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EMERGING TOOL FOR CONTROLLING POLLUTION : A REVIEW ARTICLE

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Abstract

The term "biotechnology" refers to the use of living organisms in man-made systems. Effluent treatment and fermentation both benefit from the employment of microorganisms. The widespread use of these methods could have a significant economic influence in fields including the development of novel pharmaceuticals, foods, and chemicals, the enhancement of agricultural goods, and the degradation of toxic wastes in substantial quantities. When it comes to cleaning the air in factories and cities of unpleasant odors and harmful chemicals, biotechnology provides the most cost-effective and eco-friendly solution. The environment and human health are both negatively impacted by the emission of volatile organic compounds (VOCs) and inorganic odorants. Odor-causing substances in the environment include ammonia, amines, hydrogen sulfide, methyl mercaptan, dimethyl sulfide. The need for air pollution control systems to provide peaceful, breathing air is developing as a result of rising population density and the construction of new residential areas and industrial units. This article offers a survey of the several biotechnological strategies now in use for reducing air pollution and unpleasant odors. Legal restrictions necessitate the elimination of odors and volatile organic compounds (VOCs) due to public complaints about poor air quality on-site and emission monitoring by enforcement agencies.

Keywords- volatile organic compound (VOC), biotechnology, air pollution control.

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Introduction

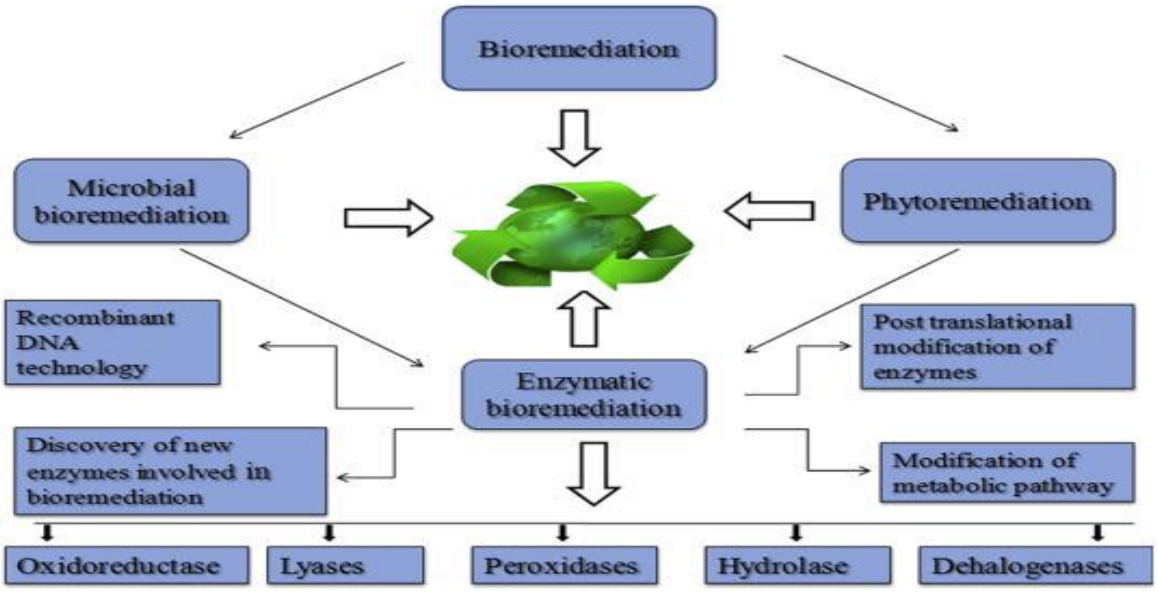
The term "biotechnology" refers to the use of living organisms in man-made systems (Rene *et al.*, 2015). Effluent treatment and fermentation both benefit from the employment of microorganisms. Potentially lucrative areas where these methods are put to use include the manufacture of novel medications, foods, and chemicals; the enhancement of existing agricultural products; and the degradation of massive quantities of toxic waste (Lyons *et al.*, 2006).

