MUNICIPAL SOLID WASTE COMPOSTING - A REVIEW

ESTHER VANLALMAWII, MAMTA AWASTHI

1,2Civil Engineering Department, NIT Hamirpur
E-mail: esthervanlalmawii@gmail.com

Abstract— Generation of municipal solid waste (MSW) continues to rise, which leads to loss of resources and increased environmental risks. The conventional treatment of wastes such as open dumping and land filling cause environmental degradation. Since the major fraction of wastes generated in India is organic wastes, composting has emerged as one of the best methods for treatment of wastes. Composting, besides reducing the volume of waste generated and providing nutrients for plants, also helps in segregation of waste at source. In this review, we have summarized the different treatments of MSW and factors affecting composting. Adding additives to the compost have also received much attention in recent years as they enhance the rate of degradation.

Keywords— Composting, Municipal Solid Waste (MSW), Food Wastes, Microorganisms, Additives.

I. INTRODUCTION

Rapid increase in population and change in life style in India have resulted in a dramatic increase in municipal solid waste (MSW). MSW includes both domestic and commercial waste account for a relatively small part of the total solid waste stream in developed countries [1]. It includes household garbage and rubbish, street sweeping, construction and demolition debris, sanitation residues, trade and non-hazardous industrial refuse and treated biomedical solid waste [2]. Quantity of MSW is increasing due to increase in population and rapid urbanization [3] and thus, safe treatment of municipal solid waste (MSW) is becoming an increasingly important issue in most industrialised countries due to the desire to move towards a more sustainable society [4]. The quality and quantity of MSW generated by a particular community varies according to their socio-economic status, cultural habits, urban structure, population and commercial activities etc. [5]. Management of municipal solid waste is becoming difficult due to its varying quality and increasing quantity. Its management includes collection, storage, transportation and disposal of solid waste. Poor collection and inadequate transportation leads to heap of MSW at many places, which causes health and environmental problems. Governments world over are making efforts to improve solid waste management in their respective countries [6]. Planning, designing and operation of municipal solid waste management system can be done on the basis of composition and the quantity of MSW generated [7].

In India, MSW contains more organic material and less hazardous material than western countries like USA, Canada etc. [7]. The comparative study of the solid wastes composition for cities in industrialized countries and Indian cities reveals that the organic matter in India solid waste is higher, due to the presence of a large percentage of vegetative matter [8]. Solid Waste Management (SWM) systems exist in most of the urban centers since last few decades. However, these systems have yet to emerge as a well-organized practice. Although, the solid waste characteristics in different urban centers vary significantly, there is a meagre effort to tailor the system configuration to the waste characteristics [9]. The solid waste management approach in India is extremely inefficient, using old and obsolete system, technology for storage collection processing, treatment and disposal. There is no formal organized system of segregation of biodegradable and non-biodegradable solid waste. The recovery and recycling of waste is only done by scavengers and scrap dealers which is highly hazardous to those which are involved in this job [8].

The disposal of large amounts of food waste generated by food service establishments is one of the most serious problems in cities. As food waste has a high water content and decomposes readily, many unpleasant environmental consequences can arise during its storage, collection and transportation [10]. With rising interest in organic agriculture, the production of organic-grade MSW compost for agriculture is also gaining popularity because of its positive effect on biological, physical, and chemical soil properties [11]. Composting MSW reduces the volume of the waste, kills pathogens that may be present, decreases germination of weeds in agricultural fields, and destroys malodorous compounds [12] and is seen as a method of diverting organic waste materials from landfills while creating a product, at relatively low cost that is suitable for agricultural purposes [13]. Composting has thus, become a preferred method for municipalities and industries to recycle a variety of organic by-products in order to apply them as soil conditioners and amendments [14].

II. DIFFERENT TREATMENTS OF MSW

2.1. Landfilling

In the majority of urban centers, MSW is disposed of by depositing it in low-lying areas outside the city without following the principles of sanitary
landfilling [15]. As no segregation of MSW at the source takes place, all of the wastes including infectious waste from hospitals generally find its way to the disposal site. Quite often, industrial waste is also deposited at the landfill sites meant for domestic waste [16]. At most disposal sites, compaction and leveling of waste and final covering by earth are rarely observed practices and these low-lying disposal sites are devoid of a leachate collection system or landfill gas monitoring and collection equipment [17]. Such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters [18].

2.2. Incineration
Incineration is the process of control and complete combustion, for burning solid wastes. It leads to energy recovery and destruction of toxic wastes, for example, waste from hospitals. The temperature in the incinerators varies between 980 and 2000 °C. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible solid waste by 80–90% [19, 20, 21]. Incineration of waste (with energy recovery) can reduce the volume of disposed waste by up to 90% [22].

2.3. Gasification and pyrolysis
These are methods for managing wastes by heating under controlled conditions to produce low to medium heating fuel gases, tars, char and ash, under a high temperature with limited oxygen [23]. Incineration of solid waste under oxygen deficient conditions is called gasification [20]. Gasification can also be used for MSW treatment after drying, removing the inerts and shredding for size reduction [18].

