Impact of the long-term armed conflicts on the ecological safety of industrial objects

Oleksii V. Pyrikov 1, Oksana V. Lunova2, Viktor M. Yermakov3, Rolf Petry3, Natalya O. Lubenska3

1 Foundation for the Development, NGO 0506463222av@gmail.com
2 State ecology academy of postgraduate education and management, Kyiv, Ukraine
3 Consultants of DMT GmbH & Co. KG, Am TÜV 1, Essen, 45307, Germany

Abstract. The article analyzes the consequences of pollution from industrial enterprises, as well as the risks of disruption of operation and flooding of mines. The armed conflict in the East of Ukraine led to serious environmental consequences – it is the pollution of groundwater, water bodies, air pollution, decommissioning of large areas of arable land, destruction and damage to objects of the nature reserve fund, forest fires, etc. It has been shown that in areas where the armed conflict continues, there has been significant pollution of the environment with chemical toxic substances, metal fragments and heavy metals due to artillery shelling and the use of explosives. As a result, numerous funnels were formed, which mutilated the land and destroyed natural protected areas, flooded mines, built fortifications, ditches, and damaged sewage and water supply networks. Risks associated with damage to communications, businesses and other facilities that pose an increased environmental risk, increase the scale of the negative impact.

The problem of flooding of mines and excessive mineralization of waters, which are the part of the production process, is very relevant for both Luhansk and Donetsk regions. Solving this problem requires significant efforts from both the Ukrainian state and international environmental organizations. The main problem is that the mines are located in both controlled and uncontrolled by the Ukrainian government. The fate of coal mines in the territory not controlled by the government of Ukraine is uncertain and requires control by international organizations that are able to conduct monitoring activities. The coal industry in the EU is at «coal-out phase», i.e. at the stage of gradual abandonment of coal mining. First of all, this is dictated by the EU’s course to reach a carbon-free economy by 2050, which means the gradual abandonment of coal generation and the transition to renewable energy sources. And also in accordance with the EU Directive No787 in 2010 On the need to close unprofitable mines.

Key words: water pollution, industrial enterprises, armed conflict, ecological consequences, flooding of mines, ecological risks, technogenic load

Anotació. В статті проаналізовано наслідки забруднення від промислових підприємств, а також ризики порушення режиму експлуатації і затоплення шахт. Збройний конфлікт на сході України призвів до серйозних екологічних наслідків – зміна природного-заповідного фонду, лісові пожежі, руйнування каналізаційних і водогінних мереж. Ризики, пов’язані з пошкодженням комунікацій, підприємств і інших об’єктів, що становлять підвищену екологічну небезпеку, збільшують масштаби негативного впливу. Проблема підтоплення шахт та надлишкової мінералізації вод, які є частиною виробничого процесу, є дуже актуальною як для Луганської, так і для Донецької областей.

Відповідно до цього, для Луганської та Донецької областей, а також для усіх інших регіонів, що мають промислову економіку, значна частина виробничих об’єктів знаходиться в двох екологічно небезпечних станах: затоплені шахти та відсутність контроль за використанням води.

Ключові слова: водне забруднення, промислові підприємства, збройний конфлікт, екологічні наслідки, затоплення шахт, екологічні ризики, техногенный навантаження.
Statement of the Problem

In areas where the long-time conflict continues, there has been a significant pollution of the environment with toxic chemicals, metal fragments, and heavy metals due to artillery shelling and usage of the explosives. As a result, numerous funnels were formed, which devastated the land and destroyed natural reserve areas, the underground mines were flooded, defense structures were built, ditches, damaged sewage and water supply networks. Risks associated with damage to communications, businesses, and other facilities that pose an increased environmental risk additionally increase the scale of the negative impact.

During the Soviet times, dozens of chemical polygons (including those used in chemical weapons production) and sludge storage facilities for harmful chemical and metallurgical industries, both existing and long-destroyed, were concentrated in eastern Ukraine. Thus, all this was stored on the surface, in the best case – under a thin layer of soil or polymer film. Mercury, phenols, and dozens of other harmful substances were not buried in specially equipped polygons but were dumped in old mines, without any hydro-insulation, near human habitations, or simply within the cities of Horlivka, Yenakiieve, and Shakhtarsk.

