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Management of Biodegradable Waste

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Abstract: Wastes that are easily broken down or destroyed by biotic (plants, animals, bacteria, fungi, etc.) and abiotic (pH, temperature, oxygen, humidity, etc.) elements are known as biodegradable wastes. This procedure makes complex materials that will decompose into more easily understood organic chemicals and eventually disappear into the soil. This is a naturally occurring process that has few environmental hazards and can proceed slowly or quickly. These waste products, which include food waste, paper waste, and biodegradable plastics like those found in municipal solid garbage, could be referred to as "green waste." Hospital waste, dead animals, plants, sewage, manure, sewage sludge, human waste, and trash from different slaughterhouses are some examples of biodegradable wastes. One could argue that garbage that biodegrades is recyclable.

Keywords: recycling, biodegradable, biotic, bio-waste, environment

I. INTRODUCTION

Waste can be said to be an inevitable constituent arising as a consequence of domestic activities or industrial action. They have little or no value, due to the fact that they generally have no alternative use. Lack of adequate waste disposal system generates a great challenge for both the environment and human life. Waste can be divided into biodegradable and non-biodegradable waste. Non-biodegradable wastes are inorganic sources of waste that are not easily decomposed by natural agents, they can remain on the planet for hundreds of decades. They are sources of great damage to the ecosystem examples include plastics, batteries, glass, metal, medical waste, etc. However, many of them can be recycled to produce new products. Biodegradable wastes are waste materials easily degraded or broken down naturally by factors such as biotic (bacteria, fungi, plants, animals, etc.) and abiotic (pH, temperature, oxygen, humidity, etc.).

The process is such that complex organic matter is broken down into simpler organic compounds such as carbon dioxide, water, methane, or simple organic molecules by microorganisms and other living things, acting in composting, aerobic digestion, anaerobic digestion, or similar processes [1]. This is a natural process that could be prolonged or rapid and poses little risks to the environment. These waste materials could be termed green waste (any biological waste that can be broken down into compost); including food waste, paper waste, and biodegradable plastics such are found in municipal solid waste. Other biodegradable wastes include human waste, manure, sewage, sewage sludge, and slaughterhouse However; if these biodegradable wastes are not properly managed they could become sources of pollution, thereby impacting the health of the environment negatively. Current clean-up strategies including recycling biodegradable waste have endeavoured to mitigate the detrimental impacts of such waste on the environment. This review chapter addresses the current methods (Recent Advances) in biodegradable waste management, which when adequately implemented, can reduce the impact of such waste on health and environment.

II. METOODOLOGY

2.1 Solid waste in rural areas

It is estimated that 0.3 to 0.4 million metric tons of solid waste are generated in rural areas per day (NIRD, 2016). Organic waste constitutes about 60–80 per cent of this waste. Cattle dung and crop residues constitute a major part of organic waste, which is estimated to be 1,650 million ton/day and 650 to 725 million ton, respectively. Biodegradable waste is generally composed of kitchen waste (fruit/vegetable peels, leftover food) and animal waste, crop residues and market waste.

Solid waste

2.2 Composition of waste in rural areas

The waste generation rate in small towns in India is 0.41 kg /capita/day while the surrounding villages generate around 0.08 kg/capita/day of solid waste (IJERMCE 2018). Biodegradable waste generated in villages includes waste from the kitchen, Agricultural waste and cattle dung, among others.

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2.3 Components of biodegradable waste management

The components of biodegradable waste management include:

» Segregation
» Collection and transportation
» Treatment
» Disposal

Due to smaller quantities of biodegradable waste (from household chores, excluding agriculture and livestock-related biodegradable waste), local usage (at generation level itself) and its resource value, its management does not need all the steps mentioned above in rural areas.

2.3.1 Segregation of waste

As far as possible, solid waste should be managed at the household level so that minimum waste is delivered for management at the community level. This may involve the following steps:

» Household waste should be segregated at the source. This can be achieved by generating awareness among people to segregate waste at the household level into dry and wet waste in two different bins/containers.
» Reusable segregated non-biodegradable waste may be reused at the household level or sold to the recyclers/*kabadiwala.*
» The common types of wet and dry wastes are as follows:
» Efforts also should be made to treat the segregated biodegradable waste at the household level by adopting a suitable composting method.

