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ENVIRONMENTAL IMPACT AND TOXICOLOGICAL PROPERTIES OF MINE DUMPS OF THE LVIV-VOLYN COAL BASIN

Abstract. To date, the environmental status of mining areas is characterized as critical. The prerequisites for this are the formation of artificial landscapes (waste heaps, mine wastewater, etc.), high concentration of mining enterprises in mineral deposits, inefficiency of measures to maintain mining facilities in a safe state, low level of continuous monitoring of environmental change. The uncontrolled impact of mining areas leads to a general exacerbation of the environmental problems of the region as a whole, as well as to the depletion of surface and groundwater and the contamination of surrounding metals by heavy metals due to their migration from the mine heaps.

The article discusses the features of the Lviv-Volyn coal basin as a background for industrial development of Western Ukraine. The characteristics of the dumps of the closed up mine of the basin has been carried out. The toxicological composition of the dumps of the Novovolynska mine has been investigated and their environmental impact has been defined. Waste dumps of mine rocks of Lviv-Volyn area have high acidity, considerable content of various salts and sulfate ions. This high mineralization is caused by the movement to the water-collection points and the interaction of such water with rock dumps besides, and its way waste water is enriched with products of rocks destruction and coal.

Key words: coal, Lviv-Volyn coal basin, environment, mine dumps, toxicological indicators.

Introduction. Sustainable socio-economic development of modern society is impossible without assessment of man-made impact on the environment. Nowadays, developmental challenges in different Ukrainian regions are caused by anthropogenic processes that lead to environmental pollution. Particular attention should be paid to the investigation of the regions in which the coal industry is developed [3].

During the period of coal mining and coal processing operations in the territory of Lviv-Volyn coal basin the geo-ecological environment has undergone significant changes. This is primarily due to the change in the natural landscape, the impact of the coal processing waste on the environment, as well as the change of geochemical indicators caused by the additional discharge of chemical and mineral compounds.

One of the main sources of environmental hazards for the region is mine dumps. Thus, when coal is extracted from the rock mass, which is brought to the surface, up to 75% of the raw material goes to waste [5]. Mine rocks accumulate in waste dumps, sludge pits, ash dumps etc. The refore a reliable assessment of toxicity of mine dumps is an important issue while designing environmental measures for minimizing their impact on the environment.

Purpose, tasks and methods of research. Problems related to the impact of mine dumps on all components of environment have been studied in Ukraine and abroad for a long time. The papers of Ukrainian authors, in which environmental issues of mining were considered in the context of environmental issues, contain analysis of the critical geo-ecological situation in specific regions and methodological approaches for assessment of their urgency as well as the recommendations for their solution. At the same time, the environmental issues of the Lviv-Volyn coal basin and the assessment of mining waste impact remain relevant. The object of the paper is determination of environmental impact and toxicological properties of mine dumps of the Lviv-Volyn coal basin (figure 1).

