MICROORGANISMS ROLE IN BIOREMEDIATION

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ABSTRACT

Bioremediation is a biological mechanism that recycles waste that can be reused and reused by other organisms. Nowadays, the world is facing the problem of different environmental pollution. Microbes are essential to an important alternative solution to overcoming challenges. Microbes live everywhere in the biosphere because their metabolic function is astonishing; Environmental conditions are present in all. The nutritional potential of microorganisms is completely different, so it is used as a biofilm of environmental pollutants. Bioremediation is highly involved in the decomposition, elimination, immobilization or toxicity of various chemical wastes and physically hazardous substances from the surrounding all-encompassing and functional microorganisms. The main policy is to degrade and replace pollutants such as hydrocarbons, oil, heavy metal, pesticides, and dyes. It is carried out in an enzymatic way by metabolism, so it has a role to play in solving many environmental problems. There are two types of factors that determine the rate of deterioration of biological and agiotic conditions. Currently, different methods and techniques are used in different parts of the world. For example, biostimulation, bioaccumulation, bioventilation, biopiles and bioautenuation are common. All biological techniques have their own advantages and disadvantages because it has its own specific application.

INTRODUCTION

The ability to metabolize is so interesting that microorganisms are widely distributed in biology and they can easily grow in a wide range of environmental conditions. The nutrient diversity of microorganisms can also be applied to the biodegradability of pollutants. This type of process is called bioremediation It continues to be based on the ability of certain microorganisms to modify, modify, and use toxic pollutants in order to obtain energy and biological production in the process [1]. Instead of simply collecting and storing the contaminant, biology is a microbiologically well-organized process that minimizes contaminants or Used to break down or transform into non-toxic base and compound forms. Bioremediators are biological agents used for bioremediation to clean contaminated sites. Bacteria, archaea and fungi are the usual major biologists [2].

The use of bioremediation as a biotechnological process involving microorganisms to solve and eliminate the hazards of many pollutants through biodegradation from the environment. Biology and biodegradable terms are interchangeable terms. Microbes act as significant pollutants in soil, water and sediment; Often due to their advantage over other solution practical protocols. Microbes restore the original natural environment and prevent further pollution [3]. The purpose of the review is to reveal the current trend, the use / role of microorganisms on biology and to provide an appropriate background to identify gaps within this thematic area. Currently, this is a hot topic of research because microbes are a valuable genetic material to solve eco-friendly and environmental threats.

FACTORS AFFECTING MICROBIAL BIOREMEDIATION

Bioremediation involves the decontamination, removal, modification, sterilization or detoxification of various chemicals and body wastes from the environment through the action of bacteria, fungi and plants. Microbes act as biochemists through their enzymatic pathways and facilitate the development of biochemical reactions that reduce the desired pollution. Microbes work against pollutants, which only when they have access to compounds of various substances that they help to produce energy and nutrients to make more cells. The effectiveness of biology depends on many factors; Including the chemical nature and concentration of pollutants, the physicochemical properties of the environment and their availability to microorganisms [4]. The reason for the rate of degradation is that the bacteria are infected and the contaminants do not interact with each other. Apart from these, microorganisms and pollutants do not spread evenly in the environment. Controlling and improving biosynthesis processes is a complex system for many factors. These factors are included here: the presence of a microbial population capable of degrading pollutants, the availability of contaminants to microbial populations and environmental factors (soil type, temperature, pH, oxygen or other electron receptors and nutrients).

BIOLOGICAL FACTORS

A biological factor influences the degradation of organic compounds through microbial competition for limited carbon sources, conflicting interactions between microorganisms, or the predation of microorganisms by protozoa and bacteriophages. The rate of contaminant degradation largely depends on the concentration of the contaminant and the level of the "catalyst". In this context, the amount of "catalyst" indicates the number of organisms that can metabolize the contaminant and the amount of enzymes produced by each cell. Exposure to specific enzymes by cells can increase or decrease the rate of contaminant degradation. Furthermore, specific enzymes involved in polluting metabolism must participate and their “contact” with the contaminant and availability of the contaminant are often required. Key biological factors are included here: mutation, horizontal gene transfer, enzyme activity, interaction (competition, succession and hunting), its own growth until it reaches vital biomass, population size and composition [5,6].

ENVIRONMENTAL FACTORS

The metabolic properties of microorganisms and the physicochemical properties of target contaminants determine potential interactions during operation. A truly successful relationship between the two; However, the contact depends on the environmental conditions of the site. PH, temperature, humidity, soil structure, water solubility, nutrients, site properties, redox capacity and oxygen content, lack of trained human resources in this field and physico-chemical bioavailability of contaminants (contaminant concentration, type, solubility, chemical composition and toxicity) . These factors listed above determine the dynamics of degradation [5,7]. Biodegradability can occur under a wide range of pH; However, a pH of 6.5 to 8.5 is generally optimal for biodegradation in most aquatic and terrestrial systems. Moisture affects the rate of pollutant metabolism because it affects the type and quantity of soluble substances available and the osmotic pressure and pH of the terrain and aquatic systems [8]. Most environmental factors are listed below.

AVAILABILTY OF NUTRIENTS

Addition of nutrients adjusts the essential nutrient balance for microbial growth and reproduction, as well as influencing the rate and efficiency of biodegradation. Nutrient balance can improve biodegradable performance by improving the C: N: B ratio, especially by providing essential nutrients such as N and P. Microbes need many nutrients such as carbon, nitrogen and phosphorus to continue and maintain their microbial functions. It also controls the amount of hydrocarbon decay at small concentrations. Adding the appropriate amount of nutrients is a favorable strategy to increase the metabolic activity of microorganisms, thus increasing the rate of decomposition in cold environments [9,10]. Biodegradability in the aquatic environment is defined by the availability of nutrients [11]. Just like the nutritional needs of other organisms, oil-eating microorganisms need nutrients for optimal growth and development. These nutrients are available in the natural environment, but occur in small quantities [12].

