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CURRENT CONDITION, DISTRIBUTION AND PROBABLE RESERVES OF MINERAL RAW MATERIALS IN TECHNOGENIC OBJECTS OF THE MINING INDUSTRY OF UKRAINE

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Abstract. In the article, distribution and number of technogenic objects of the mining industry, which include waste dumps, sludge accumulation facilities, and settling ponds are examined based on data from official sources. Thermal power plants and factories processing imported mineral raw materials were also added to the analysis, since their waste accumulation facilities are essentially similar to those of the mining sector. A total of 1,053 technogenic objects were identified, most of which are located in the Donetsk and Luhansk oblasts. The main characteristics considered include area occupied by each object and the volume of waste accumulated in it, which made it possible to study the waste accumulation of various types across administrative units of Ukraine and, accordingly, the technogenic pressure on these regions. It was established that more than 66% of the total mass of mining industry waste is located in the Dnipropetrovsk oblast.

The article provides a comparison between the largest technogenic objects of the mining industry in Ukraine.

For a more detailed analysis, the technogenic objects were classified by the types of raw material storage and by the types of minerals, the extraction, enrichment or processing of which have led to formation of these objects. It was established that 63% of technogenic objects in Ukraine were formed during the coal mining and enrichment. By type of storage, bulk technogenic objects (dumps) are the most common.

Based on the results of own experimental researches and studies by other scientists, the content of useful components in different types of technogenic objects was determined, which made it possible to calculate the probable resources of mineral raw materials.

It was established that for some minerals, technogenic objects can serve as the only raw material base of the country due to the absence of their natural reserves (or unconfirmed reserves) or their limited availability, for example, tungsten, gallium, lithium, niobium, antimony, chromium.

The richest in various types of useful components are ash and slag waste dumps of thermal power plants, while in terms of the resource mass, iron ore and coal waste dumps are the largest.

The obtained results will serve as the basis for substantiating the need and economic feasibility of mining waste dumps and tailings storage facilities in order to extract useful components from them and to reduce the technogenic pressure on the environment.

Keywords: technogenic deposits, waste dumps, tailings storage facilities, mineral raw materials, resources

1. Introduction

Ukraine has a powerful mining industry owing to the availability of numerous mineral resources, with extraction activities ongoing for more than 100 years.

According to the analysis of official statistical data [1] it follows that volume of solid mineral extraction in Ukraine increased in the period 2010–2013 (Fig. 1). Following a decline in 2014, extraction volumes were growing again till 2022, reaching approximately 500 million tons (data on mineral extraction for 2022–2024 were not made public).

As shown in Fig. 1, the amount of waste per ton of extracted mineral is increasing in Ukraine; this ratio varies between 0.5 and 1.0 tons per ton of extracted material. In recent years, 0.85–0.88 t of waste was generated per ton of extracted minerals. The increase in the amount of waste generated to the volume of minerals extracted indicates the absence of reserves ready for extraction and overburden in the reporting year [2].

The accumulation of waste in mining industry represents a major issue.

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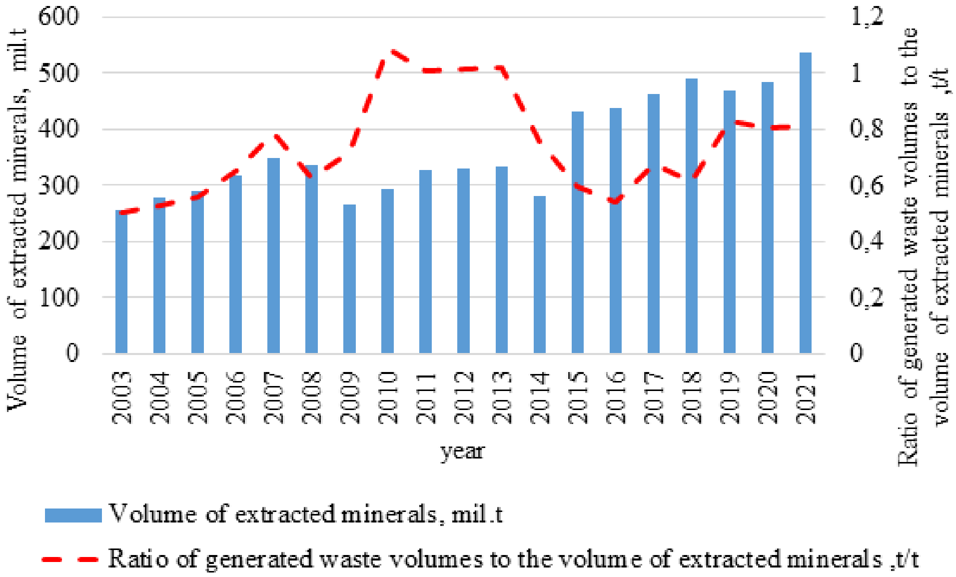


