International Journal of Research in Engineering and Innovation (IJREI)
journal home page: http://www.ijrei.com
ISSN (Online): 2456-6934

REVIEW ARTICLE

Solid waste issue: Sources, composition, disposal and recycling

A.S. Bagawan[1], S.M. Nimbalagundi[2], S.N. Poleshi[2], S.V. Gurumath[3]

[1]*Department of Chemistry, M.G.V.C College Muddebihal, Vijayapur, Karnataka-586212, India*
[2]*Department of Physics, M.G.V.C College Muddebihal, Vijayapur, Karnataka-586212, India*
[3]*Department of Botany, M.G.V.C College Muddebihal, Vijayapur, Karnataka-586212, India*

Article Information

Received: 26 November 2021
Revised: 02 December 2021
Accepted: 05 December 2021
Available online: 06 December 2021

Keywords:

Solid Waste;
Environmental Problem;
Waste Management;
Solid waste generation;
Plastics waste disposal

Abstract

In both urban and rural, developed and developing countries Solid wastes removal is a widespread and burning problem. The collection and disposal of municipal solid waste (MSW) is today’s major environmental problem in most countries around the world. The masers made by Municipal solid waste management are economically viable, technically viable, socially, legally acceptable and environmentally friendly. Even the issue of solid waste management is the biggest challenge for officials in small and large cities. The organic food waste evaluation is one of the most important research areas today. Traditional landfills, fireworks, composting and solid waste management are commonly used as waste disposal techniques. Traditionally, compost and anaerobic digestion (AD) is the most widely used technology for the processing and use of the organic component of MSW. The quantity of Organic solid waste products worldwide increases dramatically every year. Most of the Organic solid waste products consist of agricultural waste, household food waste, human and animal waste, and so on. It is commonly used as animal feed, incinerated or disposed of in landfills. Organic solid wastes are rich in proteins, minerals and sugars that can be used as substrates or raw materials in other processes.

1. Introduction

The increase in the quantity of production of solid waste, which make a financial burden on the municipal budget, that makes a biggest challenge for all small and large city governments in developed and developing countries. In addition to the high cost, solid waste management is associated with a lack of understanding of the various factors that affect the entire management system. A review of literature and waste management in developing countries shows that some articles provide quantitative information. The purpose of the reported studies was to determine the actions/behaviors of stakeholders that play a role in the management of solid waste and to determine the various factors that influence the system. The studies were conducted in 4 continents, 22 developing countries and more than 30 urban areas. The combination of variable methods used in this study has been extensively reported to encourage stakeholders and to investigate the factors influencing the performance of solid waste management [1]. In developing countries, population growth, rapid urbanization, economic prosperity and rising living standards have significantly accelerated the pace, quantity and quality of municipal solid waste production [2].

2. Sources, composition and characterization of the solid waste

Municipal solid waste (MSW) is one of the major

Corresponding author: A.S. Bagawan
Email Address: abdulrajaksd@gmail.com
https://doi.org/10.36037/IJREI.2021.5611

environmental challenges. Municipalities are responsible for waste management. They should provide an effective and efficient system to the residents. The MSWs are [3] facing many problems beyond their capacity of authorities to deal with it. The main problems that MSW always facing are mainly due to the lack of financial resources, organization, and complexity [4].

The composition of MSW varies greatly from one municipality to another and from one country to another country. Such fluctuations mainly depend on lifestyle, economic conditions, waste management regulations and industrial structures. The quantity and composition of municipal solid waste is important to determine the correct handling and management of this waste. Such information is necessary and useful for the establishment of facilities for the conversion of solid waste in to useful gaseous energy (fuel). Based on the calorific value and elemental composition of the energy (fuel) produced from the solid waste the MSW, engineers and scientists can make a decision on the utility as a fuel. Meanwhile such information will help in predicting the production of gaseous emissions. Thereafter MSW is subjecting to the energy (fuel) conversion technologies including gasification, incineration etc. Even after incineration MSW has to take care for the possible hazardous substances occurring in the ash and handling it carefully [5]. In this way, the composition of the waste will provide valuable information on the utility of the material for either composting or for biogas production as fuel via biological conversion [6].

Meanwhile, time has a major impact on the composition of the MSW. The biodegradation of solid waste is an important factor that determines the amount of recyclable material, especially organic material. The U.S. Environmental Protection Agency (EPA) estimated that the production of biodegradable solid waste in the United States was 254 million tons in 2013 [7]. The structure and material classification of such MSW is given in Fig. 1.

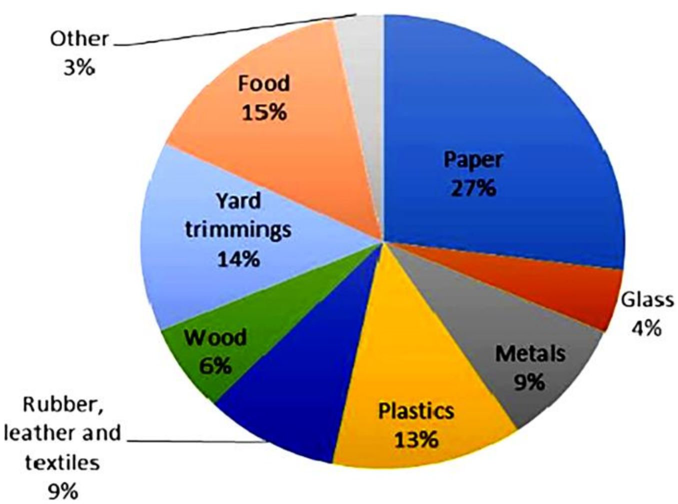

Figure 1: Composition and classification (by material) of MSW generated by the United States in 2013

