APPLICATION OF BIOREMEDIATION FOR INDUSTRIAL WASTEWATER TREATMENT

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Abstract

Many Indian cities are dependent on surface water from rivers, but the rivers are very much polluted in the downstream because of discharge of untreated waste water specially from industrial areas. Industrial pollution in the form of land and water is on rising trend. Treatment of effluents is costly by individual industries and common treatment systems do not specifically treat all the contaminants. There is a need of decentralization of industrial waste water treatment. Bioremediation is one such economic, eco-friendly and sustainable technique where environmental pollutant are degraded by naturally occurring biological organisms. This method is applicable for different industry effluents like petrochemical, textile, tannery etc. and many more. This paper briefly analyze effectiveness of bioremediation process to treat industrial waste water.

Keywords: wastewater; industry; bioremediation; microorganism

INTRODUCTION

Development of industries is common worldwide. Industries are source of major water pollution in the world. Pollutants produced in industries causes harm to nature and human. Developed countries forces industries to treat effluents to tertiary level but developing countries fail to do so. Surface and ground water gets contaminated due to polluted water. Treatment of waste water at sauce is costly but scientists are finding ways to deal with the treatment of pollutants in natural and cheaper way. This paper discusses about one such effort.

Waste Water

Water flows through a system and carries out impurities. The systems can be industrial, residential, commercial or agriculture. Waste water also includes the water from the systems like storm water, horticulture and aquaculture effluents. The liquid wastes that are discharged to a water body treated or untreated are called effluents. Sewage is also wastewater originating from toilets, bathrooms, kitchen and public toilets. Water from swimming pool, surface runoff, storm water are wastewater but not considered as sewage. Broadly wastewater can be categorized as municipal wastewater and industrial wastewater. This chapter is about industrial wastewater and its treatment.

Industrial Waste Water

Water is required in the manufacturing process in Industries such as cleaning of raw material, processing or cooling and transportation. Industrialwastewaters are generally contaminated because the water used flows through various chemicals and impurities. Processes like textilemanufacturing produces highly contaminated wastewater. The contamination of wastewater varies from industries to industries. Managing wastewater is important because it is ultimately going to get mixed with surface water.

Wastewater from industries is called effluent. To comply with the laws, certain ingredients must be removed from the waste water those are organic matter, inorganic matters like sodium, potassium, calcium, magnesium, copper, lead nickel and zinc, pathogens and nutrients. Removal of these may allow treated water to be released in the water bodies. These treated waters can also be reused in industrial plants.

There are two options of treatment of industrial wastewater. One is treating the waste water at the source or releases the waste water for treatment at the common effluent treatment plant. The first option is good but costly. Common effluent treatment plants collect wastewater from all the industries of an industrial area and collectively treat the effluent and release it to the water sources. This method is less efficient because various compositions of effluents reduce treatment efficiency.

POLLUTION OF WATER SOURCES

Ground water depletion

Unlike surface water ground water does not flow freely. Movement of ground water is three dimensional and complex. But ground water flows relatively slower than the surface water. Recharge of ground water happens through the surface runoffs and other surface water sources. When rate of ground water recharge is slower than its use it is called ground water depletion. In this case trees cannot reach the ground water level and die. Also people who depend on ground water wells find it difficult to sustain. Other problem with ground water depletion is the increase in pollution of water as salt water and other contaminated water can fill the gap and pollute fresh water underground sources.

Water pollution near polluting source

Toxic substances mix in water bodies due to negligence in waste water handling. Water for human use is ultimately extracted from these water bodies. Pollutants mixed in large water sources seep into the ground water and ultimately reach to household via household pumps. Water pollution can lead to diseases and destruction of crops. Water is essential for life and treatment of waste water is very important.

TREATMENT OF WASTE WATER

Waste water is treated in three stages. In primary stage the solid matters are separated. In this stage water is filled in a large tank and solid particles are allowed to settle. The settled solid matter are taken to the core and pumped out of the tank and separately processed. In secondary treatment some amount of speed sludge is added in the waste water. Speed sludge generally contains bacteria which speed up the process of decay of the wastewater. In the large aeration tank the waste water is mixed with air so that the process is faster. Bacteria eat up the remaining organic matters and they are separated from the water. Finally tertiary treatment can remove 99% of the impurities from the waste water. The process is similar as the treatment for drinking water but is costlier. Other than the processed treatment of waste water it can also be treated through a natural process called bioremediation.

