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Review Article

Potential Commercial Application of Microbial Surfactants

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Abstract

With current climate change and an expanding global population, there is an urgent need to create creative and cost-effective natural goods for human benefit. Biosurfactants are created by microorganisms and have numerous distinguishing qualities when compared to other synthetic surfactants, such as moderate manufacturing conditions, multifunctionality, better biodegradability, and reduced toxicity of live cell synthesis of active chemicals. Biosurfactants are produced on the microbial membrane or excreted over the outer membrane and have both hydrophilic and hydrophobic areas. Hence, biosurfactants are used in the medical industry, bioremediation, microbial enhanced oil recovery (MEOR), and the pharmaceutical industry. In the food business, biosurfactants are frequently employed as anti-adhesive agents, emulsifiers, de-emulsifiers, spreading agents, foaming agents, and detergents that have applications in a variety of industries, including agriculture, the industrial sector, and the environmental area. Oilzapper is the most recent bioremediation application. It is an immobilised culture used to clean up oil spills and grease-contaminated sites. Immobilised culture survives at room temperature for 90 days. An alternate method for removing heavy metals from industrial wastes may be made possible by biosurfactant, an effective biological surface-active agent. We attempted to critically analyse biosurfactants, their use, research linked to them, and problems encountered in this literature review.

Keywords: Biosurfactant; Emulsifiers; Oilzapper; Bioremediation; Sophorolipid

Application of biosurfactant

Biosurfactants have been studied, and a variety of applications have been published. Its importance to man in the majority of facets of human life cannot be overstated. Many synthetic, primarily petroleum-based chemical surfactants are presently used to satisfy the vast market demand for surfactants. These substances are typically not biodegradable and hazardous to the environment [14]. Studies on increased oil recovery and hydrocarbon bioremediation mostly employ biosurfactants. Shete and colleagues mapped biosurfactant and bioemulsifier patents in 2006, reporting 255 patents covering diverse features published globally. Petroleum-related sectors received the most patents (33%), followed by cosmetics (15%), pharmaceuticals (12%), and bioremediation (11%), with sophorolipids, surfactin, and rhamnolipids accounting for the majority of patents, according to Reis., *et al.* [37]. Biosurfactants have many benefits, including easy production, low toxicity, high biodegradability, and compatibility with the environment. These benefits have led to applications not only in the food, cosmetic, and pharmaceutical industries but also in environmental protection and energy-saving technology [12].

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Bioremediation of oil contaminated site

Petroleum pollution produces oxidative stress, changes in soil chemical composition, and reduced nutritional availability. Petroleum's primary harmful effects include inhibiting seed germination, reducing photosynthetic pigments, slowing nutrient assimilation, inhibiting root growth, foliar deformation, and tissue necrosis, as well as destroying biological membranes, disrupting metabolic pathway signalling, and disrupting plant root architecture. Low-molecular-weight hydrocarbons can enter plant cells and cause plant death. Moreover, petroleum and its compounds contribute to the development of cancer and other disorders. Earlier research found that petroleum pollution produced in people nervous system depression, narcosis, and irritation of the mucous membranes around their eyes. Bioremediation is a method that uses live organisms or their products, either naturally or artificially, to decrease (degrade, detoxify, mineralize, or convert) contaminants in the polluted environment. Living organisms (plants and microbes) that can withstand and flourish in polluted soil are typically use for this purpose [7]. The Oilzapper is a crude oil and oily sludge-degrading bacterial consortia created by India's The Energy Research Institute (TERI). This microbial consortium was created by immobilising five bacterial isolates (obtained from hydrocarbon-contaminated areas) with a suitable carrier substance (powdered corncob). The immobilised culture (oilzapper), which can survive at room temperature for three months, can be sealed aseptically into sterile polythene bags and transported to the contaminated site. It has been used successfully to clean up crude oil spills and remediate greasy sludge. In various locations, over 40,000 metric tonnes of oily sludge and oil-polluted soil and drill cuttings have been treated. More than 30,000 metric tonnes of oily sludge and oil-contaminated soil are being treated in various locations across India and the Middle East.

