Impact of mining of common minerals on the environment and public health

A Yu Aleksandrova and S S Timofeeva
Irkutsk National Research Technical University, Irkutsk, Russia

E-mail: aleksandrova.angelina1993@yandex.ru, sttimofeeva@mail.ru

Abstract. The impact of the extraction of common minerals on the environment and public health is an important factor in assessing the development of a region, not only in terms of economic efficiency, but also in terms of the well-being of the environment and the well-being of the population. All types of impact are important components of the final assessment and show how critical they are in the development of negative phenomena in relation to the environment and human health. This paper presents data on the impact on the atmospheric air, subsoil, relief, soil, groundwater and surface water, on the quality of life of the population. Based on literature data and our own observations, the main types of impact on the environment and humans were identified, the main list of pollutants at the facilities for the extraction and processing of common minerals were identified, the contribution of noise and vibration was assessed, accumulation of dumps in open pits has been determined, the quality of life of the population who have direct contact with this type of careers has been assessed, the professional impact on the person was determined. The assessment of the sustainability of the natural environment to mining impact has been determined.

1. Introduction
Enterprises for the extraction of common minerals are sources of negative impact on the environment and are characterized by a high level of environmental risks. Extraction of common minerals is carried out in an open way and is accompanied by a significant transformation of the stable part of the geosystem - the lithogenic base. As a result of the development of quarries, the soil cover and natural vegetation are destroyed, the hydrogeological conditions of the territory change, the atmospheric air is polluted. An environmental risk arises, characterized by the likelihood of presence of negative changes in the environment caused by anthropogenic or other impact. Environmental risk is also understood as a probability measure of the danger of causing harm to the natural environment in the form of possible losses for a certain time [1]. In turn, the assessment of environmental risks is the identification and assessment of the probability of occurrence of events that have adverse consequences for the environment, public health, enterprise activities and caused by environmental pollution, violation of environmental requirements, natural and man-made emergencies [2]. At the same time, the activities of enterprises for the extraction of common minerals should be aimed at ensuring environmental safety, and not only at obtaining economic efficiency. Understanding the specific impact of mining common minerals on the environment and public health can determine the main directions for improving conditions for the development of quarries, working conditions of the population and reducing the negative impact on the environment.

With regard to enterprises for the extraction of widespread minerals, which are the most important component of the resource potential of any region. This is the basis for road construction, for the
construction and development of fields in the gas and oil cluster, this is the prospect for the development of the production of building materials and stone-cutting jewelry production. Currently, the development process and prospects for the use of common minerals are characterized by the lack of modern predictive and prospecting studies, including geological and economic assessments of the identified objects of common minerals, as well as socially and economically justified programs for the development and use of common mineral deposits [3-4]. The impact of mining of common minerals on the environment and public health is currently being discussed in narrow professional circles, is a common phenomenon, since deposits of this type are ubiquitous. They require more careful attention in terms of assessing the risk of their impact on the environment. In this work, we will discuss the main types of such impact.

2. Types of impact of mining of common minerals on the environment and public health

The disadvantage of the development of deposits of common minerals is the negative impact on the environment, which manifests itself in the form of an impact on land resources, bowels and soils, on the atmospheric air, groundwater and surface waters.

The main types of the impact:

- air pollution by emissions of gaseous and suspended solids;
- violation of the integrity of subsoil plots, withdrawal of land and water resources, extensive use of bowels;
- changes in the relief of the Earth's surface, leading to a change in the geological structure of the earth's crust and vertical deformation of the soil-fertile layer;
- effect of noise and vibration;
- accumulation of large-scale waste, the volume of which at the stage of field development are 4-5 times higher than the extraction volume;
- pollution of surface and ground waters due to the violation of the integrity of the bowels and emissions into the atmosphere;
- deterioration in the quality of life of the population, manifested in the form of an increase in the number of morbidities, mortality, outflow of the population to the most favorable territories, etc.

Thus, according to Russia Rosstat data, mining accounts for over 40% of all disturbed lands, over 30% of harmful emissions into the atmosphere, and 10% of the volume of wastewater [5].

According to Allison AC, in general, the consequences of open pit mining, which is characterized by a large destructive effect on rocks and minerals and their movement in large volumes from the place of production to places of consumption and storage, in practice lead to total destruction of the geological and natural environment and the growth of environmental tension in areas of mass mining operations [6].

