E3S Web of Conferences **407**, 03011 (2023) https://doi.org/10.1051/e3sconf/202340703011
APEEM 2023

Dust suppression on industrial waste storage (on example of the waste storage of the Ulytau region)

Yelena Tseshkovskaya[1, *], *Natalya* Tsoy[1], *Aigul* Oralova[1], *Yuriy* Obukhov[1], and *Alexander* Zakharov[1]

[1]Abylkas Saginov Karaganda Technical University, Karaganda, Kazakhstan

Abstract. The article discusses the issues of dust suppression on industrial waste storage. The dust-suppressing properties of two chemical polymer reagents in the conditions of an industrial waste storage facility in the Ulytau region are considered. Full-scale studies of the dust-suppressing properties of the claimed reagents have been carried out. Throughout the entire period of the study, atmospheric air was monitored at the border of the sanitary protection zone (SPZ) and at the experimental sites. Fine dust, as a main air pollutan has been identified. The advantages of using these reagents as fixatives for dusty waste storages are described.

1 Introduction

The purpose of the work is to determine the best option for dust suppression on the waste storage that meets environmental and economic requirements.

Research task:

- analysis of the current state of the issue of waste storage dedusting;
- conducting research on dedusting waste storage;
- determination of optimal parameters to ensure dust suppression at the source.

For dust suppression at waste storage, various hygroscopic salts are mainly used, since they are the most economical and do not harm the environment.

The efficiency depends on the rate of leaching of salts from the upper dusty layer. This disadvantage is reduced by adding binders (adhesives) materials, which are products of chemical and petrochemical production. They are scarce and expensive, and also have a harmful effect on the environment.

In the work of A. Nemirovsky [1] considered the use of complex binders to fix the waste storage; the use of mineral binders in the form of calcium, magnesium carbonates and clayey rocks contained in the impurities of the original iron ore and enrichment waste. One of the solutions to the problem is based on the creation of physical conditions [1], under which there will be no lifting aerodynamic forces at the exit from the waste storage. A similar solution to the problem is known in the construction of windscreens.

* Corresponding author: elena_tsesh@mail.ru

An analysis of patents [3-9] showed that compositions for fixing dusty surfaces have disadvantages: insufficient strength and durability; difficult application; the impossibility of using the fixed layer to cover the surface; the occurrence of additional costs for anti-erosion measures; a large decrease in the bioproductivity of fixed dusty surfaces.

According to the research [10], phenol-formaldehyde resins showed good results for fixing both the surfaces of waste storage, and the slopes of dams for the warm season. In this case, it is advisable to use compositions containing polyacrylamide only for short-term fixing of the surface of dispersed materials. Biological fixation of enrichment waste by sowing perennial grasses and shrubs is considered in [11].

An analysis of the existing methods and methods for dedusting industrial waste storage has shown that there are many options based on various properties [12]. The most commonly used methods are chemical, mechanical, aerodynamic and biological. Chemical method is based on the use of the chemical properties of reagents (for example, hardening, binding, fixing the surface due to the contact of the reagent with the waste). The mechanical method is based on the use of the method of dumping a larger fraction onto a dusty surface. Aerodynamic is based on wind reduction in the waste storage due to the installation of wind screens. The biological is based on the cultivation of the plant medium at the waste storage. These methods are not always applicable in isolation. It is possible to use them in combination. For example, a chemical method can be used at a waste storage at a time when waste is not being stored; the use of the aerodynamic method is possible from the beginning of exploitation of the waste storage and throughout the entire period of operation; mechanical and biological methods can be used at the end of operation. This article will consider only the chemical method of dust suppression at the waste storage.

2 Materials and methods

The work was carried out at the waste storage in the Ulytau region. The waste storage is located in a continental arid climatic zone with minimal annual precipitation and high wind loads. The prevailing wind directions are north (25%) and east (18%). The average wind speed is 3.3 m/s. A distinctive climatic feature of the waste storage are sharp daily and annual temperature fluctuations. There is a low level of precipitation in this region. The high level of continentality and pronounced aridity are explained by the remoteness from the oceans and seas. The duration of the warm period is on average about 220 days (or 60% per year).The average duration of the warm period is 220 days (or 60%).

