

## THE METHODOLOGY FOR DESIGN OF INFORMATIONAL AND ANALYTICAL SYSTEM FOR ENVIRONMENTAL MONITORING OF MINING AND CHEMICAL ENTERPRISE IN THE LIQUIDATION

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**Abstract.** The impact of the mining and chemical enterprise on the state of pollution of the environment was assessed in the paper. The need to design an informational and analytical system for monitoring the territory of Rozdil state mining and chemical enterprise (SMCE) “*Sirka*” at the stage of the liquidation was proved. It was established that it is necessary to create an informational and analytical system of environmental monitoring, which will increase the ecological safety of the territory of the enterprise and the surrounding settlements.

**Key words:** informational and analytical system, mining and chemical enterprise, environmental monitoring, heavy metals

### Introduction

Lviv region is the most powerful mining region in western Ukraine. There are more than 620 deposits of various minerals on its territory, of which 247 deposits are exploited. The region mines and enriches coal, oil, gas, native sulfur, potassium salts and many other minerals.

The long-term raw material and energy specialization, as well as the low technological level of industry in Lviv region, brought it into the list of areas with the largest absolute amounts of generation and accumulation of waste. Therefore, the domination of waste that was formed during the development of deposits is sharpening. A significant amount of total volume is also the waste of chemical processing of raw materials, various in properties and in chemical activity.

Industrial waste contains a significant proportion of waste which is received resulting from the physical and chemical processing of mining raw materials. Contaminated with chemical reagents and products of

their interaction with ore, they pose a greater threat to the environment and belong to II-III classes of danger. Among them are flotation tails of sulfur ores, tails and sludge of processing polymineral ores and coal enrichment.

The volumes of hazardous waste generation are not a characteristic feature, since industrial production, in particular, mining chemistry and chemistry in general, which until recently has gave the bulk of industrial waste (90 %), has reduced its activity in several times and today is not decisive.

According to the volume of waste generation, the main ones in the region are oil-extracting and processing enterprises. All other industrial waste in the majority is a consequence or result of previously activity enterprises.

According to the location of industrial waste, the territory of the Rozdil state mining and chemical enterprise (SMCE) “*Sirka*” – there are more than 96 million tons, Stebnyk SMCE “*Polymineral*” – there are 15 million tons, and state enterprise “*Lvivvugillya*” and CJSC “*Lvivsystemenergo*” – there are more than 250 million tons.

The most complex and voluminous group is the classical waste of the mining and chemical industry (tailings flotation of sulfur ores, waste from processing of polymineral ores – there are sludges, tails, as well as phosphogypsum – this is waste processing of apatite concentrate).

These wastes are typical of mining chemistry, as envisaged by the technological regulations and are problems for most of the similar enterprises in the world. Long-term research are conducted at many of them, it was developed a number of technologies for their disposal. In some countries, they have been successfully solved (Japan, Italy, Germany, etc.), while in others are being solved.