Figure 1 – Ratio of generated waste volumes to the volume of extracted mineral for the period 2003–2021

Waste from the mining industry accumulates in the form of waste dumps, waste heaps, sludge storage facilities, and various types of landfills. Of the total waste generated, only about 2.3–3.0 million tons are utilized annually, which is about 2–3%, so there is a trend towards an increase in the waste accumulation. It is worth noting that the actual volume of accumulated waste exceeds the figures reported in the official information of the Statistics Department of Ukraine.

At the same time, it is well known that waste from the mining industry contains useful elements that could become an object of industrial importance.

However, the exact amount of technogenic reserves of useful components within mining waste remains uncertain.

Analysis of publications. The condition, distribution and probable reserves of mineral raw materials in technogenic objects have long been of interest to researchers around the world.

In work [3], the authors note that France has 2,100 objects of accumulation of waste from iron extraction and 1300 – from coal mining, which they propose to process to extract strategic metals. The authors also examined a tailings storage facilities formed as a result of the development of a lead-silver deposit. They found that the tailings contain lead at a concentration of 6–70 g/kg, arsenic – 0.9–8 g/kg, cadmium 4–107 mg/kg, zinc – 0.8–2.3 mg/kg, chromium 0.01–0.1%, which gives the tailings storage facilities industrial significance.

According to [4], there are 92 closed storage facilities from mineral mining in the northwestern part of Italy. Detailed studies of some waste dumps revealed the presence of copper and oxides of cadmium, arsenic, manganese, cobalt, nickel, lead, iron, vanadium and tungsten.

In Chile, there are 696 tailings storage facilities, most of which are associated with copper ore extraction and can serve as a raw material base for extracting critical minerals [5].

The authors of [6] studied the distribution of all types of mining industry technogenic formations in the Dnipropetrovsk oblast and assessed their potential resources for the extraction of various useful elements.

Besides, the condition and accumulated waste of iron ore raw materials [7–8], fluxes [9], coal dumps of Western Donbass [10], sludge accumulation facilities of Donbass processing plants [11] and others were studied.

However, a comprehensive study of all technogenic objects of Ukrainian mining industry has not yet been conducted.

All scientists consider it necessary to mine and process the accumulated waste of the mining industry.

The authors of the article [12] studied the global practice of utilizing ash and slag waste from thermal power plants (TTP) and showed that in the world it is primarily used in road construction.

The study [13] shows that bauxite and alumina waste contain rare earth elements (30–80 g/t), iron (40% by weight), copper, nickel, gold, silver, cobalt, vanadium. It is proposed to recovery all useful elements from the waste, and to use the remaining materials for the production of building materials. A similar approach is proposed in [14] for waste dumps from iron ore deposits.

In [15], the authors state that the waste dumps contain more useful elements than the tailings storage facilities, which is why they propose prioritizing the mining and processing of raw materials from waste dumps.

In the [16], it is noted that the bottom sediments of the settling ponds in the mining industry also contain a lot of different strategic elements, such as zinc, lead, copper, chromium. These accumulations are typically localized at the lowest point of the pond.

Studies of the composition of waste dumps and tailings storage facilities are conducted over the past decades all over the world. Almost all of them reported the presence of useful components, such as iron, aluminum, copper, cobalt, vanadium, manganese, rare earth elements, and others. Content of a specific component depends on the type of the mined mineral and the geological structure of the massif with the natural mineral bedding.

Research in [17] shows that volume of mining industry waste is 97–100% of the volume of processed raw materials, that is, approximately 1 ton of tailings is generated per 1 ton of processed ore. As a result, 10–14 billion tons of tailings are produced worldwide annually. Even in the absence of precise data on accumulated waste volumes, it is possible to estimate an approximate amount of accumulated mining waste in the world and to predict the reserves of useful elements in them based on the data on mineral extraction.

The purpose of this article is to study all accumulated mining waste in Ukraine and to estimate the probable resources of useful components they contain.

2. Methods

Statistical research methods were applied in this study.

3. Results and discussion

The information on technogenic massifs was primarily obtained from data of the Ministry of Environmental Protection and Natural Resources of Ukraine.