At the beginning of research, 3 reagents were selected. These reagents were applied to the surface of the tailings dump in early autumn. The condition of the coatings and atmospheric air was monitored on the coatings themselves and on the border of the sanitary protection zone (Fig. 1). In addition to visual observations of the coatings, air quality measurements were made using “GANK-4”, “Atmas”, “Meteoscope”, “AVA-1 Aspirator”, “Aeroqual Series 500” devices at the border of the protection zone and in the treated areas. Gases and solid fraction were measured using “GANK-4”. By the “Atmas” devic was measured the finer solid fraction (PM 2.5, PM10). The “Meteoscope” measured the climatic parameters of the air (wind speed and direction, air temperature, atmospheric pressure, humidity). Air samples were taken with an “AVA-1” aspirator. Also, the “Aeroqual Series 500” portable air quality monitor was used to determine the concentration of dust in the atmospheric air in real time. Two reagents were tested. They were studied for: strength, integrity, flexibility, slight elasticity, eliminates dusting.

Fig. 1. Air monitoring at the industrial waste storage

3 Results and discussion

In the south-western part (according to the wind rose) of the industrial waste storage, measurements were carried out: at two points more than 1 km apart; to assess emissions directly from the surface of the storage tank. Additional measurements were carried out a few days later at a wind speed of 4 m/s from the south. We also carried out measurements near the industrial waste storage at 4 points, and on the territory of the sanitary protection zone (SPZ) at 8 points. The results are presented in table 1.

Table 1. Measurement results (autumn, 1st year of research)

Observation Point (OP)	**Suspended solids, mg/m^3**	**SO_2, mg/m^3**	**H_2S, mg/m^3**	**PM 2.5, mg/m^3**	**PM 10, mg/m^3**	**Inorganic dust 70-20% SiO_2, mg/m3**	**Weather conditions**
OP1. South, boundary of the waste storage	Less than 0.07	Not detected	0.00051	0.014	Less than 0.010	0.011	t +10^{0}C. East wind, 2 m/s
OP2. West, boundary of the waste storage	0.029 mg/m^3 (weight method)	0.011	Not detected	0.012	0.012	Less than 0.01	t +10^{0}C. East wind, 2 m/s
OP3. North, boundary of the waste storage	Less than 0.07	Not detected	Not detected	0.012	0.011	Less than 0.01	t +11^{0}C. East wind, 1.5 m/s
OP4. East, boundary of the waste storage	Less than 0.07	Not detected	Not detected	0.014	0,012	Less than 0.01	t +11^{0}C. East wind, 1.5 m/s
OP5. The territory of SPZ. East	Less than 0.07	Not detected	Not detected	0.012	Less than 0.01	Less than 0.01	t +12^{0}C. East wind, 1 m/s
OP6. The territory of	Less than 0.07	Not detected	Not detected	0.012	Less than	0.015	t +12^{0}C. East wind 1 m/s

Observation Point (OP)	**Suspended solids, mg/m^3**	**SO_2, mg/m^3**	**H_2S, mg/m^3**	**PM 2.5, mg/m^3**	**PM 10, mg/m^3**	**Inorganic dust 70-20% SiO_2, mg/m3**	**Weather conditions**
SPZ. Southeast					0.01		
OP7. The territory of SPZ. South	Less than 0.07	Not detected	Not detected	0.010	Less than 0.01	Less than 0.01	t +12^{0}C. East wind, 1 m/s
OP8. The territory of SPZ. Southwest	Less than 0.07	0,019	Not detected	0.012	Less than 0.01	Less than 0.01	t +11^{0}C. East wind, 1 m/s
OP9. The territory of SPZ. West	Less than 0.07	Not detected	Not detected	0.012	Less than 0.01	Less than 0.01	t +11^{0}C. East wind, 1 m/s
OP10. The territory of SPZ. Northwest	0.08	Not detected	Not detected	0.010	Less than 0.01	Less than 0.01	t +11^{0}C. East wind, 1 m/s
OP11. The territory of SPZ. North	0.08	Not detected	Not detected	0.011	Less than 0.01	Less than 0.01	t +11^{0}C. East wind, 1 m/s
OP12. The territory of SPZ. Northeast	0.056	Not detected	0.00054	0.01	Less than 0.01	Less than 0.01	t +10^{0}C. East wind, 1 m/s

The elemental composition of dust was also analyzed. Dust samples were studied by the atomic emission method with induction-coupled plasma.

