International Journal of Advance and Applied Research (IJAAR)
Peer Reviewed Bi-Monthly
ISSN – 2347-7075
Impact Factor – 7.065
Vol.7 No.5 May – June 2020

BIOREMEDIATION: THE POLLUTION SOLUTION

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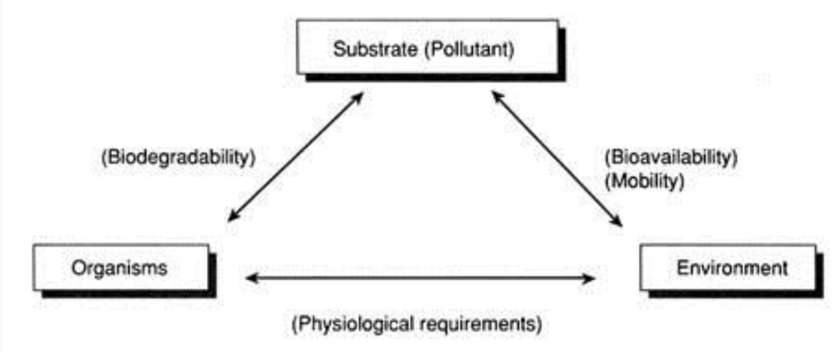
ABSTRACT:

Bioremediation is a branch of biotechnology that employs the use of living organisms, like microbes and bacteria to decontaminate affected areas. It is used in the removal of contaminants, pollutants, and toxins from soil, water, and other environments. Through agriculture, industry, and daily life, harmful chemicals have been released into the earth's air, soil, and water. Depending on their concentrations, these substances can have destructive consequences on ecosystems, as well as cause severe damage to humans and other organisms nearby. Soil pollution is of special importance because of its impact on surface, groundwater and air contamination and can easily spread and be consumed by humans.



***Biodegradation** is the biologically catalyzed modification of an organic chemical's structure. However, this modification can be through different metabolic pathways and does not necessarily mean a reduction in toxicity. Mineralization, one type of biodegradation, is defined as the conversion of an organic substance to its inorganic constituents, rendering the original compound harmless. Transformation is defined as any metabolically induced change in the chemical composition of a compound.*

Keywords:** **Bioremediation, Phytol Remediation, Bioventing, Bio augmentation, Bio stimulation, Biodegradability, Bioavailability.

INTRODUCTION:

Bioremediation refers to the use of microorganisms to degrade contaminants that pose environmental and human risks. Bioremediation processes typically involve the actions of many different microbes acting in parallel or sequence to complete the degradation process. Both in situ (in place) and ex situ (removal and treatment in another place) remediation approaches are used. The versatility of microbes to degrade a vast array of pollutants makes bioremediation a technology that can be applied in different soil conditions. Though it can be inexpensive and in situ approaches can reduce disruptive engineering practices, bioremediation is still not a common practice, A widely used approach to bioremediation involves stimulating naturally occurring microbial communities, providing them with nutrients and other needs, to break down a contaminant. This is termed **bio stimulation.** Bio stimulation can be achieved through changes in pH, moisture, aeration, or additions of electron donors, electron acceptors or nutrients. Another bioremediation approach is termed **bioaugmentation**, where organisms selected for high degradation abilities are used to inoculate the contaminated site. These two approaches are not mutually exclusive- they can be used simultaneously.

Recent awareness of the dangers of many chemicals used in society has led to research on formulation of products that are more easily degraded in the environment.

From an ecological point of view, bioremediation depends on the various interactions between three factors: substrate (pollutant), organisms, and environment, as shown in the figure at right. The interactions of these factors affect biodegradability, bioavailability, and physiological requirements, which are important in assessing the feasibility of bioremediation. **Biodegradability**, or whether a chemical can be degraded or not, is determined by the presence or absence of organisms that are able to degrade a chemical of interest and how widespread these organisms are in the site. The substrate (pollutant) can interact with its surrounding environment to change its **bioavailability**, or availability to organisms that are capable of degrading it; for example, substrate has low bioavailability if it is tightly bound to soil organic matter or trapped inside aggregates. **Physiological requirements** or set of conditions required by organisms to carry out bioremediation in the environment, include nutrient availability, optimal pH, and availability of electron acceptors, such as oxygen and nitrate. Also, the environment needs to be habitable for organisms involved in bioremediation.

