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Environmental monitoring of groundwater from the "Centralna" coal mine in eastern Ukraine

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SUMMARY

As a result of the military actions, the population of the Pokrovsky district was left without a centralized supply of drinking water. An alternative water supply method currently being implemented involved the use of groundwater from the "Centralna" mine in the city of Myrnohrad. Groundwater was purified from suspended matter and disinfected from bacteria using sodium hypochlorite. The technology did not include purification of groundwater from chemicals. The purpose of this study is to monitor the quality of groundwater from the "Centralna" mine in the city of Myrnohrad. The investigations of groundwater samples before and after purification were carried out in the "Laboratory of Chemical and Veterinary Investigation Office" (CVUA) Stuttgart, Germany. The studies were conducted on 130 parameters in accordance with European water quality standards. It was established that the following standard parameters were exceeded: sodium, chlorides, sulphates, and hardness salts. At the same time, an excess of water colourability was detected. The excess of standards for these parameters ranged from 7 to 312%. Chemicals such as Acesulfame-K (E950), Cyclamate (E952) and Trifluoroacetic Acid have been found in mine water. This water can be used very limitedly as technical water in emergency conditions of military operations.



Introduction

Climate change, reduction of fresh water reserves, ecological disasters lead to a sharp reduction of drinking water reserves. The use of groundwater from mines is an alternative source of water supply for the population and industrial consumption, especially for countries and regions experiencing a shortage of drinking water (Cień *et al.*, 2024). There are various technological schemes for the accumulation and storage of groundwater in underground reservoirs with purification for final consumption, including as drinking water (Guo *et al.*, 2023). In recent years, due to Russian aggression, groundwater from coal mines has become a strategic, and in some cases the only, source of water for the population of the eastern part of the Donetsk region (Donbas environment, 2021).

Since 2014, the main source of drinking water in Pokrovsk District of the Donetsk region has been the Karliv Reservoir (Zbykovskyy *et al.*, 2024). However, due to the destruction of the dam during military operations, water losses from the reservoir were 9.85 million cubic meters. As a result, the population of the Pokrovsk District was left without a centralized water supply. In order to provide the population of the Pokrovsk District with water, a decision was made to switch to a backup water supply using groundwater from the "Centralna" coal mine, which is located in the city of Myrnohrad (Fig. 1). At the first stage, the pumping station provided groundwater supply in the volume of 25-30 cubic meters per hour. The technological installation was designed to provide the population with only technical water. The daily productivity of this installation was 12 thousand cubic meters of water, which is two times less than the needs of two cities: Pokrovsk and Myrnohrad.

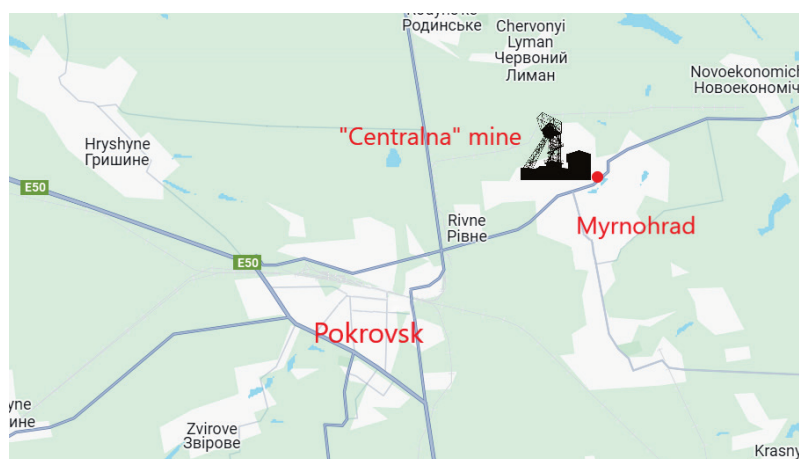


Figure 1 Geographical localization of the "Centralna" mine in the East of Ukraine.

Groundwater was collected from two mine horizons: 300 and 600 m. The water entered the catchment area at the 300 m horizon and was then supplied to the surface into open pools. Groundwater was purified from suspended matter and disinfected from bacteria using sodium hypochlorite. The technology did not include purification of groundwater from chemicals.

