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Bioremediation of industrial effluent by agro based mixed culture (ABMC)

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ABSTRACT

Industrial Effluents are mainly composed of suspended solids, high levels of organic pollutants, fats, oil and grease and are often being classified as 'high strength'. High strength effluents cannot be discharged into natural water bodies as they deplete the dissolved oxygen of the natural water body and thus render a potential threat to aquatic flora and fauna. Hence these industrial effluents must be treated before discharging, by effective methods. The conventional methods require the use of chemicals and are of high cost. Thus there is a need to develop new intensive biotechnological methods for the treatment of wastewater. A laboratory-scaled experiment was conducted to test the bioremediation potential of agro based mixed culture (ABMC) for industrial effluents. Different variables like temperature and concentration of ABMC (%v/v) were tested for 13 days of treatment. The results were compared with the wastewater sample without adding ABMC as control. The water quality parameters analyzed were pH, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). All parameters showed significant difference, improving the water quality, compared to the untreated sample. The study revealed that the ABMC could remove 75.46% BOD and 76% COD. The pH turned acidic due to the formation of acids as a result of decomposition of organic matter. This study indicated that ABMC has bioremediation potential of improving the water quality of industrial effluents. The biological treatment using ABMC is effective and the agricultural waste being cheap and easily available makes this method economical in practice.

KEYWORDS

Agro based mixed culture;
Bioremediation;
Industrial effluent.

The Agriculture Act 1947 defines "agriculture" as including:-"horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use is ancillary to the farming of the land for other agricultural purposes, and 'agriculture' shall be constructed accordingly."

To "bioremediate" means to use living things to solve the problem such as polluted soil or water. The microorganisms can degrade the pollutants present in the water or soil, and convert them into water and harmless gases such as carbon dioxide.

Bioremediation is defined as use of biological processes to degrade, breakdown, transform, and/or essentially remove contaminants or impairments of quality from soil and water.

Bioremediation is a very safe process because it relies on microorganisms which naturally occur in the environment. These microorganisms are helpful and pose no threat to the people at site or in the community.

No dangerous or harmful chemicals are used in the process of bioremediation.

In order for the microbes to do their work, the right temperature, nutrition and amount of oxygen must be present.

Bioremediation technology exploits various naturally occurring mitigation processes: natural attenuation, biostimulation, and bioaugmentation.

Bioremediation which occurs without human intervention other than monitoring is often called natural attenuation. This natural attenuation relies on natural conditions and behavior of soil microorganisms that are indigenous to soil.

Biostimulation also utilizes indigenous microbial populations to remediate contaminated soils. Biostimulation consists of adding nutrients and other substances to soil to catalyze natural attenuation processes.

Bioaugmentationinvolves introduction of exogenic microorganisms (sourced from outside the soil environment) capable of detoxifying a particular contaminant, sometimes employing genetically altered microorganisms.

All soil microorganisms require moisture for cell growth and function. Availability of water affects diffusion of water and soluble nutrients into and out of microorganism cells. However, excess moisture, such as in saturated soil, is undesirable because it reduces the amount of available oxygen for aerobic respiration. Anaerobic respiration, which produces less energy for microorganisms (than aerobic respiration) and slows the rate of biodegradation, becomes the predominant process.

Three primary ingredients for bioremediation are:

- Presence of a contaminant,
- An electron acceptor, and
- Presence of microorganisms that are capable of degrading the specific contaminant.

Generally, a contaminant is more easily and quickly degraded if it is a naturally occurring compound in the environment, or chemically similar to a naturally occurring compound, because microorganisms capable of its biodegradation are more likely to have evolved (State of Mississippi, Department of Environmental Quality, 1998). Petroleum hydrocarbons are naturally occurring chemicals; therefore, microorganisms which are capable of attenuating or degrading hydrocarbons exist in the environment. Development of biodegradation technologies of synthetic chemicals such DDT is dependent on outcomes of research that searches for natural or genetically improved strains of microorganisms to degrade such contaminants into less toxic forms.

Microorganisms have limits of tolerance for particular environmental conditions, as well as optimal conditions for pinnacle performance. Factors that affect success and rate of microbial biodegradation are nutrient availability, moisture content, pH, and temperature of the soil matrix. Inorganic nutrients including, but not limited to, nitrogen, and phosphorus are necessary for microbial activity and cell growth.