DISCUSSION:

The Global Pollution Problem:

The global population continues to rise at an astonishing rate, with estimates suggesting it will be in excess of 9 billion in 2050. The intensive agricultural and industrial systems needed to support such a large number of people will inevitably cause an accumulation of soil, water and air pollution. Estimates have attributed pollution to 62 million deaths each year, 40% of the global total, while the World Health Organization (WHO) have reported that around 7 million people are killed each year from the air they breathe. Water systems fare little better, with an estimated 70% of industrial waste dumped into surrounding water courses. The world generates 1.3 billion tonnes of rubbish every year, the majority of which is stored in landfill sites or dumped into the oceans.

Micro-organisms are well known for their ability to break down a huge range of organic compounds and absorb inorganic substances. Currently, microbes are used to clean up pollution treatment in processes known as 'bioremediation'.

The Invisible Workforce:

Bioremediation uses micro-organisms to reduce pollution through the biological degradation of pollutants into non-toxic substances. This can involve either aerobic or anaerobic micro-organisms that often use this breakdown as an energy source. There are three categories of bioremediation techniques: *in situ* land treatment for soil and groundwater; biofiltration of the air; and bioreactors, predominantly involved in water treatment.

Soil:

Industrial soils can be polluted by a variety of sources, such as chemical spillages, or the accumulation of heavy metals from industrial emissions. Agricultural soils can become contaminated due to pesticide use or via the heavy metals contained within agricultural products.

A visible example of where bioremediation has been used to good effect can be found in London's Olympic Park. The grounds that held the 2012 Olympics had previously been heavily polluted, after hundreds of years of industrial activity. Bioremediation cleaned 1.7 million cubic metres of heavily polluted soil to turn this brownfield site into one containing sports facilities surrounded by 45 hectares of wildlife habitats. Groundwater polluted with ammonia was cleaned using a new bioremediation technique that saw archaeal microbes breaking down the ammonia into harmless nitrogen gas. The converted park marked the London 2012 Olympic and **Paralympic Games as the "greenest" and most sustainable games ever held, only possible with bioremediation techniques.**

While some soil cleaning techniques require the introduction of new microbes, 'bio stimulation' techniques increase natural degradation processes by stimulating the growth of microbes already present. Natural biodegradation processes can be limited by many factors, including nutrient availability, temperature, or moisture content in the soil. Bio stimulation techniques overcome these limitations, providing microbes with the resources they need, which increases their proliferation and leads to an increased rate of degradation. Cleaning up oil-polluted soil is an example of where stimulating microbial growth can be used to good effect. Research has shown that poultry droppings can be used as a bio stimulating agent, providing nitrogen and phosphorous to the system, which stimulates the natural growth rate of oil-degrading bacteria. Systems like these may prove cheaper and more environmentally friendly than current chemical treatment options.

Air:

Air is polluted by a variety of volatile organic compounds created by a range of industrial processes. While chemical scrubbing has been used to clean gases emitted from chimneys, the newer technique of 'biofiltration' is helping to clean industrial gases. This method involves passing polluted air over a replaceable culture medium containing micro-organisms that degrade contaminates into products such as carbon dioxide, water or salts. Biofiltration is the only biological technique currently available to remediate airborne pollutants.

Water:

In the UK, access to clean, potable water and modern sanitation is something we take for granted. However, there are billions of people on Earth for which this is a luxury. The WHO estimate that each year 842,000 people die as a result of diarrhoeal diseases, many of which could be prevented if they had access to clean water and proper sanitation. Around 2.6 billion people lack any sanitation, with over 200 million tons of human waste untreated every year. Sewage treatment plants are the largest and most important bioremediation enterprise in the world. In the UK, 11 billion litres of wastewater are collected and treated every day. Major components of raw sewage are suspended solids, organic matter, nitrogen and phosphorus. Wastewater entering a treatment plant is aerated to provide oxygen to bacteria that degrade organic material and pollutants. Microbes consume the organic contaminants and bind the less soluble fractions, which can then be filtered off. Toxic ammonia is reduced to nitrogen gas and released into the atmosphere.

