Ecological impact on the environment of industrial mining of bentonite clays

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Abstract. The object of the study is the Kattakurgan deposit of bentonite clays. During the implementation of the project, an environmental analysis of the design solution and the facility itself was carried out in terms of emissions, discharges, waste generation, and the degree of their impact on the environment was assessed. As a result of the environmental analysis, 6 sources of emission of pollutants, 4 unorganized sources of emissions of harmful substances of the area type were identified. The main source of air pollution is the bentonite clay quarry. In terms of ingredients, inorganic dusts account for the bulk of emissions. Analysis of the dispersion fields of pollutant emissions showed that the maximum ground-level concentrations of the considered harmful substances outside the enterprise do not exceed the values established by quotas. The water supply of the enterprise is carried out at the expense of imported water. Wastewater only includes domestic wastewater. An inventory of production and consumption wastes was carried out. It has been established that 5 types of waste are generated in the process of production activities of the deposit. The waste is non-toxic and low-hazard. Calculation of limits for disposal of production waste.

1. Introduction

Along with the intensification of the use of natural resources, the pollution of the environment with industrial waste has rapidly increased. Mass release of harmful substances and compounds into the atmosphere, hydrosphere and soil-vegetation cover, has become dangerous, which can cause irreversible environmental changes.

Therefore, the environmental protection is the most urgent task of global importance. One of the leading areas of environmental protection work is a detailed study of pollution sources and assessment of their impact on the environment.

The purpose of this work is to solve the environmental consequences of the impact on the environment of industrial mining of bentonite clays. In the modern mechanical engineering a significant number of parts are fabricated from lead-tin-base bronzes. They include a series of parts which should possess sufficiently advanced strength characteristics (sealings and piston rings, oil-seal and expander rings). In order to enhance tribotechnical characteristics, lead is introduced into these materials. Lead reduces friction coefficient, enhances tribotechnical characteristics, however, it reduces strength significantly.
2. Calculation methods for determining the emissions (emissions) of pollutants, water consumption and the amount of generated effluents, industrial waste and waste disposal limits

According to the instruction [1], open pits are considered as single sources of emissions uniformly distributed over the area from road transport, overburden planning, excavation, loading and drilling and blasting operations.

The volume of emission of dust of inorganic origin during stripping and leveling works in a quarry by a bulldozer, according to [1], is determined by the formula:

\[ M = q \times t \times \frac{3600}{106}, \quad \text{t/year} \quad (1) \]

where: \( M \) – the total amount of emitted pollutants; \( q \) - specific indicator of dust emission, \( q = 0.044 \) g/sec; \( t \) - bulldozer operation time, hour/year;

When operating an excavator, loading crane or loader, dust is emitted mainly when material is loaded onto dump trucks. Dust emission can be described by the equation:

\[ Q_2 = P_1 \times P_2 \times P_3 \times P_4 \times G \times 106/3600, \quad \text{g/sec} \quad (2) \]

where:
- \( P_1 \) - the fraction of the dust fraction in the rock is determined by washing and sieving the average sample with the release of dust fractions with a size of 0-200 microns;
- \( P_2 \) - the proportion of flying dust passing into the aerosol with a particle size of 0-50 microns, in relation to the total dust in the material (it is assumed that all the flying dust passes into the aerosol).
- \( P_3 \) value is refined by sampling dusty air at the boundaries of a dusty object at a wind speed of 2 m/s blowing in the direction of the sampling point;
- \( P_4 \) - coefficient taking into account the wind speed in the area of operation of an excavator, loading crane or loader;
- \( G \) - amount of loaded rock, t/h. \( G = 17400 \times 1.8 = 31320 : 1016 = 30,827 \) t/h.

The movement of vehicles in the quarry causes the release of dust and gases from internal combustion engines; dust is emitted as a result of the interaction of wheels with the roadbed and blowing off from the surface of the material loaded into the car body.

