

## Advances in exopolysaccharides based bioremediation of heavy metals in soil and water: A critical review



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### ABSTRACT

Extracellular polysaccharides or Exopolysaccharides (EPS) are extensively studied bacterial byproducts with high molecular weight attributed to several applications. In spite of their application in the field of food, pharmaceutical, nutraceutical, herbicidal and cosmeceutical industries they were well known for their efficiency in the bioremediation of water and soil tainted with heavy metals. These heavy metals are comparatively high in density than water and are involved in several biological processes. But slight increase in levels can create toxicological bias. The techniques like electro dialysis, chemical precipitation, ion exchange and membrane separation have a lot of disadvantages akin to high energy consumption, high cost, partial exclusion, and creation of poisonous mire. In this context, EPS has a top role to play in the bioremediation of heavy metals. This review gives the critical assessment of the extensive work done to deal this issue by different groups in the last five years. It also explains how different natural circumstances have attributed to the advancement of EPS production, thereby increasing the capacity of bioremediation to deal the issue of heavy metal contamination in both soil and water. A detailed discussion of the EPS formation by bacteria and fungi with their applicability was reported.

### 1. Introduction

The principal consequence in the advancement of economies worldwide was not only the development and wellbeing but, massive contamination by industrialization, urbanization and agricultural practices. Comfort, growth and food security through urbanization, industrialization and vicious agrarian progression was slowly converting to unrest and disasters. In this context, heavy metals and their contamination in soil and water are at forefront. International program on chemical safety by World Health Organization has listed heavy metals Arsenic, Cadmium, Fluoride, Lead and Mercury in the top ten chemicals of primary public health concern. Many other metals added to these are dangerous, hazardous and can craft a lot of inconvenience to the humanity (Fig. 1). There are many conventional types of techniques that have been utilized like reverse osmosis, ultrafiltration, nanofiltration, ion exchange, flotation, electro dialysis, chemical

precipitation and coagulation to deal this setback. Many organizations and scientists from various disciplines utter that the bioremediation can be used to bring down the metal availability below the permissible limit. Most of them are in their advanced stages of developing different protocols and identifying a plethora of bacterial species to address the issue (Kielak et al., 2017).

The extracellular polymeric substances (EPS) are the primary macromolecular components in microbial collections. This amasses were the tranquil of different materials at different composition. EPS comprises of polysaccharides, proteins, nucleic acids, lipids, uronic acid, organic and inorganic compounds (Fig. 2).

They are the structural and functional components of microbial biofilms that play a vital role in bio-aggregate formation and survival of bacterial cells. So the development of safe and useful techniques for EPS extraction is much needed. The different extraction techniques applied so far are microwave assisted, ultrasound assisted, enzyme-assisted and

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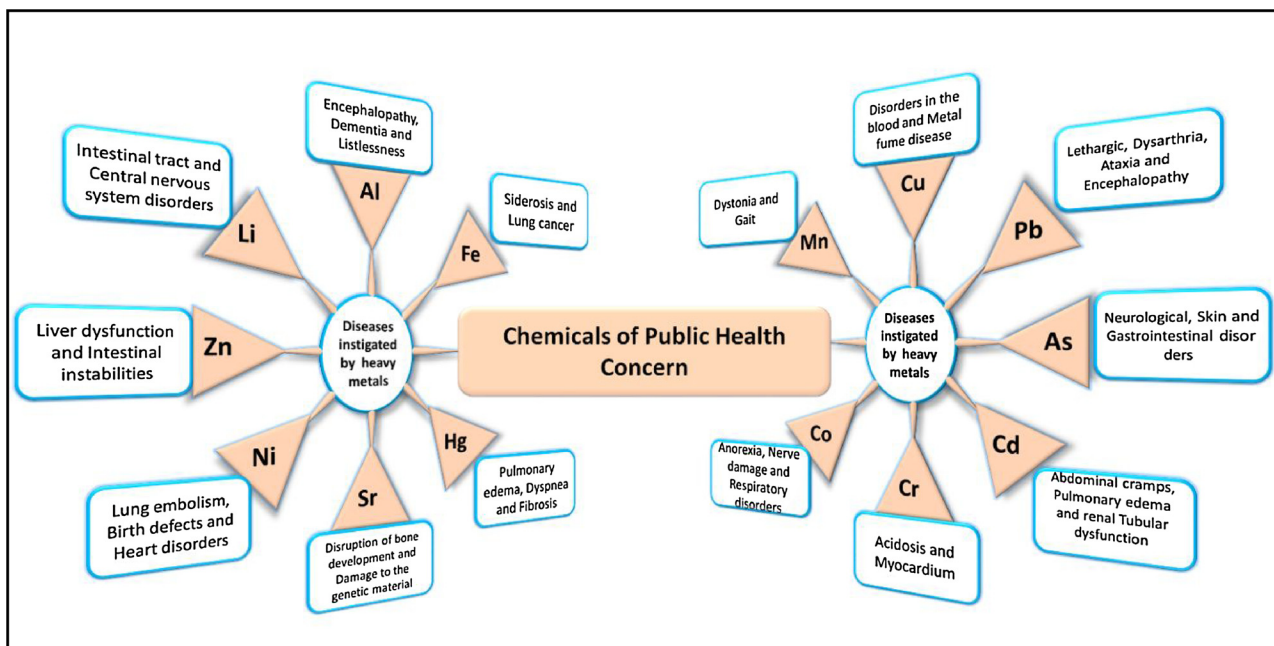