A total 1,050 objects containing waste from the mining and processing industry and thermal power plants were identified. Some of them are operating, some are preserved. There are also sludge storage facilities and waste dumps that are being developed to obtain useful components, though they are not completely liquidated.

Table 1 shows the distribution of technogenic objects by administrative units of the country, their total area and volume.

Table 1 – General characteristics of technogenic objects by administrative units Ukraine

Administrative units Ukraine	Number of technogenic objects	Volume, t	Area, ha	% area of all objects	% of total waste volume
AR Crimea	5	2,529,579	4,128.42	10.81	0.0779
Vinnytsia oblast	2	14,465,760	188.00	0.49	0.1583
Volyn oblast	13	61,185,346	133.04	0.35	0.3295
Dnipropetrovsk oblast	95	12,343,160,062	17,182.3	45.00	66.4679
Donetsk oblast *	416	1,565,729,791	4,719.01	12.36	8.4314
Zhytomyr oblast	26	71,474,465	67.748	0.18	0.3849
Zakarpattia oblast	0	0	0	0.00	0.0000
Zaporizhzhia oblast	15	53,148,314	444.9	1.17	0.2862
Ivano-Frankivsk oblast	17	40,258,992.5	424.289	1.11	0.2168
Kyiv city	3	161,600.42	15.3702	0.04	0.0009
Kyiv oblast	2	28,579,529	131.32	0.34	0.1539
Kirovohrad oblast	21	745,835,374.9	1,992.4	5.22	4.0163
Luhansk oblast	264	649,068,022.8	2,385.013	6.25	3.4952
Lviv oblast	17	152,867,995.4	800.46	2.10	0.8232
Mykolaiv oblast	7	47,522,848.19	354.014	0.93	0.2559
Odesa oblast	0	0	0	0.00	0.0000
Poltava oblast	56	2,712,793,103	4,564.25	11.95	14.6084
Rivne oblast	2	15,510,184	69.1	0.18	0.0835
Sumy oblast	77	542,252.6	21.86	0.06	0.0029
Ternopil oblast	0	0.0	0.0	0.00	0.0000
Kharkiv oblast	3	34,168,234	231.3	0.61	0.1840
Kherson oblast	4	8,380.13	225.66	0.59	0.0000
Khmelnytskyi oblast	3	6,436.6	8.448	0.02	0.0000
Cherkasy oblast	2	656,570.646	24.95	0.07	0.0035
Chernihiv oblast	3	3,576,010	71.8156	0.19	0.0193
Chernivtsi oblast	0	0	0	0	0
In total	**1,053**	**18,570,119,981**	**38,183.67**	**100.00**	**100.00**

Note: * In the Donetsk oblast, area and volume of the stored mineral raw materials were not determined for about half of the technogenic objects

As it can be seen in Table 1, the greatest number of technogenic objects are located in the Luhansk and Donetsk oblasts, 264 and 416 objects, respectively, in the Sumy and Dnipropetrovsk oblasts, 77 and 95 objects, respectively. Other oblasts of Ukraine have significantly fewer such objects.

The largest technogenic objects in terms of area are located in the Dnipropetrovsk oblast, their total area reaches almost half of the area of all technogenic objects in Ukraine

A significant area is also occupied by technogenic objects in the Donetsk and Poltava oblasts, the Autonomous Republic of Crimea, the Luhansk and Kirovohrad oblasts.

More than 66% of the stored mining industry waste (by mass) is located in the Dnipropetrovsk oblast. The Poltava oblast holds 14.6%, Donetsk – 8.4%, Kirovohrad – 4%, in Luhansk – 3.5% of all waste by mass. In the rest oblasts, it is less than 1%.

As it is already mentioned, technogenic objects are of different types such as waste dumps, sludge storage facilities, ash dumps, sludge pits, small-scale accumulation facilities, slag storage facilities, settling ponds.

Each type of technogenic objects was assigned to groups according to the type of minerals, during the extraction/enrichment of which the object was formed (Table 2).

