## SUMMARY

Biodiversity, especially the taxonomic and functional diversity of plants and its influence on ecosystem processes, has long been a significant research subject in the natural sciences worldwide. Certain aspects of the relationship between taxonomic and functional diversity and soil respiration processes have been understood only in some natural semi-natural ecosystems and agrocenoses. Human activities increasingly affect the environment, and there is an urgent need to understand how these changes affect soil respiration and, thus, the global carbon cycle. Many researchers believe that newly created habitats that are a by-product of mineral exploitation provide a unique opportunity to study primary succession processes in a wide range of specific habitat conditions. Specific biotic and abiotic habitat conditions lead to the association of so-called non-analogous plant communities of previously unknown species composition and the formation of novel ecosystems (Hobbs et al., 2013). According to many researchers, novel ecosystems represent distinct ecological units that have not existed before. They should be identified and studied according to their independently developed principles for studying biological and ecological processes.

Mining, the exploitation of mineral resources, significantly alters the natural landscape. The complex habitat conditions of post-mining areas provide a unique experimental system for large-scale studies of spontaneous natural processes. This provides a basis for conducting studies to understand the functioning of Novel Ecosystems and the complexity of the relationship between microorganisms, plants, and abiotic and biotic conditions. Studies conducted in Novel Ecosystem type systems will advance understanding relationships in natural and semi-natural ecosystems.

This study aims to comprehensively analyze the role of biotic and abiotic factors on the processes of carbon dioxide release in patches of spontaneous vegetation occurring on the mineral substrate of new ecosystems developing on waste rock heaps created in connection with coal mining.

This paper conducted a comprehensive analysis of the influence of abiotic and biotic conditions, taxonomic and functional diversity, and spontaneous vegetation on the amount of $CO_2$ released from the mineral substrate of waste rock piles in newly formed ecosystems, using various research methods. Plant biomass measurement techniques were used to determine the aboveground biomass of the dominant and associated species, allowing accurate determination of the contribution of individual species to the plant community and ecosystem structure. The

analysis of the metabolic processes of soil microorganisms was supported by measurements of the respiration of the mineral substrate, enabling the assessment of metabolic activity. In addition, enzymatic activity, expressed by dehydrogenase, urease, acid phosphatase, and alkaline phosphatase activities, was determined, allowing the assessment of soil biological functions and biogeochemical processes. Analysis of the soil fauna, based on quantitative assessment of the presence of vascular nematodes and nematodes, was a key research aspect for understanding the dynamics of the soil ecosystem and the relationships between organisms. Detailed physicochemical analyses of the soil were conducted, including pH, nutrient content, and soil texture measurements. These studies aimed to understand the physical and chemical properties of the soil's mineral substrate, which is crucial to maintaining biodiversity and functioning ecological processes. The research methods used within the framework of this work provided a comprehensive set of tools for ecosystem analysis, enabling the most possible understanding of its structure, functioning, and interactions between organisms. The results can significantly contribute to developing natural science knowledge and have practical environmental protection and management implications.

In the first part, the main objective was to study the relationship between the abiotic factors of the mineral bed of waste rock piles and the intensity of carbon dioxide release. The focus was on analyzing soil respiration levels in abiotic parameters such as water content, soil texture, pH, water holding capacity (WHC), exchangeable cations, nitrogen content, and electrolytic conductivity (EC). These parameters were compared with $CO_2$ release from mine dumps in Novel Ecosystems in the root zone of patches of spontaneous vegetation types. Contrary to expectations, the respiration intensity of the mineral substrate of the waste rock piles is not exclusively related to carbon content. All habitat factors analyzed were statistically significant, except for total nitrogen content. The substrate's potassium (K) content and the intensity of soil respiration showed a significant correlation in the plant community patches studied.

In the next stage, investigating the relationship between the biotic factors of the mineral substrate of the waste rock piles and the intensity of carbon dioxide release, the focus was on the analysis of enzymatic activity, the presence of nematodes and vascular nematodes (abundance) and the amount of vegetation biomass in the context of species diversity and the amount of organic matter (SOM) in the mineral soil substrate. The research hypothesis was that in vegetation types with higher amounts of organic matter, substrate respiration processes would be more intense and that vegetation types with higher enzymatic activity and a more

significant presence of soil fauna in the root zone would be characterized by higher intensity of mineral substrate respiration. Our results showed that the substrate of vegetation patches with more biomass shows higher respiration values, respiring more intensively. The study showed that this relationship in patches of spontaneous vegetation, forming newly formed ecosystems on the mineral habitats of waste rock piles formed after coal mining, is positively strong and statistically significant between the respiration parameters of the mineral substrate and the amount of plant biomass. The activity of soil enzymes such as dehydrogenase, acid phosphatase, and alkaline phosphatase in our study was positively correlated with the amount of $CO_2$ released. Still, there was no correlation between urease activity and soil $CO_2$ emissions.

In the third part of the study, the goal was to determine the relationship between the diversity of spontaneous vegetation and the intensity of the respiration process of the mineral bed of the waste rock dump. Based on the knowledge available from studies of vegetation in natural and semi-natural ecosystems, a hypothesis was adopted that the greater the diversity in a given vegetation patch, the more intense the respiration. The paper first identifies the environmental gradients affecting the diversity of the studied vegetation both taxonomically and functionally. Next, the relationships between various measures of vegetation diversity and soil substrate respiration parameters were analyzed. It was found that the intensity of the respiration of the mineral substrate differs between vegetation types. Contrary to our expectations, soil respiration was highest in the less diverse vegetation types. Among the functional components, only functional dispersion (an indicator of low habitat filtering) is weakly negatively and significantly correlated with respiration (SRL). However, all indicators of functional diversity are correlated, indicating that the conditions that promote the association of plant communities on mineral substrate in waste rock dumps act differently than in semi-natural and natural ecosystems. Therefore, respiration depends on several abiotic and biotic factors in new ecosystems and requires further research.

Knowing and understanding the functioning of Novel Ecosystems type systems and the processes leading to the co-evolution of the best-adapted organisms and their interrelationships will enable this knowledge to be used to support the regeneration of environmental functioning (ecosystem services and human quality of life). Supporting the emergence of New Ecosystems type systems can be considered a better way to manage post-mining areas than taking the risk of losing time and financial resources to restore, for example, post-mining heaps to their previous state.

Understanding the relationship between various abiotic and biotic factors and the soil respiration process is crucial to assessing the impact of environmental changes on the functioning of soil ecosystems. As human activities increasingly affect the environment, there is an urgent need to understand how these changes affect soil respiration and, thus, the global carbon cycle.

In conclusion, the research brings new knowledge on the determinants of vegetation diversity and the interactions between biotic and abiotic elements in mineral habitats of post-mining heaps. There has yet to be an extensive analysis considering abiotic and biotic factors on post-mining mineral sites. Conclusions from these studies can be crucial for developing strategies for managing the natural environment and protecting biodiversity, taking into account the influence of various factors on the respiration processes in mineral substrates.

The hypotheses posed in the study were falsified. This indicates that the course of the studied processes: the relationship between biotic and abiotic factors, the diversity of plant communities spontaneously developing on the mineral substrate of waste rock heaps, and the processes of carbon dioxide release in newly emerging ecosystems (Novel ecosystems), is different than in natural and semi-natural ecosystems.

**Keywords:** soil respiration, coal mine heaps, biotic factors, abiotic factors, taxonomic diversity, functional diversity, new ecosystems.