The basic principles underlying the negative impact on the geoenvironmental state of the environmental system are the maximum load of the technological process on each of the environmental components, taking into account the consumption of energy resources under normal and unfavorable weather conditions, compared with the established standards of maximum permissible concentrations of impact on human health, objects of fauna and vegetation, as well as recreational areas. When analyzing these impacts, optimal schemes, models and methods are developed to reduce the negative anthropogenic impact on ecosystems [6].

So, according to the draft standards for maximum permissible emissions, developed at enterprises for the extraction of common minerals, the main components that have a negative impact on the natural environment are the substances presented in Table 1.
Table 1. List of pollutants at common minerals extraction and processing facilities.

| Substance                          | Hazard class |
|------------------------------------|--------------|
| Metal dust                         | 3            |
| Sulphuric acid                     | 3            |
| Coke residues                      | 3            |
| Coal ash                           | 3            |
| Iron oxide                         | 3            |
| Manganese and its compounds        | 2            |
| Nitrogen dioxide (Nitrogen (IV) oxide) | 3         |
| Nitrogen (II) oxide (Nitrogen oxide) | 3          |
| Carbon black (Soot)                | 3            |
| Anhydrous sulfur                   | 3            |
| Dihydrosulfide (Hydrogen sulfide)  | 2            |
| Carbon oxide                       | 4            |
| Gaseous fluorides                  | 2            |
| Poorly soluble fluorides           | 2            |
| Benz / a / pyrene (3,4-benzpyrene) | 1            |
| U / v for kerosene                 |              |
| Saturated hydrocarbons C12-C19, including aromatic | 4 |
| Inorganic dust 20-70% SiO₂ (welding) | 3        |
| Inorganic dust <20% SiO₂           | 3            |
| Coal dust                          | 3            |
| Ash and slag waste dust            | 3            |

Quarrying of common minerals is carried out, in most cases, by an open-cut method and, therefore, has a negative impact on the atmospheric air as a result of dust formation and gas formation. Dust formation and gas formation are formed due to excavation and loading and overburden works, dumping works, due to the movement and excavation of raw materials, rock heaps, transportation along an open-pit truck web, crushing and transferring raw materials. The concentration of dust during the development of a deposit depends on the strength and natural moisture content of the rock, the volume of simultaneously unloaded rock, the height of unloading, and the angle of rotation of the excavator. When transporting raw materials along intra-quarry roads, dust is released from the surface of the material loaded into the body of a dump truck and the interaction of automobile wheels with the road surface. The intensity and volume of dust formation depend on the speed of movement, the carrying capacity of vehicles, as well as on the type of road surface. Common to all dumping methods is the formation of large loose surfaces (planar sources), which, under unfavorable conditions, lead to intense dust formation, depending on the type of material, particle size distribution, meteorological conditions [7]. Analysis of the data shows that at all open pits, the main sources of pollution are emissions from vehicles and dust from enclosing rocks.

3. Impact on the bowels of the Earth

Another significant source of negative impact on the environment during the development of deposits of common minerals is the impact on the bowels: violation of the integrity of bowels plots, withdrawal of land and water resources, extensive use of bowels, changes in the Earth's surface relief, leading to a change in the geological structure of the earth's crust and vertical deformation of the soil - the fertile layer. These impacts depend on the depth of development, possible complications in the form of groundwater flooding and the development of exogenous processes. According to Jerry K et al., the mechanism of the negative impact of small open pits on the environment is similar to the impact of overburden operations at mining enterprises, differing only in scale. The area occupied by each quarry and dump does not exceed 5-15 hectares and, depending on the location, sometimes has a specific impact on the environment. Mining operations lead to the activation of some relief-forming processes [8-9].
According to the maps of disturbed lands and their reclamation, morphological analysis of the relief shows that the massive development of small, medium and large quarries of common minerals leads to the emergence of a technogenic relief of a large areal distribution. During long-term exploitation of such quarries and poor-quality work on their recultivation, in the development of quarries by the spontaneous method, such negative processes as weathering, slide, landslides, subsidence phenomena, erosion, deflation, accumulation of the technogenic layer of rocks, and flooding are provoked. Besides, in a number of cases, during mining operations, the surface of gentle slopes is disturbed by the plows of bulldozers along and across the slopes with the formation of long furrows, narrow trenches or randomly filled ditches, ruts and quarries. Subsequently, they become sources of increased occurrence of gullying processes, which can stretch for several kilometers [10-11].