Table 2 – Distribution of technogenic objects by type of minerals, during the development / enrichment / use of which the object was formed

Type of mineral	Sludge storage facilities	Dump	Ash dumps	Small-scale accumulation facilities	Settling ponds	Sludge pits	Storage	Total
TTP	6	-	44	-	1	-	0	51
Tuclear power plants	3	-	-	-	-	5	-	8
Coal	80	558	-	-	23	-	-	661
Iron ore	11	46	-	-	-	-	-	57
Peat	-	-	2	-	-	-	-	2
Gas and oil	8	--	-	128	-	-	-	136
Manganese	9	-	-	-	-	-	-	9
Titanium	3	-	-	-	-	-	-	3
Uranus	11	6	-	-	1	-	2	20
Flux	2	27	-	-	2	-	-	31
Mercury	-	3	-	-	-	-	-	3
Graphite	2	1	-	-	-	-	-	3
Alumina	2	-	-	-	-	-	-	2
Polymineral	1	1	-	-	-	-	-	2
Building materials	10	49	-	-	-	-	-	59
Phosphogypsum	-	6	-	-	-	-	-	6

The table 2 shows that 63% of technogenic objects were formed as a result of coal mining and enrichment, 13% – during oil and gas production, 5.6% – during building mineral mining, 5.4% – during iron ore extraction. About 5% of technogenic objects were formed during coal combustion at thermal power generating and distributing plants.

By type of the objects, the majority are waste dumps, totaling 697. Besides, there are also many sludge storage facilities in Ukraine totaling 148.

The total area and volume of accumulated waste were determined for different types of objects shown in Table 2 (Tables 3–4).

The largest area is occupied by technogenic objects formed as a result of iron ore extraction and enrichment – 17,583 hectares or 51.6% of the area occupied by all technogenic objects in Ukraine. Technogenic objects for the coal mining and enrichment occupy 5,816 hectares or 17.1% of the area of all technogenic objects. Significant areas are also occupied by the objects for coal combustion at thermal power plants and manganese enrichment, respectively 10.6% and 6.6% of the area of all technogenic objects.

Sludge pits formed as a result of drilling wells for gas and oil occupy a small area. The area of one sludge pit typically is within 0.01–0.2 hectares, though a few larger pits, such as those at the Bugruvate and Anastasivske fields in the Romny region of the Sumy oblast, reach about 1.0 hectare and were formed as a result of drilling wells No. 553, 530, 163. However, all sludge pits fall into the Environmental Hazard Category B – dangerous. Besides, once sludge is deposited, the pits are no longer in use and, therefore, all are closed. Each sludge pit contains between 250 and 3,000 tons of sludge. Almost all sludge pits in Ukraine are open, excavated and of mixed type depending on the type of material stored.

By type of objects, the largest area is occupied by rock waste dumps and sludge accumulation facilities – 49.4% and 36.9% of the area of all objects, respectively.

The largest sludge storage facilities are tailings storage facilities for iron and manganese ore enrichment waste.

Figures 2–3 show characteristics of storage sites for iron and manganese ore enrichment waste (sludge, tailings).

A comparison of manganese ore sludge storage facilities and iron ore tailings storage facilities shows that the latter are larger both in terms of the stored waste volume and area. In terms of amount of the stored waste, the largest is the tailings storage facility of the Ingulets Mining and Processing Plant, which contains almost 1.2 billion tons of enrichment tailings. Among manganese ore sludge storage facilities, the largest in terms of amount of the accumulated waste is the tailings storage facility in the Morozov ravine operated by the Marganets Mining and Processing Plant.

In terms of area, the largest iron ore tailings storage facilities are in the Velyka Lozuvatka ravine (the Central Mining and Processing Plant), in the Petrykov ravine (the Northern Mining and Processing Plant) and at the Poltava Mining and Processing Plant. The Ob'yednane tailings storage facility is being developed – construction of the Second section has been completed, and the Third section is in progress. The total area of the tailings storage facilities of the Ob'yednane Second section is 513.82 hectares, area of the Third section is not yet known.

Table 3 – The total area of all technogenic objects by it types and type of minerals