When it comes to cleaning the air in factories and cities of unpleasant odors and dangerous chemicals, biotechnology is the most cost-effective and eco-friendly option. Volatile organic compounds (VOCs) and inorganic odorous chemicals pose threats to the environment and human health when released in excessive quantities. To put it simply, substances like ammonia, amines, hydrogen sulfide, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide are incredibly odiferous and should be avoided at all costs. The need for pollution-free, healthy air is only going to increase as the population grows and more buildings, both residential and industrial, are constructed. In this chapter, we will examine the several biotechnological strategies that have been implemented to reduce air and odor pollution. Regulations, usually implemented in response to public complaints about poor local air quality and through emission monitoring by enforcement authorities, necessitate the elimination of smells and VOCs. It was not simple for businesses to choose a biotechnology system in the early 1990s to cut down on odor or VOC air emissions for regulatory purposes (Shareefdeen *et al.*, 2005).

The various methods currently in use to curb pollution:

Bioremediation-

The term "bioremediation" is a portmanteau of the terms "bio" (which means "life") and "remediates" (which means "to fix a problem" or "to restore things to their original state"). Biological organisms can be used in conjunction with technology advancements to "bio-remediate" polluted soil and water (Thakur *et al.*, 2015). Bioremediation refers to the utilization of living organisms like microbes or plants and the enzymes they produce to restore a contaminated area to its originalstate.



Diagrammatic representation of Bioremediation

Due to its potential cost-effectiveness and environmental friendliness, microbial bioremediation is a promising field for future research and development. Bacteria, fungi, yeasts, and even some types of algae are capable of functioning as biologically active methylators, modifying hazardous species in some way. Metal ions are often removed from the cell through efflux or exclusion during microbial detoxification processes, which can lead to high local concentrations of metals near the cell surface, where they might react with biogenic ligands and precipitate. Microorganisms can't damage metals, but they have a surprising number of ways to change their chemical properties. This chapter's primary goal is to review the most recent research on the topic of microorganism-based solutions for cleaning up metal pollution in water systems and to critically examine their relative merits and drawbacks. Particular attention is paid to heavy metals like lead (Pb), cadmium (Cd), and chromium (Cr), which might pose a threat to ecosystems as a result of environmental contamination (Coelho *et al.,* 2015).

Both In-situ and Ex-situ bioremediation techniques exist.Both the topsoil and subsoil can be used for bioremediation, as can water.There are three main levels at which bioremediation studies can be conducted: the lab, the pilot scale, or the field (Robert *et al*., 1993).Bioremediation techniques, both in and out of the ground, and their potential uses. About 40 percent of the world's food supply comes from irrigated agriculture, which uses a lot of groundwater (Wilkin *et al*., 2007), and as many as 2 billion people get their drinking water from aquifers directly. The ex situ bioremediation business for treating contaminated soils is currently dominated by two technologies: biopiles and windrow composting. Conventional permeable reactive barriers (PRBs) were developed as chemical and physical intervention techniques, with biodegradation occurring by accident; the idea of intentionally transforming PRBs into bioremediation technology emerged only lately. Although garden waste's major job in bioremediation is to produce heat-generating materials during composting, the material also provides extra microbial populations. There is hope that in the future, GMOs will be used for bioremediation, allowing for the removal of the most stubborn pollutants in hostile environments at a low cost, despite the fact that most of these organisms are still in the laboratory or early field test stage. Immobilized delivery of bioaugmentation cultures may allow for more thorough and/or faster breakdown. Accelerating the rates of pollutant degradation in situ, particularly in groundwater, in a predictable and cost-effective manner may be crucial to the long-term effectiveness of bioremediation (Philip *et al*., 2005).

