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Review Biodegradation a Real tool in environmental cleaning

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Abstract: This paragraph explains there are several bioremediation techniques that use a range of microorganisms to treat contaminated settings. Biodegradation has been used in the last 20 years as a tool for environmental cleanup. By using their extracellular enzymes to speed up the bioremediation process, bacteria, algae, yeast, and fungi can all be utilized in the remediation of polluted environments. Due to its exceptional capacity to adapt to a variety of pollutants as well as its ability to bio-absorb and bio-convert the pollutants into less harmful products than the parental recalcitrant pollutants, fungi have attracted a lot of interest in their ability to decontaminate polluted environments.

Keywords: Filamentous fungi; biodegradation.

1-Introduction

Biodegradation is a type of biotechnology that can degrade and eliminate environmental pollutants through the physical metabolism of bacteria, fungi, and algae. It has the advantages of low energy consumption, high efficiency, and high environmental safety.
It is projected that biodegradation would be one of the major development topics in environmental technology throughout the early 21st century [1] since it is a demanding, cutting-edge technology.
In the recent two decades, there has been an increase in the generalized use of fungus to biodegrade resistant materials. In order to bio-convert heavy metal compounds into simple elemental forms that are less toxic, the technique uses processes of extracellular and intracellular release of lignin-degrading enzymes that are non-specific in their mode of operation. These fungi primarily produce laccases, manganese peroxidases, and lignin peroxidases as their extracellular and intracellular enzymes [2].

2- Concepts and overview of biodegradation

In order to completely remove the intermediary contaminants from the soil and water, biodegradation must first reduce toxins into less dangerous metabolites. This is officially described as the manipulation of living organisms through natural biological processes [3]. Natural environmental agents including bacteria, fungus, and plants can break down pollutants into less harmful or benign intermediary metabolites [4]. The conversion of chemical pollutants into less dangerous metabolites is achieved through biochemistry processes involving metabolic interactions between these organisms and the chemical contaminants they use as a source of energy. This technology can be used in a variety of situations where environmental degradation of soil and water results in disasters, whether on purpose or by accident [5]. Utilizing this technology, it is possible to remove toxins that have been dumped in the soil and water, including metals (lead, mercury, and chromium), hydrocarbons, non-chlorinated organic solvents, nitrogen compounds, radionuclides, halogenated organic compounds, radionuclides, radioactive materials, and radioactive substances [6]. The degradation of the soil through biological, chemical, and physical changes is largely due to anthropogenic activities such as agriculture, mining, and industrial processes. Mine dumps, which are constantly growing as a result of mining activities in Zimbabwe and around the world [7]. The environment has suffered irreparable harm as a result of human development being given priority over it. As a result, in the relatively near future, the next generation won't be able to enjoy the same economic and social benefits that the generations before them did because the environment won't be able to sustain the resources it once provided to the human population. It's also vital to remember that once the environment has been harmed, repairing the ecosystem's damage can be highly expensive. [8] stated that the deposition of pyritic heavy metals in the topsoil has been the primary cause of up to 40% of the soil and water contamination caused by mining activities on a global scale.

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3-Characteristics of bioremediation microorganisms