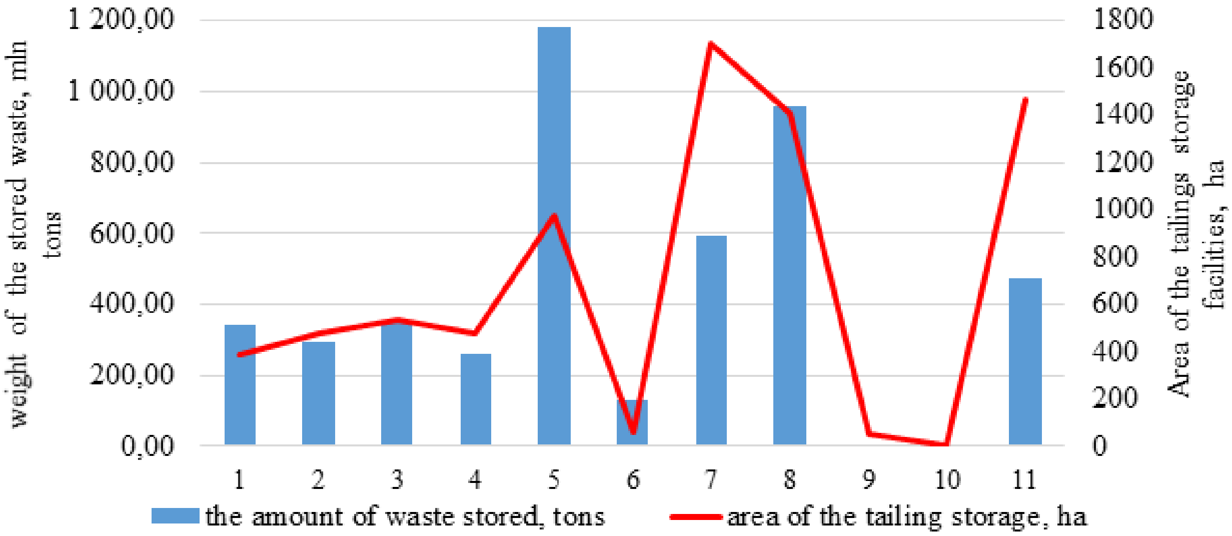
Type of mineral	Sludge storage facilities	Dump	Ash dumps	Small-scale accumulation facilities	Settling ponds	Sludge pits	Storage	Total
Thermal power generating and distributing plants	3.828	-	3624,207	-	n/a	-	0	3628.035
Tuclear power plants	7.118	-	-	-	-	17.944	-	25.062
Coal	1068.303	4397.185	-	-	350.9	-	-	5816.388
Iron ore	7552.55	10030.3	-	-	-	-	-	17582.85
Peat	-	-	2	-	-	-	-	2
Gas and oil	8.5722	-	-	58.3	-	-	-	66.8951
Manganese	2246.739	-	-	-	-	-	-	2246.739
Titanium	40.42	-	-	-	-	-	-	39.68
Uranus	646.81	41.2465	-	-	614.94	-	0.215	1303.212
Flux	n/a	1301.9	-	-	n/a	-	-	1301.9
Mercury	-	n/a	-	-	-	-	-	0.0
Graphite	315.5	109	-	-	-	-	-	424.5
Alumina	338	-	-	-	-	-	-	338
Polymineral	242.5	n/a	-	-	-	-	-	242.5
Building materials	112.73	636.338	-	-	-	-	-	749.068
Phosphogypsum	-	312.8095	-	-	-	-	-	312.8095

Note: n/a - no data available

Table 4 – The total volume of all technogenic objects by it types and type of minerals

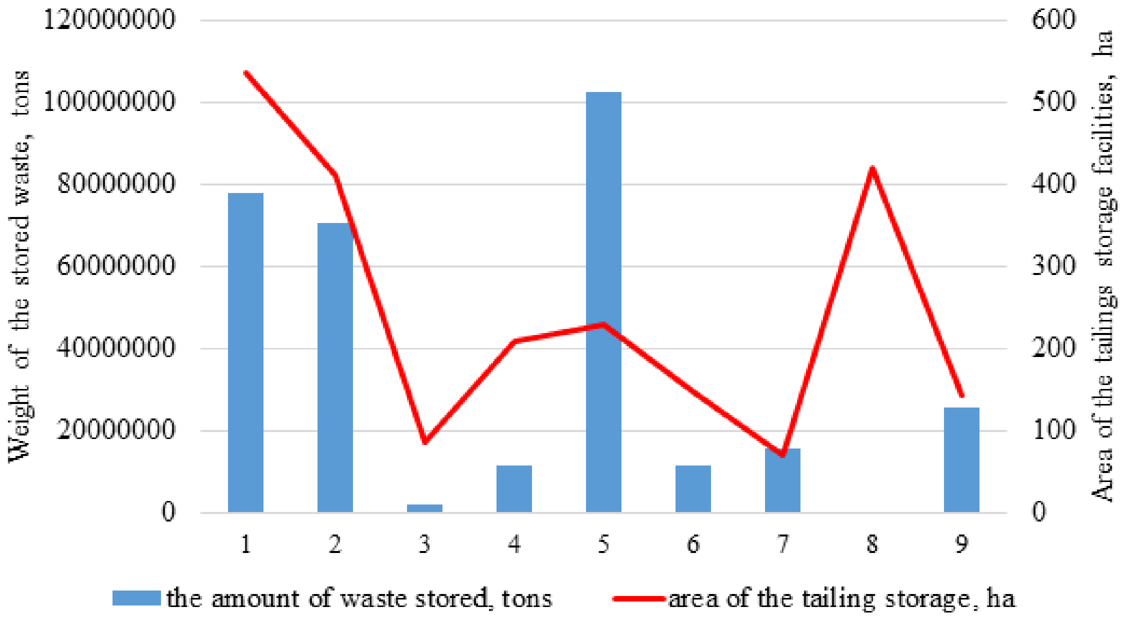
Type of mineral	Sludge storage facilities	Dump	Ash dumps	Small-scale accumulation facilities	Settling ponds	Sludge pits	Storage	Total
Thermal power generating and distributing plants	1464936.9	-	467699579	-	-	-	0	469164515.9
Tuclear power plants	110426.6	-	-	-	-	483705.1	-	594131.7
Coal	144693127	1716054150	-	-	4368727	-	-	1865116004
Iron ore	4590383453	10288307278	-	-	-	-	-	14878690731
Peat	-	-	37660	-	-	-	-	37660
Gas and oil	161172.7	-	-	1348270	-	-	-	1509442.7
Manganese	316294039	-	-	-	-	-	-	316294039
Titanium	59920754	-	-	-	-	-	-	1289754
Uranus	88873585	8378623	-	-	27487000	-	3479.45	124742687.5
Flux	n/a	578209700.4	-	-	n/a	-	-	578209700.4
Mercury	-	n/a	-	-	-	-	-	0
Graphite	15455496	147816636	-	-	-	-	-	163272132
Alumina	47039153	-	-	-	-	-	-	47039153
Polymineral	3742320	n/a	-	-	-	-	-	3742320
Building materials	26629068	88359652	-	-	-	-	-	114988720
Phosphogypsum	-	18351921	-	-	-	-	-	18351921

