Ecological Assessment of Formation of Solid Man-Made Wastes of Mining Production

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Abstract. The article deals with environmental problems of formation of fine white marble wastes on the territory of Koelga deposit and total mining complex. The inventory analysis of marble wastes was carried out. The calculations to determine the amount of fine marble waste accumulated from the beginning of development of the deposit were included in the inventory analysis of waste. It also includes researches on the mineral, material, grain-size, element compositions of these wastes. The microstructure and x-rayphase analyses of these wastes present in this article. On the basis of the inventory analysis the ecological assessment of fine marble wastes and their impact on the ecology of the territory of complex was carried out and justified theoretically. The article outlines and scientifically substantiates the ways of large-scale utilization in the production of ceramic bricks. The authors believe that recycling of man-made wastes is required and is associated with the depletion of mineral resources available in the bowels of the Earth. The authors also note fast growth of volume of man-made waste and growth of abandoned territories under dumps, as well as a negative impact on the environment.

1. Introduction
The growth of industrial and mining production, the progress of civilization increase environmental problems due to the increasing consumption of mineral and other resources from the bowels of the Earth [1-8], due to the rapid rise in the number of solid man-made wastes of different productions. These wastes can be used for the production of building materials [1,2,3] and to improve the environmental safety of mining regions. Abandoned lands are exempted from waste dumps and territories have environmental and economic benefit [1,2].

2. Relevance, scientific significance, review of literature
In the world and in the Russian Federation there are the technologies of extraction and processing of non-metallic mineral resources. During these technological processes man-made wastes are formed [1,2,3]. Their quarries and the surrounding areas are withdrawn from economic circulation, violate natural landscapes - their man-made options are created. It destroys the soil, changes modes of rivers, lakes, reservoirs, underground and surface groundwater and causes great damage to the environment [1,2,4-10].

Koelga deposit of white marble began the work from 1924. During this time in the dumps huge amounts of fine wastes of extraction and processing marble were accumulated [11-15,16-20].
Almost all kinds of new productions require new construction, materials and mineral resources. Therefore, to improve the environmental safety of the regions it is necessary to carry out comprehensive development of deposits [9,10], and also to utilize man-made wastes in the production of building materials [1-3,11-15]. To solve the above problems a comprehensive environmental assessment of man-made wastes is required. The assessment should include amount of accumulated volumes for large-scale utilization of man-made waste in the production of building materials, products [1,2].

3. Problem statement
The purpose of the article is the ecological assessment of formation of man-made waste products of mining production in the form of white marble with a decrease in the available subsoil mineral resources for the production of building materials and products.

To achieve the goal, it is necessary to justify the use of these wastes as raw materials for the production of building materials and products. This will simultaneously improve the environmental safety of the territories due to large-scale utilization of man-made waste marble and will free up the areas occupied by dumps.

4. Theoretical part
For the environmental assessment in the Russian Federation and Europe international norms are used: GOST R ISO 14050-2009 “Environmental management” and GOST R ISO 14040-2010 “Environmental management. Life cycle assessment. Principles and framework”.

On these standards inventory and classification analyzes are carried out. The inventory analysis determines the mass and life cycle of wastes, their material, mineral and element, grain-size compositions, physical and technical properties.

The environmental danger of waste of the respective productions is determined using the classification analysis[1,2].

The resource approach [1,9,10] makes it possible to assess the quality of development of Koelga deposit of white marble in the Chelyabinsk region. The large number of fine waste marble is formed on this deposit [1,11-15]. It is one of the largest in the world. In recent years, the extraction of marble is between 50 to 80 thousand m³. Wastes in the amount up to 35% from mined marble create significant environmental problems. Therefore, in the year up to 50 thousand tons of man-made waste of fine white marble are formed [1,4]. According to the catalogue of waste the fine marble wastes apply to danger class 3 [1,11-15]. It has a negative impact on the environment of deposit territory and all Southern and Middle Urals. As a result of utilization of wastes and elimination of their dumps lands will be vacated and ecological conditions surrounding territory will improve significantly.