The total amount of dust emitted by vehicles can be characterized by the following equation:

\[ q = C_1 \times C_2 \times C_3 \times N \times a_1 \times q_1 / 3600 + C_4 \times C_5 \times C_6 \times F_0 \times n \times q_2, \quad \text{g/sec} \quad (3) \]

where:
- \( C_1 \) - coefficient taking into account the average carrying capacity of a vehicle unit [1];
- \( C_2 \) - coefficient taking into account the average speed of movement of transport in the quarry [1];
- \( C_3 \) - coefficient taking into account the condition of roads [1];
- \( C_4 \) - coefficient that takes into account the surface profile of the material on the platform and is defined as the ratio \( F_{\text{act}} / F_0 \)
where: \( F_{\text{act}} \) - actual material surface on the platform; \( F_0 \) - average platform area. The \( C_4 \) value ranges from 1.3 to 1.6 depending on the size of the material and the degree of filling the platform;
- \( C_5 \) - coefficient that takes into account the blowing speed of the material, which is defined as the geometric sum of the wind speed and the reverse sector of the average vehicle speed [1];
- \( C_6 \) - coefficient that takes into account the moisture content of the surface layer of the material, equal to \( C_6 = K_5 \) (equation 1.36) [1];
- \( N \) – the number of walkers (there and back) of all vehicles per hour;
- \( a_1 \) - average length of one pass within the quarry, km.
- \( C_1 = C_2 = C_3 = 1 \), taken equal to 1450
- \( q_1 \) - dust emission per unit of the actual surface of the material on the platform, g/m² * s;
- \( n \) is the number of cars working in the quarry.

The amount of hydrocarbons emitted into the atmosphere per year from one tank or a group of tanks is determined by summing up the losses of oil products, calculated based on the “Norms of natural loss of oil and oil products when receiving, supplying and storing in tanks” [1].

\[ P = (n_1 + n_2) \times 2 \times Q \times 10^{-3}, \quad \text{t} \quad (4) \]

where, \( n_1 \) - is rate of natural loss of petroleum products when receiving, dispensing and storage in the autumn-winter period;
- rate of natural loss of petroleum products when receiving, dispensing and storage in the spring and summer; Q – the amount of oil products entering the tanks in throughout the year, t.

During the operation of quarry machines and technological equipment, fuel combustion products are emitted (carbon monoxide, hydrocarbons, nitrogen dioxide, sulfur dioxide, soot, benz (a) pyrene). The quantitative characteristics of pollutant emissions from each source were calculated according to the approved methods [4, 5, 10], and also the passport data of the technological equipment were used. The concentration of pollutants in the atmospheric air during the operation of the projected enterprise was calculated using the VARSA-RADUGA program on an area of 1.5 x 1.5 km with a step of 300 m. Estimated water flow rates and the amount of generated effluents were calculated according to the current regulatory documents [8-9].

To determine the specific indicators and norms of waste generation, methods and guidelines are used [10-11], given in the list of references and approved by both higher-level organizations and the bodies of the State Committee for Ecology of the Republic of Uzbekistan. Waste hazard class is determined according to the classification catalog of waste [1, 9, 12].

The calculation of waste disposal limits is carried out in accordance with the guidelines [1, 9, 13, 14]. The size of the placement limit for each type of waste (L) is calculated by the formula:

\[ L = \frac{P_p \cdot n_f \cdot t_1}{t + K_1 \cdot q_y} \]  

(5)

where: \( P_p \) – planned production output, t/year; \( n_f \) – specific amount of waste formation, t/t, kg/t, etc.; \( t_1 \) – the time for which the limit is set (usually 3-365 days are taken); \( t \) – the period of placement of waste, considered temporary - 365 days; \( K_1 \) – the coefficient of increasing the maximum amount of waste disposal in the event of their disposal taken equal to 0.25; \( q_y \) – amount of disposed waste, t/year.

The total maximum area of temporary waste disposal at the enterprise (S1) is calculated by the formula:

\[ S_1 = K_s \cdot S_2 \cdot (1 + 0.5 \cdot \frac{q_y}{P_p \cdot n_f}) \]  

(6)

where: \( K_s \) – the ratio of the total area of temporary waste disposal on the territory of the enterprise to its total area; \( S_2 \) – total area of the enterprise territory, ha, m²; 0.5 – coefficient of increasing the maximum area of temporary waste disposal during their disposal.

