Endophytes from *Phragmites* for metal removal: evaluating their metal tolerance, adaptive tolerance behaviour and biosorption efficacy

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**ABSTRACT**

This study determined the potential of fungal endophytes as novel group of biosorbents for metal removal. The endophytic fungi were first isolated from *Phragmites*, a plant typically used to treat wastewater or leachate, and screened for tolerance and biosorption potential towards various metals. Results revealed that all 21 endophytes demonstrated tolerance to metals tested (Cd$^{2+}$, Cu$^{2+}$, Cr$^{3+}$, Pb$^{2+}$ and Zn$^{2+}$), with three isolates (*Trichoderma asperellum* Iso11, *Phomopsis* sp. Iso9 and *Saccharicola bicolour* Iso22) showing the most potential. Of the three, *T. asperellum* demonstrated better tolerance and adaptive tolerance behaviour to various metals compared to *Phomopsis* sp. and *S. bicolour* which were unable to adapt to increasing metal concentrations (up to 2,000 mg L$^{-1}$). All three isolates showed similar efficacy in removing metals in single-metal solutions. On the contrary, in multi-metal solutions, *T. asperellum* and *S. bicolour* showed higher affinity to adsorb Cu$^{2+}$, followed by Cr$^{3+}$ and Pb$^{2+}$, while *Phomopsis* sp. had affinity towards metals in the following trend: Cu$^{2+}$ > Pb$^{2+}$ > Cr$^{3+}$. This study is the first to document the metal tolerance and sorption efficacy of endophytes from *Phragmites*.

**Keywords:** Adaptive behaviour; Biosorption; Endophytes; Metal tolerance; *Phragmites*