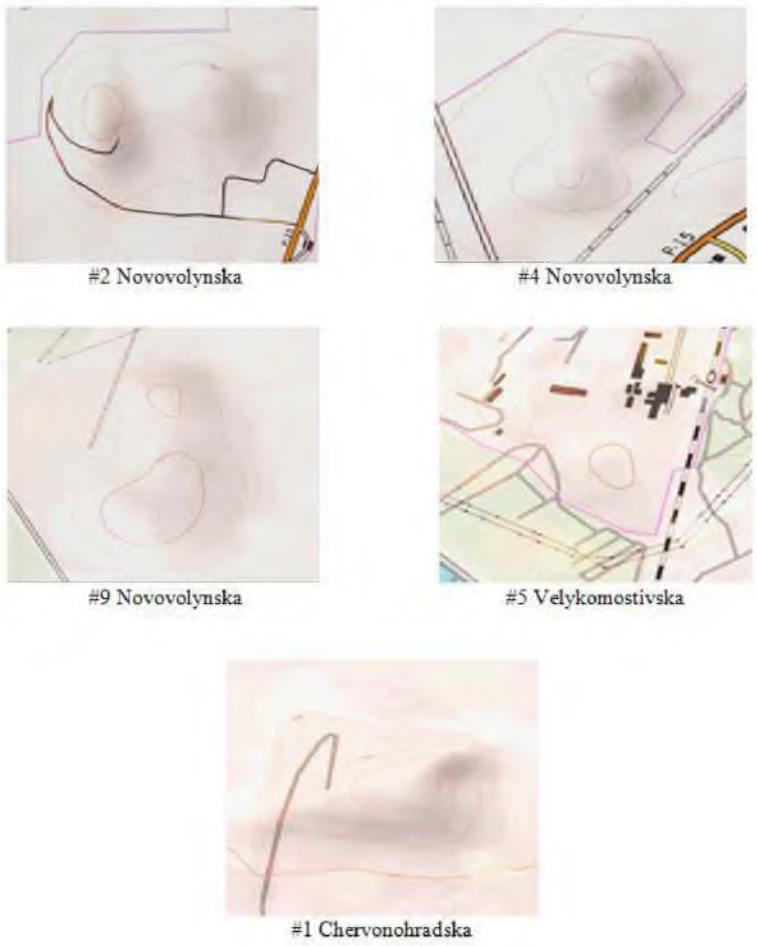

Figure 1 – Cartographic map of coal mine dumps #2 Novovolynska,
#4 Novovolynska, #9 Novovolynska, #5 Velykomostivska, # 1 Chervonohradska

Results and their discussion. The Lviv-Volyn coal basin is located in Western Ukraine. It covers the territory of the northwestern part of Lviv and southwestern part of Volyn region. The northern border of the basin is defined by the line of Volodymyr-Volynskyi – Torchin, and the eastern border by the Torchin-Olesko line. The coal here lies almost horizontally at a depth of more than 315-550 m [7]. The geographical location of the Lviv-Volyn basin is generally favorable for its economic development. It caused the intensive coal mining. In the second half of the twentieth century a powerful cross-sector fuel-power complex was created. The main component in the functional structure of the basin is the coal-energy production cycle, which includes the coal industry and related coal consumption sectors (electricity, transport) and production services (production of building materials, building and construction, repair of mining equipment). Basing on the coal and electricity industries, mechanical engineering, chemical, food and consumer industries have also developed, an extensive industrial and social infrastructure has been created, an area of intensive peri-urban agriculture has been formed [6].

In the early 90's the coal industry of the Lviv-Volyn coal basin included 21 mines and a central processing plant. In the Lviv part of the coal basin there were 12 coal mines (in Hirnyk - 2, in Sosnovka - 3, in Chervonograd - 7 mines). What is more the central Chervonograd processing plant was built in Sosnovka. In the Volyn part of the basin there were 9 mines (2 in the village of Blagodatny (Zhovtneve) and 7 in the Novovolynsk district). However, due to the economic crisis, the situation in the coal industry of the Lviv-Volyn basin has deteriorated significantly. Due to the fact that coal production has decreased significantly, the number of employees in the industry has decreased, renovation of production facilities has stopped, and the process of unprofitable mining sites closure has begun.

Only since 2002 the slow revival of the Lviv-Volyn coal basin did begin. Unprofitable mines were abandoned, and coal companies were reorganized into state-owned enterprises. Today, the Lviv-Volyn

Basin coal basin industry includes two state-owned enterprises, Lvivvugillya and Volynvugillya, comprising 9 and 4 coal mines respectively. The main consumers are Burshtyn, Dobrotvir, Ladizhin and Kalush CHPPs, the regional fuel department of the western regions of Ukraine, some commercial organizations and people [4].

As some mines within the Lviv-Volyn coal basin were closed, the problem of their technogenic risk remained unresolved. The factors of man-made pressure on the environment of the basin are: flooding of mines, blockages and landslides of mine shafts, subsidence of the surface, high radiation background of waste dumps and terrain, the release of toxic elements, compounds and products of combustion into water reservoirs, soils, air [2].

At the present time, considerable attention is paid to the environmental safety of the mine waste dumps, as a large number of people living near these man-made objects suffer from smog, products of self-ignition and smoldering of the rock, disfigurement of a landscape, etc. The main technogenic impact of mine complexes is so-called technogenic landscapes - dumps of waste rock - waste heaps, which cause a number of problems. They pollute almost all elements of the environment: air, ground water, land runoff, soil, plants. In this regard, we decided to investigate the toxicological composition of the dumps of mine # 9 "Novovolynska" and their on environmental impact [9].

Mine # 9 "Novovolynska" belongs to the State Enterprise "Volynvuhillya" and is located on the territory of Ivanychi region of Volyn region. Coal has been produced here since 1963. The flat dump is located 150 m north of the industrial site. Its height is approximately 30 m. 5.5 million tons of waste covers the area of over 120 000 m^2. Samples were taken at a depth of 15-20 cm from the surface of the dump. Investigation of the toxicological properties of waste heaps of mine # 9 "Novovolynska". The results are in tables 1 and 2.