The maximum areas for the disposal of waste of different classes of toxicity are assigned based on the condition of equality of the potential hazard of the placed masses of waste of individual groups that differ in toxicity:

\[ \frac{w_1}{d_1} = \frac{w_2}{d_2} = \frac{w_3}{d_3} = \frac{w_4}{d_4} \]  

(7)

and are determined by the formulas:

\[ w_1 = S_1 \cdot d_1 \]
\[ w_2 = S_1 \cdot d_2 \]
\[ w_3 = S_1 \cdot d_3 \]
\[ w_4 = S_1 \cdot d_4 \]  

(8)

where, \( w_1 - w_4 \) - limiting areas of placed masses of waste 1, 2, 3 and 4 classes of toxicity / hazard, m²; \( d_1 - d_4 \) - average values of relative indicators of toxicity (MPC, concentrations of water extracts), determining the separation of waste into 1, 2, 3 and 4 classes of toxicity / hazard.

When introducing a small amount of the aluminum oxide powder, the distance between the axes of the second-order dendrites and the average grain size reduces. This implies that a considerable part of the powder particles is effective crystallization centers. When increasing the nanopowder content, the structure starts coarsening relatively that, which was obtained using low powder concentrations. Introduction of the large quantity of the modifier leads to its coagulation and reduction of its influence on the structure.

3. Research results

The source of emissions of pollutants into the atmospheric air at the enterprise is a quarry for the extraction of bentonite clays (a source of emissions of the areal type), as well as sources of emissions evenly distributed over the area from road transport, overburden planning and excavation and loading
operations. The quantitative characteristics of pollutant emissions from each source were calculated according to the above methodology, and also the passport data of the technological equipment provided by the customer were used.

During the operation of the enterprise, 2 types of pollutants enter the atmospheric air from stationary emission sources. The main production emissions contain mainly inorganic dust - 0.5688 t/year. Hydrocarbons are released into the atmosphere from the sources of emissions of auxiliary production - 0.0012 t/year.

To determine the impact of emissions from the Kattakurgan deposit of bentonite clays on the atmospheric air, the concentration of pollutants was calculated using the VARSA - RADUGA program. Based on the calculated data, the following level of atmospheric air pollution was determined:

Inorganic dust. The maximum concentration of inorganic dust in the atmospheric air at the border of the enterprise was 0.09 MPC with a set quota of 0.33 MPC (Figure 1).

Figure 1. Schematic map of the fields of dispersion of inorganic dust in the surface layer of the atmosphere of the Kattakurgan bentonite clay deposit
Hydrocarbons. The maximum concentration of hydrocarbons in the atmospheric air at the border of the enterprise was less than 0.01 MPC with a set quota of 0.50 MPC (Figure 2).

**Figure 2.** Schematic map of hydrocarbon dispersion fields in the surface layer the atmosphere of the Kattakurgan bentonite clay deposit

Thus, the analysis of the dispersion fields of pollutant emissions from the Kattakurgan deposit of bentonite clays showed that the maximum surface concentration of the considered substances at the enterprise border does not exceed the established quotas.

Water supply of the open pit of the Kattakurgan bentonite clay deposit is carried out at the expense of imported water. Water is used for household, drinking and production needs of the quarry. Water consumption for household and drinking needs of workers and employees is 0.373 m$^3$/day or 94,742 m$^3$/year.
Water consumption for production needs includes water consumption for moistening the mined rock mass and dust suppression inside the quarry roads and at the loading site. The water consumption for the production needs of the field will be 4.11 m$^3$/day or 1044 m$^3$/year. The standard water consumption of the enterprise will be 4.483 m$^3$/day or 1138.742 m$^3$/year.

At the open pit of the Kattakurgan deposit of bentonite clays, only domestic wastewater is formed in the amount of 0.373 m$^3$/day or 94.742 m$^3$/year. Domestic wastewater is collected in a cesspool.

During the production activities of the Kattakurgan deposit of bentonite clays, 5 types of waste are generated in the amount of 12343.188 t/year. Wastes belong to hazard classes 2, 4 and 5 and are non-toxic and low-hazard. The 2nd class includes 1 type of waste in the amount of 1.4 tons (0.01%). The 4th class includes 2 types of waste in the amount of 12249.635 tons (99.24%). The 5th class includes 2 types of waste in the amount of 92.153 tons (0.75%). Table below shows an inventory of production and consumption waste generated at the Kattakurgan deposit of bentonite clays.

