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ARTICLE

Bioremediation of Emamectin Benzoate-Contaminated Soil by Indigenous Fungi: Degradation Kinetics and Restoration of Soil Carbon and Nitrogen Cycling

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ABSTRACT

The excessive application of Emamectin benzoate (EMB) can impair soil health and disrupt key biogeochemical processes in the living cells. This study evaluated the bioremediation potential of three indigenous fungal isolates including: *Alternaria infectoria*, *Lichtheimia corymbifera*, and *Aspergillus* fumigatus in EMB-contaminated soil under increasing pesticide stress up to 250 mg L^{-1}. The EMB degradation kinetics were determined by High-Performance Liquid Chromatography (HPLC), while soil respiration (CO_2 evolution) and urease activity were monitored as indicators of carbon and nitrogen cycling, respectively. The fungal inoculation significantly enhanced 100 mg L^{-1} EMB degradation, reducing the half-life from 4.70 days in the control to approximately 1.6 days. At the lethal concentration 250 mg L^{-1}, *A. infectoria* maintained the highest degradation rate k = 0.388 day^{-1} and the shortest half-life 1.79 days, compared with 5.84 days in the control. This isolate also produced the highest cumulative CO_2 emission 1680.9 mg kg^{-1} soil, indicating efficient EMB mineralization. In contrast, *A. fumigatus* showed the greatest capacity to restore nitrogen cycling by sustaining urease activity and overcoming the initial inhibition phase. Overall, *A. infectoria* exhibited the strongest bioremediation potential, highlighting its suitability for the remediation of EMB-contaminated agricultural soils.

Keywords: *First-order kinetics, Half-life, High-Performance Liquid Chromatography (HPLC), Soil respiration, Urease enzyme*

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INTRODUCTION

Microorganisms, particularly fungi, represent the fundamental engine for the sustaining soil health and fertility. They play a crucial role in the managing biogeochemical cycles, specifically the functional synergy between the carbon and nitrogen cycles. However, the intensive expansion of agricultural activities and the excessive reliance on pesticides such as the widely used compound Emamectin benzoate—have imposed severe toxic stress that threatens this ecological balance in agricultural lands. This environmental hazard is clearly manifested in the ability of these pesticides to paralyze extracellular enzymes, such as urease, which is considered the core backbone of nitrogen mineralization processes. The previous studies have demonstrated that chemical stress sharply reduces the enzyme-secreting microbial biomass and interferes with their active sites, leading to the deterioration of soil fertility and a decline in its productive efficiency (Baćmaga *et al*., 2015).

To evaluate the impact of this chemical stress, soil respiration and the release of carbon dioxide (CO_2) serve as the most prominent biological indicators for measuring microbial response and carbon cycling efficiency. Under the high pollution