Since the Ukraine’s independence until the beginning of the armed conflict in Donbas, no complex measures were taken to prevent technogenic environmental impact in the industrial districts of Donetsk and Luhans regions, but some measures were taken to prevent the problematic environmental situation from becoming an ecological catastrophe.

The beginning of the armed conflict in eastern Ukraine has led to severe environmental consequences – pollution of groundwater and water reservoirs, air pollution, decommissioning of large areas of arable land, destruction and damage to nature reserves, forest fires, and more so on.

Among many industrial enterprises damaged during the armed conflict the most environmentally hazardous industries are Yasyunuva, Avdiivka, and Yenakiieve coke plants, Yenakiieve metallurgical plant, Lysychansk oil refinery, Donetsk state chemical plant, heat and electricity production plants in Slovyansk, Luhansk and Kurakhovo, the chemical plant «Azot» in Severodonetsk and the plant «Styrol» in Horlivka.

In addition to the destruction of industrial and civil infrastructure, the armed conflict has led to a loss of control over areas beyond the control of the Ukrainian government by state environmental authorities and organizations to comply with the rules of storage of harmful substances, operation of factories, mines and so on.

Due to the lack of regular supervision and monitoring of numerous storage facilities for toxic substances, mines, and industrial enterprises that fail to operate, soils, waters (both reservoirs and horizons of groundwater), and air are at risk of pollution. It is obvious that people’s health is also under the risk.

Among the most dangerous industrial facilities in Donbas today there are the Yunkom mine, where a nuclear explosion took place in 1979; Horlivka and Donetsk chemical plants with a large number of storage facilities for toxic substances; production facilities of the concern «Styrol»; the radioactive polygon in the middle of an explosive site in Donetsk; Avdiivka Coke Plant, if its filter system is shut down it will lead to the release of large amounts of deadly substances into the air, as well as numerous dams of heat and electricity production plants and filter stations.

On the one hand, over the years of the JFO, air pollution has decreased significantly due to the cessation of industrial production. Various sources report the shutdown of such industrial giants as the metallurgical plants in Donetsk, Yenakiieve, and Makivka. However, despite the official ceasefire, the «line of contact» is under constant fire from small arms of various calibers, as well as mortars and artillery.

An explosion of one kilogram of TNT releases about 300 liters of nitric oxide and carbon monoxide. Nitrogen oxide released during the shelling in the atmosphere combines with water leads to acid rainfalls.

A separate implication from flooding is a decrease in the strength of mine rocks. Due to the lack of comprehensive measures for degassing of layers, methane is displaced to the surface and accumulates in residential premises’ basements. It should be noted that the accumulation of methane and even explosions in homes occurred before the armed conflict, but then degassing wells were drilled in time, and the situation was brought under control.

The accumulation of heavy metals and toxic compounds in groundwater makes them dangerous to human health. The use of such water causes toxic poisoning and disorders of the gastrointestinal tract, in combination with the risk of radiation contamination due to leaks of radionuclides from storage, the probability of cancer increases.

In 2014, experts from the International Charitable Organization «Ecology-Law-Human» conducted a study of fires in natural reserve areas in the area of

The fires caused by the shelling covered 17% of forests and 24% of the steppes. Among other things, the fire-damaged nature reserves – branches of the Luhansk Reserve «Provalsky Steppe,» «Three Hizben Steppe,» regional landscape parks «Donetsk Ridge,» «Zuevsky,» the national park «Holy Mountains» and 13 reserves. In the Holy Mountains National Park, a fire caused by shelling spread to 1,000 hectares of forest, and fires also affected reserves in the Luhansk region – Nagolchansky, Volnuhinsky, Bilorichansky, Luhansk, Perevalsky, and Pischchany. In 2014, there were recorded 2,901 fires in forest and steppe areas of the armed conflict zone, 14 times more than outside this zone. The fire covered 36,226 hectares of forests, 114 hectares of pastures and hayfields, 147 hectares of arable land. The fire affected 20% of all rocky steppes within Ukraine.

Gases formed by shell ruptures can cause respiratory disorders and increase the incidence of bronchitis and asthma. Also, the acid rains, which we mentioned above, carry sulfur, nitrogen, and harmful sulfates over long distances, which negatively impact human respiration.