Ecological Safety and Risk Assessment in Bioremediation:

Researchers and scientists are putting bioremediation to the test in an experimental setting. As reported by (Yergeau *et al*., 2012). Protection against oil spill, plastics, synthetic dyes, organic hydrocarbons (Yadav *et al*., 2015), pesticides (Jaiswal *et al*., 2019a), heavy metals (Hemmat-Jou *et al*., 2018; Lebrazi and Fikri-Benbrahim., 2018), and other xenobiotics, etc.

Since bioremediation is performed outside of a contained fermentation tank, it is important to ensure that the bacteria used in the process are ecologically friendly. Due to their metabolic versatility, microbes are a more cost-effective and environmentally friendly bioremediation option than traditional physical and chemical methods (Gillan *et al*., 2015).

Typically, regulatory agencies are the ones that conduct risk evaluations. Environmental Security as defined by the OECD (Russo *et al*., 2019; Alam and Murad, 2020; Pastor-Jáuregui *et al*., 2020) has been H. implemented at the application level. Native members of microbial consortiums may be contaminated with foreign DNA, which could disrupt their ability to express their native features (Mills *et al*., 2019; Pineda *et al*., 2019; Rycroft *et al*., 2019). . Selective pressure on non-target microbiota can result from competition between native and transgenic species (Kumar N.M. *et al*., 2018; Mohapatra *et al*., 2019).

Sewage Treatment-

Sewage is mostly water (99.9%), but it also contains some particulates (0.1%) that must be removed before the water may be reused. Sewage treatment represents a serious environmental issue that has affected modern society for the past century (Bonito 2008). As a result, many new rules and controls have been implemented to reduce the risk of introducing disease-causing bacteria, harmful chemicals, and eutrophic nutrients into our waterways.

Preliminary, primary, secondary, and tertiary treatment are introduced as the very straightforward engineering classification of sewage treatment phases. Through wastewater treatment and reducing the absorption of contaminants at the source, Europe has reduced its overall pollution load in recent decades thanks to advances in technology and their better applications (Scholz, 2015). Sludge from wastewater treatment that successfully removes a high concentration of pollutants has increased dramatically in both quantity and quality, and there has been a concerted effort to find new uses for this material rather than simply dispose of it. As a result, there has been a renewed focus on soil and its potential uses in dealing with the latter. Soils can be used to absorb, recycle, or dispose of sewage sludge, which is important because the sludge must be disposed of in an environmentally sound manner.

Treatment in the Beginning: Large-scale physical sorting of contaminants such as fibers, plastics, wood, paper, etc. Common Preliminary-level physical unit operations include: To separate smaller particles from larger ones, a screen with uniformly sized apertures is utilized. remove The standard is a maximum of 10mm. Sedimentation is a physical water treatment method that relies on the force of gravity to settle particles trapped in the liquid. To be more specific, it is employed in the clarification of particulates from fluids.

Primary treatment entails the removal of suspended particles and organic matter, both of which float and can be settled out. This degree of treatment employs both physical and chemical processes. Reactions at the molecular level: Asiwal *et al.* (2016) note that chemical unit processes are often paired with physical operations and biological treatment procedures. The quality of anything can be altered by a chemical process by adding chemicals to the mix. Wastewater treatment examples include acid neutralization, coagulation, chemical precipitation, and oxidation. Controlling the pH of treated wastewater involves modifying the pH of the wastewater (NaOH, neutral, CaCO3, or CaOH) for acidic wastes (low pH). For alkaline wastes, use sodium carbonate and hydrochloric acid. High-pH conditions and chemical coagulation: H2SO4 Coagulation, or flocculation, is the process of aggregating the many tiny solid particles that are suspended in a liquid into a single, bigger mass. Wastewater is treated by adding chemical coagulants like Al2 (SO4)3, also called alum, or Fe2 (SO4)3, to increase the attraction between tiny particles, causing them to cluster together and create bigger particles called flocs. By clumping together smaller particles into larger flocs that are then easier to settle out, a chemical flocculent (often a polyelectrolyte) speeds up the flocculation process. When particles are gently mixed together, they collide and speed up the flocculation process.