BIOREMIDIATION

Bioremediationis a waste management technique that uses living microbes to degrade or detoxify the environmental contaminants into less hazardous or nonhazardous forms. It uses natural bacteria and fungi or plants to degrade substances toxic to human health and/or the environment [2]. For example, catalase enzyme producing bacteria can detoxify Reactive Oxygen Species hydrogen peroxide into water and oxygen in textile effluents. Bioremediation being an easy, quick, eco-friendly method, is a socially acceptable approach. As environment friendly and cost saving features are amongst the major advantages of bioremediation compared to both chemical and physical methods of remediation. Bioremediation can be a good option of remedy to those damages. By the action of cultured microorganisms there is hope to save ecosystem [17].

Bioremediation seems to be a good alternative to conventional clean-up technologies. Well developed country like United States is rapidly adapting this method as a tool for cleaning pollutants most rapidly developingfields of environmental restoration, utilizing microorganisms [18].

Brief History of Bioremediation

Bioremediation is an old technology developed around 600BC by Romans. The process used by the Romans was not as developed as it is today. Bioremediation was officially invented by George Robinson in the year 1960. The scientist experimented about bioremediation inside polluted glass jar. The microbes where finally tested in real life situation in the year 1972. Biological sewage treatment plant was already created in Sussex, U.K in the year 1891 however the word bioremediation appeared first in peer reviewed journal in 1987. Improvement in the research has led to understanding of individual microbes and their characteristics. Microbes have capacity to breakdown complex compounds in to simple forms and help to decompose them. Still research is needed to deal with varieties of effluents [11].

Types of Bioremediation

Broadly there are two types of bioremediation practiced for removal of contaminants from soil or water. In situ bioremediation as the term suggest the microbial agents responsible for bioremediations are spread or implanted and grown on the contaminated site. In situ bioremediation help to remove hydrocarbon, chlorinated compounds, nitrates, toxic metals and other pollutants through series of natural reactions. Ex situ bioremediation process involves removal of contaminants from the site and treating the same in a bioreactor where in controlled environment the contaminants are treated through the specific amount of microbes and catalysts. Both the processes have advantages and disadvantages.

Advantages and Disadvantages of Bioremediation

Advantages	**Disadvantages**
1) Bioremediation is a natural process.	1) Bioremediation is a slow process and months of time are required for treatment of contaminants.
2) Bioremediation is cost effective because microbes act on effluents on their own without any supervision	2) Heavy metals are not removed through bioremediation.
3) Chemicals in the effluents are separated destroyed and removed from environment.	3) For in-situ bioremediation site must have soil with high permeability.
4) Capital expenditure for bioremediation is low.	4) It does not remove all quantities of contaminants.
5) If compared to other technologies bioremediation requires very less energy.	5) There is a gap in understanding of microbes and their characteristics in treatment of effluent.
6) Supervision is not required in bioremediation	

APPLICATION OF BIOREMEDIATION

Electroplating, Tannery, Paint, Petroleum and Dyeing Industry

As per regulatory agencies like United States Environmental Protection Agency (USEPA), there are lots of industries that extensively used chromium or its compounds in industrial processes. As a result, they discharge chromium containing wastes intothe environment on a regular basis. [5]. Those industries include electroplating, tannery, paint, petroleum and dyeing industry [13, 15]. Chromium is highly toxic as they are carcinogenic and mutagenic [19, 9]. They can exist in different valence states, among them hexavalent chromium is most harmful as they are able to damage living cells [10] through its strong oxidizing potential. Reduction of Cr(VI) to Cr(III) not only leads to detoxification to less hazardous form, also, solubility of trivalent chromium is very less than the hexavalent one, which is also a great advantage[8]. Microbial detoxification of Cr(VI) are economical, safe, and sustainable method. There are many bacterial species which are having chromate reductase activity, where the enzyme converts the highly toxic hexavalent chromium to less toxic trivalent.This is a good example of metal bioremediation.

So, utilization of diverse chromate reductase bacterial species in bioremediation of chromium is a good alternative to the conventional methods. In the late 1970s, Romanenko and Koren'Kov first time observed Cr(VI) reduction capability in *Pseudomonas dechromaticans*.

A variety of Cr-resistant bacteria with high Cr(VI)-reducing potentialare of genera *Bacillus, Enterobacter, Agrobacterium, Escherichia, Deinococcus, Shewanella* etc.Other example includes*Ochrobactrum* sp. isolated from chromium landfill [6, 8] also *Microbacterium* sp. *Bacillus thuringiensis* and *Bacillus subtilis* isolated from tannery effluent irrigated soil [9].