A significant contribution to the increase in land disturbance and the lack of reclamation of quarries is made by unauthorized quarries for the extraction of common minerals. According to the inventory of the Ministries of Natural Resources and Environment, there are about several thousand such development in the regions. Despite the adoption of active preventive and prohibitive measures of influence on administrative penalties for unauthorized development, the number of them is growing. Often, the difficulties of excluding unauthorized quarries are associated with the imperfection of the legislative system and the impossibility of identifying the persons conducting the development and, as a consequence, the impossibility of bringing to administrative responsibility for each stage of geological exploration and development of common mineral deposits [12-13].

In addition to unauthorized quarries, there are quarries, which store huge quantities of quarry dump complexes of the spent part of quarries for the extraction of common minerals. The owners of such quarries have licenses for development, but they do not complete the reclamation process in full, thereby violating the terms of the agreement on the use of the bowels plot. This entails a technogenic negative load on the soils and relief of the territories adjacent to the quarry. The production of work in the quarry should be preceded by the removal of a potentially fertile layer with a thickness of 25 cm with an appropriate humus content and soil salinity. Due to the existence of unauthorized developments for the extraction of common minerals, this requirement goes against the abovementioned standard and makes a negative contribution to the state of undisturbed lands [14].

4. Effect of noise and vibration

Noise and vibration in quarries for the extraction of widespread minerals are generated during drilling and blasting operations, excavation, loading and unloading of rocks, the movement of vehicles, the operation of screens and other technological equipment at concentrating plants. In addition to the listed noise sources, the permissible noise level will depend on the proximity to roads, railways and residential buildings. The characteristic of the noise level penetrating from the production area into the residential area consists in comparing the calculated noise level at the design point (the nearest residential area) for simultaneously operating equipment with the permissible noise level for objects located on this territory (residential buildings). Noise regulation is carried out for day and night time.

Noise characteristics are taken according to the passport data of the special equipment and vehicles used in the quarry. The permissible sound levels for residential areas are 40 dBA in the daytime and 30 dBA at night [15]. In open pits for the extraction of widespread minerals during the development of deposits without drilling and blasting operations, the noise level does not exceed the established standard for adjacent residential areas, but exceeds the permissible level for employees of the enterprise and is a significant condition for classifying working conditions at such a workplace as a hazardous class of working conditions. In open pits for the extraction of widespread minerals, where drilling and blasting is used, the sound pressure level is in the range from 70 to 92 dBA. And despite the short-term impact of such a noise level (drilling and blasting operations are carried out at intervals of 1 to 4 times a month), this is a significant negative factor in the impact on the environment and humans. The main part of the energy generated in an industrial explosion is spent on soil destruction and thermal radiation and, due to this, propagates into the air as a shock wave. Explosions in quarries for the extraction of widespread
minerals are intense noise pollution that spreads over large areas, which lead to irreversible consequences [16].

5. Accumulation of dumps in quarries
The next type of environmental impact is the accumulation of large-scale waste, the volume of which at the stage of field development are 4-5 times higher than the production volume. As a result of mining activities, a huge amount of various waste is stored in dumps. Over the past 50 years, there has been an increase in anthropogenic impact on landscapes created for millennia, associated with the extraction of mineral raw materials from the depths of the lithosphere. Over the years of existence of dozens of enterprises, over 1 billion cubic meters of rocks and more than 300 million cubic meters of waste have been brought to the surface during their enrichment. Due to the difference in the depth of quarrying, rocks of various geological ages and chemical composition from neutral to strongly acidic and alkaline are removed to the day surface.

Such rocks, as a rule, are represented by carbonate loams, sands of different ages, siltstones, Callovian and Devonian clays, chalk. Man-made modified lands are stored on territories with a total area of over forty million hectares around the world. In the context of the development of deposits for the extraction of common minerals, the dumping of rocks is carried out by mixing. Thus, some of them turn out to be higher than the fertile layer, get to the top of dumps, and remain naked for decades. In such conditions, no plant seeds, microorganism spores and planted plants survive and die after possible germination. The selective method of storing rocks is expensive due to the need to store overburden rocks in accordance with their location in the stratigraphic columns of quarries, and no company uses this method.