Domestic or municipal waste is usually generated from variable sources where different human activities occur. Several studies report that municipal solid waste generated by developing countries mainly comes from households (55-80%), followed by markets or commercial areas (10-30%). The latter consists of a number of variables generated by industry, roads, institutions and many others [8]. In general, solid waste from these sources is plentiful and heterogeneous in nature. As such, they have varying physical and chemical characteristics depending on the original source. Their composition is yard waste, food waste, plastic, wood, metal, paper, rubber, leather, batteries, aggregates, fabrics, paint containers, demolition and construction materials and many more which would be difficult to classify. The heterogeneity of solid waste produced is the most important obstacle in sorting and using it as a material. Therefore, there is a proper need for fractionation and segregation of these wastes prior to any substantial treatment process. The classification and separation of such wastes is one of the most important and traditional methods as a basic step in solid waste management to provide quality data of separated fractions for each possible use. However, the success of any waste segregation project depends primarily on the awareness of the community and the active involvement of the waste producers in the various communities (i.e., how they follow the basics and principles of sorting and sorting waste) [9].

Solid waste generation (SWG) is a big problem everywhere in the world especially in all urban centres. Most of the developing countries are considered such solid waste generation (SWG) is one of the most challenging problems. Because of huge amount of solid waste generation (SWG) serious environmental pollution problems are occurring [10]. The increase in waste generation in urban cities has dramatically affected basic services such as sanitation, water supply, waste management and transportation infrastructure [11]. Several studies have shown that the collection, storage, transportation, and final disposal of waste is a major problem in cities and urban areas [12]. Cities in East and North Africa as well as most developing countries are also facing the same serious problems related to SWG. The main reason for this problem is attributed to the poor economy in this area due to the low achievement in waste management [12]. Most of these developing countries fail to manage and dispose of solid waste due to limited availability of resources and competitive advantage over their own resources. So SWG is actually one of the serious and major problems faced by many cities in the world.

Meanwhile, SWG and composition are influenced by other socio-economic factors, including average family size, number of rooms, monthly income, and employment status [13]. It was also reported that there is a direct relationship between waste composition and social activities in the community [14]. In addition, other factors, including changes in resource classification behaviour and consumption of goods, among others affect the composition and quantity of household waste [15]. Socio-cultural, economic, legal, political and environmental factors as well as available resources are the

main issues affecting municipal solid waste management in all countries [10]. This is why the adoption of any new technology for the management of the MSW and SWG must take into account its impact and impact on the socio-cultural and economic economy of the community.
As a result of changing consumer attitudes and rapid technological advances, the number and composition of MSW have also changed. A study conducted by the European Environment Agency [16] to study the annual per capita MSW of 32 European countries during the period 2001-2010 found that this waste increased in 21 countries and decreased in 11 countries. The study also looked at the amount of waste in 26 countries between 2001 and 2008. It was found that the amount decreased in 6 countries [16]. Thus, the amount and characteristics of waste vary from country to country, as well as from region to region and even within the same city according to these factors, including human usage habits [17].

2.1 Food solid waste

A sustainable and effective supply of positive industrial chemicals can be achieved from large quantities of waste generated worldwide. Food scraps and wastes include rubbish, rubbish and soil [18], commonly described as by-products and as food waste. Such waste is generated from the processing, cooking, distribution, production and quantity of food. However, food waste and its definition are significantly more numerous, from cities and nations to different cities and nations. Food waste In the EU "is cooked or cooked without food ingredients that can be wasted, or that means or should be wasted". The US Environmental Protection Agency (EPA), on the other hand, defines food waste as "food waste and food from homes and industrial facilities, including restaurants, grocery and transportation, institutional cafeterias and kitchens." rooms. In addition, "food shortages" and "food waste" are recognized differently in the United Nations. The term "food loss" refers to the first degree and / or amount of food. Alternatively, the term "food waste" refers to food losses caused by the behaviour of retailers and / or consumers [19]. However, food waste is suitable for raw cooked food, food waste, as well as for human consumption by grocery or liquid markets.

2.2 Disposal of solid waste

Improper collection practices, collection, transfer and / or transportation systems have been reported to have a major impact on the properties of solid waste. In addition, the poor planning route, lack of information regarding the collection schedule [20], the number of vehicles for the collection of solid waste and poor roads and insufficient infrastructure can also have an effect on the characteristics of the solid waste. The effective ways and affordable waste collection services have been studied and reported by Sharholy-et- al. [21]. Knowledge of treatment by authorities is one of the important factors influencing the management of solid waste. Factors influencing the disposal of household waste were identified by Tadesse-et-al [22]. Their results indicated that the provision of waste facilities significantly influences the choice of waste disposal. They reported that the insufficient supply of waste containers as well as the longer distance to transport these containers increases the possibility of dumping such waste in open areas and along the roadside. Pokhrel and Viraraghavan [23] mentioned that insufficient financial resources, absence of legislation, well-equipped and designed landfills all contribute to limiting the safe disposal of solid waste.

3. Plastics waste disposal

Plastic disposal is one of the major global environmental problem. 50 million tons of plastic waste to consumers are generated annually by Europe, the USA and Japan. The disposal of this plastic waste in the landfill is considered unsustainable from the point of view of the environment. In addition, landfills and their capacity are declining rapidly. On the other hand, legislation worldwide is strict. US legislation and several European regulations concern the disposal and management of plastic waste [24].
Since plastic is essentially hydrocarbons, it has a caloric value of 30 to 40 MJ / kg. They can therefore be burned or incinerated in the municipal or other special waste with power and heat generation. It can also serve as an additional fuel to replace the fossil fuels in various production processes such as blast furnaces and cement kilns. Through these thermal applications, this plastic waste can be completely destroyed. The burning of plastic waste therefore replaces fossil fuels. However, this leads to additional advanced pollution control measures [25].
Nevertheless, greenhouse gas emissions can be reduced through efficient waste management. Several reports are published on the environmental impact of incineration and / or landfills [26]. These studies emphasized that plastics and other non-biodegradable materials will remain in the landfill, while the biological solids (bio-solids) will be converted anaerobically into biogas from landfills, as an energy source. Therefore, the impact of burning the plastic and other non-biodegradable materials is dangerous due to the release of more greenhouse gases than landfill.

