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REVIEW ARTICLE

The Problem of Solid Waste: Origins, Composition, Disposal, Recycling, and Reusing

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Abstract

Solid waste disposal is a major challenge in many industrialized and developing nations, both in metropolitan regions as well as rural ones. The collection and disposal of municipal solid waste (MSW) is a serious issue facing metropolitan areas in many nations today. An effective MSW management strategy must satisfy all of these criteria: financial viability; technical feasibility; social and legal acceptability; and ecological friendliness. Small and large cities alike have a major difficulty in dealing with solid waste management. One of the current study topics is the valuation of food organic waste. Existing waste disposal methods include the typical landfill, incineration, composting, and other methods of handling solid waste. Composting and anaerobic digestion have traditionally been the most widely employed methods for the treatment and exploitation of the organic part of MSW (AD). The amount of organic solid waste (OSW) being generated globally is rising at an astronomical rate. Agricultural waste, domestic food waste, human and animal wastes, etc. comprise the majority of OSW. They're often used as animal feed, disposed of in landfills, or burnt. OAWs are made up of protein-, mineral-, and sugar-rich components that may be employed as substrates or raw materials in other processes.

Keyword: Valorization of plastic and municipal solid wastes; Waste -to- energy; Organic solid state fermentation technology; Anaerobic digestion of organic solid wastes; Enhanced Land fill Mining

Introduction

Small and big cities in developing countries have the greatest waste disposal challenge. In part, this is due to an increase in the quantity of solid rubbish being created and the financial burden it throws on communities. Additionally, there is a lack of understanding of various factors that affect the entire handling system in solid waste management. Research on waste management in impoverished countries has shown that very little of the relevant literature and studies offer quantitative data. The major purpose of the study cited above was to identify and analyze the various factors that influence solid waste management. The investigation included four continents, 22 developing countries, and over 30 urban areas. In order to inspire participants and assess the factors that influence the success of solid waste management in the cities studied, a range of methodologies were outlined in detail[1].

Because of rapid population expansion, rapid urbanization, booming economies, and growing standards of life, municipal solid waste generation has expanded significantly in developing countries. Waste management, particularly of municipal solid waste (MSW), is a major environmental concern. For the most part, municipalities are in charge of trash disposal. A well-functioning system must be provided to the locals. Despite this, they are often confronted with a wide range of issues that go much beyond the local authority's capacity to manage MSW[2].

The composition of municipal solid waste (MSW) varies greatly from municipality to municipality and nation to country. The lifestyle, economic position, waste management legislation, and industrial structure all play a role in this wide range of difference. There is a direct correlation between the volume and composition of municipal solid waste and the proper treatment and management of these wastes. For the construction of the municipality's municipal solid waste to energy conversion plant, this information is required and relevant. Engineers and scientists can determine if MSW is suitable for use as a fuel based on its calorific value and elemental makeup. In addition, this data may be used to estimate the composition of gaseous emissions. These MSW are then processed using various energy conversion methods, such as gasification and incineration to name a few. However, it is important to be aware of the potential dangers posed by the ash. If the trash can be composted or converted to biogas as a fuel by biological conversion, this knowledge on its value will be invaluable[3].

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MSW composition is greatly influenced by time. A significant aspect in determining how much recyclable material can be recovered from such waste is how quickly it degrades. In 2013, the EPA projected that 254 million tons of MSW were generated in the United States.

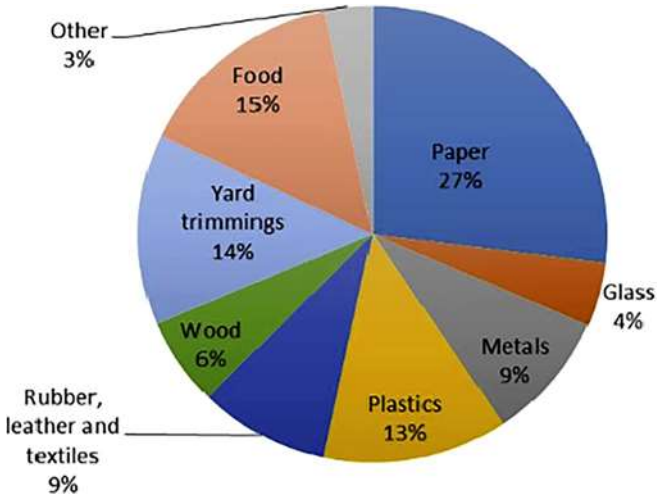

Fig. 1. Composition and classification (by material) of MSW generated by the UnitedStatesin2013[7].

Variable sources of household or municipal garbage are common. Solid waste created in developing nations is mostly produced in homes, followed by market or commercial sectors (10–30 percent). Quantities created from many sources, such as factories, streets, institutions, and so on, make up the second. As a general rule, solid waste generated from these sources is extremely; diverse. Consequently, they have a wide range of physical and chemical properties depending on where they came from. Many other types of items may be found in these piles include yard and food trash as well as a wide variety of other things that would be difficult to categorize, such as plastics and rubbers as well as leather and inert materials like paint cans and various paint syringes. The problem with separating and using this garbage as a material is that it is so diverse. Before any significant treatment can begin, these wastes must be fractionated and sorted. This process is one of the most significant and conventional stages in solid waste management since it provides data on the quality of the separated fractions for any prospective usage, which is crucial. But the public knowledge and active engagement of trash producers in various communities (i.e., how they follow the basic and principles of garbage sorting and separation) is critical to the success of any system for solid waste segregation[4].

Everywhere throughout the globe, especially in metropolitan areas, solid waste generation (SWG) is a problem and a matter of concern. Since SWG pollutes the environment in such huge amounts, many poor nations see it as a particularly difficult problem to solve. Waste creation in metropolitan areas has a significant impact on the sanitary and basic services such as sanitation facilities, water supply, waste management and transportation facilities Researchers have shown that metropolitan regions have a big challenge with the collection, storage, transportation and disposal of solid wastes. In cities in East and North Africa, and in the majority of developing nations, SWG poses a substantial threat to public health. The weak economy of these places is largely to blame for the lack of progress in solid waste management. Due to the lack of resources and conflicting objectives, many developing nations are unable to effectively manage their solid waste populations. As a result, the SWG is one of the world's most significant and pressing issues. SWG and composition are also impacted by other socioeconomic characteristics, such as the average family size, number of rooms, monthly earnings and job status. Solid waste composition and community social activities have been shown to have a direct correlation. Additionally, the content of household trash and its volume are affected by other variables, such as changes in source-sorting behavior and consumption of commodities. MSW management in all nations is affected by socio-cultural, economic, legal, political, and environmental aspects, as well as the availability of resources. The impact on the community's culture and economics of implementing any new MSW management or SWG technology should be considered[5].

The volume and content of municipal solid waste (MSW) have changed as a consequence of shifting consumer habits and fast technological advancements. It was observed that the amount of MSW generated per capita in Europe grew in 21 countries and dropped in 11 countries during the period 2001–2010, according to research by the European Environmental Agency. The quantity of garbage produced in 26 nations was also examined, and it was shown to have reduced in 6 of them between 2001 and 2008. In other words, the number and characteristics of trash differed throughout countries and even within the same city based on the criteria described above, including people's use patterns[6].

Certain industrial chemicals may be derived from wastes created across the globe, which is a sustainable and valuable source. A wide range of food wastes, including kitchen trash, rubbish, and swill, are referred to as food residues. Food processing, cooking, distribution, manufacture, and consumption all contribute to the development of these wastes. However, the definition of food wastes varies widely from city to city and country to country. In the EU, food waste is defined as "any food items that are wasted, or intended or obliged to be thrown," whether they are raw or cooked. While un-eaten food and food preparation wastes from restaurants, grocery shops and produce markets, institutional cafeterias and kitchens, as well as industrial sources such staff lunchrooms are considered food wastes by the (EPA) U.S. Environmental Protection Agency. "Food waste" and "Food loss" are both acknowledged by the United Nations in distinct ways. Losses in food quality and/or quantity are known as "food losses." Instead of referring to losses caused by merchants and/or customers' actions, the phrase "food waste" is more accurate. Although food wastes include uncooked raw materials, discarded foodstuffs, and even edible items from supermarkets or the wet market, they are not the only kind of waste. Using trash as a means of earning money[7].

The solid wastes were studied extensively. Solid wastes were also studied to see whether they might be used for economic gain. waste management in the Sakarya area, Turkey, was examined and investigated. Over the course of a year, gathered one ton of solid waste samples for the purpose of his research, after which he proposed the most effective and efficient methods for managing these wastes. The collected solid wastes were characterized over the course of a year, throughout each of the four distinct seasons. Wastes from Lahore, Pakistan, were divided into three distinct categories based on the city's socioeconomic structure. Depending on the area's socioeconomic status and household income, he discovered huge variations in the makeup of the garbage collected. Furthermore, Banar and Ozkan explored the characterisation of solid wastes in the region of Eskisehir, Turkey. They broke down their findings into various income levels to organize their research. They classified the people into three income tiers: the very poor, the middle class, and the very rich. Because of this, they determined the components of solid waste and the proportions of each category depending on their income. Based on income levels, further in-depth research was conducted to characterize the population. For example, they had some thoughts on how to better manage garbage. the features of the solid wastes were classified according to the seasonal fluctuations in their properties. In their research, they focused on three distinct socioeconomic categorie[8].

