СЕКЦІЯ 6. ТОЧНІ ТА ПРИРОДНИЧІ НАУКИ

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SECTION 6. EXACT AND NATURAL SCIENCES

Bondarchuk, V. M.,
Senior Lecturer, Department of Robotics, Electrical Power Engineering and Automation named after Prof. B. B. Samotokin, Zhytomyr Polytechnic State University, Zhytomyr
Valerko, R. A.,
Doctor of Agricultural Sciences, Associate Professor, Associate Professor of the Department of Ecology and Environmental Technologies, Zhytomyr Polytechnic State University, Zhytomyr

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IDENTIFICATION OF POLLUTION SOURCES AND CLUSTERING OF HYDROCHEMICAL PARAMETERS OF QUARRY WATER IN THE AREA OF MINING ENTERPRISE OPERATIONS

The extractive industry plays a crucial role in maintaining social and economic well-being, serving as a supplier of raw materials, promoting infrastructure development, and creating employment opportunities [1]. However, mining operations may have a range of negative environmental and social consequences, including environmental degradation, soil erosion, air and water pollution, noise and vibrations, conflicts with local communities, and risks to human safety [2, 3].

During the extraction and processing of granite rocks, a significant volume of mine and quarry water is generated. Studying their composition makes it possible to identify both natural and anthropogenic factors that determine the specific chemical characteristics of these waters.

A hydrochemical analysis of quarry waters was carried out in the area of activity of the Private Joint Stock Company "Transnational Corporation Granit," which operates in the Korosten district of Zhytomyr region. The study was conducted over

the period 2021–2023. Discharge of quarry waters takes place into the Uzh River, a right tributary of the Pripyat River.

The results of the analysis of quarry water composition formed during the company's operations indicated that the hydrochemical condition of the studied area is relatively stable. The most notable fluctuations were observed in the concentrations of ammonium nitrogen, nitrites, total iron, phosphates, and BOD_5. In several cases, the concentrations of nitrites, ammonium nitrogen, and iron exceeded the maximum allowable limits established for fisheries water bodies.

To enable deeper interpretation of the results, a correlation matrix was constructed to identify relationships among various water quality indicators. Based on this matrix, a correlation heatmap (Fig. 1) and a clustering dendrogram (Fig. 2) were created.

The correlation analysis revealed numerical dependencies between the main hydrochemical parameters of quarry water in the enterprise's operational area. Significant (moderate and strong) correlations were found among several indicators, indicating likely common pollution sources or interdependence of physicochemical processes in the water. For instance, ammonium nitrogen showed a strong positive correlation with COD (r = 0.73), phosphates (r = 0.63), and total dissolved solids (r = 0.62), pointing to the influence of organic pollution of anthropogenic origin. Nitrites were strongly correlated with total iron (r = 0.74), COD (r = 0.74), and BOD_5 (r = 0.72), suggesting synchronous increases, likely due to active transformation of nitrogen-containing compounds in the presence of organic matter. Nitrates had a moderate correlation only with BOD_5 (r = 0.58), potentially reflecting their role in microbial oxidation processes.

Total iron showed a strong correlation with nitrites (r = 0.74) and a moderate one with phosphates (r = 0.38), indicating potential simultaneous migration under altered redox conditions. Phosphates also had a significant correlation with COD (r = 0.73), possibly due to wastewater or dissolution of mineral components of rocks. COD showed strong correlations with ammonium nitrogen (r = 0.73), nitrites (r = 0.74), phosphates (r = 0.73), and BOD_5 (r = 0.63), confirming the substantial contribution of organic matter to pollution.

Sulfates had a negative correlation with suspended solids (r = –0.57) and a weak negative correlation with total dissolved solids (r = –0.45), likely due to differences in their origin. BOD_5 demonstrated a strong association with nitrites, COD, and other organic pollutants, confirming active biochemical transformation of substances in the aquatic environment (Fig. 1).

