

Impact of Fly Ash on Soil Microbial Ecology: A Metagenomic Perspective from Kolaghat Thermal Power Plant Region, India

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Abstract

Fly ash contamination from thermal power plants has become a significant environmental concern, particularly in agricultural ecosystems. This study investigates the long-term impact of fly ash exposure on soil microbial diversity and function in the vicinity of the Kolaghat Thermal Power Plant (KTPP), which has been operational since 1984. Soil samples were collected from eight agricultural sites surrounding KTPP and composited (BP1) for Whole Genome Shotgun (WGS) metagenomic sequencing. The analysis revealed a distinct microbial signature shaped by chronic contamination. Bacterial communities were dominated by Actinobacteria (48.28%) and Proteobacteria (40.80%), indicating high resilience to environmental stress. Fungal communities were heavily skewed toward Ascomycota (89.50%), particularly Sordariomycetes, while viral profiles were enriched in Negarnaviricota and Siphoviridae, reflecting dynamic virus-host interactions in stressed soils. Functional analysis identified key stress-response genes, including ABC transporters and 3-oxoacyl-acyl-carrier protein reductase, along with metabolic pathways associated with lipid processing, xenobiotic degradation, and nutrient transport. Notably, *Halobacillus mangrovi* was identified via GTDB-Tk as a prominent stress-tolerant taxon. These findings underscore the significant and lasting ecological footprint of over four decades of fly ash deposition by KTPP. The enriched presence of pollutant-degrading and stress-adapted microbes demonstrates the potential for leveraging native microbial communities in bioremediation strategies. This study contributes vital baseline data for environmental monitoring, microbial resource management, and the development of sustainable interventions to restore soil health in fly ash-impacted agroecosystems.

Biography

Biswajit Paul and Palash Pan have recently submitted their PhD theses at Vidyasagar University in India, and they are currently serving as faculty members in zoology and biotechnology, respectively, at Panskura Banamali College, India. Prof. (Dr.) Bhattacharyya completed his postdoctoral studies at the Cleveland Clinic Foundation of Cornell University in the United States. He is presently the Principal and Chairman of Panskura Banamali College and Research Centre in India. He has authored over 100 papers in esteemed journals and has been a member of several reputable editorial boards.

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