The categorization and composition analysis of solid waste play a key role in the selection and planning of the most appropriate transportation, storage, and disposal system. Characterization, on the other hand, is critical for assessing the potential effects on nature and civilization. Most municipal solid waste (MSW) contains between 0.5 and 0.7 percent nitrogen, 0.5 to 0.8 percent phosphorus, and 0.5 to 0.8 percent potassium by weight. Between 200 and 3000 Btu/lb, the calorific value is found. The properties of solid wastes may be greatly affected by poor bin collection techniques, collection, transfer, and/or transport systems. Other factors that may impact the characteristics of solid trash include inadequate route planning, a lack of collection schedule information, a shortage of solid waste collection trucks and bad roads, as well as a lack of infrastructure. effective and cheap garbage collection services were researched and reported. Organizing and developing microenterprises in the unorganized sector. One of the most significant variables influencing the processing of solid waste is the public's understanding of how the garbage is handled by the government studied the factors that impact household garbage disposal. According to their findings, the availability of waste facilities has a substantial impact on consumers' decisions on how to dispose of their garbage. According to their findings, the shorter supply of garbage containers and the longer distances these containers must travel enhance the likelihood of such wastes being dumped in open areas and along roadway shoulders. Furthermore, lack of regulation, well-equipped, properly built landfills all contribute to the inability to safely dispose of solid waste [9].

There is a worldwide environmental concern with the disposal of plastic garbage. Europe, the United States, and Japan create an average of 50 million tons of post-consumer plastic garbage each year. Using landfills to dispose of this plastic trash is deemed environmentally unsustainable. Landfills and the capacity of such sites are also diminishing significantly. On the other hand, the laws of the land are strict over the globe. Laws in the United States and many European Union regulations are concerned with the disposal and management of plastic garbage.

Plastics have a calorific value between 30 and 40 MJ/kg since they are mainly hydrocarbons. In other words, they may be cremated or burnt in municipal or other waste facilities to generate electricity and heat. They may also be used to supplement or even replace fossil fuels in a variety of manufacturing processes, such as blast furnaces and cement kilns, as an extra source of energy. Thermal applications may be used to completely decompose these plastic wastes. As a result, fossil fuels are being replaced by plastic trash in this new use. As a result, newer and more complex pollution control techniques are necessary. However, waste management may minimize greenhouse gas emissions. Incineration and/or landfill practices have been the subject of many studies non-biodegradable plastics and other non-biodegradable items will remain in the landfill, while biosolids will be converted anaerobically into landfill biogas, which may be used as an alternative source of energy. Incineration of plastics and other nonbiodegradable materials, on the other hand, releases more greenhouse gases than landfilling[10].

The collection, handling, and disposal of municipal solid waste (MSW) in metropolitan areas is a significant source of pollution. Significant environmental issues are being caused by improper management and disposal of municipal solid waste (MSW). Soil, water, and aesthetic pollution all fall under this category. Because of the rise in greenhouse gas emissions, these kinds of environmental issues have been linked to health concerns in humans.

The hazardous compounds found in residential garbage are distinct from those found in industrial waste streams. In the European Hazardous Waste Directive 91/689/EEC and the United States Resource Conservation and Recovery Act 1976 (RCRA), they are not rigorously regulated. All types of home garbage, including household hazardous waste (HHW), are dumped in landfills (HW). This kind of waste isn't properly accounted for in terms of quantity, quality, and relevance. Because the volume of HHWs is thought to be limited, the dangers associated with their disposal are also considered to be modest. Separate disposal of industrial, municipal solid waste (MSW), and other hazardous and toxic wastes increases their relevance [52]. Concerns have been expressed concerning the presence of a number of chemicals in home items. Disposal of HHW has also resulted in implications and impacts on the ecosystem. As a result, the landfilling of such HHW should comply with existing regulations in order to reduce environmental risk[11].

Approximately 71% of all municipal solid waste (MSW) is dumped in landfills across the world [54]. Batteries, paints, mercury waste, medicines, and car maintenance items are only a few of the numerous hazardous materials included in MSW. On the other hand, anaerobic bacteria can biodegrade more than 53% of the landfilled waste, including hard board paper, yard trash, papers, and food. In Europe and the United States, land filling is now the principal technique of disposing of rubbish[12].

Many solid wastes, including MSW, are deposited in landfills. A rudimentary knowledge of landfill design is thus useful. Furthermore, landfills are governed by Clean Air Act New Source Performance Standards as well as Subtitle D (Resource Conservation and Recovery Act), among other laws in the United States and other countries. As a result, landfills have progressed from being simple open-air dumping sites to highly constructed structures and sites specifically built to handle trash disposal. Leachate and gas migration are controlled by separating them from the environment and capturing contaminated water that comes into contact with the waste. Typically, a landfill is dug and lined with a system that contains layers to minimize leachate migration to the ground layers and collect such leachate for treatment, with the goal of protecting groundwater. In Fig. 2, a typical landfill design is shown[13].

Garbage disposal as solid wastes is a noxious and pervasive issue in many developing nations, affecting both urban and rural regions. Domestic organic and inorganic trash is deposited in a variety of open areas, including canals and sewers. Wastes are being dumped into open canals and drainage channels since there are no continuous rubbish collection services in place. As a result, they're no longer useful. Aside from some plastic and paper, these wastes contain very little hazardous material. In addition to the environmental hazards posed by the breakdown of their degradable elements, such hazardous materials also contribute considerable loads of BOD to the surrounding eco-system owing to their toxicity[14].

Many individuals and most organizations were unable to deal with environmental preservation measures because they did not plan for on-site treatment and/or safe disposal of solid wastes. People's disposal of rubbish and untreated sewage into surrounding sewers is, thus, negligent and unaware of the chain of events leading up to a health threat. There are no "financial incentives" to dissuade people from engaging in this practice and to urge them to change their behaviors. Individuals realize how cost-effective and environmentally friendly it is for them to dispose of their garbage in this manner. In reality, it's a major catastrophe for the local community and the nation as a whole. It is a proven truth that even little amounts of sewage may contaminate vast areas of water. The regulations now in place to protect the environment from such harmful practices are ineffective unless better solutions are found[15].

Solid waste disposal and recycling found that there are evidence that higher rates of recycling are connected with higher tipping costs at the disposal site. Recovery of produced solid waste is aided by high disposal prices. Solid waste value chains and the effective reuse of this material go hand in hand. They cited social, humanitarian, and regulatory considerations as reasons why certain communities have developed significant recycling practices. In addition, the author found that persons who often go to the trash cans are more inclined to recycle particular items at home. As the distance to recycling bins reduces, the number of fractions that individuals separate, sort, and collect their solid trash at home grows. By encouraging markets for recycled materials and increasing the number of specialists at recycling enterprises, Minghua et al. say that recycling rates may be increased. Scholars cited other key variables, such as financial assistance for various recycling programs, to help strengthen recycling infrastructure in their nation. Drop-off and buy-back facilities were recommended by other researchers. the informal sector should be organized to recycle solid wastes[16].

Many nations have a severe environmental challenge today because of the difficulty of collecting and disposing of municipal solid waste (MSW). MSW management systems must be financially sustainable, technically possible, socially and legally acceptable, as well as ecologically beneficial in order to be considered sustainable. Currently, European policy favors a variety of reasonable approaches to managing natural resources. In the present day, waste valorization is a promising technology. MSW may be separated at source and combined with material recycling as well as waste-to-energy generating processes to create a process that is feasible. Disposal or mechanical sorting of MSW at landfills, on the other hand, do not significantly enhance MSW management. Because of this, landfills must be the final destination for the MSW waste. Conventional landfills for the disposal of municipal solid waste (MSW) are still being built in several nations. noted, the insufficient public acceptability that leads to several social issues is a critical consideration when selecting a landfill location[17].

The amount and classification of solid waste is critical to the long-term viability of waste management programs. the most crucial procedures are the measurement and characterization of all sustainable solid waste management systems. In order to integrate recycling and resource recovery technologies into the relevant solid waste management systems, it is necessary to analyze the composition and categories of solid waste at a specific location. Additionally, the data may be used to aid in the development of infrastructure, policy, and program sizing for the integrated solid waste management system[18].

The management of these wastes is very necessary in order to avoid any major environmental health problems and to treat them. Landfills are the most common and least expensive method of disposing of solid waste. People have been producing solid trash since the dawn of time. Solid garbage was deposited in broad open regions of land during these early periods. The population density was low at the time. Instead, rising standards of living, an expanding population, and fast urbanization have resulted in massive accumulations of solid waste around the globe MSW are a result of a wide range of activities, including those carried out in individual residences, public and private institutions, and commercial establishments. They all contribute significantly to today's solid trash[19].

