Ecological risks observed during extracting semi-precious, facing and ornamental stones in Irkutsk region

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Abstract. The paper under consideration is devoted to the problem of evaluating a mining production negative effect on the atmosphere air. The assessment of the ecological risk has been made in the context of four working areas of a mining production with regard to statistical data resulting from a production activities control. The index of the atmosphere pollution is determined with regard to investigation materials obtained as a result of production control and standard projects of marginal release. Pollution zones of production areas with the dust of rocks extracted have been patterned and an ecological and economic damage caused by mineral extracting activities of works and typical for ecostresses has been calculated, the latter being promotive of a considerable atmosphere loading. Direct and indirect effects of the above-mentioned production on the elements of the environment are assessed.

1. Introduction

There are most abundant and various resources of precious, semi-precious, facing and decorative stones in the interior of Irkutsk region, and they are widely used in the national economy. Mineral-primary resources of stones can be divided for clarity into two groups, namely, semi-precious and facing. Charoite, nephrite, lapis-lazuli, ophicalcite, gagate belong to the group of semi-precious stones. The group of facing stones covers nontransparent and free-cutting stones distinguished for their beautiful colouring, their resistance to atmospheric exposure, their high mechanical strength. They are, first of all, marble and onyx marble, granite and granodiorite and also dolerite, syenite, laurelvite.

A number of mining works are engaged in extracting stones on the territory of the Irkutsk region, OAO/OJ-SC (open joint-stock company) of "Baikalkvartssamotsvety" and AO/CL (Company Limited) of "Pereval" being the greatest.The above mentioned works like other mining works of the region effect negatively the environment and the humans.

2. The assessment of ecological risk

In accordance with the modern ideas, the assessment of ecological risk is the only analytical instrument enabling to identify scientifically the factors of risk with regard to people's health and the surrounding and their correlation. It should cover both the assessment of probability for dangerous pollution of air, water, soil along with the dangerous concentration of toxic substances in the above objects of the environment including plants and animals and the probability definition of some or other disease or death of a human [1]. Being aware of the risks actions can be taken to make the risks minimum, that is to monitor them.

The assessment of risk is aimed at determining the level of the action taken or standards (norms) that

are safe from the biomedical science point of view as well as a marginal pollution of the environment. Such levels are calculated basing on the data obtained in experiments with animals engaged or in the situations where a human was exposed to a negative affect (e.g. as a result of an emergency or neglect, etc.). First of all, a level of concentration is determined that does not show any exposure, or it shows also primary functional disturbances that represent the lowest level of the affect revealed (i.e. the threshold itself) which is after that divided by the factor of safety characterizing the value of suspence. The last operation results in obtaining the values of an acceptable human exposure level. These final results represent either maximum marginal levels of pollution belonging to one definite environment (MPC, MTD), etc.), or acceptable daily doses (ADD) of chemical substances invading from different backgrounds simultaneously [2]. In the cases mentioned a person exposed to some substance in a dose smaller than standard (norm) or its equal is considered to be safe.

The procedure of a risk assessment consists of four major stages. The first stage is a risk identification or revealing a potential danger. It includes the assessment of a substance toxicity level with regard to humans or an ecosystem. For example, in the presence of fundamental research data, it is possible to ascertain that a temporary or permanent availability of a certain substance can cause unfavourable affects, such as grave diseases or serious environmental impacts. At the stage being considered of the risk assessment procedure, the analysis is made at a qualitative level. The second stage is an exposure assessment that is a real negative impact on human health and the environment. It includes the determination of an effect scope (a real level), its regularity and duration. The third stage is the assessment of the "dose-reaction" correlation, that is a quantitative evaluation of a human health and the environment reaction to a definite dose of impact. The final stage of the risk assessment procedure is the result of the above-mentioned ones, namely, a risk characteristic anticipating both qualitative and quantitative values showing if the impact being analyzed is dangerous and how great the risk is in the given conditions.

The paper under consideration is aimed at the assessment of the ecological risk in the conditions of extracting semi-precious stones at the mining enterprise "Baikalkvartssamotsvety".

