A REVIEW PAPER ON BIODEGRADATION PRODUCTS

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DOI: 10.5958/2249-7137.2021.02649.5

ABSTRACT

Thousands of chemicals and materials with a wide range of characteristics and functions are produced and utilized for commercial and everyday purposes, with little knowledge of their final destiny in the environment. These chemicals are often released into the environment during their production and usage through various pathways in the air, water, and land. Massive amounts of solid waste of all kinds, as well as its efficient disposal, have created a slew of issues that need technical advances. Many of these chemicals take a long time to decompose and have harmful effects on plants and animals, resulting in widespread environmental damage. Pollution from discarded plastic items is also a major issue. Industrial wastewaters connected with the production of organic compounds are large and often have concentrations ranging from a few parts per million to thousands of parts per million. The biodegradation of such dissolved contaminants is of great interest to a variety of industries.

KEYWORDS: *Aerobic, Anaerobic, Biodegradation, Concentration, Pollution.*

1. INTRODUCTION

VOC emissions from a variety of sources have a negative impact on the quality of the oxygen we breathe and on air pollutants. Biodegradation, whether aerobic or anaerobic, is a method for cleaving large molecules into smaller molecules from a mosaic of agrochemicals in a series of steps, with some of the smaller molecules being valorized as a pollution abatement strategy and a source of energy through biogas. Biogas may be made from virtually any kind of biomass, including main agricultural sectors and different organic waste streams, which can be used as a sustainable energy source. Animal dung that has not been properly handled or managed is a significant cause of pollution in the air and water. Some of the most serious concerns are nutrient leakage, particularly of nitrogen and phosphorus, as well as ammonia evaporation and microbial contamination. Steinfeld, estimate that the animal production sector is responsible for 18 percent of total CO_2 equivalent emissions and 37 percent of anthropogenic methane, which has 23 times the global warming potential of CO_2[1]–[3]. Furthermore, the global animal production industry is responsible for 65 percent of anthropogenic nitrous oxide and 64 percent of anthropogenic ammonia emissions. Biogas may be produced from the digestion of animal dung and slurries to reduce greenhouse gas emissions, especially ammonia and methane.

Plastics are both a curse and a blessing. Plastic is manufactured in excess of 230 million tons per year. Plastics are utilized in almost every aspect of life and offer better insulation, lighter packing, and are present in automobiles, aircraft, trains, phones, computers, medical equipment, and other places, but proper disposal is frequently overlooked. On the one hand, plastic trash and disposal is a contentious problem across the world, but it may also help to decrease carbon emissions. By implementing an integrated waste and resource manage plan to handle each waste stream with the best choices, several top European nations are recovering more than 80% of their old plastics. Sorting and separation of plastics, recycling, depolymerization, breaking, and fuel generation are some of the methods utilized to reduce plastic pollution. Biopolymer development is being pursued aggressively. The most efficient method seems to be the biodegradation of plastics by microbes and enzymes. When plastics are employed as microorganism substrates, their biodegradability should be assessed not only on the basis of their chemical composition, but also on physical characteristics like melting point, glass transition temperature, crystallinity, storage modulus, and so on[4]–[7].

Biodegradation processes, biodegradation of a range of industrial chemicals, plastics, and other biomass, advancements in anaerobic digestion technology and biogas production, plastic processing, and biopolymer synthesis and degradation have all been addressed in this chapter. Biopolymer synthesis is discussed. The potential for processing municipal organic solid waste, manure, and polymers to produce biogas as a sustainable energy source and pollution abatement method is addressed, as well as technical considerations. Biohydrogen, bioethanol, biobutanol, and other biotransformation that lead to useful compounds, including the breakdown of bigger molecules, polymers, and biomaterials, are not included. Biorefinery is a petrochemical-like concept in which biomass is transformed into usable platform chemicals through extraction, controlled pyrolysis, fermentation, enzyme, and chemical catalysis.

1.1. Biodegradation mechanisms:

Because cellulose, lignocelluloses, and lignin are polymeric compounds and significant sources of plant biomass, their recycling is critical for the carbon cycle. Each of these polymers is destroyed by a variety of bacteria, each of which produces a large number of enzymes that operate together. The wide range of cellulosic and lignocelluloses substrates have added to the enzymatic treatment challenges. The best-known microbes that can degrade these three polymers are fungi. Due to the insoluble nature of the substrates, both bacterial and fungal breakdown occurs exo-cellularly, either in conjunction with the outer cell envelope layer or extra-cellular. Extracellular enzymatic systems in microorganisms are divided into two types: the hydrolytic system, which generates hydrolases and is responsible for cellulose and hemicelluloses degradation; and a distinct oxidative and extracellular ligninolytic system, which depolymerizes lignin. Man-produced chemicals and materials are made up of a variety of entities and functional groups that must be efficiently destroyed by microbes, and no one microorganism seems to be capable of doing so[8].