A wide range of disciplines are involved in waste management, including engineering, humanities, sociology and biology. A country's degree of development is reflected in the effect on solid waste management and in the choice of such management. Waste management in many affluent nations is used to produce renewable energy and other new goods, like compost. Investing in trash recycling for agricultural use is a priority in these nations. The choices made by municipal officials and the structures connected to the type, amount, and quality of local trash influence the choice of solid waste management. The term "household waste" refers to any garbage that originates in the home and is disposed of there. More than two-thirds of the municipal solid waste (MSW) stream is made up of this. Open-dump dangers and risks must be adequately recognized and analyzed to provide the best possible environmental protection. Collection, transportation, and disposal issues arise as more solid waste is generated. It makes it more difficult to deal with this kind of solid trash. It's true that the MSW has a lot of money to make. MSW management efficiency has an impact on the waste's potential economic worth, though[20].

The management of MSW requires thorough familiarity with the categorization of solid wastes prior to disposal. Solid waste management may be complicated by the fact that it contains a variety of different types of materials. There are several factors to consider when choosing the collection, transportation, recoverable matter and energy transformation as well as the correct disposal techniques for solid wastes. MSW's composition, calorific value, and moisture content (MC) should all be well-understood before selecting an appropriate management strategy. Solid wastes had moisture contents ranging from 5% to 40%, with an average of 20%. According to the socioeconomic structure and the geographical peculiarities of solid waste, there is a broad range of the MC. Despite this, the MC might rise as high as 55% to 70% depending on the environment and the content of the solid waste. The calorific value of solid waste is largely dependent on the MC, hence it's necessary to highlight this. For the design of combustion processes for solid waste recovery, this is an important consideration. Solid waste management adds between 3% and 5% to the production of greenhouse gases (GHGs), according to UNEP. In large part, this is because to the leakage of CH_4, CO_2, and N_2O from open wastes. From transportation and garbage collection, there are additional CO_2 emissions. While trash management may decrease or conserve GHG emissions in a variety of ways, including energy generation, compost application to soil as fertilizer, carbon storage in landfills, and material recovery from garbage, there are many more ways in which waste can be managed. UNEP claimed that international organizations have suggested a 3R approach to waste management in the future (namely: Reduce, Reuse, and Recycle). The three Rs are waste avoidance, the construction of a circular economy, cleaner products, and the conversion of trash into energy and materials. Inadequate waste management has a direct impact on human health through altering ecosystems, including air, water, and soil contamination. The public health consequences of dumping and incineration of MSW have not been thoroughly investigated. The local population around MSW facilities has low birth weight, congenital abnormalities, and just a few forms of cancer. In terms of the local population, the effects seem to differ according to the study population. This method to epidemiologic surveys has to be clarified, especially with regard to the doubts about human illnesses. Due to the lack of financial resources in many developing countries, insufficient waste treatment is a major issue. The majority of these countries dispose of their municipal solid waste (MSW) in an unregulated manner. Because of this, contamination of the air, land, and water is a consequence. In this regard, waste management is one of the most pressing challenges that humanity faces. In addition to being a source of metals, glass, plastics, and fibers (metals), garbage may also be used to save oil and preserve the environment. Global energy production may be as much as 50 billion tons of oil equivalent if solely agricultural organic waste and crop leftovers were used [77]. The UNEP states that successful energy production requires proper separation of organic and non-organic waste. Actually, it is the organic residues that have compromised the thermal technology's efficiency with regard to energy production and GHG emissions[21].

To reduce costs and fulfill consumer demand, fuels have lately pushed industrial producers and environmentalists toward greater sustainability. In recent years, one of the most active study fields has been the repurposing of food waste. Attracted a lot of interest as an alternative to traditional solid waste disposal for a broad variety of wastes. In addition, environmental techniques for processing this kind of solid waste are a fascinating subject that is becoming more important in today's society. Traditional methods of disposing of garbage such as landfills, incineration, and composting have become commonplace. But they aren't ideal for dealing with organic garbage. Toxic methane gas is produced as well as a foul smell, which results in significant energy usage. In fact, new methods for decomposing organic waste have been the focus of research efforts. Nevertheless, the breakdown process produces nothing of value. To generate energy from food waste rather than dispose and decompose it, current research has concentrated on this topic (e.g., bioethanol and biodiesel production). Aside from bioplastics and succinic, valuable organic compounds may be created from organic waste using bio-refinery or white biotechnology (e.g., bio plastics and/or succinic)[22].

Valorization is the conversion of waste resources into more usable goods such as fuels, materials or chemicals. Such a method has been used for a long time for garbage management. However, the rapid depletion of fossil fuels and other fundamental resources has resurrected interest in this idea in our culture. Increased trash creation and landfilling throughout the globe has highlighted the need of more sustainable and cost-effective waste management methods. In order to fulfill industrial needs, many valorization procedures are now showing significant promise and optimism. To turn trash into useful goods, flow chemical technology may be used in a variety of ways. The benefits of continuous flow valorization methods for biomass and/or food waste emphasized were simplicity of scaling up, efficient reaction cycles that provide greater yield, reaction control, and no catalyst separation needed. As a well-known processing approach, flow chemistry may still be used to the treatment of biomass solid waste and its subsequent valorisation. In this case, the energy required to breakdown extremely stable recalcitrant chemicals and biopolymers is the bottleneck (e.g., lignin). As a green valorization process, microwave heating may be used to create the high pressure and temperature needed to breakdown these biopolymers. These standards aren't easy to meet. A variety of approaches, including microwave irradiation, are required to meet these preconditions. However, the biggest issue for such a combination is the technology and the scale-up of the process itself. By adding back-pressure regulators to flow devices, confirmed that the microwave and flow chemistries are related the ability to rapidly synthesize goods is a key benefit of this technique, which is redefining industrial valuation. Due to the continual use of microwave heating, this result may be explained (flow process). However, the major difficulty of transferring the temperature from the microwave to the flow remains unsolved. This strategy is conceivable. It's possible that an instrument's malfunction or inefficiency might be caused by an ever-increasing temperature gradient within the device[23].

The use of pyrolysis in the synthesis of energy or fuels is another valorization approach. In order to create the necessary breakdown products, biomass is heated at high temperatures without any air Biopolymers that have been stable for a long time may now be synthesized into smaller molecules via pyrolysis, which is an age-old method of generating char. Bio-Oil, a liquid with a low viscosity, is one of the many products made using this method. Short-chain ketones, aldehydes, and carboxylic acids make up the complicated combination. According to Heo et al. [85], waste furniture sawdust was subjected to pyrolysis under a variety of settings. The yields of Bio-Oil do not always increase as the temperature rises. The optimal pyrolysis temperature was determined to be 450 C utilizing a fluidized bed reactor (e.g., 57 percent Bio-Oil yield). Thus, the production of Bio-Oil does not follow a straight line with the temperature. This nonlinear relationship between yield and temperature of bio-oil is due to the potential gasification of certain molecules. The rise in the number of gaseous products as a result of rising temperatures aided in the establishment of this company. used quick pyrolysis under a fluidized bed reactor to extract BTEX chemicals (xylenes, benzophenone, ethanolphenone and toluene) from a variety of polymers in an intriguing investigation. The maximum BTEX output was achieved at a temperature of 719 degrees Celsius. Another method for producing good biofuel from cotton stalks has been disclosed. The quantity of H_2 and CO_2 collected during pyrolysis at higher temperatures was shown to rise, whereas the amount of CO_2 collected decreased. Carbon dioxide emissions may have decreased because the gases that produce CO and O_2 at higher temperatures have degraded. For both bio-oil as well as syngas production, synergy between these initially suggested technologies, such as microwave and pyrolysis, has been demonstrated to be a step ahead[24].

Approximately 2,881,500 metric tons of olive oil were produced worldwide in 2010. Europe accounts for 78.5 percent of the global olive oil output, making it the most populous region. In 2010, the EU produced an average of 2,136,000 metric tons. Olive oil usage climbed by over 80% between 1990 and 2010. Wastewater from olive mills may be cleaned up using a variety of standard and non-conventional adsorption techniques Large volumes of solid and liquid waste are generated by the olive oil business, posing major environmental hazards. As the amount of olive oil produced rises, so is the amount of trash generated by olive mills. This has resulted in serious environmental issues for the manufacturing of olive oil owing to a lack of viable solutions for waste from olive mills. There is thus a pressing need to discover a method of managing olive mill waste materials that is practical and feasible in order to limit environmental damage and the accompanying health hazards to humans. Olive oil mill waste control is always a challenge. In order to exploit these wastes in various valuable products, researchers have made great efforts [25].