TEMPERATURE

Temperature is one of the most important factors in determining the survival of microorganisms and the composition of hydrocarbons [13]. In colder climates such as the Arctic, oil decomposition through natural processes is much slower and microbes can be used to clean up spilled petroleum. Subject to high pressure. The sub-zero temperature of the water in this region causes the transport pathways within the microenvironment to close or freeze the entire cytoplasm, making most oleophilic microorganisms inactive [12,14]. Biological enzymes participate in the degradation path at an optimal temperature and there will not be the same metabolic return at each temperature. Furthermore, the degradation process for a particular compound requires a specific temperature. Temperature accelerates or slows down the biological process because it greatly affects the physiological properties of microorganisms. The rate of microbial activity increases with temperature and reaches its maximum at optimum temperature. The temperature rises or falls further and then drops abruptly, eventually stopping after reaching a certain temperature.

CONCENTRATION OF OXYGEN

Different organisms need oxygen, while others do not need oxygen based on their need, which facilitates the decomposition rate in the best possible way. Biological decomposition is carried out in an aerobic and anaerobic state because oxygen is a gas that most organisms need. In most cases the presence of oxygen can improve hydrocarbon metabolism [12].

MOISTURE CONTENT

Microbes need enough water to complete their growth. Soil moisture has a detrimental effect on biodegradable agents

PH

The composition of the pH is acidic, basic and alkaline, which has its own influence on the microbial metabolic process and enhances and slows down the elimination process. Measurement of soil pH indicates the potential for microbial growth [15]. High or low pH values showed poor results; Metabolic processes are susceptible to even small changes in pH [16].

SITE CHARACTERIZATION AND SELECTION

Adequate solution testing tasks should be performed before proposing a biological solution to adequately classify the amount and level of contaminants. This task should include at least the following factors: Complete determination of horizontal and vertical levels of pollution, modeling of parameters and locations and list the rationale for their selection and describe the methods to be used for sample acquisition and analysis.

METAL IONS

Metals are important to bacteria and fungi in small amounts, but in large quantities inhibit the metabolic activity of cells. Metal alloys have a direct and indirect impact on the rate of degradation.

TOXIC COMPOUNDS

When the toxicity of certain contaminants is high, it can produce toxic effects on microorganisms and slow down decontamination. The extent and mechanisms of toxicity vary with specific toxins, their concentration and exposure to microorganisms. Some organic and inorganic compounds are toxic to targeted lifestyles [5].

PRINCIPLE OF BIOREMEDIATION

Biochemistry is defined as the process by which organic wastes under controlled conditions are biologically degraded to a biologically harmless state or below concentration concentrations established by regulatory authorities. Microbes are best suited for the task of decontamination

because they contain enzymes that allow them to use environmental contaminants as food. The purpose of biosynthesis is to encourage them to work by providing optimal amounts of nutrients and other chemicals needed for their metabolism in order to degrade / poison substances that are harmful to the environment and organisms.
All metabolic reactions are mediated by enzymes. These belong to the group of oxidorectases, hydrolases, lysates, transplants, isomerases and ligases. Many enzymes have significant degradation potential due to their specific and specific substrate relationship. For biology to be effective, microorganisms must ferment pollutants and turn them into harmless substances. Because biology is only effective where environmental conditions allow for microbial growth and function, its application often involves dealing with environmental parameters, allowing microbial growth and degradation to proceed at a rapid rate [17].

Biology occurs naturally and is promoted in addition to organisms and fertilizers. Biotechnology technology is mainly based on biodegradability. It refers to the complete removal of organic toxins from harmful or naturally occurring compounds, such as carbon dioxide, water, and minerals that are safe for human, animal, plant, and aquatic life [18]. Several mechanisms and pathways to the biodegradability of various organic compounds have been clarified; For example, it is completed in the presence and absence of oxygen.

THE ADVANTAGE OF BIOREMEDIATION

It is a natural process, an acceptable waste treatment process for contaminants such as soil, which takes some time. Microbes that can reduce contamination and increase numbers when contaminated. As pollution increases, the biodegradable population declines. The residue of the treatment is usually a harmless product including water carbon dioxide and cell bio.

This requires very little effort and can often be carried out on site without causing major disruption to normal operations. This eliminates the amount of waste leaving the site and poses a threat to human health and the environment during transportation.

It is used in less costly operation as it has less loss than other conventional methods (technologies) used to clean hazardous waste. An important method of treating oil-contaminated sites [19].

It helps to completely eliminate contaminants, many hazardous compounds can be converted into harmless products, and this feature also eliminates the possibility of future liability related to treatment and removal of contaminants.

It does not use any hazardous chemicals. Nutrients especially fertilizers add active and fast microbial growth. Commonly used in meadows and gardens. Harmful chemicals are completely destroyed as biochemistry converts harmful chemicals into water and harmless gases [20].

Natural is simpler, less labor intensive and cheaper due to its natural role in the environment. Eco-friendly and sustainable [21].
Environmental pollutants are destroyed and they are not transferred to different environmental media.
It allows continuous, continuous use of the site.
Implementation Implementation is relatively easy [17].
Natural Pollution is the best way to fix the natural ecosystem from a number and acts as eco-friendly options [22].

THE DISADVANTAGE OF BIOREMEDIATION

It is limited to those compounds that are biodegradable. Not all compounds undergo rapid and complete degradation.

There are some concerns that biodegradable products may be more persistent or toxic than biodegradable compounds.