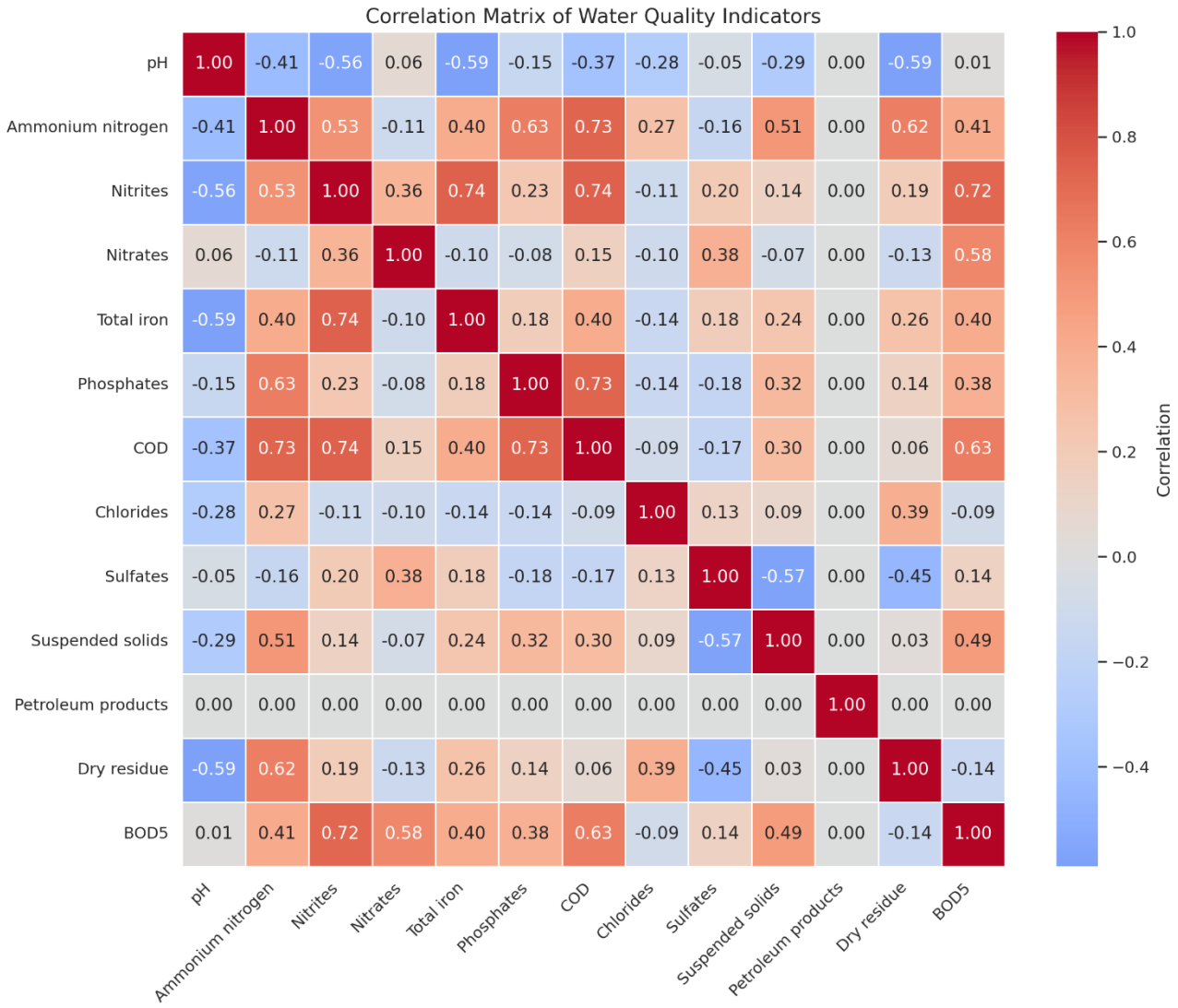

Fig. 1. Heat map of the correlation between quarry water composition indicators

Overall, the highest correlation values were observed among organic indicators (COD, BOD_5, phosphates, ammonium nitrogen), indicating their interdependence and a probable common source—technogenic wastewater or filtrate from mining development areas.

A dendrogram is a graphical representation of the results of hierarchical clustering, which is used to identify similarities between objects. The dendrogram illustrates which indicators are grouped together and share similar variation profiles or correlations in the dataset. The level of similarity between indicators is reflected in the height at which two branches are joined—the lower the height, the stronger the similarity. The clusters visually represent groups of indicators that exhibit similar behavior or possibly originate from a common pollution source.

