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Sustainable Wastewater Treatment using Microorganisms: What is next?

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Abstract: *Among the large range of studied materials, the potential of microorganisms in biosorption and bioaccumulation processes has been for many years an important research subject together with other types of renewable biomass. Different microbial organisms such as bacteria, yeasts and microalgae have been successfully used directly or after further enhancements. The functional properties of the microorganisms enable them to form a good substrate and also to incorporate in their cells persistent pollutants and generate enzymes that digest their structure. Owing to this, microbial-based removal methods are characterized by a higher selectivity in wastewater treatment. In this context, the scientific world has carried out extensive lab-scale analyses and subsequently, significant progress has been made in analyzing their potential. The results obtained when applying these low-cost substrates were generally demonstrated to be similar to the ones generated by synthetic materials and conventional methods for a large range of pollutants, from inorganic to organic pollutants. Different physical and chemical techniques were carried out to improve to an even higher extent the removal efficiency of the microorganisms. Applied biotechnology has evolved substantially and in this context, we are asking: What is further necessary for these non-conventional materials with significant wastewater treatment properties to become the conventional ones and to be applied at large scale?*

Introduction

Types of Microorganisms:

- **Microalgae**
- **Bacteria**
- **Fungi**

- **Single cell organisms that can be used in the bioremediation of aqueous systems;**

- Their application as a non-conventional innovative method can be used for the removal of a large range of pollutants.

Biosorption an Bioaccumulation Processes using Microorganisms

Biosorption	Bioaccumulation
Takes advantage especially of cell wall functional groups that the pollutants are bound to.	Takes advantage of microbial cell processes that are highly-adaptable to external environment and stressors.
Chemical enhancements are provided by treatments with different chemicals that influence the surface of the microbial cell wall and its functional groups.	By varying the environmental conditions and the nutrients that are used to grow the microorganisms, different chemical compositions can be obtained.

Types of Sorptive Materials based on Microorganisms

Adsorbtive microbial material
- Inactivated bacteria
- Inactivated yeasts
- Non-living microalgae
- Microbial biochar

Absorptive microbial material
- Single type of living microorganism
- Algae-bacteria consortia
- Biofilms
- Multiple microbial biomass systems

Types of Treatments applied to the Microbial Sorptive Materials

Physical

- tap water and distilled water **washing**, **grinding;**

Chemical

- using **acids** (H_2SO_4, HNO_3)**, bases** (NaOH)**, etc.**

Environmental and Costs Analyses (LCA/LCC)

There are only a few scientific articles with LCA and LCC analyses for biosorption and bioaccumulation processes. A search on Web of Science indicates only 3 articles when using key words „LCA biosorption" and „LCA bioaccumulation". None of these results include the use of microorganisms.

Inactivated (dead) microbial biomass as adsorbent can be more sustainable in terms of resources consumption because it doesn't require the constant allocation of nutrients in a cultivation system.

The application of LCA methodology for some pollutants like PPCPs (Pharmaceutical and Personal Care Products) is still under development (category factors). Life cycle inventory (LCIA) expansion for emergent pollutants is very important.

Sorption/Desorption cycles can extend the usability of the microbial biosorbents and reduce wastewater treatment costs. Economic analyses of pilot and industrial scale plants using microorganisms for the removal of various pollutants, like heavy metals, still need to be performed.

Conclusions

Microbial organisms (living and non-living) have a great potential to be applied successfully and cost-effectively in bioremediation processes.

In order to apply these biomaterials at large scale, further environmental and economic analyses are required.

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