DRY WASTE:
Empty shampoo bottles
Empty bottles/containers
Empty milk pouches
Use door mats
Used toothbrush
Newspaper/packaging materials/cardboard pieces
Metal boxes/containers
Glassware
Used shoes/leather items
Broomstick

WET WASTE:
Vegetable peels
Fruit peels
Rotten fruits and vegetables
Leftover food
Used tea leaves/teabags
Eggshells
Coconut shells
Used flowers, leaves
Cow dung
Agricultural crop residues

2.4 Collection and transportation

For the collection and transportation of solid waste in rural areas, the following strategy may be followed:

Self-help groups (SHGs) or groups of unemployed youth in the village could be identified for collection and transportation of household waste into the village segregation shed/solid waste processing centre (SWPC). Each member may be responsible for the collection of waste for about 75–100 households. SHG members need to be provided with a suitable number of carts or tricycles for collection and transportation of waste to community storage bins. The number of tricycles may be decided based on the size of the panchayati raj institution (PRI) and the density of the population. Normally one tricycle should suffice for 100–200 households. At least few spare tricycles have to be kept so that the collection system is sustainable even in the case of breakdown of few tricycles. Indicative photos of tricycles and pushcarts.

2.5 Treatment and disposal

Waste collected at the village segregation shed/solid waste processing centre can be segregated into different waste streams. Whereas biodegradable waste can be converted into compost by simple composting methods, recyclable waste can be sold to the waste recyclers/kabadiwalas by Gram Panchayats.

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For effective management of biodegradable waste in rural areas, the following two methods can be adopted:
i. Composting
ii. Biogas/biomethanation

2.6 Composting - Process and
Types
Composting is a process of controlled decomposition of the organic waste in which the organic matter breaks down under bacterial action, resulting in the formation of humus-like material called compost.

Factors affecting the composting process
» Microorganisms: Microorganisms breakdown organic matter and produce carbon dioxide, water, heat and humus.
» Moisture content: Moisture is necessary to support the metabolic activity of the microorganisms.
» Temperature: By affecting the growth of microorganism, temperature plays an important role in composting process.
» Carbon to nitrogen (C/N) ratio

Materials to be avoided in composting
» Non-biodegradable waste- like plastic, rubber, polythene packaging materials, Coal Ash.
» meat scraps, bones, grease, whole eggs to the compost pile/pit because these material decompose slowly, cause odours and can attract rodents/animal.

Advantages of composting
» Composting minimizes or avoids greenhouse gas (GHG) emissions.
» By proper decomposition, biodegradable waste gets converted into good quality organic manure.
» Composting also prevents vector breeding and breeding of rodents.
» In the aerobic composting process, considerable heat is generated, destroying pathogens and weed seeds.
» Insanitary conditions arising out of solid waste are removed and the environment looks neat and clean.
» The economic benefits of the use of composts include improved soil quality, enhanced water retention capacity of the soil, increased biological activity, micronutrient content and improved pest resistance of crops.

MANUAL: BIODEGRADABLE WASTE MANAGEMEN

T**3.1 The composting process**
Several biological, chemical and physical processes take place during composting.

A. Biological process
The process of aerobic composting involves two stages: **thermophilic and mesophilic**. Various organisms are known to play a predominant role in the decomposition of organic waste. Different types of microorganisms are therefore active at different times and locations within the mass of organic matter depending upon the availability of substrate, oxygen supply and moisture content.

(i) Thermophilic stage
This is the first stage of composting wherein microorganisms decompose the easily degradable organic substances, resulting in the production of heat due to intense metabolic activity. In most cases with the moisture content of 55–60 per cent and airspace of 20–30 per cent in the bed of biodegradable waste, temperature rise from 35°C to 55–65°C is achieved within 2–3 days. Typically, thermotolerant fungi, thermophilic bacteria and actinomycetes are the predominantly active microorganisms at this stage. Heaps of waste are flipped at regular intervals to expose the material in the inner core to air so that temperature in these fresh sections rises again, and gradually the whole waste is sanitized from pathogens.