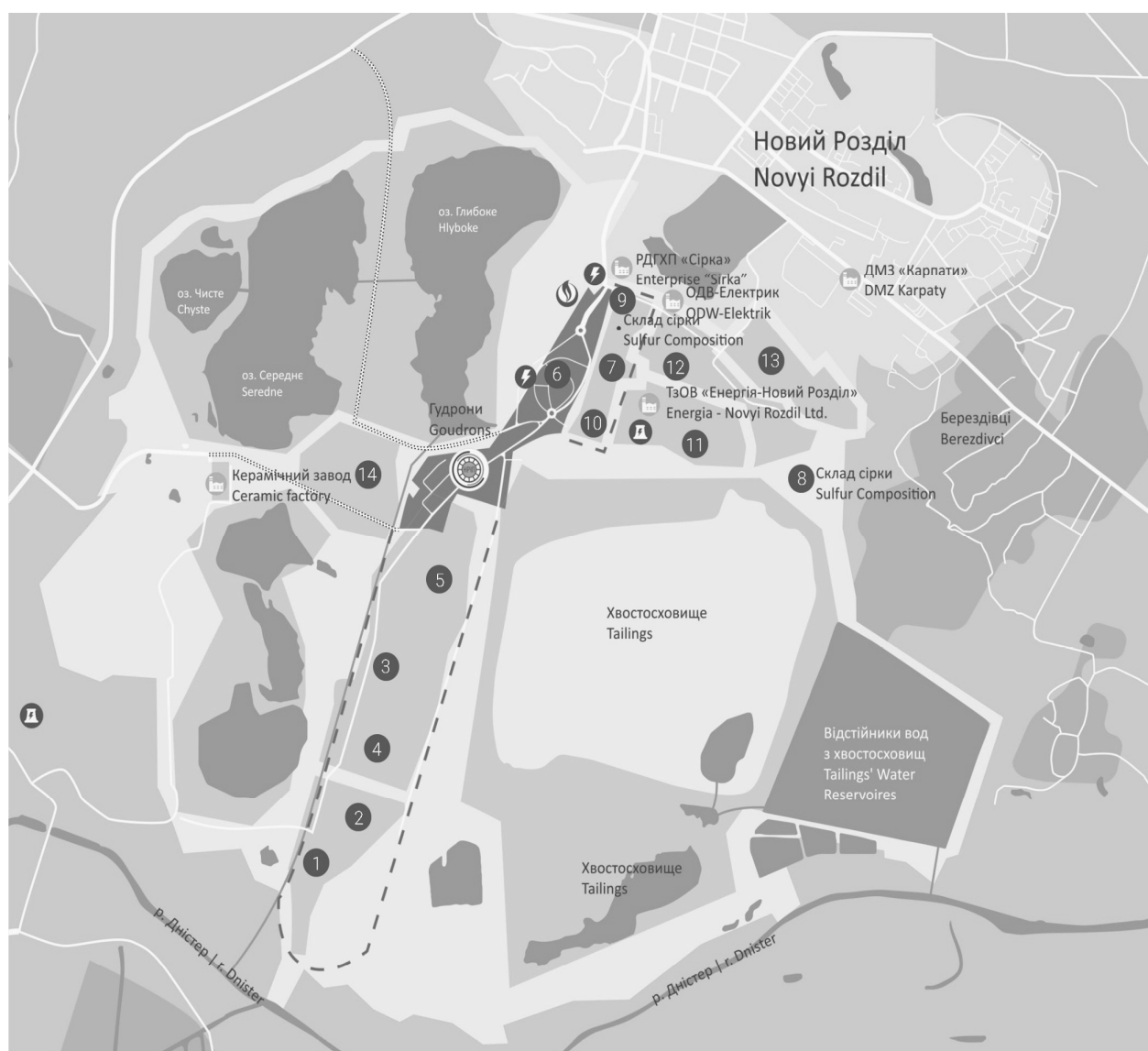
Although the total volumes of mining of mineral resources in Lviv region have significantly decreased in recent years, many mining and extractive enterprises have been closed or conserved, but the ecological situation within the mining industry has not significantly improved. This is due to insufficient attention to the issues of cadastre, monitoring and reclamation of territories affected by mining developments. As a result, levels of environmental pollution are increasing, dangerous natural and man-made processes, such as subsidence, flooding, karst, linear erosion, etc., are intensifying, which ultimately leads to a deterioration of the landscape and ecological situation in the region [1-3].

## Materials and methods

An example is Rozdil SMCE “Sirka” (Fig. 1). Large-tonnage wastes like phosphogypsum (over 3 million

tons) were formed on its territory in connection with the production of mineral fertilizers for 22 years (from 1974 to 1996), and also there are about 60 million t of sulfur ore tailings on the territory of the enterprise. In addition, on the territory of the enterprise 17,195 tons of “MG” type modifiers, made from neutralized tar residues and residues boiler anhydrite maleic acid were imported from Hungary. The wastes contain heavy metals that migrate in the soil and the water environment. Currently, the enterprise does not work and is in the stage of the liquidation. It poses an environmental hazard to the Dniester River and surrounding settlements.

**The purpose of the work** is to develop methodological approaches for the design of an informational and analytical system for monitoring the territory of Rozdil SMCE “Sirka” in the liquidation.



**Fig. 1.** The territory of Rozdil state mining and chemical enterprise “Sirka”

## Results and discussions

Disturbance of the ecological balance from the influence of the activity of the mining and chemical enterprise leads to the emergence of geochemical anomalies of anthropogenic origin. There arise areas of increased concentration of individual chemical elements and their compounds in the zone of influence of the mining and chemical enterprise. The influence of geochemical anomalies on the environment has mostly local nature with radius of pollution spreading up to 2–3 km. However, in some cases, this effect can be appreciable at a distance of 5–10 to 50 km [4]. Fig. 2 demonstrates the environmental problems that arise on the territory of the mining enterprise, which is the result of the joint activity of many natural and man-made factors.