As a result, it is extremely desired to handle these wastes in an eco-friendly manner that reduces their negative influence on the environment and promotes resource conservation. Olive mill solid wastes were employed as low-cost adsorbents for water pollution prevention in intriguing research, which was published in the journal. The development of low-cost adsorbents for wastewater treatment using environmentally beneficial natural occurring and agricultural industrial waste materials has recently been studied. It's easy to get your hands on these resources, which are also renewable and inexpensive. The use of industrial solid wastes or byproducts has recently received a great deal of attention. This trash might be difficult to dispose of at times. As a result, it offers a two-fold reduction in pollutants to the environment. Some waste from olive mills might be decreased in bulk first. The second advantage is that the low-cost adsorbents used may treat industrial wastewater at a reasonable and realistic cost. In comparison to the $4500/ton cost of granular-activated carbon, it has been anticipated that the wastes from the olive industry may be transformed into low-cost adsorbents. Olive mill solid wastes have been utilized to manufacture adsorbents capable of removing a wide range of aquatic contaminants using a variety of physical and chemical treatment processes. An adsorbent created from olive wastes' precursor, processing conditions, and activation type (chemical or physical) are all factors that influence its ability to adsorb. The characteristics of the resultant adsorbent are determined by the dehydrating agent concentration, pyrolysis temperature, and impregnation ratio in chemical activation. Analytical methods have been used to differentiate between several types of olive mill solid waste. It has been shown that olive waste contains functional groups such as methoxy, hydroxyl and carboxylic groups that may be useful in the removal of heavy metals from the environment. Olive solid wastes are able to bind metallic ions and other contaminants from wastewater because of their unique composition. Water treatment applications might benefit from their unique bio-sorbent nature.

Composting and Anaerobic Digestion have long been the most widely utilized methods for treating and valuing municipal solid waste's Organic Fraction (OMF) (AD). The microbial metabolism utilised by these two waste treatment methods differed significantly. AD is mostly based on anaerobic microorganisms, notably methanogenic bacteria, and their metabolism. By using CO_2 to make H_2 (hydrogenotrophs) or CH_3COOH as a carbon source, such anaerobic metabolism generates CH_4 (acetoclastics). It is necessary for AD digestion to occur at a certain temperature. An ideal operating temperature is between 35 and 55 degrees Fahrenheit for the reactor. The psicotrophic process, on the other hand, may occur at temperatures as low as 10–20 C. Biogas, mostly composed of CH_4, is generated as a byproduct of this AD. Often, the digestant is stabilized by the presence of oxygen in the atmosphere. Anaerobic bacteria can't thrive in a composting process if there isn't enough oxygen for the aerobic microbes. To compost small quantities of organic waste is simple. Although mechanical aeration such as energetic imputes is required for large-scale composting, it may range from 40 to 70 kW/t of waste depending on the technique employed. The composting system is often the source of this energy. Many facilities use the AD process followed by aerobic stabilization to generate the energy required for the composting process from their own biogas supply (methane). If the municipal organic waste (MOW) is anaerobically digested at a rate of 25 percent or higher, the wastewater treatment system as a whole might become energy self-sufficient. As a soil conditioner, the stabilized organic matter produced by a composting system may be utilized as long as it is free of chemical or biological pollutants. Synthetic fertilizer consumption may be reduced by roughly 20%, according to IPCC, by using composted municipal organic wastes in field applications. GHG emissions from fertilizer production and N_2O emissions from soil are reduced significantly by the use of soil conditioners. The use of herbicides, irrigation, and tillage are all reduced as well [98]. Small-scale composting is an eco-friendly and viable alternative for impoverished nations because of its simplicity and cheap cost. Furthermore, this strategy might be a low-cost and effective solution for organic solid waste and wastewater treatment in developing impoverished nations.

Every year, the amount of organic solid waste generated throughout the globe rises precipitously. There have been a number of issues with disposing of organic solid waste in recent years as a consequence. As a result of the quick rate of progress toward global modernization and lifestyle shifts, this is the case. People and animals produce a lot of the organic material that is thrown away as garbage. In most cases, they are fed to livestock, burnt, or deposited in landfills. While incineration is expensive and pollutes the air, it is still the most used technique of disposing of hazardous waste. The organic trash in landfills, on the other hand, is generally broken down and digested by microbes, resulting in leachate that pollutes the groundwater. Degradation of these organic wastes creates methane, a greenhouse gas 25 times more damaging than carbon dioxide, which is emitted as a byproduct. Public health and environmental issues may emerge from improper solid waste management procedures, such as disagreeable smells and infections. However, proteins, minerals, and carbohydrates found in organic solid waste may be employed as substrates or raw materials in other processes. Carbon, nutrients, and moisture are the primary ingredients needed for microbe culture and growth. Because of this, organic waste might be an ideal source of nutrients and conditions for these bacteria to thrive. The bioconversion of organic wastes employed as substrate or inert support is considered a potential method for organic waste valorization through organic solid-state fermentation (SSF). In order to turn organic wastes into high-value goods, microbes will play a vital part in the decomposition of such wastes into their components. During the bioremediation of organic solid waste, SSF demonstrates long-term viability. High product yields and productivity, minimal energy usage, and a solution to organic waste disposal issues were all shown by SSF. In the absence of or near absence of water, microorganisms grow on solid and wet substrates that serve as nutrition sources, allowing the SSF process to take place. In bioprocessing, this SSF is not a novel technique. As far back as the ancient ages, it was predominantly used in Asian countries. It's gotten a lot of attention lately since more and more organic waste is being used, and because more and more high-value goods are being produced. Searches for a sustainable and ecological alternative to typical chemical processes also showed the potential of SSF. Bioconversion of solid organic wastes into useful bioproducts may thus replace non-renewable resources and change chemical processes into cleaner ones. SSF has the benefit of being a reasonably simple method that utilizes readily accessible low-cost biomaterials and requires minimum or no pretreatment for bioconversion. Aside from mimicking comparable micro-environments that encourage the development of microorganisms, it produces less trash. When it comes to encapsulation and decomposition, SSF mimics natural microbial processes.

Fruit peel, straw, stalk, cobs, husk, and bagasse are only some of the lingo-cellulose by-products generated by agricultural and agroindustrial processes. Cellulose (35 – 50 percent), lignin (25–30 percent), and hemicellulose (25–30 percent) make up the bulk of these wastes. Lingo-cellulosic materials often have glucose as their primary ingredient. Five distinct sugars (Larabinose, D-glucose, D-galactose, D-xylose, and D-mannose) and a few organic acids make up the hemicellulose, which is a heterogeneous polymer. The phenyl propane molecule forms a complicated three-dimensional structure in the lignin. Hydrolytic and lignin lytic enzymes have recently been produced using the SSF. In SSF, maize cobs were successfully used as a substrate for the production of lignin per oxidase. Though grains are becoming more expensive as a bespoke feed, lignocellulosic materials offer significant potential to make palatable animal feed. However, the presence of lignin decreases the digestibility, making direct use to animal feedstuffs very restricted.

SSF was used to degrade cellulose and lignin in various pre-treatments of straw to improve the feed's digestibility. SSF has the capacity to create enzymes and increase the digestibility of fiber-rich materials, such as soybean cotyledon, which is worth noting. Jatropha seed cake has been reported to be utilized in SSF without pre-treatment for the synthesis of celluloses. Activated carbons and/or reinforcing of composite materials used in building materials, furniture, nets, etc. are two more documented applications for comparable materials, according to many researchers. Animal manure is a common component of agricultural organic waste. The high nitrogen concentration of cow dung has been established, making it ideal for producing methane. On the other hand, the use of cow dung and chicken manure enhanced the formation of activated carbon and biochar. An amino acid hydrolyzed from animal carcasses that is added to mature compost of either pig dung or chicken by SSF may generate a high-quality biofertilizer.

Organic waste from a wide range of businesses, such as fruit and vegetable processing, slaughtering, poultry processing, the sugar industry, the dairy industry, and the production of paper and pulp, are all considered industrial organic waste. As a substrate or support for SSF processes, most of these organic wastes have the potential of generating valuable products. Solid waste from the wood industry such as sawdust may be utilized as a substrate in SSF to increase laccase production with white rot mushrooms such as Coriolopsis gallica. Additional protein-containing organic waste is generated in slaughterhouses and the leather industry, including animal fleshing and skin trimmings, hair wastes, shavings of chrome and keratin from buffing. These wastes are mostly discarded. Proteases are produced in SSF by using animal fleshing as a substrate. Anaerobic or aerobically digested sludge, in combination with slaughterhouse hair waste, produced a large output of protease [108]. While sugarcane bagasse and molasses from the sugar industry were used for the synthesis of invertase by SSF, it was also reported. Because cane sugar is too costly as a feedstock for ethanol production, molasses was chosen as a substitute. Poly-3hydroxybutyrate (PHB) was effectively produced from tapioca industrial waste, which includes significant organic materials coupled with a strong odor that might pollute the environment. As a result, a new industrial method might be developed, and the overall manufacturing cost may be significantly reduced. According to this study, the food processing industry generates a wide range of by-products that may be employed in SSF to produce a variety of useful bio-products. Organic acid and essential enzymes may be produced from vegetable and fruit trash, according to reports. As a result of its high and readily degradable organic content, vegetable waste has tremendous potential for bioconversion, notably in the generation of biofuels. Industrial seafood processing byproducts may be utilized to produce chitinase, which has a broad variety of applications and implementation in the biomedical, culinary, and agricultural sectors, according to a study. For microbe development, however, fish processing wastes are ideal since they are inexpensive and offer ideal SSF conditions. Esterase may be produced from fish processing wastes because of their high lipid and protein content. When it comes to organic chemical processing as well as detergent formulations, the latter is a product that can be used in a wide range of industries.

