salt waste.

Research methods. The work uses complex research methods, including scientific generalizations, theoretical and experimental studies in laboratory and landfill conditions to study the environmental aspects of the Dehkanabad ore complex for the extraction of potash ores, the study of a tailings dump for the placement of salt waste, methods of mathematical programming, as well as methods of mathematical statistics and correlation analysis of research results using modern computer technology.

The main content of the work. During the development of potash ore deposits, a number of problems were identified, the most important of which are the violation of the geological and structural structure of the mined area when using the mine mining method and the formation of significant masses of waste formed as a result of salt enrichment and represented by water-soluble compounds. After analyzing environmental problems, it is concluded that the extraction of potash salt has a significant impact on the environment, but the use of safety technologies and the use of modern innovative technologies can significantly reduce the negative impact of production activities on the natural environment.

The analysis allows us to conclude that during the extraction of potash ores, it is necessary to carry out work so that the new landscapes, salt dumps, tailings dumps, etc.can be used in the future with maximum effect and low impact on the environment. One of the ways to solve the problem of reducing the negative impact on the environment of salt waste placed on the daytime surface is to increase the capacity and height of salt dumps without expanding the area of its base and the introduction of reclamation works with insulation of the surface of salt dumps. To date, reclamation works of salt dumps on an industrial scale have not been carried out in the Republic of Uzbekistan.

At the Tyubegatan mining complex, a chamber-column development system is used for the extraction of potash salts [8-12]. At the same time, the main environmentally significant sources are:

formation of gas-air mixtures during ventilation;

gas release in spent workings, including spent empty and substandard rocks;

reservoir water effluents saturated with various salts;

geodynamic active zones on the area of the primary mining site of the mine;

sites of preliminary preparation of the initial downhole ore;

objects of storage and storage of averaged ore, waste rock dumps and tailings of silvinite processing waste;

underground and surface loading and unloading areas of raw and crushed ore;

dumps of rock and waste rock of the mine;

tailings of halite waste;

conveyor and automobile transport of crushed silvinite;

the near-barrel area of the exhaust mine air discharge;

areas of averaging and temporary storage of crushed silvinite;

other.

The deterioration of the environmental situation of the Dehkanabad mining complex takes place throughout the entire territory of the mining district. Therefore, it is necessary to approach the further development of the field in a comprehensive manner, taking into account the solution of all possible environmental problems during the operation of the Dehkanabad mining complex and processing enterprise [11].

Solutions have been developed for the placement of rock salt from the sinking of mine workings during the construction of a mine in the salt dump and salt waste from the processing plant of the Dehkanabad potash fertilizer plant in the tailings pond [22].

The method of anti-filtration protection of the salt dump and the brine collector No. 1 is recommended. According to this method, anti-filtration protection is performed in the form of an artificial screen on the area of the brine collector, including a prepared (planned and compacted) soil base, a waterproofing element (geomembrane) and a protective soil layer.

As a geomembrane, it is recommended to use a geosynthetic roll material based on bentonite clays (GBM) BENTOMAT (Bentomat) of the ASL100 brand with a film layer [6-12].

The bentomat is laid with a film layer up. Immediately before laying the Bentomat, the prepared ground base is well soaked with fresh water. The approximate amount of water is 500 m^3 per 1 ha (50 l/m^2). When laying the Bentomat during the precipitation period (winter, early spring), artificial wetting of the base is not required. The break between wetting and laying the Bentomat panels should not exceed 15-20 minutes in summer and 1 hour in winter.

The protective layer is the local soil (loam) with a layer of 0.6 m along the slope, 0.5 m on horizontal and slightly inclined areas, with a slight compaction (rolling). For laying on the next section of the screen, the soil is cut off on the area of the next section.

To prevent erosion, a protective layer is provided for fixing: 0.05 m rammed crushed stone, on top of it crushed igneous rocks of a fraction of 20-40 mm or equivalent local soil (pebbles, crushed rock mass) layer:

0.15 m on the upper slope of the brine collector dam;

0.10 m in the upper part of the brine collector between the horizontal lines 952.0 and 946.0 m.

The anti-filtration protection of the salt dump base includes a screen device of the described design and above-screen drainage.

The requirements for preparing the base for the screen are similar to the previous one. The protective layer is the local soil (loam) with a layer of 0.5 m, with a slight compaction.