3. Methodology of investigating

The investigation is based on an analytical generalization of famous research and technical results, in vitro and in situ methods of studying conditions of dust dispersion formation, microscopic, sedimentary and mechanical analyses of material dispersion. Initial data used for risk assessment were norm projects of marginal production discharges, the materials of production control, the results of the research dealing with dust level assessment in the regions of mining works [3]. The following factors are used as ecological risk criteria: the atmosphere pollution index; the index of MPC excess with regard to the dust level in the atmosphere (identified zone of the greatest concentrations); ecologi-economical damage of the atmosphere.

In the works being investigated, semi-precious stones different in their nature are extracted. The objects of investigation are technological ones distributed on four areas: the extraction of ophicalcite from the deposit of Alzagai (U. Sayan. of Irkutsk region) (Area 1),the extraction of nephrite from the deposit of Ospinskiy (Okinski region of Buryatia republic) (Area 2), the extraction of charoite from thr deposit of "Sireneviy kamen/Lilac stone" (the massif of Murun at the border of Irkutsk region and Sakha-Yakutia republic) (Area 3), the area of refining semi-precious stones in the settlement of Smolenshchina of Irkutsk region (Area 4). The areas are different as concerned geoecological, engineering and technical, natural and regional factors.

The assessment of the areal distribution with regard to ecological risk is performed using GIS technologies [4]. Using GIS technologies in mapping levels of dust impact on the environment in the conditions of open pit mining works makes it possible to show the spatial distribution of pollutant concentrations. The above technologi is aimed at determining the rating of polluted areas.

The calculations were carried out in the presence of the software package of Golden Software Surfer.

Atmosphere pollution with harmful substances is evaluated with integrated sanitary measurements, namely, API (atmosphere pollution index) [5-8]. The last is dependent on an average annual

concentration of a substance in the atmosphere, its marginal daily concentration (MDC) and the class of danger (p1). It can be calculated following the relation:

$$API = \sum_{j=1}^{m} \left(\frac{C_j}{MDC_j} \right)^{p_i}$$

where *Ci* is a real average annual concentration of an *i*-substance in the atmosphere air and its *MDCi* (marginal concentration, average daily index); p_i index; *m* is the number of substances to be identified.

4. Results and their discussion

To make a comparative analysis of 4 areas under investigation, some ecostressors that are similar by their chemical nature were chosen from a great variety of substances released in the atmosphere, such as nitrogen, sulphur, carbon oxides, nonorganic silicate dust, aerosols that are discharged during welding, hydrocarbons [9].

From the context of the data above, it is seen that the greatest atmosphere pollution index is registered in the vicinity of Area 2 (Ospinski deposit). This area contributes considerably to the atmosphere pollution by carbon oxides, nitrogen and silicate dust. Fig.1 represents the rating of the areas being investigated belonging to the PTC (Publicly Traded Company) of "Baikalkvartssamotsvety" with regard to the atmosphere pollution index.