The environmental monitoring in the territories beyond the control of the Government of Ukraine is catastrophic: surface water and air quality control posts in Donetsk, Makivka, Horlivka, Yenakieev, Luhansk, and Alchevsk are closed, the work of the State Ecological Inspectorates is frozen, and the radiation background is not controlled. For example, 39 posts of the Seversko-Donetsk basin management of water resources in Donetsk region and 24 – in Lugansk, 20 and 6 accordingly, are out of work. A similar situation has been developed with air quality control posts of regional hydrometeorological centers. 11 of 25 posts work in the Donetsk region, and 4 of 11 posts in the Luhansk region.

Beyond the control of the government of Ukraine without special projects and environmental assessments of the possible impact on the environment, mines and factories are closed, people and armed groups uncontrollably cut metal constructions of the enterprises, sewage treatment plants, water supply, sewerage networks, dams and other infrastructure facilities in the region become unusable.

As a result of fires and uncontrolled felling of protective forest stripes, agricultural land is rapidly degraded. Territories not beyond the control of the government of Ukraine can exist for a certain period, wasting available resources, destroying them, and not ensuring their restoration.

Thus, it can be concluded that the armed conflict in Donetsk and Luhansk regions has raised several significant environmental problems that negatively affect flora and fauna of the region. Among these problems is chemical pollution due to the use of large amounts of ammunition. About 20 mines of Luhansk region are flooded with polluted water, which leads to further groundwater pollution. In the area of the armed conflict, there is massive contamination of soils with fuel and lubricants, metal fragments from shells and land mines, and depleted uranium, which is used to increase the armor-piercing ability of some ammunition. When water is supplied to the temporarily occupied territories, it is often not disinfected with active chlorine, what can cause infections.

Analysis of the consequences of pollution from industrial enterprises

Eastern Ukraine has always been characterized by a wide range of threats of natural and technogenic origin. Thus, among the threats of natural origin, the most relevant are meteorological phenomena, dangerous exogenous geological processes, fires in natural ecosystems, hydrogeological, medical and biological threats. Technogenic threats are caused by potentially dangerous objects, including many enterprises in the metallurgical, chemical, coal industries, energy and machine-building complex, and a network of product pipelines. For example, in terms of the general level of technogenic saturation and the number of industrial enterprises, the Donetsk region leads not only in Ukraine but also in Europe in general.

Negative trends in environmental and technogenic threats and the changes they characterize significantly worsen the level of security of the population in the zone of armed conflict in eastern Ukraine and adjacent ecologically connected territories of Donetsk and Luhansk regions due to pollution of river and groundwater basins, destruction of lands and objects of the nature reserve fund. Therefore, the urgency of further social and economic development, taking into account the impact of environmental and technogenic threats, which are significantly exacerbated in the context of armed conflict, becomes an urgent issue.

During 2017, 7 radiation incidents during scrap metal operations were recorded: 4 cases of supply of radioactively contaminated scrap metal to metallurgical enterprises and 3 cases of removal of industrial sources of ionizing IRS radiation from scrap metal wagons. 2 IRS were seized on the territory of PJSC Metallurgical Plant AZOVSTAL (industrial IRS with a cesium-137 radionuclide, which was in a metal pipe up to 40 cm long and about 3 cm in diameter, and radioisotope icing detector type RIO-3 with radionuclide + yttrium-90). Another IRS was seized on the territory of PJSC «Yenakieev Metallurgical Plant,» which is located in the territory beyond the control of the Government of Ukraine (gamma-ray unit type «BGV-75»). All seized radiation-hazardous objects were transferred for temporary storage to the storage of the SSE «Dnipropetrovsk SCC,»
except for the object seized on the territory of the PJSC «Yenakieve Metallurgical Plant.»

In addition, at the Novotroitskoye entry/exit checkpoint, the State Border Guard Service of Ukraine detected a radiation anomaly on the surface of a car traveling from a territory by beyond the control of the Ukrainian government. Officers of the Volnovakha police department of the GUNP in the Donetsk region found a suspicious object among the personal belongings of the car owner, which turned out to be a gyrocompass, which contained radionuclides – radium-226 and thorium-232. The object has been removed and placed in temporary storage. The management of the Volnovakha district state administration sent a request to the State Enterprise «Dnipropetrovsk SCC» UkrDO «Radon» to transfer the identified object for storage. There are no signs of a criminal offense.

