A Comprehensive Review on Biodegradable Waste: Generation, Processing Management, and Environmental Applications

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Abstract

This unique class of biodegradable waste has advanced rapidly over the past few decades, propelled by the growing importance of the biopolymers area. Due to their unique adjustable electrical conductivity and biodegradability properties, which make them attractive in many applications, biodegradable polymers have garnered a lot of attention since they play a crucial part in our life. We discussed the development of biodegradable waste, its various types, their effects, Management and their potential applications in this article. An emphasis on the applications of biodegradable waste in drug delivery, tissue engineering, wound healing, showcasing the latest research, and various biodegradable polymer applications in contemporary biological applications will be special. Our review offers a thorough analysis of current developments, upcoming difficulties, and opportunities related to the commercial applications and evolution of biodegradable waste.

Key words: Biodegradable waste, composting, management, segregation.

1. Introduction

Waste can be defined as an unavoidable component that results from household or workplace operations. An insufficient waste disposal system poses a serious threat to human health and the environment[1]. Biodegradable and non-biodegradable garbage are two categories of waste. Non-biodegradable wastes are organic waste sources that take hundreds of years for the earth's natural processes to break them down. Medical waste, plastics, batteries, glass, metal, and other materials can cause significant harm to the ecology[2]. Many of them, nevertheless, are recyclable and can be used to create new goods. Waste materials that are easily broken down or destroyed by biotic (such as bacteria, fungi, plants, animals, etc.) and abiotic (such as pH, temperature, oxygen, humidity, etc.) factors are known as biodegradable wastes[3].

2. Types of biodegradable waste

Green Waste: This is also known as "biological waste," which is any organic waste that is compostable[4]. Its constituents include typically refuse from gardens, such as grass clippings or leaves, as well as kitchen trash from homes or businesses. Materials that are high in carbon, like pine, hay, dried leaves, or straw, are referred to as "brown wastes"; in contrast, green wastes have concentrations of nitrogen[5].

Food Waste: Environmental challenges are driving a rapid increase in the attention being paid to biodegradable waste management (FBWM) and sustainable food in the municipal solid waste management system[6]. For example, Japan produces a huge amount of FBW due to their love of raw foods, including raw eggs, raw veggies, and raw fish or meat (sashimi, sushi, etc.)[7]. Particularly fresh fruits, together with other foods, population increase, and improvements in lifestyle and living standards, have inevitably brought about a number of logistical issues that lead to enormous volumes of FBW[8].

Paper Waste: Paper waste poses serious issues in numerous countries and industries worldwide. Such paper may account for over 70% of an organization's overall waste due to printing errors, billing errors, junk mail, and pack-aging. One crucial way to lower pollution and trash accumulation is by recycling. You can recycle outdated news pages, notebooks, and used envelopes. Unfortunately, carbon paper, stickers, and anything that has come into contact with food cannot be recycled[9].

Biodegradable plastics: These polymers are typically made from mixtures of renewable raw materials, microbes, petroleum chemicals, or all three. Biodegradable polymers can break down into carbon dioxide, water, and biomass by the action of living things, most commonly microbes. It is known that there are two types of biodegradable plastic: hydro-biodegradable (HBP) and oxo-biodegradable (OBP). Both of them degrade first by chemical processes called hydrolysis and oxidation, respectively, which are subsequently followed by biological processes[10].

Fig. 1 Classification of biodegradable waste

3. Harmful effects of biodegradable waste

- A significant number of microbial flora grows around the wastes, which may raise the possibility of microbe-caused infectious diseases in individuals, animals, and plants.
- Certain gases may be released during burning, which might cause a bad smell[11].
- Garbage dungeons created by waste collection might encourage the development of infectious diseases by mosquitoes, rodents, and other vectors[12].
- An unfavourable impact on the climate could result from improper treatment of biodegradable garbage. For example, the release of methane during anaerobic fermentation could lead to the creation of landfill gas[13].

4. Management of biodegradable wastes

4.1 Segregation of Wastes

When these wastes combine with the soil, manure is created. Non-biodegradable wastes are those that do not disintegrate due to the action of other organisms. Metals, glass, and plastic are a few examples. A large number of them can be recycled to create new items[14].

Two trash cans should be utilised, one for biodegradable wastes and another for non-biodegradable wastes, depending on the kind of wastes. This will make it simpler to sift rubbish and recycle it to create useful items. Biodegradable trash such as fruit and vegetable peels, spoilt food, tea leaves, egg shells, tissue paper, hair, etc. should go in green bins. Glass bottles, plastic waste, used batteries, chocolate wrappers, polythene bags, and other recyclable materials go in the blue bins[15].

4.2 Composting

Biodegradable wastes, also known as organic wastes, are composted to create manure. Examples of these wastes contain vegetable peels, food scraps, leaves, dead flowers, and egg shells[16]. Composting is the recycling process that involves burying organic wastes such as vegetable peels, food residue, leaves, etc.—in compost pits. The recycling process of composting is easy and nearly straightforward. The action of microscopic organisms like bacteria and fungi breaks down the biodegradable wastes. Red worms, commonly known as red wrigglers, are a type of earthworm that breaks down waste materials in a particular type of composting[17].

