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Bioremediation

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ABSTRACT:
Environmental pollution has been on the rise at alarming rate during the past few decades. Reason being unsafe agricultural practices, population blast and rapid industrialization. However, in recent times awareness to curb the environmental pollution has increased and so has the research, adoption and implementation of the various methods to clearly cut or reduce the stress of environmental pollution and to have a sustainable resource for the future of the mankind. The most of the culprit here is the increase in the population and the increase in demand due to that. Industries work day in and day out to supply the increased demand, increasing the pressure on the environment all over the globe. Whether they be industrial waste or oil spills bioremediation is the best and low-cost option available for the sustentation. In this paper we will review the term bioremediation in general, the types and the concerns, the various processes of Bioremediation, challenges and future of the Bioremediation, forming a conclusion to what's coming ahead in the future.
Keywords : Bioremediation, Environment Pollution.

DEFINITION:

Bioremediation generally refers to any process where in a biological system typically bacteria, microalgae, fungi and plants, living or dead, are employed for removing environmental pollutants from air, water, soil, flue gasses, industrial effluents etc., in natural or artificial settings.

Increase in population or population blast increases demand in all sections, and increased demand calls for surplus production which leads to increase in industries and increase in industries creates pollution. It is as simple as it gets. Pollutants have to dumped somewhere and to do that we need more space on the earth but if the same is treated and removed biologically it will sustain the resources and reproduction will increase.

INTRODUCTION:

Environmental pollution is a major global problem that affects the quality of life for all living organisms. Pollution can be caused by various sources such as industrial activities, transportation, and agricultural practices, leading to the release of toxic substances into the environment. These toxic substances can cause serious health problems for humans and other living organisms. Bioremediation is a process that utilizes microorganisms to clean up environmental pollutants, reducing their harmful effects. This review aims to provide an overview of the bioremediation process, its effectiveness in removing environmental pollutants, and the challenges associated with this technology. And further the future of the bioremediation in the sustention of the ecological environment.

So far, various methods for the detection, identification, cleaning and removal of the pollutants have been propsed, used and implemented for the removal of the environmental pollution and for the eco friendly and sustainable development of the ecological environment. Some of the processes like fluorescent-based sensors and electrochemical sensors for detection purposes, immobilized enzyme-based catalytic systems and photocatalytic systems for degradation purposes, along with other physiochemical-based process, etc. are most widely used. But each of them has its own merits and demerits.

BIOREMEDIATION PROCESS:

Bioremediation is a process that utilizes microorganisms to break down and degrade environmental pollutants. The microorganisms involved in bioremediation can be naturally occurring or can be added to the contaminated site in a process called bioaugmentation. Bioremediation can be carried out in situ or ex situ, depending on the nature of the pollutant and the site conditions. In situ bioremediation involves the use of microorganisms to degrade pollutants at the site of contamination, while ex situ bioremediation involves the removal of contaminated soil or water to a treatment facility.

INSITU REMEDIATION: Means on site. The remedies are employed directly on the site of the pollutants. The types of the Insitu remediation are:

1. BIOVENTING: Venting or bioventing was one of the first technologies to be applied in large scale in the 1990s (Leeson and Hinchee, 1997) and is now widely used in commercial applications. It is a process that increases the oxygen or air flow into the unsaturated zone of the soil, this in turn increases the rate of natural *in situ* degradation of the targeted hydrocarbon contaminant. Bioventing, an aerobic bioremediation, is the most common form of oxidative bioremediation process where oxygen is provided as the electron acceptor for oxidation of petroleum, poly aromatic hydrocarbons (PAHs), phenols, and other reduced pollutants. Oxygen is generally the preferred electron acceptor because of the higher energy yield and because oxygen is required for some enzyme systems to initiate the degradation process. Microorganisms can degrade a wide variety of hydrocarbons, including components of gasoline, kerosene, diesel, and jet fuel. Under ideal aerobic conditions, the biodegradation rates of the low- to moderate-weight aliphatic, alicyclic, and aromatic compounds can be very high. As molecular weight of the compound increases, the resistance to biodegradation increases simultaneously. This results in higher contaminated volatile compounds due to their high molecular weight and an increased difficulty to remove from the environment.

2. BIOSTIMULATION: In this the remediation is carried out by the bacteria that is naturally present on site by stimulating and increasing the size of the same by adding nutrients. Bacteria can in principle be used to degrade hydrocarbons. Specific to marine oil spills, nitrogen and phosphorus have been key nutrients in biodegradation. Bioremediation can involve the action of microbial consortium. Within the consortium, the product of one species could be the substrate for another species. The term bio stimulation refers to the adjustment of the environmental conditions (e.g., temperature, moisture, aeration, pH, redox potential) and the application of nutrients (e.g., nitrogen, phosphorus) and electron acceptors to contaminated soil, in order to enhance the growth of degrading microbial populations and, then, reduce the concentration of soil contaminants.

3. BIOATTENUATION OR INTERINSIC: During bio attenuation, biodegradation occurs naturally with the addition of nutrients or bacteria. The indigenous microbes present will determine the metabolic activity and act as a natural attenuation, which involves passive remediation of polluted sites, without any external force

(human intervention). The process relies on both microbial aerobic and anaerobic processes to biodegrade polluting substances including those that are uncooperative.

4. BIOSPARGING: Is quite like bioventing but here it focuses on saturated contaminated zones, specifically related to ground water remediation. UNICEF, power producers, bulk water suppliers, and local governments are early adopters of low-cost bioremediation, such as aerobic bacteria tablets which are simply dropped into water.