3.1 Disposal of municipal solid waste

One of the biggest environmental problems is the collection of solid waste and its disposal in urban areas. This is due to the lack of efficient of management of MSW, it leads to the significant environmental problems. These include soil, air, water and aesthetic pollution. Such environmental problems are related to human health disturbance due to the increase in greenhouse gas emissions [27]. The waste streams from industrial sources differ from the hazardous substances in household waste [28]. They are not strictly controlled under the regulations of hazardous waste, such as the European Hazardous Waste Directive 91/689 / EEC and the US Resource

Conservation and Recovery Act 1976 (RCRA) (US Code, 1976) [29]. The household hazardous waste (HHW) is disposed of together with general household waste in landfills. The quantities, quality and significance of such disposal are poorly understood. It is generally accepted that the amount of HHWs is small, and therefore the risks of disposal are insignificant. Nevertheless, the separate disposal of industrial, MSW and other wastes increases the importance of the toxic and hazardous element in such wastes. There is great concern about the presence of various chemicals in household products. The consequences and the impact on the environment are also the results of the disposal of HHW are. The disposal of such HHW to landfill should therefore address current legislation to reduce the risk to the environment [30].

Worldwide, approximately 71% of MSWs are disposed of in landfills [31]. MSW contains mostly hazardous substances, including some batteries, paints, mercury-containing waste, pharmaceuticals, vehicle maintenance products, and many other products. On the other hand, more than 53% of the dumped waste consists of hard cardboard, yard waste, papers and food that is biodegradable by the anaerobic bacteria [32]. This makes landfill the primary method of removing waste in Europe and the USA.

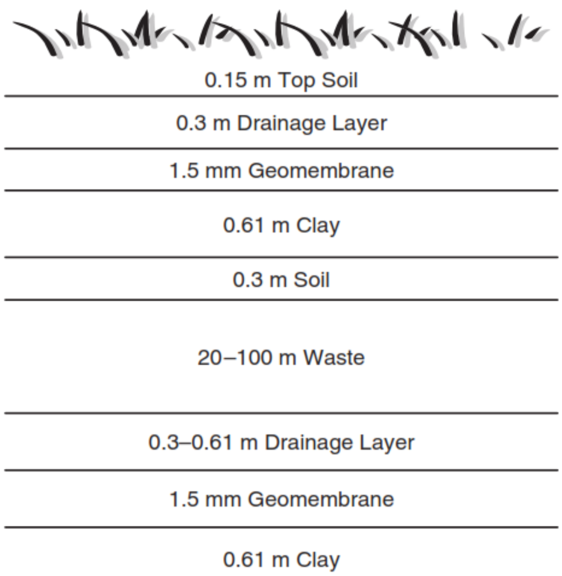

Figure 2: Typical cross-section of a landfill receiving MSW [32].

Most MSWs as well as many other solid wastes are disposed of at landfills. A basic understanding of the design of the landfill is therefore useful. In the US for example, the design and operation of landfills are regulated by the New Source Performance Standards of the Clean Air Act, and subtitle D of the Resource Conservation and Recovery Act, as well as the other related state regulations. Therefore, landfills have evolved from just open landfills to highly manipulated facilities and sites designed to contain waste. They are separated from the environment, capture polluted water that comes into contact with the waste (ie percol), and control gas migration. A landfill is designed as usual excavated and executed with a system containing layers to protect groundwater by minimizing the migration of leachate to the ground layers and collecting such leachate for treatment. A cross-section of typical landfill design is given in Fig. 2.

3.2 Problems of solid waste disposal within rural communities in developing countries

Waste disposal as solid waste is a serious and widespread problem in urban and rural areas in several developing countries. Various canals and drains as open spaces are widely used to dump garbage as a source of household organic and inorganic waste. Because there are no continuous garbage disposal systems, convenient landfills, open canals and drains are blocked by dumping large amounts of solid and garbage waste. Hence they therefore no longer in function. This garbage waste is mostly plastic and paper and few toxic materials. However, such toxic materials represent a hazard to the environment due to the degradation of their degradable constituents, a matter that adds significant amounts of BOD to the local ecosystem. Many people and most organizations have not provided for on-site treatment and / or safe disposal of solid waste to deal with the environmental conservation measures. The disposals of garbage solid waste and untreated waste water by people in nearby drains is therefore irresponsible and are not aware of the consequences of their health hazard. There are no financial incentives to keep them from this practice and encourage them to change their habits. Individuals see that the way they dispose of their waste is effective and inexpensive. It is actually a serious disaster for the surrounding communities and for the country. The fact is that small amounts of effluent cause pollution in a very large volume of water bodies. Meanwhile, laws are not effective in preventing the environment from causing dangerous practices unless a better solution can be found.

4. Management and recycling of solid waste

In terms of rates for solid waste disposal, Scheinberg-et-al reported that there are indications that high recycling rates for recycling are associated with disposal fee [33]. High pricing has a positive effect on the recycling of generated solid waste. It is about the beneficial reuse or the value chains of solid waste. Gonzalez-Torre and Adenso-Diaz mentioned that social influences, altruistic and regulatory factors are important reasons why certain communities can develop strong recycling habits [34]. The author also reported that people who regularly throw away their general rubbish in the bins are more likely to recycle certain products at home. In most cases, as the distance to the rubbish bins decreases, the number of fractions that people separate, sort and collect at home increases. Minghua-et-al added that the local government should encourage the markets for recycled materials to increase recycling rates and the professionals in the recycling businesses should increase. Further important factors were mentioned by other scholars including financial support for various recycling projects [35], in support of the infrastructure of the recycling companies in their country. Other investigators have suggested downloading and repurchasing centres [36]. Sharholy et al.Proposed that the informal sector for solid waste recycling be organized.