Table 1 – Characteristics of waste dumps of closed mines

Dump	Mine	City, district	Shape of the dump	Dump state burning, not burning)	The organization to which the dump was handed over
1	# 1 Chervonohradska	Chervonohrad	frustum of a cone	not burning	The rock was taken out, the land was handed over to the Chervonograd land fund in 2000
1	#5 Velykomostivska	Volsvyn, Sokal region	conical	not burning	Handed over to the Volsvyn (Sokal region) land fund in 2005
2			flat	not burning	
3			flat	not burning	
1	#2 Novovolynska	Novovolynsk	conical	not burning	Handed over to the Novovolynsk land fund
2			flat	not burning	
1	#4 Novovolynska	Novovolynsk	conical	not burning	Under recultivation
2			conical	not burning	
1	#9 Novovolynska	Hryadiv, Ivanychiv region	conical	not burning	Handed over to the Hrydiv (Ivanychi region) land fund in 2006
2			flat	not burning	
3			flat	not burning	
4			flat	not burning	

Table 2 – Toxicological properties of waste rock of mine # 9 "Novovolynska"

Index	Unburnt rock	Raw rock	Southern slope	Western slope
pH	3,63-4,81	5,59	7,18	8,4
Hydrolytic acidity mg-eq./100g of soil	10,6	0,21	0,22	0,29
Total absorbed bases (Ca+Mg), eq./100g. of soil	13,5	30,1	48,1	51,4
Humus, %	2,21-6,94	9,52	7,53	0,49
Nitrogen, mg/kg	49,8-59,9	29	14,2	16,9
P_2O_5, mg/kg	13	214	11	28
K_2O, mg/kg	64	201	79	42

Investigation of the toxicological properties of the waste rock of mine # 9 "Novovolynska" have shown that the unburned rock is acidic: the pH of salt extract varies within 3,63-4,81. The hydrolytic acidity is quite high - 10.6 mg/100g of soil and more. The soil on the slopes has an alkaline reaction and a much lower hydrolytic acidity (0,22-0,29). The total absorbed bases (Mg and Ca) is minimal in the dump rock and averages 16.29 mg/100g of soil. It is higher on the slopes - 48.1 mg/100g of soil. The humus index of unburned rock ranges from 2,21-6,94%. The humus content differs in the samples taken on the western and southern slopes (0,49% and 7,53%). The highest humus content is in the raw rock – 9,52% [1,12].

Technical unburned rock is characterized by a very low content of exchange nitrogen 49,8 mg / kg. Much less N_2 is present in soil on the slopes of the dump 14.2 mg/kg. The highest content of phosphorus and potassium is found in raw rock. The mineral and chemical composition of the dump rock affects both the geochemical environment of the region and the health of the population, as some trace elements accumulated in the dumps lead to poisoning of flora and fauna and humans, since their content exceeds the MPC [8]. The content of heavy metals in the waste dump is as follows (figure 2 and 3).

