Management of Integrated Utilization of Industrial Waste Storage Facilities

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Abstract. At the current stage of development, access to mineral resources is becoming a critical factor in economic growth, which requires an increase in the use of both natural and technogenic raw materials. The article is dedicated to the management of industrial waste. An algorithm has been developed for the recycling system for technogenic deposits, which can serve as a methodological basis for strategic management of the process of involving them in the economy. An organizational and management model of a private eco-industrial park of the Greenfield type is proposed as an integrated system aimed at the use of technogenic resources, as well as environmental rehabilitation of waste localization sites. The possibility of its application for the processing of stale tailings of the former Tynnyauz tungsten-molybdenum plant is estimated. It is concluded that, as a result of the integrated use of the unique resource potential of the waste accumulators of this mining and processing plant, the formation of prerequisites for its restoration is possible.

1. Introduction

For modern Russia and many of its regions, one of the most acute problems is that of integrated disposal of accumulated storage facilities for industrial waste (IW). Commissioning of stale technogenic deposits can contribute to solving a number of interrelated tasks. On the one hand, this represents the potential to utilise these additional raw material sources in a cost effective manner, especially given the increased need in society for them. On the other hand, there is a reduction in environmental risks and the negative impact on the socio-economic systems of the adjacent territories, which over time start to become globally irreversible.

2. Relevance

To date, more than 80 billion tons of IW has been accumulated in the Russian Federation, a significant part of which are dumps and tailings of mining and processing plant (MPP) and mining and metallurgical plant (MMP). About 5 billion tons of mining waste and overburden rocks are stored annually by domestic industrial enterprises, and about 700 million tons of dumps are formed by processing plants [1-3]. With such a significant amount of accumulated mining waste (AMW), their disposal is not more than 10% of the annual output [4].

Thus, the export and raw materials orientation of the domestic economy, the level of technological development contribute to a steady annual growth of IW at low rates of their use as secondary raw materials. In this situation, the relevance of scientifically applied support for the effective development
of the mineral resources of technogenic deposits and their full utilization for the purpose of environmental rehabilitation of waste localization sites is significantly increasing.

3. Statement of the problem
This work is based on the consideration of recycling of technogenic storage of MPP and MMP as a process of involving AMW in the further technological redistribution as a secondary mineral raw material on an economically rational basis. It is also based on the need to develop fundamentally new and/or improve existing technological processes, and organizational and economic mechanisms in order to completely utilize man-made accumulations and minimize the generation of secondary waste. The variety of technical, economic, environmental, managerial, legal, and other problems of recycling stale IW with little (single) experience in their processing emphasizes the complexity and multifacetedness of the problem.

In the framework of this article, we will review the organizational and managerial problems of utilizing stale storage facilities for gas storage facilities using the example of the tailings of the former Tyrnyauz Tungsten-Molybdenum Plant (TTMP) located in the Elbrus region of the Kabardino-Balkarian Republic.

4. Theoretical part
In the context of an increase in anthropogenic overload on ecosystems, harmonization of the interaction between nature and society is of key importance [5]. In this context, a special role is given to rationalizing subsoil use, the integrated use of the entire aggregate of extracted mineral resources, including valuable components of technogenic deposits (TD), on the principles of environmental and economic efficiency.

Recent decades have been characterized by a noticeable increase in attention to the problems of the utilization of TD, which began to be considered in a new fundamentally wider (resource-efficient) aspect [6-8]. Recycling of TD mineral resources is a multifaceted problem, which covers a number of branches of material production, services, scientific and technical fields, and environmental protection. Its solution requires an integrated ecosystem approach and taking into account the entire set of problems associated with the efficient organization and management of the IW utilization process.

In Russia, the “Strategy for the development of industry in the processing, utilization and neutralization of production and consumption wastes for the period up to 2030” became the basis for the implementation of state policy in the field of waste management, resource conservation and their involvement in the economy [9]. It defines a list of necessary conditions and priorities aimed at ensuring the environmental safety of the regions, reducing waste generation, changing the structure and system of waste management in favor of recycling (instead of disposal), preventing environmental damage, increasing the level of environmental and technical safety of technologies waste disposal.

An analysis of the literature [10-14] made it possible to develop a system for recycling used industrial waste, which can serve as a methodological basis for strategic management of AMW utilization in order to use it as a demanded mineral raw material and to reduce the negative impact on public health and the environment (Fig. 1).

Since the disposal of waste storage facilities of specific industrial enterprises requires the development of methods and technologies for IW recycling taking into account the specifics of the entire set of their characteristics, the complex formula of geological research is given a special place:

- the establishment of mineral, particle size distribution;
- determination of chemical, physical and mechanical properties;
- identification of the toxicity and radiation safety class of AMW;
- conducting visual and other geological studies of potential threats of environmental disasters as a result of their long-term storage, etc.

The data on TD liquidity can serve as the basis for the development of effective innovative technologies and technological equipment for the most thorough extraction of economically important components of stale IW and their processing into products / goods that are in demand on the market.
Figure 1. Formula for complex utilization of technogenic storage facilities.