Food industries

Due to the increased use of emulsifying and thickening agents in food products, the food industry looks for additives that can improve the value and characteristics of food. Commonly used hydrocolloid emulsifiers that successfully emulsify and stabilise oil-in-water emulsions include lecithin, xanthan gum, and gum acacia. As food additives, biosurfactants have various intriguing applications in the food business. They can be utilised as emulsifiers in the processing of raw materials, in particular. Emulsification is critical in achieving the desired consistency and texture, as well as in phase dispersion. Emulsifiers are used in baking to improve dough rheology, water retention, ingredient mixing, and handling. They work well as food preservatives [14]. The desire to expand the range of emulsifiers and reduce reliance on plant emulsifiers, particularly with the ever-dwindling sources of nongenetically modified soybean, the main source of lecithin, and the desire to benefit from the favourable antioxidant, antiadhesive, antimicrobial, and biofilm disruption properties, has led to an increase in interest in finding alternative natural sources of amphiphilic molecules suitable for use in some food industries [14]. Glycolipids are made from low-cost raw materials such as distillery waste, fruit and vegetable by-products, bagasse, rapeseed, sweet potato flour wastewater, bird's feather protein, and beverage effluent [14]. Biosurfactants reduce fat globule aggregation, stabilise aerated systems, increase the texture and shelf-life of starch-containing goods, adjust the rheological characteristics of wheat dough, and improve the consistency and texture of fat-based products. Liposan, on the other hand, has been demonstrated to lower surface tension and emulsify edible oils. Moreover, biosurfactants work as fat stabilisers when boiling fats and delay staling, solubilize flavour oils, and enhance organoleptic qualities in bread and ice cream formulations [25]. By adding rhamnolipid surfactants, dough stability, texture, volume, and preservation of bakery items were improved [42]. Rhamnolipids may be used to enhance the qualities of butter cream, croissants, and frozen confectionary items, according to the authors. The authors of the companies are also advised to use rhamnolipids to improve the qualities of butter cream, croissants, and frozen confectionary goods. Additionally, a variety of biosurfactants have demonstrated antimicrobial activity against bacteria, yeast, fungi, algae, and viruses [29]. These biosurfactants can be used directly as additives or indirectly as detergent formulations to clean surfaces that come into contact with food to prevent food contamination.

Cosmetic industries

Chemically produced surfactants are frequently used in the cosmetics industry due to their detergency, wetting, emulsifying, solubilizing, dispersion, and foaming properties. Long-term exposure to such compounds may have detrimental consequences for both people and the environment. Because of the current demand for ecologically and animal-friendly natural cosmetics, adopting natural alternative components is very important. In these applications, glycolipid biosurfactants such as sophorolipids, rhamnolipids, and MELs are very desirable. Using their hygroscopic qualities, sophorolipids and their derivatives with propylene glycol are used in cosmetics as moisturisers or softeners [11]. Kao Co. Ltd. manufactures sophorolipids for use as humectants in cosmetic products by companies like Sofina. The product can be used in eye shadow, lipstick, moisturiser for skin and hair products, compressed powder cosmetics, and aqueous solutions [19]. For the cosmetics business, the French firm soliance develops and markets active compounds based on sophorolipids. For use in deodorants, face cleansers, shower gels, makeup removers, and the treatment of skin that is prone to acne, as well as in Sophogreen, a high-performance bio-solubilizer, sophorolipids have an antibacterial function and sebo-formulation. It has also been suggested that rhamnolipids are appropriate for use in a variety of healthcare goods, including toothpaste, antacids, acne pads, anti-dandruff products, contact lens solutions, deodorants, nail care products, and acne pads. Moreover, they are said to cause less skin irritability, and certain formulations, including rhamnolipids, have been trademarked as anti-aging and anti-wrinkle treatments [33]. Moreover, they have been advocated for use in commercial skin care cosmetics, personal care products (sprays, soaps, shampoos, conditioners, and creams), and cleaning solutions for animals as antimicrobial agents [9]. Additional uses for creating emulsions and liposomes, two crucial components in the cosmetics sector, have also been patented [12]. Studies have shown that MELs, in particular, might be used as cosmetic compounds to moisturise dry skin, mend damaged hair, activate fibroblast and papilla cells, have protective effects on skin cells, and serve as antioxidants. Daito Kasei Kogyo Co., Ltd., a Japanese business, recently began selling a new foundation powder with metal oxide particles coated with MELs as a product with exceptional moisture retention capabilities [14]. When employed as emulsifiers, lipopeptides were said to have little effect on the skin, making them ideal for external skin preparations such as transparent cosmetics with a sequestering function [46]. Additional significant uses of lipopeptides include anti-aging cosmetics, stretch mark treatment and prevention and cleaning solutions with great washability and little skin irritation [12].