On the sides, the screen is interfaced with the brine drainage channels, in the lower part – with the screen of the brine collector.

According to the log tag, drainage is arranged at the base of the salt dump above the protective layer of the screen. The purpose of drainage is the removal of brines from the body of the salt dump in a safe mode, which excludes the development of the most dangerous form of salt karst – sinkholes.

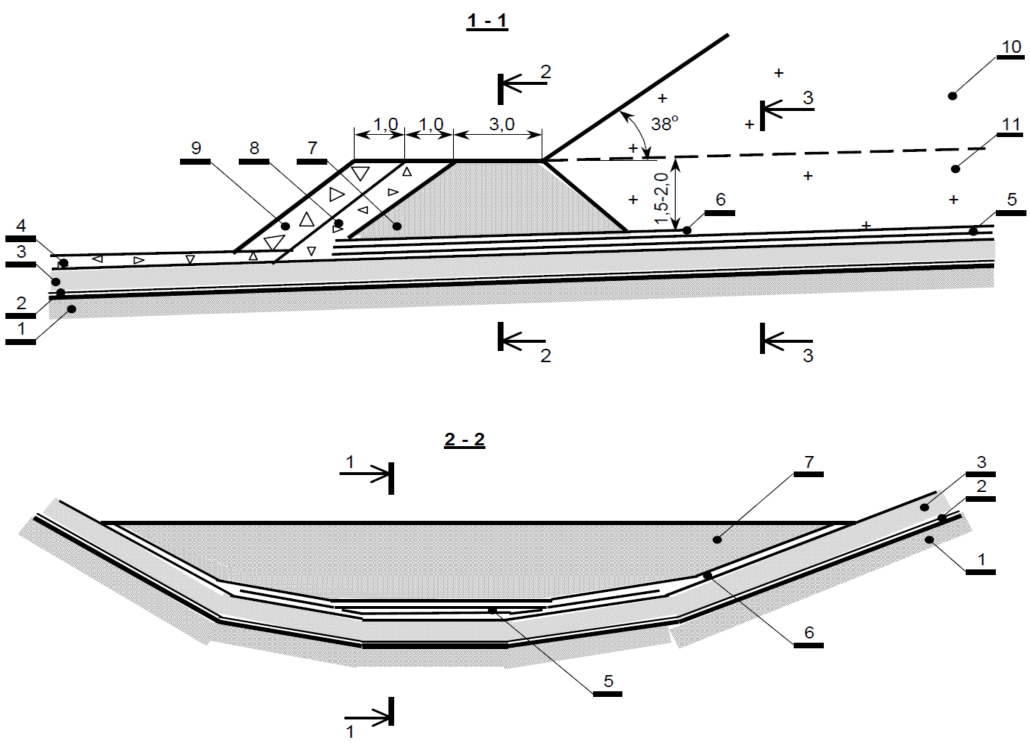
For the drainage device, it is recommended to use the geocomposite material TenCatePolyfelt DC

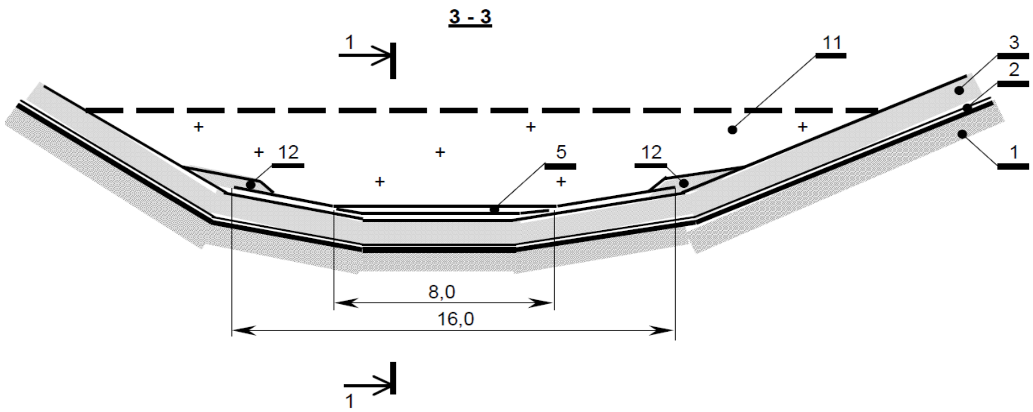
602E, consisting of a rigid HDPE geogrid protected on both sides (top and bottom) by a filter geotextile made of non-woven polypropylene fiber with a surface density of 120 g/m^2. According to the passport data, the water permeability of the material in the plan (in the plane of the material) at a slope of i=0.1 and a vertical pressure of 500 kPa (50 t/m2) is 0.1 *l/s* per 1 m.