The further research was carried out during the warm period of the year. The air temperature during coating was +35 ^{0}C. The experiment was subjected to 2 reagents. The reagent I is a white anionic liquid. Specific gravity is 1.04 - 1.1 kg/m^3. Reagent freezing point is 0 ^{0}C. The reagent is chemically stable, the reagent solution does not separate. Reagent II is an opaque liquid of anionic polyacrylamide. Specific gravity at a temperature of 25 ^{0}C is 1 - 1.1 kg/m^3. Reagent freezing point is -18^{0}C.

For this purpose, 2 sections of the same size were selected on the waste storage. The area of each was 200 m^2 (10 m by 20 m).

For the accuracy of the experiment, the processing of areas was carried out simultaneously under the same conditions:

- the concentration of solutions was 5%;
- specific reagent consumption – 50 g/m^2;
- the application of the solution was carried out with watering cans (Fig. 2);
- at the time of the experiment, the average market price of reagents was in the same price range.

Fig. 2. Application of reagents at experimental sites

The next day after the application of reagents at experimental sites, primary visual inspections were made for the integrity and hardening of the surface. Monitoring of the researched areas was carried out throughout the warm period of the year [13, 14]. At the same time, special attention was paid to research on the sanitary protection zone. In the spring of next year, studies similar to the previous year were carried out on the drives. Considering that the main factor of air pollution at the facilities is dust, it was decided to increase the frequency of studies, covering the maximum possible range of changes in environmental factors (Table 2).

Table 2. Fragments of measurement results (summer-autumn period, 2nd year of research)

Observation Point (OP)	PM 2.5, mg/m^3	PM 10, mg/m^3	Weather conditions
1st day			
OP 1. Boundary of the SPZ. North	0.007	0.011	t +28^{0}C, North wind, 5 m/s
2nd day			
OP 2. Boundary of the SPZ. Northwest	0.028	0.039	t +21^{0}C, East wind, 10 m/s
3rd day			
OP 15. Boundary of the SPZ. West	0.092	0.181	t +33^{0}C, Northeast wind, 12 m/s
OP 21. Boundary of the waste storage. Leeward, South	0.242	0.457	t +33^{0}C, North wind, 14 m/s
OP 22. Behind the SPZ. Background point	0.098	0.194	t +33^{0}C, North wind,14 m/s
OP 23. Boundary of the waste storage. Southwest	0.247	0.392	t +22^{0}C, North wind,14 m/s
4th day			
OP 18. Boundary of the SPZ. Southwest	0.012	0.024	t +32^{0}C, Northwest wind, gusty,17 m/s
OP 25. Behind the SPZ. Background point. Southwest	0.104	0.204	t +32^{0}C, Northwest wind, 10 m/s
5th day			
OP 26. Point without coverage	0.345	0.424	t +32^{0}C, Northwest wind, gusty, 12 m/s
OP 27. Coverage 1 (reagents 1)	0.192	0.938	t +32^{0}C, Northwest wind, gusty, 9 m/s

Observation Point (OP)	PM 2.5, mg/m^3	PM 10, mg/m^3	Weather conditions
OP 28. Coverage 2 (reagents 2)	0.321	1.33	t +32^{0}C, Northwest wind, gusty,16 m/s
6th day			
TH 19. Boundary of the SPZ. South	0.008	0.011	t +32^{0}C, Northeast wind, gusty, 6 m/s
OP 23. Boundary of the waste storage. Leeward. Southwest	0.075	0.127	t +32^{0}C, Northeast wind, gusty, 6 m/s
OP 24. Boundary of the waste storage. North	0.009	0.021	t +32^{0}C, Northeast wind, gusty, 5 m/s
OP 25. Behind the SPZ (2 km). Background point. Southwest	0.008	0.015	t +32^{0}C, Northeast wind, gusty, 6 m/s
7th day			
OP 20. Boundary of the SPZ. Southeast	0.018	0.028	t +27^{0}C, Northeast wind, 6 m/s
OP 28. Behind the SPZ (2 km). Background point. Southwest	0.008	0.009	t +27^{0}C, Northeast wind, 6 m/s
8th day			
OP 21. Boundary of the SPZ. East	0.036	0.281	t +6^{0}C, North wind, gusty, 6 m/s
OP 27. Boundary of the waste storage. East	0.016	0.019	t +5^{0}C, North wind, gusty, 6 m/s
OP 28. Behind the SPZ (2 km). Background point. Southwest	0.008	0.012	t +5^{0}C, North wind, gusty, 6 m/s

An analysis of air quality measurements showed that no gas emissions from the surface of the waste storage were recorded. The main type of pollution is dust. At the same time, fine dust PM 2.5 and less predominates. And this dust has similar chemical composition with waste. It was also found that the intensity of dusting is directly proportional to the wind speed.

