Chapter 14
Safety and Efficacy of Pseudomonas Exopolymer in Sequestration of Iron From Aqueous Environments

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ABSTRACT

The present study reports the iron binding characteristics and safety of an exopolymer (EBP) of an environmental isolate of Pseudomonas *sp. The EBP was predominantly polysaccharide in composition with pyruvic and uronic acid residues. A prevalence of carboxyl and hydroxyl groups was observed in the Fourier-transform infrared spectroscopy (FTIR) results, while scanning electron microscopy (SEM) revealed a porous structure in a linear fashion with large number of grooves. The purified EBP was stable for over two months and exhibited rapid binding of iron (25mg/L) within 10 minutes at ambient temperature. X-ray diffraction (XRD) and energy-dispersive X-ray spectroscopy (EDAX) analysis of iron challenged EBP suggested the involvement of carboxyl groups in potentiating iron removal. Both Langmuir and Freundlich adsorption isotherms depicted high iron removal capacity in comparison to reported biomasses or biopolymers. Cytotoxic effects were not observed upon challenging various doses of EBP in RAW 264.7 cell lines implying a strong possibility of application of the EBP.*

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INTRODUCTION

Metal ions, especially heavy metal ions, discharged into water bodies by human activities, persist and accumulates in the food chain leading to serious environmental problems. Additionally, the bioaccumulation and biomagnifications of heavy metals at each step of the food chain poses health issues in animals and humans due to their mutagenic and carcinogenic potential (Bawuro et al., 2018; Latif et al., 2018; Yen et al., 2018). As the second most abundant element in earth's crust, Iron is a crucial cofactor in enzymes involved in various metabolic processes and electron transport in plants and animals. Despite the physiological importance of iron in all genera of life, high levels of iron in water can exert untoward effects in aquatic ecosystems. An increase in iron levels beyond a threshold can impact species composition of lakes by stimulating growth of green algae and cyanobacteria while also adversely affecting growth of aquatic and submerged plants. Adverse health effects such as liver cancer, infertility and diabetes are common by overloading of iron (Staniek and Wojciak, 2018). The presence of iron beyond 0.3 mg/L imparts colour (yellow to reddish), odor and taste to drinking water. In view of this both World Health Organization (WHO) and the United States Environment Protection Agency (US EPA) have recommended levels of 0.3 mg/L iron in drinking water (WHO, 1996).

In recent years, biological methods of pollutant and toxicant removal have gained increasing attention as an easy and cost effective substitute to conventional chemical and physical methods of remediation (Wang et al., 2012; Xue et al., 2006; Yang et al., 2004). Although the bioremediation protocols have been successfully employed for non-specific removal of phosphate, metals and other pollutants/ toxicants, iron removal in wastewater is generally achieved by conventional chemical and physical methods like precipitation, crystallisation, flocculation, ion exchange, ultrafiltration, reverse osmosis and others(Kurniawan et al., 2006). However, with the realization of environmental impact of iron in recent years, the research focus has now shifted to development of novel, bio-based systems for iron removal (Horzum et al., 2010; Kousalya et al., 2010; Ngah et al., 2005; Reiad et al., 2012; Tapia et al., 2011; Xue et al., 2006; Yang et al., 2004).

Microbial exoproducts, most notably exobiopolymers (EBPs), have found applications in removal of metals from industrial wastes, oil refining, waste water treatment and as thickeners and emulsifying agents (Hay et al., 2014; Paniagua-Michel Jde et al., 2014). EBPs are mainly composed of polysaccharide and proteins and exhibit metal ion sorption capability due to presence of carboxyl, amine and hydroxyl groups. Recent studies have demonstrated that dried biomass of activated sludge as well as exobiopolymers produced by several microbial species exhibit significant iron binding capacity (Aryal and Liakopoulou-Kyriakides, 2013; Emtiazi et al., 2004; Huang et al., 2011; Moppert et al., 2009; Shokoohi et al., 2009; Tapia et al., 2013; Tapia et al., 2011; Yu et al., 2009).

In an attempt to identify bacterial strains for iron bioremediation, an EBP-producing bacterium was isolated from industrial sludge. The major objectives of the study were identification of the microorganism, characterization of its iron sorption behaviour and *in vitro* cytotoxicity in cell line. This appears to be the first report describing exobiopolymer production by *Pseudomonas* sp. and its iron binding efficiency with an objective of removing iron from water.

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