Microorganisms used in bioremediation techniques, like all other living things, have a variety of environmental conditions they can tolerate at a particular site. This directly affects how well the microbes perform, which is largely influenced by a number of variables, including the availability of nutrients, soil temperature, moisture content, and pH [9]. Inorganic nutrients are crucial for the lag phase of microbial growth and for the oxidation and reduction cycle, which gives energy to the microorganisms. Since the nutrients (nitrogen and phosphorus) are necessary for microbial activity, which is necessary for the growth, development, and reproduction of the microbial population, they shouldn't be limited. In experiments, nitrogen was added to a soil medium that had been contaminated with petroleum. This treatment boosted cell division, decreased growth in the log phase, maintained the activity of the microbial population, and resulted in a high rate of hydrocarbon breakdown. [10] On the other hand, excessive nitrogen levels in the soil medium caused microbial activity to be inhibited. In line with [11], To ensure a sustained biodegradation of the pollutant, nitrogen levels should be kept below 1800 mg/kg $H2O$. It is also possible to replace nitrogen with phosphorus, although this has the same restrictions because excessive phosphorus application might decrease microbial activity [12]. Water is necessary for the growth and development of soil bacteria' cells as well as for their normal operation. Thus, moisture is the main component, and its availability is crucial to activities like diffusion, osmosis, and the passive and active flow of water into and out of the cells of microorganisms. However, excessive wetness is undesirable as it can prolong anaerobic conditions, which would directly reduce the amount of oxygen available for aerobic respiration by bacteria. When compared to aerobic respiration, anaerobic respiration gives bacteria less energy, which slows down the rate of biodegradation. According to [13], for petroleum hydrocarbons to degrade most effectively, the soil medium should have moisture levels of between 12 and 30 percent by weight.[14]. Another crucial aspect to think about is the soil's acidity or alkalinity. For activity and survival, microbes demand a specific pH range, and pH directly influences whether nutrients are available or not. If the soil is either excessively acidic or highly alkaline, it may be advised to add limes in the form of calcium sulphate ($CaSO4$), calcium carbonate ($CaCO3$), calcium hydrogen carbonate 4 ($Ca(HCO)3$), and any other bases [15]. The rate of biodegradation of hydrocarbons is directly influenced by temperature since it optimizes enzymatic responses in microorganisms. According to the general rule, cell response doubles for every 10°C increase in temperature [16]. Microorganisms have a maximum temperature that they can endure. The majority of soil-dwelling microorganisms, including those that may biodegrade petroleum hydrocarbons, are mesophiles, able to withstand a temperature range of 25 to 45 °C [17]. Another crucial factor to take into account when choosing the biodegradation mechanism that will best fit to a specific situation is the soil characteristics associated to their type. At the particular location where the pollutant is present and/or in place, biodegradation refers to soil treatment. The in-situ strategy is based on bioventing, in which nutrients and oxygen are artificially delivered through injection pumps to boost aerobic respiration of the bacteria, which aids in accelerating the rate of contaminant biodegradation [18]. The uniform distribution of nutrients and oxygen throughout the polluted soil medium is an important element to take into account. Because of how it influences porosity, soil texture also has a direct impact on bioventing. High bulk density soils are very porous and allow for high rates of bioventing. The soil's textural properties determine how permeable it is to air and water. Because of their fine texture and low permeability index, clays and silts naturally prevent nutrients and oxygen from being disseminated uniformly throughout the soil medium [19]. Due to the small pores and high surface area to volume ratio in fine textured soils, which makes the soil flexible in water retention, moisture content is also difficult to control. Due to the difficulty of water drainage on fine-textured soils when they are saturated with water, anaerobic conditions develop in the soil medium, depriving soil microbes of oxygen throughout the polluted region [20].

4-Role of fungi to nature

Due to their capacity to decompose hazardous material that has been dumped into the soil and water as a result of various anthropogenic activities, fungi have drawn the interest of numerous researchers [21]. Mycoremediation is the process of cleaning up pollutant-damaged soils using fungi specifically. The key to fungi's function in decomposing a variety of soil toxins left behind by anthropogenic activities like mining, agriculture, and industrial operations is their capacity to coexist peacefully with a variety of other living organisms. In the natural world, fungi are saprophytes that coexist in enormous communities with a variety of

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other living things [22]. Fungi are known for their innate capacity to secrete enzymes that can dissolve intricate plant structures including lignin, cellulose, and pectins. The basidiomycotina white-rot fungus are of interest for mycoremediation studies. Although basidiomycotina have received the majority of attention in bioremediation experiments, attention is now shifting to native soil-borne fungi and endophytes that have not been studied in terms of their economic roles in the soil, necessitating more research ([23]. Since they are edible grown mushrooms and because it is well understood how they grow, the lignin decomposing basidiomycotina are fundamentally frequently employed. The basidiomycotina of fungus are also known to contain highly specialized lignin-degrading enzymes, and they have evolved methods of dissolving complicated carbon-based compounds over time. It has been discovered that lignin and heavy toxins in contaminated soils share structural similarities, making basidiomycotina fungi capable of degrading these toxins in both the soil and the water where they have been deposited [24]. In the natural wilderness where they coexist, plant and fungal species have coevolved over many millions of years to the point where there is dependency between the two and high diversity is also linked with both. Given that an undisturbed environment is still maintained, it is well known that the largest gene pool for fungal species can be found in the wild where both plant and fungi species co-exist [25]. Another reality is that during the past two centuries, industrial pollutants have multiplied in many different ways, expanding their diversity and contaminating water, soil, and other resources with a variety of contaminants. The need to assess the functions and potentials of fungi to reduce this continuously growing problem of pollution brought on by anthropogenic activities is gaining momentum. This is because cumulative pollution on water and soil resources has a negative impact. Research has even identified particular species of fungi and the toxins that can be broken down by them [26].