The complexity of the use of coatings lies in compliance with the conditions: the presence of a certain amount of water, weather conditions, the use of specialized equipment (machines for watering with a solution). And also, after coating, it is necessary to rinse the nozzles so that the reagent does not harden in the holes.

Inspection of the experimental areas at the waste storage in the Ulytau region showed that:

- on the area treated with the reagent I, the coating safety was 100%, the coating thickness is the same and approximately is 3–4 mm. The coating is hard, does not bend, breaks into large pieces. The test coating can withstand the weight of a person (90 kg) over the entire area;

- on the area treated with reagent II, the coating safety was 100%, the coating thickness was uniform 2–3 mm. The coating is flexible, plastic, stretchy, withstands the weight of a person (90 kg) in the entire area, bends under the weight of a person, retains strength (does not break).

4 Conclusions

The advantages of using reagents as coatings include:

- long-term preservation of the coating (warm period of the year);
- with a thickness of 2–4 mm, the coating is characterized by such properties as flexibility, elasticity, plasticity;
- coating can withstand weight up to 90 kg;

- simple application technology.

The use of reagents to eliminate dusting of waste accumulators in the warm period of the year until the reclamation is optimal. As a rule, reagents are usually applied to areas where waste is not temporarily stored.

References

1 A.V.Nemirovskiy Razrabotka metoda formirovaniya namyvnogo khvostokhranilishcha, ustoychivogo k vetrovomu potoku Dissertatsiya, Moskva 2016 URL: https://misis.ru/science/dissertations/2016/3280/ (Data obrashcheniya: 15.03.2023)

2 Patent RF № 2151301 Sposob krepleniya napravlennykh vzglyadov. Opubl. 20.06.2000

3 Patent RF № 2683014 Sposob pylepodavleniya na otkrytykh ugol'nykh skladakh. Opubl. 25.03.2019

4 Patent RF № 2683014 Sposob pylepodavleniya na otkrytykh ugol'nykh skladakh. Opubl. 25.03.2019

5 Patent RF № 2029775 Obespylivayushchiy sostav. Opubl. 27.02.1995

6 Patent RF № 2407891 Sposob zakrepleniya pylyashchikh poverkhnostey. Opubl. 27.12.2010

7 Patent RF № 2513786 Sposob zakrepleniya pylyashchikh poverkhnostey. Opubl. 20.02.2014

8 Predpatent RK № 19861 ot 25.05.2008 Sostav dlya zakrepleniya pylyashchikh poverkhnostey khvostokhranilishch i drugikh ob"yektov

9 Predpatent RK № 9457 ot 19.09.2000 Sostav dlya zakrepleniya pylyashchikh poverkhnostey

10 S.D.Mikhaylova, T.N.Il'ina, A.F. Yeliseyev in: Sbornik nauchnykh trudov po materialam simpoziuma «Nedelya gornyaka - 99», 157 (MGGU,Moskva, 1999)

11 A.A. Ismailova Tekhnologiya vyrashchivaniya zelenykh rasteniy s tsel'yu obespylivaniya khvostokhranilishch. Dissertatsionnaya rabota ot 29.06.2020. URL: https://nauka.kz/page.php?page_id=107&lang=1&new&day_from=1&day_to=1&month_from=1&month_to=12&year_to=2020&page=2708 (Data obrashcheniya: 01.03.2023)

12 Ye. A. Tseshkovskaya, A. T. Oralova, E. I. Golubeva, N. K. Tsoy, A. M. Zakharov *NEWS* National Academy of Sciences of the Republic of Kazakhstan SERIES OF GEOLOGY AND TECHNICAL SCIENCES ISSN 2224-5278 **2, 452** (2022), 230-241 https://doi.org/10.32014/2022.2518-170X.172

13 D. Ozhygin, V. Šafář, D. Dorokhov, S. Ozhygina, S. Ozhygin, H.Staňková. IOP Conf. Series: Earth and Environmental Science, **906(1)**, 012062 (2021)

14 S. Ozhigina, D. Mozer, D. Ozhigin, S. Ozhigin, O. Bessimbayeva, E. Khmyrova ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, **3** (2016)