Precipitation, solar radiation, alternating temperatures, wind, surface ground water exert an adverse effect on marble waste dumps. Ultafine and hollowness of wastes in dumps, small solubility of particle marble in water, their water absorption, their chemical, material and mineral compositions also exert impact on the environment.

White marble consists of calcite, it is well processed, grinded and polished [4-7]. In construction rubble and sand are used [16] and fine wastes are used as filler in bricks, linoleums, paints, dry building mixes, etc. [1,2,11-15,17-20].

The inventory analysis of particles of fine white marble wastes determines, that more than 70% of them are less than 100 microns. This helps generate dust in the wind. Specific surface area of marble particles is 2541…2553 cm²/g. True density of white marble is equal to 2,66 ... 2,68 g/cm³. X-rayphases (fig. 1), microstructure (fig. 2) analyzes, element and oxide compounds of fine marble wastes were analyzed (table 1).
### Table 1. Elemental and oxide analyzes of marble waste.

| Element | Content, % | Oxides | Content, % |
|---------|------------|--------|------------|
| Ca      | 41.2...42.8 | CaO    | 57.1...57.62 |
| C       | 10.1...10.8 | CO₂    | 42.4...42.73 |
| O       | 46...46.55  | -      | -          |

![X-ray phase analysis of marble wastes.](image)

**Figure 1.** X-ray phase analysis of marble wastes.

In the papers [1,2,11-15] the environmental assessment of man-made wastes on their life cycle is adequate.

During their life cycle marble wastes have the following negative impacts on the environment:
- the depletion of the lithosphere and hydrosphere;
- imbalance in the ecological system;
- hydrosphere pollution, including: underground and surface ground water, changing modes of streams and small rivers and other bodies of water;
- the disruption and destruction of the fertile soil of the biosphere;
- the destruction of natural landscapes, the formation of man-made landscapes;
- atmospheric pollution by dust;
- high noise load during extraction, transport and processing;
- formation of man-made wastes during extraction, processing, placing, moving or burial, utilization; the destruction or degradation of flora and fauna.

The life cycle of a fine marble wastes consists of the following technological operations, such as:
- the removal and relocation of soil surface over the whole area of the white marble deposit;
- removal of overburden and their carriage in the dumps;
- extraction of large blocks of marble rocks and transport to the place of processing;
- rough processing and sawing the blocks on the specified sizes;
- grinding and polishing of marble products;
- collection and sorting of marble wastes;
- transportation of marble wastes in the dumps;
transportation of marble wastes from the dumps to the place of manufacture of building products on the basis of these wastes.

Figure 2. Microstructure analysis of marble wastes.

After delivering fine marble wastes to the warehouse of feedstocks shop on manufacture of building products, their life cycle, as a waste, concludes. Its cycle is included as an integral part in the life cycle of a construction product.

For most building products based on recyclable man-made waste the classification analysis determines the reduction of the level of the environmental risk of products compared to the risk class of the original waste [1,2,11-15, 21].

5. Practical significance and results of research
It was calculated that in 2018 the total mass in the dumps is more than 25 million tons of fine marble wastes, and the area of dumps - more than 20 hectares. An important task was also the calculation of the environmental damage from the abandoned territories under the dumps of fine marble waste.

To calculate it was analyzed the environmental effect from their utilization by reducing the area under the dumps, and the pollution of the environment of mining complex territory [1,11].

When calculating it was determined that for the Chelyabinsk region the damage to the environment from storage of fine marble waste in dumps is about 500 thousand rubles a year (in the prices of 2018). Taking into account the amount of wastes already placed in dumps of JSC "Koelgamramor", the environmental damage will amount to over 30 million rubles [1,11-15].