Note: n/a - no data available



1 – The Ob'yednane tailings storage facility. IV section; 2 – The Myrolyubivske tailings storage facility; 3 – The Voykovo tailings storage facility; 4 – The Ob'yednane tailings storage facility. I section; 5 – The tailings storage facilities at the Inhulets Mining and Processing Plant; 6 – The tailings storage facilities in Rozbery ravine; 7 – The tailings storage facilities in Velyka Lozuvatka ravine; 8 – The tailings storage facilities in Petrykov ravine; 9 – The Tsentralne tailings storage facility; 10 – The temporary tailings storage facilities at the ArcelorMittal Kryvyi Rih; 11 – The tailings storage facilities at the Poltava Mining and Processing Plant

Figure 2 – Characteristics of iron ore tailings storage facilities



1 – Sludge storage facility at the Chkalovsky concentrator; 2 – The tailings storage facility to the Kryvi Luki tract; 3 – The ravine Svynarevsky tailings storage facility; 4 – The ravine Suhyi Chortomlyk tailings storage facility; 5 – The tailings storage facility in the Morozov ravine; 6 – The tailings storage facility in the Baburina ravine; 7 – The tailings storage facility in the Berehove ravine; 8 – Sludge storage facility of the Central Processing Plant in the floodplain of the Tomakivka River

Figure 3 - Characteristics of manganese ore sludge storage facilities

However, the total area of the Ob'yednane tailings storage facility (of all four sections) can be up to 2 thousand hectares. The photo in Fig. 4 shows the condition of the Ob'yednane tailings storage facility during the construction of the Second section, and the photo in in Fig. 5 – tailings storage facility at the Northern Mining and Processing Plant.

Figure 4 – Photo of the Ob'yednane tailings storage facility (A. Novak, 2021)

Figure 5 – Photo of the tailings storage facilities in Petrykov ravine
(the Northern Mining and Processing Plant)

The Kryvbas tailings storage facilities are also characterized by the high dams – ranging from 25 m (tailings storage facilities in Lozuvatka ravine) to 112 m (tailings storage facilities at the Inhulets Mining and Processing Plant).

The sludge storage facilities at coal industry enterprises are significantly smaller in size. For example, the tailings storage facility at the Pavlohrad Central Processing Plant, which served 10 mines, has an area of only 120 hectares.

Tailings storage facilities vary in structure and heights, which affects the area they occupy and the amount of waste they can contain.

By mass, the largest amount of accumulated waste comes from iron ore extraction and enrichment – 80% of all accumulated waste. Mass of waste from coal mining and enrichment is 10% of all accumulated waste, 3% is occupied by waste from flux extraction, 2.5% – by waste from coal combustion at thermal power plants, 1.7% – by waste from manganese processing. All other waste is less than 1% by mass in the total volume of all technogenic objects in the mining industry.