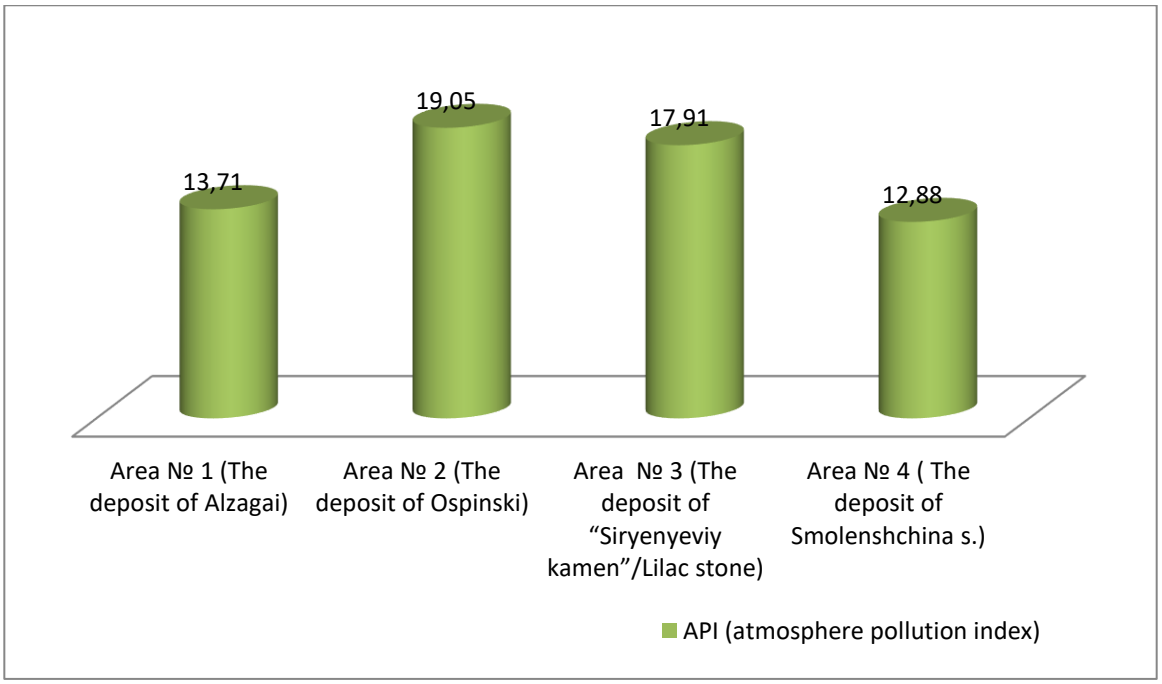


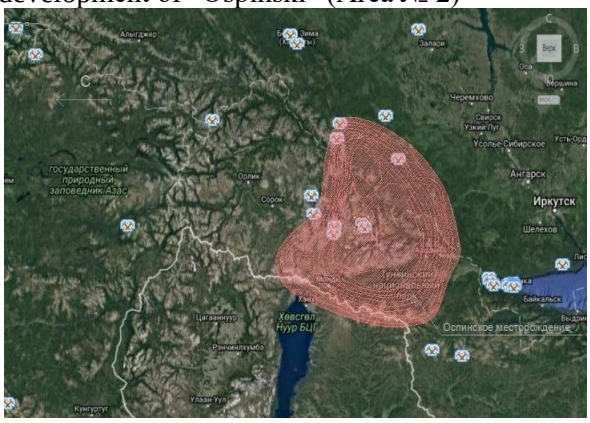
Figure 1. The atmosphere pollution index characteristic for the areas belonging to the PTC of "Baikalkvartssamotsvety".

The atmosphere pollution level on the areas of extraction is determined as belonging to the category of badly polluted ones, while the one on the area of stone treatment is polluted in average.

The results of mapping dust effects during mining operations (Figure 2) prove that the maximum area characterized for the marginal dust concentration is registered on the area of nephritis extraction (620345 m^2); the second in size is the area of extracting ophicalcite (534256 m^2), the third one is the area of charoite extracting (380200 m^2), the smallest one is the area of stone treatment in the settlement of Smolenshchina.

1) A dust spreading project caused by a deposit development of "Alagaiski" (Area № 1)

2) A dust spreading project caused by a deposit development of "Ospinski" (Area № 2)



3) A dust spreading project caused by a deposit development of "Sirenievyi Kamen" (Area № 3).

4) A dust spreading project caused by operating a production area (settlement of Smolenshchina).

Figure 2. Dust spreading projects resulting from deposits development and operating a production area (№ 4).

The choice of environment protection measures aimed at a lower environment dust load is advisable to carry out with consideration for the regularities of relative values variations concerning the ecological risk, the variations being calculated basing on the inter-relation of areas and dust fractional composition spreading in the environment.

The production program analysis of a mining enterprise operation ("Baikalkvartssamotsvety" is meant in our case) shows that the greatest ecological-economic damage is registered in ophiocalcite extraction of Alzamai deposit (Figure 3), while the smallest one is observed with regard to charoite extraction.