The purpose of this study is to monitor the quality of groundwater from the "Centralna" mine in the city of Myrnohrad, which is used as a backup water supply for the population of the Pokrovsk District of the Donetsk Region.

Method

This article is based on the data obtained as a result of the analysis of groundwater quality parameters from the "Centralna" mine, located in the city of Myrnohrad, Donetsk region. The investigations of groundwater samples before and after purification were carried out in the "Laboratory of Chemical and Veterinary Investigation Office" (CVUA) Stuttgart, Germany. The content of chemicals and other substances in groundwater was determined by the methods given in Table 1.



Table 1 Laboratory methods used to determine chemicals and other substances in groundwater.

Groups of parameters	Number of parameters	Research method/equipment
Physical and physico-chemical parameters	16	Photometry, Electrometry; Ion Chromatography (IC) with Conductivity Detection
Chemical elements: B, Al, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Cd, Sb, Ba, Ti, Pb, U, V	17	Inductively Coupled Plasma Mass Spectrometry, ICP-MS
Hg	1	Atomic Fluorescence Spectroscopy (AFS) and the Cold Vapor (Kaldampf in German) technique, AFS-Kaldampf
Pesticide	40	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS
Non-relevant pesticide metabolites, degradation and reaction products	29	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS
Artificial sweeteners	3	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS
Drugs and drug degradation products*	9	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS
Xenobiotic screening	1	Gas Chromatography-Mass Spectrometry (GC/MS) with Acetonitrile Extract, Liquid Injection; Liquid Chromatography (LC) and Orbitrap Mass Spectrometry (MS), LC/Orbitrap-MS
Per- and polyfluorinated alkyl substances (PFAS)	1	Ion Chromatography coupled with tandem Mass Spectrometry, IC-MS/MS, Direct measurement
Other industrial chemicals	3	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS, Direct measurement
Other parameters	3	High-Performance Liquid Chromatography (HPLC) coupled with Tandem Mass Spectrometry (MS/MS), HPLC-MS/MS
Radioactive isotopes	7	Gamma Spectrometry

* In accordance with the German Standard "Water quality - Determination of dissolved fraction of selected active pharmaceutical ingredients, transformation products and other organic substances in water and treated wastewater"

Results

Mining and geological conditions and the tectonic structure of mine workings, as well as climatic conditions, determine the chemical composition and characteristics of mine waters [Vergelska and Verkhovtsev, 2023]. Groundwater from coal deposits, penetrating into mine workings, interacts with rocks, metal fasteners and equipment (Bondarenko et al., 2024). As a result, the composition of groundwater and its filtration properties change, which subsequently determine the technological capabilities of groundwater treatment. In the Pokrovsk coal mining region, groundwater is located close to the surface, which also significantly affects its composition. A significant contribution to the pollution of groundwater and surface areas of the Pokrovsk District is made by the results of the economic activities of numerous industrial enterprises, primarily mining and metallurgical plants, storage facilities of industrial and household waste, mineral fertilizers and pesticides, wastewater from livestock farms [Starovoi, 2021].

The study of groundwater in the "Centralna" mine before and after treatment was carried out according to 12 groups of parameters. The total number of studied parameters was 130. This study is unique in the number of quality parameters of groundwater from a coal mine in Ukraine. It is especially necessary to highlight such groups of parameters that have never been studied in Ukraine and are not provided for by the Ukrainian standard for the quality of drinking water [DSTU, 2014].



These include non-relevant pesticide metabolites, degradation and reaction products; artificial sweeteners; drugs and drug degradation products; xenobiotics; per- and polyfluorinated alkyl substances (PFAS) and other chemicals of industrial origin.

Drinking water samples were analysed chemically and analytically. The parameters were determined in accordance with European water quality standards adapted in Germany, as well as standards for determining individual water quality parameters. Research methods and assessment of water quality parameters differ in Germany and Ukraine. For example, German standards do not include such parameters as total mineralization and total hardness. Instead, they define electrical conductivity, which characterizes the total amount of chemical compounds dissolved in water.