Biological and chemical procedures are utilized during the **secondary treatment** stage. Removal or diluting of organic and inorganic chemical concentrations by means of a biological unit process there are many different kinds of biological treatment processes, but they all rely on bacteria and other microbes. Treatment methods that require air (oxygen) are called "aerobic." Aerobic microorganisms are used for this process; these organisms may assimilate organic pollutants by breaking them down into carbon dioxide, water, and biomass using molecular or free oxygen. Anaerobic treatment procedures are those that happen without the presence of air (oxygen). Uses microorganisms (anaerobes) that can break down organic waste without air (molecular or free oxygen). Methane gas and biomass are the end results.

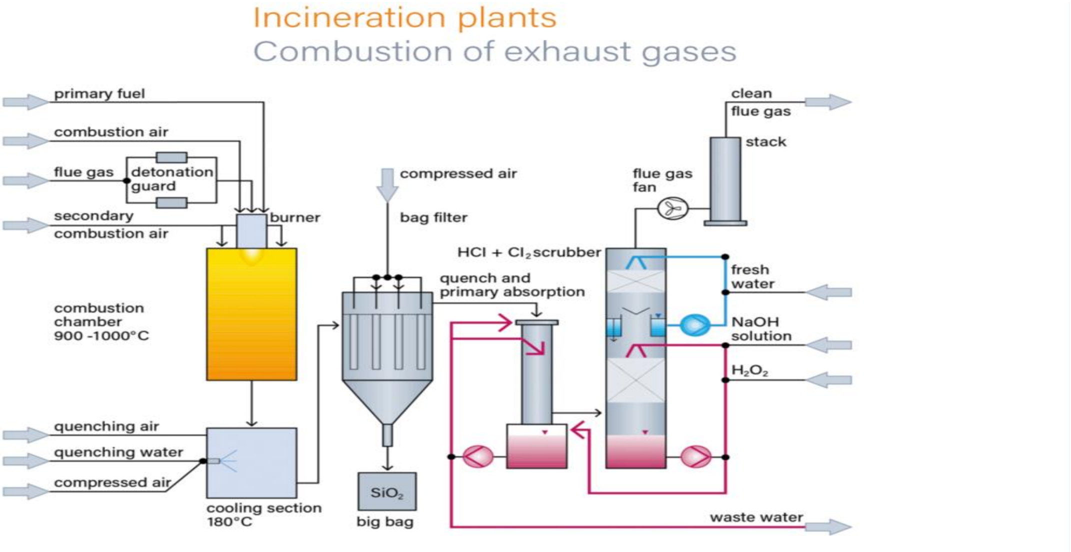
Tertiary treatment, also known as advanced treatment, is the last step in purifying wastewater before it is discharged back into the environment for reuse or recycling. Mechanism: Gets rid of any lingering inorganic chemicals and substances (Sahu et al., 2016). At this point, the dangerous bacteria, viruses, and parasites are also eliminated. Methods: Alum is added to the mixture to aid in the elimination of any leftover phosphorus particles and to facilitate the filtering out of any remaining solids. Tertiary treatment with a chlorine contact tank kills any remaining bacteria, viruses, or parasites in the treated effluent. The released chlorine is neutralized by adding sodium. Bisulfate right before it's released.

Incineration-

This is the process of destroying trash through combustion. "Thermal treatment" is a term used to describe incineration and other high-temperature waste treatment technologies (Thakur *et al*., 2012). Solid, liquid, and gaseous waste can all be disposed of using this method. Waste incineration produces energy, gas, steam, and ash. It's seen as a viable option for getting rid of some types of hazardous waste, such as biomedical waste.