(ii) Mesophilic stage (decomposition)
This is the second stage in the biological process of composting. Due to the reduction in available nutrients and readily available carbon, the microbial activity reduces, causing a decline in the temperature of the heap. There is a shift in the type of active microbial species in the compost heaps. The composted material turns dark brown during this stage due to humus formation and starts to stabilize.

B. Chemical parameters

i. **Moisture:** Moisture is a critical factor in establishing stable conditions conducive for composting because the microbes need moisture for survival and growth. Moisture tends to occupy the free airspace between the decomposing particles. Hence, when the moisture content is very high, anaerobic conditions set in.

ii. **Aeration:** The composting process requires an adequate supply of oxygen for biodegradation by microbes. Under aerobic conditions, the decomposition rate is 10–20 times faster than under limited oxygen supply or anaerobic conditions. High oxygen levels in air voids should be maintained within heaps of waste through turning and mixing at regular intervals.

III. RESULTS AND DISCUSSION

Production of Biogas from Biodegradable Municipal Waste

It is estimated that in 2011 around 1.3 billion tons of kitchen waste were generated worldwide, and this amount is constantly growing. In the interests of the environment and society, kitchen waste management has become important in waste management. Efficient management involves the disposal of this fraction of waste in an ecological manner and in accordance with the principles of sustainable development [19]. Traditional methods of recycling biodegradable waste consist only in neutralizing them.

Therefore, the process of anaerobic decomposition of organic matter is used, the effect of which is the production of biogas and digestate. Selected municipal waste, such as household kitchen waste, restaurant waste and expired food, can be successfully used as substrates in biogas plants. The biogas obtained from them has a high methane content [20]. Contrary to other fractions, biodegradable waste of food origin is characterized by biochemical diversity (heterogeneity) and therefore it is a good material for anaerobic treatment. It is caused by a relatively high concentration of proteins, carbohydrates, fats and the lack of heavy metals. Thanks to these features, food waste has the greatest biogas potential compared to other waste. During anaerobic digestion, 100-200 m3 of biogas can be produced per 1 Mg of food waste [21]. Assuming that biogas contains 60% methane, it means the possibility of producing 60-120 m3 of fuel with the parameters of high-methane natural gas from 1 Mg of waste. Assuming that 50% of biodegradable waste collected in 2020 (see Table 1) was kitchen waste, potentially the equivalent of 45.6-91.2 million m3 of natural gas can be produced.

Polish regulations, which clearly define what may be a substrate for agricultural biogas plants, do not include biodegradable municipal waste, which is kitchen waste (code 20 01 08) [22]. According to the act, kitchen waste includes: food scraps (excluding meat), fruit and vegetable peelings and skins, expired fruit and vegetables, egg shells, unused bakery products, coffee and tea grounds, green waste, including paper coffee filters [23]. In agricultural biogas plants, waste specified in the Act can be utilized, thus becoming installationsthat fit into the area of closed-loop management.The introduction of the possibility of using kitchenwaste as substrates for the production of agriculturalbiogas could contribute to an increase in the numberof agricultural biogas plants in Poland. They wouldbe created in suburban areas, around large cities,constituting a source of renewable energy and a placefor safe disposal of biodegradable waste generated incities and suburban areas.An alternative solution for agricultural biogas plantswould be Danish technology, i.e. centralized anaerobicdigestion plants (CAD). Centralized biogas plantsuse waste generated in their area, such as manure,slaughterhouse waste, sewage sludge, biodegradablewaste from households and various types of wastefrom the food industry.

The owners of such plants are agricultural cooperatives. Such installations arelocated close to cities, as they produce electricit and heat supplied to the power and heating networks,respectively. Due to the location near cities, the higheststandards of environmental protection and odornuisance control must be maintained. Substrates arestored in airtight tanks and sterilized or pasteurized before transhipment, by means of a sealed installation,to the fermentation chambers. All the air in the system passes through the odor filters and the plants built with the latest technology are completely closed and all odorsare removed by chemical processes [24]. In Poland, such biogas plants should be built in the areas of large municipalities, which would beinvestors, because they are more expensive to build than agricultural biogas plants. The use of substratein the form of kitchen and agrifood waste allows toincrease profitability, enabling economic activity in Poland, where subsidies are lower than, for example,in Germany or Austria. Equally important benefits are energy production, allowing to achieve the mandatoryshare of renewable energy in the national energy mixfor 2030. The target set by the EU is 32% and the achievement of the goals set out in the European GreenDeal, such as greenhouse gas emissions to at least55% by 2030 from 1990 levels, transition to a circular economy and improvement in energy efficiency by at least 32.5% [25].

