Promising methods of chemical melioration of mobile soils and sands using composition from local structuring formers

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Abstract. An analysis of the literature on the preparation of fixers for mobile saline sands and their use in various regions showed that the selection of the structure former should be carried out taking into account their climatic characteristics, composition and properties of the fixed dispersions, their subsequent use in breeding the corresponding flora, etc. At the same time, the forming crust (film) must have a certain mechanical strength that does not interfere with the further growth of the planted plants. Moreover, the use of industrial waste as additives will not only reduce the cost of production and use of the developed fixers, but also allow them to be disposed of without causing damage to the ecology of the region.

1. Introduction
Currently, all over the world, large-scale projects are underway to reduce areas and desert zones in many continents, including the Central Asian states. This is due to a significant deterioration in environmental safety and a reduction in agricultural land, where the population is in poverty from a shortage of food products and the spread of chronic diseases of the lungs, digestive tract, etc. in these regions. Therefore, the problem of surface fixation of mobile soils and sands from wind erosion by chemical reclamation followed by phyto-reclamation is considered a globally urgent task for each country located between the Karakum and Kizilkum deserts in Central Asia.

The solution to such a complex environmental problem is complicated by the drying up of a significant part of the Aral Sea, located near the Bukhara-Khiva region. Therefore, it is advisable to solve these interrelated problems using an integrated approach, which includes both the tasks of fixing mobile soils and sands of the Bukhara-Khiva region, as well as the problems of their salinization with various mineral salts of the Aral Sea.

The development and implementation of various fixers and technologies for their application to consolidate mobile soil and sand using cheap local raw materials and industrial waste is relevant in the world. Particular attention is paid to obtaining crust-forming mechanical strong (within sufficient limits) structures on the surface of mobile soil and sand, which, under certain external influences, make it possible to create conditions for solving the problems of phyto-melioration. When developing composite fixers for the dispersion of saline mobile soils and sands, it is necessary to substantiate the corresponding scientific solutions, in particular: studying the possibility of direct binding of particles of mobile soil and sands with fixer compositions obtained from local raw materials; establishment of the formation of
a strong crust structure depending on the composition and properties of the selected fixers; development of a technology for obtaining a composition of fixers using mechanochemical dispersion of solid particles.

2. Theoretical research

Until now, these preparations are of particular importance as structure-forming agents, especially polyacrylates, as well as polyacrylamides and polymethacrylates close to them in chemical structure. These include the well-known structurant polyacrylamide (PAA), a copolymer of acrylic acid and calcium acrylate, which swells in water due to the electrostatic effect with the cleavage of intermolecular hydrogen bonds.

Polymers based on polyacrylamide contribute to the formation of a water-resistant structure. An increase in the size of soil aggregates and an increase in their water resistance significantly increases the rate of water filtration into the soil, reducing the likelihood of water and irrigation erosion. The stabilizing effect of the structure-forming agents makes soil aggregates resistant to wind erosion; dry polyacrylamide began to be produced in the USA under the name Separan [1].

As you can see, over the past decade, tens of thousands of different preparations have been created and tested as structure-forming agents, but only a few have found practical application in agriculture. This is primarily due to the fact that, despite their effectiveness, all these preparations increased the water resistance of the structure, improved water and air conditions, but were very expensive and did not always provide an economically beneficial increase in yield.

In connection with the synthesis and testing of more and more new soil and sand fixers, it became necessary to identify the mechanisms of interaction of structure-forming agents with their mineral part.

Electron microscopic images of polyanionic ICPs showed that the polymers that bind the primary particles are filamentary. At low concentrations, these polymers form branched filaments when dried, and at higher concentrations, a reticular structure. Moreover, the decisive role is played by the number and distribution of functional groups (\(-\text{COOH}, -\text{OH}, -\text{NH}_2\)) in the polymer. Along with the direct bond between the clay and the polymer, the formation of a bridging bond through cations (\(-\text{COO}^-\text{Ca}^{2+}\text{clay}\)) plays a certain role. The same importance is attached to bonds of secondary valence, especially to water-strong bridging bonds, and the interaction of molecules saturated with primary valence determines the retention of polymer molecules on the surface of clay minerals. Finally, the Van der Waals forces also participate in the stabilization process. The degree of strength of these 3 possible bonds decreases in the following sequence: the bond of the main valence - the bond of the secondary valence - Van der Waals forces [2].

The effect of polyelectrolytes on the aggregation of clay minerals depends on many factors. Particularly strong influence on the degree of aggregating action of polyaniions is exerted by their dosage. This can be traced by the example of coagulation of clay suspensions when increasing doses of linear polymers are added to them; with increasing dose, aggregation increases. As the processes of coagulation, peptization and precipitation show, when neutral salts or electrolytes of a certain concentration are introduced into the solution and the pH of the solution is brought to the appropriate level, it is possible to both increase and decrease the degree of aggregating action of polyaniions. Of particular interest are the issues of changes in the mechanisms of interaction of drugs with soil (in particular, various aspects of the effect of polymers on the microstructure of soils), which have not been studied so far.

Thus, summarizing the influence of the types of soil fixers and sand, we can say that the loose lumpy structure of the soil, formed during mechanical processing, is stabilized under their influence, and as a result, the soil remains loose for a long time. Even after heavy rainfall, its surface does not float with silt and is not covered with a crust, but retains a lumpy structure. Large clods and lumps formed during the plowing of the layer treated with polymers easily disintegrate into smaller pieces or give in to crumbling without mechanical force. In contrast, the lumpy structure of untreated soils with fixers can usually only be changed after repeated mechanical treatment [3].
The work [4] shows the dependence of the structure-forming ability of polymers on their chemical characteristics. The efficiency of water-soluble polymers increases 3-4 times when the absorbing complex is saturated with calcium ions. Thus, the effect of fixing polymers has a versatile effect on the soil, improves water-physical properties, enhances the biological activity of soils, increases the anti-erosion resistance of soils, prevents erosion processes, which ultimately has a positive effect on the vegetation of agricultural crops.