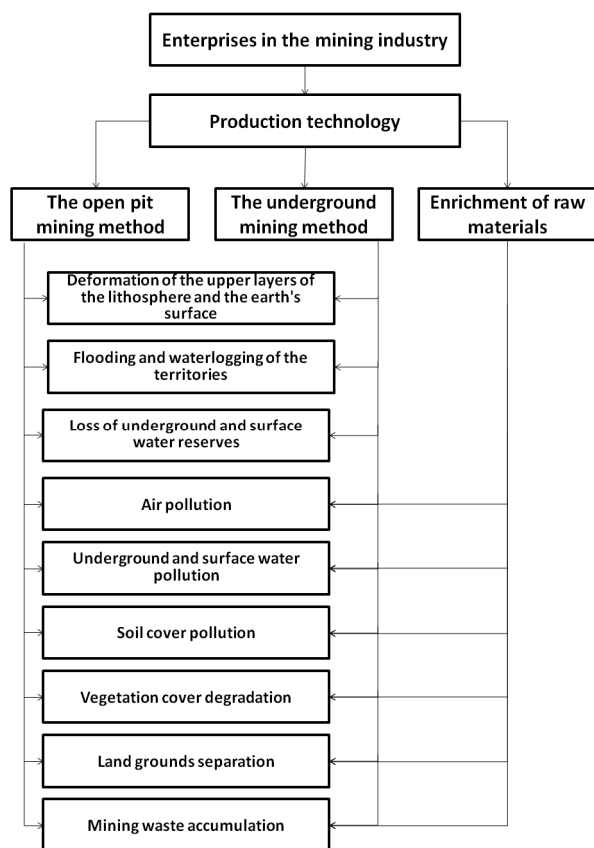


Fig. 2. Environmental problems that arise on the territory of the mining enterprise [4]

The design of an informational and analytical monitoring system, which is set of targeted measures for the accumulation and efficient use of varied information, is the necessary organizational, methodological and material and technical basis for the management of the processes of formation and

development of the natural and man-made system of the mining and chemical enterprise. The structure of this system is realized through the direct collection of information, the use of its initial types of evaluation of the status of objects and the solution of the problems of regulation and effective management of processes that are formed. On the basis of the informational and analytical system, the tasks are solved: optimal valuation, rational planning, as well as operational and long-term prediction of system state indicators.

The control of the state of the mining and chemical enterprise at the stage of the liquidation is a set of targeted measures that allow prevent the development of dangerous geological, physical and geochemical processes. The procedure for assessing the state of the environment within the control system definition is based on a comparison of natural and man-made conditions and factors that allow establish the parameters of stability of the investigated part of the geological space and technogenic situation at the stage of the liquidation.

A number of maps characterizing the state of various environmental elements, in particular, the map of the territory's impact by exogenous geological processes, the map of the assessment of the background environmental impact on the environment, are the cartographic base for the development of a management strategy.

The strategy of control is based on the formulation of a problem that reflects the content of the problem within the studied part of the environment. The main strategic tasks of controlling the territory of the mining industry are, in particular, the study of the development of geodynamic processes with allocation zones of stressed-deformed states of rocks, assessment of the state of the surface and underground hydrosphere, observation and evaluation of geochemical parameters. The decision of the tactical tasks determines the detail of the strategic assessment of the system for choosing the justified conditions of interaction or information cells of the appropriate scale. The actual material that laid down in the development of the tactics of controlled control is the results of geological, hydrogeological and engineering-geological studies.

On the territory of the Rozdil SMCE "Sirka" the problems that are indicated in the figure constitute a threat to the territory, surrounding settlements and the Dniester River. Fig. 3 demonstrates the main sources of environmental hazard of Rozdil SMCE "Sirka". In addition to the depicted sources, there is a landfill of solid household wastes on the territory, the infiltration of

which is distributed by groundwater and water environments.

It is necessary to create an informational and analytical monitoring system since the enterprise is in the liquidation, but still poses a threat to the environment. It is necessary to consider the organization of the monitoring system of mining objects depending on the types of influence on the sources of environmental impact, since each source

may have several types of influence on the elements of the biosphere.

The informational and analytical monitoring system of the Rozdil state mining and chemical enterprise "Sirka" is intended for analysis of the state of:

- soils;
- industrial waste;
- geophysical processes;
- water objects.