Energy from waste facilities is produced by those that use garbage to create useful byproducts like steam and heat. The advantages of incineration are preserved by modern combustion technologies, which also generate clean energy (Patil *et al*., 2014). Emissions from the combustion of municipal garbage, sewage, sludge, and coal byproducts for energy production are kept to an absolute minimum. Depending on the waste's composition and the level of material recovery, incinerators can reduce its volume by as much as 95–96%.

It is the controlled, direct burning of garbage at high temperatures (about 8000 °C) in the presence of oxygen. This process generates heat energy, gases, and inert ash. The net energy output is proportional to the waste's density and composition. The ignition temperature, the size and form of the constituents, the design of the combustion system, etc. (Kulkarni *et al*., 2014). The relative percentage of moisture and inert elements, which add to the heat loss. Heat energy recovered from decomposing organic matter can be used for direct thermal uses or to generate electricity via steam turbine generators, recouping anywhere from 65% to 80% of the organic matter's original energy content. Traditional incinerators run at temperatures of around 760 °C in the furnace and above 870 °C in the secondary combustion chamber when burning only waste. Some of the inorganic materials, like glass, cannot be burned or even melted at these temperatures, but they are necessary to prevent odors caused by incomplete combustion. Some cutting-edge incinerators use supplementary fuel to reach temperatures of up to 16500 °C, thereby avoiding the drawbacks of traditional incinerators. They can reduce garbage by 97% in volume and turn some inorganic materials like metal and glass into harmless ash. Depending on the type of waste being burned, the only additional fuel required may be at the beginning of the process. Due to the trash's varying energy content or a lack of available waste, supplementary fuel may be employed in conjunction with the pulverized refuse when steam production is the goal. Although incineration has become increasingly popular as a means of waste management, it is linked to a number of harmful outputs that raise environmental concerns. Fortunately, the installation of pollution control systems and the appropriate design and control of the furnace's combustion process may effectively regulate these.



A **landfill** is a landfill because it is a place where garbage is buried. Since their introduction, landfills have become the standard for waste management. Landfills might be single-use facilities utilized just by one manufacturer, or they can be shared by several. Landfills serve a variety of other waste management functions, such as the short-term storage of trash, the consolidation and transfer of trash, and the processing of trash.

Most landfills may be found in populated places because that's where the greatest amounts of trash accumulate and need to be disposed of. Dung pits are filled with waste and then covered to prevent rodents and flies from breeding. Each night, garbage is covered with soil and compacted using a mechanical device. Once the landfill is full, the area will be covered in a thick layer of mud, making it suitable for park development.

- The United States' landfills have changed little since they were first used as dumps in the early 20th century.
- Landfills in the majority of third-world countries. The risk of contamination was not taken into account.
- Waste leachate is taken carefully due to a widespread misconception that it is harmless.
- There are still waste dumps in the United States that date back to before the 1950s.
- Landfills in the majority of third-world countries. The risk of contamination was not taken into account.
- Waste leachate is taken carefully due to a widespread misconception that it is harmless.

Sanitary Landfill Biochemical Processes Degradation of waste materials in a sanitary landfill is the result of a complicated series of chemical and biochemical reactions that might occur in parallel or in quick succession. MSW's organic components breakdown quickly, producing landfill gas and liquids. Carbon dioxide (CO2) is initially produced as the primary gas during the biochemical events that occur in a sanitary landfill under aerobic conditions (where oxygen is the terminal electron acceptor). Decomposition reactions continue in partially aerobic to mostly anaerobic conditions, with carbon dioxide (CO2), methane (CH4), traces of ammonia (NH3), and hydrogen sulfide (H2S) as the primary waste gases produced as most of the available oxygen (O2) is exhausted. Anaerobic breakdown of municipal solid waste (MSW) can be described by the following general biochemical reaction (Tchobanoglous *et al*., 1993).