Indeed, the collection and disposal of MSW is today one of the biggest problems in the urban environment in most countries worldwide. MSW management solutions must be financially sustainable, technically feasible, socially and legally acceptable as well as environmentally friendly. European policy is currently insisting on adapting various rational governance to natural resources. Today, valorization is a promising technological perspective. It becomes a process made possible by sorting the MSW at the source, and combining it with material recycling as well as waste-to-energy methods. However, technologies such as removal or mechanical sorting of the MSW at landfills do not effectively improve MSW management. Therefore, landfills should be the ultimate landfill of the MSW. Yet in many countries construction of conventional landfills for the removal of MSW is still being done. This was reported by Hadjibiros et al. that the site selection of the landfill site is extremely important due to the lack of public acceptance which results in various social problems [37]. For sustainable management of solid waste, effective planning and development strategies on the quantity and categories of such waste are of great importance. Thus, the most important processes are quantification and characterization of all the sustainable systems management systems according to Senzige et al. [38]. In a specific place, the study of the composition and the categories of solid waste is important for the integration of technologies, including recycling and recovery of resources, in the relevant solid waste management systems. The information can also certainly help with infrastructure, policy development and planning for any size decisions regarding the integrated solid waste management program [39].

In order to prevent serious environmental risks for the health and treatment of these wastes it is strongly necessary. The most commonly used and cheapest solid waste disposal sites are landfills as waste management techniques. From the beginning of civilization, humans have been producing solid waste. During these earliest times, solid wastes were dumped in large open areas. At that time, the population density was low. On the contrary, the development of living standards, increasing population and rapid urbanization, have today created large amounts of solid waste in all countries worldwide. MSW comes from various activities carried out in homes, in public and private service as well as buildings and commercial services. They all form an important part of the solid waste today [40]. Waste management is actually about the use of multidisciplinary approaches ranging from engineering, humanities, sociology and biology. The level of development of a country reflects the impact on the management of solid waste and the choice of such management. Riber et al. [41] mentioned that many developed countries use different methods of waste management for the production of renewable energy and other new products, including compost. These countries invest in waste recycling for the benefit of agricultural activities. The choice of solid waste management depends on the decisions made by the city leaders, as well as the structures related to the nature, quantity and quality of local waste. Household waste is recognized as any waste produced at home from a household source. It usually represents more than two-thirds of the MSW stream. In this regard, all potential hazard items must be identified and properly assessed to obtain the maximum environmental protection against the hazards and risks associated with open dumping. Increasing the amount of solid waste causes various problems with collection, transportation and disposal. This complicates the management of this solid waste. The MSW indeed has great economic potential and revenue. However, the efficiency of MSW management affects the potential economic value of this waste [42]. A good knowledge of the characterization of solid waste before it is removed is important for the management of MSW. During the management of solid wastes, problems can arise due to their possible heterogeneous structure. The physical characteristics of solid waste are important for the choice of the method of collection, transport, recyclable materials and energy transformation, as well as for the choice and design of the right disposal methods. The physical characteristics of MSW, including composition, calorific value (heating) and moisture content (MC), should therefore be well known to select the appropriate management methods. The moisture content of solid waste varies from 5% to 40% with an average of 20%. This very wide range of MC depends on the socio-economic structure and the regional characteristics of the solid waste. Nevertheless, the MC can reach up to 55% -70%, depending on the climatic conditions and the composition of solid waste. It is important to mention that the caloric value of solid waste depends a lot on the MC. It is also an important parameter for determining the design procedures of incineration for the recovery of solid waste. UNEP [43] estimated that the management of solid waste contributes to the emission of greenhouse gases (greenhouse gases) between 3 and 5%. This is mainly due to the emissions of CH_4, CO_2 and N_2O that escape from the open rubbish dumps. Additional gas emissions from CO_2 come from upstream processes, such as transportation and waste collection. However, managing waste adequately can certainly reduce or save greenhouse gas emissions in a variety of ways, including: energy production, applying compost to soils as fertilizer, carbon storage in landfills and avoiding the primary material through material recovery from waste. It has been reported by UNEP that the internationally recognized institutions recommend a future waste management that is focused on the 3R concept (namely: Reduce, reuse and recycle). This 3R is waste prevention, establishment of circular economy, cleaner productions and valorization of waste by conversion into a source of energy and materials. Inadequate waste management causes changes in ecosystems, including air, water and soil pollution, and thus poses a real threat to human health. The impact of dumping and incineration of MSW on public health has not been fully studied. Rushton [44] mentioned that some studies have shown that the local population in the vicinity of MSW facilities has a low weight at birth, congenital disorders and few cancers. However, it seems that the impact on this local population varies according to the population studied. Explanation of this approach regarding the epidemiological surveys should receive more attention, especially the doubt about human diseases. Problems related to inadequate waste treatment are usually a serious problem in developing countries due to the limited financial resources. Most of these countries dump their MSW without proper control. As a result, it causes air, soil and water pollution. Waste management is therefore one of the most important issues facing humanity today. However, waste should not only be considered as a source of material recycling (metals, glass, plastic and fibre) and energy, but also as a result of oil conservation and an aid to environmental protection. If we look at the global energy that can only be produced from agriculture's organic waste, including crop residues, it is estimated to be around 50 billion tonnes of oil equivalent. According to the UNEP, an adequate separation between organic and non-organic waste is necessary as a prerequisite for an efficient energy generation. The organic residues are actually responsible for compromising the efficiency of thermal technology in terms of the energy produced as well as the emission of greenhouse gases. The manner in which this waste is handled is given in Fig. 3.