A significant threat to natural and technogenic origin emergencies is the presence in the Donetsk and Luhansk regions of a large number of flooded and semi-flooded mines that have a constant hydraulic connection with the working mines. The unsatisfactory ecological condition of coal mining areas, especially Donbas, is also complicated by the high concentration of metallurgical and chemical enterprises, which increases the technogenic load on the environment and poses real threats to public health.

According to state-owned coal mining enterprises, sales of coal products in 2017 amounted at 1,855.9 thousand tons, 449.6 thousand tons (19.5 %) less than in 2016. The cost of sold coal products (excluding VAT) amounted at UAH 2,945.0 million. The enterprises received UAH 3308.8 million for coal products. The development of coal deposits in the Donbas has been going on for over 200 years, during which time more than 1,000 mines have operated here. This created a heavy load and led to a significant accumulation of negative factors affecting the environment. The impact of mining on the environment is associated with many years of irrational use of natural resources using outdated technologies and is characterized by:

– activation of deformations of the earth’s surface,
– formation of dips;
– displacement of active gas emission zones, uncontrolled methane emissions;
– violation of the hydrological regime, flooding of territories;
– pollution of water and air basins;
– negative impact of waste heaps;
– destruction of soil and vegetation in areas much larger than the land allotments of enterprises.

The negative impact on the environment of the consequences of many years of intensive coal mining and the closure of dozens of deep unprofitable mines, whose activities have led to irreversible changes in the geological environment over a large area, remains an urgent and acute problem for the Donets region. Production activities of mining enterprises lead to a deterioration of the environmental situation in the region. On the Donets region’s territory, half of the coal enterprises of Ukraine are liquidated – it is 37 mines and one coal preparation plant. Today, the vast majority of these enterprises (33 mines and one preparation plant) are located in the territory temporarily beyond the control of the Government of Ukraine.

There are 5500 industrial enterprises and infrastructure objects in the region, which, if damaged, will be a source of significant negative impact on the environment.

Pollution of rivers, including the Don, threatens the health of the population. The area of armed conflict, including agricultural land, is heavily saturated with unexploded ordnance, which will take years or even decades to demine and eliminate. It is necessary to assess the environmental damage caused by the armed conflict as soon as possible and to minimize it.

In the mining areas of Donbas, the unauthorized shutdown of mines and open pits during the year threatens catastrophic flooding and inundation of nearby towns and villages, unpredictable movement of explosive and toxic gases to areas of industrial and residential buildings, surface water pollution, and groundwater pollution. Therefore, one of the priorities of state policy to reduce environmental and technogenic threats in the zone of armed conflict in eastern Ukraine is to improve the environmental monitoring system, control the critical infrastructure to prevent emergencies with large-scale negative consequences.

The metallurgical enterprises of the Donetsk region are implementing a large-scale program for modernization and reconstruction of production, decommissioning obsolete and physically obsolete equipment, improving existing and introducing new technologies. Reconstruction of the blast furnace No 4 has been completed at PJSC Azovstal Metallurgical Plant, and reconstruction of the blast furnace No 3 is underway. The development of design documentation for treatment systems of the converter shop of the enterprise is underway. At the PJSC «Mariupol Metallurgical Plant Ilyichya,» the modern gas cleaning equipment for converter No 1 and No 2 is installed next to the converter No 3. The sinter plant of the enterprise is implementing the most significant environmental project in the history of Ukraine with a planned investment of over UAH 5 billion within the framework of the Mariupol Environmental Protection and Rehabilitation Program for 2012–2020. Modern Italian industrial gas purification systems will appear on all 12 sintering machines, reducing dust emissions by 90 %, sulfur oxide – by 43 %. 
Threats of pollution of water sources, reduced reliability of water supply, and deteriorating access of the population to drinking water are among the primary environmental threats in the armed conflict zone in eastern Ukraine. Water pollution occurs due to emergencies at water supply facilities and a lack of control over the work of industrial enterprises in the territories beyond the control of the Government of Ukraine. Hazardous is the numerous storage facilities of industrial enterprises, the destruction of dams that threaten negative consequences for both the population and the region’s environment.