The scheme of the anti-filtration protection device at the base of the salt dump is shown in Fig. 1.

The tailings storage facility for the placement of salt waste from the processing plant of the Dehkanabad potash fertilizer plant has been studied. The salt waste of the processing plant is located in the tailings pond. The amount of salt waste at the design capacity of the mine for ore extraction of 700 thousand tons / year is 473.1 thousand tons / year at a humidity of 7%, including the solid phase of 425.8 thousand tons / year. For the period of mining of the central part of the mine field (approximately 22.6 years), the total number of salt wastes placed in the tailings storage is 9.6 million tons of solid, their volume is 6.4 million m^3. The area of the base of the salt waste dump will reach 16 hectares by the end of this period. The calculation has established that in the future it is possible to expand the salt waste dump within this site to 6.8 hectares for technical salt and 14.9 hectares for technical waste with an increase in the capacity to 19.4 million tons for solid.

The main solution for artificial fixing of salt waste is a solution of sodium silicate with initial data ρ =1.45-1.50 g/sm^3, a silicate module of 3.0-3.5 and hardeners-bentonite and low-grade phosphorite (P_2O_5<9.0%) of fine grinding. Silicate-a block welded with a certain silicate module (SiO_2/Na_2O), corresponds to Government Standart of Uzbekistan (GS) KST-072, 284-98, is produced by the Navoi Mining and Metallurgical Combine.





1 – planned and compacted subgrade; 2 – screen-geomembrane Bentomat ASL100; 3 – layer protection screen made of local soil 0.5 m; 4 macadam mount protective layer;5 –nadarevic drainage - 2 layer TenCatePolyfelt DC602E; 6 – additional layer DC602E on the drainage outlet; 7 – hard-drainage prism of salt gravel; 8 – rubble FR. 20-40 mm; 9 – gravel fraction 40-70 mm; 10 –salt; 11 – the first layer of dumping of a salt; 12 – sealing the edges of the drainage

Fig. 1. The scheme is impervious protection at the base of the salt

According to the obtained experimental data, a generalizing dependence of the change in the strength of the fixed salt waste and the area of the specific total surface of the particles at different modules of sodium silicate is established.

The obtained dependence (Fig. 2) shows that with an increase in the area of the specific total surface of the particles to 100 sm^2, the strength limit for fixing the salt waste with a silicate module equal to 2.5 and 2.7 is, respectively, 5.7 and 6.7 MPa. The obtained data show that with a further increase in the area of the specific total surface from 250 to 300 sm^2, the tensile strength of fixing the salt waste is, respectively, 7.1 and 9.0 MPa for the silicate module, equal to 2.5 and 2.7.

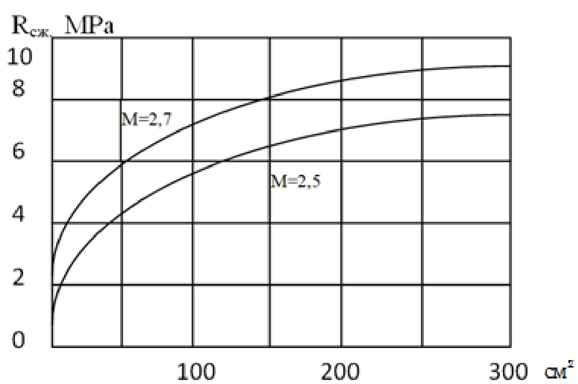


Fig. 2. Determination of the strength of the salt solution by the area of the specific total surface of the particles

The dependence of the change in the strength of fixing the salt waste on the density of the silicate solution for different silicate modules is established. With an increase in the density of the sodium silicate solution, the strength limit of fixing the salt waste increases.