The two processes of biodegradation are growth and co-metabolism. Growth occurs when organic matter is utilized as the only source of carbon and energy, resulting in total deterioration (mineralization). Mineralization is dominated by archaebacteria, prokaryotes, and eukaryotes (fungi, algae, yeasts, and protozoa). Co-metabolism, on the other hand, refers to an organic compound's metabolism in the presence of a growth substrate that serves as the main carbon and energy source. Thus, biodegradation methods and speeds vary significantly depending on the kind of substrate and circumstances such as temperature, pH, and aqueous phase solubility, although carbon dioxide and methane are usually the main end products of the degradation.

1.2. Aliphatic compound degradation in response to growth:

CO2, H2O, and cell biomass are produced through growth-associated breakdown. Degradation is catalyzed by the cells, which serve as complex biocatalysts. Furthermore, when the degradable contaminants in a polluted location have been exhausted, cell biomass may be mineralized. Aromatic hydrocarbons such as benzene, toluene, ethyl benzene, xylenes, and naphthalene, as well as other bulk chemicals, are extensively utilized as fuels, industrial solvents, and feedstock for the petrochemical industry. Another family of chemicals is phenols and chlorophenols, which are used in a number of industries. Because all microbes produce significant quantities of aromatic chemicals such aromatic amino acids, phenols, and quinines, many have developed catabolic mechanisms to breakdown them. When the molecules of man-made organic substances (xenobiotics) are comparable to natural ones, bacteria may breakdown them[9].

Benzene, condensed ring, and similar compounds have greater thermodynamic stability than aliphatic molecules in general. A dioxygenase catalyzes hydroxylation of benzene, resulting in a diol (Scheme 1), which is subsequently converted to catechol by a dehydrogenase.

1.3. Monooxygenase and dioxygenase processes:

Monooxygenase integrates one O atom from O2 into the xenobiotics substrate and reduces the other to H2O in this mechanism. Dioxygenase, on the other hand, integrates both atoms into the substrate.Other aromatic hydrocarbons' breakdown pathways include hydroxylation and dehydrogenation. The addition of a substituent group to the benzene ring opens up new possibilities for attacking side chains or oxidizing the aromatic ring. Only a few processes, such as hydroxylation, oxygenolytic ring breakage, isomerization, and hydrolysis, may degrade many aromatic substrates. Because of the inducible nature of the enzymes and their substrate specificity, bacteria with high degrading activity, such as pseudomonads and rhodococci, may adapt their metabolism to the efficient utilization of substrate combinations in contaminated soils and proliferate at a fast rate[10].

1.4. Organ pollutant co-metabolic degradation:

Co-metabolism is a common microbial activity and the foundation of biotransformation, which is utilized in biotechnology to change chemicals into usable modified forms. Microorganisms that thrive on one substrate also oxidize a different substrate. Although the co-substrate isn't included, the result may be used as a substrate for other species in a mixed culture. The enzymes of developing cells and the production of cofactors required for enzymatic processes, such as hydrogen donors (reducing equivalents, NADH) for oxygenases are the foundations of co-metabolic transformation. Several aromatic substrates, such as catechol and protecatechuate, may be transformed enzymatically to natural degradation intermediates.

1.5. Co-metabolic degradation of organo-pollutants:

Chloroaromatic co-metabolism is a common bacterial activity in mixtures of industrial contaminants. 2-chlorophenol undergoes co-metabolic transformation to produce dead-end metabolites such 3-chlorocatechol, which may be auto-oxidized or polymerized in soil to create humic-like structures. The detoxifying function may be fulfilled by irreversible binding of dead end metabolites. The development of novel catabolic characteristics is fueled by the buildup of dead-end products inside microorganisms under selection pressure. As a result, the recalcitrance of organic contaminants rises as the halogenations level raises. An increase in the molecule's electrophilicity allows halogen, nitro, and sulfo groups to be substituted at the aromatic ring. These chemicals are resistant to the electrophilicity assault of aerobic bacteria's oxygenases. Polychlorinated biphenyls (PCBs), chlorinated dioxins, and certain pesticides like DDT are examples of compounds that survive in atoxic environment. The reductive assault of anaerobic bacteria is very useful in combating the relatively high persistence of halogenated xenobiotics. Anaerobic bacteria's reductive dehalogenation is either a byproduct or a novel form of anaerobic respiration. The procedure lowers the degree of chlorination, making the product more accessible to aerobic bacteria for mineralization.

The initial stage in the breakdown of PCBs, reductive dehalogenation, requires anaerobic conditions with organic substrates acting as electron donors. To enable anaerobic bacteria to transmit electrons to these chemicals, PCBs receive electrons. Reductive dehalogenation-catalyzing anaerobic bacteria seem to be quite common in nature. Mixed consortia make up the majority of dechlorinating cultures. The results of anaerobic dechlorinating are invariably di- and monochlorinated biphenyls. Aerobic bacteria may further metabolize these products.