Pollution due to the activities of industrial enterprises can be both overt and covert. Many industrial enterprises can pollute the atmosphere by emissions and water bodies by discharging by-products of their activities without authorization, in the absence of environmental control. Recently, the problem of water pollution by microplastics, minerals, especially phosphorus-containing fertilizers has intensified when chemical companies violate the technology of their production and add a large number of prohibited substances to detergents, and so on.

 PJSC Avdiivka Coke Plant (AKHZ) pays considerable attention to environmental protection. Currently, the company is implementing an environmental project to eliminate harmful compounds from tanks and storage of the tar distillery. This will improve the environmental situation at AKHZ (reduction of pollutant emissions from 7.56 t / year to 0.0 t / year) and ensure compliance with the regulations of Ukraine. Modern equipment was purchased for the factory laboratory for water and air pool protection. The quality of treatment and the pollution level of the company’s wastewater is now monitored using a binocular microscope of a new modification and a thermostat. The new modern pneumatic installation will allow to carry out qualitative sampling of air on clearing installations and chimneys. This will reduce the time spent on research and increase the efficiency of the laboratory for environmental protection.

 On the territory of the Luhansk region, there is a large number of giant enterprises of the most environmentally hazardous industries: coal mining, chemical and petrochemical industries, thermal energy, and others, which are characterized by large amounts of wastes. In this case, the vast majority of wastes is not recyclable but gets to the places of industrial waste disposal. According to preliminary data of the Main Department of Statistics in the Luhansk region in the territory of the region controlled by the government of Ukraine, during 2018, 6.72 thousand tons of I–III hazard class wastes were generated, of which 4.1 thousand tons were incinerated specially allotted places or objects – 1.1 thousand tons.

 Currently, there are no business entities under the control of the government of Ukraine in the region that have licenses to conduct business in the management of hazardous wastes (according to the official register of licensees of the Ministry of Environment). This fact leads to the fact that economic entities of the region are forced to enter into contracts for the removal and disposal of hazardous waste with licensees of other regions, which significantly increases the cost of transport services or deposit waste in industrial waste landfills.

 The central place in the generation of industrial waste in the Luhansk region belongs to the fuel and energy, and coal industries, concentrated mainly in the southern part of the region (territory not controlled by the Government of Ukraine) and in the Lysychansko-Rubizhansky industrial district (territory controlled by the Government of Ukraine). The technology of coal mining and coal purification involves the formation of a large amount of rock wastes. Coal mining waste accounts for the largest share of total waste generation in the region. In this area, there is still a problem of minimizing the accumulation of waste. The disposal of this waste is almost not carried out. According to the coal industry, there are 44 waste heaps of coal mines under the control of the government of Ukraine in the region, 33 of which are closed.

 It should be noted that no waste heap was recultivated. The lack of widespread use of technologies to dispose this wastes creates the accumulation of large-scale wastes. The impact of these wastes on the environment is significant: the occupation of land areas, dust creation, pollution of land and water, and the impact on human health.

 Thus, the following conclusions can be drawn. Industrial enterprises in Donetsk and Luhansk oblasts are one of the biggest threats to the region’s ecology. The biggest threats to the environment are metallurgical and chemical enterprises, as well as coal mining enterprises. The giants of the chemical and metallurgical industries of the region spend significant funds to solve the region’s environmental problems.

 **Safe risks of violation of the mode of operation and flooding of mines**

 The industrial area of mining is about 15,000 km, the area of influence with additional coverage is about
20,000 km. Still, there is a river runoff that will expand this area by almost 30-35 thousand km, and it is -50% of the total area of the Donetsk and Luhansk regions. However, the population is concentrated mainly in the industrial part.

The main risk to the soil during an armed conflict is the shutdown of coal mines. It is currently known that about ten mines are flooded in Donbas, and there is a risk of stopping total production and flooding the same number of coal mining companies.

In the territories beyond the control of the government of Ukraine, mines are flooded, water is not pumped out of mine shafts. Currently, international organizations are aware of 39 flooded mines, some of which contain hazardous industrial waste.

The most dangerous are the mines, which until 2014 stored various wastes. In particular, a radiation capsule was stored at the Young Communist mine (near Yenakievo), where a radioactive explosion was carried out in the 1970s. (Yermakov, 2000).

Due to the flooding of mines in the Donetsk region, subsidence began - now experts are recording from a few cm to 10 cm (according to the OSCE, obtained in cooperation with the Space Agency of Ukraine).