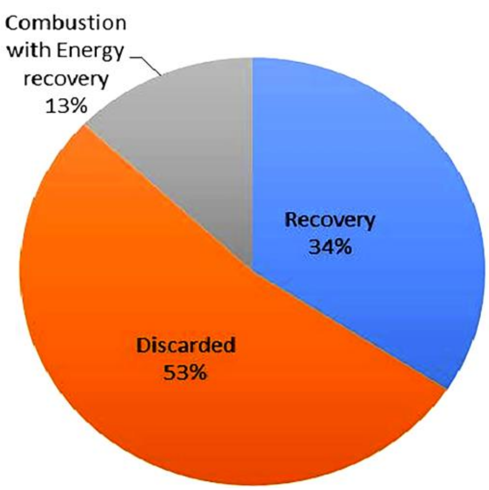

Figure 3: Management of MSW

5. Agriculture organic solid waste

It is well known that agriculture as well as agricultural activities generate a large amount of lingo-cellulose by-products, including fruit peel, straw, stem, stalk, cobs, peel and bagasse. Such wastes consist mainly of cellulose (35% –50%), lignin (25% –30%) and hemicellulose (25% -30%) [45]. Normally, glucose is the most important ingredient. The hemicellulose is a heterogeneous polymer consisting mainly of five different sugars (namely: larabinose, D-glucose, D-galactose, D-xylose and D-mannose) as well as some organic acids. The lignin is formed by a complex three-dimensional structure of phenylpropane units [100]. Recently, the SSF has been successfully applied to produce hydrolytic and lignin lytic enzymes. The lignin per oxidase was successfully produced by using maize heads as substrate in SSF. Despite the rising price and the significant shortage of grains as a customized animal feed, it was reported by Graminha et al. [46] that the lignocellulosic materials have a great potential to produce edible animal feed. Nevertheless, the direct application to animal feed is very limited due to the presence of lignin which reduces its digestibility.

Several straw pretreatments have been implemented using SSF for cellulose and lignin degradation to increase feed digestibility. It is worth mentioning that SSF may have a valuable potential to produce enzymes and to improve the digestibility of rich fibrous materials, including soybean cotyledons. Jatropha seed cake has been reported to be used for the production of cellulose by SSF without any prior treatment. Several investigators have reported other uses for similar materials, including the reinforcement of composite materials found in building materials, furniture, fishing nets, and so on. and / or when activated carbon is applied. The organic waste from agriculture mostly includes livestock manure. It is confirmed that the cow dung contains a high nitrogen content which makes it suitable for methane production. On the other hand, the production of activated carbon and biochar has been favoured through the use of cattle manure and chicken manure. Meanwhile, high-quality bio-fertilizers can be produced using liquid amino acid hydrolyzed from animal carcasses, as an additive to mature compost from pig manure or chicken by SSF [47].

5.1 Industrial organic solid waste

All organic by-products from a wide variety of industries, including fruit and vegetable processing plants, butchers, poultry processing, sugar industry, the dairy industry, paper and pulp manufacturing, as well as many others, are the industrial organic waste. Most of this organic waste has the potential to be used as a substrate or support in SSF processes to produce valuable products. Sawdust, which is the solid waste and available by-product of the timber industry, is used, for example, as a support substrate in SSF to obtain high lacquer production by using white rot fungi, namely Coriolopsis gallica. In addition, the abattoir and the leather industry generate various organic waste products that contain proteins, as well as livestock, pruning, hair, chrome shaving, waste and keratin waste that are underutilized. The flesh of animals has been reported to be used as a substrate in SSF for protease production. The mixture of the hair waste from the slaughterhouses mixed with aerobically activated sludge or anaerobically digested sludge showed a high yield of protease production. Meanwhile, the by-products of the sugar industry, such as sugarcane bagasse and molasses, have been reported for the production of invertase via SSF. In addition, molasses was chosen as an inexpensive substrate to replace an expensive raw material (cane sugar) to produce ethanol. In addition, the waste from the tapioca industry, which contains significant organic matter associated with a strong odor that can cause environmental pollution, has been successfully converted into poly-3-hydroxybutyrate (PHB) via SSF. An alternative industrial process and a significant reduction in total production costs can thus be achieved [48]. This proved that the food processing industries usually generate several by-products that can be used in SSF for the production of various valuable bio-products. It has been widely reported that the vegetable and fruit wastes can be used for the production of organic acid and vital enzymes. Vegetable waste shows a great potential for energy conversion of energy due to its high and easily degradable organic content, especially in the production of biofuels. It has been reported that crustaceans can be used by products generated in industrial seafood processing for the production of chitinase and chitosanase with a wide range of applications and implementation in biomedical, food and agrochemical sectors. Meanwhile, fish processing waste is beneficial because this waste is easily available at a low cost and provides suitable SSF conditions for the cultivation of microorganisms. Due to the rich content of lipids and proteins, such fish processing waste has been found suitable for producing esterase. The latter is a product with a versatile industrial application in organic chemical processing, in detergents, in the surfactant and oleo-chemical industry [49].