So, according to [17-19], when the natural landscape is disturbed, not only fertile soils, agricultural lands, forests are lost, but also a new technogenic landscape is formed with all its negative properties: desolation, sterility, great dissection, erosion. Man made lands can be attributed to one of the types of marginal ecosystems characterized by great instability, their relief, vegetation cover, water regime, forming soils, do not undergo large changes and often degrade under the influence of water and wind erosion, slides, landslides, soil shrinkage, toxic rocks poured onto the day surface of the microclimate and other factors. Technogenic lands, in contrast to undisturbed landscapes, lack groundwater, have a significant area of surface evaporation, steep slopes, high contrast in hygroscopic conditions and illumination according to slopes exposures [20].

6. Impact on surface and groundwater
In a number of cases, during the development and extraction of common minerals, surface and ground waters are polluted due to the violation of the integrity of the bowels and emissions into the atmosphere. Thus, in most regions, there is a problem of protection and rational use of water resources, where the main sources of groundwater pollution are storage facilities for common minerals processing. The hydrogeological conditions of the deposits play a significant role in determining the depth of development of a quarry, as well as in choosing the subsequent direction of reclamation of disturbed lands. In most cases, the extraction of common minerals is carried out in open quarries without additional drainage and water disposal measures. Quarries in the process of development pollute nearby water bodies with turbid waters, oils, and waste generated as a result of their work. So, the construction and operation of mining enterprises lead to the violation of the hydrodynamic regime of groundwater in connection with the formation of extensive depression funnels around the quarries and domes of spreading man-made waters under the tailing dumps. Under these conditions, there is a gradual replacement of natural groundwater by technogenic wastewaters and deterioration of their quality [21-22].

The consequences of technogenic impacts during the development of quarries for the extraction of common minerals on groundwater do not appear immediately and are practically irreversible. The detection of groundwater pollution is determined in most cases at the later stages of the process, when it becomes impossible to prevent the consequences of this pollution. The main ecostressors for
groundwater in quarries for the extraction of common minerals are: waste storage, tailing dumps, since they have a significant impact on the chemical and qualitative composition of groundwater; the use of groundwater for public water supply; the use of groundwater as a product of the technological process; violation of the hydrodynamic regime of groundwater due to the formation of extensive depression funnels around the quarries and domes of the spreading of technogenic waters under the tailing dumps.

Under these conditions, there is a gradual replacement of natural groundwater by technogenic effluents and deterioration of their quality [23].

7. Impact on human health
Recently, as criteria for assessing the living conditions of the population, the integral indicator "life quality", which characterizes the living conditions of society, has begun to be widely used. Today, the problem of the life quality of people is one of the most discussed both in scientific circles and in the socio-political media. Currently, a number of methods for assessing the quality of life have been proposed, with each researcher considering his own aspects, since the concept of life quality is used by economists, sociologists, physicians, security specialists, and above all by the technosphere. With regard to the life quality of workers of enterprises for the extraction of common minerals and the population living in the area of operation of such enterprises, it is necessary to rely on the impacts on the natural environment described above, which in one way or another affect humans. The level of development of social infrastructure, health status, natural and climatic conditions, the level of morbidity and mortality are used as indicators for assessing the life quality. So, according to research [24], in the area of action of quarries for the extraction of such common minerals as granite and marble, primary morbidity (Table 2-3), occupational morbidity is widespread and is at a high level.