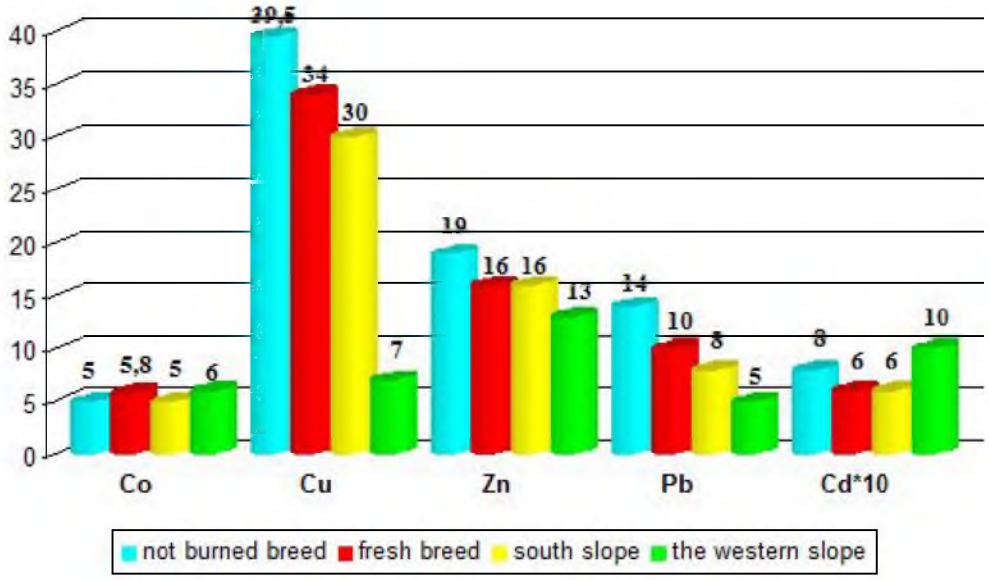

Figure 2 –Total content of heavy metals in the dump rock, mg/kg

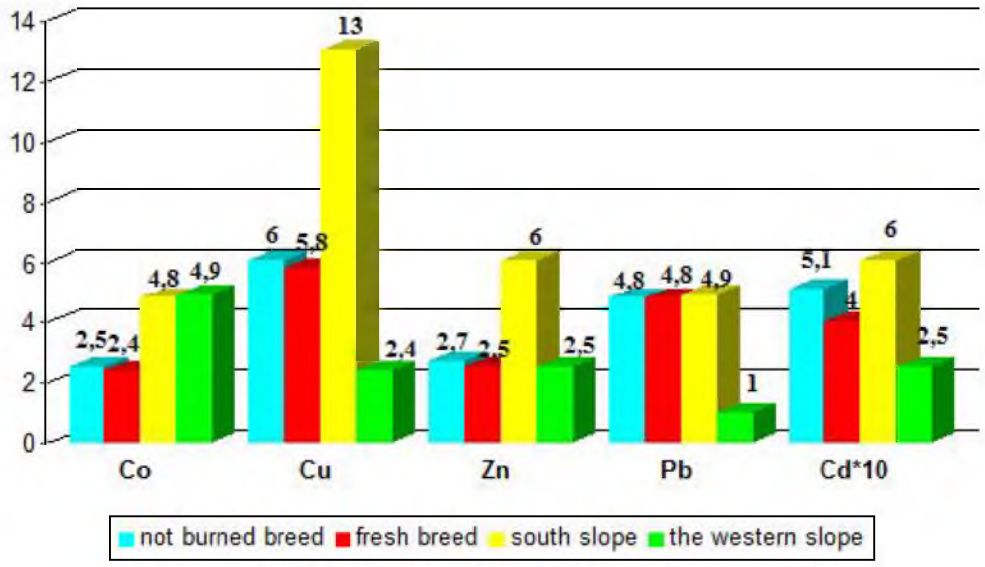

Figure 3 – Content of active forms of heavy metals in dump rock, mg/kg

The distribution of lead in the dump is uneven. Higher concentrations of lead are found in the waste rock, although the concentrations exceeding MPC are detected both on the slope of the dump and in the rock itself. The average total zinc content in rocks and slopes reaches 0.3% of MPC. Most of the active zinc can be found on the slopes of the dump. Its content doesn't exceed the acceptable limits.

The best aggregates for copper accumulation are unburnt rocks. The highest content of active copper is defined in the technical soil of the slopes, while on the southern slope its content exceeds of the MPC by more than 4 times. The slopes of the dump are characterized by a high content of cobalt that exceeds the content in the rock by 4 times. The maximum concentration of the total cadmium is detected on the slopes of the dump, the minimum - in the dump rock. In general, its content does not exceed the MPC in the soil 3.0 mg/kg. The maximum concentration of active cadmium is also detected on the slopes of the dump, and the minimum - in the waste rock. In general, its content does not exceed the MPC in the soil 0.7 mg/kg [10,14].

As a result, we should note that the accumulation of waste dumps of mine rocks causes the following technogenic changes in the area around "Novovolynska" mine # 9:

– accumulation of loose and unstable waste rock containing corrosive chemical substances;

– change of the groundwater balance and depletion of aquifers due to disturbance of natural circulation;

– lands loss due to flooding and pollution;

– pollution of the atmosphere, soil and groundwater, especially by heavy metals;

artificial formation of an uncharacteristic microclimate around the mine.

Conclusions. The investigation revealed significant differences in the toxicological composition of mine waste dumps in different locations. Unburnt rock is the most acidic in comparison to the raw one and to the soil on the slopes of the dump. Raw rocks are rich in phosphorus and potassium and are also characterized by a high humus content [11,13]. The best accumulators are the slopes of the dump.

Accumulation of toxic constituents in technological dumps creates a significant man-made danger. To prevent the emergence of hazardous manifestations of sewage to the ecological situation in the study area, it is necessary to use natural resources rationally, to timely carry out demineralization and reclamation, phytomelioration of disturbed lands and use a method based on phytotechnology – a hydrophytic structure of the type of bio-plateau, which performs the destruction, transformation and accumulation of nitrogen-containing substances, heavy metals and other toxic substances, ensuring the biological purification of water from pollutants.