5. BIOAUGMENTATION: Addition of specifically prepared culture of organisms to carry out specific functions such as biodegradation in the environment.

EXSITU REMEDIATION: These techniques involve excavating pollutants from polluted sites and subsequently transporting them to another site for treatment. Ex situ bioremediation techniques are usually considered based on: the cost of treatment, depth of pollution, type of pollutant, degree of pollution, geographical location and geology of the polluted site

1. BIOPILES: This involves the nutrient amendment of the piling of excavated polluted soil above ground and aeration for the enhancement of bioremediation by increased microbial action. The components used in this technique are aeration, irrigation, nutrient and leachate collection systems, and a treatment bed. The use of this particular ex situ technique is increasingly being considered due to its constructive features including cost effectiveness.

2. WINDROWS: Another of ex situ bioremediation techniques, windrows rely on turning of piled polluted soil, periodically to enhance bioremediation by increasing degradation activities of indigenous and transient hydrocarbon degrading bacteria or oil degrading bacteria present in polluted soil. The periodically turning of the polluted soil and addition of water bring about increase in aeration, uniform distribution of pollutants, nutrients and microbial degradative activities, thus speeding up the rate of bioremediation, which can be accomplished through assimilation, biotransformation and mineralization.

3. LANDFARMING: Landfarming, also known as land treatment or land application, is an aboveground remediation technology for soils that reduces concentrations of petroleum constituents through volatilization and biodegradation. It usually involves spreading of excavated contaminated soils in a thin layer on the ground surface and stimulation of aerobic microbial activity within the soils by aeration and/or addition of minerals, nutrients, and moisture. It may be insitu or exsitu depending on the depth of pollutants in the ground. It is $>$ 1meter it is treated insitu and if it is $<$ 1.7 meters deep it is treated as exsitu.

EFFECTIVENESS OF BIOREMEDIATION:

Bioremediation has been shown to be an effective technology for removing a wide range of environmental pollutants. Some of the processes like landfarming have been used more than 100 years. The effectiveness of bioremediation depends on various factors such as the nature of the contaminant, the microbial community present at the contaminated site, and the environmental conditions. Bioremediation has been used to remove various types of pollutants, including organic compounds such as polycyclic aromatic hydrocarbons (PAHs), chlorinated solvents, and petroleum hydrocarbons. Bioremediation has also been used to remove heavy metals such as mercury, cadmium, and lead associated with the cancer-causing contaminants. The Insitu techniques are basically cost effective whereas Exsitu techniques are more costly and time consuming due to extraction and transportation of the piles to treatment sites.

CHALLENGES:

Despite the effectiveness of bioremediation, there are various challenges associated with this technology. One of the main challenges is the slow rate of degradation of pollutants. Bioremediation can take several months to several years to achieve complete degradation of pollutants. The slow rate of degradation is due to various factors such as the availability of nutrients, the presence of inhibitors, and the microbial community's activity at the contaminated site. Another challenge is the limited range of pollutants that can be effectively removed using bioremediation. Some pollutants, such as persistent organic pollutants (POPs), cannot be effectively removed using bioremediation due to their chemical stability and persistence in the environment.

RECENT ADVANCES:

Recent advances in bioremediation have focused on improving the effectiveness and efficiency of this technology. One area of research has focused on the use of genetically modified microorganisms to improve the degradation of pollutants. Genetic modification can improve the ability of microorganisms to degrade specific pollutants by introducing genes that encode for specific enzymes involved in the degradation process. Another area of research has focused on the use of nanotechnology to improve the delivery of nutrients and other compounds to the contaminated site. Nanoparticles can be used to deliver nutrients and other compounds to the site, improving the activity of the microbial community and the rate of degradation of pollutants.

CONCLUSION:

Bioremediation is a promising technology for the removal of environmental pollutants. It utilizes microorganisms to degrade pollutants, reducing their harmful effects on the environment and living organisms. Bioremediation has been shown to be effective in removing a wide range of pollutants, including organic compounds and heavy metals. Despite its effectiveness, bioremediation faces various challenges, such as the slow rate of degradation and the limited range of pollutants that can be effectively removed. Recent advances in bioremediation have focused on improving the effectiveness and efficiency of this technology through the use of genetically modified microorganisms and nanotechnology. Bioremediation has the potential to play a significant role in addressing the global problem of environmental pollution, but it is essential to continue researching and developing this technology to overcome the challenges and improve its effectiveness further. It is also important to consider the potential risks associated with bioremediation, such as unintended consequences of genetically modified microorganisms and the potential for the spread of pathogens. Proper regulation and monitoring of bioremediation processes are crucial to ensure their safety and effectiveness.

In conclusion, bioremediation is a promising technology that can contribute to solving the problem of environmental pollution. It offers a sustainable and cost-effective approach to remediate contaminated sites and reduce the harmful effects of pollutants. However, it is crucial to acknowledge the challenges associated with this technology and continue to improve its effectiveness and safety through research and development. With proper management and regulation, bioremediation can be a valuable tool in addressing the global problem of environmental pollution and protecting the health and well-being of all living organisms.

The foremost step to a successful bioremediation is site characterization, which helps establish the most suitable and feasible bioremediation technique (ex situ or in situ). Ex situ bioremediation techniques tend to be more expensive due to additional costs attributed to excavation and transportation. Nonetheless, they can be used to treat wide range of pollutants in a controlled manner. In contrast, in situ techniques have no additional cost attributed to excavation; however, cost of on-site installation of equipment, coupled with inability to effectively visualize and control the subsurface of polluted site may render some in situ bioremediation techniques inefficient.

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