| Nosological classes                        | Granite quarry (n=1027) abs.% | Granite quarry (n=1027) per 100 employees | Marble quarry (n=1214) abs.% | Marble quarry (n=1214) per 100 employees |
|-------------------------------------------|-------------------------------|-------------------------------------------|-------------------------------|------------------------------------------|
| Respiratory diseases                      | 189 (18.4)                   | 55.2                                      | 194 (15.9)                   | 47.7                                     |
| Diseases of the musculoskeletal system and connective tissue | 157 (15.2)                   | 45.6                                      | 163 (13.4)                   | 40.2                                     |
| Diseases of the eye and its adnexa        | 149 (14.5)                   | 43.5                                      | 138 (11.3)                   | 33.9                                     |
| Diseases of the skin and subcutaneous tissue | 138 (13.4)                   | 40.2                                      | 141 (11.6)                   | 34.8                                     |
| Diseases of the circulatory system        | 124 (12.0)                   | 36.0                                      | 133 (10.9)                   | 34.8                                     |
| Endocrine, nutritional and metabolic diseases | 91 (8.8)                     | 26.4                                      | 89 (7.3)                     | 21.9                                     |
| Diseases of the ear and mastoid           | 64 (6.2)                     | 18.6                                      | 71 (5.8)                     | 17.4                                     |
| Diseases of the nervous system            | 51 (4.9)                     | 14.7                                      | 49 (4.0)                     | 12.0                                     |
| Diseases of the digestive system          | 44 (4.2)                     | 12.6                                      | 38 (3.1)                     | 9.3                                      |
| Diseases of the genitourinary system      | 12 (1.1)                     | 3.3                                       | 14 (1.1)                     | 3.3                                      |
| Diseases of other organs and systems      | 8 (0.7)                      | 2.1                                       | 6 (0.4)                      | 1.2                                      |

Lack of knowledge of the exact content of materials and inappropriate handling of toxic chemicals lead to occupational diseases, and the incidence of occupational diseases is usually underestimated. The main documented occupational diseases were pneumoconiosis (silicosis, chronic dust bronchitis). The second most common occupational disease was carbon monoxide toxicity followed by lead poisoning and noise-induced hearing loss. Less than five percent of occupational illnesses were due to other causes,
including decompression syndrome, heatstroke, toxic hepatitis, neurological disorders, and hematological disorders.

Table 3. Common (to a greater extent) occupational diseases of workers in marble and granite quarries.

| Diseases                               | Granite quarry (n=1027) | Marble quarry (n=1214) |
|----------------------------------------|-------------------------|------------------------|
|                                        | abs.% per 100 employees | abs.% per 100 employees |
| Chronic bronchitis                      | 54 (5.2)                | 61 (5.0)               |
| Silicosis                               | 42 (4.0)                | 39 (3.2)               |
| Vibration disease                       | 31 (3.0)                | 44 (3.6)               |
| Deforming osteoarthritis               | 19 (1.8)                | 28 (2.3)               |
| Curvature of the nasal septum with impaired respiratory function | 29 (2.8)                | 19 (1.5)               |
| Cataract                                | 23 (2.2)                | 34 (2.8)               |
| Chronic radiculopathy                  | 28 (2.7)                | 24 (1.9)               |
| Sensorineural hearing loss              | 38 (3.7)                | 23 (1.8)               |

The number of occupational diseases and the impact of dust emissions in quarries is considered to be seriously underestimated. Industrial hygienists and doctors training to recognize health hazards in the workplace and diagnose occupational diseases, and raising awareness of mining personnel about the negative effects of stone dust, should be priorities for improvement. Recognition of occupational diseases as one of the important components of negative impact on human life can subsequently highlight the health risks in the workplace and prevent their occurrence.

8. Conclusion

As a result of the analysis of the impact of mining of common minerals on the environment and public health, it was revealed that the main types of impact are air pollution by emissions of gaseous and suspended substances, violation of the integrity of bowelsl areas, withdrawal of land and water resources, extensive use of bowelsl, relief changes, leading to a change in the geological structure of the earth's crust, the effect of noise and vibration, the accumulation of waste dumps, pollution of surface and ground waters, a deterioration in the life quality of the population, manifested in the form of an increase in the number of morbidity, mortality, outflow of the population to the most favorable territories. All types of impact of opencast mining are a direct destruction of natural ecosystems in the development areas and areas of overburden formation.

All types of impact should be recognized not only as processes of economic activity, but also as processes involved in the destruction of natural ecosystems. Indeed, the degree of stability of such ecosystems is determined by a combination of natural and natural-anthropogenic factors, on the basis of which there are different degrees of stability. The degree of stability that is determined at each of the common minerals quarrying sites may allow the identification of point critical adverse events and will help reduce environmental degradation. In addition to the degree of stability, the intensity of the mining technical load should be determined, as well as the ability of the ecosystem to heal itself. Knowing the listed indicators, it becomes possible to assess the risk of one or another specific negative impact on the environment and humans, and thus there are barrier tools, preventive measures to reduce the impacts considered in this work.

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