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Exploration and Prevention of Marine Pollution Through Bio-Amends

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Abstract

Marine contamination was examined by pulling together the most recent literature on the subject and revising it. Marine animals are known to be hurt or killed by pollution, which could put their survival at risk. This is especially true because many of these species are already threatened by other forms of human activity. Marine creatures are particularly vulnerable to pollution-induced harm because of their propensity for becoming entangled in and ingesting contaminants. Addressing the problem in seas is a difficult challenge that necessitates a diversity of techniques and a discussion of prophylactic measures implemented in a natural way. As a warning to the next generation, explicit and implicit repercussions on future generations are also considered. Analyzing the incidents in history brings up the question of how to deal with the negative impacts of pollution in the marine environment and how to employ natural methods to counteract them. There is a possibility for the contaminated marine environment to be remediated by bioremediation to deliver the absolute blend about eradicating the pollution causing factor

Keywords: Bioremediation; Marine Environment; Hydrocarbons; Heavy metals; Pollution;

1. Introduction

Marine pollution, like other forms of pollution, has recently increased rapidly. Few studies have examined the policy and economic consequences of marine pollution, as well as the effectiveness of economic incentives in reducing marine pollution. As a result of the advantages marine microorganisms have over petroleum hydrocarbons in the removal process, bioremediation may be the sole option for the time being for fragile marine ecosystems with a high level of biodiversity. Marine microorganisms and their biosurfactants are preferable to non-marine and synthetic sources because of the urgent need to create environmentally acceptable solutions for petroleum hydrocarbon bioremediation and biodegradation in the marine environment. The goal of this review is to examine the use of bioremediation to marine environments.

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2. Sources of Marine Pollution

2.1 Eutrophication

Eutrophication is characterized as the excessive growth of plants and algae in marine settings, resulting in an excess of minerals, mainly nitrogen (N) and phosphorus (P). Controlling non-point sources, such as agricultural supply of both N and P (point and nonpoint resources), and fossil fuel burning for N, is more difficult than regulating point sources. Eutrophication of coastal and marine ecosystems is a result of increasing agricultural yields as a result of greater use of nitrogen and phosphorus fertilisers, which infiltrate freshwater systems and travel to coastal areas via streams and rivers. It enhanced aquatic eutrophication, as shown in figure 1[1]. Over-application of phosphorus (P) fertiliser may result in a large transfer of P to nearby freshwater bodies, which may eventually reach coastal waters. It's clear that the nitrogen pool can exchange and escape to space while the phosphorus pool is trapped in receiving marine waters due to a variety of particulate and non-gaseous phosphorus forms dominating the phosphorus cycle, whereas the nitrogen pool contains both dissolved and particulate nitrogen. Nitrous oxide, a climate-changing atmospheric trace gas, is produced through nitrification and denitrification processes defects.

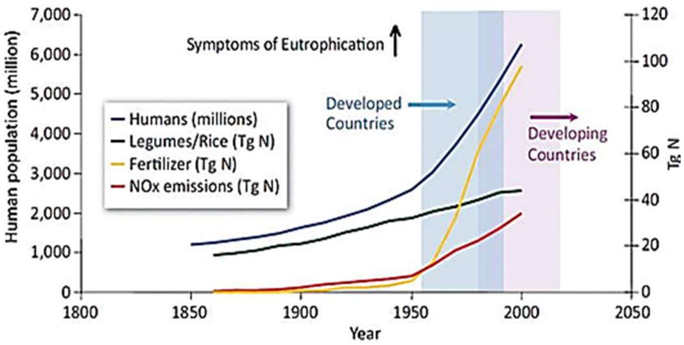

Fig. 1. Pollution by humans leads to Eutrophication over years

2.2 Acidification

Ocean acidification is the chemical change in the global ocean's chemistry induced by growing carbon dioxide levels in the atmosphere, and it is directly accountable for today's climate change-related concerns. Between CO2 emissions and CO2 absorption, there has existed a balance. The concern is that CO2 is being created at a quicker rate than natural processes can absorb it, resulting in an overabundance of CO2. When a considerable amount of CO2 is absorbed into the water, ocean acidification occurs. Carbonic acid (H2CO3) is formed when it combines with water molecules to generate a hydrogen ion (H+) and bicarbonate (HCO3-). Acidification occurs when all of these hydrogen ions are present in the ocean. This can be summarized using the chemical equation shown below:

$$CO_2 + H_2O = (H^+) + (HCO_3^-) \qquad (1)$$

2.3 Toxins

Toxins are highly toxic chemical contaminants that have a detrimental effect on the marine environment. DDT, PCBs (polychlorinated biphenyls), mercury, arsenic, cadmium, and lead are just some of the most toxic contaminants. Scientists believe that the DDT that destroyed bald eagle egg shells and ultimately resulted in their extinction on Catalina Island is connected to the DDT in the San Pedro Channel. Years later, once DDT was prohibited, bald eagles were reintroduced to Catalina Island, but rapidly became extinct. Eagles were discovered to be swallowing the chicks and eggs of seagulls, which feed on DDT-contaminated seafood. Thus, even though DDT was no longer used in the San Pedro channel, it persisted in the diet, making it harder for the new generation of eagles to hatch their eggs [2]. In both 20 and 40 g L1 AgNP, B. pharaonis' respiration rate and heartbeat rate increased dramatically without acclimatization. Reduced absorption efficiency may be a result of energy constraints [3]. Ascertain that none of the chemicals listed above are used in close proximity to streams of water, and aim to minimize your use of such compounds. Farmers use chemical fertilizers and pesticides in favor of organic farming practices and chemical or oil leaks also add up marine pollutants [4]. As the production of the majority of PBDEs was phased out in North America, the level of PCBEs (Polybrominateddiphenyl ethers) in the food web of salish sea aquatic bird eggs began to fall, as illustrated in Fig.2[5] [6].

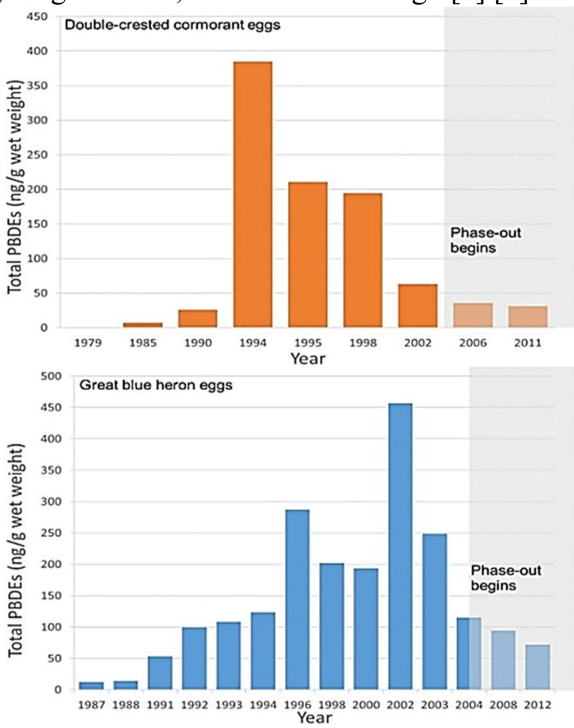

Fig. 2. Double-crested Cormorant and PDBE levels in aquatic bird eggs in the Salish Sea (1979-2011 and 1987-2012)

2.4 Plastics

Plastic bags, cups, and straws account for the majority of the world's annual production of plastic waste, which totals over 300 million tonnes. Floating plastic trash is by far the most common type of marine litter at the moment. Waste plastic accounts for over 80% of all marine debris, from surface waters to deep sea sediment. Microplastics (polyethylene and polystyrene) contaminated with polyaromatic hydrocarbons were found in the digestive glands and gills of Mytilusgalloprovincialis mussels [6].

2.5 Oil Spills

Oil spills are the unintentional release of liquid petroleum hydrocarbons into the environment, most notably the marine environment, as a result of human activities. People’s impact on the oceans is becoming increasingly evident, from rising ocean temperatures causing coral bleaching to plastic waste wreaking havoc on bird, fish, and animal populations [4].

2.6 Land runoff

There are two ways in which rainwater is replenished: by seeping into the Earth's surface and by running off as runoff. In order to preserve the land, runoff is vitally important. There is extensive penetration of rainfall in wooded watersheds, which is retained in the earth and progressively released into streams through seeps and springs. Because even sporadic or low-level sediment loading can harm coral reefs and sea grass beds, marine ecosystems exhibit considerable differences in their susceptibility to nutrient or sediment loads. In contrast to other resilient ecosystems such as kelp forests, low but chronic nutrient loading can potentially affect coral reefs ecologically. Sites that are vulnerable to nutrient loading, sediment loading, or a mix of the two are classified as "land-based drivers critical" as a result of this ecological contradiction [7].