The Future:

Bioremediation is not a new technique, but as our knowledge of the underlying microbial reactions grow, our ability to use them to our advantage increases. Frequently, bioremediation requires fewer resources and less energy than conventional technology, and doesn't accumulate hazardous by-products as waste. Bioremediation has technical and cost advantages, although it can often take more time to carry out than traditional methods.

Bioremediation can be tailored to the needs of the polluted site in question and the specific microbes needed to break down the pollutant are encouraged by selecting the limiting factor needed to promote their growth. This tailoring may be further improved by using synthetic biology tools to pre-adapt microbes to the pollution in the environment to which they are to be added. Pollution is a threat to our health and damages the environment, affecting wildlife and the sustainability of our planet. Damage to our soils affects our ability to grow food, summarised in our policy briefing on Food Security. Bioremediation can help to reduce and remove the pollution we produce, to provide clean water, air and healthy soils for future generations.

MATERIALS AND METHODS:

Bioremediation Treatment Methods:

In order for bioremediation to be successful, it requires sufficient proof for the degradation of contaminants. However, determining the effectiveness and completeness to reach sufficient results is one of the major issues. Natural attenuation relies on natural processes to clean up or attenuate pollution in soil and groundwater This remediation is done without human interaction, and is primarily used as a monitoring technique, to make sure more aggressive cleanup strategies are not needed. Abiotic and biotic factors play a distinguishing factor of how effective bioremediation is.

Current monitoring practices determine the disappearance of contaminants and their degradation products to regulatory levels that are monitored by toxicity testing, usually on single organisms or species to ensure there are no induced changes that may result in residual toxicity. The problem with these monitoring techniques is that the assessment of contaminants may result in an inaccurate indicator of residual toxicity. Rather, studying the

microbial community response may be a more comprehensive indicator of residual toxicity than a single species. Once sufficient evidence is provided, human intervention may be needed for a more effective cleanup process.
There are two types of remediation that are done, ex situ: which is done by removing the contaminated soil or water and treating it outside the source, and in situ: which treatment takes place within the contaminated area. There are some treatments methods that can be either ex situ or in situ.

CONCLUSION:

Advantages:

1. Bioremediation that involves natural attenuation or biostimulation is a publicly accepted treatment of polluted soil because it is based upon natural processes. Microbes that metabolize contaminants often increase in population when the contaminant is present and thus rates of biodegradation may increase over time, up to a point. If biodegradation is complete (i.e. mineralization) the products from treatment are harmless; such as carbon dioxide, water, and cellular biomass.
2. In situ bioremediation can result in complete degradation of pollutants into harmless products on site. This removes the risks involved with transportation for treatment and elimination of contaminated substances.
3. Bioremediation can be a cheaper alternative to other technologies used for pollution mitigation.

Disadvantages:

1. Only biodegradable compounds are capable of undergoing bioremediation. Not every compound is capable of fully degrading quickly.
2. The products of biodegradation may potentially be even more persistent or toxic than the original contaminant.
3. Biological functions are usually extremely specific and require the presence of microbes that are capable of metabolizing the contaminants. In order for the correct microbes to be present, the appropriate environmental conditions, levels of nutrients, and contaminants need to be met.
4. Scaling up the size of studies from small initial studies to commercial-scale field operations is difficult.
5. The real environment contains contaminants that are mixed, unevenly distributed, and in different phases (solid, liquid, gas). More research needs to be completed to create technologies that can adapt.

6. Compared to other treatment technologies, bioremediation often takes more time.
7. Problems with ensuring adequate contact between the microbes and the contaminant. Preferential pathway and soil structure can leave uncertainty in remediation dispersal.

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