Because of the high expense of treatment, many underdeveloped nations do not sufficiently treat their residential wastewater. Domestic food waste management is a major issue in most nations nowadays. Wet, combined with inorganic garbage and metals, then thrown together at random. Aside from that, the composition of home food waste is quite complicated since it comprises paper, water and oil as well as rotten and leftover foods from kitchen trash and markets. Everything from fats to cellulose to carbohydrates to proteins and other biological materials makes up these waste products. Unpleasant scents are produced when organic waste is rapidly decomposed due to the high moisture and salt content. Several illnesses are spread by flies and other insects attracted to this environment. In addition to being perishable, municipal solid wastes such as kitchen garbage and food waste from restaurants and marketplaces include high lignocellulosic components that might be digested and used to generate valuable bio-products. It has been shown that Aspergillus awamori may produce glucoamylase enzymes from waste savory, bread, cakes, fruits, vegetables, onion or potato peels and cafeteria wastes using SSF technology. Amylase has been made from domestic bread trash. For the most part, SSF made its cellulose from MSW and kitchen waste leftovers such onion and potato peel, carrot and cauliflower leaf peels, orange peel, banana and pea stalks and pods. Recently, a large production of fragrance esters was achieved by cultivating chosen industrial yeast strains on orange peel as a substrate. Ethanol may be produced from home food wastes that have a high dry content using SSF, according to many research. SSF may also create glucoamylase- and protease-rich medium from restaurant food waste infected with fungal inoculum. These media may be used to create succinic acid as a feedstock. Medicine manufacture, polymers, and laundry detergents are just some of the many uses for the latter. A typical kitchen waste in Nigeria, for example, cocoyam peel, has the potential to be a valuable substrate for oxy-tetracyclines, an essential antibiotic used to treat a wide range of infections. SSF may be used to manufacture Bt bio-pesticide from food wastes because of their complex makeup, which makes them ideal for microbial development.

Recently, there has been an increase in awareness of organic solid waste management in low- and middle-income nations. This resulted in an increase in collection coverage and a decrease in waste management dumps and landfills. As a result, organic solid waste recycling and repurposing have gained prominence on a global scale. Organic garbage in particular continues to get less attention than other types of trash, such as paper, metal, and glass. In many cases, these organic components are not included in the value-added chain at all. Despite its high energy level, it ends up in landfills or on city streets. Aside from drawing disease-carrying mosquitoes, it also creates greenhouse gases on-site. As a viable and long-term treatment alternative for organic waste, the black soldier fly larval (Hermetia illucens) treatment method is a major step forward.

Organic waste may be valorized by the Hermetia illucens bug, which is now the most significant option. The black army fly is another name for this insect. The fly's larvae are ravenous eaters that feed on the decomposition, faeces, excrement, dead animals, etc. of the wastes. It has a relatively brief life cycle, during which the larva migrates to a dry habitat after being fed. The mature fly emerges after 14 days. Larvae are at their biggest at chrysalis stage. They include a lot of protein and fat. Organic matter volume is reduced by between 50% and 95%, and the goods produced by this process have an economic value. It is not uncommon for researchers to focus on the use of animal protein in fish farming (pisciculture) and biofuels.

The feeding action is important because it decreases the biomass of organic waste by up to 80%. It. Animal dung, food scraps, and human excrement are all included. There are several advantages to using the last larval stage known as prepupa as a feed for livestock since it contains 40% protein and 30% fat. Black soldier fly treatment yields a second product in addition to prepupae: the digestate or residue. So the dry bulk is reduced, but so are various nutrients, such as nitrogen and phosphorus, by larval and bacterial activity. As an example, in pig dung, 80.5 percent of the total nitrogen and 75.7 percent of the phosphorus were eliminated. As a result of cow dung trials, nitrogen and phosphorus levels were reduced by 43 and 67% respectively. It is feasible to utilize these wastes in agriculture as fertilizer or in biogas generation, comparable to compost. Other veggies and fruits are good.

In the presence of oxygen, organic matter (OM) decomposes in a regulated manner. There are a number of small-scale composting businesses in Florianópolis. Composting has the benefit of being simple to do from a technological standpoint. Despite this, the lack of financial returns makes this approach less appealing. It is possible to produce high-quality compost and a reliable supply of animal protein by using the easy alternative method of worm farming (worms). As a result of this, the AD is also often referred to as a biogas generator or biomethanation. In the absence of oxygen, anaerobic microorganisms break down organic matter (OM). Adsorption decomposition, in contrast to composting, is a technically sophisticated process that might malfunction due to little changes in the governing factors, such as temperature or pH. (such as odors). A valuable and low-cost energy resource is biogas, which is the last byproduct of the AD process. It is regarded as an environmentally favorable local energy matrix source that lessens reliance on fossil fuels.

Anaerobic digestion (AD) of organic waste has shown to be an effective method for treating sewage sludge while simultaneously producing biogas for use as a sustainable energy source. Sludge organic matter is broken down and converted to biogas by anaerobic bacteria during the AD process, which may be utilized to generate power, heat, and biofuel. Methane and carbon dioxide make up the bulk of the biogas. Meanwhile, the sludge has stabilized and its dry matter content has decreased significantly. Sludge treatment with the AD method is highly accepted for its advantages and the technique is well-established all over the globe. In many countries, the biogas generated by AD plants is derived in large part from municipal wastewater treatment facilities, which is utilized to supplement the energy requirements of these facilities. Many nations have yet to fully realize the full potential of this technology.

Sewage sludge is often generated in WWTPs as a byproduct of the treatment process in order to get cleaner effluent. In most cases, the sludge is made up of debris particles that were cleaned from the wastewater. As a result, the treated effluent is free of dangerous substances and may be discharged back into the environment without harming the environment. Many nations' rapidly rising urban populations and industries are well-served by WWTPs and other facilities. This leads to a significant increase in the amount of sewage sludge being generated. One of the many stakeholders impacting the evolution towards energy sustainability is WWTPs, which are key users and providers of energy.

Biogas generation from anaerobic digestion of sewage sludge with heavy metals present Heavy metals and chemicals may be present in sewage water that is combined with industrial and home effluent. Heavy metals in municipal sewage have been linked to a decline in the anaerobic digestion process' effectiveness. According to these findings, gas production and the removal of volatile organic materials have both decreased significantly. Additional evidence of methanogenic bacteria suppression was found in the form of an increase in organic acid intermediate buildup. Heavy metal poisoning is to blame for this stifling effect. For anaerobic digestion, Hg, Cd, and Cr(III) are the most poisonous heavy metals, according to the following decreasing order: Hg (146). Because the digester bacteria were quickly poisoned by heavy metals, buildup of heavy metals during the pulse feed was found to be quite restricted. As a result, it was advised that the anaerobic digester prevent or considerably reduce the presence of hazardous metals such as Hg, Cd, and Cr (III) in organic solid waste. For the generation of biogas, the anaerobic digestion of industrial waste and/or sludge containing heavy metals should also be avoided.

When technology and research are coupled, man has the ability to discover new and novel methods to generate electricity exclusively (excludingefficiencylosses). increasing the lifespan of goods and products by making effective use of the latent value contained within the many waste streams that are created. As a result, mankind may get several benefits from such garbage. Resource efficiency and the circular economy are closely linked to waste valorization. There are two new ideas that aim to put landfill mining and waste management in a sustainable context: the Enhanced Landfill Mining (ELFM) and EWM [150]. It is no longer seen as the definitive answer to the problem of solid waste, but rather as a temporary storage facility that should be repurposed. With ELFM, it's possible to narrow down the pool of materials that can be best used for valorization. Waste-to-Energy, or WtE, is the process of converting waste into energy (Waste-toProduct, WtP). The kind of waste streams and the level of the technology both play a role in this. An essential substantial change in both waste management vision and technology is anticipated by the ELFM idea. On its way to success, however, the ELFM will have to overcome several socioeconomic constraints as well as technical advancements and discoveries (i.e. social acceptance, economic uncertainty, regulations, and feasibility). Waste to energy (WtE) and waste to materials (WtP) may be used to generate energy, which can then be combined with an environmentally friendly strategy to avoid CO2 and other pollutants from being emitted as a result of the valuing processes.