Temperature influences rate of biodegradation by controlling rate of enzymatic reactions within microorganisms. Generally, “speed of enzymatic reactions in the cell approximately doubles for each $10^{o}C$ rise in temperature”. There is an upper limit to the temperature that microorganisms can withstand. Most bacteria found in soil, including many bacteria that degrade petroleum hydrocarbons, are mesophiles which have an optimum temperature ranging from 25 ^{0}C to 45 ^{0} C. Thermophilic bacteria (those which survive and thrive at relatively high temperatures) which are normally found in hot springs and compost heaps exist indigenously in cool soil environments and can be activated to degrade hydrocarbons with an increase in temperature to 60 degree C. This finding “suggested an intrinsic potential for natural attenuation in cool soils through thermally enhanced bioremediation techniques”[5].

Bioremediation can be done either *In situ* or *Ex situ*

In situ bioremediation causes minimal disturbance to the environment at the contamination site. In addition, it incurs less cost than conventional soil remediation or removal and replacement treatments because there is no transport of contaminated materials for off-site treatment. However, *in situ* bioremediation has some limitations:

1. It is not suitable for all soils,
2. Complete degradation is difficult to achieve, and
3. Natural conditions (i.e. temperature) are hard to control for optimal biodegradation.

Ex situ bioremediation, in which contaminated soil is excavated and treated elsewhere, is an alternative.

Ex situ bioremediation approaches include use of bioreactors, landfarming, and biopiles. In the use of a bioreactor, contaminated soil is mixed with water and nutrients and the mixture is agitated by a mechanical bioreactor to stimulate action of microorganisms. This method is better-suited to clay soils than other methods and is generally a quick process[5].

The time taken for the bioremediation process depends on several factors:

- Types and amount of pollutant present.
- Size or area or quantity of polluted zone or water.
- Type of soil or water and conditions present. The conditions vary from site to site[3].

Advantages

- The need for trained personnel at local level allows for potential development of small to medium scale enterprises, which could aid in job creation in especially rural areas. The technology required to multiply micro-organisms may be ideally suited for small business development. In addition the technology developed will remain in the country and continent.
- The technology has a high potential for technology transfer
- Non-disturbance of the soil will insure soil integrity and fertility remains intact.
- The implementation of a bioremediation system will require labour, which can be provided through training of locals.
- The implementation of the system is likely to be more cost effective than incineration, especially where soil contamination is addressed.

Disadvantages

- The main disadvantage of implementation of bioremediation systems as a destruction technology lies in the longer time required for clean-up. The sites to be addressed are likely to contain a mixture of contaminants. A single micro-organisms system is not likely to degrade all the pollutants components. It will likely be necessary to isolate and culture stocks of micro-organisms for some pollutants. There is thus likely to be some development phase required prior to implementation.
- The implementation of such a project will require training of local personnel to enable them to apply all required aspects of the technology.
- Bioremediation requires a longer term monitoring action to be implemented through which the pollution status must be determined
- Some compounds may not be prone to microbial degradation and may require an additional chemical degradation step or bio-augmentation step.

Studies have shown that the utilization of microbiotic consortiums offers considerable advantages over the use of pure cultures in the degradation of pollutants.

It could be attributed to the synergistic interactions among members of the association.

Alexander (1999) mentioned that it is possible that one species removes the toxic metabolites, that otherwise may hinder microbial activities of the species preceding it. It is also possible that the second species are able to degrade compounds that the first are able to only partially.

Rambeleloarisoa *et al.* (1984) supported the theory that each member in a microbial community has a significant role and may need to depend on the presence of other species or strains to be able to survive.

Forgacs *et al.* (2004) found out that the individual strains of mixed cultures may attack the molecule of pollutants at different positions or may use decomposition products produced by another strain for further decomposition.

Microorganisms need nutrients for their growth. According to Carandang (2006), in creating bionutrients, the materials are fermented by adding molasses, making nutrient more available and easily broken as well as improving the population of microorganisms.

Most organisms that contaminate are harmless when ingested by humans but play a significant role in spoilage of the product. According to Brody (1979), microorganisms are natural and normal flora in or on fruits, and serve as reservoir to contaminate fruit products when they processed.

Concluding remarks

20% ABMC showed best results with all the three industrial effluents. In case of Sugar and Dairy industrial effluents, 60% and 100% ABMC concentrations also showed good reduction in COD values, but in case of textile no much reduction was seen with these two concentrations. Thus it can be said that 20% ABMC concentration is optimum for this method.

Due to the presence of large amount of biodegradable organic matter, the Sugar and Dairy effluents showed better reduction in COD values than that of Textile effluent.

Thus it can be concluded that this method can be used for various industrial effluents, and show best results with the effluents having biodegradable organic matter.

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