During the lifetime of a sanitary landfill, five distinct stages can be distinguished based on the formation of primary landfill gases and physico-chemical conditions (Ghosh *et al*., 2012). The amount of biodegradable organic matter present in the waste, the availability of moisture and nutrients necessary for biodegradation, and the final landfill closure measures are the primary determinants of the duration of each phase, as well as the nature and quantity of various landfill gases generated during each phase.

Degradation of Xenobiotic Compounds by Microorganisms -

The combination of the Greek words xeno, meaning foreign or unusual, and biotic, meaning living things, produces the word xenobiotic. The xenobiotic chemicals are very resistant to heat. There is a wide variety of substances used in both industrial and agricultural settings that fall under the umbrella term "xenobiotics" (Narwal *et al*., 2017). Pesticides, fossil fuels, solvents, alkanes, PAHs, polyaromatic, chlorinated, and nitro aromatic chemicals are all examples of common xenobiotics (Gupta *et al*., 2017).

A worldwide problem has been produced by the steady discharge of stubborn xenobiotic chemicals into the biosphere. Carcinogenic, mutagenic, and environmental persistent: these are all characteristics of xenobiotic substances. Biodegradation of xenobiotic substances uses biological mechanisms similar to those found in nature to totally remove harmful pollutants. The microorganisms used in this procedure utilize numerous catabolic biodegradation pathways and derive all of their carbon and energy needs from these hazardous xenobiotics. Various bacteria and fungi, such as Pseudomonas, Mycobacterium, Rhodococcus, etc., degrade xenobiotics.

Biodegradation Techniques:

Detoxification methods can be broken down into three categories: (i) Physical; (ii) Chemical; and (iii) Biological. The physical methods include washing, cooking, peeling, sun drying, brushing, solvent washing/removal, washing with water, soaps; adjuvant or surfactant, burial and disposal. Hydrolysis, high-energy breakdown, and oxidation/reduction are all examples of chemical changes (Jain *et al*., 2015). Biocatalysis, enzyme oxidation, and microbial degradation are all examples of biological processes that can be used to replace another substrate's carbon content or to facilitate co-metabolism.

Biological decomposition mechanism:

Cleavage of chemical bonds mechanism. Some xenobiotic chemicals may be resistant for a variety of reasons: I. When halogens are substituted for hydrogen in a molecule, the carbon-halogen bond becomes extremely strong and requires a lot of energy to break. II. The replacement of hydrogen atoms with groups such as nitro, sulfate, methoxy, amino, and carbonyl. III. More so than linear chain or aliphatic compounds, IV, cyclic structures, aromatic compounds, cyclo alkanes, and hetrocyclic compounds are stubborn. Linear chains with branches are more difficult to degrade. Cytochrome P-450 oxidation is crucial to biodegradation; reactions involving heme protein P-450 are the most common kind of monooxygenase reaction. Cytochrome P-450, like mitochondrial cytochromeoxidase, may react with O2 and bind CO (the reduced CO complex absorbs 450nm, hence the name P-450). In the hydroxylation reaction catalyzed by cytochrome P-450, an organic substrate, RH, is converted to R-OH by the incorporation of one oxygen atom, O2.

Biodegradation microorganisms:

