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INFORMATION SUPPORT OF STEBNYK GEOPARK DESIGN

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Abstract. Sustainable development of Stebnyk Mining Industrial Area (MIA) is due to low subsoil use culture, negative impact of mining activities on the environment. Potential danger in the territory of influence of the enterprise is created by underground mine workings which are the centers of formation of karsts, and also a tailings dam. Therefore, the development and application of phytomelioration technologies of the tailings pond to stabilize the environmental situation is relevant.

Keywords: information directions, sustainable development, environmental safety.

1. Introduction

Sustainable development of Stebnyk Mining Industrial Area (MIA) is fully consistent with the goal of the National Program for the Development of the Mineral Resources of Ukraine until 2030. It is ensuring the urgent needs for mineral resources without the risk of depriving future generations of their needs (On Approval of the National Program…, 2011). The triune concept of sustainable development is based on the economic, environmental and social components. For practical implementation of the sustainable development strategy of Stebnyk MIA, it is expedient to design, create and operate Stebnyk natural and man-made geopark based on the domestic (Zinko, Shevchuk, 2011; Mokryi et al., 2017) and European (Alexandrowicz., 2006) experience. Expert assessments of the environment indicate the need to use the information and analytical technologies of management, modelling and design of environmental safety of Stebnyk MIA.

The relevance of the development of marketing and information directions of sustainable development of Stebnyk MIA is due to man-made destabilization of the geological environment. In accordance with the Mining Law of Ukraine (Mining Law of Ukraine, 1999), during the development of minerals, areas and objects must be brought into a state that is safe for people and property and is suitable for the economic use.

The aim is to provide information on the sustainable development strategy of the transformed landscapes of mining operations of potash mineral fertilizers of Stebnyk MIA, the receipt, processing, and storage of environmental and economic information.

The tasks determine the relationship of semantic data on natural and man-made objects, environmentally hazardous processes and phenomena as karst chasms and landslides inherent in the study area.

The methods of the research are based on the systematic scientifically substantiated analysis of theoretical research, generalization and systematization of experimental data, technologies of landscape spatial and temporal forecasting of exogenous geological processes and karst phenomena based on the account of the influence of natural and anthropogenic factors, geo-information technologies, software complexes and tools of the analysis of the proximity of geospatial objects on their development.

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The analysis of the research of ecological problems of mining of potassium mineral fertilizers indicates the existence of a fundamental basis of the phenomenology of environmental safety of mining regions of Ukraine (Rudko et al., 2016). The authors (Rudko, Shkitsa, 2001; Hoshovskyi et al., 2002) summarize the numerical, in-depth and detailed but fragmentary and disparate results of geo-ecological studies of salt-mining industrial complexes of the Precarpathian region. Landscaping, geological, geographic studies of the influence of the mining industry on the environment are devoted to the works of Grodzynskyi M. D., Ivanov Ye. A., Kovalchuk I. P. et al. Problems of ensuring environmental safety at the stage of liquidation of mines of potassium deposits are dedicated to the works of Semchuk Ya. M., Kryzhanivsky Ye. I., Koryn S. C. et al. The works of Rudko H. I., Gaidin A. M., Zozulia I. I., Dyakiv V. O. et al. are devoted to the issues of engineering protection of salt and sulfur deposits of the Carpathian region. Information, software and mathematical support for evaluating the karstic and shift processes induced by mining workings are covered in the works of Adamenko Ya. O., Chepurnyi I. V., Kuzmenko E. D., Ivanik O. M. et al.

The considered works indicate the necessity of an integrated approach to environmental protection in salt-mining industrial complexes, the use of elements of unification and adaptation of technologies of the protection of the natural and man-made environment to real objects. The logical continuation of technological schemes and technical decisions of monitoring, stabilization of technogenesis and ensuring environmental safety, presented in the scientific works, is the development of conceptual foundations of sustainable development of Stebnyk MIA and their implementation by creating a natural and man-made geopark. The network of geoparks is created in 24 countries and comprises 77 objects. The reason for the creation of European geoparks was the implementation of the program of the International Geological Union and the European Association for the Conservation of Geological Heritage on the allocation of geological sites of international importance for the major regions of Europe. The geopark development program was developed by UNESCO in cooperation with the International Union of Geological Sciences and Governmental Institutions and approved at the XXIXth General Conference of UNESCO in March 1999. According to this program, it is foreseen to provide this international status each year to 20 territories that meet the criteria of the new international category of conservation of the heritage. In June 2004, an international network of cowpox was created under the auspices of UNESCO.