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ШАХТА ТАМШЫЛАРЫНЫҢ ТОКСИКОЛОГИЯЛЫҚ СИПАТТАРЫ ЛЬВОВ-ВОЛЫН ТАС КӨМІРІ ЖӘНЕ ОЛАРДЫҢ ҚОРШАГАН ОРТАГА ӘСЕР ЕТУІ

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ТОКСИКОЛОГИЧЕСКИЕ СВОЙСТВА ОТВАЛОВ ШАХТНЫХ ПОРОД ЛЬВОВСКО-ВОЛЫНСКОГО КАМЕННОУГОЛЬНОГО БАССЕЙНА И ИХ ВЛИЯНИЕ НА ОКРУЖАЮЩУЮ СРЕДУ

Аннотация. На сегодняшний день экологическое состояние горнопромышленных районов характеризуется как критическое. Предпосылками этого является образование искусственных ландшафтов (отвалы шахтных пород, сточные шахтные воды), высокая концентрация горных предприятий в местах залежей полезных ископаемых, неэффективность мер поддержки горно-технологических объектов, низкий уровень

постоянного мониторинга за изменением экологического состояния окружающей среды. Неконтролируемое влияние горнопромышленных районов приводит как к общему обострению экологических проблем региона в целом, так и к истощению поверхностных и подземных вод и загрязнению тяжелыми металлами прилегающих территорий в результате их миграции с пород шахтных терриконов.

Согласно физико-географическим признакам площадь Нововолынского горнопромышленного района относится к Малому Полесью. С начала добычи каменного угля экологическое состояние Нововолынского горнопромышленного региона значительно ухудшилось. Благоприятными условиями для этого стало образование искусственных породных насыпей, техногенных форм отвалов, накопление шахтных отходов. Нововолынский горнопромышленный район находится под влиянием воздушных масс, поступающих с Атлантического океана и юго-западных континентальных масс Европы. Такое географическое положение сформировало океаническо-континентальный климат, который характеризуется неустойчивыми погодными условиями, высокой относительной влажностью, большим количеством осадков. Ежегодно действующие шахты города Нововолынска выбрасывают на поверхность более 100 тыс. тонн отвальной породы. На породных отвалах накоплено более 30 млн. тонн шахтной породы. Разработка угольных месторождений сопровождается весомыми изменениями геологической среды, обусловленными перемещениями большого количества массивов горных пород. В состав отвальной породы входит много минеральных и химических веществ, что в некоторых случаях приводит к самовозгоранию. Процесс самовозгорания шахтных терриконов региона наблюдается в виде: торможения процесса рекультивации вследствие выгорания саженцев древесных пород; возникновения завалов, оползней; повышения температуры окружающей среды; вредных выбросов пыли и газов в атмосферу; высокой концентрации опасных химических соединений в окружающей среде и т.д. Во время обдувания ветром терриконов и отвалов шахтных пород воздух загрязняется пылью и газами. Водяные потоки сносят рыхлые породы в гидрографическую сеть, загрязняя балки и речные долины, заиливая пруды, реки, озера. Это приводит к устранению из природных мест обитания многих видов растений и животных.

В статье рассматриваются особенности Львовско-Волынского угольного бассейна как предпосылки промышленного развития Западной Украины. Осуществлено характеристику породных отвалов ликвидированных шахт бассейна, а также изучен токсикологический состав отвалов Нововолынской шахты и определено их влияние на окружающую среду. Отвалы шахтных пород Львовско-Волынского каменноугольного бассейна имеют высокую кислотность, значительное содержание различных солей и сульфат-ионов. Эта высокая минерализация обусловлена движением к водосборным пунктам и взаимодействию такой воды с отводами горных пород, а также ее сточные воды обогащаются продуктами разрушения горных пород и угля. Исследования породных отвалов является актуальным, поскольку даёт возможность оценить насколько токсичным является собственно террикон и какую опасность он может представлять для окружающей среды. С тех пор как в городе Нововолынске начали добывать уголь, экологическое состояние региона значительно ухудшилось. Причиной этого стало образование искусственных породных насыпей, техногенных форм отвалов, накопления шахтных отходов, ненадлежащий мониторинг нарушенных земель.

Ключевые слова: уголь, Львовско-Волынский угольный бассейн, окружающая среда, отвалы, токсикологические свойства.

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