During the life cycle of mines, the drainage of water that enters the gate roads from the ground is constantly pumped out. Stopping the pumping leads to flooding of mines and rising water levels. Mine water is saturated with a large number of harmful salts, heavy metals, and mercury. Rising above the horizon, unpumped mine waters saturate the fertile layers of the earth on the surface with salts from the lower layers of the soil, turning them into salt marshes unsuitable for agricultural activities.

The consequences of this process is the change in the hydrodynamic aquatic environment. As of today, 15 of 19 mines in the Central district of Donbass are already flooded by more than half (Fig. 1-3). It is highly probable that flooding of mines with a further rise of groundwater levels and a decrease in the size of the depression will increase the deep supply of groundwater; the processes of flooding and inundation, as well as water saturation and reduction of the strength of the lower horizons of rocks with the manifestation of high-gradient sediments and violations of the continuity of rocks will continue (Bondar, 2018, Lunova, 2018, 2019, 2020, Denisov, 2018, Nabyvanets, 2018).
In Luhansk region (Fig. 2) there is a threat of hydrogeological catastrophe due to the flooding of mine workings by mine waters from inactive mines of Pervomaisk group – «Pervomaiska» and «Golubivska», located in the uncontrolled territory and hydrogeologically connected with existing mines of Pervomaisk state enterprises «Zolote», «Karbonit» and «Hirska», located in the territory controlled by Ukraine. Taking into account the value of the spatial distance from the place of flow of mine water from the mine «Rodina» to the mine «Zolote», the estimated level of flooding of the «Rodina» mine workings of is at the absolute mark – 88.5 m. (Bondar, 2018, Nabyvanets Yu., 2018., Yermakov, 2019, Lunova O., 2020).

![Fig. 2. Level of flooding in the period since 30.06.3019 till 1.04.2021 * Updated data as of April 2021 (OSCE)](image)

![Fig. 3. Schematic cross-section of the Pervomaisk group of mines of Lugansk oblast and level of flooding as of 01.02.2021.](image)
As we can see on the Fig. 3 in last years the absolute mark of the flooding of mine workings grew up as follows: mine Pervomaiska – 90.1; mine Kirova – 108.5; mine Golubivska – 84.1.

Also, in abandoned mines, there is subsidence of mine workings and landslides, sinkholes, and destruction of structures.

In the territory beyond the control of the government of Ukraine, there are significant problems with flooded mines. An example of this is the illustration of the events that took place in the territory of Zolote. In the spring of 2018, the pumps of the Zolote mine suddenly stopped working – experts claim that the additional water went from the other side of the «collision line.» Or from the territory along the «line of contact.» Accordingly, due to the armed conflict, no work can occur there, it is flooded, all the mines are hydraulically connected, the way to the mine «Rodina» tried to block by a brick wall, but it did not help.

On May 2, 2018, the accident happened when the water inflow into the mine «Zolote» reached a speed of 2000 m$^3$ per an hour. This turned out to be an unbearable load for the pumps of the Zolote mine, and it was flooded. The water level was stabilized only on July 4, when the mine water was stopped at minus 700 meters. As of May 2, it was minus 867, and all the mine workings fell into these 167 meters lost. Coal mining at the Zolote mine is nowhere to be found. To keep the water level in the mine shaft at the level of «minus 700 meters», 900 m$^3$ are pumped out per hour. If the level rises higher and floods the entire shaft, then saline, polluted mine water will fall into the aquifers and inevitably into the water intake of the water channel Popasnyansky. It also feeds the city of Luhansk.

The situation is stalemate. If the coal mine «Zolote» is be flooded, it will inevitably fill with water and close the next mines «Karbonit» and «Hirska», in the city and villages nearby people will get no work, mineralized water will go up to the aquifers and drinking problems will start (if not already started) for a half of a million people around. A project to increase water pumping is currently being developed, and Ukrainian government has allocated 131 million hryvnias for pumps. According to local engineers, if you pump 2,000 m$^3$ per an hour, you can drain the production site and save the Zolote mine in a few months, and half of the population of the city of Zolote with work. The project of sewage treatment plants is being discussed, but whether the Ministry of Coal Industry of Ukraine (local mines are state-owned) can provide such investments and when such sewage treatment plants can be built is a rhetorical question. According to the head of the military-civil administration of the town of Zolote, Konstantin Ilchenko, due to the dual power at the state-owned coal enterprise, even the same funds allocated by the government for pumping water by German pumps have been frozen.