Algae are also utilized in pesticide decontamination, albeit to a smaller extent than bacteria and fungus. Isolated from either soil or water, several green and blue-green algae have been shown to breakdown the organophosphorus insecticides chlorpyriphos, monocrotophos, and quinalphos (Mukherjee *et al*., 2004). Pendimethalin degradation by actinomycets has been demonstrated (Gopal *et al*., 2005). Pseudomonas species. or aspergillus niger, which has the ability to hydroxylate 2,4-D in industrial waste. The soil microbe Agrobacterium radiobacter was examined in batch culture for its ability to degrade three different benzonitrile herbicides: bromoxynil (3,5-dibromohydroxy- benzonitrile), ioxynil (3,5-diiodo-4-hydroxy- benzonitrile), and dichlobenil (2,6-dichloro- benzonitrile). Degradation of carbofuran residues was accelerated to 96% in just 10 days thanks to the bacterial culture mixture. (Mohapatra and Awasthi, 1997). Bacteria that thrive on chicken manure, newspaper, straw, and wood chips can eliminate harmful organochlorins like DDT. DDT is decomposed by bacteria that thrive in garbage dumps. In order to create an enzyme that destroys dichlorobenzene and other soil pollutants, chemists at Oxford University in Southern England "tweaked" a gene from pseudomonas putida. Plasmid transfer can be used to engineer bacteria with unique properties. The species Alcaligenes, for instance. generate hazardous 5-chlo-2-hydroxymuconic semialdehyde from 4-chlorophenol (through meta ring cleavage). The genes for the enzyme 1, 2-di-oxygenase that cleaves 4-chlorophenol by the ortho route are carried on plasmids in Pseudomonas strain B13.

Bioremediation is a powerful method of treatment that makes advantage of organisms' enzymatic activity. However, the biodegradation process has drawbacks, such as the slow development of microorganisms or the difficulty in controlling and maintaining the appropriate condition for the microbial growth. Novel methods of enzyme stabilization are developed since direct application of enzymes in the environmental treatment process has been fairly limited due to loss of enzyme function. Many enzymes have shown to be useful targets in the design of enzyme systems for bioremediation (Jha *et al*., 2015) due to their extensive substrate specificity despite their use against a variety of substrates. Microbes and the enzymes they produce are directly involved in biogeochemical cycles due to their role in decomposition, and they have the potential to be extremely valuable in the advancement of bioremediation technology. Dichlormethane dehalogenase (DcmA), haloalkane dehalogenases (DhlA, DhaA,LinB), and atrazine chlorohydrolase (AtzA) all destroyed xenobiotic halogenated substrates as carbon sources. Indeed, the dehalogenase genes are typically located on movable plasmid and are frequently found in close proximity to integrase genes, invertase genes, or insertion elements. It appears that the variety of dehalogenases that operate on xenobiotics is smaller than that of those that act on things like alkanes. Due to the high number of undiscovered functional sequences, the potential for expansion and scaling of the microbial system is considerable.

Bioscrubbers

Bioscrubbers are two-stage systems that first physically separate the absorption of volatile compounds into water before proceeding to cleanse the water biologically. An absorber, also known as a gas-liquid contactor, is used to purify the waste gas by transferring the contaminants from the gaseous to the liquid state. Absorption columns with a packed bed and counter-current flow of gas and water make up the gas-liquid contactor (Johan *et al*., 2001). Polluted water is recycled after passing through an absorber and being subjected to biological treatment in a bioreactor.

The water phase should be supplemented with a nutrient solution to promote microbial decomposition activity. Wastewater should be generated because suspended biomass and dissolved chemicals may build up in the water phase. Water that is lost to evaporation or waste is constantly replaced with new water.

The two main components of a bioscrubber are the gas scrubber and the biological reactor. To remove unwanted substances, a gas scrubber uses wash water to adsorb them from the gas stream. The biological reactor is responsible for biologically degrading the contaminants that the wash water has absorbed. The scrubber's cleansed liquid is recycled for further pollution absorption.

The bioscrubber breaks down the biodegradable hydrocarbons into water and carbon dioxide. Hydrocarbons that do not biodegrade stay in the wastewater after washing. Sulfate and nitrate are formed from H2S and NH3 correspondingly. Salt and non-biodegradable hydrocarbon levels must be maintained through routine draining. Conductivity or a constant discharge can be used for this purpose. The composition of the flue gas is what determines the amount of discharge. Salt content equal to a conductivity of 5 mS/cm has been shown to still allow for steady biological degradation. Good outcomes are achieved with a hydraulic residence time for wash water of 20–40 (maximum) days.

