Biogenic Fixation of Dusting Surfaces

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Abstract. In the present-day practice of mining the available ways and means of reduction of technogenic arrays dust exhaust are either not effective enough or are sources of workspace pollution themselves. Alternatively, in order to solve this problem, the National University of Mineral Resources has developed the technology, the essence of which is an application of biogenic protective layer, consisting of a mixture of biohumus and sodium carboxymethyl cellulose in the ratio of 125:1, onto dusting surfaces. If compared with the known solutions, the proposed method improves the efficiency of dusting surface fixation, while forming bioproductive environment that will facilitate the creation of secondary ecosystems on disturbed technogenic arrays.

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Introduction

Mineral resources mining and processing generate considerable dust streams and large areas of disturbed land. The main types of degraded areas are dumps, tailings and tailings beaches, sludge pits, etc. [1].

Mining enterprises in Russia and other countries use mainly methods and means presented in Table 1 [2, 3, 4] in order to reduce the intensity of dust emission from the exposed surfaces and dust control at the source of emission.

Table 1. Means of Dusting Surfaces Fixation

Composition	Components Consumption	Bioefficiency + / -	Adhesive properties
Water and wetting agents	12,000 m^3/ha · year	+	Practically do not appear
$CaCl_2$ + H_2SO_4	40 kg/ha 30 kg/ha	-	Appear weakly
Bitumen emulsion: (Petroleum bitumen, sulfite-alcohol draff, water) + Hay mulch	300 l/ha (at concentration of 15-20%) 2.75 t/ha	-	Appear clearly
Various powder polymers, latex solution	2.5-5 kg/ha	-	Appear clearly
Zeolite Vegetable extract Blue-green algae Sapropel Water	15-33% 10.5% 0.05% 70-35% 10-23%	+	Practically do not appear

Methods.

The National University of Mineral Resources performed an assessment of causes for reduction of work efficiency on dust suppression, together with the identification of the main present-day negative factors in processes of dust emission on used technogenic arrays through field observations in the period from July, 20th to August, 13th on tailings and dumps of the Alekseevskiy career of cement raw materials (Republic of Mordovia), as well as through similar situations modeling in the laboratory.

On the basis of simulated conditions of existing coatings [5], a unique conclusion was drawn about the absence of a protective coating formation of currently used binding compositions for 50-100 meter of the beach adjacent to tailing pond and wet surfaces of newly deposited sands.

Thus, in the laboratory the samples of wet beaches of area of 0.25 m^2 treated with standard latex-silicate mixture (LSM) of consumption of 1.2 l/m^2 demonstrated the absence of formation of anti-erosion coating of the required strength. On the surface of these laboratory samples a loose crystal surface of white colour formed. The formed coating was destroyed by wind flow of rate of more than 4 m/sec.

Thus, latex and latex-silicate mixtures did not provide the fixation of the most unfavorable part of the beach (from the viewpoint of dust emission), and work on dust control in a condition of a great amount of precipitation dramatically weakens the strength characteristics of the coating, which requires a repetition of costly works.

The obligatory condition of chemical fixation efficiency increasing is the performance of works within a short period – not more than 3-4 weeks -immediately after the disappearance of snow cover (usually, starting from 15-20 of May), otherwise the situation becomes much more complicated by the transfer of sand from untreated areas of beaches to already fixed ones.

The dependence of the rate of formation of a protective coating after the application of standard LSM on beach surface temperature has been analyzed.

Laboratory experiments have shown that at the surface temperature within the range from +2 °C to + 5 °C the time required for polymerization and an increase in strength of applied LSM coating increases about twice.

The course of day and night temperatures for each day of August-September 2013 has been analyzed: the comparison of the obtained data testifies the inability to obtain effective coating in rainy weather.

Thus, laboratory experiments and an analysis of weather conditions allowed to conclude that the use of traditional binding compositions cannot guarantee the timely start and subsequent optimal terms of works completion.

In this paper other detected negative factors of existing practice of works performance on dust control at the Alekseevskiy career complex are defined:

- the absence or weak development of bioproductive technological environment on fixed technogenic arrays;
- the presence of extended shallow beaches connected with industrial safety requirements;
- the absence of possibility of tailing main pond level raising in winter time;
- insufficient strength characteristics of the coating.

Thus, in our studies there was noticed a fairly high adhesion of latex-silicate mixture to many materials, which prevents the formation of bioproductive environment on the basis of the offered mixture, as well as insufficient strength of connection of LSM with sand caused by a large difference of Poisson ratio for these materials, which leads to gradual stratification and inability to use the fixed layer for the surface sodding.

The main part.

In order to eliminate the shortcomings of the existing dust control technologies, a patent analysis and a considerable amount of laboratory researches with the usage of binding compositions, but with a considerable bioproductive potential, have been performed.

Studies carried out with different types of binding compounds [6, 7] allowed to make a principal conclusion about the fact that for a particular type of building material (dolomite, sand, sandstone, tripolite, etc.) the development of specific bioproductive mixture with certain set of properties (stability, adhesion, the depths of penetration into the soil, concentration and components relation, etc.) is required.

From the point of view of nature protection the developed compositions considerably increase the effectiveness of work on prevention of dust removal from the surface of the technogenic arrays being treated, in its turn, not increasing the load on the environment. According to the results of biological testing the toxicity degree of dumps and tailings of the Alekseevskiy career complex is not changed as well.