5.2 Municipal/domestic food solid waste

Several developing countries treat their domestic wastewater inadequately due to the high financial cost. In addition, most countries worldwide face a serious challenge in managing household food waste. It is wet, in a random way, and sometimes mixed with impurities of inorganic waste and metals. The composition of such household food waste is particularly complex because it includes papers, water, oil, as well as spoiled and leftover food from kitchen waste and markets. All of these wastes are chemically composed of fats, cellulose, starch, lipids, proteins and other organic materials. The moisture and salt content leads to a rapid decomposition of the organic content in the waste, which causes unpleasant odours. This condition can attract bugs and flies, which are vectors for various diseases. In addition to being perishable, this municipal solid waste, including household kitchen waste as well as household food waste from restaurants and markets, consists of high lignocellulosic materials that can be decomposed and extracted to produce valuable bioproducts. This household food waste, including salt, bread, waste cakes, fruits, vegetables, onion and potato peelings and cafeteria waste, has been proven to be a suitable substrate for the production of glucoamylase enzymes by Aspergillus awamori via SSF technology. Household bread waste was used to produce amylase [50]. MSW and kitchen waste residues, which consist mainly of onion peel, potato peel, carrot peel, cauliflower leaves, orange peel, banana stalks and pea pods, have been used together to produce cellulose by SSF. Recently, the cultivation of selected industrial yeast varieties with the use of orange peel as substrate has led to a high yield of aroma esters. Several studies have reported on the use of high-dry household food waste to produce high-yield ethanol via SSF. In the same way, mixed food waste collected from restaurants and vaccinated with fungal vaccine can produce glucoamylase-rich media and protease-rich media by SSF. This media is suitable for use as a raw material for the production of succinic acid. The latter has a wide range of applications, such as the manufacture of medicines, plastics and detergents. In Nigeria, for example, coconut peel is a common household kitchen waste that can become a very useful substrate for oxytetracyclines, which is an important antibiotic to treat many infectious diseases. It is important to mention that the complex composition of food waste makes them very suitable for microbial growth as possible media to produce Bacillus thuringiensis (Bt) bio pesticide by SSF [51].

5.3 Anarobic digestion of sewage sludge for biogas production as affected by heavy metals in the sludge

Sewage water mixed with industrial and domestic wastewater can be contaminated with heavy metals and chemicals. The presence of heavy metals in municipal sludge has been reported to reduce the efficiency of the anaerobic digestion process. These studies indicated that a significant decrease in gas production and the removal of volatile organic matter was recorded. In addition, an accumulation of organic acid products has also been recorded which refers to inhibition of methanogenic bacteria. This inhibition is due to the toxicity of heavy metals. It has been reported that the toxicity of the heavy metals for the anaerobic digestion of the sludge can be regulated in the following descending order: Hg <Cd <Cr (III). In this study, the accumulation of heavy metals during the pulse was limited, which can be attributed to the rapid poisoning of the bacteria in the digestion. It is therefore recommended that the presence of toxic metals in organic solid waste, such as Hg, Cd and Cr (III), be avoided or eliminated in the anaerobic digest. In addition, the industrial wastewater and / or sludge associated with heavy metals should also be avoided in the anaerobic distributors for biogas production [52].

6. Solid waste management in the developing countries

Due to demographic change, consumer behavior, rapid urbanization and fast-growing population municipalities in developing countries, decision-makers face serious new challenges in solid waste management. Many cities have made efforts over the past few decades to find a sustainable solution to the problem of solid waste management. Specific focus was to develop integrated strategies for solid waste management, including construction, operation and maintenance of sanitary landfills and the related problem. To cover part of the cost, it was found that the appreciation and recycling of activities became a valuable income. In Ankara, Turkey, for example, it is reported that 50% of the recyclable waste produced by households, trade and commerce is collected and sold, yielding a total amount of $ 50,000 per day. In Delhi's waste management system, at least 150,000 waste pickers dispose of more than 25% of all waste generated to recyclable products. This management system saves the municipal authorities considerable costs [53]. In low- and middle-income countries, organic waste still causes many problems, as no definitive solution has yet been found. A successful development of experimental to full-scale waste treatment systems offers several benefits by using the larvae of the black soldier fly. Since such systems can be developed, implemented and operated at low cost (including low construction, operating and maintenance costs independent of power supply), they are more adapted to developing countries. In addition, the creation of additional value and further income generated by the sale of harvested prepupae and / or its use in animal husbandry can certainly strengthen the economic income of farmers or small businesses. Agricultural studies have confirmed that the high feed cost is definitely an important factor for poultry production in Africa (Malawi, Ghana). The latter can be raised with other feeds (snails, water hyacinths). Another further option could be to supplement and / or replace the feed with alternative other materials produced locally or by the farmers themselves to alleviate and reduce the financial burden of the small farmers. Prein and Ahmed emphasize the benefits of the Integrated Agricultural Agriculture (IAA) systems, which offer many successful examples from Africa (Malawi, Ghana) as well as Asia (Bangladesh, Philippines). In addition, Ahmed and Lorica emphasize the positive impact of small-scale aquaculture on household income, employment, and consumption. It has therefore been concluded that the use of a CORS system of a black soldier fly for well design and under achievable operation can meet the requirements of these extensive cultures, because the yield in prepupae can be used directly. In low- and middle-income countries, the fly can act as an ecological engineer. The high nutrient content of dried soldier fly preparations, namely protein and fat content, enhances its high potential value as fly meal in animal feed production. Thus, the aquaculture industry is becoming a fast growing and very attractive market for dried soldiers' fly prey. Such economic activity grew by an average of 6.1% worldwide between 2002 and 2004. Many low and middle-income countries have growth rates of 11.2% for Chile, 16.5% for Iran, 30.6% for Vietnam and 40, 1% for Myanmar, and the youngest showed the highest growth rate [54]. The fish meals and the fish oil have become the main food sources for most water species. Currently, the rapid spread of aquaculture worldwide is leading to an increase in the demand for fishmeal from wild fish stocks. It has also increased the price of fishmeal and put pressure on the natural fish populations. As a result, alternative animal protein sources will be very attractive to farmers who are currently dependent on fishmeal. Therefore, the prepupae of Hermetia illucens can serve as this alternative source of protein.