2.7 Radioactivity

The existence of radioactive materials in the Earth's crust is the primary source of radioactivity in surface continental seas. Nuclear power plants, weapons testing, and the production and use of radioactive sources are all examples of human-caused radionuclides. There are three types of radioactive materials present in drinking water: uranium, thorium, and actinium, which are all naturally occurring and contain the radioactive gas radon. As a radioactive element, radium can build up in bones, where it increases the risk of cancer development. In addition to bone cancer, uranium is hazardous to the renal system [8]. There are numerous sources of marine pollution, including chemical and solid waste; radioactive element discharge; industrial and agricultural effluents; sedimentation induced by humans; and oil spills. The majority of marine pollution is created by land, which accounts for around 80% of total marine pollution; air pollution also transfers chemicals and dust from farms into coastal areas.

3. EFFECT OF MARINE POLLUTION

The potential for human effect is obvious as the world's population continues to grow. It is hypothesized that rivers and terrestrial runoff from sewage and industrial waste transfer toxins into the coastal environment. Eutrophication of near shore habitats is caused by excess nitrogen and phosphorus nutrients delivered into coastal habitats by agriculture inorganic fertilizers. As a result, the water becomes depleted of oxygen. Petroleum hydrocarbons are still accidentally introduced into marine transportation, posing a variety of problems for marine ecosystems. Plastics are being dumped into the coastal environment on a vast scale, harming all trophic levels of the ecosystem. It is estimated that during the next 25 years, plastic will outnumber fish in the water. There has been a growing awareness of the magnitude of microplastic garbage and the potential consequences. In areas with less ice cover, such as the High Arctic, oil development and transportation have a greater influence on coastal areas [9]. Invasive chemicals, solid waste, radioactive element discharge, industrial and agricultural effluents, man-made sedimentation, and oil spills, among other factors, damage and destroy the maritime ecosystem. Land-based pollution accounts for up to 80% of marine pollution. An important contributor to the growth in marine pollution levels is air pollution, which transfers chemicals and dust from farms into the ocean.

3.1 Effect of heavy metals

Metals eventually become incorporated into the silt at the bottom, where they may be gathered by organisms that live there (benthic organisms). Heavy metals also have an influence on species at a greater depth in the water. As a result of human activity, metal ion concentrations have inevitably risen in many of these naturally occurring water systems. Agricultural runoff and acid rain have also contributed to an increase in the metal load in these streams, which eventually becomes integrated into sediments. Xiangshan Bay seafood may pose non-carcinogenic dangers to children and adults. Exposure to Cd, which is found in some shellfish, is hazardous to one's health. Given the pollution of seawater and coastal sediments by heavy metals, the potential of heavy metal contamination in seafood merits more attention [13]. In Bangladesh, ships are quickly broken up on the beach, allowing harmful pollutants to enter the coastal ecosystem. It has a direct impact on dynamic and ecologically diverse areas that support critical terrestrial and aquatic habitats such as mangrove forests, seasonal and permanent wetlands, and tidal flats. The Bay of Bengal is polluted by shipwreck debris, which includes oils and persistent organic pollutants (POPs) [10].

3.2 Impact on reproductive systems

It is important to note that pollution can have a wide range of physiological consequences, including affects on breeding adults and embryos. There are a number of consequences for embryos, including death or reduced hatchability, failure of chicks to thrive (wasting syndrome), and teratological abnormalities such as skeletal malformations and insufficient differentiation of the reproductive and neurological systems due to oestrogen-mimicking processes. Gull populations have been affected by environmental oestrogens including organochlorine pesticides and other harmful compounds such as PCBs, o,p'-DDT and organochlorine combinations. Toxic to birds are oestrogenicorganochlorines because oestrogen is essential for the development of birds' reproductive systems [11].