The proposed method of dusting surfaces fixation lies in the application of a mixture consisting of biohumus obtained from Eisenia Foetida compost earthworm and sodium carboxymethyl cellulose (CMC) in the ratio of 125:1 onto dusting surfaces of used technogenic arrays. The fixation of dusting surfaces with the formation of a strong bioproductive layer is carried out under natural or artificial humidification.

Sodium carboxymethyl cellulose has the following chemical formula $(C_6H_7O_2(OH)_{3-x}(OCH_2COONa)_x]_n$, where n = 300 - 1,000. It represents an amorphous colourless substance with density of 1.59 g/cm^3. Having a softening point of 170 °C, sodium CMC is soluble in water and in aqueous solutions of alkalines, ammonia, and sodium chloride, at that the degree of solubility is defined by the degree of cellulose etherification. On the contrary, CMC is not dissolved in organic solvents and mineral oils [8].

When dissolved in water, CMC forms viscous clear solutions characterized by pseudo-plasticity, and for some varieties of a product by thixotropy (the ability to spontaneously rebuild an original structure damaged by mechanical action). In aqueous solutions, CMC, demonstrating the properties of a surfactant, is well mixed with other water soluble organic substances, for example, with a biohumus. The compound is degraded in aqueous solutions of mineral acids and alkalis with oxygen. Aqueous solutions of sodium carboxymethyl cellulose form transparent films characterized by elongation of 8-15%. Dry mix of CMC has little corrosive effect; it is biologically inactive and resistant to biodegradation, but its aqueous solutions at prolonged storage on air are enzymaticly hydrolyzed.

In order to prevent biologically destructive processes, while fixing dusting surfaces, the biohumus obtained from Eisenia Foetida compost earthworms is used.

Biohumus is a complex capillary-porous material, the intercellular space of which is filled with water with a low concentration of saccharose. In biohumus obtained from Eisenia Foetida compost earthworms, the content of dry solids varies from 20 to 25%, with PH having slightly alkaline medium [9].

Biohumus is mixed with sodium carboxymethyl cellulose in the ratio of 125:1 (in terms of volume) for the neutralization of the medium to obtain the acidity equal to pH 7.1-7.4, which is optimal for the formation of bioproductive environment in future based on a fixed dusting surface. At that the adhesiveness of sodium carboxymethyl cellulose will be saved, allowing to form a solid layer on a dusting surface, which is slightly prone to destructive water and air erosion processes.

Under natural sprinkling and the force of gravity CMC penetrates between factions of biohumus and fixes the dusting layer. Sodium carboxymethyl cellulose has an adhesive property and glues fine mineral component of biohumus, allowing to protect the soil from water and wind erosion, while forming a bio-productive environment.

The bioefficiency of the obtained mixture has been investigated [10]. Sheldow lawn grass seeding (Table 2) was used as an indicator of the possibility of such an environment creation.

Table 2 shows that the composition No. 2 of the mixture has an optimal ratio of components to achieve the greatest bioefficiency.

Table 2. Determination of Bioefficiency of Biohumus and Sodium Carboxymethyl Cellulose Mixture

No.	Biohumus, %	Sodium carboxymethyl cellulose, %	Germination of grass mixture, %	Germs colour (at 60th day)	Maximum height of germs, cm	Lifetime, days
1	100	0	95	Dark green	14	160
2	99.2	0.8	95	Dark green	15	160
3	98.5	1.5	50	Yellow-green	12	80
4	97	3	20	Green	5	30
5	95	5	-	-	-	-

The obtained mixture was tested in a laboratory installation [11], generating an artificially created wind load on pallets with different bioproductive layers of equal weights. The wind flow with the rate of 2.5-3 m/sec acted in a horizontal direction on layers for 1 minute. The experimental results are presented in Table 3.

Table 3. Determination of Adhesion Properties of Biohumus and Sodium Carboxymethyl Cellulose Mixture

No.	Biohumus, %	Sodium carboxymethyl cellulose, %	Weight before blowing, g	Weight after blowing, g	Integrity of a formed layer, %
1	100	0	250	137	95
2	99.2	0.8	250	245	95
3	98.5	1.5	250	245	80
4	97	3	250	244	50
5	95	5	250	242	20

Table 3 shows that composition No. 2 of the mixture is the strongest and demonstrates the best integrity after the blowing. It is an evidence of the fact that the proneness to wind erosion at the combination of components, corresponding to composition No. 2 of the mixture, is minimal.

Conclusion.

If compared with the known solutions, the offered method allows to improve the efficiency of dusting surfaces fixation while forming a bioproductive environment that will facilitate the creation of secondary ecosystems on disturbed technogenic arrays.

Findings.

1. Currently applied technologies of dusting surfaces fixation of the used technogenic arrays have a number of fundamental flaws, being rather expensive, labor-intensive and demonstrate a great consumption of binding substances.

2. The offered original way to reduce dust emission from external dumps of building materials careers based on application of a biogenic protective layer, consisting of a mixture of biohumus and sodium carboxymethyl cellulose in the ratio of 125:1, on dusting surfaces is rational.

3. It was established that an increase in the concentration of a binder (Na-CMC) above a specified proportion inconsiderably increases the efficiency of dust control, strength and wind resistant properties of a protective layer, while decreasing its bioefficiency.

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