Biological processes are often very specific. Microbial populations with metabolic potential, appropriate environmental growth conditions and appropriate amounts of nutrients and contaminants are essential site factors for success.
It is difficult to expand from bench and pilot scale surveys to full scale field operations.
Research is needed to develop and engineering biotechnology technologies suitable for sites with complex compounds of pollutants that are not evenly dispersed in the environment.
Contaminants can be solids, liquids and gases.

This often takes longer than other treatments, i.e. excavation and soil removal or incineration.
There is regulatory uncertainty regarding acceptable performance criteria for biodegradation.
There is no accepted definition of “pure” and it is difficult to assess biological efficacy.

MICROORGANISMS AND POLLUTENTS (TABLES 1-5)

Table 1: Microorganisms and Hydrocarbon (organic compound) interaction.

Microorganisms	Compound	Reference
Penicillium chrysogenum	Monocyclic aromatic hydro carbons, benzene, toluene, ethyl benzene and xylene ,phenol compounds	[23,24]
P. alcaligenes P. mendocina and P. putida P. veronii, Achromobacter, Flavobacterium, Acinetobacter	Petrol and diesel polycyclic aromatic hydrocarbons toluene	[25,26]
Pseudomonas putida	Monocyclic aromatic hydrocarbons, e.g. benzene and xylene.	[25,27]
Phanerochaete chrysosporium	Biphenyl and triphenylmethane	[28]
A. niger, A. fumigatus, F. solani and P. funiculosum	Hydrocarbon	[29]
Coprinellus radians	PAHs, methylnaphthalenes, and dibenzofurans	[30]
Alcaligenes odorans, Bacillus subtilis, Corynebacterium propinquum, Pseudomonas aeruginosa	phenol	[22]
Tyromyces palustris, Gloeophyllum trabeum, Trametes versicolor	hydrocarbons	[31]
Candida viswanathii	Phenanthrene, benzopyrene	[32]
cyanobacteria, green algae and diatoms and Bacillus licheniformis	naphtalene	[33,34]

Acinetobacter sp., Pseudomonas sp., Ralstonia sp. and Microbacterium sp,	aromatic hydrocarbons	[35]
Gleophyllum striatum	striatum Pyrene, anthracene, 9- metil anthracene, Dibenzothiophene Lignin peroxidasse	[36]
Acinetobacter sp., Pseudomonas sp., Ralstonia sp. and Microbacterium sp,	aromatic hydrocarbons	[35]
Gleophyllum striatum	striatum Pyrene, anthracene, 9- metil anthracene, Dibenzothiophene Lignin peroxidasse	[36]
Acinetobacter sp., Pseudomonas sp., Ralstonia sp. and Microbacterium sp,	aromatic hydrocarbons	[35]
Gleophyllum striatum	striatum Pyrene, anthracene, 9- metil anthracene, Dibenzothiophene Lignin peroxidasse	[36]

Table 2: Groups of microorganisms important for oil bioremediation.

Microorganisms	Compound	Reference
*Fusarium*sp.	oil	[37]
Alcaligenes odorans, Bacillus subtilis, Corynebacterium propinquum, Pseudomonas aeruginosa	oil	[22]
Bacillus cereus A	diesel oil	[38]
Aspergillus niger, Candida glabrata, Candida krusei and Saccharomyces cerevisiae	crude oil	[39]

B. brevis, P. aeruginosa KH6, B. licheniformis and *B. sphaericus*	crude oil	[40]
Pseudomonas aeruginosa, P. putida, Arthobacter sp and Bacillus sp	diesel oil	[41]
Pseudomonas cepacia, Bacillus cereus, Bacillus coagulans, Citrobacter koseri and Serratia ficaria	diesel oil, crude oil	[42]

Table 3: Representative examples of most dominate microorganisms in the involvement of dyes bioremadation.

Microorganisms	Compound	Reference
B. subtilis strain NAP1, NAP2, NAP4	oil-based based paints	[43]
Myrothecium roridum IM 6482	industrial dyes	[44-46]
Pycnoporus sanguineous, Phanerochaete chrysosporium and Trametes trogii	industrial dyes	[47]
Penicillium ochrochloron	industrial dyes	[48]
Micrococcus luteus, Listeria denitrificans and Nocardia atlantica	Textile Azo Dyes	[49]
Bacillus spp. ETL-2012, *Pseudomonas aeruginosa, Bacillus pumilus* HKG212	Textile Dye (Remazol Black B), Sulfonated di-azo dye Reactive Red HE8B, RNB dye	[50-52]
Exiguobacterium indicum, Exiguobacterium aurantiacums, Bacillus cereus and Acinetobacter baumanii	azo dyes effluents	[88]
Bacillus firmus, Bacillus macerans, Staphylococcus aureus and Klebsiella oxytoca	vat dyes, Textile effluents	[53]

Table 4: Microorganisms serve for utilizing heavy metals.

Microorganisms	Compound	Reference
Saccharomyces cerevisiae	Heavy metals, lead, mercury and nickel	[55-57]

Cunninghamella elegans	Heavy metals	[58]
*Pseudomonas fluorescens*and *Pseudomonas aeruginosa*	Fe 2+, Zn2+, Pb2+, Mn2+ and Cu2	[59]
*Lysinibacillus sphaericus*CBAM5	cobalt, copper, chromium and lead	[60]
Microbacterium profundi strain Shh49T	Fe	[61]
Aspergillus versicolor, A. fumigatus, Paecilomyces sp., *Paecilomyces* sp., *Terichoderma* sp., *Microsporum* sp., *Cladosporium* sp.	cadmium	[62]
Geobacter spp.	Fe (III), U (VI)	[63]
Bacillus safensis (JX126862) strain (PB-5 and RSA-4)	Cadmium	[64]
Pseudomonas aeruginosa, *Aeromonas* sp.	U, Cu, Ni, Cr	[65]
*Aerococcus*sp., *Rhodopseudomonas palustris*	Pb, Cr, Cd	[66,67]

Table 5: Potential biological agents for pesticides.