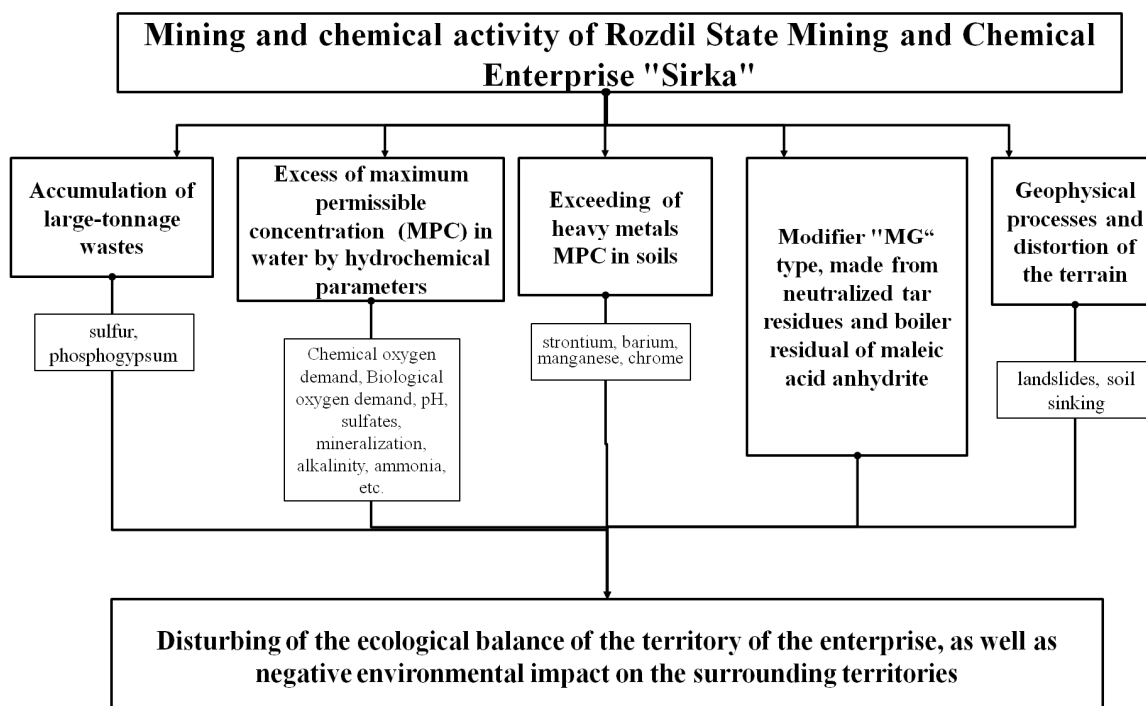


Fig. 3. The main sources of environmental hazard of Rozdil SMCE "Sirka"

The subsystem of environmental monitoring of soils of the Rozdil SMCE "Sirka" will allow responding in a timely manner to adverse changes in the composition of the soils of the territory, to predict and simulate the process of migration of heavy metals in soils, and to reduce the area of pollution (Fig. 4).

Soils, industrial waste, geophysical processes (landslides, flooding, waterlogging and subsidence) are objects of soil monitoring and geological and hydrological environment.

The monitoring of the industrial waste of an enterprise should provide information on the formation, availability, disposal and use of industrial waste. Information on the composition and hazard of waste for environmental elements is also important.

The analysis of the composition and content of industrial waste from Rozdil SMCE "Sirka" was performed in work [5].

The priority direction is the remote research methods, which allow, through aerospace surveys of the earth's space, to obtain a picture of the ecological and geological state of the territories [6–9].

The results, what was done in 2015, of hydrochemical monitoring of lakes Serebnie, Hlyboke, Chyste and Kysle indicate that in the surface layer of these lakes and the leakage from Hlyboke, are excess of normative indicators for mineralization and sulfates, in the lake Serebnie for phosphates [10]. The chemical analysis of the waters flowing along the canal from Hlyboke Lake in the Dniester was made only once in July, although the mineralization of water was 2.4 MPC, sulfates 3 MPC, hydrogen sulfide was in amount 21.5 mg /l (it should not be at all). There are no measures to prevent the pollution of the Dniester River.

