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The Importance of Biodegradation for Preventing Coastal and Marine Pollution

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Abstract

The intensification of contaminants in the marine environment has made marine and coastal pollution a global issue in recent years. Due to the presence of toxic organic compounds, the release of crude oil into the marine environment during exploitation and transportation results in significant environmental pollution. Crude oil, the world's most common energy source, is a complex mixture of hydrocarbons that contains aromatics, naphthenes, resins, and more than 70% alkanes. Due to its non-volatile nature, the crude oil's long chain alkanes remain persistent and pose a significant threat to marine and terrestrial ecosystems. Biodegradation has emerged as a promising and cost-effective method for remediating oil spills. It offers an environmentally friendly, cost-effective, and effective remedy for both on-shore and offshore oil spills. Using a biosurfactant-producing microorganism known as Bacillus subtilis, the present study investigates the maximum degradation of crude oil. Crude oil was degraded with the help of Bacillus subtilis, which was isolated from a polymer dump site in Chennai, India. In just ten days, crude oil degradation and viscosity reduction were observed to be 80 percent and 60 percent, respectively. The potential of the microorganism for oil spill treatment is demonstrated by its high microbial adherence, surface tension reduction, emulsification activity, and production of a greater quantity of biosurfactant, stability of the produced biosurfactant under extreme environmental conditions, viscosity reduction, and high rate of degradation.

Keywords: Marine environment; Toxic organic compounds; Bacillus subtilis; Microbial adherence; Viscosity reduction

Introduction

The expansion of the global economy and industry cannot occur without crude oil. As of now, the petrol business has gone into a time of modernization and progress. Crude oil pollution of seawater has increased as a result of this industrial development, resulting in serious issues. Marine contamination happens when impractical parts went into water body causing antagonistic organic entities, infections and in the end water becomes poisonous and influences the marine and earthly biological system. Significant wellsprings of marine contamination are overflows from cargo/mass sea transporters [1]. Typically, oil spills occur during production, transportation, and storage near the coast. Examples include the recent oil spill in the Gulf of Mexico, Montora, and tanker collision on the Mumbai coast. These issues have been the subject of numerous studies. Microbial debasement of hydrocarbons has acquired a consideration because of its non-cancer-causing, non-flammable, broad and eco-accommodating in nature when contrasted with other traditional strategies. Petroleum hydrocarbons are removed from the marine environment through biodegradation, which also restores the oil-contaminated ecosystem. Crude oil typically consists of a complex mixture of aromatics, alkanes, hydrocarbons, asphaltene, and resins. Different microscopic organisms can involve these hydrocarbons as their energy and carbon source and oxidize the petrol hydrocarbons [2]. The microbes' primary role in maintaining a healthy ecosystem is degradation. The variety of microbes, which can be found in nature, ensures high operational safety, performance, and ease of handling for environmentally friendly development. Moreover, different metabolites, for example, biosurfactants, unsaturated fats, alcohols and solvents delivered in-situ by organisms solubilize the paraffin parts, decreases the basic micelle focus, interfacial pressure and surface strain, work on the remediation. Biosurfactants fosters the capacity of the microbial cells to develop on the hydrophobic substrates and increment their bioavailability. This study focuses on Bacillus subtilis performance in order to determine changes in the physicochemical properties necessary for the degradation of waxy crude oil [3]. Analyses of the bacteria's growth on waxy crude oil, interaction with the oil, production of biosurfactants, surface tension, emulsification activity, degradation of waxy crude oil, and viscosity reduction demonstrate the potential of Bacillus subtilis for oil spill remediation.

Results and Discussion

The primary requirement for carrying out biodegradation is the growth of the bacteria. Biosurfactant production, which aids in the breakdown of hydrocarbons, is directly attributed to the microbial population. At room temperature, the growth of Bacillus subtilis on waxy crude oil is depicted in Figure 2. When the CFU reaches its maximum, the biomass dry weight reaches 2.11 g/L, establishing the steady state further. The expansion, according to N. Sakthipriya, Up until day 12, Procedia Engineering 116 213–220 217 was increased, maintained through day 15, and then decreased [4]. The maximum CFU concentration in the bacterial culture is 28 106/mL.

The utilization of biosurfactants has been seen to further develop the raw petroleum corruption. Biosurfactants emulsify the crude oil's hydrocarbons, improve water solubility, lower surface tension, and facilitate the removal of oily substances from the porous medium. Figure 3a shows the creation of biosurfactant as a component of time. One day's production of biosurfactant was 0.98 g/L, peaking at 4.1 g/L after 10 days [5]. The observed decrease in surface tension and rise in emulsification in waxy crude oil culture confirmed the production of

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biosurfactants. In 10 days, surface tension drops to 25 mN/m, and in 20 days, it drops to 21 mN/m, with no further change.

The biosurfactant's compatibility with crude oil and other hydrocarbons was examined through emulsification. Since emulsification activity improves contact with the interface between crude oil and water, microbial degradation typically increases with it. 60 percent of the emulsification was observed in one day, while the maximum of 82 percent was attained in 15 days. In just one day, the CSH reached 82% and then reached the steady state. The presence of CSH is a sign that bacteria might be able to grow on hydrophobic substrates. The hydrophobic substances' insufficient bioavailability to microorganisms typically impedes biodegradation. The biosurfactant that the bacteria produce acts as a bond between the bacteria and crude oil, facilitating the microbe's connection to the hydrocarbon substrate and raising CSH [6, 7]. According to the findings of the experiments, the biosurfactant that is produced when waxy crude oil is present can speed up the degradation process by enhancing the relationship that exists between the bacterial cell and the crude oil.

It has been observed that treating waxy crude oil with bacteria increased its fluidity. The consistency decrease is viewed as around 25% in one day and arrived at around 60% in 8 days, and achieved a consistent state from there on. Between days 4 and 8, viscosity decreased more noticeably [8]. This is because of the explanation that the microorganisms have accomplished the greatest development during that period.

When the incubation time was increased, crude oil's degradation rate increased as well. Corruption of waxy unrefined petroleum was seen to be 62% in 1 day and 80% following 10 days, and didn't change from that point. The debasement rate developed quickly between day 1 and 10. However, after day 10, the degradation rate did not rise. The bacterial count peaked at 28 106 CFU/mL on day 10, remained constant for a week, and then began to decline. The progression of microbial growth is analogous to that of crude oil degradation. As indicated by Bordenave the singular microbes could utilize the unrefined petroleum just to a restricted hydrocarbons and the total biodegradation requires combination of various bacterial gatherings [9, 10]. Rather than this, the outcomes uncover that the singular Bacillus subtilis could corrupt extensive variety of hydrocarbons present in the unrefined petroleum.

Conclusion

It would be possible to develop strategies for using bacteria to remove hydrocarbons from polluted water based on the knowledge gained from laboratory-scale experiments on the degradation of crude oil by bacteria. Every one of the outcomes exhibited that the microscopic organisms chose in our review is good for the biodegradation of destinations debased with oil hydrocarbons. By GC-MS, the chemical composition of the crude oil before and after bacterial growth has shown that the oil's components have been used as sources of carbon and energy, indicating that biodegradation of crude oil that is suitable for coastal and marine environments can occur.

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Conflict of Interest

None

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