The generated dendrogram contains four clusters, namely:

- Cluster 1 (organic pollution): total iron, BOD_5, nitrites, COD — this is the most cohesive group, reflecting a strong interdependence in terms of oxidizability and contamination indicators;

- Cluster 2 (dissolved substances): ammonium nitrogen, phosphates, suspended solids — likely associated with domestic wastewater;

- Cluster 3 (mineral salts): chlorides and total dissolved solids — indicators of mineralization;

- Cluster 4: sulfates, pH, nitrates — a less pronounced correlation group (Fig. 2).

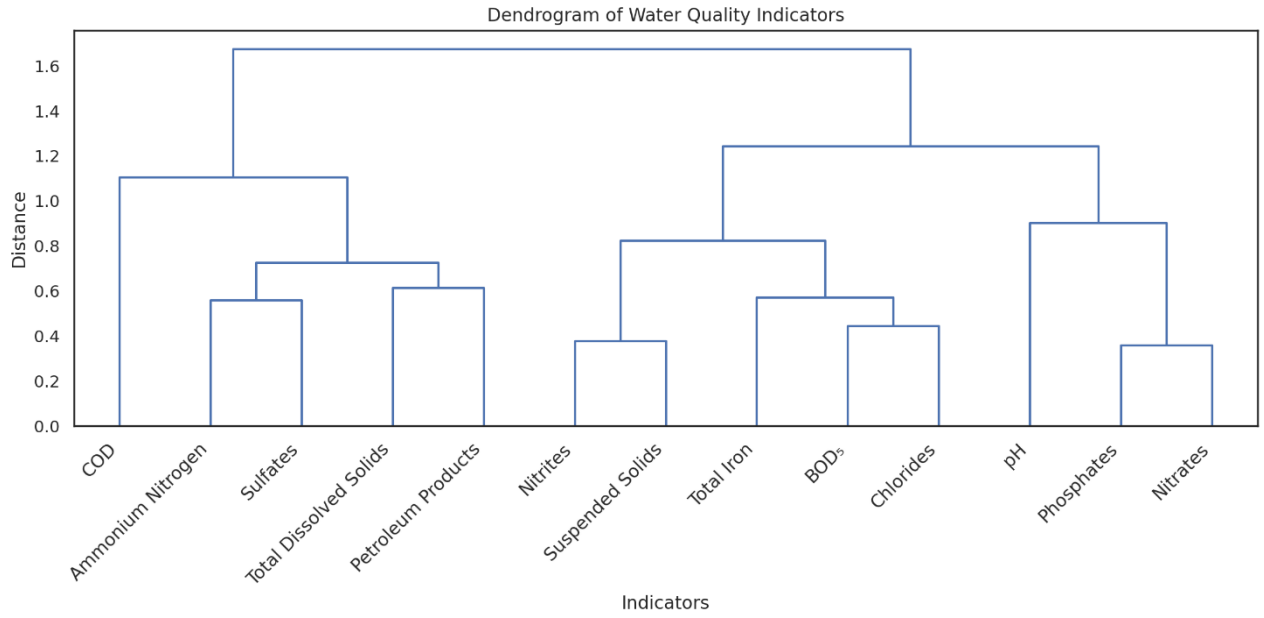

Fig. 2. Dendrogram of parameter clustering

Thus, the obtained results are essential for understanding the structure of hydrochemical loading and for planning environmental protection measures aimed at controlling water quality within the area affected by mining activities.

References

1. Mohsin, M., Zhu, Q., Naseem, S., Sarfraz, M., & Ivascu, L. (2021). Mining Industry Impact on Environmental Sustainability, Economic Growth, Social Interaction, and Public Health: An Application of Semi-Quantitative Mathematical Approach. *Processes*, *9*(6), 972. https://doi.org/10.3390/pr9060972.

2. Varouchakis, E. A., Perez, G. A. C., Loaiza, M. A. D., & Spanoudaki, K. (2022). Sustainability of mining activities in the European Mediterranean region in terms of a spatial groundwater stress index. *Spatial Statistics*, *50*, 100625.