Analysis of the literature data on the implementation of measures related to the surface fixation of mobile sands shows that the transfer of mobile sand from a free-dispersed state to a cohesive-dispersed state during chemical reclamation under natural conditions is carried out in two stages: first, dispersions of the ameliorant are prepared, for which a special technology is developed for obtaining a working composition with taking into account the properties of the components, and then the prepared dispersions are applied to the surface of the sand.

Physicochemical properties of protective crusts depend on the depth of impregnation and the nature of the distribution of the ameliorant in the pore space of the sand. Therefore, it is important to determine the optimal concentration and dosage of the fixative per unit of the fixed surface [5].

The penetration of the ameliorant into the sand is accompanied, first of all, by the consumption of water solvent for wetting the sand surface, which probably contributes to the thickening of the ameliorant solutions, and the consequence of the forces of intermolecular interactions leads to the predominance of cohesive phenomena over the adhesion ones with the appearance of a surface film, and giving a three-dimensional structural and giving sandy crust [6].

The interaction of sand particles with the ameliorant depends on the nature of the dispersion medium in which the ameliorant is prepared. In the case of using, for example, oil, bitumen, adhesion processes occur after the formation of a surface film by the ameliorant. When aqueous dispersions of ameliorants are used, the interaction between the sand particles and the ameliorant is determined by the wettability of the solid phase with water (the hydrophilicity of the sand). The possibility of reducing the deflatability of soils and sands by treatment with chemicals was also studied in [7]. The experiments were carried out in different climatic zones and on different types of soils and sands. In all experiments, a close relationship was observed between the indicators of the artificial structure, liquid runoff, washout, and deflation, and this relationship was inversely straightforward [8].

3. Results and discussion

For an objective assessment of the ecological efficiency of the developed method of fixing mobile soil and sand, it is advisable to use an integrated approach that takes into account the changes after the implementation of this work in the atmosphere, the earth's surface, etc. Of course, it is not always possible to quantify changes in some fixation parameters, which is due to the scale of measurement, the lack of standardized methods of analysis, etc. Therefore, sometimes a qualitative assessment of environmental indicators is used in order to characterize the change made.

From the studies carried out, it has been established that the consolidation of mobile soil and sand is a complex process, where chemical reactions take place for root formation from inorganic and organic substances.

A distinctive feature of the proposed method of fixing mobile soil and sands of desert road tracts is a two-stage process of crust formation, where at the first stage, enrichment with mineral-organic fertilizers is carried out, and at the second stage, the formation of Na, Ca contained roots with the addition of sodium silicate, K-4, gosypol and its derivatives or petroleum resins. It should be noted that the first layer favors the development of phytomelioration, and the second increases the mechanical strength, moisture resistance and other indicators of the roots.

Table 1 shows the environmental effects from the implementation of the proposed method of fixing mobile soil and sand, established in the Bukhara-Khiva region.

Table 1 shows that the use of a two-layer consolidation of mobile soils and sands in the Bukhara-Khiva region can significantly improve the ecological situation, solve the cultivation of desert plants and increase the service life of protective formations by using local raw materials and waste.
Table 1. Environmental efficiency of the proposed two-layer anchorage of mobile soil and sand in the Bukhara-Khiva region.

| Research object | Environmental performance indicator | Amount |
|-----------------|-------------------------------------|--------|
| Atmosphere      | Content:                           |        |
|                 | - dispersnost decreases            | from 18 to 7% |
|                 | - oxygen rises (Changed)           | by 3 - 5%  |
| Soil            | Content:                           |        |
|                 | - mineral-organic fertilizer increases | by 10 - 12% |
|                 | - the mechanical strength of the crust increases | at 3 - 5 MPa |
|                 | - the thickness of the fastening crust increases | at 20 - 30 mm |
|                 | - moisture resistance of the crust increases | by 10 - 15% |
| Plants          | - the intensity of plant growth increases | the intensity of plant growth increases |
|                 | -the type of fixing the urinary wall expands | -the type of fixing the urinary wall expands |
|                 | -increases resistance to wind and drought in desert zones | -increases resistance to wind and drought in desert zones |

Thus, we can draw the following conclusion that two or more-layer structures should be considered a more effective protective formation, where each layer performs certain tasks of fixing and enriching mobile soil and sand with mineral-organic fertilizer. This is consistent with the modern strategy for the development of the desert regions of Uzbekistan not 2021-24, where, along with the use of chemical, the use of phytomelioration is envisaged, especially in those zones where there are settlements, etc.

As can be seen from table 1, for an objective assessment of environmental efficiency, it is necessary to use an integrated approach that studies the atmosphere, buds and plants as a whole system.

4. Conclusion

Thus, we can conclude that the successes of colloidal chemistry and physicochemical mechanics make it possible to predetermine the transfer of a free-dispersed system of sand, where particles freely move relative to each other, into a coherent-dispersed one, when all particles are connected with each other, forming a single spatial structure, which is characterized by strength, size and other mechanical properties of a solid. The type of structure formed, the strength of the contact between the sand particles in this structure depends on the type of ameliorant. Hence, it becomes necessary to study the physical and mechanical properties of the structured system of sand in each specific case of using the ameliorant, as well as to establish the proportionality of the structural and kinetic units of the ameliorant with the pores of the substrate to optimize the process of creating a coherent-dispersed system.

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