The gas scrubber should be constructed so that gases spend no more than a second in the scrubber at a time. Depending on the components' solubility, this could be a little more or a little less. To avoid clogging from biosludge, the scrubber needs specialized open packing and spray nozzles.

The biological system requires nutrients in addition to carbon (hydrocarbons) as a source of energy. Bioscrubbers require a special nutrient cocktail for this function. There is nitrogen, phosphate, and various trace components in this nutrient blend. In order to provide bacteria with enough oxygen to decompose the components, the biological reactor is equipped with an aeration device. There is a genuine possibility of components being released into the air if they are poorly soluble or difficult to breakdown. The air from the aeration device should be recycled through the bioscrubber to eliminate the need for stripping and the subsequent release of polluted air.

The biological reactor can be built up as either a biofilm system on a transport medium or an active sludge system. Sludge formation is typically reduced in systems that employ a carrying medium. Sludge from a biological water purification system or another bioscrubber is put into the biology before the bioscrubber is turned on. This sludge requires a tailored approach to suit the unique chemical make-up of flue gases. It may take up to a month for the system to reach its target efficiency after making the switch to components that degrade slowly.

Rendering factories, cattle farms, the food industry, and foundries are just some of the places where bioscrubbing systems are used to biodegrade odorous substances. There are fewer than 100–500 milligrams per cubic meter of air of biodegradable chemicals in the waste air streams. The microbes in this scenario are suspended in water in an activated sludge tank, which serves as the bioreactor.

Hydrocarbon emissions from many industries (including the chemical industry, the coating and painting industry, fiber production, and the chemical cleaning business) are subject to strict reductions under the Dutch "Hydrocarbon 2000" Programme.

Most hydrocarbons can be broken down by bacteria in soil or water. When high degradation capacity bioreactor techniques are used, which can accommodate changing concentrations and prolonged durations of production stoppage, bioscrubbing may hold promise in this area.

In these industries, active-carbon pellet bioscrubbers, which have a buffer capacity for hydrocarbons and support microorganisms, have a better probability of success than traditional bioscrubbing systems with activated-sludge tanks.

Sustaining the Environment:

Environmental sustainability refers to the practice of ensuring that current interactions with the environment are followed with the aim of keeping the ecosystem as pristine as naturally achievable based on ideal-seeking behavior. Natural capital, which includes all of the resources found in nature, is said to be in a "unsustainable situation" when it is consumed faster than it can be replenished. For development to be considered sustainable, natural resources must be used fairly and at a rate that does not deplete them. Theoretically, environmental degradation leads to a planet that can no longer sustain human life. Degradation on this global scale could spell the end of the human race. Reference: (Chukwuma S. Ezeonu., 2012).

When the ecosystem provides for the needs of the various species within it, including humans, we may say that the environment is healthy. Both reducing human impact and increasing the viability of the ecosystem's plant and animal inhabitants will help achieve this goal. "(Daly HE, 1990)"

Conclusion

Microbial bioremediation has been found to be the most effective strategy for cleaning polluted areas. Synthetic biology is being used to address the problem of xenobiotics and related compounds in the environment. Building synthetic models of bioremediation has been found to necessitate an in-depth familiarity with existing metabolic pathways. In addition, research into bioremediation has a solid grounding thanks to genome reconstruction technologies and methods (Luo *et al*., 2014; Marco and Abram. 2019). Many elements play into how toxicants in the environment affect living things. (Sobh & Vulpe., 2019) Risk assessment and environmental governance can benefit from learning more about the ways in which genetic variables and environmental toxicants interact. The return of healthy ecosystems is intrinsically linked to microbes. Changes in soil microorganisms were explored by (Sun and Badgley. 2019) by monitoring the metagenome of soil microbes while forest ecosystems were restored. Changes in soil microbial community were shown to be possibly linked to shifts in soil nutrition and vegetation succession.

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