If the mine is rescued, 48,000 tons of orange water will daily flow to the Seversky Donets and Don in that case. The fields must also be watered from the Seversky Donets in the Rostov region, and the Don flows into the Sea of Azov. Radioactive elements and traces of mercury compounds in the Seversky Donets will be observed no earlier than a year and a half. There really will be no sharp and fast catastrophe in Donbas.

Such cases in the territory not controlled by the government of Ukraine are not accidental, and their number is constantly growing. At the same time, there are problems with flooding and large-scale mineralization in the Donetsk and Luhansk regions, which are under control of the Ukrainian government.

The issue of successors of reclaimed land plots of industrial sites together with waste heaps also remains unsolved. During the underground development of minerals, there is a constant need to protect mine workings from flooding by groundwater. To address this issue, each mine is equipped with a drainage complex, which includes a reservoir, a pumping chamber with drainage systems, pressure pipelines laid along the shaft to the surface.

State mines engaged in coal mining in the region’s territory are controlled by the government of Ukraine having a constant water inflow from 200 to 600 m$^3$/h each. These are: the SE «Selidivvuhilya» – mines 1–3 «Novogrodivska», «Kurakhivska», «Ukraine», «Kotlyarevska»; the SE «Mirmogradugol» – mines «Capital» (Stakhanov), 5–6 «Central»; SE «Toretskvyuhilya» – mines «Toretska», «Central»; SE «SHU «Pivdenodonbaske No 1» «Mine named after M. S. Surgaya», Coal Company» Krasnolimanskaya». Safety rules require three identical pumps (one in operation, one as a reserve,, and one under repair), each of which is designed to pump for 20 hours of expected daily inflow of the mine – the total capacity of the equipment must have three times reserve. For the main drainage in mines, mainly centrifugal multistage sectional pumps are used, which allow the content of mechanical impurities in the water (size up to 0.1–0.2 mm) up to 0.1–0.2 % and are capable of pumping up to 300 m$^3$/h at the height of the shaft up to 600 m. Mine water accumulates in settling reservoirs on the surface, and after chlorination and treatment, is sent to the local hydrological network. Mines that are in the process of liquidation or are preparing for it in some cases must also pump water. This is due to the prevention of flooding of adjacent mines and facilities, waterlogging of the earth’s surface, violation of the hydrogeological regime of groundwater. The safety requirements for such plants for drainage equipment are the same as for working mines. These are mines No 2.
The critical water level, which will cause flooding of mine No2 «Novogrodovska» and the flow of water into the workings of mine 1/3 «Novogrodovska,» is +70.0 m. The absolute mark of the water level in the shaft of the coal mine No2 «Novogrodovska» is +88.2 m (initial level + 30.6 m). That is, during nine months, the water level rose by about 58 m. Presently, the daily water level rise has decreased significantly and is from 3 to 8 cm.

Further flooding of mine No2 «Novogrodovska» may lead to an increase in water inflow at the SE «Mine DS Korotchenko». As of July 5, 2018, it is an absolute mark water level in the mine workings +155.0 m. The rate of rising of the water level is about 5 cm per a day. The critical level at which mine water can enter the surface water system of Selidove is considered to be +155.0 m. It should be noted that the operation of the mine drainage complex was stopped in December 2017 due to the failure of the submersible pump. On May, 29, 2018, the pump was repaired, and the drainage was resumed. There is a gradual decrease in the water level in the shaft.

According to the SRGE «Donetskgeologiya,» the exploration mine was developed in the late ‘50s of the last century. The works were performed by a specialized organization (Kirov GRE), the actual data on their results are not reflected in open sources. According to the results of research, the ore occurrence is recognized as not economically perspective. Later, the territory was used as core storage and station to prepare clay solutions by the Slavic Exploration Party. In the 1990s, the shaft site was liquidated, and the area with adjacent plots was rehabilitated. As a result of the commission inspection, it was found that the overlap of the mouth of the main shaft was destroyed and opened. The diameter of the shaft, fixed with solid concrete, is 5.0 m, the depth to the water mirror is more than 10.0 m. According to available data, the total depth of the shaft is 220 m. The radiation background on the site is 17.0 μR / h. Donetsk region – 20.0 μR / h).