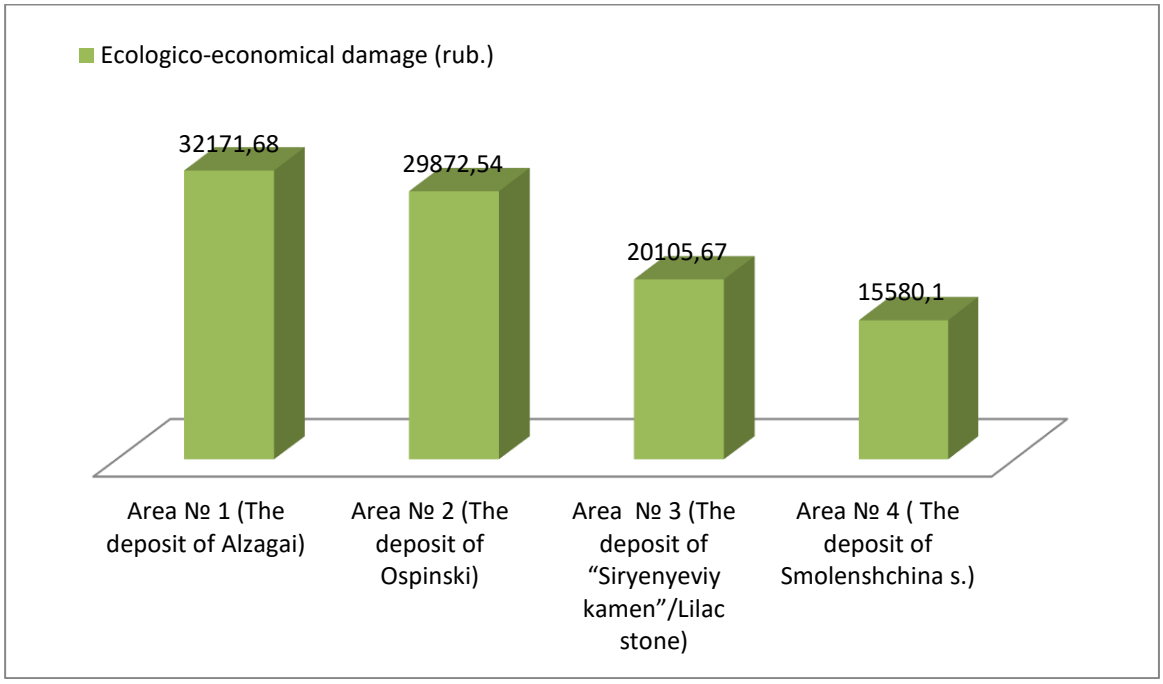


Figure 3. Annual ecologico-economical damage (rub.) caused to the atmosphere air by mining works of "Baikalkvartssamotsvety" PTC as a result of operating production areas.

5. Conclusion

Thus, from the analysis of dusty effect sources being considered during extracting semi-precious stones, one can see that the technological processes connected with extracting and processing mineral wealth are the main sources of dust release. They can be well-boring, blasting, excavation and loading operations, transportation of mined rock. Spreading dust concentration reaches its maximum as the dust is moving away from the dust release source and it gets lower beyond the distance of 500-1000 m, the particles of more than 250 microns in size spreading for the distance smaller than 500 m from the source. Particles of 10-100 microns in size spread for the distance of 1500-2000 m, while the particles affecting humans most gravely (<10 microns) spread for the distance of over 3000 m.

Ecological risk distribution was investigated with regard to dust pollution of the environment in the conditions of operating different areas of "Baikalkvartssamotsvety". The analysis of the investigation results has shown that the areas characterized by the relation of dust concentration and its marginal concentration being 3 are considered to be the areas of a high ecological risk (the deposit of Ospinski): the areas with the inter-relation of C/MPC being 2 or 2.5 are considered to be the areas of an average risk, whereas the inter relation of 1.5 indicates a low risk (the deposit of "Sirenyevi kamen").

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