Uses in agriculture

Biosurfactants are potential candidates for future crop protection applications due to their diverse functionalities and participation in biological control by acting as either antifungal agents or inducers of induced systemic resistance. In terms of biological control, biosurfactants often work by disrupting the pathogen's cell surface and creating channels in the cell wall [36]. From among the various kinds of biosurfactants, glycolipids, such as cellobiose lipids and rhamnolipids, and cyclic lipopeptides, such as surfactin, iturin, and fengycin, protect plants through their antifungal activities against phytopathogenic fungi [3]. The possible use of biosurfactants as biological control agents was addressed by Stanghellini and Miller [41]; they explain how rhamnolipids can break zoospore membranes and induce lysis of zoospores of several oomycete plant diseases. Since then, several papers have covered the significant function of rhamnolipids in the defence against different phytopathogenic fungi. By preventing *B. cinerea's* mycelial development and spore germination, rhamnolipid biosurfactants were discovered to exhibit direct antifungal effects [43]. The main component of di-rhamnolipid in this cell-free medium, which is distinguished by better lysis traits over mono-rhamnolipid to rupture the spore membranes, could be responsible for the cell-free medium's significantly better antifungal effectiveness. This is especially true for plant pathogens that produce zoospores. Similar to rhamnolipids, cyclic lipopeptides are a type of biosurfactant that have antifungal efficacy against phytopathogenic fungi. The method of hydrophilization employing biosurfactants results in good wettability, suppression of pesticide toxicants, and uniform dispersion of fertilisers in the soil [14].