Microorganisms	Compound	Reference
Bacillus, Staphylococcus	Endosulfan	[68]
Enterobacter	Chlorpyrifos	[69]
Pseudomonas putida, Acinetobacter sp., Arthrobacter sp.	Ridomil MZ 68 MG, Fitoraz WP 76, Decis 2.5 EC, malation	[70,71]
Acenetobactor sp., Pseudomonas sp., Enterobacter sp. and Photobacterium sp.	chlorpyrifos and methyl parathion	[72]

Heavy metals are not biodegradable ("no degradation", changes occur in the atomic structure of the element), but are only transferred from one oxidation state or organic compound to another. Besides, bacteria are capable of biodegrading heavy metals. Microbes have developed the ability to protect themselves from heavy metal toxicity by various means such as absorption, uptake, methylation, oxidation and reduction. Microbes take heavy metals actively (bioaccumulation) and / or passively (absorption). Microbial methylation plays an important role in the biosynthesis of heavy metals because methylated compounds are often volatile. For example, Mercury, HG (II) et al Alkalogenes faecalis, Bacillus pumilus, Bacillus sp., B. Aeruginosa and previbacterium iodine can be biodegraded with mercury [54] from the first gas.

TYPES OF BIOREMIDIATION

There are different types of treatment techniques or techniques under biological processes. Basic biochemical methods: stimulation, awareness, multiplication, venting and piles.

BIOSTIMULATION

This type of strategy is incorporated by injecting specific nutrients into the site (soil / groundwater) to stimulate the activity of native microorganisms. It is a native or naturally occurring bacterium And focuses on the stimulation of the fungal community. First, by finding fertilizers, growth supplements and minerals. Second, by providing other environmental requirements such as pH, temperature, and oxygen to accelerate their metabolic rate and pathway [7,17].

The presence of small amounts of contaminants can act as a catalyst by activating opioids for biological enzymes. This type of strategic pathway often continues with the addition of nutrients and oxygen to help native microorganisms. The presence of small amounts of contaminants can act as a catalyst for the activation of opioids into biological enzymes. This type of strategic path is often followed by the addition of nutrients and oxygen to help the native microbes. These nutrients allow the basic building blocks and microorganisms of life to create the basic need, for example, energy, cell biology and enzymes to reduce pollution. They all require nitrogen, phosphorus and carbon [5].

BIOATTENUATION (NATURAL ATTENUATION)

Bioautenization or natural awareness is the destruction of surrounding pollutant concentrations. It is carried out in biological processes (aerobic and anaerobic compost, plant and animal growth), physical events (Adsorption, dispersion, dilution, diffusion, evaporation, suction / disorption) and chemical reactions (ion exchange, complex, azotic transformation). Terms such as intrinsic solution or biotransformation are included within the most common definition of natural awareness [73].

When polluted by environmental chemicals, nature can act in four ways to clean [74]: 1) Small bugs or microorganisms that live in soil and groundwater use certain chemicals for food. When they fully digest the chemicals, they can be converted into water and harmless gases.

2) Chemicals can stick or crumble in the soil and keep them in place. It does not clean the chemicals, but it does prevent groundwater contamination and leaving the site. 3) As the contaminant moves through the soil and groundwater, it can mix with clean water. It reduces or dilutes the pollution. 4) Some chemicals such as oil and solvents can evaporate, They change from liquids to gases in the soil. If these gases escape into the air at the ground surface, sunlight can destroy them. If natural awareness is inadequate or inadequate, bioremediation can be enhanced by biostimulation or bioaccumulation.

BIOAUGMENTATION

It is one of the mechanisms of biodegradation. These processes are called biochemistry, the addition of polluting degraded microorganisms (natural / foreign / engineering) to increase the biodegradability of the native microbial population in the contaminated area. To rapidly increase the population growth of natural microorganisms and to improve the priority degradation at the site of contaminants. Microbes are collected from the site of treatment, cultured individually, genetically modified and returned to the site. Believe it or not, all essential microorganisms are found in areas where soil and groundwater are polluted by chlorinated ethyns such as tetrachloroethylene and trichlorethylene. It is used to ensure that in situ microorganisms completely remove these contaminants into non-toxic ethylene and chloride [75].

Bioaccumulation is the process of adding embedded microorganisms into a system that acts as aphoridometers to quickly and completely remove complex contaminants. Furthermore, genetically modified microorganisms show and demonstrate that they can enhance the degradation efficiency of a wide range of environmental pollutants. Because it has a different metabolic profile to be converted into less complex and harmless end products [76-78]. Natural species are not strong enough to break down some compounds, so genetic modification must be done by DNA manipulation; Genetically engineered microorganisms break down pollutants much faster than natural organisms and are highly competitive with native species, predators and various agiotic factors. Genetically engineered microorganisms have demonstrated the potential for biosynthesis of soil, groundwater, and activated sludge, revealing enhanced degradation capabilities of a wide range of chemical and physical pollutants [79,80].

GENETICALLY ENGINEERED MICROORGANISMS (GEMs)

Genetically engineered microorganisms are microorganisms whose genetic material has already been altered, either by natural or synthetic genetic transfer between microorganisms. By using inspired genetic engineering techniques. This kind of artwork and a scientific practice is mainly called restorative DNA technology. Genetic engineering has improved the use and disposal of hazardous waste under laboratory conditions by creating genetically modified organisms [81]. Regenerative organisms that can be regenerated by DNA techniques or by natural genetic material transfer between organisms. A gene suitable for the production of a specific enzyme that can mutate various enzymes can now be inserted [82].