As reviewed, the rates of biodegradability of a particular substrate are primarily determined by the accessibility of the substrate to enzymes, which can be improved by a variety of methods, including

- Mechanical methods: disintegration and grinding of solid particles present in sludge: releases cell compounds and creates a new surface where biodegradation can occur.
- ultrasonic disintegration
- Chemical Method
- Thermal pretreatment: heat hydrolysis may divide and dissolve a substantial portion of the solid component of sludge into soluble and less complicated molecules.
- Enzymatic and microbial pre-treatment: a promising method for the future for some specific substrates (e.g. cellulose, lignin, etc.).
- Anaerobic micro-organism stimulation: some organic compounds (e.g. amino acids, cofactors, cell content) act as a stimulating agent in bacteria growth and methane production. The majorities of the techniques listed above take place prior to methanation and result in a superior supply of methanogenic bacteria through appropriate substrates.

1.6. Biodegradation in anaerobic conditions:

Many bacteria thrive in aerobic environments. Aerobes use oxygen to oxidize substrates like carbohydrates and fats to generate energy, which is referred to as the cellular respiration process (CSP). Glucose molecules are digested into smaller molecules in the cytoplasm of the aerobes prior to the start of CSP. The smaller molecules are subsequently transported to a mitochondrion, which is where aerobic respiration occurs. Small entities are broken down into water and carbon dioxide with the release of energy using oxygen. Unlike anaerobic degradation, aerobic degradation does not generate unpleasant gases. In most instances, the aerobic process results in a more thorough digestion of solid waste, which reduces build-up by more than 50%. Oxidations catalyzed by oxygenases and peroxidases are the most important enzyme processes in aerobic biodegradation. Oxygenases are oxido-reductases that incorporate oxygen into the substrate. Oxygen is required by degradative organisms at two metabolic sites: the first assault on the substrate and the end of the respiratory chain. Higher fungi have a unique oxidative mechanism based on extracellular ligninolytic peroxidases and laccases for lignin breakdown. The co-metabolic breakdown of persistent organic pollutants relies on this enzymatic system. The bacteria that dominate contaminated soils come from a variety of genera and species. Mineral oil components and halogenated petrochemicals are the two most significant groups of organic contaminants in the environment, and aerobic microorganisms' biodegradation capabilities are critical. Petroleum hydrocarbons, chlorinated aliphatics, benzene, toluene, phenol, naphthalene, fluorine, pyrene, chloroanilines, pentachlorophenol, and dichlorobenzenes are among the contaminants that degrade most quickly and completely under aerobic circumstances. Many bacteria cultures can thrive on these compounds and produce enzymes that breakdown them into non-toxic forms.

2. DISCUSSION

The author has discussed about the Biodegradation Products, This chapter covers biodegradation techniques, as well as the biodegradation of a wide variety of industries chemicals, plastics, and other biomass, as well as advances in anaerobic digestion innovation and biogas generation, plastic handling, and biocomposites synthesis and degradation. The synthesis of biopolymers is addressed. Technical issues, as well as the possibility for processing municipal organic solid waste, manure, and polymers to generate biogas as a sustainable energy source and pollution abatement technique, are discussed. Biohydrogen, bioethanol, biobutanol, and other biotransformation that result in valuable chemicals, such as the breakdown of larger molecules, polymers, and biomaterials, are excluded. During their manufacture and use, these chemicals are often discharged into the environment via different routes in the air, water, and land. Massive quantities of solid waste of all sorts, as well as its effective disposal, have spawned a host of problems that need technological advancements. Many of these compounds degrade slowly and have negative effects on plants and animals, causing extensive environmental damage. Pollution caused by abandoned plastic goods is also a significant problem. Industrial wastewaters from organic compound manufacturing are enormous, with concentrations ranging from a few parts per million to millions of parts per million.

3. CONCLUSION

The author has concluded about the Biodegradation Products, Biodegradation, both aerobic or anaerobic, is a technique for cleaving big particles into smaller in a series of stages from a mosaic of agricultural inputs, with some of the large molecules ultimately valorized as an emission control approach and a source of energy in biogas. Biogas, which may be utilized as a sustainable energy source, can be produced from practically any kind of biofuel, including major agricultural sectors and other organic waste streams. Animal excrement that has not been properly handled or maintained is a major source of air and water pollution. Nutrient leakage, especially nitrogen and phosphorus leakage, as well as ammonia absorption and contaminations, are among the most severe problems. According to Steinfeld et al., the animal production sector accounts for 18 percent of total CO_2 equivalent production and 37 percent of artificial methane, which has a global warming potential of 23 times that of CO2. Furthermore, 65 percent of artificial nitrous oxide and 64 percent of humankind ammonia emissions are attributed to the worldwide animal production sector.

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