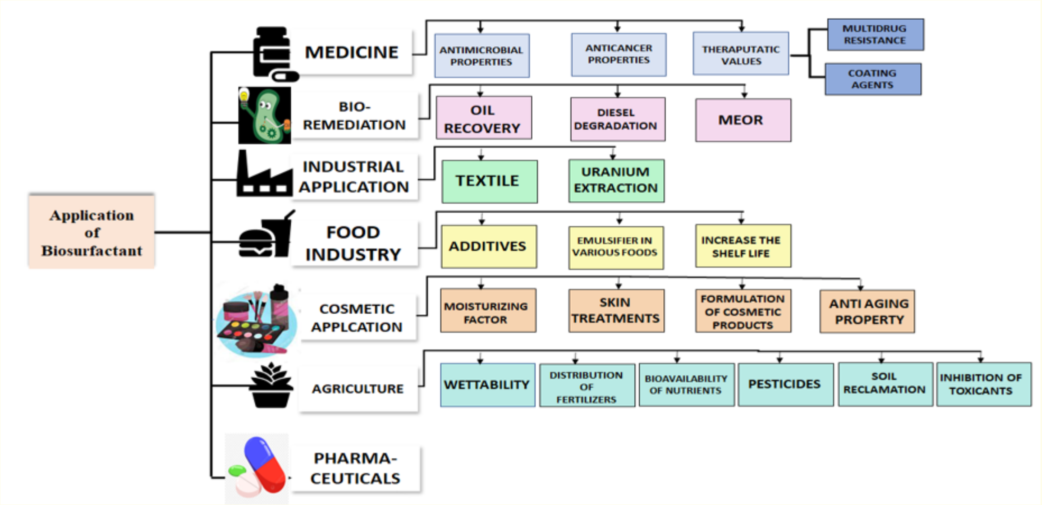

Figure 1: Biosurfactant used in a number of fields.

In textile industries

The finishing of textiles is a sector that uses a lot of water. For the textile finishing procedures to produce high-quality final products, the pretreatment of textiles is a crucial step. To make textiles ready for the next stage of production, various fibre admixtures and particular formulations of lipophilic chemicals that were utilised as lubricants to provide the best friction behaviour during the creation of a fabric must be removed from the fibre surface [23]. In order to reduce the possibility of environmental pollution, biosurfactant usage has been documented in textile finishing for emulsification, solubilization, dispersion, wetting, and detergency [12]. Nowadays, biosurfactants are utilised in commercial detergents, which are also used to clean fabrics. But the use of biosurfactants has additional uses in the textile dyeing sector. Dye solubility is one of the major issues facing the textile industry. Low dye water solubility results in non-homogenous dye dispersion throughout the fabric solid phase and preferred dye accumulation on the fibre surfaces. Surfactants can be added to dye mixtures to increase the dye's water solubility, which improves dye dispersion and results in more even dye penetration into the fibre [35]. In addition to their aesthetic effects, dyes can have an adverse effect on the environment if they are metabolised or reduced in a way that produces carcinogenic aromatic amines. The cHAL biosurfactants worked effectively to maintain or improve the dye penetration and fixation to the fabric, as well as to increase the colour uniformity and intensity of the cellulose acetate fabric. As all of the utilised biosurfactants were above their critical micelle concentration levels, there were no differences between them, and there were also no changes when compared to commercial surfactants such as sodium dodecylbenzenesulfonate and ethofor [14].

Applied in MEOR (microbial enhanced oil recovery)

Successful oil wells are frequently begun using traditional primary and secondary recovery procedures, which generate just 20% to 30% of the total oil in the well on average. At that point, enhanced oil recovery (EOR), also known as tertiary oil recovery technologies, is used to allow recovery of an extra 10%–15% of the leftover oil. They comprise both chemical and microbiological-based techniques; the latter is known as microbial EOR or MEOR [2]. MEOR makes use of a number of microbiological activities, including biosurfactant generation, gas production, selective plugging, and the partial breakdown of large oil molecules [32]. All the major categories of microbial surface-active chemicals have been suggested for MEOR use, even though rhamnolipids were the initial candidates for such an application. Particularly, lipopeptides like emulsan, surfactin, and lichenysin have been shown to be particularly successful at boosting oil recovery [12]. Whereas Xia., *et al*. [45] achieved an efficiency of 9.02% with the injection of *P. aeruginosa* cells, She., *et al*. [40] found incremental oil recoveries of 4.89%–6.96% with the inclusion of several *Bacillus* cultures. In a sand-pack system, injecting *Rhodococcus ruber* Z25 biosurfactant as a cell-free supernatant resulted in higher percentages of oil recovery, up to 25.78%. Biosurfactants can be used in the oil industry for a variety of additional purposes in addition to MEOR. For instance, recent research on the application of different microbial surfactants for oil extraction from oil sludge showed that, depending on the washing conditions, it was feasible to achieve an oil recovery of up to 74.55% [49].