By type of technogenic objects, the largest waste mass is contained in waste dumps (69.1%) and sludge accumulation facilities (28.2%).

The operational lifespan of a sludge storage facility depends primarily on its capacity, as its dimensions are limited. In production, due to the lack of additional areas for new sludge accumulation facilities, companies either increase the height of the dams to expand capacity or undertake the dam clearing.

Due to the imperfection of technological processes, a part of useful minerals enter the waste, the amount of which depends on the type of the process, its technological level, the ability of minerals to be enriched, and the complexity of a mineral extraction from the host rocks. Besides, the enrichment sludge (tails) usually contains valuable by-product raw materials (both ore and non-ore).

As a result, in the process of formation of a dump or filling of a sludge accumulation facilities and due to the segregation of waste particles, mineral raw materials of a certain granulometric composition are concentrated. The areas with concentration of technogenic raw materials constitute a technogenic deposit.

Clearing of a sludge storage facility not only frees up capacity for storing newly formed waste, but also increases the resource intensity of production through the reprocessing the waste and extracting the useful components.

According to the results of own research conducted at various technogenic objects in Ukraine, as well as data from other scientists [15–16, 18–23], the average content of useful components in technogenic objects of the mining industry was established by their types. Using the data from Table 3 and the content of specific useful components, their probable resources were calculated (Table 5).

As the obtained data (see Table 5) show, resources of iron, aluminum and coal constitute the largest mass among the technogenic resources. However, the greatest interest lies in the resources of strategic minerals, the reserves of which in Ukraine are limited, and their extraction from technogenic objects could cover the country's needs for raw materials.

Table 5 – Probable mineral resources in technogenic objects of Ukraine

Element name	Resources in different types of technogenic objects, thousand tons												
	Alumina sludge storage facilities	Uranium sludge storage facilities	Titanium sludge storage facilities	Mercury mining wastes	Zinc processing waste	Graphite sludge storage facilities	Iron ore dumps	Iron ore sludge storage facilities	Coal sludge storage facilities	Coal dumps	Ash and slag dumps	Manganese sludge storage facilities	Total
Al	9,407.831	-	-	-	-	-	-	-	-	257,408.122	102,893.907	1,581.470	371,291.3
Fe	2,4930.751	-	-	-	-	-	823,064.582	596,749.849	-	257,408.122	51,446.954	3,162.940	1,756,763
Ti	2,257.879	-	59.921	-	-	-	-	-	-	-	5,144.695	-	7,462.495
V	70.559	-	-	-	-	-	6,172.984	642.654	43,407.94	-	140.310	-	7,069.915
Sc	2.822	-	-	-	-	-	-	-	-	-	14.031	-	16.85334
Zr	-	-	11.984	-	-	-	-	-	-	-	46.770	-	58.75411
Cr	-	-	-	-	-	-	-	-	-	-	33.674	-	33.67437
Ge	-	-	-	-	-	-	-	45.904	0.724	94.383	-	-	141.0103
Ga	1.176	-	-	-	-	-	-	-	-	171.605	-	-	172.7814
S	-	-	-	-	-	-	-	-	-	34.321	4,676.996	-	4,711.317
Ca	3,763.132	-	-	-	-	-	-	-	-	-	14,030.987	31,629.404	49,423.52
Mg	141.118	-	-	-	-	-	-	-	-	-	-	31,629.404	31,770.52
Gr	-	-	-	-	-	772.775	-	-	-	-	-	-	772.7748
Mn	658.548	-	-	-	-	-	-	-	-	-	935.399	63,258.808	64,852.76
Au	-	-	-	-	-	-	-	4.590	-	-	-	-	4.590
W	-	-	-	-	-	-	-	22.952	-	-	-	-	22.952
Ag	-	-	-	-	-	-	-	13.771	-	-	-	-	13.771
Cu	-	-	-	-	8.0	-	1,028.831	-	-	-	93.540	-	1,130.371
Ni	-	-	-	-	-	-	1,028.831	-	-	-	46.770	-	1,075.601
Zn	-	-	-	-	24.0	-	3,086.492	-	7.958	-	140.310	-	3,258.76
FeTi	-	-	125.834	-	-	-	-	-	-	-	-	-	125.834
Hg	-	-	-	2.682	-	-	-	-	-	-	0.136	-	2.818
Sb	-	-	-	35.770	-	-	-	-	4.341	-	-	-	40.111
U	-	13,331.038	-	-	-	-	-	-	-	-	-	-	13,331.04
Cd	7.056	-	-	-	-	-	-	-	-	-	-	-	7.056
As	-	-	-	-	-	-	-	-	10.129	-	2.432	-	12.561
Pb	-	-	-	-	-	-	-	-	11.575	-	-	-	11.575
Nb	-	-	-	-	-	-	-	-	-	-	46.770	-	46.770
C	-	-	-	-	-	-	-	-	28,938.625	171,605.415	140,309.874	-	340,853.9
Li	-	-	-	-	-	-	-	-	9.405	-	-	-	9.405