According to calculations the utilization of fine marble waste in brick production will significantly reduce the environmental load on the environment [1,11-15]. It will take place by reducing waste mass in dumps, that will allow to reduce the abandoned areas under dumps and to return the land to use [1,11-15].

In the articles [1,11-15] it was determined the amount of recyclable fine marble waste at 1 m$^3$ of molding mixture for the production of ceramic bricks of multiple colors: terracotta or dark brown; light red or pinkish; fawn or straw.

Number of bricks was calculated with standard size 250x120x65 mm, with specified colors, that can be produced with full utilization of marble wastes in the dumps of JSC "Koelgamramor". The results present in table 2.

The analysis of the results of technical tests showed that, on the basis of fine marble wastes, it is possible to obtain ceramic bricks of danger class 4, which corresponds to state standard GOST of the Russian Federation. It was found that burning of over-moulded ceramic raw makes at temperature 850 ... 900° C. It is proved that at that temperature, the particles of marble are not affected by the process of decarbonization.
Table 2. Consumptions of components and number of bricks.

| Color and number of bricks | Components of composition | Consumptions, kg/m³ |
|---------------------------|---------------------------|---------------------|
| Dark brown 41.7...50 million pieces | Clay rock + water | 1500+465 |
| Pinkish 33.8...40.5 million pieces | Clay rock + water | 1300+403 |
| Straw 28.4...34.1 million pieces | Clay rock + water | 1100+341 |
| Straw 28.4...34.1 million pieces | Fine marble waste | 440 |

Therefore, there is no greenhouse gas emissions - carbon dioxide, i.e. ecology of this mining territory is not the subject to harmful effects. Moreover, as above stated, the level of danger of marble wastes was higher (class 3) by one step, than the level of danger of the ceramic bricks produced (4 class) on the basis of these wastes. Also amounts of energy for manufacture of these ceramic bricks reduced significantly as compared to a common ceramic brick [4-7].

6. Conclusion

Thus, the total mass of accumulated fine marble wastes and environmental damage to mining area of Koelgo deposit were determined. The technology of improving the ecology of the region due to large-scale utilization of the above marble wastes in the production of ceramic bricks was elaborated. The possible number of bricks of different colors at full disposal of accumulated marble wastes was determined. Using environmental life cycle assessment of finished products based on fine marble wastes the possibility of obtaining an environmentally safe effective bricks was theoretically justified and the technology of their production was elaborated. The dependence of color products on consumption of fine marble waste was determined. So, at an amount of 20% of fine marble waste in the mixture by mass of clay rocks the ceramic brick has a dark brown color, and at 40% - has straw color. The influence of the elemental composition of the mixture on the color of the brick was determined.

It was proved that the most environmentally safe, resource-saving way of man-made waste disposal is their utilization in the production of building materials and products. This method releases territories abandoned for storing waste and provides environmental and economic effects from the elimination of dumps.

Thus, the environmental problems of the Russian Federation connected with rise of man-made wastes of white marble with a decrease in available reserves of mineral resources for the production of building materials and products were specified. The scientific foundations of the integrated environmental assessment methodology of man-made wastes and their large-scale utilization in the production of building materials and products were elaborated. The possibility to use these wastes as raw components for their production, while solving environmental problems of the territories due to large-scale utilization of man-made waste was justified. This extends the raw material base and contributes to the integrated development of bowels, their mineral and man-made resources. Utilization of man-made wastes allows to get a huge environmental and economic effects on the territory of the Russian Federation.