7. Conclusions

Solid waste is one of the most important challenges for the environment. Inadequate waste management causes changes in ecosystems, including air, water and soil pollution, and thus poses a real threat to human health. Some studies have shown that the local population in the vicinity of MSW facilities has a low weight at birth, congenital disorders and few cancers. The increasing generation of solid waste has placed the burden on the high cost of the municipal budget. The increase in population, the rapid urbanization, the growing economy and the rise in the standard of living have significantly accelerated the pace, quantity and quality of municipal solid waste production. The biodegradation of MSW over time is an important factor that determines the amount of recyclable material, especially the organic content. MSW generated from developing countries is high; heterogeneous in nature.

The improper waste practices, collection, transfer and / or transport systems have a great influence on the properties of the solid waste. Plastic removal is a major global environmental problem. Since plastic is essentially hydrocarbons, it has a caloric value of 30 to 40 MJ / kg. They can therefore be incinerated or incinerated in the municipal or other special waste with power and heat generation.

The most commonly used and cheapest solid waste disposal sites are landfills as waste management techniques. Waste Valuation deals with the process of converting waste materials into more useful products, including fuels, materials, and chemicals. It is estimated that the waste from the olive industry can be converted into cheap adsorbents at a cost of <$ 50 / ton versus $ 4500 / ton for granular activated carbon. Anaerobic digestion of municipal solid waste produces CH_4 from CO_2 and H_2 (hydrogen) and / or from CH_3COOH (acetic acid). The anaerobic digestion of sewage sludge for biogas production can be limited by the presence of heavy metals. This is attributed to the rapid poisoning of the various active bacteria in the digestive tract.

Organic solid state fermentation (SSF) is offered as a promising technology for organic waste. The use of household food waste with a high dry content to produce high yields of ethanol through SSF valorisation is obtained by the bioconversion of these waste products. Microorganisms play an important role in the breakdown of organic waste into their ingredients to convert it into high value-added products.

Most countries worldwide face a serious challenge in managing household food waste. Household bread waste was used to produce amylase. By using orange peel as a substrate, the cultivation of selected industrial yeast strains resulted in a high yield of aroma masters. Mixed food waste collected at restaurants and vaccinated with fungal vaccine can produce glucoamylase-rich media and protease-rich media through SSF. This media is suitable for use as a raw material for the production of succinic acid. The latter has a wide range of applications in the manufacture of medicines, plastics and detergents. Treatment technology of such organic waste, using larvae of the black soldier fly: Hermetia illucens, is an important way as a feasible and sustainable treatment option. Valuation of organic material solid waste can be done through composting and anaerobic digestion. The advantage of producing compost is the technical simplicity of the process. To cover part of the integrated costs for the management of solid waste strategies, it was found that the appreciation and recycling of activities became a valuable income.

References

[1] L.A. Guerrero, G. Maas, W. Hogland, Waste Manage. (Oxford) 33 (2013) 220– 232.

[2] Z. Minghua, F. Xiumin, A. Rovetta, H. Qichang, F. Vicentini, L. Bingkai, A. Giusti, L. Yi, J. Waste Manage. 29 (2009) 1227–1233.

[3] M. Sujauddin, M.S. Huda, A.T.M. Rafiqul, J. Waste Manage. 28 (2008) 1688– 1695.

[4] S.J. Burntley, J. Waste Manage. 27 (10) (2007) 1274–1285.

[5] American Society of Mechanical Engineers (ASME), Waste to Energy, Summary Report Accessed July 5, 2014 http://www.asme.org, 2014.

[6] S.J. Kumar, K.V. Subbaiah, P.V.V. Rao, J. Environ. Sci. 1 (2) (2010) 26–28.

[7] U.S. Environmental Protection Agency, Wastes – Non-Hazardous Waste – Municipal Solid Waste, 1200 Pennsylvania Ave., N. W. Washington, DC 20460, U.S.A. (2013).

[8] A.B. Nabegu, J. Hum. Ecol. 31 (2) (2010) 111–119.

[9] C. Valkenburg, C.W. Walton, B.L. Thompson, M.A. Gerber, S. Jones, D.J. Stevens, Municipal solid Waste (MSW) to Liquid Fuels Synthesis, Pacific Northwest National Laboratory, Richland, WA, 2008.

[10] I.A. Al-Khatib M. Monou S.F. Abdul Q.S. Hafez K. Despo Solid, waste characterization, quantification and management practices in developing countries. A case study Nablus district – Palestine 2010.

[11] C.M. Liyala, Modernizing Solid Waste Management at Municipal Level: Institutional arrangements in urban centers of East Africa PhD Thesis, Environmental Policy Series. Wageningen University, The Netherlands, 2011.

[12] J. Okot-Okumu, R. Nyenje, Habit. Int. 35 (2011) 537–543.

[13] F.P. Sankoh, X. Yan, A.M.H. Conteh, J. Environ. Prot. 3 (2012) 562–568.

[14] E. Gidarakos, G. Havas, P. Ntzamilis, Waste Manage. 26 (6) (2006) 668–679.

[15] L. Dahlén, Household Waste Collection Factors and Variations, Department of Civil, Mining and Environmental Engineering Division of Waste Science and, Technology Luleå University of Technology, Luleå, Sweden, 2008.

[16] European Environmental Agency (EEA), Managing Municipal Solid Waste—A Review of Achievements in 32 European Countries; EEA Report No. 2/2013, Publications Office of the European Union, Luxembourg, 2013.

[17] D. Khan, A. Kumar, S.R. Samadder, Waste Manage. 49 (2016) 15–25.

[18] R. Zhang, H.M. El-Mashad, K. Hartman, F. Wang, G. Liu, C. Choate, et al., Bioresour. Technol. 98 (2006) 929–935.

[19] W. Russ, R. Meyer-Pittroff, Crit. Rev. Food Sci. Nutr. 44 (2004) 57–62.

[20] T. Hazra, S. Goel, J. Waste Manage. 29 (2009) 470–478.