According to calculations, the limit for the disposal of 2 wastes of the 4th hazard class is 9103.312 tons on an area of 1897.2 m$^2$; 2 waste of hazard class 5 - 15.147 tons on an area of 9.22 m$^2$ and one waste of hazard class 2 - 0.464 tons on an area of 1.0 m$^2$. The total amount of waste disposed will be 9118.923 tons and they will occupy an area of 1907.42 m$^2$.

**Table.** Inventory list of production and consumption waste at the Kattakurgan deposit of bentonite clays

| №   | Name                     | Specific indicator | Code   | № passport retreat |
|-----|--------------------------|--------------------|--------|-------------------|
|     |                          | The quantity       |        |                   |
| 1   | Overburden waste         | 0,704 t / m$^3$ of rock | 1      |                   |
| 2   | Cleaning rags            | 0,002 kg / m$^3$ of rock | 2      |                   |
| 3   | MSW                      | 0,083 t / person per year | 1.48.00 | 3                 |
| 4   | Waste oils               | 0,08 kg / m$^3$ of rock | 1.12.00 | 4                 |
| 5   | Waste from cesspools     | 5,338 m$^3$ / person per year | 1      | 5                 |

Overburden waste is temporarily stored in external dumps with an area of 1897 m$^2$ located outside the production areas. Waste overburden is removed by a bulldozer and reused in full for reclamation of the worked-out areas.

The cleaning rags will be stored in a special container and, as they accumulate, will be taken to a special facility for disposal.

Municipal solid waste. At the production site, temporary storage points will be installed – containers and as they are filled, they will be transported to an auxiliary site with subsequent disposal.

Waste fuels and lubricants (waste passport No. 4) are collected in a special metal barrel and, as they are filled, are sent for processing, to the tank farm.

Waste from cesspools (waste passport No. 5) will be stored at the places of their formation, i.e. in cesspools of sewage. As the accumulation proceeds, the pits will be cleaned and the waste will be taken to the district landfill for the storage of low-toxic waste.

Production wastes are either delivered for disposal to other enterprises, or used and disposed of at the mine itself. For temporary storage of waste on the production site, special places are provided. Production wastes are classified as hazard classes 2, 4 and 5. Their storage conditions are such that the waste will not have a negative impact on the environment and working personnel.

Consequently, from the above, we can conclude that the organization of industrial development of the Kattakurgan deposit of bentonite clays in compliance with the production technology and labour safety rules will not lead to irreversible environmental consequences.
The danger of negative impact on the natural environment and working personnel may arise in case of emergency. Accidental processes during the operation of a quarry are associated with various deformations of the sides and slopes of the quarries themselves, causing slipping or shedding of the soil.

Landslides are considered the most dangerous type of disturbance in quarries. They are formed in the slopes of weak rocks with a long standing and are confined to the upper horizons of the quarry, along which the cargo transportation is carried out. Due to the high hardness and density of rocks, landslides on the sides are excluded. Erosion is also impossible in conditions of little precipitation. The negative consequences of possible accidents will be localized within the territory of the quarry and will not have a negative impact on the natural environment.

A quarry for the extraction of bentonite clays, an industrial site of a quarry with mining and mining equipment is not a fire hazardous enterprise.

Thus, the organization of industrial production of bentonite clays at the Kattakurgan deposit with strict adherence to technological regimes and the implementation of environmental protection measures will not lead to irreversible environmental consequences.

4. Conclusion

The environmental assessment of the environmental impact of emissions, discharges and wastes from the industrial development of the Kattakurgan bentonite clay deposit showed that the organization of production in a normal technological mode will not lead to irreversible environmental consequences.

The working project for the organization of production implemented technological solutions aimed at reducing emissions of harmful substances into the atmosphere. Emissions of pollutants at the border of the enterprise do not exceed the established quotas.

Wastewater from production facilities is not discharged into surface watercourses and onto the terrain, therefore it will not have a negative impact on the environment.

References

[1] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 14 dated January 21, 2014 "Regulations on the procedure for the development and approval of draft environmental standards." Application.

[2] «Instructions on the inventory of pollution sources and the regulation of emissions of pollutants into the atmosphere for enterprises of the Republic of Uzbekistan », approved by order No. 105 of December 15, 2005.

[3] Calendar plan for the development of mining operations at the Kattakurgan deposit of bentonite clays of Samarkandmarmar OJSC in the Samarkand region. Samarkand - 2012.