Genetically engineered microorganisms (GEMs) have demonstrated potential for biological applications in soil, groundwater and activated sludge environments, and exhibit enhanced degradation capabilities involving a wide range of chemical contaminants. Recently, there are many opportunities to improve degraded performance using genetic engineering techniques. For example, rate-controlling steps in known metabolic pathways can be manipulated genetically to produce increased degradation rates, or completely new metabolic pathways can be linked to bacterial strains for the degradation of previously remodeled compounds. Four functions / strategies to be performed in GEMs: (1) Enzyme specification and relationship modification,(2) The essential genes of bacteria are carried on a chromosome, but the genes that represent the enzymes needed for the catabolism of some of these abnormal substrates can be carried in plasmids. Plasmids are subject to catabolism. Therefore, GEMs can be used effectively for biodegradable purposes and lead to represent / mark a research frontier with broad implications in the future [83].

Advantages of GEMs in biosynthesis: Accelerate the recovery of waste contaminated sites, increase subatomic degradation of the substrate, exhibit high catalyst or utilization capacity with small cell mass, Great safe and purified environment by purifying or neutralizing any harmful substances.

Deficiency of GEMs in biosynthesis: Conventional practice never causes major defects, in some cases cell death occurs, there is a challenge associated with their release, growth and subatomic degradation at a certain level, seasonal variation and other aziotic factor fluctuations have a direct and indirect impact on microbial function ; Finally, foreign modified strain is not introduced into the system and has an immeasurable adverse effect on the social structure and occurrence of natural structural and functional microorganisms.

BIOVENTING

Expelling oxygen through the soil to stimulate the growth of natural or introduced bacteria and fungi in the soil by providing oxygen to existing soil microorganisms Biovending is involved; In fact, it acts on aerobically degradable compounds. Biovending uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is usually supplied by direct air injection to residues in the soil through wells.Injected fuel residues are biodegradable, and volatile compounds are biodegradable as the volatiles move slowly through the biologically active soil. The effective biology of petroleum contaminated soil using bioventilation has been demonstrated by several researchers [84,85]

BIOPILES

Biophiles are a form of excavated soil contaminated with excavable hydrocarbons that can be treated in “biopiles”. Biophiles (also known as biocells, biohypes, biomounds and compost piles) are used to reduce the concentration of petroleum pollutants in the soil excavated during bioremediation. In this process, air is supplied to the biofilm system during piping and pumps, which force air into the pile under positive pressure or attract air through the pile under negative pressure [86]. Microbial activity is enhanced by microbial respiration, followed by increased degradation of adsorbent petroleum pollution [87].

CONCLUSION

Biodegradability is the most effective and attractive option for repairing, cleaning, managing and restoring the technique of resolving the polluted environment by microbial activity. The rate of decomposition of unwanted wastes is determined by their ability to compete with biological agents, essential nutrients, adequate external aerodynamic conditions (ventilation, humidity, pH, temperature) and low bioavailability of the pollutant. Due to these factors, biodegradability in the natural state is not very successful, which is less favorable. Biology is only effective where environmental conditions allow microbial growth and function. Bioremediation is used within different levels of success worldwide within different levels of success.

Importantly, the advantages outweigh the disadvantages, which is evident from the number of sites that choose to use this technology and its growing popularity over time. In general, different species are explored from different sites and are useful in the control mechanism.

REFERENCES

1. Tang CY, Criddle CS, Leckie JO (2007) Effect of flux (trans membrane pressure) and membranes properties on fouling and rejection of reverse osmosis and nano filtration membranes treating perfluorooctane sulfonate containing waste water.Environ Sci Technol 41: 2008-2014.
2. Strong PJ, Burgess JE (2008) Treatment methods for wine-related ad distillery wastewaters: a review. Bioremediation Journal12: 70-87.
3. Demnerova K, Mackova M, Spevakova, V, Beranova K, Kochankova L, et al. (2005) Two approaches to biological decontamination of groundwater and soil polluted by aromatics characterization of microbial populations. International Microbiology 8: 205-211.
4. El Fantroussi S, Agathos SN (2005) Is bioaugmentation a feasible strategy for pollutant removal and site remediation? Current Opinion in Microbiology 8: 268-275. Link:
5. Madhavi GN, Mohini DD (2012) Review paper on – Parameters affecting bioremediation. International journal of life science and pharma research 2: 77-80. Link:
6. Boopathy R (2000) Factors limiting bioremediation technologies. Bioresource Technology 74: 63-67.
7. Adams GO, Fufeyin PT, Okoro SE, Ehinomen I (2015) Bioremediation, Biostimulation and Bioaugmention: A Review**.** International Journal of Environmental Bioremediation & Biodegradation3: 28-39.
8. Cases I, de Lorenzo V (2005) Genetically modified organisms for the environment: stories of success and failure and what we have learned from them. International microbiology 8: 213-222.
9. Couto N, Fritt-Rasmussen J, Jensen PE, Højrup M, Rodrigo AP, et al. (2014) Suitability of oil bioremediation in an Artic soil using surplus heating from an incineration facility. Environmental Science and Pollution Research 21: 6221-6227.
10. Phulia V, Jamwal A, Saxena N, Chadha NK, Muralidhar, et al. (2013) Technologies in aquatic bioremediation. 65-91.
11. Thavasi R, Jayalakshmi S, Banat I M (2011) Application of biosurfactant produced from peanut oil cake by *Lactobacillus delbrueckii*in biodegradation of crude oil. Bioresour Technol 102: 3366–3372.