3.3 Coral reef cycle

Pollution can bring pathogens. Reefs located near human settlements may face local constraints such as poor water quality caused by land-based pollution. Pesticides have the ability to suffocate and kill corals. Sunscreen chemicals contribute to coral bleaching by decreasing the viral tolerance of zooxanthellae. Using damaging fishing methods like deep water trawling, in which the bottom of the sea is scraped in order to force fish out of crevices, and muro-ami netting, which involves shattering reefs with heavy bags in order to frighten fish away, is not an option. Debris from fishing nets is common in areas prone to wave disturbance [12].

4. CRUCIAL IMPACTS THROUGH BIOREMEDIATION

4.1 Bioremediation for heavy metal pollutants

During bioremediation processes, microorganisms mineralize organic contaminants and convert them to end products like carbon dioxide and water or metabolic intermediates that serve as primary substrates for cellular growth. Microorganisms are capable of producing degradative enzymes for the pollutants they are targeted for, as well as resistance to heavy metals. By oxidising, binding, immobilising, volatilizing, and converting heavy metals, microbes replenish the environment. Toxic and contaminating heavy metals such as Ni and Hg can be found in the marine environment when their concentrations exceed the maximum permitted concentration in water set by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Numerous anaerobic bacterial strains possess iron-reducing enzymes, which improve the solubility of the ion as Fe(III) is reduced to Fe(II) [13]. Certain bacteria, such as those in the Thiobacillus class, can also undertake heterotrophic or autotrophic bioleaching, in which the microbes acidify their environment by releasing protons or organic acids and oxidising metal sulphides to create soluble metal sulphates [14].

4.2 Bio remediation for petroleum hydrocarbons

Petroleum contains a total of hydrocarbons (TPH) Crude oil is used to manufacture petroleum products, which contribute to environmental pollution. Oil spilled along the coast line may be bio repaired, which is more effective after the oil has been physically removed. Pb>Ni>V>Zn>Cd are the most commonly found heavy metals following oil spills. Zn> Cr>Cd> Al> Ni> Hg> Co> and Ag were found to be the least harmful heavy metals to bacterial growth [15] [16]. Hydrocarbon degraders are plentiful in the sea. The kinetics of bioremediation are drastically slowed down when there is only one microbial species present that can digest one or two different types of hydrocarbons found in crude oil. Consortia of microorganisms are necessary in these instances to biodegrade a considerable part of crude oil. When the indigenous microflora is incapable of digesting hydrocarbons, bio supplementing may be a viable option. As a result, the environmental conditions will dictate the planting of active degraders. A consortium of bacteria composed of Pseudomonas Corynebacterium, Arthrobacter, Mycobacterium, and Nocardia is capable of degrading pollutants. Genetically modified bacterial strains are employed to enhance bioremediation. In 1979, It was Anand Mohan Chakrabarty who discovered a kind of pseudomonas putida that had plasmids XYL and NAH as well as an OCT/CAM/XYL hybrid plasmid. In 1990, the US government authorised him to use this superbug to clean up an oil spill in the state of Texas's waterways. Straw was placed on top of oil slicks; the straw absorbed the oil, and microorganisms degraded it into non-polluting particles. In Antarctica, the marine bacterium AQ5-AO1 degrades fuel and is resistant to heavy metals such as Al, Cd, Co, Cr, Hg, Ni, and Zn, At values of 1 ppm, the metal Ag significantly inhibited the breakdown of diesel by strain AQ5-AO1.

Hexane, benzene, toluene, xylenes, naphthalene, fluorine, gasoline components, and several other fuels are all found in Total Petroleum Hydrocarbon. While a large number of microbe consortia are required to degrade a considerable portion of crude oil, one or two classes of hydrocarbons can be degraded by a single microbial species, which helps to minimise the kinetics of bioremediation due to its limited use. Numerous aspects influence the utilisation of allochthonous (remote) microorganisms and their degradative efficiency. Considerations include pH, salinity, temperature, nutrient quantity and quality [17].

Petroleum hydrocarbons degrade more quickly and completely under aerobic conditions [18]. As the earliest oxidative activities of oxygen support essential intracellular enzymatic events, cell growth and biomass biosynthesis are stimulated through oxygenates' catalytic activity [19]. An oil production facility in Oklahoma found that Marinobacterhydrocarbonoclasticus, a halophilic Marinobacter-dominant culture that destroyed BTEX at 14 percent salinity, was capable of degrading both aromatic and aliphatic hydrocarbons [20] [21].