Chemical, Textile, Coal and Petroleum Industries

Phenol are manufactured and used in many industrial activities. Phenol and products made from phenol are major organic pollutants such as coal conversion, petroleum refining, wood preservation, petroleum refining and textile dying [12].

These industries produce wastewaters that consist of the phenol & phenolic derivatives. Tyrosinaseenzyme can oxidize the phenols into insoluble substances that can be eliminated by precipitating or filtering. Sources of tyrosinase enzyme include*Agaricusbisporus, Rhizobium, Pseudomonas putida, Bacillus thuringiensis,Lysinibacillus* sp.,*Lentinulaboryana*etc [14] [7].

Azo dyes are harmful for environment. Azo dyes are byproduct of leather, textile, paper and pharma industries. In some condition azo dyes are decolorized by bacteria and further degraded by tyrosinase [3] [16].

Horseradish peroxidase from Horseradish (*Armoraciarusticana)* has great role. It can degrade phenolic compounds in effluent of textile & chemical, oil, gas & coal industries, wood & construction etc. Also in some insecticide and pesticide.

A waste product of the starch industry is potato pulp which contains a lot of peroxidases. It's a good tool to clean phenolic contaminants. Under optimal condition, this enzyme can work with 90% efficiency.

Petrochemical Industry

Hydrocarbon compounds are carcinogens and neurotoxic. Organic pollutants from petrochemical industry are extremely dangerous to living tissue, may cause death or mutations. Releasing petroleum based products in the environment whether accidently or intentionally, was estimated to be 600,000 metric tons per year. Mechanical and chemical methods generally employed to remove hydrocarbons from contaminated sites, but have limitation in effectiveness and can be expensive process. Bioremediation is good technology for treatment of these contaminated sites also cost-effective natural process. Microorganism and fungi belonged to genera *Amorphoteca*, *Neosartorya*, *Graphium*, *Talaromyces*, , *Candida*, *Yarrowia*, *Pichia*, *Aspergillus*, *Cephalosporium*, *and Pencillium*, some of them were isolated from petroleum-contaminated soil, some from contaminated water, but all of them proved themselves as good candidate for hydrocarbon compound degradation [4].

Several bacteria are known to feed exclusively on hydrocarbons, Bacterial strains named *Aeromicrobium*, *Brevibacterium*, *Burkholderia*, *Dietzia*, *Gordonia*, and *Mycobacterium*, *Acinetobacter*sp., *Sphingomonas*, *Arthrobacter*, *Pseudomonas*, *Rhodococcus*, *Bacillus* sp.,*Corynebacterium* sp., *Flavobacterium sp.*, an alga *Protothecazopfi*, proved to be the potential organisms for hydrocarbon degradation [4].

CASE STUDY: BIOREMEDIATION OF OILY WASTE WATER FROM REFINERIES IN INDIA

Crude oil from various regions in world is transported to countries and region. Further the crude oil is refined to make it usable. The process is carried out in refineries. During the process a lot of wastewater is released from the process and it contains effluents with lots of oil in it. The effluents are released in the environment after taking preventive care. One of the effective ways to treat wastewater from the refineries is bioremediation. Bioremediation is most environment friendly method for treatment of oil generated from various petroleum industries. Bioremediation is also cost effective.

TERI, India, has treated 48,914 tons of waste oily sludge in batches at various oil refineries in India. The bio remediated soli was showing positive sign of recovery and contamination reduced. Use of microorganism to treat oily waste in batches took 2 to 12 months' time. Longest time taken by one refinery that is 20 months was due to heavy and continuous rain slowing down the bioremediation process [1].

CONCLUSION

Industrial pollution in the form of land and water is on rising trend. Treatment of effluents is costly by individual industries and common treatment systems do not specifically treat all the contaminants. In these cases bioremediation can be useful. Bioremediation is a natural occurring phenomenon which can be used for the treatment of waste and hazardous material released as effluents from industries. There are two forms of bioremediation, ex situ and in situ. Application of bioremediation in treatment of wastewater from petrochemicals, textile, dying industries etc. is under research. As the understanding of microbes and their characteristics will be developed then bioremediation can be processed in controlled environment and will be easily applicable for all types of industrial effluents.

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