Environmental monitoring of water objects of the enterprise territory analogous to the system of ecological monitoring of soils and should be based on:

- sampling;
- data collection;
- analysis of the existing complex of environmental measures to reduce the level of water bodies pollution;
- detection of sources of water bodies pollution;
- assessment of the ecological state of water objects;
- prediction of the process of water bodies pollution and ecological balance disturbance;
- design of informational and analytical or geo-information system of monitoring;
- developing measures to improve the ecological state and restore ecological balance.

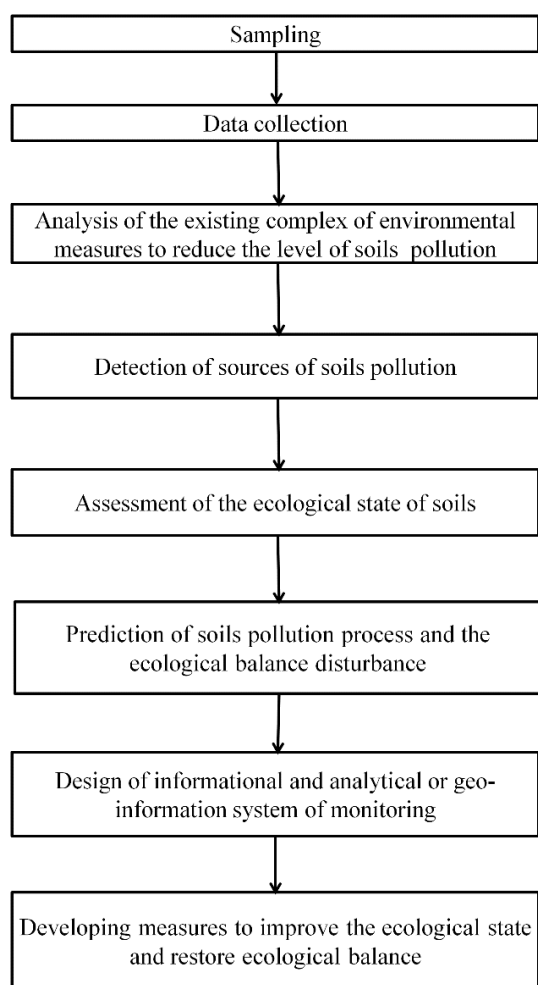


Fig. 4. The procedure of ecological monitoring of soils

The informational and analytical system of water objects of the mining and chemical enterprise in the liquidation makes it possible:

- formation of state information resources for the registration of water objects for further analysis, prediction and development of managerial decisions;

- timely detection of negative changes of the state of water objects;

- simple access to information on the status of water bodies [11].

In addition, the design of the informational and analytical system of environmental monitoring of the Rozdil state mining and chemical enterprise “Sirka” will provide:

- raising the level of exploring and knowledge about the ecological state of the territory;
- promoting the operation and quality of information provision of interested users at all levels;
- reliable and qualitative substantiation of environmental measures and increase of efficiency of their implementation;
- prediction environmental changes;
- increase of the state of ecological safety of the enterprise and adjoining territories.

Creation of such a system is an important step to increase the ecological safety of the territory, because timely information about the ecological state provides a timely solution to the problem with minimal risks and consequences.

At present, the theoretical and methodological approaches to environmental monitoring of a mining enterprise in the liquidation stage, as well as its material and technical and financial support have not been developed. This problem is only at the initial stage of the solution. The need for a scientific substantiation of the monitoring system in the area of former mining activity, where the mosaic of technogenesis is very complex, requires the use of various theoretical positions, concepts and methodological tools, and interdisciplinary studies of various sciences [12–16].

### Conclusion

Restructuring and liquidation of Rozdil state mining and chemical enterprise “Sirka” has been going on for almost 15 years, however, the enterprise remains a source of increased danger to the environment, life and health of people, poses a real threat of man-made and ecological catastrophe and emergencies. The environmental problems of the Rozdil state mining and chemical enterprise “Sirka” were analyzed and the sources of soil and water environment pollution and the accumulation of large-tonnage hazardous industrial waste have been identified, what it confirms the necessity of organizing the informational and analytical system of environmental monitoring. The main stages of the environmental monitoring procedure of the enterprise are formed. It was established that the informational and analytical system of environmental monitoring of Rozdil state mining and chemical

enterprise “*Sirka*” will enable to increase of the state of ecological safety of the enterprise and adjoining territories.

Design this system is a prerequisite for restoring the ecological balance of the territory of Rozdil state mining and chemical enterprise “*Sirka*”.

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