5-Co-metabolizable mechanisms

Co-metabolism in biodegradation, in general, refers to the metabolic transformations that environmental contaminants go through when microorganism populations use other chemicals as their carbon or energy source. Pollutant detoxification and elimination occur as accidental or indirect byproducts of this process. These days, this unique action has emerged as one of the key elements of the bio degrading approach. Unfortunately, there have been significant challenges in regulating and controlling this process on-site, and significant research costs have been incurred. This pricey co-metabolism process is thought to be involved in the efficient bioremediation of phenanthrene (PAH). Studies [27] revealed that some enzymes that are utilized by specific bacteria to breakdown PAHs are also capable of oxidizing other PAHs. Several academics [28, 29]. the white rot fungus were separated, with fluoranthene serving as the only source of carbon and energy. Naphthalene, fluorine, acenaphthene, phenanthrene, anthracene, 2-methylnaphthalene, 2-, 6-dimethylnaphthalene, benzo [b] fluorine, biphenyl, and benzo [a] py rene are just a few of the PAHs that they can biotransform. According to data [30], DDT breakdown occurs as a co-metabolism process in anaerobic environments. Additionally, the aerobic microorganisms might destroy the co-metabolite. One noteworthy aspect is that co-metabolism could never be optimized in the preset ecological circumstances intended to encourage the breakdown of PAHs by local microorganisms. Typically, it is unclear precisely which PAHs are acting as the main carbon and energy source. It is impossible to maintain the concentration of the appropriate PAHs, which act as the carbohydrate and energy source, at the ideal amount required to maximize cometabolism. Sometimes the addition of low concentrations of PAHs can encourage the co-metabolism of the microorganism community to further breakdown high molecular weight PAHs. Identification of the co-induced metabolism's products is also crucial. Laboratory tests [32] revealed that the biphenyl-cultivated strain is capable of cometabolizing dibenzofuran. Due to co-metabolism, several pollutants, including petroleum hydrocarbons and organic dyestuffs, can biodegrade to create certain compounds that are far more hazardous than their matrices [33]. In other words, although original pollution concentrations are lower, transformed products can have considerably higher hazardous effects on ecosystems. Additionally, some of the co-oxidation metabolism's end-products aren't always broken down by local microbes. From a toxicological perspective, biological assessments of processes that lead to biodegradation are required. the inhibition test of plant root elongation, test of seed germination, test of the early stage of seedling growth, and toxic test of horse bean root tips; the acute toxicity tests of earth worms; the subacute toxicity; the chronic toxicity; the protozoan ecotoxicological methods; and the fish embryo indication test are currently the methods in use. the Ames mutagenesis assessment technique. These experiments were first primarily used to examine the toxicity

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of pure substances [34]. These techniques have been used to evaluate waste dumps, environmental pollution sites, the cometabolism in bio remediation of contaminated soils and ground water, etc. as a result of the advancement of research on environmental issues and growing demand for the ecological quality of the environment[35].

6-Bioavailability and its improvement

Due to the adsorption and immobilization of pollutants in environmental medium like soil and sediments, direct interactions between particular microbes, enzymes, and plants and pollutants are frequently decreased, even under the best ecological conditions. This reduces the capacity of contaminants to biodegrade and the availability of nutrients for particular bacteria, enzymes, and plants [36, 37]. This way, the effectiveness of biodegradability during bioremediation might be described as the observed bio-concentration of chemical contaminants in environmental systems. When thinking about bioavailability, two criteria are sometimes overlooked. The separation of bacteria from biological membranes and the interaction of pollutants with special surfaces are major contributors to the fact that effective concentrations based on individual cells are frequently fairly low, especially at the level of microbial remediation [39]. This crucial issue hasn't been considered in biodegradation techniques or their on-site implementations up to now. Surfactants may be used in bioremediation to increase bioavailability and speed up the process in specific circumstances. [40] Shown how an increase in bioavailability can also boost biological exploitability and biodegradation rate. Studies [41, 42]. The biodegradability of petroleum hydrocarbons and PAHs by soil microorganism communities was unknown when surfactants were used to biodegrade them. To prevent negative consequences brought on by onsite distribution of pollutants, such as the infiltration of pollutants into a non-polluted area and impacts of secondary pollution, it should also be taken into consideration to remove compounds that can increase bioavailability. Although the overall concentration of hydrophobic organic pollutants is rather large, the amount of bacteria present in a water-droplet interface is relatively low because to these pollutants' hydrophobic properties. This category includes wastes from petroleum products, creosote, coal tar, and PCBs. There hasn't been any investigation into how bacteria can engulf and eat hydrophobic contaminants up to this point[43].

