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Waste Management of Mining Enterprises of the Arctic Zone of the Russian Federation, Case Study for Murmansk Region

V A Tsukerman¹, S V Ivanov¹

¹Luzin Institute for Economic Studies – Subdivision of the Federal Research Centre «Kola Science Centre of the Russian Academy of Sciences», 184209, Murmansk Region, Apatity, Fersmana st., 24a, Russia

E-mail: tsukerman@iep.kolasc.net.ru

Abstract. The paper discusses relevant problems associated with the exploitation and processing of mineral waste accumulated from mining enterprises during the industrial era. To ensure the preservation of a vulnerable Arctic environment it is necessary to search for the new innovation technologies aimed at increasing the comprehensive use of waste for various purposes of the national economy. The main aim of the work is to assess the efficiency of industrial waste management for the period 2010-2019 by the Arctic mining enterprises which provide open access to the necessary research information. The methodological basis of the analysis are annual reports of enterprises, official documents and scientific publications. The analysis showed that wastes of I-III hazard classes are significantly reduced which meets the requirements of the legislation but wastes of IV and V classes showed multidirectional dynamics and growth respectively. It is shown that for the further improvement of the waste management system there is a need of directions for the search for new comprehensive approaches as development of innovation technologies, reuse of waste with release of new products as part of transition to a circular economy and use of green technologies.

1. Introduction

Exploitation of the Arctic Zone of the Russian Federation (hereinafter - the Arctic) is accompanied by the modernization of industrial enterprises mainly associated with the mining and processing of natural raw materials and mineral resources. Mineral formations accumulated in the industrial era significantly affect the ecological situation in the Arctic which makes waste management of mining enterprises an extremely relevant issue. Since the ecosystems of the Arctic are very sensitive to external influence the spatial exploitation of these territories can lead to such a negative impact on the environment the consequences of which are irreversible. To ensure the operation of mining enterprises while preserving a particularly vulnerable environment in the Arctic it is necessary to search for new innovation solutions for the rational use of industrial waste [1-3].

Basic principles, provisions and legal foundations of state policy in the field of waste management are defined in federal laws and various legislative acts. Companies need to comply with Russian and international legislation, invest in the development and implementation of new technologies and take the necessary measures to efficiently use and reduce industrial waste [4-9]. However, flaws in the legislation in the sphere of environmental management leads to an aggravation of the ecological situation in the Arctic regions.



2. Materials and methods

The main aim of the paper is to assess the efficiency of industrial waste management for the period 2010-2019 by Arctic mining enterprises. This aim was considered on the example of mining enterprises of the Murmansk region which form the largest share of waste in this region and provide open access to the necessary research information:

- JSC Kola MMC of PJSC "MMC "Norilsk Nickel" producing nickel and cobalt concentrate, cathode copper, electrolyte cobalt, precious metal concentrates, sulfuric acid, sodium sulfate, sodium chloride, nickel matte, nickel matte, copper matte;
- Kirovsk branch of JSC Apatit of PJSC PhosAgro producing apatite and nepheline concentrates;
- JSC Kovdorskiy GOK of JSC MCC EuroChem producing iron ore, apatite concentrate and baddeleyite;
- JSC Olcon of PJSC Severstal producing iron ore concentrate, ferrite strontium powders, crushed stone;
- PLC Lovozerskiy GOK producing loparite concentrate;
- Kandalaksha aluminium smelter of JSC RUSAL Ural producing aluminum and its alloys;
- JSC North-Western Phosphorous Company of PJSC Acron producing apatite concentrate.

The information basis for state control over production and consumption wastes is the data of the annual statistical reporting of enterprises [10-11]. Thus, the methodological basis of the analysis are the annual reports of enterprises, reports of regional divisions of the Ministry of Natural Resources and Environment, official documents and scientific publications [11-15]. The following main indicators in the field of waste management are considered: the amount of generated, used (including processed, utilized and neutralized) and buried waste without taking into account the transfer to third-party organizations. Waste classes were studied in accordance with the Order of the Ministry of Natural Resources and Environment of the Russian Federation No. 536 which established 5 hazard classes of waste according to the degree of negative impact on the environment: class 1 - extremely hazardous, class 2 - highly hazardous, class 3 - moderately hazardous, class 4 - low-hazard, class 5 - practically non-hazardous [9]. Table 1 shows the total amount of generated, used and buried waste in the Murmansk region for 2010-2019.