Conclusions

Thus, the following conclusions can be drawn. The flooding of mines and excessive mineralization of waters, which are the part of the production process, is very relevant for both Luhansk and Donetsk regions. And to get the solution of this problem requires significant efforts from both the Ukrainian state and international environmental organizations.

The main problem is that the mines are located in both controlled and uncontrolled areas of the Ukrainian government. The fate of coal mines in the territory beyond the control of the Government of Ukraine is uncertain and requires control by international organizations which can conduct monitoring activities.

Thus, the coal industry in the EU is at the stage of «coal phase-out», i. e. at the stage of gradual abandonment of coal mining. First of all, this is dictated by the EU’s course to reach a carbon-free economy by 2050, which means the gradual abandonment of coal generation and the transition to renewable energy sources. And also in accordance with the EU Directive No787 in 2010 On the need to close unprofitable mines by January, 1, 2019 (Weberink, 2018).

In general, the World Bank draws conclusions that it recommends to governments of countries involved in mine closures.

1. The state should give clear requirements and recommendations for the closure of mines. All relevant institutions and organizations should take part in determining the state policy on mine restructuring.
2. Allocation of large funds for solving technical problems with the closure and rehabilitation of production sites, as well as for the payment of monetary compensation to miners who lost their jobs.
3. Cooperation with regional administrations and trade unions.
4. Planning for the transformation period for mine closure should begin as early as possible.
5. The state must provide a social base for the employment of miners in the format of a national strategy. For example, in Germany, 50 years passed from the planning to the closure of the last mine in December, 2018. (Yermakov, 2021).
6. It is necessary to develop a system of temporary benefits, compensations, social insurance against unemployment, the possibility of early retirement for miners who have lost their jobs.
7. It is necessary to develop mechanisms for the employment of miners who have lost their jobs, which will further relieve the burden on social funds. Miners have not only knowledge in the field of mining, they are excellent electricians, mechanics, fitters, etc. In Germany, there is excellent experience in merging mining teams into service companies that outsource work to other companies.
8. Issues of rehabilitation of industrial sites should be taken into account at the planning stage of the mine. Along with the assessment of possible negative impact on the environment, issues of long-term monitoring, pumping and treatment of mine water, etc.
9. Financial mechanisms should be identified to cover the costs of liquidation of mines, as often the company is unable to solve this problem on its own, and in case of bankruptcy it completely falls into the area of state responsibility.

The outlined conclusions are also applicable in the realities of Ukraine, but we should not forget that
the above issues are still national and local problems associated with the fact that some coal enterprises in the Donetsk coal basin are separated as a result of hostilities in the Donbass. At the moment, there is an uncontrolled flooding of mines in the Donetsk and Luhansk regions, which will affect single-industry towns and organizations related to the coal industry, as well as social institutions, which were often on the balance of coal enterprises or supported by them. These are kindergartens, schools, medical institutions. In addition, these include the issues of coal-fired boilers and heating of private households using coal.

References


Denisov N., Averin D., with contributions from Yushchuk A., Yermakov V., Ulytskyi O., Bystrov P., Zibtsev S., Chumachenko S., Nabyvanets Y., 2018. Assessment of environmental damage in eastern Ukraine and recovery priorities. This publication has been prepared under the project «Assessment of Environmental Damage in Eastern Ukraine», implemented by the OSCE Project Co-ordinator in Ukraine with financial support from the Governments of Austria and Canada and in cooperation with Zoï Environment Network, Switzerland. 1–88.


Lunova O., 2018. Metodolohia vyboru tekhnolojichnykh rishen optymizatsii’ funktsionuvannia tekhnokoensystem [The methodology for choosing the technological solution allowing optimizing the techno-ecosystem functioning]. Heotekhnichna mehanika: mizhvid. zb. nauk. 141. 70–78. (In Ukrainian)


Yermakov V., 2019. Vplyv vul’kanyv’ koz,pidpryjemstv na riven’ ekologichnoi’ bezpeky tehnokoensystem Donbasu [Influence of coal mining enterprises on the level of ecological safety of technical ecosystems of Donbass] 137–142 (In Ukrainian)