2. Results and Discussion

The status of Stebnyk Geopark will attract the attention of entrepreneurs and the public to the value of the natural resources of this region, the need to preserve the geological heritage, the urgency of the preservation and restoration of natural and man-made landscapes, the profitability of production capacities of potash production, which together will positively affect the quality of life of the population. A wide range of investment projects demonstrates that geoparks become business cards of the country's ecological safety, the cult objects of geotourism, successful business projects. The most effective business project is the often visited geotourist object of natural and man-made origin “Welichka salt mine” (Poland).

Presentation of the main material and the substantiation of the received results of the research refer to the complex development of educational and information-analytical methods and technologies for the presentation of the ecological, economic and social basis of sustainable development of Stebnyk MIA. At the present stage, the ecological factor determines the development perspective. The impact of environmental conditions on the development of all components of society without exception has become obvious. Preventing the negative effects of human activities and taking preventive measures to create security for the population and the environment is one of the most important tasks that require serious organizational and managerial costs.

Environmental safety of Stebnyk MIA is due to the negative influence of mining activity on the environment (Rudko, Shkitsa, 2001; Hoshovskyi et al., 2002). The potential danger to the territory of the enterprise is created by underground mining, which is the centre of the karst formation, as well as tailings storage During the extraction of potassium ore, several hundreds of chambers were completed, resulting in more than 30 million m^3 of voids in two mines. The voids were formed at depths from 90 to 370 m, their length is tens of kilometres The voids are separated with an inter-camera partition. Penetration into the water mines leads to the erosion of the partitions. The consequence is the subsidence of the earth's surface and the activation of karst phenomena with rapid development and intensity of manifestation, large areas of distribution and depth, as well as the intensification of landslides, landslips and screes. There are residential buildings of the city of Stebnyk, high-voltage transmission lines, water supply networks of the cities of Drohobych and Truskavets, the national railway of Kyiv-Truskavets and the highway in the zone of influence of underground voids. The underground workings reach the II and III zones of sanitary protection of Truskavets resort. The destruction of waste voids may cause man-made earthquakes up to 7

points, which can cause damage to buildings in the cities of Stebnyk, Truskavets and Drohobych, and destruction of the tailing storage.

Stebnyk tailing storage is intended for the accumulation and storage of a huge quantity of waste of production of potassium-magnesium concentrate. In the tailing storage area, 11.2 million m³ of waste is accumulated in the form of slimes – "tailings", stable fine dispersions. The main components are salt brines, galite and sludge solid wastes, which are formed as a result of the processing of potassium ore. The amount of waste from the production of potassium salts at Stebnyk State Mining and Chemical Enterprise (SMCE) "Polymineral" has reached over 25 million 478 thousand tons (of which 4 million 162 thousand tons is the liquid phase).

Salt dumps and tailing storages remaining after the development of the largest deposits of potassium salts in Ukraine have a negative impact on the state of natural waters. In the settlements located near these facilities, there is a problem with providing drinking water. The impregnation of the crater through the bottom, the sides and the foundation of the tailing storages and infiltration from saline gullies lead to salinization of soils, the growth of the mineralization of surface and groundwater, a significant deterioration of the mining and geological conditions, contributes to the development of salt karsts and the subsidence of the surface over the mining space.

To develop constructive measures to ensure the environmental safety of Stebnyk MIA, it is expedient to develop a system of monitoring karst subsidence and landslide processes. An automated information-analytical monitoring system is offered. It comprises:

1. Network of vibration-seismic sensors for registration of soil landslides;
2. Information and analytical system of data analysis and forecasting of geodynamic processes;
3. Alarm system, operational notification and response.

The task of the monitoring system is to obtain operational spatio-temporal information about the karst and dump-proof processes for the prevention of emergencies, scaling up and consequences.

The use of geo-information systems allows operatively to predict the development of the situation, to provide risk management of possible emergencies by performing functional tasks: technological and geophysical; informational and analytical; operational and managerial.