Fig. 1. Heavy metals of public health concern and their related associated diseases (Kielak et al., 2017).

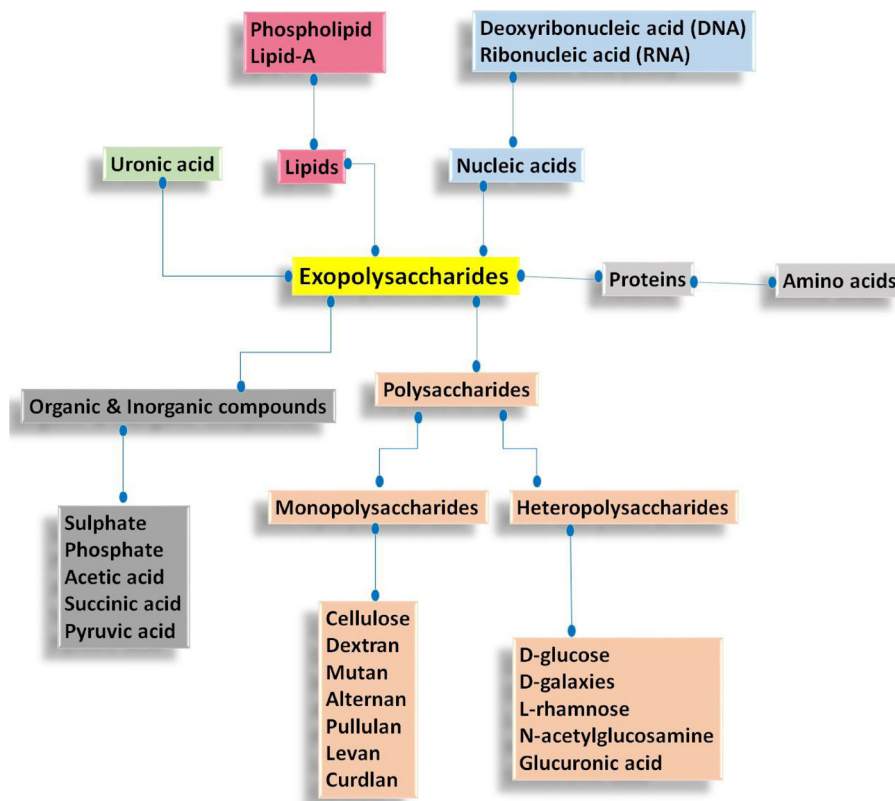


Fig. 2. Different constituents and sub constituents of Exopolysaccharides (Hu et al., 2012; Poli, Di Donato, Abbamondi, & Nicolaus, 2011).

hot water assisted extraction. Controlled centrifugation techniques and heating assisted techniques at different temperatures (40, 45, 50 and 60 °C) along with different chemicals (H<sub>2</sub>SO<sub>4</sub>, EDTA, NaOH etc) are also involved in the extraction of EPS. One of the most important approaches of microbes to fight against metal stress is exopolysaccharide production. EPS is produced from nasty environment under heavy stress and different nutrition conditions (Mohite, Koli, Narkhede, Patil, & Patil, 2017). The essential characteristics of EPS are cost effective,

environmentally friendly, sustainable biofilm formation. For the above reason, EPS is preferable to remove heavy metal impurities rather than conventional methods. Therefore to meet the current challenges, we must make EPS a business like (efficient) biosorbent for heavy metals. Polysaccharides produced by various microorganisms contain repeating sugar units named as EPS. They exist in two forms namely capsular polysaccharides (CPS) which are tightly associated with cell wall and ropy EPS which are free loose slime layer. Metal removal varies for both

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