4.3 Bioremediation for Radio-active pollutants

While many microbes increase metal solubility, others, such as the uranium-reducing Desulfovibriodesulfuricans, are capable of directly reducing or oxidising metal ions in order to decrease their solubility - reducing U(VI) to U(IV) [22]. B. sphaericus was discovered growing in uranium mining waste piles, a toxic environment contaminated with a variety of metal species including uranium, copper, lead, aluminium, and cadmium. The S-layer of B. sphaericus was shown to have a paracrystallineproteinaceous surface to which these dangerous metals localised. To capture uranium ions in waste water or sediment, a filter incorporates an S-layer of bacteria into its construction. Remove huge amounts of radionuclides from the S layer by immobilising radioactive uranium species on the layer. To recover part of the waste uranium for use in power plants, additional chemical treatment may be necessary. The introduction of a mercury-resistant gene (merA) from E. coli (Brim et al.) is described. When E. coli is transformed into the most radiation-resistant organism yet discovered in Deinococcus radiodurans, the bacterium can endure radiation doses up to 50 Gy/hr, a level higher than that found in most radioactive waste sites. Increased radioactive resistance has been discovered to correlate with the ability of dangerous, volatile metal species to change into a less reactive, less toxic state. The bacteria were capable of converting toxic Hg(II) ions to elemental mercury. Additionally, it was demonstrated that by inserting separate gene clusters encoding toluene and chlorobenzene metabolism into a single strain of organism, numerous remediation processes can be introduced. radiodurans through the introduction of additional genes, meaning that a single strain of bacteria is capable of cleaning up different contaminants (metallic and organic) associated with nuclear waste sites [23].

4.4 Marine bio -surfactants

Normally, bio surfactant production requires the presence of a miscible hydrophilic and oily/hydrocarbon carbon source in the culture medium. Microbial biosurfactants are appealing due to their biodegradability, low toxicity, and effectiveness in improving the biodegradability and solubilization of insoluble compounds under harsh environmental circumstances. Through the two mechanisms outlined below, biosurfactants can efficiently promote bioremediation. The interfacial surface area between water and oil may limit the growth rate of bacteria that feed on hydrocarbons if the bioavailability of substrate is increased. For bacteria whose surfaces are confined in water, biomass increases linearly rather than exponentially. By interacting with the cell surface, the microbial cell wall can become more hydrophobic, which facilitates bacterial adhesion to hydrophobic substrates. For bioremediation of oceans polluted by crude oil, these chemicals are being studied because of their decreased surface and interfacial tension in both aqueous solutions and hydrocarbon mixtures. The microbial cell is a biosurfactant in and of itself because of its ability to amass biosurfactants on its cell surface and to bind them to hydrocarbons. Glycolipids, phospholipids, lip peptides, naturally occurring lipids, fatty acids, and lipopolysaccharides comprise the majority of microbial surfactants. To help hydrocarbons get into cells, biosurfactants are amphipathic compounds that have both water-loving and water-phobic domains.

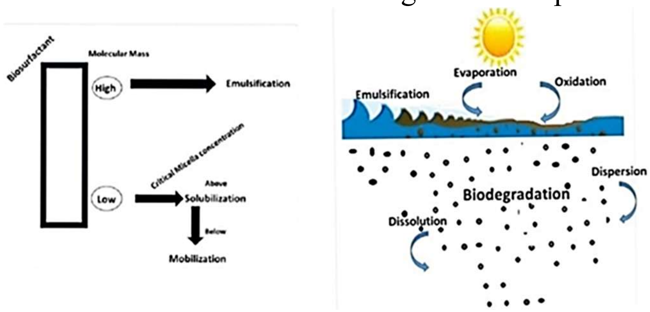

Fig. 3. a) Action of bio surfactants in a procedural manner, b) Cyclical process of microorganism degradation

Only bacteria and microbial consortia have been proven to be successful in eliminating hydrocarbons from saltwater, however yeasts, algae, and protozoa are currently being studied because of their highly promising potential. Figure 3a [17] shows the effect of biosurfactants in relation to the molecular mass. The biodegradation of hydrocarbons by local microbial communities is the principal means by which pollution-causing hydrocarbons are eliminated from the environment. Polycyclic aromatic hydrocarbons such as phenanthrene, for example, can be made more bioavailable by biosurfactants. Figure 3b [24] depicts the entire biosurfactant breakdown route. A large-scale bio cleaning of the Exxon Valdez oil spill was reported to be effective. In this instance, Rhamnolipid from P. aeruginosa was used to demonstrate the ability of Rhamnolipid to effectively remove oil from contaminated Alaskan gravel [24].