The dependence of the change in the strength of the fixed salt waste on the density of the sodium silicate solution when using various salt wastes with a porosity of 39, 42 and 44% is also established.

The obtained dependence, shown in Fig. 3, shows that with an increase in the density of sodium silicate from 1.05 to 1.2 g/sm^3, the strength of the fixed salt waste increases.

The dependence of the change in the strength of the fixed salt waste on the modulus of sodium silicate at different solidification times is established.

The obtained dependence (Fig. 4) shows that with an increase in the sodium silicate modulus from 2.8 to 3.0, the strength of the fixed salt waste increases and amounts to 1.2, respectively; 1.6; 1.95 MPa at a solidification time of 2, 12 and 36 hours. It has been established that with an increase in the modulus of sodium silicate from 2.8 to 3.0, the strength of the fixed salt waste decreases to 0.4 MPa.

The obtained dependence (Fig. 4) shows that with an increase in the modulus of sodium silicate from 2.8 to 3.0, the strength of the fixed salt waste increases and amounts, respectively, to 1.2; 1.6; 1.95 MPa at a solidification time of 2, 12 and 36 hours. It was found that with an increase in the modulus of sodium silicate from 2.8 to 3.0, the strength of the fixed salt waste decreases to 0.4 MPa.

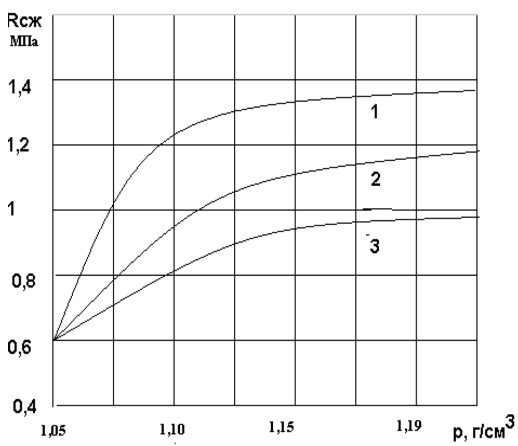


Fig. 3. Dependence of the strength of the fixed salt waste on the density of the sodium silicate solution

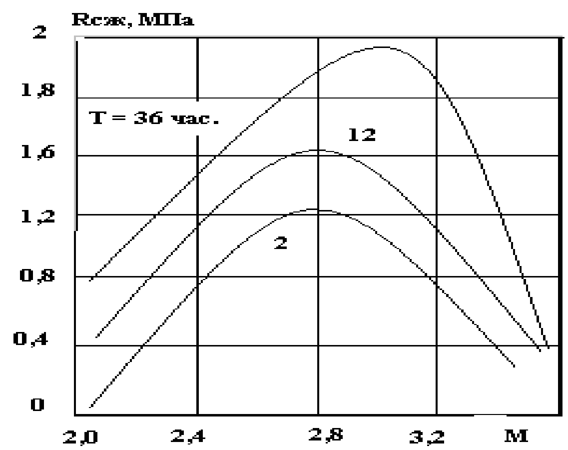


Fig. 4. The effect of the modulus of sodium silicate M on the strength of the fixed salt waste Rsf

Based on the analytical, computational and experimental studies of the processes of fixing salt waste, a sodium silicate solution with initial data ρ =1.45-1.50 g/sm^3, a silicate module of 3.0-3.5 and hardeners-bentonite and low – grade phosphorite (P_2O_5< 9.0%) of fine grinding was selected with a fixative. The optimal parameters of the proposed fixing mixtures are: sodium silicate solution ρ =1.45-1.50 g / sm^3, η =3-5 MPa*s, silicate modulus 2.5-2.8, temperature from 5 to 30^{0}C. The content of additives in the selected first formulation is 1.0-1.2% bentonite, in the second-from 2 to 5% low-grade phosphorite (P_2O_5≤9%) [16].

The prepared fixing solution must be "introduced" into the salt waste by spraying. Based on the available mathematical expressions, taking into account the geotechnological and physico - chemical characteristics of the fixed layer of salt waste, the volume and consumption of the fixing solution for fixing 1 m^3 of sand are determined. The technological scheme 1 + 3 → 2 + 4 and the rate of injection of the fixing solution are established: according to the schemes: four-point-paired, diagonal-sequential.

