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Mechanisms of humic substances degradation by fungi

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Humic substances (HS) are formed by secondary synthesis reactions (humification) during the decay process and transformation of biomolecules originating from plants and other dead organisms. In nature, HS are extremely resistant to biological degradation. Thus, these substances are major components in the C cycle and in the biosphere and therefore, the understanding of the process leading to their formation and transformation and degradation is vital.

Fungi active in the decomposition process of HS include mainly ascomycetes and basidiomycetes that are common in the upper layer of forest and grassland soils. Many basidiomycetes belong to the white-rot fungi (WRF) and litter-decomposing fungi (LDF). These fungi are considered to be the most efficient lignin degraders due to their nonspecific oxidizing enzymes: manganese peroxidase (MnP), lignin peroxidase (LiP) and laccase. Although bacteria dominate compost and participate in the turnover of HS, their ability to degrade stable macromolecules such as lignin and HS is limited.

The overall objectives of this research were to corroborate biodegradation processes of HS by WRF. The specific objectives were: (i) To isolate, identify and characterize HS degrading WRF from biosolids (BS) compost; (ii) To study the biodegradation process of three types of HS, which differ in their structure, by WRF isolated from BS compost; and (iii) To investigate the mechanisms of HA degradation by WRF using two main approaches: (a) Study the physical and chemical analyses of the organic compounds obtained from direct fungal degradation of HA as well as elucidation of the relevant enzymatic reactions; and (b) Study the enzymatic and biochemical mechanisms involved during HA degradation. In order to study the capability of fungi to degrade HS, seventy fungal strains were isolated from biosolids (BS) compost. Two of the most active fungal species were identified based on rDNA sequences and designated Trametes sp. M23 and Phanerochaetesp., Y6. These strains were used throughout this study.

This research shows that WRF are able to degrade different HA and under different culture conditions. We found that significant degradation occurred in high C/N media – conditions which are commonly present in the natural habitats of WRF. We suggest that in addition to lignin, these fungi play a crucial role during HS degradation in the environment.

This work raises additional questions that are worth investigating in the future: what is the role of these fungi in dissolved organic matter degradation and its relationship to HA degradation? What is the detailed mechanism of iron reduction in Trametes sp. M23 as well as in other WRF? What is the exact involvement of hydroxyl radicals during degradation and what are the mechanisms of H_2O_2 production in Trametes sp. M23?