In order to identify problems related to the collection of municipal biodegradable waste in the period October2020 - March 2021, biodegradable and mixed waste was systematically weighed in two households that conduct selective collection of municipal waste. In the first household, there were three adults living in a single family house with its own dumpster shelter. The shelteris large enough to accommodate a rack for bags in which glass, plastics and metals, paper and glass are collected once a month. There is also a mixed waste container in the shelter. Biodegradable waste from garden careis collected in a brown bag stored separately. Kitchen waste is collected in a brown bag, which is placed *The Importance of Biodegradable Waste...2251* in a closed metal container to protect against rodents. Mixed waste and kitchen waste were weighed before collection. Mixed and biodegradable waste is collected every 2 weeks. It is too rare, especially when the temperatures are high, which accelerates the rotting and molding of the waste.

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In the second household, waste was generated bytwo adults living in a multi-family building in one of the Krakow estates. The apartment segregated waste (mixed waste, biodegradable waste, plastic, metal, glass and paper). The waste was thrown into containers placed in the dumpster shelter located next to the building.

The capacity of the containers was too small in relation to the amount of waste generated by the inhabitants. Therefore, instead of being placed in containers, waste was thrown close to them. The lack of proper segregation and placing individual fractions in the wrong containers was noticed. The biodegradable] waste container is too small in relation to the amoun of biodegradable waste generated. Large amounts of this waste are produced by the inhabitants of the ground floor apartments with their own gardens. More green waste is generated in them than in flats on the upper floors. The container for biodegradable waste in the dumpster shelter is not adapted to the collection of green waste from gardens. As a result, such waste is dumped in a mixed waste container. Fig. 2 shows howthe amounts of mixed and kitchen waste per person developed in the period from October 2020 to March 2021. Looking at the graphs, you can see that there are differences in the amount of waste collected inindividual months.

In household 1, the amount of mixed waste collectedper person was almost constant and did not exceed 2 kg.

This is due to the fact that in this household only dairy products are purchased in factory packaging, which, after emptying, are washed in the dishwasher and put in bag for plastic and metal waste. The amount of kitchen waste was greatest in October, as a small amount of fruit and vegetable preserves was made. In the household 2, the amounts of mixed waste and kitchen waste changed throughout the year. This was due to the situation related to the renovation of the apartment and the removal of plants (flowers and vegetables) on the large terrace belonging to the apartment. October 2020 was the month of producing biodegradable waste both from the balcony and from preserves made at that time for the winter. The use of fruits and vegetables gave large amounts of fruit and vegetable peels. The last months of 2020 in household 2 were devoted to renovation. A lot of mixed waste was created then, which did not qualify for segregation.The months from January to March showed stabilization and there were slight differences in the amounts of both biodegradable and mixed waste.

The Impact of Biodegradable Waste On Sustainable Development - Economic, Social and Environmental Aspect

Biodegradable waste is an important area of the waste management system both in the European Union and in individual Member States. In Poland, the problem of selection, collection and management of biodegradable waste is a big challenge both in terms of organization, administration and technology. Unfortunately, despite the large potential of this fraction of waste, there are barriers to its management.