There has been a significant growth in the amount of garbage generated by the EU since 1980, from 150 million tons in 1980 to more than 300 million tons in 2015, and it is expected to rise to 330 million tons by 2020. A heterogeneous feedstock, EU MSW comprises a broad range of components, including a wide range of compositions and sizes as well as a large range of forms. If this MSW is utilized to generate energy (WtE), the operating circumstances may be unpredictable, resulting in a changing quality of the final output. Refuse-derived fuel (RDF) is typically used as an input to create energy WtE in the form of processed MSW as organic wastes. As part of the treatment procedure, many aspects such as sorting and screening are often reduced. To facilitate handling and uniformity, this procedure may involve drying and/or rough packing. Converting MSWs to RDF has several advantages in terms of both economics and the environment, not the least of which are lower emissions of pollutants, a higher heating value and less need for additional air during combustion. Other advantages include more uniform physical and chemical compositions, easier storage, handling, and transportation. Solid waste management is a difficult endeavor that requires a great deal of time and effort. A multi-faceted strategy is required. An innovative waste management strategy known as "Integrated sustainable waste management" is now being implemented in the United States (ISWM). To maximize environmental and economic advantages at the lowest possible cost, this ISWM is ideal for municipalities and other comparable organizations. As a result of using the solid-state fermentation approach, biomolecules concentrations have been shown to be better and higher. As compared to submerged fermentation, it simplifies extra downstream processes (SmF). Because of this, SSF was able to reduce the amount of resources it needed for extra energy, equipment, and water use. 30–40 percent of overall manufacturing expenses are accounted for by the cost of substrates. This substrate's organic solid waste may be used in the SSF in a cost-effective manner. From the standpoint of appealing economic feasibility, the various biotechnological methods used by SSF outperform those of SmF. For bioethanol production, SSF and SmF cellulose economic analyses were compared. SSF costs ($15.67 kgcellulase1) and SmF costs ($40.36 kgcellulase1), whereas SmF costs roughly $90 kgcellulase1, according to this research, which reported on the unit costs of cellulose manufacturing. SSF had a 99.6 percent efficiency rate, which was lower than SmF's, according to a subsequent study by the same researchers comparing manufacturing costs. As a result, it was stated that the economic analysis of the hydrolases enzyme cocktails employing A. onababassu cake in SSF suggests that the solid residues created after enzyme extraction is a byproduct that may be used as animal feed. This, in turn, may help to offset the expenses of enzyme manufacturing.

Decision-makers in emerging nations face major new issues in solid waste management as a result of demographic changes, consumer behavior, rapid urbanization, and rapidly rising populations. There has been a surge in the number of cities looking for sustainable waste management solutions in recent decades. Construction, operation, and maintenance of sanitary landfills, as well as the resulting issue, were all given particular attention in developing integrated solid waste management strategies. It was discovered that operations such as valorizing and recycling might provide a significant amount of revenue to help offset some of the expenses. More than half the recyclable rubbish generated by Turkish families and businesses is sold by scavengers to middlemen for a total of USD 50,000 every day in Ankara. In addition, more than 150,000 garbage pickers in Delhi's waste management system turn almost 25% of all waste produced into recyclables. The local authorities save a lot of money with this management approach.

Organic waste is still a major concern in low- and middle-income nations since no concrete remedy has yet been found. The larvae of the black soldier fly may be used in a variety of waste treatment systems, from experimental to full-scale. They are more suited to underdeveloped nations since they can be designed, implemented and run at a lower cost (including cheap construction, operating, and maintenance expenses that do not rely on power supply). Prepupae harvesting and usage in animal husbandry may also help farmers and small business owners generate extra cash and increase their economic output. Research on smallholder chicken production in Africa found that high feed costs are a significant influence (Malawi, Ghana). Other poultry species, notably waterfowl, may be used as a strategy to counterbalance and overcome the high feed costs. Other feed may be used to raise the latter (snails, water hyacinths). Another option is to augment and/or replace the feed with other materials produced locally or by the farmers themselves in order to lighten and lessen the financial strain on smallholder farmers. emphasized the benefits of IAA systems, which give extremely effective examples from Africa (Malawi, Ghana) and Asia (Japan, Korea, and Taiwan) (Bangladesh, Philippines). In addition, he emphasized the favorable impact of small-scale aquaculture on family income, employment, and consumption. To this end, it was shown that using an efficient CORS system with a black soldier fly may satisfy the needs of large-scale cultures since the prepupae produce can be utilized directly. The fly is an ecological engineer in poor and middle-income nations.

The high protein and fat content of dried soldier fly prepupae strengthens its utility as a fly meal for animal feed production. This means that the dried soldier fly prepupae business in the aquaculture sector is rising fast and becoming more appealing. A global increase of 6.1% in this kind of economic activity occurred between 2002 and 2004. Low and middle-income nations showed growth rates of 11.2 percent for Chile, 16.5 percent for Iran, 30.6 percent for Viet Nam, and 40.1 percent, and the most recent showed the greatest growth rate. For the majority of aquaculture species, fish meals and fish oil were the primary sources of nourishment. Fishmeal obtained from wild fish sources is in high demand because of the fast growth of aquaculture across the globe. In addition, the price of fishmeal rose, placing further strain on wild fish populations. As a consequence, farmers who presently rely on fishmeal will find other animal protein sources particularly appealing. Because of this, Hermetia illucens prepupae might be used as a protein source.

Discussion

One of the biggest environmental issues is the disposal of trash. As a result of the ecosystem-altering effects of insufficient waste management, such as air pollution, water pollution, and soil contamination, human health is in actual danger. Several studies have shown that the local population around MSW plants had low birth weights, congenital abnormalities, and a small number of malignancies in its early years. The rising expenditures of municipal budgets were exacerbated by the growing output of solid wastes. Municipal solid trash output has increased dramatically due to population growth, urbanization, economic prosperity, and rising standard of life. MSW biodegradation is a key component in determining the quantity of recyclable material, especially organic material, that may be recovered. MSW produced in underdeveloped nations is quite diverse.

The properties of solid waste may be greatly influenced by poor bin collection techniques, collection, transfer, and/or transportation systems. Disposal of plastic garbage is a huge environmental issue on a worldwide scale. Plastics have a calorific value of 30 to 40 MJ/kg since they are mostly hydrocarbons. Consequently, they may be burnt to generate electricity and heat at municipal or other specialized trash facilities.

Landfills are the most common and least expensive method of disposing of solid waste. Materials that can be turned into valuable goods like fuels, materials, and chemicals are all part of waste valorization. As compared to granular-activated carbon, which costs $4500/ton, olive industry wastes might be turned into low-cost adsorbents for under $50/ton. CH4 is produced by Anaerobic Digestion of Municipal Solid Waste (OFMSW) from CO2 and H2 (hydrogenotrophs) as well as from CH3COOH (acetoclastics). A lack of heavy metals might impede the anaerobic digestion of sewage sludge to produce biogas. In part, this is due to the fast poisoning of the digester's many active bacterium types.

Organic solid-state fermentation (SSF) is touted as a potential solution to the problem of organic waste. Via the process of bioconversion, household food wastes with a high dry content may be used to make large amounts of ethanol through the SSF valorization process. In the process of turning organic wastes into high-value goods, microorganisms play a critical role in breaking them down into their component parts.

The management of home food waste is a major issue in the majority of nations across the globe. Amylase has been made from domestic bread trash. When industrial yeast strains were grown on orange peel as a substrate, they produced a large amount of aroma esters. SSF may be used to make glucoamylase- and protease-rich medium from food waste collected from restaurants that have been contaminated with fungal inoculum. These media may be used to create succinic acid as a feedstock. The second is used in a broad variety of products, including pharmaceuticals, polymers, and even laundry detergents.

The black soldier fly, Hermetia illucens, larvae, is an essential treatment option for organic waste since it is a realistic and long-term solution. Solid organic waste may be salvaged by composting and anaerobic digestion. Composting has the benefit of being simple to do from a technological standpoint. Valorization and recycling operations have proved out to be a beneficial source of money for covering a portion of the expenditures of an integrated solid waste management strategy.In the presence of oxygen, organic matter (OM) decomposes in a regulated manner. There are a number of small-scale composting businesses in Florianópolis. Composting has the benefit of being simple to do from a technological standpoint. Despite this, the lack of financial returns makes this approach less appealing. It is possible to produce high-quality compost and a reliable supply of animal protein by using the easy alternative method of worm farming (worms). As a result of this, the AD is also often referred to as a biogas generator or biomethanation. In the absence of oxygen, anaerobic microorganisms break down organic matter (OM). Adsorption decomposition, in contrast to composting, is a technically sophisticated process that might malfunction due to little changes in the governing factors, such as temperature or pH. (such as odors). A valuable and low-cost energy resource is biogas, which is the last byproduct of the AD process. It is regarded as an environmentally favorable local energy matrix source that lessens reliance on fossil fuels.