[21] M. Sharholy, K. Ahmad, G. Mahmood, R.C. Trivedi, J. Waste Manage. 28 (2008) 459–467.

[22] T. Tadesse, A. Ruijs, F. Hagos, North. Ethiop. J. Waste Manage. 28 (2008) 2003– 2012.

[23] D. Pokhrel, T. Viraraghavan, J. Waste Manage. 25 (2005) 555–562.

[24] A. Brems, J. Baeyens, R. Dewil, Thermal Science 16 (3) (2012) 669–685.

[25] K. Everaert, J. Baeyens, Therm. Process. Chemosphere 46 (3) (2002) 439–448.

[26] A.M. Raggossnig, C. Wartha, R. Pomberger, Waste Manage. Res. 27 (9) (2009) 914–921.

[27] H. Weigand, J. Fripan, I. Przybilla, C. Marb, Composition and Contaminant Loads of Household Waste in Bavaria, Germany: Investigating Effects of Settlement Structure and Waste Management Practice, Proc. of the 9th International Waste Management and Landfill Symposium, Cagliari, 2003.

[28] H.I. Abdel-Shafy, M.S.M. Mansour, J. Sci. Ind. Res. 76 (2017) 119–127.

[29] US Code. (1976). Solid Waste Disposal Act, as amended. Resource Conservation and Recovery Act: Subtitle D (Solid Waste Program). US Code (Acts of Congress) Title 42, Chapter 82, Subchapter I (Section 6901); 1976.

[30] R.J. Slack, J.R. Gronow, N. Voulvoulis, Sci. Total Environ. 337 (1–3) (2005) 119– 137.

[31] A. Zacarias-Farah, E. Geyer-Allely, J. Clean. Prod. 11 (2003) 819–827.

[32] M.A. Barlaz, B.F. Staley, F.L. de los Reyes, Anaerobic Biodegradation of Solid Waste, in: R. Mitchell, J. Gu (Eds.), Environ. Microbiol., Wiley-Blackwell, Hoboken, NJ, 2010, pp. 281–299.

[33] A. Scheinberg, D.C. Wilson, L. Rodic, Solid Waste Management in the World's Cities. Water and Sanitation in the World Cities, Earthscan Published for UNHabitat, London, UK, 2010.

[34] P.L. González-Torre, B. Adenso-Díaz, Waste Manage. (Oxford) 25 (1) (2005) 15–23.

[35] I. Nissim, T. Shohat, Y. Inbar, J. Waste Manage. 25 (2005) 323–327.

[36] N. Matete, C. Trois, J. Waste Manage. 28 (2008) 1480–1492.

[37] K. Hadjibiros, D. Dermatas, C.S. Laspidou, Glob. NEST J. 13 (2) (2011) 150– 161.

[38] J.P. Senzige, Y. Nkansah-Gyeke, D.O. Makinde, K.N. Njau, Int. J. Environ.Protect. Policy 2 (5) (2014) 147–152.

[39] A.A. Alqader, J. Hamad, Int. J. Environ. Sci. Develop. 3 (2) (2012) 172–176.

[40] S.C. Dogˇruparmak, M.K. Yenice, E. Durmus_ogˇlu, B. Özbay, H.O. Öz, Pol. J. Environ. Stud. 20 (2) (2011) 479–484.

[41] C. Riber, C. Petersen, T. Christensen, Waste Manage. (Oxford) 29 (2009) 1251– 1257.

[42] P. Simoes, R. Marques, J. Environ. Manage. 106 (2012) 40–47.

[43] L. Rushton, Br. Med. Bull. 68 (2003) 183–197.

[44] L. Giusti, Waste Manage. 29 (8) (2009) 2227–2239.

[45] S.S. Behera, R.C. Ray, Int. J. Biol. Macromol. 86 (2016) 656–669.

[46] E.B.N. Graminha, A.Z.L. Gonçalves, R.D.P.B. Pirota, M.A.A. Balsalobre, Da.R. Silva, E. Gomes, Anim. Feed Sci. Technol. 144 (2008) 1–22.

[47] H. Liu, D. Chen, R. Zhang, X. Hang, R. Li, Q. Shen, Front. Microbiol. 7 (2016) 1– 10.

[48] G. Sathiyanarayanan, G.S. Kiran, J. Selvin, G. Saibaba, Int. J. Biol. Macromol. 60 (2013) 253–261.

[49] P. Esakkiraj, R. Usha, A. Palavesam, G. Immanuel, Food Bioprod. Process. 90 (2012) 370–376.

[50] A. Cerda, M. El-Bakry, T. Gea, A. Sánchez, J. Environ. Chem. Eng. 4 (2016) 2394–2401.

[51] W. Zhang, H. Zou, L. Jiang, J. Yao, J. Liang, Q. Wang, Biotechnol. Bioprocess Eng. 20 (2015) 1123–1132.

[52] H.I. Abdel-Shafy, M.S.M. Mansour, Egypt. J. Petrol. 23 (4) (2014) 409–417.

[53] Un-Habitat, Solid Waste Management in the World's Cities, Earthscan, London and Washington, DC, 2010.

[54] S. Kroeckel, A.G.E. Harjes, I. Roth, H. Katz, S. Wuertz, A. Susenbeth, C. Schulz, Aquaculture 364–365 (2012) 345–352. 1290 H.I. Abdel-Shafy, M.S.M. Mansour / Egyptian Journal of Petroleum 27 (2018) 1275–1290

Cite this article as: A.S. Bagawan, S.M. Nimbalagundi, S.N. Poleshi, S.V. Gurumath, Solid waste issue: Sources, composition, disposal and recycling, International journal of research in engineering and innovation (IJREI), vol 5, issue 6 (2021), 414-422. https://doi.org/10.36037/IJREI.2021.5611.