Use in development of detergents

The washing and cleaning industries use almost half of all produced surfactants. Interest in choosing and including "green" components in detergent formulations is growing as environmental protection and the use of substances with low toxicity, a low carbon footprint, and high biodegradability become more and more important Anionic and nonionic materials are two classes of chemical surfactants that have been used for many years as detergent active ingredients. Cleaning fabrics, dishes, kitchenware, and hard surfaces, including glass, glazed surfaces, plastics, metals, and enamels, are the main uses for detergent formulations [16]. Because of their versatility as cleaning agents, antimicrobial effects, and decreased need for solvents in manufacturing, biosurfactants are becoming more and more desirable. Henkel, a well-known detergent producer, began utilising sophorolipid surfactant in some of its regionally branded glass-cleaning goods, including Sidolin, Instanet, Sonasol, Tenn, and Breff, which were all offered for sale in Europe. A surfactant with strong washing ability and the ability to create easily removable foam is necessary for laundry detergents. According to reports, sophorolipids are ideal for low-foaming applications, including hard surface and auto-dish cleaning solutions. A unique sophorolipid-containing biodegradable low-foaming dishwashing detergent with effective cleaning power across a wide temperature range has been created [13]. The low-foaming, high-temperature-resistant surfactants required by jet washing technology are specifically included in this new detergent formulation for use in dishwashing machines [12].

Pharmaceuticals and therapeutics

A wide range of prospective pharmaceutical and biomedical applications have been made possible by the various and intriguing physicochemical and biological characteristics of biosurfactants. Its capacity to disrupt cell membrane integrity and permeability [30] and its capacity to influence microbe adherence by altering surface properties are particularly advantageous for biomedical use. Certain experimental findings in the literature imply that they are less harmful than synthetic surfactants or nontoxic [10]. Because of their mechanism of action to rupture lipid membranes due to their antibacterial activity, lipopeptide forms of biosurfactants are frequently utilised. Pore creation in membranes happens following lipopeptide oligomer binding, some of which are Ca2+-dependent multimers, according to studies on the mechanisms of action of lipopetides. Several lipopeptides, including daptomycin, the echinocandins caspofungin, micafungin, and anidulafungin, have achieved commercial antibiotic status [12]. Numerous preparations that have the potential to be used in pharmaceutical applications, including those described by Neuhof., *et al.* [28] and Hill., *et al*. [17], contain lipopeptides with antimicrobial activity that is suitable for the treatment and prevention of microbial infections. Lipopeptides were patented for use in topical pharmaceutical products for treating or preventing illnesses of the mucosa and skin in addition to their antibacterial properties. Inhibiting the growth of *Mycobacterium TB, Herpes simplex* virus 2, and/or *Trypanosoma cruzi* are the lipopeptides viscosin and analogues, which have been patented as antibacterial, antiviral, and antitrypanosomal medicinal substances. The idea that rhamnolipid biosurfactants may speed up wound healing has emerged as a relatively novel use for biosurfactants. Rhamnolipid-containing formulations have been developed to treat burn shock, promote wound healing with less fibrosis, and induce re-epithelization in adult skin tissue. It's interesting to note that these rhamnolipid compositions were also recommended for the treatment and prevention of atherosclerosis, organ rejection, depression, and schizophrenia [33]. Rhamnolipid liposomes were patented in 1988 as drug delivery systems, biomimetic models for biological membranes, as sensors for pH changes, and as microcapsules for drugs, proteins, nucleic acids, dyes, and other compounds. These innovative liposomes were characterised as being secure, physiologically degradable, suited for biological organisms, and having increased stability and shelf life [12].

Paper industry

Biosurfactants can be used for deresinification in the paper processing industry and related fields. In the paper industry as defoaming, colour levelling, and dispersion agents, and the washing of pulp as wetting and levelling, coating, and colouring chemicals for calendaring [25]. In a different study, extracellular polymeric materials from pulp and paper mill waste sludge demonstrated promise for use as a wood adhesive [12].