The economic basis for the sustainable development of Stebnyk MIA is the revival of the potash industry based on PJSC "Stebnyk MCE "Polymineral" for the production of potash fertilizers (Haidin et al., 2015). Location of Ukraine on the combination of geosyncline with the platform resulted in the richness of various minerals: sulfur, stone and potash salts, coal, ozokerite, oil and gas, mineral waters, etc. A salt craft in Stebnyk has been known since ancient times. In the last century, in Lviv, there were powerful mining and chemical enterprises. However, the use of outdated technologies in the new economic conditions, as well as the increase of environmental restrictions, led to unprofitable enterprises.

The variety of the chemical and mineral composition, sparingly soluble or insoluble minerals, along with easily soluble ones, high content of clay admixtures in the Precarpathian ores have caused technological difficulties in their industrial processing. The cessation of potash production is due to the imperfection of mining and chemical technologies, which resulted in low extraction of useful components, inferior quality of products obtained, multi-stage and extremely high energy production. This led to the cessation of the flotation technology at the Stebnyk enterprise (1987). However, the enterprise has a productive potential for economic development. There is a powerful infrastructure: a network of access railroads, highways, concrete frameworks of factories, highly skilled engineering and working personnel.

According to expert estimates, the required amount of potash fertilizers for agrarian production in Ukraine is 1.2–1.5 million tons of active substance (K_2O). Sulfate potassium-magnesium fertilizers, besides potassium, contain magnesium which positively affects the processes of photosynthesis and the formation of hydrocarbons, and sulfur, which is part of plant proteins, enzymes, vitamins, essential oils, and plays an important role in oxidation-reduction processes. There are no alternatives to the use of such fertilizers. However, the restoration of the production of processing of potassium-magnesium sulfate ores to produce non-chloride sulfate potassium-magnesium fertilizers requires the use of the latest environmentally friendly, energy-saving and resource-saving technologies.

The uniqueness of Precarpathian potassium ores is that they contain over 16 potassium and non-calcareous minerals, which enables, in the process of their complex processing, to obtain a wide range of related commodity products: food and technical kitchen salt, magnesium sulfate, bichofit, metallic magnesium, magnesium oxide (magnesia), caustic soda, gaseous chlorine, etc. The scientific basis for the revival of the potash industry in Stebnyk, based on modern energy-saving technologies for the processing of ore and accumulated brine for tailings, is the State Program for the Development of Potash Industry of Ukraine, developed by the specialists of the State Research Institute of Galurgy (Kalush) and Lviv Polytechnic National University reviewed, supported and approved by the meeting of the Western Scientific Center of the Academy of Sciences of Ukraine (2003).

The social basis for sustainable development of Stebnyk MIA is the creation of a speleological hospital

(Diakiv, et al., 2015). Speleotherapeutic method of treatment, based on the long-term stay in the microclimate of salt mines, has been known for hundreds years. For the first time this method was scientifically substantiated in the middle of the nineteenth century by a well-known Polish doctor-physician F. Bochkovsky, who noticed that there were no asthma sufferers among the miners who work in the salt mine "Wieliczka" near Krakow. Since then, the underground workings and caves of Wieliczka have been used both for recreation purposes and tourism business. In addition, speleotherapeutic objects have been specially developed in other salt mines: Bochnia in Poland; "Turda", "Okna Dej", "Cacica" in Romania; underground speleology hospitals "Belaruskaliy" (Belarus, Soligorsk); "Salt Symphony" (Donetsk region, Soledar). Since 1968, speleotherapy has been successfully used until 2009 based on the Solotvyno salt-mine, where about 6.5 thousand patients with bronchial asthma have been treated each year. Unfortunately, since 2009, Solotvyno mines do not function because of flooding. At present, allergic hospitals in Solotvyno successfully use the method of halotherapy based on Solotvyno rock salt, using the experience of speleotherapeutic treatment. According to statistics, today, about 2 million people in Ukraine require such treatment.

The opportunity of recreational use of the underground space of mine № 1 for the organization of speleotherapy and prevention of patients with bronchial asthma and allergy has been discussed for over 18 years (Diakiv, et al., 2015). A warning factor was the possible presence of potentially toxic clay (silicate) dust in an atmosphere of mining, inhalation of which can cause allergic reactions and other side effects, up to the occupational diseases of miners such as silicosis. The reason for such reservations is the peculiarities of the mineral composition of potassium ores and ore-containing salt-and-ore-bearing rocks. The second limiting factor is the man-made safety of mine №1.