Water treatment of mine water had almost no effect on its quality. The sulphate content before/after purification was 1030/1020 mg/l (standard – 200 mg/l), chlorides – 267/269 mg/l (standard – 250 mg/l), sodium content – 620/615 mg/l (standard – 200 mg/l), electrical conductivity – 3610/3630 $\mu\text{S}/\text{cm}$ (standard – 2790 $\mu\text{S}/\text{cm}$), spectral absorption coefficient at 436 nm – 0.96/1.42 1/m (standard – 0.5 1/m). The excess of standards for these parameters ranged from 7 to 312% (Fig. 2).

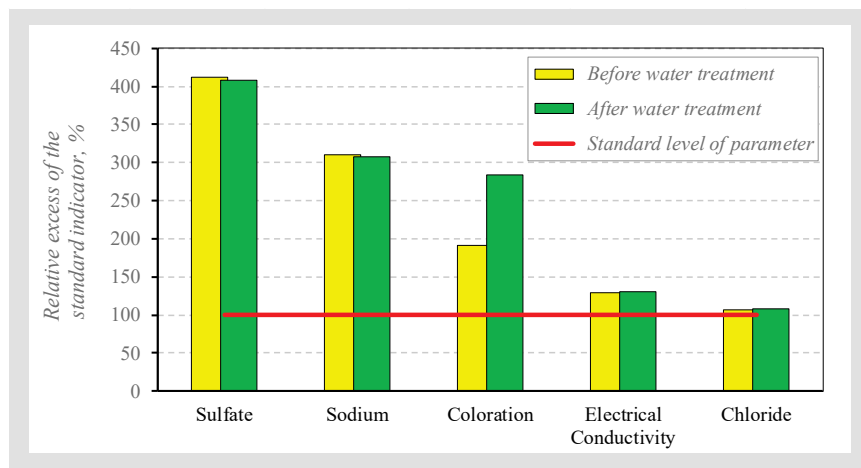


Figure 2 Relative excess of groundwater quality parameters compared to the standard level of parameters for drinking water.

There was a deterioration in water quality in some parameters, and a significant deterioration in the colourability parameter. The presence of some unacceptable chemicals in the drinking water was established. These are artificial sweeteners: Acesulfame-K (E950) – 0.097 $\mu\text{g}/\text{l}$ and Cyclamate (E952) – 0.025 $\mu\text{g}/\text{l}$, as well as Trifluoroacetic Acid – 0.136/0.125 $\mu\text{g}/\text{l}$. However, while Acesulfame-K is considered safe for humans in limited doses, Cyclamate is prohibited for use in the US food industry, as it can contribute to the development of cancer. Trifluoroacetic Acid is widely used in the chemical industry as a protein solvent and chemical reagent, does not linger in the soil, and is highly soluble in water. Therefore, its detection in groundwater in a region with a developed chemical industry is not unusual. These studies did not reveal any other excesses of quality standards in mine water. However, it is necessary to take into account the long period of time between sampling, transportation and analysis. This fact can have a significant impact on the final results of the analysis, for example on the iron content in water (Zbykovskyy *et al.*, 2025). The presence of high hardness of groundwater did not allow measuring the level of radioactive substances. However, studies of radiation levels in coal mines indicate the presence of radium in mine water (Wysocka *et al.*, 2019; McDevitt *et al.*, 2024).

Conclusions

The results of the groundwater quality study allow us to conclude that it is unacceptable to use the water from the "Centralna" mine as drinking water without preliminary deep purification from contaminants: sodium, chlorides, sulphates, and hardness salts. Chemicals such as Acesulfame-K



(E950), Cyclamate (E-952) and Trifluoroacetic Acid have been found in mine water. Their content in drinking water is not regulated by standards, because they should not be there. The groundwater from the "Centralna" mine, which was supplied to the water supply system of the cities of Myrnohrad and Pokrovsk, does not meet the requirements of both Ukrainian and European water quality standards in 5 quality parameters. This water can be used very limitedly as technical water in emergency conditions of military operations.

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