4. Conclusions

According to the results of the study, totally 1,053 technogenic mining objects were identified, which unevenly distributed across the territory of Ukraine – the largest number of them are in the Donetsk, Luhansk, Sumy and Dnipropetrovsk oblasts. The area and volume of the stored waste were determined for each of the objects, which made it possible to estimate the total area of such objects by administrative units, by type of objects and by type of mineral. The largest both in terms of area and mass of the stored waste are tailings storage facilities, which were formed as a result of iron ore enrichment, therefore, despite their small number in the Dnipropetrovsk oblast, the largest volume of mining waste is stored here. Iron ore tailings storage facilities are also the highest among the liquid-based technogenic facilities in Ukraine, making them a constant source of risk for developing a potential emergency.

Based on the previously established mass content of useful components in waste dumps and tailings storage facilities, their probable resources were determined. Due to the fact that most technogenic objects contain iron, its technogenic resources are the largest (66% of all technogenic resources of various minerals). Aluminum and coal are also among the largest among technogenic resources.

Of greatest interest are technogenic minerals, the natural reserves of which in Ukraine are absent or limited: aluminum, vanadium, tungsten, gallium, lithium, arsenic, copper, niobium, antimony, lead, zinc, chromium.

The results obtained will serve as a basis for justifying the feasibility of extracting useful components from the technogenic objects.

Conflict of interest

Authors state no conflict of interest.

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СУЧАСНИЙ СТАН РОЗМІЩЕННЯ ТА ЙМОВІРНІ ЗАПАСИ МІНЕРАЛЬНОЇ СИРОВИНИ В ТЕХНОГЕННИХ ОБ'ЄКТАХ ГІРНИЧОЇ ПРОМИСЛОВОСТІ УКРАЇНИ

Бубнова О., Міщенко Т., Буняєва І.

Анотація. В статті на підставі даних офіційних джерел розглянуто розташування та кількість техногенних об'єктів гірничодобувної промисловості, до яких відносяться відвали, шламонакопичувачі, ставки-відстійники. Також в аналіз додано ТЕС та заводи з переробки імпортованої мінеральної сировини, оскільки їх відходонакопичувачі за своєю суттю схожі з відходами добувного комплексу. Встановлено наявність 1053 техногенних об'єктів, більшість яких розташована в Донецькій та Луганській областях. В якості основних характеристик обрано площа, яку займає кожен з об’єктів, та об’єм накопичених в ньому відходів, що дало змогу дослідити накопичення відходів різних типів по адміністративних одиницях України та відповідно техногенне навантаження в них. Встановлено, що більш ніж 66% маси всіх відходів гірничодобувної промисловості знаходяться в Дніпропетровській області.

В статті наведено порівняння найбільших техногенних об’єктів гірничодобувної промисловості України.

Для більш детального аналізу виконано розподілення техногенних об’єктів по типам складування в них сировини та по типах корисних копалин, внаслідок розробки, збагачення або переробки яких вони утворились. Встановлено, що 63% техногенних об’єктів в Україні утворились при розробці та збагаченні вугілля. За типом складування найбільше насипних техногенних об’єктів (відвалів).

За результатами власних експериментальних досліджень та досліджень інших науковців визначено вміст корисних компонентів в різних типах техногенних об’єктів, що дало змогу розрахувати ймовірні ресурси мінеральної сировини.

Встановлено, що за деякими корисними копалинами, техногенні об’єкти можуть слугувати єдиною сировинною базою країни, оскільки їх природні запаси відсутні (непідтверджені) або обмежені, наприклад вольфрам, галій, літій, ніобій, сурма, хром. Найбільш багатими на різні типи корисних компонентів є золошлаковідвали ТЕС, а за масою ресурсів – відвали залізорудні та вугільні.

Отримані результати слугуватимуть основою обґрунтування необхідності та економічної доцільності розбиранні відвалів та розробки хвостосховищ з метою вилучення з них корисних компонентів та задля зниження техногенного навантаження на довкілля.

Ключові слова: техногенні родовища, відвали, хвостосховища, мінеральна сировина, ресурси