[4] Handbook of an expert ecologist. - State Committee for Nature Protection of the Republic of Uzbekistan. - Tashkent - 2009.

[5] Collection of methods for calculating air emissions of pollutants by various industries / Ed. L.I. Veres, Leningrad, Gidrometeoizdat, 1986.

[6] The draft EIS "Industrial development of a part of the approved reserves of the Kattakurgan deposit of bentonite clays of Samarkandmarmar OJSC" in the Samarkand region. Tashkent-2012.

[7] Methodology for calculating the concentration of harmful substances in the atmospheric air contained in the emissions of enterprises. OND-86. Goskomgidromet. - Leningrad. - Gidrometeoizdat. - 1987.

[8] KMK 2.04.01-98 Internal water supply and sewerage of buildings. State Committee of the Republic of Uzbekistan for Architecture and Construction. Tashkent, 1998.

[9] KMK 2.04.03-97 Construction norms and rules. Sewerage. External networks and facilities. State Committee of the Republic of Uzbekistan for Architecture and Construction. Tashkent, 1997.

[10] O'z RH 84.3.15: 2005. Guiding document of the Republic of Uzbekistan. Production and consumption waste management. The procedure for organizing and conducting an inventory of waste.
[11] O'z RH 84.3.21: 2005. Guiding document of the Republic of Uzbekistan. Production and consumption waste management. Methodical recommendations for the determination of waste generation standards. - State Committee for Nature Protection of the Republic of Uzbekistan. - Tashkent - 2005.

[12] O'z RH 84.3.8: 2004. Guiding document of the Republic of Uzbekistan. Production and consumption waste management. Methods for a comprehensive assessment of waste hazard. - State Committee for Nature Protection of the Republic of Uzbekistan. - Tashkent - 2004.

[13] O'z RH 84.3.16: 2005. Guiding document of the Republic of Uzbekistan. Production and consumption waste management. Guidelines for determining the limit for the disposal of production waste. - State Committee for Nature Protection of the Republic of Uzbekistan. - Tashkent - 2005.

[14] O'z RH 84.3.17: 2005. Guiding document of the Republic of Uzbekistan. Production and consumption waste management. Organization and procedure for developing a draft limit for the disposal of production and consumption waste. - State Committee for Nature Protection of the Republic of Uzbekistan. - Tashkent - 2005.

[15] Alladustov U B 2019 Development of draft environmental standards for enterprises for the extraction and processing of nonmetallic rocks Monograph, Samarkand

[16] Alladustov U B, Immonazarov Sh N, Usanova S 2020 Environmental standards for emissions and discharges of pollutants into the environment / Materials of the international scientific-practical conference on the topic "Problems and solutions of innovative technologies in the field of engineering communications" (2020 May 21) Samarkand, SamGASI, part 2 pp 155-159 pages.

[17] Kofi Asante-Kyei, Alexander Addae 2016 The Economic and Environmental Impacts on Clay Harvesting at Abonko in the Mfantsiman West District of Central Region, Ghana American Scientific Research Journal for Engineering, Technology, and Sciences 18 (1) pp 120-132

[18] Okafor F C 2006 Rural Development and the Environmental Degradation verse Protection Environmental Issues and Management in Nigerian Development pp 150-163.

[19] Fedra K, Winkelbauer L and Pantulu V R 2005 Systems for Environmental Screening An Application in the Lower Mekong Basin International Institute for Applied Systems Analysis. A-2361 Laxenburg, Austria p 169

[20] Mukherjee S 2013 Environmental Impacts of Clay-related Industries Applications in Industry, Engineering and Environment 19 280-295

[21] Bellard C, Bertelsmeier C, Leadley P, Thuiller W and Courchamp F 2012 Impacts of climate change on the future of biodiversity Ecol. Lett. 15 365–377

[22] Bissett A, Brown M V, Siciliano S and Thrall P H 2013 Microbial community responses to anthropogenically induced environmental change: towards a systems approach Ecol. Lett. 16 128–139

[23] Simberloff D, Martin J L, Genovesi, P, Maris V, Wardle D A, Aronson J 2012 Impacts of biological invasions – what’s what and the way forward Trends Ecol. Evol. 28 58–66

[24] Turnbull L A, Levine J M, Loreau M and Hector M 2013 Coexistence, niches and biodiversity effects on ecosystem functioning Ecol. Lett. 16 116–127