7- Biological evolution and its utilization

A tolerance for organisms can develop in contaminated surroundings. Some microorganisms or plants with high degradability or hyperaccumulative characteristics of some contaminants will be simple to screen [44]. In contrast, it will never be easy to find the miracle microbes or the highly accumulative plants required for bioremediation processes in a clean environment. According to the theory of biological evolution, polluted environments provide some advantages for the discovery of particular bacteria and hyperaccumulative plants. Identification of biodegradation and bioaccumulation processes in the contaminated environment is necessary, on the one hand.

Developing microorganisms or plants with even stronger biodegradability and bioaccumulation characteristics through intentional, long-term breeding with respect to biological evolution is important in order to lay the groundwork for the technical perfection of bio remediation. This includes applying those biological evolution mechanisms, such as the modulation and utilization of transcriptional factors [45]. On the other hand, the deliberate control of introduced specific microorganisms should be done in accordance with the theory of biological evolution, including the method of extracting specific microorganisms to apply to some polluted spots elsewhere and the decrease in introduced microorganism population with the disappearance of pollutants [46]. The tolerance of living elements in an ecosystem to pollutants is typically increased due to the globalization of environmental contamination and the prolonged exposure of many species to contaminated environments. The environment has changed on its own in the interim [47]. When establishing judging standards for the success of bioremediation, one should take into account economic benefits and resource conservation, and some relevant study on biological evolution under bioremediation settings should be done.

8-Monitoring and control of bioremediation

How can the efficiency of biodegradation of contaminated soil be assessed? The conventional approach is chemical analyses, which can only do either qualitative or quantitative tracing on target contaminants. Giving

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an accurate assessment of the ecological toxicity of metabolite contaminants that are produced during bioremediation processes is challenging [48]. The structure toxicity correlation analysis of contaminants, among other eco toxicological techniques, can be used to supplement chemical tests [49]. With the use of these new techniques, it is also possible to identify underlying issues and anticipate how well a particular bioremediation will go. These elements make it possible to do some engineering reconstruction in order to enhance bioremediation procedures. Biotechnology has been extensively used recently to monitor bioremediation. For instance, nucleic acid probes recognizing monooxygenase and dioxygenase genes that may initially oxidize aromatics have been produced; the method of gene expression can identify specific microorganisms with biodegradability based on the cloned necessary gene. By separating the specific gene probe from tagged RNA, advances in natural science have shown a correlation between environmental expression of a particular gene responsible for the first metabolism of contaminants and the removal of specific pollutants. such as the gene expression of monooxygenases and dioxygenases, which are in charge of the initial metabolism; the method of stressing the activation of start-up genes, which can induce special metabolism bypass to degrade some pollutants by environmental activation of start-up genes, such as the start-up gene activated by the low nutrition level or different temperature; and, when combined with spectrophotometry, the method of stable isotope can determine fluxes of organic substances. The identification of biological variety is now one of the biotechnological techniques that can be used for this type of monitoring. the chemical species design, the informative gene, and the immunological test[50,51]. Many microbiological and botanical ecological difficulties can now be understood better thanks to the application of biotechnology. There are little worries concerning process management and long-term bioavailability of bioremediation processes at this time because the majority of bioremediation studies are concentrated on the study and creation of new ecological processes. The most effective, affordable, and sensitive method for process monitoring and control is expected to be molecular biology and biotechnology in the end [52].

Conclusion

The future of environmental management of dirty places appears to be biodegradation. Its use promotes sustainable resource management and is extremely environmentally friendly. The technique is still quite new, and because it hasn't been well documented globally, it's not generally understood how it works. The other issue has to do with granting patent rights for technology to end users, as some people say that technology can only be used after paying them for the privilege to do so.

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