12. Macaulay BM (2014) Understanding the behavior of oil-degrading micro-organisms to enhance the microbial remediation of spilled petroleum. Appl Ecol Environ Res 13: 247–262.
13. Das N, Chandran P (2011) Microbial degradation of petroleum hydrocarbon contaminants: An overview. Biotechnol Res Int 2011: 1-13.
14. Yang S Z, Jin H J, Wei Z He, RX, Ji YJ, et al. (2009) Bioremediation of oil spills in cold environments: A review. Pedosphere 19: 371–381.
15. Asira, Enim Enim (2013) Factors that Determine Bioremediation of Organic Compounds in the Soil. Academic Journal of Interdisciplinary Studies 2: 125-128.
16. Wang Q, Zhang S, Li Y, Klassen W (2011) Potential Approaches to Improving Biodegradation of Hydrocarbons for Bioremediation of Crude Oil Pollution. Environ ProtectionJ 2: 47-55.
17. Kumar A, Bisht B S, Joshi V D, Dhewa T (2011) Review on Bioremediation of Polluted Environment: A Management Tool. international journal of environmental sciences 1: 1079-1093.
18. Pankaj Kumar Jain, Vivek Bajpai (2012) Biotechnology of bioremediation- a review. International journal of environmental sciences 3: 535-549.
19. Montagnolli RN, Matos Lopes PR, Bidoia E D (2015) Assessing *Bacillus subtilis*biosurfactant effects on the biodegradation of petroleum products. Environ. Monit. Assess 187: 1-17.
20. Shilpi Sharma (2012) Bioremediation: Features, Strategies and applications**.** Asian Journal of Pharmacy and Life Science 2: 202-213.
21. Dell Anno A, Beolchini F, Rocchetti L, Luna G M, Danovaro R (2012) High bacterial biodiversity increases degradation performance of hydrocarbons during bioremediation of contaminated harbor marine sediments. Environ Pollut 167: 85–92.
22. Abha Singh, Vinay Kumar, Srivastava JN. (2013) Assessment of Bioremediation of Oil and Phenol Contents in Refinery Waste Water via Bacterial Consortium. J Pet Environ Biotechnol 4:1-4.
23. Pedro P, Francisco J E, Joao F, Ana L (2014) DNA damage induced by hydroquinone can be prevented by fungal detoxification. Abdulsalam S, Adefila SS, Bugaje IM, Ibrahim S (2013) Bioremediation of soil contaminated with used motor oil in a closed system. Bioremediation and Biodegradation3
24. Safiyanu I, Isah AA, Abubakar US, Rita Singh M (2015) Review on Comparative Study on Bioremediation for Oil Spills Using Microbes. Research Journal of Pharmaceutical, Biological and Chemical Sciences 6: 783-790.
25. Sani I, Safiyanu I, Rita SM (2015) Review on Bioremediation of Oil Spills Using Microbial Approach. IJESR 3: 41-45.
26. Sarang B, Richa K, Ram C (2013) Comparative Study of Bioremediation of Hydrocarbon Fuel. International Journal of Biotechnology and Bioengineering Research 4: 677-686.

27. Erika A W, Vivian B, Claudia C, Jorge FG (2013) Biodegradation of phenol in static cultures by *Penicillium chrysogenum*erk1: catalytic abilities and residual phytotoxicity.Rev Argent Mcrobiol 44: 113-121.
28. AI-Jawhari IFH (2014) Ability of Some Soil Fungi in Biodegradation of Petroleum Hydrocarbon. Journal of Applied & Environmental Microbiology 2: 46-52.
29. Aranda E, Ullrich R, Hofrichter M (2010) Conversion of polycyclic aromatic hydrocarbons, methyl naphthalenes and dibenzofuran by two fungal peroxygenases. Biodegradation 21: 267–281.
30. Karigar CS, Rao SS (2011) Role of microbial enzymes in the bioremediation of pollutants: a review. Enzyme Res 1-11.
31. Hesham A, Khan S, Tao Y, Li D, Zhang Y, et al. (2012) Biodegradation of high molecular weight PAHs using isolated yeast mixtures: application of metagenomic methods for community structure analyses. Environ Sci Pollut Res Int 19: 3568-3578.
32. Sivakumar G, Xu J, Thompson RW, Yang Y, Randol-Smith P, et al. (2012) Integrated green algal technology for bioremediation and biofuel. Bioresour Technol 107: 1-9.
33. Lin C, Gan L, Chen ZL (2010) Biodegradation of naphthalene by strain Bacillus fusiformis (BFN). *J Hazard Mater* 182: 771-777.
34. Simarro R, Gonzalez N, Bautista LF, Molina MC (2013) Assessment of the efficiency of in situ bioremediation techniques in a creosote polluted soil: change in bacterial community.J Hazard Mater 262: 158-167.
35. Yadav M, Singh S, Sharma J, Deo Singh K (2011) Oxidation of polyaromatic hydrocarbons in systems containing water miscible organic solvents by the lignin peroxidase of Gleophyllum striatum MTCC-1117. Environ Technol 32:1287-1294.
36. Hidayat A, Tachibana S (2012) Biodegradation of aliphatic hydrocarbon in three types of crude oil by *Fusarium* sp. F092 under stress with artificial sea water. Journal of Environmental Science and Technology 5: 64-73.
37. Maliji D, Olama Z, Holail H (2013) Environmental studies on the microbial degradation of oil hydrocarbons and its application in Lebanese oil polluted coastal and marine ecosystem. Int J Curr Microbiol App Sci 2: 1-18.
38. Burghal AA, Najwa MJA, Al-Tamimi WH (2016) Mycodegradation of Crude Oil by Fungal Species Isolated from Petroleum Contaminated Soil. International Journal of Innovative Research in Science,Engineering and Technology 5: 1517-1524.
39. Aliaa M El-Borai, Eltayeb KM, Mostafa AR, El-Assar SA (2016) Biodegradation of Industrial Oil-Polluted Wastewater in Egypt by Bacterial Consortium Immobilized in Different Types of Carriers.Pol J Environ Stud25: 1901-1909.
40. Sukumar S, Nirmala P (2016) Screening of diesel oil degrading bacteria from petroleum hydrocarbon contaminated soil.Int J Adv Res Biol Sci 3: 18-22.
41. Kehinde FO, Isaac SA (2016). Effectiveness of augmented consortia of Bacillus coagulans, Citrobacter koseri and Serratia ficaria in the degradation of diesel polluted soil supplemented with pig dung. Afr J Microbiol Res 10: 1637-1644.