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Biogas generation from anaerobic digestion of sewage sludge with heavy metals present Heavy metals and chemicals may be present in sewage water that is combined with industrial and home effluent. Heavy metals in municipal sewage have been linked to a decline in the anaerobic digestion process' effectiveness. According to these findings, gas production and the removal of volatile organic materials have both decreased significantly. Additional evidence of methanogenic bacteria suppression was found in the form of an increase in organic acid intermediate buildup. Heavy metal poisoning is to blame for this stifling effect. For anaerobic digestion, Hg, Cd, and Cr(III) are the most poisonous heavy metals, according to the following decreasing order: Hg (146). Because the digester bacteria were quickly poisoned by heavy metals, buildup of heavy metals during the pulse feed was found to be quite restricted. As a result, it was advised that the anaerobic digester prevent or considerably reduce the presence of hazardous metals such as Hg, Cd, and Cr(III) in organic solid waste. For the generation of biogas, the anaerobic digestion of industrial waste and/or sludge containing heavy metals should also be avoided.

When technology and research are coupled, man has the ability to discover new and novel methods to generate electricity exclusively (excludingefficiencylosses). increasing the lifespan of goods and products by making effective use of the latent value contained within the many waste streams that are created. As a result, mankind may get several benefits from such garbage. Resource efficiency and the circular economy are closely linked to waste valorization. There are two new ideas that aim to put landfill mining and waste management in a sustainable context: the Enhanced Landfill Mining (ELFM) and EWM [150]. It is no longer seen as the definitive answer to the problem of solid waste, but rather as a temporary storage facility that should be repurposed. With ELFM, it's possible to narrow down the pool of materials that can be best used for valorization. Waste-to-Energy, or WtE, is the process of converting waste into energy (Waste-toProduct, WtP). The kind of waste streams and the level of the technology both play a role in this. An essential substantial change in both waste management vision and technology is anticipated by the ELFM idea. On its way to success, however, the ELFM will have to overcome several socioeconomic constraints as well as technical advancements and discoveries (i.e. social acceptance, economic uncertainty, regulations, and feasibility). Waste to energy (WtE) and waste to materials (WtP) may be used to generate energy, which can then be combined with an environmentally friendly strategy to avoid CO2 and other pollutants from being emitted as a result of the valuing processes.

There has been a significant growth in the amount of garbage generated by the EU since 1980, from 150 million tons in 1980 to more than 300 million tons in 2015, and it is expected to rise to 330 million tons by 2020. A heterogeneous feedstock, EU MSW comprises a broad range of components, including a wide range of compositions and sizes as well as a large range of forms. If this MSW is utilized to generate energy (WtE), the operating circumstances may be unpredictable, resulting in a changing quality of the final output. Refuse-derived fuel (RDF) is typically used as an input to create energy WtE in the form of processed MSW as organic wastes. As part of the treatment procedure, many aspects such as sorting and screening are often reduced. To facilitate handling and uniformity, this procedure may involve drying and/or rough packing. Converting MSWs to RDF has several advantages in terms of both economics and the environment, not the least of which are lower emissions of pollutants, a higher heating value and less need for additional air during combustion. Other advantages include more uniform physical and chemical compositions, easier storage, handling, and transportation. Solid waste management is a difficult endeavor that requires a great deal of time and effort. A multi-faceted strategy is required. An innovative waste management strategy known as "Integrated sustainable waste management" is now being implemented in the United States (ISWM). To maximize environmental and economic advantages at the lowest possible cost, this ISWM is ideal for municipalities and other comparable organizations. As a result of using the solid-state fermentation approach, biomolecules concentrations have been shown to be better and higher. As compared to submerged fermentation, it simplifies extra downstream processes (SmF). Because of this, SSF was able to reduce the amount of resources it needed for extra energy, equipment, and water use. 30–40 percent of overall manufacturing expenses are accounted for by the cost of substrates. This substrate's organic solid waste may be used in the SSF in a cost-effective manner. From the standpoint of appealing economic feasibility, the various biotechnological methods used by SSF outperform those of SmF. For bioethanol production, SSF and SmF cellulose economic analyses were compared. SSF costs ($15.67 kgcellulase1) and SmF costs ($40.36 kgcellulase1), whereas SmF costs roughly $90 kgcellulase1, according to this research, which reported on the unit costs of cellulose manufacturing. SSF had a 99.6 percent efficiency rate, which was lower than SmF's, according to a subsequent study by the same researchers comparing manufacturing costs. As a result, it was stated that the economic analysis of the hydrolases enzyme cocktails employing A. onababassu cake in SSF suggests that the solid residues created after enzyme extraction is a byproduct that may be used as animal feed. This, in turn, may help to offset the expenses of enzyme manufacturing.

Decision-makers in emerging nations face major new issues in solid waste management as a result of demographic changes, consumer behavior, rapid urbanization, and rapidly rising populations. There has been a surge in the number of cities looking for sustainable waste management solutions in recent decades. Construction, operation, and maintenance of sanitary landfills, as well as the resulting issue, were all given particular attention in developing integrated solid waste management strategies. It was discovered that operations such as valorizing and recycling might provide a significant amount of revenue to help offset some of the expenses. More than half the recyclable rubbish generated by Turkish families and businesses is sold by scavengers to middlemen for a total of USD 50,000 every day in Ankara. In addition, more than 150,000 garbage pickers in Delhi's waste management system turn almost 25% of all waste produced into recyclables. The local authorities save a lot of money with this management approach.

Organic waste is still a major concern in low- and middle-income nations since no concrete remedy has yet been found. The larvae of the black soldier fly may be used in a variety of waste treatment systems, from experimental to full-scale. They are more suited to underdeveloped nations since they can be designed, implemented and run at a lower cost (including cheap construction, operating, and maintenance expenses that do not rely on power supply). Prepupae harvesting and usage in animal husbandry may also help farmers and small business owners generate extra cash and increase their economic output. Research on smallholder chicken production in Africa found that high feed costs are a significant influence (Malawi, Ghana). Other poultry species, notably waterfowl, may be used as a strategy to counterbalance and overcome the high feed costs. Other feed may be used to raise the latter (snails, water hyacinths). Another option is to augment and/or replace the feed with other materials produced locally or by the farmers themselves in order to lighten and lessen the financial strain on smallholder farmers. emphasized the benefits of IAA systems, which give extremely effective examples from Africa (Malawi, Ghana) and Asia (Japan, Korea, and Taiwan) (Bangladesh, Philippines). In addition, he emphasized the favorable impact of small-scale aquaculture on family income, employment, and consumption. To this end, it was shown that using an efficient CORS system with a black soldier fly may satisfy the needs of large-scale cultures since the prepupae produce can be utilized directly. The fly is an ecological engineer in poor and middle-income nations.

The high protein and fat content of dried soldier fly prepupae strengthens its utility as a fly meal for animal feed production. This means that the dried soldier fly prepupae business in the aquaculture sector is rising fast and becoming more appealing. A global increase of 6.1% in this kind of economic activity occurred between 2002 and 2004. Low and middle-income nations showed growth rates of 11.2 percent for Chile, 16.5 percent for Iran, 30.6 percent for Viet Nam, and 40.1 percent, and the most recent showed the greatest growth rate. For the majority of aquaculture species, fish meals and fish oil were the primary sources of nourishment. Fishmeal obtained from wild fish sources is in high demand because of the fast growth of aquaculture across the globe. In addition, the price of fishmeal rose, placing further strain on wild fish populations. As a consequence, farmers who presently rely on fishmeal will find other animal protein sources particularly appealing. Because of this, Hermetia illucens prepupae might be used as a protein source.

Conclusions

One of the biggest environmental issues is the disposal of trash. As a result of the ecosystem-altering effects of insufficient waste management, such as air pollution, water pollution, and soil contamination, human health is in actual danger. Several studies have shown that the local population around MSW plants had low birth weights, congenital abnormalities, and a small number of malignancies in its early years. The rising expenditures of municipal budgets were exacerbated by the growing output of solid wastes. Municipal solid trash output has increased dramatically due to population growth, urbanization, economic prosperity, and rising standard of life. MSW biodegradation is a key component in determining the quantity of recyclable material, especially organic material, that may be recovered. MSW produced in underdeveloped nations is quite diverse.

The properties of solid waste may be greatly influenced by poor bin collection techniques, collection, transfer, and/or transportation systems. Disposal of plastic garbage is a huge environmental issue on a worldwide scale. Plastics have a calorific value of 30 to 40 MJ/kg since they are mostly hydrocarbons. Consequently, they may be burnt to generate electricity and heat at municipal or other specialized trash facilities.

Landfills are the most common and least expensive method of disposing of solid waste. Materials that can be turned into valuable goods like fuels, materials, and chemicals are all part of waste valorization. As compared to granular-activated carbon, which costs $4500/ton, olive industry wastes might be turned into low-cost adsorbents for under $50/ton. CH4 is produced by Anaerobic Digestion of Municipal Solid Waste (OFMSW) from CO2 and H2 (hydrogenotrophs) as well as from CH3COOH (acetoclastics). A lack of heavy metals might impede the anaerobic digestion of sewage sludge to produce biogas. In part, this is due to the fast poisoning of the digester's many active bacterium types.