Table 1. Total amount of generated, used and buried waste in the Murmansk region for 2010-2019, million tons [11].

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Generated	197	236	237	241	195	187	200	211	230	260
Used	19	45	26	42	42	42	56	58	54	41
Buried	179	192	211	199	151	126	121	122	121	160

Annual amount of generated, used and buried waste varies depending on a number of reasons such as possibilities of technology development for waste use.

Table 2 shows amount of generated waste of I-IV hazard classes in the Murmansk region for 2010-2019.

Table 2. Amount of generated waste of I-IV hazard classes in the Murmansk region for 2010-2019, thousand tons [11].

Hazard class	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
I	0.105	0.107	0.099	0.512	0.104	0.106	0.082	0.049	0.088	0.04
II	45	45	43	5	6	6	6	3	1	<0,1
III	49	23	71	43	54	54	30	14	18	9
IV	144	123	107	131	128	141	139	97	134	160

It can be noted that the dynamics of waste generation of hazard class I-III shows a decrease. Hazard class IV waste generation does not show stable trends.

According to the annual reports of enterprises 99.7% of the generation of all production and consumption waste in the region are consist of wastes from the mining industry (tailings, overburden and tunneling rocks, etc.). Actual amount of generated, used and buried waste of hazard class V in the Murmansk region for 2010-2019 is shown in table 3.

Table 3. Amount of generated, used and buried waste of V hazard class in the Murmansk region for 2010-2019, million tons [11].

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Generated	197	236	237	241	195	186	199	211	229	260
Used	18	44	26	42	41	41	56	58	54	41
Buried	178	192	211	199	151	126	121	122	120	160

It can be noted an increase of waste generation associated primarily with the volume of mining operations according to the reports of enterprises.

3. Results and discussion

The use of waste by mining enterprises is aimed at various purposes, the main ones are as follows. JSC Kola MMC of PJSC "MMC "Norilsk Nickel" uses mining and enrichment wastes for the preparation of backfill mixtures, as a flux for metal smelting in smelting furnaces, for the construction and strengthening of tailings dams, railroad embankments and road backfilling. JSC North-Western Phosphorous Company of PJSC Acron places waste of III hazard class at specialized facilities. Waste of JSC Olcon of PJSC Severstal are inert materials and are not in demand for mass use and are partially used at own enterprises for the production of crushed stone, the organization of on-site driveways, backfilling of roads, and embankment of dams. Kirovsk branch of JSC Apatit of PJSC PhosAgro uses waste generated from open pit mining for road construction [12-15].

According to the data obtained it can be said that the amount of generated waste of I-III hazard classes is decreasing. Waste of IV hazard class do not allow to make unambiguous conclusions. The management system of waste of V hazard class requires further improvement based on the development of innovation technologies for the waste use.

4. Conclusion

It can be proposed to use green technologies being less harmful production processes than traditional production methods, based on the principles of sustainable development and reuse of resources and developed by scientific institutions as one of the directions of the search for new comprehensive approaches to ensure the development and implementation of environmentally friendly technologies for the extraction and processing of mineral raw materials. Such technologies allow to improve production processes, environmental protection and economic development and have already been introduced in the countries of North America and Europe in various sectors of the economy [16-17].

For mining enterprises, it is also possible to propose the concept of waste-free use of mineral resources proposed by Academician Alexander Fersman in the last century. It is aimed at creating a closed chain of mines and metallurgical facilities and can be one of the directions of the search for management solutions that ensure the transition to a circular economy. The modern approach can be based on a rational combination of traditional ore processing with hydrometallurgy which makes it possible to use not only natural ores but also man-made waste. This requires the provision of comprehensive joint research of enterprises and scientific organizations [18].

Besides the need to comprehensively use of mineral resources there is also required a further scientific research to develop and implement innovation technologies for the industrial waste use for the national economy, to ensure favorable living conditions for the population, to preserve biological

diversity and rational use of natural resources and to ensure measures to prevent and reduce negative impact on the environment as well as removal of consequences.

5. References

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