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Approaches for treatment of soils and water contaminated with heavy metals

Подходи за обработка на почви и води, замърсени с тежки метали

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Presence of heavy metal in environment and their effect to living organisms

Heavy metals are found in the environment as a result of natural and anthropogenic factors. Their natural presence is related to soil and sediment composition when their concentrations are low and they are considered to be trace elements (less than 10 ppm) (Kabata-Pendia, Pendia, 2001). Excessive levels of trace metals in nature may be caused by geographical phenomena like volcanic eruptions, weathering of rocks, and leaching into recipients (El-Sayed et al., 2017). The main anthropogenic sources of the heavy metals pollution are industrial activity, generation of various types of energy, production waste effluent, discharges and disposal of harmful solid waste, ect. (Miladinovic et al., 2012; Grace et al., 2016).

From a biological perspective, heavy metals can be divided into two groups. The first group consists of heavy metals in low concentrations (micro elements and trace elements), which have important biochemical and physiological function (Nies, Silver, 2007). These metals are essential nutrients (e.g. Co, Cu, Cr, Fe, Mg, Mn, Mo, Ni, and Zn) (Trace Elements…, 1996). Inadequate supply of these nutrients can caused the various illnesses or deficiency syndromes. Their bioavailability is influenced by factors such as temperature, phase association, adsorption, and many chemical factors (Hamelink et al., 1994). Biological factors like the characteristics of the species, trophic interactions and biochemical/physiological adaptation, also play an important role (Verkleji, 1993). The second group includes macro elements, i.e. heavy metals which are harmful to human health and the environment (e.g. emissions of Cd and Hg vapors and precipitation of Pb, Mn, Co, and Ni) (Wu et al., 2010). These metals cause various physiological irregularities at the cellular level (Nies, Silver, 2007; Banfalvi, 2011). The toxicity of heavy metals depends on their concentration, chemical form, penetration, solubility, and biochemical reactions (metabolic processes) (Sawicka-Kapusta et al., 2010).

Treatment of heavy metal pollution

Heavy metal pollution presents persistent environmental problem due to their toxicity, no degradability and chemical properties – possibility to interaction with other molecules in surroundings. Intensive industrial development followed with no adequate waste management led to increased contamination of soil and water resources. In order to resolve problem of these pollutants several approaches are developed (Parmar, Singh, 2015; Lambert et al., 2016).

Physico-chemical treatment

Physico-chemical treatment of heavy metal pollution often include excavation and stabilization. Excavation is the oldest method for the treatment of contaminated soils (the practice of dig-and-dump or encapsulation process). Stabilization presents traditional remediation method, in which the contaminated soil is treated at that very site to reduce the effects of the heavy metal contaminants. Treatment of heavy metal pollution could be carried out *in situ* and *ex situ*. Additional factors that could help to inhibit and reduce the effects of the heavy metals in soil are: soil pH (6.5 or more), properly drained wet form soil, application of phosphates, plant cultivation. Disadvantages of these approaches are treatment duration, potential spreading of contamination or new pollution (phosphates), residues of heavy metals in environment (Ghatak, Madathil, 2016).

Biotechnological treatment

Ecofriendly alternatives for heavy metal pollution treatment are bioremediation and phytoremediation. Bioremediation involves use of microorganism (viable

or dead biomass and/or their metabolites) for remediation of contaminated soil or water. Microbial response and mechanisms to heavy metal exposure are diverse, depending on metal and microbe its self, and involve: biofilm formation, metabolism alteration, biosorption, bioaccumulation, biochelation (Izrael-Zivkovic et al., 2018). This field of applied microbiology is permanent subject of study. *Pseudomonas* spp and *Bacillus* spp due to their genetic capacity are promising candidates for bioremediation of heavy metals, but result of process highly depends on process optimization, isolate characterization and understanding of microbe and environment interactions (Syed, Chinthala, 2015; Izrael-Zivkovic et al., 2018).

Phytoremediation as approach in treatment of heavy metal use plants to reduce or inhibit their toxic effect by rhizofiltration (root absorption of metal), phytostabilisation (growing metal resistant plants in contaminated environment) and phytoextraction (absorption and accumulation of metal in upper plant tissues and organs). Application of plants in treatment of heavy metal pollution is simple and low cost, but could generate additional waste (above ground parts of plant saturated with metal), which require further treatment and potentially production of new pollutant (Parmar, Singh, 2015; Lambert et al., 2016).

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