Paint and protactive industry

Biosurfactants are used in the paint and protective coatings industry to disperse and wet pigment during grinding as well as for emulsification, pigment dispersion, latex stability, sedimentation prevention, and pigment separation in latex paints. A new international patent describes the use of a biosurfactant generated by the gram-negative aquaculture bacterium *Cobetia marina* as an ingredient in paint compositions for submersible surfaces [12].

Leather and plastic industry

Potential uses for biosurfactants in the leather sector include skin detergents, emulsifiers for wetting and penetrating, and promoters for tanning and colouring. For the degreasing of sheep skins, Kilic [24] evaluated a saponin biosurfactant as a low-cost, natural alternative to artificial surfactants and came to the conclusion that it was a feasible solution with potential ecological benefits. They can be used as emulsifiers, wetting agents, solubilizers, and antistatic agents in the plastics sector [25].

Biological application

Anticancer activity

Many individuals across the world are at risk for developing cancer. Traditional cancer treatment involves the employment of highly cytotoxic chemicals that non-specifically target any proliferating cells, with the result that patient survival only slightly improves [6]. Focus is placed on the potential of biosurfactants, particularly lipopeptides and glycolipids, to be employed as anti-cancer drugs that block the progression of cancer [15]. Signal transduction, cell differentiation, and cellular immune response are just a few of the intercellular molecular recognition processes that these bioactive chemicals are engaged in [38]. They also exhibit minimal toxicity, simple biodegradability, and high effectiveness, all of which are desirable qualities in an anti-cancer drug. The delay of cell cycle progression, inhibition of important signalling pathways like Akt (Protein Kinase B),reduction of angiogenesis, activation of natural killer T (NKT) cells, and induction of apoptosis through death receptors are some of the proposed mechanisms underpinning the anti-cancer activity of biosurfactant [21]. Many studies have demonstrated that lipopeptides and glycolipids can target cell growth and break cell membranes, leading to the lysis of the cells through apoptotic pathways [15]. The biosurfactants with the greatest anti-cancer potential are lipopeptides and sophorolipids. The lipopeptides have anticancer action *in vitro* and are made up of a peptide and a carboxylic acid chain [48].

Antimicrobial, antiadhesive and biofilm disruption activity

The antibacterial properties of certain biosurfactants have been demonstrated against bacteria, fungus, algae, and viruses. *B. subtilis* lipopeptide iturin has shown strong antifungal action [4]. In concentrations ranging from 0.4 to 10.0 mg/L, rhamnolipids reduced the development of the toxic bloom algae *Heterosigma akashivo* and *Protocentrum dentatum* [44]. It has been discovered that sophorolipids and rhamnolipids are powerful antifungal agents against plant and seed pathogenic fungi. *Phytophthora* and *Pythium* species mycelial growth was 80% reduced by 200 mg/L of rhamnolipids and 500 mg/L of sophorolipids [47]. A collection of microorganisms that have colonised a surface is referred to as a biofilm. On PVC plates and vinyl urethral catheters, Surfactin reduced the quantity of biofilm development by *Salmonella typhimurium, Salmonella enterica, E. coli,* and *Proteus mirabilis* [27]. Rhamnolipids have been shown to disrupt *Bordetella bronchiseptica* biofilms and more recently, it was shown that silicone rubber conditioned with rhamnolipids reduced the adhesion rates of *Candida tropicalis* and *Streptococcus salivarius* by 66%.