7. References

[1] Oreshkin D V 2017 Stroymaterialy Environmental problems of integrated development of mineral resources in the large-scale utilization of man-made mineral resources and waste in the production of building materials 8 55-63
[2] Telichenko V I and Oreshkin D V 2015 Ecology of Urban Areas Material science aspects of geocological and ecological safety in construction 2 31-33
[3] Meshheryakov Yu G, Kolev N A, Fedorov C V and Suchkov V P 2009 Stroymaterialy Production of granulated phosphogypsum for the cement industry and building products 5 104-06
[4] Tseytlin E M 2012 Features of environmental hazard assessment of mining enterprises Theses of the report of VII Krakow conference of young scientists (Krakow: AGH University of Science and Technology) pp 809-19

[5] Khokhryakov A V, Fadeichev A F and Cejtlin E M 2011 News of higher educational institutions. Mountain magazine Dynamics of the impact of the leading mining enterprises of the Urals on the environment 8 44-53

[6] Khokhryakov A V, Fadeichev A F and Cejtlin E M 2013 News of the Ural State Mining University Application of an integral criterion for determining the environmental hazard of mining enterprises 1 25-31

[7] Fadeichev A F, Khokhryakov A V, Grevcev N V and Cejtlin E M 2012 News of higher educational institutions. Mountain magazine Dynamics of negative impact on the environment at different stages of mining development 1 39-46

[8] Oreshkin D V 2009 Vestnik MGSU Material science aspects of geocological safety in construction of wells 2 105-10

[9] Chanturiya V A, Chaplygin N N and Vindergauz V E 2005 Strategy of reduction, recycling and processing of fine marble and industrial waste in research of the Russian Academy of Sciences Modern problems of complex processing of natural and technogenic raw material (St. Peterburg: Roza Mira) pp 230-35

[10] Chaplygin N N 2006 Foundations of Ecological Theory of Comprehensive Exploitation of Mineral Resources (Moscow: IPKON RAN) p 102

[11] Oreshkin D V, Papichev V I, Zemlyanushnov D Yu and Popov P V 2018 Mountain magazine Ecological problems of territories in open cut mining and processing of marble, ways to solve them 40(1) 88-91

[12] Zemlyanushnov D Yu, Sokov V N, Oreshkin D V and Skanavi N A 2014 Vestnik IrGTU Disposal of fine marble waste processing in the production of facial ceramics 9(92) 122-26

[13] Zemlyanushnov D Yu, Sokov V N and Oreshkin D V 2014 Scientific and Technical Volga region Bulletin Using fine-grained marble of processing waste in the technology of facing ceramics 4 108-114

[14] Zemlyanushnov D Yu, Sokov V N and Oreshkin D V 2014 Vestnik MGSU Ecological and economic aspects of the use of fine marble waste in the production of facing ceramic materials 8 118-26

[15] Oreshkin D V and Perfilov V A 2017 Solid State Phenomena Environmental and Technical Possibilities of Marble Waste Recycling in Bricks and Sorbents Production 265 39-42

[16] Moumouni A, Goki N G and Chaanda M S 2016 Natural Resources Geological exploration of marble deposits in Toto Area, Nasarawa State, Nigeria 7 83-92

[17] Merem E C et al 2017 International Journal of Mining Engineering and Mineral Processing Assessing the ecological effects of mining in West Africa: the case of Nigeria 6(1) 1-19

[18] Onimisi M, Obaje N G and Daniel A 2013 Advances in Applied Science Research Geochemical and petrogenetic characteristics of the marble deposit in Itoke Area, Kogi State, Central Nigeria 4 44-57

[19] Bilgin N, Yeprem H A, Arslan S, Bilgin A, Günay E and Mars M O 2012 Construction and Building Materials Use of waste marble powder in brick industry 29 449–457

[20] Gimaltdinov I K, Levina T M, Stolpovskii M V, Solovev D B 2018 Dynamics of the Localized Pulse in Bubbly Liquid IOP Conference Series: Materials Science and Engineering 463 Part 1 Paper № 022002 [Online]. Available: https://doi.org/10.1088/1755-1315/463/2/022002

[21] Hebhour H, Aoun H, Belachia M, Houari H and Ghorbel E. 2011 Construction and Building Materials Use of waste marble aggregates in concrete 25(3) 1167–71