Based on the results obtained, it was found that the gelation time, the penetration rate of the solution and the strength of the fixing of salt waste are affected by the density and calcium modulus of the fixing solution, as well as the porosity and filtration coefficient of the fixed salt waste.

Thus, as a result of the introduction of the recommended technology of anti-filtration protection of the salt dump and the brine collector No. 1, the negative impact of salt waste from potash ores on groundwater has been reduced by 55%. As a result of the introduction of the developed chemical method for fixing salt waste from potash deposits, environmental pollution was reduced by 22%, as well as salinization of natural ecosystems and the earth's surface was reduced by 34%, salinization was prevented and the environmental impact of salt waste from potash ores was minimized.

Conclusions:

1. Solutions have been developed for the placement of rock salt from the sinking of mine workings during the construction of a mine in the salt dump and salt waste from the processing plant of the Dehkanabad potash fertilizer plant in the tailings pond.

2. The technology of anti-filtration protection of the salt dump and the brine collector No. 1 is recommended, which allows reducing the negative impact on the environment and groundwater.

3.The tailings storage facility for the placement of salt waste from the processing plant of the Dehkanabad potash fertilizer plant was studied. The salt waste of the processing plant is located in the tailings pond. The amount of salt waste at the design capacity of the mine for ore extraction of 700 thousand tons / year is 473.1 thousand tons / year at a humidity of 7%, including the solid phase of 425.8 thousand tons / year. For the period of mining of the central part of the mine field (approximately 22.6 years), the total number of salt wastes placed in the tailings storage is 9.6 million tons of solid, their volume is 6.4 million m^3. The area of the base of the salt waste dump will reach 16 hectares by the end of this period. The calculation has established that in the future it is possible to expand the salt waste dump within this site to 6.8 hectares for technical salt and 14.9 hectares for technical waste with an increase in the capacity to 19.4 million tons for solid.

4. A detailed study of the essences, features and practical possibilities of existing methods and methods for fixing salt waste that differ in chemical composition, physico-mechanical and geotechnological characteristics has established that the most suitable method for fixing salt waste from the Tyubegatan potash deposit is a chemical method – the method of silicatization by a single-solution method with additives of hardeners similar in nature and origin of the processed salt waste substances.

5. Based on the analytical, computational and experimental studies of the processes of fixing salt waste, a sodium silicate solution with initial data ρ =1.45-1.50 g/sm^3, a silicate module of 3.0-3.5 and hardeners-bentonite and low – grade phosphorite (P_2O_5<9.0%) of fine grinding was selected with a fixative. The optimal parameters of the proposed fixing mixtures are: sodium silicate solution ρ =1.2 g / sm^3, η =3-5 MPa*s, silicate modulus 2.5-2.8, temperature from 5 to 30^{0}C. The content of additives in the selected first formulation is 1.0-1.2% bentonite, in the second-from 2 to 5% low-grade phosphorite ($P_2O_5 \leq 9\%$).

6. The prepared fixing solution must be "introduced"into salt waste by spraying. Based on the available mathematical expressions, taking into account the geotechnological and physico - chemical characteristics of the fixed layer of salt waste, the volume and consumption of the fixing solution for fixing 1 m3 of sand are determined. The speed is set, the scheme of 1 + 3 → 2 + 4 injection of the fixing solution: four-point-paired, diagonal-sequential.

7. Based on the results of laboratory experiments and pilot tests, it was found that the time of gelation, the penetration rate of the solution and the strength of fixing salt waste are affected by the density and calcium modulus of the fixing solution, as well as the porosity and filtration coefficient of the fixed salt waste.

8. Based on the results of theoretical, laboratory and pilot-industrial studies of the process of fixing salt waste, a method, recipe, project and action plan for checking the quality of work and safety of implementing a chemical method for fixing salt waste from the Tyubegatan potash deposit have been developed.

9. The technology of anti-filtration protection of the salt dump and brine collector No. 1, as well as the chemical method of fixing salt waste was introduced in the Dehkanabad potash fertilizer plant of the Tyubegatan potash deposit, as a result of which the negative impact of salt waste of potash ores on groundwater was reduced by 55%, environmental pollution by 52%, and salinization of natural ecosystems and the earth's surface was reduced by 42%, salinization was prevented and the environmental impact of salt waste of potash ores was minimized.

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