Nanoparticles based therapeutics

Due to their potential to prolong drug accumulation in solid tumours by increasing permeability retention (EPR) and reversing MDR through bypassing or blocking P-gp activity, nanoparticle-based therapies are regarded as the most promising platforms in drug delivery application. Also, it had been shown that SL-capped ZnO nanoparticles, which produced necrobiosis in *C. albicans*, caused membrane breaking, the seeping out of proteins, and the release of intracellular materials. The biosurfactant SUR has been discovered to possess a variety of bioactive characteristics, including qualities that make it an adjuvant for immunisation and anticancer properties, in addition to its role as a cyclic lipopeptide. Surfactin has the ability to self-assemble (under specific circumstances) into nanoparticles to serve as a drug carrier for loading hydrophobic medicines, which is supported by its distinctive amphipathic characteristics. By using surfactin as a carrier to carry anti-cancer medications, cancer treatment might be made more effective by combining the anti-cancer properties of SUR with the properties of nanoparticles, such as EPR effects and MDR reversal. MDR, or multidrug resistance, is one of the main challenges to effective cancer treatment [18]. Surfactin (SUR) was constructed using a solvent emulsion technique in an examination by Huang., *et al*. [18] to load the anti-cancer medication doxorubicin (DOX). It has been demonstrated that the DOX@SUR assembly causes more cytotoxicity when used with DOX@-SUR nanoparticles, which have increased cellular uptake and lower cellular efflux. Besides that, *in vivo* DOX@-SUR nanoparticles aggregated in tumours more effectively than free DOX.

Bio nanotechnology

The next generation of green chemistry or bioengineering nanocatalyst sources is currently thought to be a combination of biosurfactants formed from microbes and nanoparticles. There is great potential for environmental remediation in the manufacturing of nanoparticles employing biosurfactants. Yet, the biosurfactant-generated nanoparticles must be commercially feasible. It must also be ecologically acceptable, have a high rate of toxicant removal, and be energy efficient. Organisms in biosurfactants may stabilise and reduce the formation of nanoparticles. Microorganisms play a role in the creation of nanoparticles, including titanium, silver, and gold [14].

Heavy metal removal by using biosurfactant

Biosurfactants are used to mobilise and remove impurities by pseudo-solubilization and emulsification during a cleaning process in order to improve the bioavailability of organic molecules like hydrocarbons. The use of biosurfactants in heavy metals remediation has undeniable advantages because microorganisms that can produce surfactant compounds do not need to be able to survive in heavy metal-contaminated soil, even though biosurfactants need to be continuously replenished with new amounts of these substances. You can use biosurfactants on a tiny patch of polluted soil. The biosurfactant metal complex is taken out of the soil and placed in a huge cement mixer. The biosurfactant-metal complex is subsequently processed to precipitate the biosurfactant, leaving the metal behind, and the soil is redeposited into the earth. Usually, the link created by the positively charged metal and negatively charged tensioactive chemical is so strong that the metal-surfactant complex is washed away by water washing through the soil [39]. Using experiments in columns to determine the removal of the heavy metals by a rhamnolipid, Juwarkar., *et al*. [22] investigated the removal of cadmium and lead by a biosurfactant produced by *P. aeruginosa BS2*. The rhamnolipid removed more than 92% of the cadmium and 88% of the lead within 36 hours at a concentration of 0.1% [22]. Lipopolysaccharides (LPS), are one of the primary forms of biosurfactants. Langley and Beveridge conducted the earliest heavy metal extraction tests on them and showed that LPS improved the hydrophilicity of the outer cell walls, making it easier for bacterial cells to absorb metallic cations [26]. Other forms of biosurfactants (mainly sophorolipids in nature) generated by species of the genus *Candida* have also shown the ability to remove more than 90% of cations in columns and air-dissolved flotation processes [1].

Mechanism of removal of heavy metals

The ability of biosurfactants to form complexes with metals is the basic basis for their application in the bioremediation of heavy metals from polluted soil. Ionic bonds, which are stronger than the link between the metal and soil, are used by anionic biosurfactants to form complexes with metals. Due to the decreased interfacial tension, the metal-biosurfactant complex is then adsorbed from the soil matrix into the soil solution. By competing with certain, but not all, negatively charged surfaces, cationic biosurfactants can replace the same charged ions. Biosurfactant micelles can also remove metal ions from the soil [22].