4.3 Vermicomposting

Vermicomposting is the process of composting with the aid of red worms, a particular kind of earthworm. The organic matter is broken down by red worms producing nutrient-rich manure that improves soil fertility. Vermicompost is a loose soil-like material that can be made in three to four weeks. Animal products and greasy materials shouldn't be placed in the pit since they may encourage the growth of organisms that cause disease[18].

4.4 Landfills

Landfills are large spaces utilised for disposing of trash. Another way to handle enormous volumes of biodegradable garbage is through landfills. Trash is buried in a landfill so as not to harm the surrounding environment. Because it breaks down so slowly, garbage buried in landfills stays here for a very long period. A landfill may be turned into a park once it is filled. As an illustration, consider Indraprastha Park[19].

4.5 Waste handling and transportation

The local garbage management facilities handle the rubbish collected from households. Local government agencies frequently offer domestic waste collection services, while private businesses handle commercial and industrial waste removal.

There are no official garbage collection systems in many parts of the developing world, particularly in the less developed nations. Waste transportation is the railroads' conveyance of waste over predetermined zones[20]. vehicles such as trucks, barges, tankers, or other kinds. incidents involving trains or automobiles can cause trash to leak and toxins to be released, potentially contaminating the air, water, and soil. Additionally, trash could spill out during loading or unloading dumping in the course of transit[21].

The risks associated with transporting rubbish through communities is a concern shared by many residents. Some people are also concerned that hazardous chemicals or materials that could contaminate nearby drinking water sources could be present in the municipal waste from metropolitan regions. Lastly, the creation of a possible legislative proposal's impact assessment is most important. The goal is to investigate different approaches to biodegradable

waste management, such as those used in the EU, and to develop suitable policies. choices for assessment, including the effects on the economy, society, and environment, as well as potential advantages or hazards[22].

5. Uses and application of biodegradable waste in pharmaceutical

5.1 In Drug Delivery

These days, one of the main concerns for drug delivery experts is creating effective drug delivery systems. The process of guiding a pharmacologically active substance to produce a therapeutic effect in people is known as drug delivery[23]. Notably, a number of drug delivery techniques have been developed and investigated at the intended drug delivery site[24]. Drug delivery applications for biopolymers include parenteral, nasal, and oral administration; additionally, transdermal drug delivery management, protein and gene delivery, and implant-based disease treatment. Numerous aliphatic polyesters and cross-linked polyorthoesters have been investigated for application in drug delivery, particularly in the delivery of vaccines, antineoplastics, and antidiabetics[25]. Moreover, synthetic peptides can form cross-links in synthetic hydrogels since they are enzymatically decomposable peptides. Similar to this, new polyphosphoesters based on phosphazenes need to have a distinctive backbone made up of P-atoms connected to carbon and/or oxygen[26]. In particular, hydrophilic and lipophilic medications can be encapsulated in phosphazine biopolymers and copolymers. Biodegradable polymers based on chitosan have favorable absorption, well-organized release, and bioadhesive properties[27]. Biopolymers have been investigated as polymeric vectors for delivering genetic or medicinal cargo[28].

5.2 Wound Healing

These biodegradable polymers, which include monomers of amino acids, nucleotides, monosaccharide etc., are composed of a series of repeating units bound by various covalent linkages[29]. Furthermore, due to the three-dimensional network structure of these biodegradable polymers, biological fluids can quickly saturate them. They are a suitable material for pharmaceutical and medical applications, particularly for implants, tissue engineering with drug delivery, and wound healing applications because of their inherent curative properties. There are also other varieties of chitosan-based material dressings available worldwide[30]. Hemostatic and antibacterial properties are shared by dextrosan and dextatic[31]. Opticell is used for medical wounds, donor sites, diabetic foot ulcers, pressure ulcers, medical wounds, partial and thicker wounds, and first- and second-grade burns. Also, many biodegradable polymers such as starch, glucan, dextran, and silk have been reported to have their uses in the healing of wounds[32].

5.3 Hygiene and Medical devices

Alginate fibers, catgut, collagen, chitosan, and super absorbent polymer are examples of biodegradable materials that are mostly used in the medical and hygiene fields[33]. These many regenerative medicine approaches should eventually make the transition from "bench to bedside." However, in order to enhance the mechanical properties of biomaterials—which are crucial for this kind of biological application—significant study is needed[34].

PEA materials enable applications in tissue engineering, hydrogel, and drug delivery. They also have reasonable thermomechanical properties. More significantly, hospitals deal mostly with supplies linked to cleanliness and health, including surgical masks and gowns, gloves, sterile napkins, bedding, scrubs for medical professionals, nursing uniforms, antimicrobial textiles, wipes, etc. Surgical costumes made of biobased PET can be made instead of traditional cotton, polyester, and PE[35].

6.Conclusion

Although biodegradable garbage presents serious risks to the environment and human health, its negative impacts can be lessened with good management and use practices. We can create focused remedies to lessen its effects by comprehending the several kinds of biodegradable trash, including food waste, agricultural waste, and human waste. This review showed embracing sustainable biodegradable waste types, harmful effects, management and innovative pharmaceutical applications, we can minimize environmental harm, promote human health, and foster a more circular economy.

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