42. Phulpoto H, Qazi MA, Mangi S, Ahmed S, Kanhar NA (2016) Biodegradation of oil-based paint by Bacillus species monocultures isolated from the paint warehouses. Int J Environ Sci Technol 13: 125–134.
43. Jasin ska A, Rózalska S, Bernat P, Paraszkiewicz K, Długon ski J (2012) Malachite green decolorization by non-basidiomycete filamentous fungi of Penicillium pinophilum and Myrothecium roridum. Int Biodeterior Biodegrad 73: 33–40.
44. Jasin ska A, Bernat P, Paraszkiewicz K (2013) Malachite green removal from aqueous solution using the system rapeseed press cake and fungus Myrothecium roridum. Desalin. Water Treat 51: 7663-7671.
45. Anna Jasin ska, Katarzyna Paraszkiewicz, Anna Sip, Jerzy Długon sk. (2015) Malachite green decolorization by the filamentous fungus Myrothecium roridum – Mechanistic study and process optimization. Bioresource Technology 194: 43–48.
46. Yan J, Niu J, Chen D, Chen Y, Irbis C (2014) Screening of Trametes strains for efficient decolorization of malachite green at high temperatures and ionic concentrations.Int Biodeterior Biodegrad 87: 109–115.
47. Shedbalkar U, Jadhav J (2011) Detoxification of malachite green and textile industrial effluent by *Penicillium ochrochloron.* Biotechnol Bioprocess Eng 16: 196–204.
48. Hassan M M, Alam M Z, Anwar M N (2013) Biodegradation of Textile Azo Dyes by Bacteria Isolated from Dyeing Industry Effluent.Int Res J Biological Sci 2: 27-31.
49. Maulin P Shah, Patel KA, Nair SS Darji AM. (2013) Microbial degradation of Textile Dye (Remazol Black B) by *Bacillus spp*. ETL-2012. J Bioremed Biodeg 4:1-5.
50. Yogesh P, Akshaya G (2016) Evaluation of Bioremediation Potential of Isolated Bacterial Culture YPAG-9 (Pseudomonas aeruginosa) for Decolorization of Sulfonated di-azodye Reactive Red HE8B under Optimized Culture Conditions. Int J Curr Microbiol App Sci 5: 258-272.
51. Das A, Mishra S, Verma VK (2015) Enhanced biodecolorization of textile dye remazol navy blue using an isolated bacterial strain Bacillus pumilus HKG212 under improved culture conditions.
52. Adebajo SO, Balogun SA, Akintokun AK (2017) Decolourization of Vat Dyes by Bacterial Isolates Recovered from Local Textile Mills in Southwest. Microbiology Research Journal International
53. Jaysankar D, Ramaiah N, Vardanyan L (2008) Detoxification of toxic heavy metals by marine bacteria highly resistant to mercury. Marine Biotechnology 10: 471-477.
54. Chen C, Wang J L (2007) Characteristics of Zn2+ biosorption by *Saccharomyces cerevisiae. Biomed. Enviro Sci*, 20: 478–482.
55. Talos K, Pager C, Tonk S, Majdik C, Kocsis B, et al. (2009**)** Cadmium biosorption on native *Saccharomyces cerevisiae*cells in aqueous suspension. Acta Univ Sapientiae Agric Environ1: 20–30.
56. Infante JC, De Arco RD, Angulo ME (2014) Removal of lead, mercury and nickel using the yeast *Saccharomyces cerevisiae*. Revista MVZ Córdoba 19: 4141-4149.