Ionic biosurfactants remove metals from soil in the following steps: (1) sorption to the soil surface and complexation with the metal; (2) detachment of the metal from the solution; and (3) adsorption to the biosurfactant's micelles. According to Figure 2, electrostatic interactions cause heavy metals to bind to micelles, which are then simple to remove using membrane separation techniques [39].

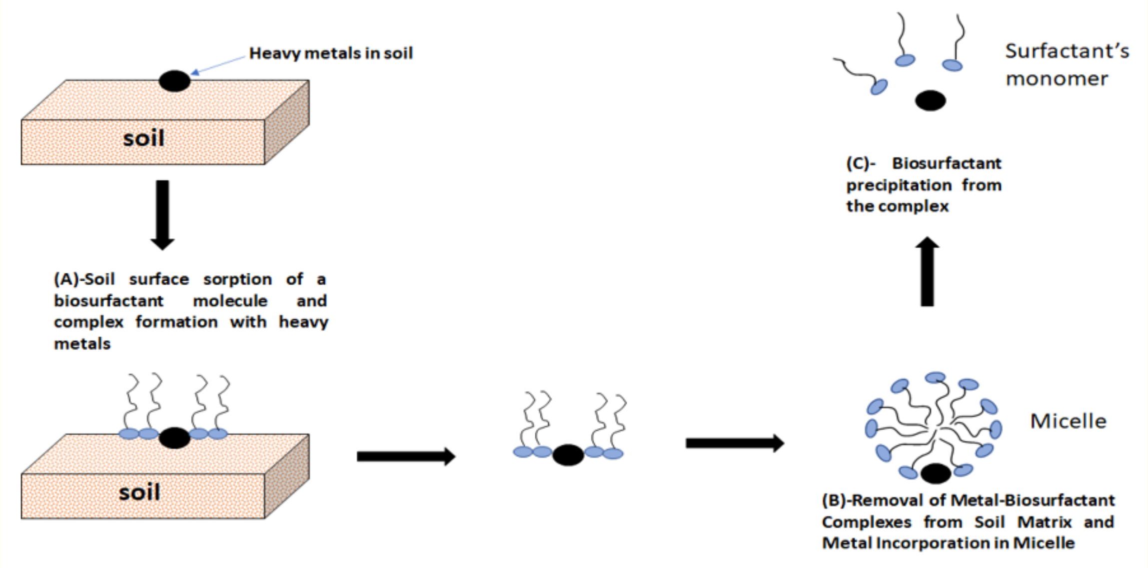

Figure 2: Mechanism of removal of heavy metals from soil with the help of biosurfactant.

Conclusion

The biosurfactant market is a highly successful and competitive sector that leverages the pharmaceutical, cosmetic, petroleum, and food industries' biodegradation and develops advantages for renewable energy sources. The global need for surfactants has increased dramatically; nevertheless, the majority of the surfactants now available are chemically reliant. This review elucidates the possible benefits of biosurfactants in adjusting their activities in a variety of applications. Furthermore, the comparison with synthetic surfactants aids in determining how surfactant composition affects physicochemical qualities and in making optimal formulation decisions. Heavy metal remediation by a biosurfactant occurs by either a complex interaction with free metal residues or through accumulation at a solid-liquid interface, resulting in direct contact between the metal and the biosurfactant. As a result of the desorption route, biosurfactant metal complexes exit the soil surface and form micelles. It is feasible to precipitate and separate the biosurfactant from the metals further. Organic surfactants account for a sizable portion of the surfactant sector, owing to tighter restrictions for greener practises and increased demand. Farmers are creating ecologically friendly surfactants from a variety of natural and renewable sources as they fast become a popular market alternative. Bio-based surfactants are intended for use in the treatment of heavy metals, contaminated soils and water, the treatment of skin diseases, the enhancement of oil restoration, the preservation of food, and the elimination of plant disease.. Additionally, given the social and economic advantages of these minerals, the best circumstances for their preparation must be researched further.

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Conflicts of Interest

We declare that there are no conflicts of interest.

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