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Impact of Environmental Disruption on Microbial and Enzymatic Dynamics of Chornozem Soils

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INTRODUCTION & AIM

Chornozem soils, also known as black earth soils, represent one of the most fertile soil types globally and are critical to agricultural productivity in Eastern Europe. These soils are characterized by their deep humus-rich horizons, excellent structure, and abundant microbial communities that drive essential ecosystem services. However, severe anthropogenic disturbances including military activities, industrial contamination, intensive agriculture, and environmental pollution can induce long-term ecological shifts, particularly affecting sensitive biological systems such as soil microbial communities and their associated enzymatic functions.

Soil microorganisms play pivotal roles in nutrient cycling, organic matter decomposition, soil structure formation, and plant health. The fermentation processes mediated by diverse microbial communities are fundamental to maintaining soil fertility and ecosystem resilience. Enzymatic activities serve as sensitive bioindicators of soil health, reflecting the metabolic capacity of microbial populations and the overall biochemical functioning of soil ecosystems. Understanding how environmental disruption impacts these critical biological processes is essential for developing effective restoration strategies.

METHOD

- Tenfold dilution techniques for microbial quantification
- Selective media for microorganism determination
- Enzymatic activity assessment of key soil ferments
- Analysis of agronomically important microbial groups

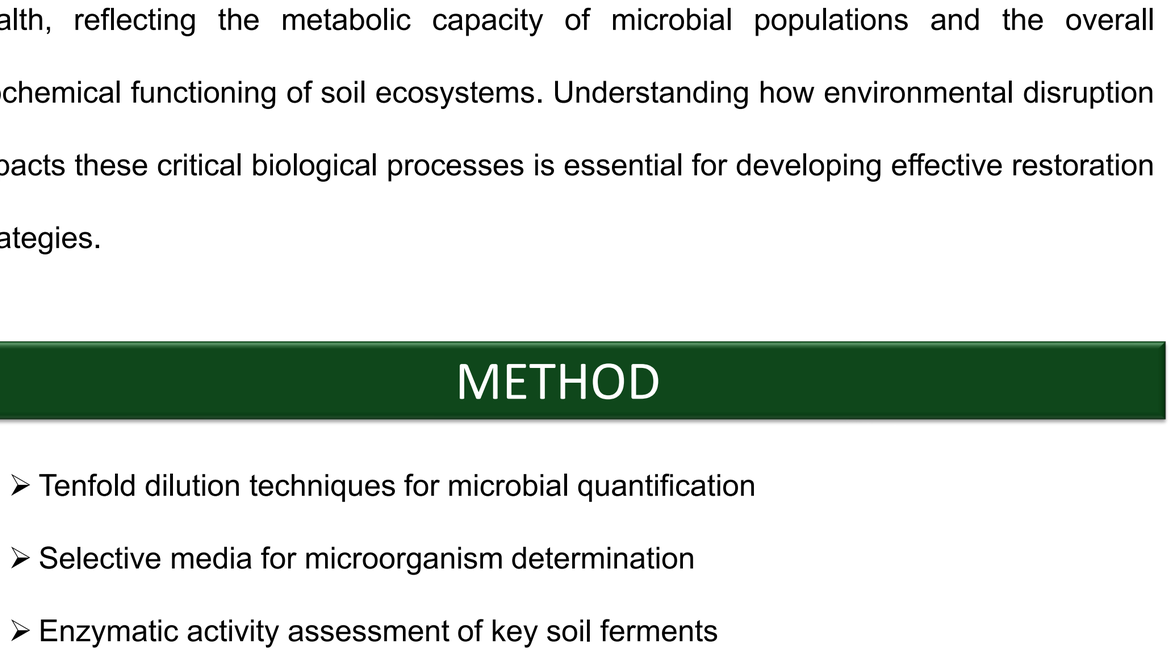
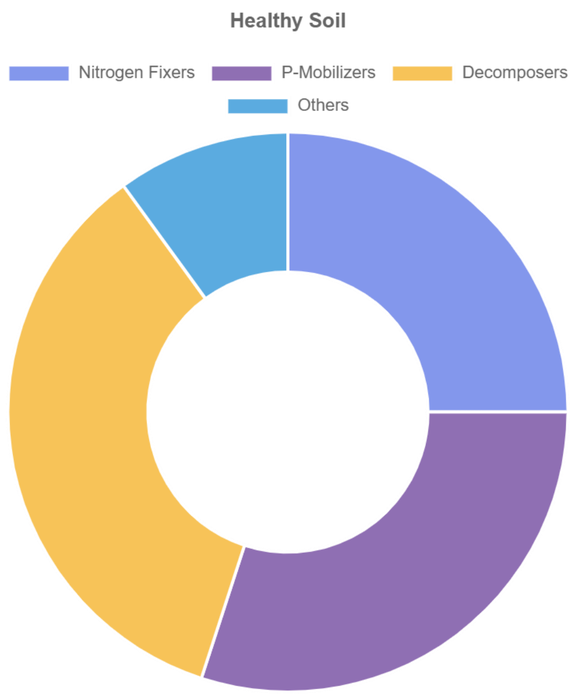


Fig. 1 *Multi-parameter soil health assessment*

RESULTS & DISCUSSION

Enzymatic activity analysis revealed a comprehensive collapse of soil biochemical functions. Hydrolytic enzymes responsible for organic matter fermentation and nutrient mineralization showed severe reductions, indicating stalled decomposition processes and nutrient cycling. The parallel decline in both microbial abundance and enzymatic activity confirms that environmental disruption has profoundly impaired the metabolic capacity of the soil ecosystem.

Fig. 2 *Relative abundance of microbial functional groups in healthy soil*



Biological Restoration Approach

Given the magnitude of biological collapse, restoration requires a comprehensive, multi-phase approach targeting microbial community re-establishment, enzymatic function recovery, and nutrient cycling reactivation. The severe depletion of keystone functional groups necessitates active biological intervention rather than passive natural recovery.

Table 1
Comprehensive enzymatic activity comparison with functional interpretation and ecological consequences

Enzyme	Biochemical function	Healthy soil	Disturbed soil
Invertase	Sucrose hydrolysis, organic C cycling	45.2 mg glucose/g	12.3 mg glucose/g
Urease	Urea hydrolysis, N mineralization	8.6 mg NH_3/g	2.1 mg NH_3/g
Protease	Protein degradation, amino acid release	3.8 mg tyrosine/g	0.9 mg tyrosine/g
Phosphatase	Organic P mineralization	12.4 mg phenol/g	3.2 mg phenol/g
Dehydrogenase	Microbial respiration indicator	15.7 mg TPF/g	4.1 mg TPF/g
Catalase	H_2O_2 decomposition, stress response	6.2 ml O_2/g	8.9 ml O_2/g
Polyphenol oxidase	Phenolic oxidation, humus formation	4.3 mg purpurogallin/g	3.4 mg purpurogallin/g
Peroxidase	H_2O_2-dependent oxidation	2.8 mg purpurogallin/g	2.3 mg purpurogallin/g

CONCLUSION

The severe degradation of microbial fermentation potential and enzymatic function in disturbed chornozem soils highlights the need for biological restoration. The 2-3 order magnitude decline in microbial abundance, coupled with reduction in key enzymatic activities, indicates a critical disruption of soil ecosystem services. Our findings provide a biochemical basis for developing remediation strategies focused on reactivating microbial fermentation critical for ecosystem recovery and sustainable soil management in the Kharkiv region.