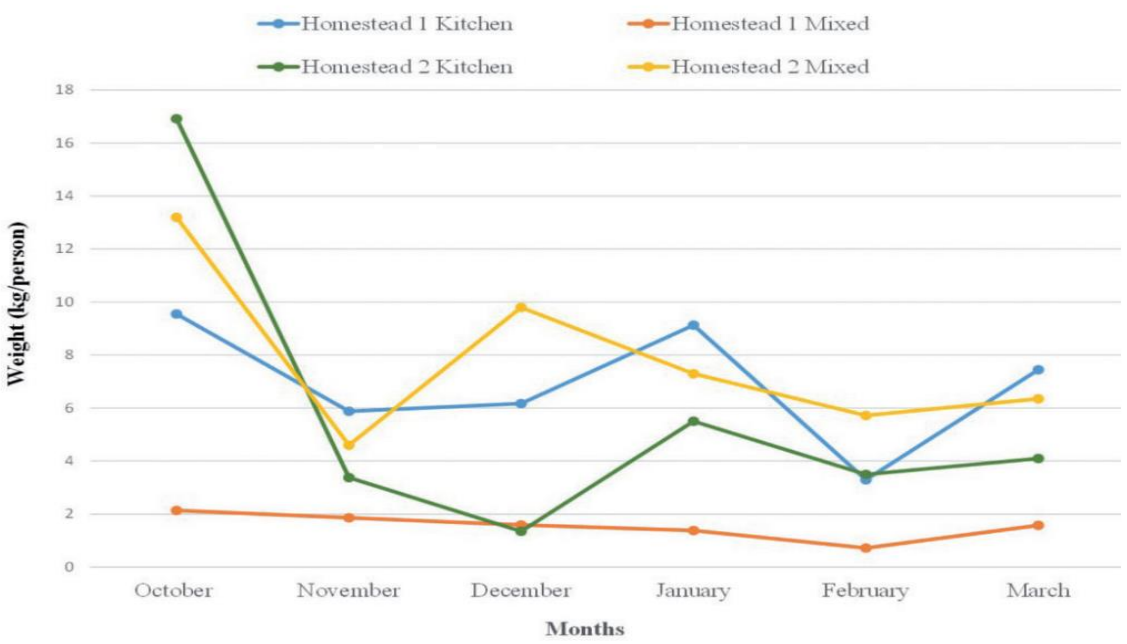

Fig. 2. Amount of mixed and kitchen waste collected per person from households 1 and 2 in the period from October 2020 to March 2021.

Difficulties arise for the waste generating entities themselves, as well as for the local administration. The use of biodegradable waste includes in the goals and directions of sustainable development [26]. The issues raised in the article concern environmental, economic and social aspects. Changes in waste management are necessary both on a macro and a micro scale. The United Nations Development Program goals set by 2030 [27]. The subject of the work is based on several of them.

The social aspects include the acquisition of knowledge and skills needed to promote sustainable development, for example through education for sustainable development and a sustainable lifestyle and the transfer of knowledge about proecological solutions used by waste management entities. Therefore, more effective environmental education and increasing public awareness will be of key importance for the acquisition and more effective management of biodegradable waste. Another environmental and economic goal is clean and available energy. This is related to ensuring universal availability of stable, sustainable and modern energy sources at an affordable price. Hence, it is planned to significantly increase the share of renewable energy sources in the global energy mix to 32% by 2030 [28]. Biogas obtained from biodegradable waste is one of the examples of solutions that meet these criteria. The undisputed environmental benefits include increasing the use of renewable energy sources, and thus the elimination of fossil fuels used for energy production. Additionally, it favour s the development of sustainable consumption and production models. The amount of municipal waste generated by its citizens is often used to measure the level of consumerism in a given region's society. If more biodegradable waste, which is often not separately collected for various reasons, could be obtained, it would be possible to achieve a greater economic benefit with simultaneous benefits for the environment, protecting its components against pollution to a greater extent and reducing the use of non-renewable resources. Such measures contribute to a higher level of protection of human health and the functioning of ecosystems, and can contribute to intergenerational fairness, taking into account the use of natural resource.

IV. CONCLUSION

The term "biodegradable wastes" refers to wastes that can be broken down by microbes or other living things, usually from plants or animals. Green garbage, food waste, paper waste, biodegradable plastics, and other waste materials are frequently found in municipal solid waste. If not correctly handled, they may contribute to contamination of the environment, which could cause illnesses and diseases, possibly even lead to human and other living things' deaths. Biodegradable trash can be disposed of after it has been collected, transported, treated, and stored in several ways. Biodegradable trash is quickly consumed rather than building up, joining biogeochemical cycles and contributing to quick turnover. They have the ability to generate

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