The selection of the most preferred methods, technologies and mechanisms for cost-effective recycling of specific MPP storage facilities is determined not only by their specificity and value of components, but also by economic feasibility and market conditions. Along with this, one of the main selection criteria is the principle of complete utilization of IW (cleaning from hazardous elements to a level below the Threshold Limit Value of adjacent territories, surface watercourses, and rehabilitation of the disturbed natural environment).

Special cluster formations based on intersectoral cooperation – regional eco-industrial parks (REIP) – can become a promising form for the implementation of the proposed system for recycling stale AMWs.

We will consider REIP a special form of combining industrial facilities (buildings, structures, technological and laboratory equipment) used in the utilization, disposal and minimization of various types of waste burials, as well as organizations/institutions engaged in research and related economic activities for their processing and production of demanded products on their basis [9].

The distinctive features of REIP as an integrated system in which the consumption of resources is organized on the principles of their repeated involvement in the economic turnover, are the combination of production, infrastructure, research and development, the presence of internal energy and material flows.

The definition of REIP as a complex designed to solve certain functional tasks of the region allows us to consider various managerial models for the formation of such associations, depending on the choice of a particular contractual (legal) form, namely:

- legal construction of an eco-industrial park as a type of industrial technopark;
- Public Private Partnership Agreements (PPPs);
- concession agreement;
- special investment contract;
- investment agreement [15, 16].

We will illustrate the feasibility of implementing the proposed recycling system by the example of the processing of stale waste from a former TTMP located in the Elbrus region of the KBR, identifying a private greenfield type EIP as the optimal organizational and management model.

Currently, the MPP tailing dump is represented by two blocks (the first and second storage fields with reserves of 105 and 26 million tons, respectively) related to the mixed type of prospective use. They were identified by the geological service of TTMP as “a unique integrated technogenic deposit of metallic and nonmetallic raw materials”. According to preliminary estimates, the total metal reserves in the storages were: about 213 thousand tons of tungsten, more than 67 thousand tons of molybdenum, 15 thousand tons of copper, 5 thousand tons of bismuth, and others. It also indicates the presence of valuable and rare (about 30 items) chemical compounds of metals, including environmentally hazardous elements [13, 17 and 18].

The IW has significant reserves of garnet sand (more than 30% of the content) of a natural chemically inactive, non-metallic natural mineral, the main fields of application of which are associated with its increased hardness. Garnet is used for the production of various types of abrasives and fillers demanded by the market, as technical stone and other products. The high content in the tails of silica, calcium carbonate, alumina, and iron oxide makes them suitable for the production of cement, building (concrete blocks, silicate brick, reinforced concrete panels) and ceramic (feldspars) materials. In quantitative terms, non-metallic raw materials amount to tens of millions of tons. Thus, significant reserves of economically valuable components in the tailings of the former TTMP indicate the possibility of their cost-effective disposal through the production of various types of liquid products.

Along with this, a number of circumstances should be pointed out. Firstly, the presence near the AMW storage of the Tyrnyauz MPP flat levels suitable for the construction of processing facilities, asphalt and grader roads, a high-voltage power transmission line and a high pressure gas pipeline indicate favorable infrastructural conditions for the formation of an investment site for their complete processing. Secondly, the presence in the region of sufficient human and scientific potential. Thirdly, the waste collectors of the former TTMP pose a real threat to the environmental safety of Elbrus. As a result of their long-term storage in rural and earthquake-prone areas, the risk of technological disasters associated with wind deflation of tails, violation of the integrity of the bulk dam, drainage tunnel and other protective structures increases [19, 20].

And finally, an important prerequisite for creating an EIP is the high interest of regional and municipal authorities in the development of the mining industry. Their willingness to support potential investors in resolving administrative issues of business development, in creating favorable social and infrastructural conditions, financial instruments and other measures to facilitate the implementation of investment projects to restore the mining industry in the region on the basis of the Tyrnyauzsky tungsten-molybdenum ore deposit.

The creation of a profile REIP should be based on a single concept for the development of the territory as a platform for investment. This requires the formation of differentiated conditions for attracting a large business that can become an anchor resident/investor of individual entrepreneurs and smaller residents specializing in complementary production and provision of services. The prerogative of regulating their interaction as objects of high-tech IW utilization, united by territorial localization, focus on the organization of cost-effective production, the principle of mutually beneficial partnership, is assigned to the Coordination Center (Fig. 2).

One of the most important areas of the strategy for attracting residents to the EIP is the determination of the status of the investment site, as well as the corresponding incentive instruments (tax incentives, preferences).
5. Practical significance and results
The practical application of the proposed recommendations for managing complex recycling of industrial waste storage facilities based on the formation of EIP will help to solve the problems of involving them in the economic turnover as a demanded mineral raw material. They can also contribute to improving the effectiveness of regional authorities in the process of creating and regulating the development of REIP. As an element of the scientific understanding of the changes taking place in the waste disposal and utilization industry, the research results can serve as the basis for further study of rationalization of subsoil use and integrated use of technogenic resources.

6. Conclusion
Effective organization of the process for managing the complete utilization of MPP drives, in particular the former TTMP, based on the formation of EIP will not only contribute to the integrated use of the components contained in the gas treatment facilities, but also reduce their negative impact on the environmental situation and ecosystem services of adjacent territories. As a result of the effective use of the resource potential of the former TTMP storages based on the ecosystem approach, the formation of prerequisites for its restoration is possible.

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