The authors (Diakiv, et al., 2015) scientifically substantiated the technogenic safety and expediency of the arrangement of speleotherapy treatment in Stebnyk. It has been experimentally proved that the atmosphere of mine № 1 of Stebnyk GHP "Polymineral" is actively self purified from potentially toxic clay dust and is saturated with salt spray only. It is characterized by the high potential for speleotherapy, and has the greatest prospects for the restoration of speleotherapeutic treatment in Western Ukraine.

On the balance sheet of Stebnyk Mining and Chemical Enterprise "Polymineral", there is mine № 1, which today is practically dry and suitable for the recovery of potassium ores extraction. It is one of the oldest salt mines in the world, which began functioning in the first half of the nineteenth century. The mining diversion of mine № 1 is located in rather unfavourable engineering-geological and hydrogeological conditions due to the location mainly within the boundaries of urban development of the city of Stebnyk and the flow of the Solonets River at a slight depth from the level of the salt mirror.

Considering this, through the exploratory mining workings of mine №1, during the last fifty years, five established water flows have been detected, the working out of static reserves of which has threatened the catastrophic scenario of the salt karst development, by analogy with the current emergency mine № 2. However, with the timely arrangement of several powerful waterproofing jumpers, the situation is taken under control.

Besides the chambers made and prepared for the development of deposits of potassium ores of the dominant cainite-langbeinite composition, within the minefield along the line of the central drift "Kubek-Liarysh", in a rock mass composed of 90–95 % of the halite, 11 leaching fields – dome-shaped mining workings with arched vaults were formed as a result of the controlled dissolution of sodium chloride with fresh water and pumping brine to the surface to obtain salt. The largest leaching field is № 2, with an area of over 2 hectares (Diakiv, et al., 2015). With the exploitation on the 3rd horizon of the Kubek trunk of a layer of "bitter" salts, in 1922 the extraction of potassium ores began for mineral fertilizers. For this reason, in the middle of the twentieth century, the extraction of kitchen salt by the method of leaching at Stebnyk mine was discontinued, and the leaching fields whose age exceeds 150 years, and mining developments on the first horizon, which provide approaches to them, have remained to this day in an almost inviolable and quite satisfactory state. In the opinion of the authors (Diakiv, et al., 2015), the mining workings around the leaching fields are best suited for the arrangement of speleotherapy treatment at mine № 1.

Conclusions and perspectives of further research refer to the practical use of the developed block model of the system of monitoring of ecological safety in the infrastructure-investment strategy of sustainable development of transformed landscapes of mining workings of potassium mineral fertilizers of Stebnyk mining industrial complex. The functionality of the monitoring system is the basis of the information-analytical platform for the design and operation of the natural and man-made geopark.

It is proposed to create Stebnyk geopark since the resource potential for the further development of man-made territories is sufficient, which determines the expediency of their conservation, restoration and development by modern ecologically safe technologies and effective environmental protection measures.

3. Conclusion

The conceptual development of Stebnyk geopark is based on a number of sustainable development policy provisions:

1. The territory should include a certain number of important objects of geo-ecological heritage, with exclusive geological, mineralogical, paleontological and geomorphological features that have a scientific, technical and educational value, a unique character and recreational and tourist attraction, geo-ecological objects that have archaeological, historical-cultural, ecological-technological and economic significance.

2. Implementation and demonstration of methods and technologies of environmental protection and efficient production and economic activity at natural and man-made objects, solving geo-ecological problems, and development of newest environmental measures.

3. Development of cooperation with local residents, assistance to the educational and cultural development of the community, speleotherapy treatment of people.

4. Information-analytical and ecological-economic support of the functioning of scientific, medical and geo-tourism, which promotes the development of people's ideas and knowledge about the geopolitical heritage.

5. Development of management plan for socio-economic development of the geopark territory.

6. Creation of local hydro-ecological and forest-ecological corridors as components of the global ecological network, which demonstrates the professional experience of preservation and restoration of natural technogenic ecosystems and integrates into European programs of sustainable development.

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