CHALLENGES AND SOLUTIONS IN OIL BIODEGRADATION: A CRUCIAL ROLE OF BIOSURFACTANTS IN ENVIRONMENTAL BIORREMEDIATION

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ABSTRACT

Petroleum is actually one of the most important energy sources in the world, however It's exploration and transport are directly responsible for oil spills that cause damage to marine ecosystems. PAHs present in the oil represents a critical Danger for human and ecosystems healthy, persisting in the environment for long periods and causing significant damage to soil and water. Physical, chemical and biological treatment methods are used to remediate these spills, with bioremediation being a sustainable and effective alternative option. Bacteria play a key role in the degradation of PAHs during this process, with biosurfactants, produced by microorganisms, facilitating the solubilization of contaminants and improving the effectiveness of bioremediation. This approach offered a promising solution for mitigating the impacts of oil contamination on the environment.

Keywords: Petroleum. PAHs. remediation. bioremediation. biosurfactants.

1 INTRODUCTION

Oil, as a primary energy source and industrial raw material, is essential for meeting the growing global demand for energy (POUDYAL et al., 2019). However, the transportation of crude oil, mainly by oil tankers, has increased the occurrence of spills, resulting in significant environmental damage to the oceans (CHILVERS; MORGAN; WHITE, 2020). Estimates indicate that more than one billion gallons of oil are spilled into the oceans every year, representing an average of 6 million tons per year. In addition, industrial activities contribute to environmental pollution by releasing toxic chemicals, especially PAHs, which are harmful to human health and the ecosystem (FAKHRZADEGAN et al., 2019).

The presence of these organic contaminants in soil and water has substantial environmental impacts, posing a significant threat to wildlife and human health (GENNADIEV et al., 2015). Bioremediation is emerging as an effective strategy to remediate petroleum hydrocarbon contamination, especially through microbial degradation. Bacteria are recognized as the main agents in the degradation of these contaminants (OSSAI et al., 2020).

PAHs, which are commonly present in oil, are particularly persistent in the environment, making bioremediation a valuable approach for their elimination. In addition, biosurfactants, produced by microorganisms, play a crucial role in bioremediation, facilitating the solubilization of contaminants and increasing their accessibility to degrading microorganisms (KACHIENG'A; MOMBA, 2017). These organic compounds have been recognized for their effectiveness in improving the biodegradation of hydrocarbons, offering a sustainable and efficient alternative to accelerate the environmental remediation process (MACHADO et al., 2020).

2 MATERIAL & METHODS

The methodology used in this work is of a theoretical nature, i.e. based on authors who have made it possible to discuss and raise interesting and conclusive points about a certain field of study or research, where searches were carried out in electronic databases: ELSEVIER, SCOPUS and PUBMED, using the following descriptors and Boolean operators: "BIORREMEDIATION" OR "CONTAMINATION OIL" AND "BIOSSURFACTING MICROORGANISMS". This led to the collection of recent and relevant articles on the subject, as well as information that could contribute to a better understanding of the content.

3 RESULTS & DISCUSSION

Oil spills pose a significant threat to marine life, with chemically synthesized surfactants showing toxicity to aquatic organisms. The search for alternatives has led to the identification of biosurfactants, such as lichenisins, rhamnolipids and surfactin, which have shown success in remediating oil contamination (DAI et al., 2022). These compounds emulsify hydrocarbons, facilitating their solubilization in water. Studies show that the introduction of biosurfactant-producing bacteria can stimulate the degradation of hydrocarbons, promoting the assimilation of these compounds by the bacteria (RAVANBAKHSH et al., 2022).

Biosurfactants produced on a large scale through fermentation, such as lichenisins derived from *B. licheniformis* JF-2, have shown efficacy in reducing surface tension and forming stable emulsions. Research into enhanced microbial oil recovery highlights the importance of genetic engineering to increase the secretion of biosurfactants (NITSCHKE; PASTORE, 2006). The bioremediation of Polycyclic Aromatic Hydrocarbons (PAHs) has also been addressed in several studies, due to the enormous damage caused by these carcinogenic compounds and their great persistence in the environment, as well as their tiny insolubility in water (RYLOTT; BRUCE, 2020). We can see the action of the biosurfactants below in figure 1, which shows the formation of emulsions that accelerate oil degradation.

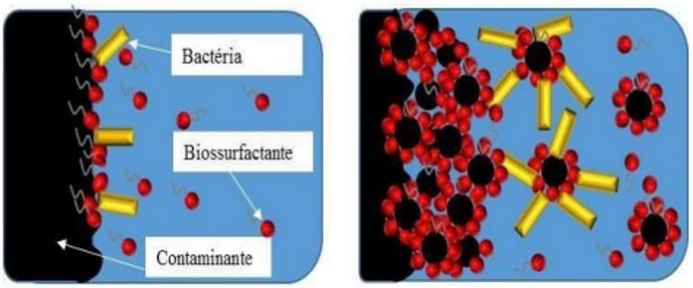

Figure 1 Schematic showing the action of biosurfactants on oil (Santos et al., 2016).

Bacteria that produce biosurfactants, such as surfactin, have been widely recognized for their efficacy in the bioremediation of oil-derived compounds, due to their unique ability to carry out a series of complex metabolic processes. These microorganisms have the ability to secrete biosurfactants, such as surfactin, which have emulsifying and solubilizing properties, allowing for greater solubilization and dispersion of hydrophobic petroleum compounds in the aqueous medium. In addition, these biosurfactant compounds promote the reduction of surface tension, facilitating the migration and removal of contaminants present in soils and groundwater, which contributes significantly to the bioremediation process. The strategic use of these biosurfactant-producing bacteria therefore represents a promising and environmentally sustainable approach to mitigating the environmental impacts caused by oil spills and other forms of hydrocarbon pollution (ZAHED et al., 2022).

4 CONCLUSION

Because of the environmental damage caused by various accidents related to the extraction and transportation of oil and waste from the industry that uses crude oil derivatives, various studies have been conducted to find new solutions and strategies for containing the oil and recovering the ecosystems and communities affected by such disasters. In particular, work in the area of bioremediation stands out, with the discovery and development of bacteria that degrade oil compounds, using biosurfactants produced by the metabolism of microorganisms, providing a solution with lower costs, less damage compared to chemical surfactants and efficiency against the various components present in crude oil, making it possible to solubilize them in water and adsorb them onto substrates. In this way, the development of new bioremediation techniques contributes significantly to the recovery of areas affected by spills, reducing the exposure of animals and the population to carcinogenic and persistent compounds, as well as reducing the damage related to remediation compared to the physical and chemical methods that currently exist.

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