

Mineral induced antibiotic transformation products and their impact on bacterial growth and denitrification activity

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The abiotic transformations of quinolones and tetracyclines facilitated by redox-active minerals has been studied extensively, however limited information is available regarding the antimicrobial activity and toxicity of their resultant transformation products. In this study, we first investigated the mechanisms underlying the transformation of two commonly used antibiotics, ciprofloxacin (CIP) and tetracycline (TC), by the ubiquitous redox soil mineral, birnessite (MnO₂). Subsequently, we evaluated the impact of these transformation products on both the growth and activity of the environmental denitrifier *Pseudomonas veronii*. Following the reaction with birnessite, four transformation products for CIP and five for TC were identified. Remarkably, the antibacterial activity of both CIP and TC was lost upon the formation of transformation products during their interaction with birnessite. This loss of antimicrobial efficacy was associated with specific chemical transformations, such as the opening of the piperazine ring for CIP and hydroxylation and demethylation for TC. Interestingly, denitrifying activity, quantified in terms of nitrate reduction rates, remained unaffected by both CIP and TC at low concentrations that did not impact bacterial growth. However, under certain conditions, specifically at low concentrations of CIP, the second step of denitrification—nitrite reduction—was hindered, leading to the accumulation of nitrite. Our findings highlight that the transformation products induced by the mineral-mediated reactions of CIP or TC lose the initial antibacterial activity observed in the parent compounds. This research contributes valuable insights into the intricate interplay between antibiotics, redox-active minerals, and microbial activity in environmental systems.