57. Tigini V, Prigione V, Giansanti P, Mangiavillano A, Pannocchia A, et al. (2010) Fungal biosorption, an innovative treatment for the decolourisation and detoxification of textile effluents. Water *2*: 550–565.
58. Paranthaman SR, Karthikeyan B (2015) Bioremediation of heavy metal in paper mill effluent using *Pseudomonas*spp. International Journal of Microbiology 1: 1-5.
59. Peña-Montenegro TD, Lozano L, Dussán J (2015) Genome sequence and description of the mosquitocidal and heavy metal tolerant strain *Lysinibacillus sphaericus*CBAM5. Stand Genomic Sic 10: 1-10.
60. Wu YH, Zhou P, Cheng H, Wang CS, Wu M (2015) Draft genome sequence of *Microbacterium profundi*Shh49T, an Actinobacterium isolated from deep-sea sediment of a polymetallic nodule environment. *Genome Announcments* 3: 1-2.
61. Soleimani N, Fazli MM, Mehrasbi M, Darabian S, Mohammadi J, et al. (2015) Highly cadmium tolerant fungi: Their tolerance and removal potential. Journal of Environmental Health Science and Engineering 13:1-9.
62. Mirlahiji SG, Eisazadeh K (2014) Bioremediation of Uranium by *Geobacter*spp. Journal of Research and Development1: 52-58.
63. Priyalaxmi R, Murugan A, Raja P, Raj KD (2014) Bioremediation of cadmium by *Bacillus safensis*(JX126862), a marine bacterium isolated from mangrove sediments. International Journal of Current Microbiology and Applied Sciences 3: 326-335.
64. Sinha SN, Biswas M, Paul D, Rahaman S (2011) Biodegradation potential of bacterial isolates from tannery effluent with special reference to hexavalent chromium. Biotechnology Bioinformatics and Bioengineering 1: 381- 386.
65. Sinha SN, Paul D (2014) Heavy metal tolerance and accumulation by bacterial strains isolated from waste water. Journal of Chemical, Biological and Physical Sciences 4: 812-817.
66. Sinha SN, Biswas K (2014) Bioremediation of lead from river water through lead-resistant purple-nonsulfur bacteria. Global Journal of Microbiology and Biotechnology 2: 11-18.
67. Mohamed AT, El Hussein AA, El Siddig MA, Osman AG (2011) Degradation of oxyfluorfen herbicide by Soil microorganisms: Biodegradation of herbicides. Biotechnol 10: 274-279.
68. Niti C, Sunita S, Kamlesh K (2013) Bioremediation: An emergingTechnology for remediation of pesticides. Research Journal of Chemistry and Environment 17: 88-105.
69. Mónica P, Darwin RO, Manjunatha B, Zúñiga JJ, Diego R, et al. (2016) Maddela. Evaluation of various pesticides-degrading pure bacterial cultures isolated from pesticide-contaminated soils in Ecuador. Afr J Biotechnol 15: 2224-2233.
70. Hussaini S, Shaker M, Asef M (2013) Isolation of Bacterial for Degradation of selected pesticides. Bull Environ Pharmacol Life Sci 2: 50-53.
71. Ravi RK, Pathak B, Fulekar MH (2015) Bioremediation of Persistent Pesticides in Rice field Soil Environment Using Surface Soil Treatment Reactor. Int J Curr Microbiol App Sci 4: 359-369.

72. Mulligana CN, Yong RN (2004) Natural attenuation of contaminated soils. Environment International 30: 587 – 601.
73. Li CH, Wong YS, Tam NF (2010) Anaerobic biodegradation of polycyclic aromatic hydrocarbons with amendment of iron (III) in mangrove sediment slurry. Bio resource Technology 101: 8083−8092.
74. Niu GL, Zhang JJ, Zhao S, Liu H, Boon N, et al. (2009) Bioaugmentation of a 4-chloronitrobenzene contaminated soil with Pseudomonas putida ZWL73. Environmental Pollution 57: 763-771.
75. Malik ZA, Ahmed S (2012) Degradation of petroleum hydrocarbons by oil field isolated bacterial consortium. African J Biotechnol 11: 650–658.
76. Alwan AH, Fadil SM, Khadair SH, Haloub AA, Mohammed DB, et al. (2013) Bioremediation of the water contaminated by waste of hydrocarbon by use Ceratophyllaceae and Potamogetonaceae plants.
77. Gomez, Sartaj M (2014) Optimization of field scale biopiles for bioremediation of petroleum hydrocarbon contaminated soil at low temperature conditions by response surface methodology (RSM). Int Biodeterior Biodegradation 89: 103–109.
78. Sayler GS, Ripp S (2000) Field applications of genetically engineered microorganisms for bioremediation processes. Current Opinion in Biotechnology 11: 286-289.
79. Bijay Thapa, Ajay Kumar KC, Anish Ghimire (2012) a review on Bioremediation of petroleum hydrocarbon contaminants in soil. Kathmandu University. Journal of science, engineering and technology 8: 164-170.
80. Jain PK, Gupta VK, Bajpai V, Lowry M, Jaroli DP (2011b), GMO's: Perspective of Bioremediation. In: Recent Advances in Environmental Biotechnology, Jain PK, Gupta VK and Bajpai V (Eds.). LAP Lambert Academic Publishing AG and Co. KG, Germany, pp. 6-23.
81. Jain P K, Gupta V, Gaur R K, Bajpai V, Gautama N, Modi D R (2010c), Fungal Enzymes: Potential Tools of Environmental Processes. In: Fungal Biochemistry and Biotechnology, Gupta, VK, Tuohy M and Gaur RK (Eds.). LAP Lambert Academic Publishing AG and Co. KG, Germany. 44-56.
82. Kulshreshtha S (2013) Genetically Engineered Microorganisms: A Problem Solving Approach for Bioremediation. J Bioremed Biodeg 4: 1-2.
83. Lee TH, Byun IG, Kim YO, Hwang IS, Park TJ (2006) Monitoring biodegradation of diesel fuel in bioventing processes using in situ respiration rate. Water Science and Technology53: 263-272.
84. Samuel Agarry, Ganiyu K. Latinwo (2015) Biodegradation of diesel oil in soil and its enhancement by application of Bioventing and amendment with brewery waste effluents as Biostimulation-Bioaugmentation agents. Journal of Ecological Engineering 16: 82–91.
85. Delille D, Duval A, Pelletier E (2008) Highly efficient pilot biopiles for on-site fertilization treatment of diesel oil-contaminated sub-Antarctic soil. Cold reg sci technol 54: 7-18.

86. Emami S, Pourbabaee AA, Alikhani HA (2012) Bioremediation Principles and Techniques on Petroleum Hydrocarbon Contaminated Soil. Technical Journal of Engineering and Applied Sciences 2: 320-323.
87. Kumar S, Chaurasia P, Kumar A (2016) Isolation and Characterization of Microbial Strains from Textile Industry Effluents of Bhilwara, India: Analysis with Bioremediation. Journal of Chemical and Pharmaceutical