4.5 Terms in Bioremediation

4.5.1 Bio Stimulation

Bio stimulation is the process of altering the environment in order to excite existing bacteria capable of bio remediation, such as P,N,O, or C. Alternatively, halogenated pollutants can be corrected in anaerobic environments by adding electron donors (organic substrates), which allow indigenous bacteria to use the halogenated contaminants as electron acceptors. Fig.4[25] illustrates the bio stimulation process in broad strokes. In order to transfer chemicals to the subsurface in a way that makes them freely accessible to microorganisms, the local geology of the subsurface is critical. Sulfate-contaminated groundwater poses a threat to both the environment and human health. Bio stimulation can be used to rectify this biologically. Sulphate reduction and cleanup must be boosted by an electron donor change [26].

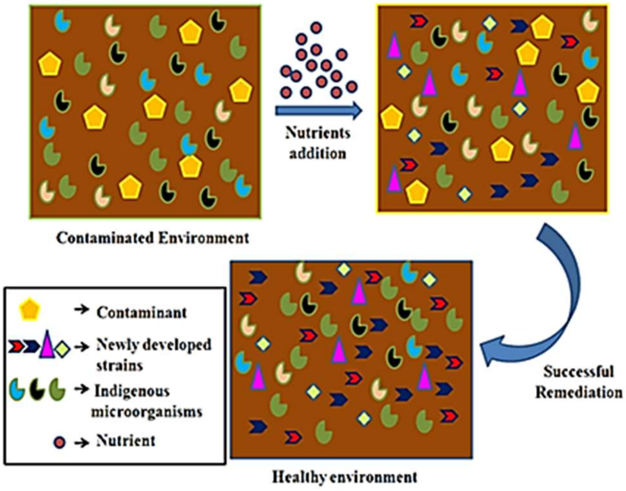

Fig. 4. Bio stimulation process

4.5.2 Bio augmentation

Bio augmentation is the manual addition of an organic culture to an environment, such as a bioreactor, with the objective of treating sewage or other contaminated wastes. The goal of bioaugmentation is to enrich this population and increase its effectiveness in decreasing pollution levels. Bio reactors and other treatment equipment can fast attain maximal performance when pre-grown microbe cultures are added. While adding microorganisms makes sense in terms of increasing the efficiency and effectiveness of operations, each microorganism can only handle this transformation at a certain rate. If the ratio of active microorganisms to hazardous pollutants is not optimal, the efficiency of the procedure will be significantly reduced, and harmful compounds may remain after the treatment phase. Despite its long history in agriculture and wastewater treatment, bio enhancement is still considered experimental in some extreme conditions [27].

5. Prevention of Marine Pollution

Recycling waste is a means of decreasing marine pollution that is being used on-board maritime vessels, particularly cruise liners, where waste creation is four times that of conventional maritime operations. Even on conventional marine vessels and installations, waste management systems should prioritise trash recycling in order to contribute to a cleaner environment. Numerous non-profit marine conservation organisations operate on a global scale to protect our seas on our behalf. These organisations work to protect the ocean from destruction and to restore thriving marine life through a variety of campaigns and other activities.

6. Conclusion

Bioremediation is a low-cost and environmentally friendly method of cleaning up oily estuaries, shorelines, seas, and oceans. Bioremediation has a lower environmental impact than mechanical, physical, and chemical techniques of polluting water. Microbial population studies and the development of bio-amendments are expected to aid in the biodegradation of oil spills, heavy metals, and other marine pollutants. Hydrocarbons can be reduced and converted into non-harmful and recyclable products like carbon dioxide (CO2), water (H2O), and biomass (biomass). Biodegradable microbial strains capable of detoxifying toxins in salty environments are necessary, as are new bioremediation approaches tailored to specific contaminated sites. Increased levels of pollutants will have a negative impact on coastal biodiversity, productivity, and food supply; hence, information and public awareness regarding pollution causes and their negative consequences have been addressed

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