Organic solid-state fermentation (SSF) is touted as a potential solution to the problem of organic waste. Via the process of bioconversion, household food wastes with a high dry content may be used to make large amounts of ethanol through the SSF valorization process. In the process of turning organic wastes into high-value goods, microorganisms play a critical role in breaking them down into their component parts.

The management of home food waste is a major issue in the majority of nations across the globe. Amylase has been made from domestic bread trash. When industrial yeast strains were grown on orange peel as a substrate, they produced a large amount of aroma esters. SSF may be used to make glucoamylase- and protease-rich medium from food waste collected from restaurants that have been contaminated with fungal inoculum. These media may be used to create succinic acid as a feedstock. The second is used in a broad variety of products, including pharmaceuticals, polymers, and even laundry detergents.

The black soldier fly, Hermetia illucens, larvae, is an essential treatment option for organic waste since it is a realistic and long-term solution. Solid organic waste may be salvaged by composting and anaerobic digestion. Composting has the benefit of being simple to do from a technological standpoint. Valorization and recycling operations have proved out to be a beneficial source of money for covering a portion of the expenditures of an integrated solid waste management strategy.

References

[1] L. Simão *et al.*, "Assessment of the recycling potential of stone processing plant wastes based on physicochemical features and market opportunities," *J. Clean. Prod.*, vol. 319, Oct. 2021, doi: 10.1016/J.JCLEPRO.2021.128678.

[2] F. Russo *et al.*, "Sustainable asphalt mastics made up recycling waste as filler," *J. Environ. Manage.*, vol. 301, Jan. 2022, doi: 10.1016/J.JENVMAN.2021.113826.

[3] D. F. Andrade, J. P. Castro, J. A. Garcia, R. C. Machado, E. R. Pereira-Filho, and D. Amarasiriwardena, "Analytical and reclamation technologies for identification and recycling of precious materials from waste computer and mobile phones," *Chemosphere*, vol. 286, Jan. 2022, doi: 10.1016/J.CHEMOSPHERE.2021.131739.

[4] S. V. Bonato, D. Augusto de Jesus Pacheco, C. Schwengber ten Caten, and D. Caro, "Circularity in small breweries' value chains: Unveiling strategies for waste management and biomass valorization," *J. Clean. Prod.*, p. 130275, Dec. 2021, doi: 10.1016/J.JCLEPRO.2021.130275.

[5] K. Kabirifar, M. Mojtahedi, C. Wang, and V. W. Y. Tam, "Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review," *J. Clean. Prod.*, vol. 263, Aug. 2020, doi: 10.1016/J.JCLEPRO.2020.121265.

[6] Y. Feng *et al.*, "Fabrication of hydrochar based on food waste (FWHTC) and its application in aqueous solution rare earth ions adsorptive removal: Process, mechanisms and disposal methodology," *J. Clean. Prod.*, vol. 212, pp. 1423–1433, Mar. 2019, doi: 10.1016/J.JCLEPRO.2018.12.094.

[7] N. Han, J. Zhang, M. Hoang, S. Gray, and Z. Xie, "A review of process and wastewater reuse in the recycled paper industry," *Environ. Technol. Innov.*, vol. 24, p. 101860, Nov. 2021, doi: 10.1016/J.ETI.2021.101860.

[8] S. Kalisz, K. Kibort, J. Mioduska, M. Lieder, and A. Małachowska, "Waste management in the mining industry of metals ores, coal, oil and natural gas - A review," *J. Environ. Manage.*, vol. 304, p. 114239, Feb. 2022, doi: 10.1016/J.JENVMAN.2021.114239.

[9] M. Keppert, V. Davidová, B. Doušová, L. Scheinherrová, and P. Reiterman, "Recycling of fresh concrete slurry waste as supplementary cementing material: Characterization, application and leaching of selected elements," *Constr. Build. Mater.*, vol. 300, Sep. 2021, doi: 10.1016/J.CONBUILDMAT.2021.124061.

[10] K. P. Gopinath, V. M. Nagarajan, A. Krishnan, and R. Malolan, "A critical review on the influence of energy, environmental and economic factors on various processes used to handle and recycle plastic wastes: Development of a comprehensive index," *J. Clean. Prod.*, vol. 274, Nov. 2020, doi: 10.1016/J.JCLEPRO.2020.123031.

[11] A. Almasi *et al.*, "Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste," *Resour. Conserv. Recycl.*, vol. 141, pp. 329–338, Feb. 2019, doi: 10.1016/J.RESCONREC.2018.10.017.

[12] Z. Laldinpuii, S. Lalhmangaihzuala, Z. Pachuau, and K. Vanlaldinpuia, "Depolymerization of poly(ethylene terephthalate) waste with biomass-waste derived recyclable heterogeneous catalyst," *Waste Manag.*, vol. 126, pp. 1–10, May 2021, doi: 10.1016/J.WASMAN.2021.02.056.

[13] D. Vamvuka, G. Papaioannou, S. Alexandrakis, and A. Stratakis, "Control of the mobility of heavy metals in soil from disposal of bio-solid and olive by-product ashes using waste additives," *Environ. Pollut.*, vol. 266, Nov. 2020, doi: 10.1016/J.ENVPOL.2020.115136.

[14] G. Fredi and A. Dorigato, "Recycling of bioplastic waste: A review," *Adv. Ind. Eng. Polym. Res.*, vol. 4, no. 3, pp. 159–177, Jul. 2021, doi: 10.1016/J.AIEPR.2021.06.006.

[15] G. Jandieri, "A generalized model for assessing and intensifying the recycling of metal-bearing industrial waste: A new approach to the resource policy of manganese industry in Georgia," *Resour. Policy*, vol. 75, Mar. 2022, doi: 10.1016/J.RESOURPOL.2021.102462.

[16] T. A. Kurniawan *et al.*, "A societal transition of MSW management in Xiamen (China) toward a circular economy through integrated waste recycling and technological digitization," *Environ. Pollut.*, vol. 277, May 2021, doi: 10.1016/J.ENVPOL.2021.116741.

[17] W. Lawler *et al.*, "Towards new opportunities for reuse, recycling and disposal of used reverse osmosis membranes," *Desalination*, vol. 299, pp. 103–112, Aug. 2012, doi: 10.1016/J.DESAL.2012.05.030.

[18] C. O. Ugwu, C. G. Ozoegwu, P. A. Ozor, N. Agwu, and C. Mbohwa, "Waste reduction and utilization strategies to improve municipal solid waste management on Nigerian campuses," *Fuel Commun.*, vol. 9, p. 100025, Dec. 2021, doi: 10.1016/J.JFUECO.2021.100025.

[19] R. Jha, S. Dwivedi, and B. Modhera, "Measurement and practices for hazardous waste management," *Hazard. Waste Manag.*, pp. 89–115, 2022, doi: 10.1016/B978-0-12-824344-2.00011-2.

[20] C. Dwivedi, S. Manjare, and S. K. Rajan, "Recycling of waste tire by pyrolysis to recover carbon black: Alternative & environment-friendly reinforcing filler for natural rubber compounds," *Compos. Part B Eng.*, vol. 200, Nov. 2020, doi: 10.1016/J.COMPOSITESB.2020.108346.

[21] L. Keßler, S. A. Matlin, and K. Kümmerer, "The contribution of material circularity to sustainability—Recycling and reuse of textiles," *Curr. Opin. Green Sustain. Chem.*, vol. 32, Dec. 2021, doi: 10.1016/J.COGSC.2021.100535.

[22] O. Dogu *et al.*, "The chemistry of chemical recycling of solid plastic waste via pyrolysis and gasification: State-of-the-art, challenges, and future directions," *Prog. Energy Combust. Sci.*, vol. 84, May 2021, doi: 10.1016/J.PECS.2020.100901.

[23] V. G. Altieri, M. De Sanctis, D. Sgherza, S. Pentassuglia, E. Barca, and C. Di Iaconi, "Treating and reusing wastewater generated by the washing operations in the non-hazardous plastic solid waste recycling process: Advanced method vs. conventional method," *J. Environ. Manage.*, vol. 284, Apr. 2021, doi: 10.1016/J.JENVMAN.2021.112011.

[24] M. Salem, K. Raab, and R. Wagner, "Solid waste management: The disposal behavior of poor people living in Gaza Strip refugee camps," *Resour. Conserv. Recycl.*, vol. 153, Feb. 2020, doi: 10.1016/J.RESCONREC.2019.104550.

[25] B. Alawa, M. N. Galodiya, and S. Chakma, "Source reduction, recycling, disposal, and treatment," *Hazard. Waste Manag.*, pp. 67–88, 2022, doi: 10.1016/B978-0-12-824344-2.00005-7.