2.4. Recycling
A number of recyclable materials such as paper, glass, plastic, rubber, ferrous and non-ferrous metals present in the MSW are suitable for recovery and reuse. It has been estimated that the recyclable content varies from 13% to 20%. In India, about 40–80% of plastic waste is recycled compared to 10–15% in the developed nations of the world [18].

III. COMPOSTING- AN OVERVIEW

Composting is defined as the biological decomposition of organic matter under controlled aerobic conditions to form a stable, humus-like end product. The process is facilitated by a diverse population of microbes, whose population dynamics vary greatly both temporally and spatially, and generally involves the development of thermophilic temperatures as a result of biologically produced heat [24]. It is one of the best-known processes for the biological stabilization of solid organic wastes by transforming them into a safer and more stabilized material that can be used as a source of nutrients and soil conditioner in agricultural applications [25]. Aerobic composting is the process where decomposition takes place in the presence of oxygen [26]. As the quickest way to produce high quality compost, aerobic composting is a widely accepted way of stabilizing organic wastes and converting them to a usable, and value added compost product [27]. It is largely a microbiological process based upon the activities of several bacteria, actinomycetes, and fungi [28]. The main product is rich in humus and plant nutrients; the by-products are carbon dioxide, water, and heat [29].

IV. FACTORS AFFECTING COMPOSTING

4.1 Microorganisms
Microorganisms decompose or oxidize the organic compounds to simple, stabilized end products, with the production of heat [22]. The first microorganisms to colonize a heap of biodegradable solid waste are mesophilic bacteria, actinomycetes, fungi, and protozoa [30]. They grow between 10 and 45°C and break down easily degradable components such as sugars and amino acids [31, 32]. When the temperature of a waste heap reaches 45–50°C, thermophilic microorganisms replace mesophilic ones. The second phase called the thermophilic phase can last several weeks. It is the active phase of composting and most of the organic matter is degraded and consequently most oxygen is consumed in this phase. [30]

4.2 Aeration
With composting being an aerobic biodegradation process, oxygen is its lifeline [30]. Aeration is one of the components of the controlling process, as it ensures the growth of adequate aerobic microbe populations and the development of stabilizing temperature [33]. Aeration supplies the depleted oxygen to the composting mixture and carries away excess heat from the system. Inadequate oxygen may lead to the growth of anaerobic microorganisms, which can produce odorous compounds. To enable better aeration at appropriate stages of composting, either the mechanical means of aeration, turning, is employed or air is supplied through pipes with or without the aid of pumps [30].

4.3 Temperature
The temperature within a composting mass determines the rate at which many of the biological processes take place and plays a selective role in the development and the succession of the microbiological communities [30]. Usually, in an aerobic system, the temperature rises to 50–60°C in just a few days and can even go up to 70°C in some cases. If done correctly, a compost pile will heat to high temperatures within 24 to 48 hours. A temperature in the range of 55 to 65°C ensures
destruction of pathogenic organisms [34]. A temperature of 65°C for at least 30 minutes is considered a critical threshold for plant pathogens [35]. The maximum temperature of the composting process reaches 60–70°C, the temperature level where many microorganisms become less active. Temperatures of composting material below 20°C have been demonstrated to significantly slow or even stop the composting process. Temperature in excess of 60°C has also been shown to reduce the activity of the microbial community, and above this temperature, microbial activity declines as the thermophilic optimum of microorganisms is surpassed [30]. In a study [36], it was found that optimum composting temperatures, based on maximizing decomposition, were in the range of 52–60°C.

4.4 pH
The pH is another parameter that greatly affects the composting process. The range of pH values suitable for bacterial development is 6.0–7.5, while fungi prefers an environment in the range of pH 5.5–8.0 [30]. A rise in pH beyond 7.5 could make the environment alkaline, which may cause loss of nitrogen as ammonia [30]. The optimum pH for most microorganisms is between 6.5 and 7.5 according to [28]. Below pH 5.0, bacterial biocontrol agents are inhibited. Well-aerated compost piles generally have a high pH, whereas piles with anaerobic conditions have decreased pH values [30].

4.5 C/N ratio
Carbon serves primarily as an energy source for the microorganisms, while a small fraction of the carbon is incorporated to the microbial cells. Nitrogen is critical for microbial population growth, as it is a constituent of protein that forms over 50% of dry bacterial cell mass. Rapid and entire humification of a substrate essentially depends on it initially having a C/N ratio between 25 and 35 [30].

4.6 Moisture content
The ideal moisture content to start a compost is generally 60–70%. At later stages of decomposition, the ideal moisture content may be 50–60%. Moisture management requires a balance between microbial activity and oxygen supply [30]. Moisture content lower than 30% or higher than 75% inhibits microbial activities due to early dehydration or anaerobiosis [37]. Excess moisture will fill many of the pores between particles with water, thereby limiting oxygen transport. This in turn would create anaerobic conditions and brings about putrefaction, resulting in disagreeable odour and undesirable products [30].

4.7. Particle nature and size
Particles size affects oxygen movement into the pile, as well as microbial and enzymatic access to the substrate. Smaller size particles of organic material increase the surface area available for microbial attack [22]. Large size particles reduce surface area for microbial attack which slows down or may stop composting process altogether [38].

V. ADDITIVES IN COMPOSTING
Additives are usually mixtures of different amounts of various microorganisms, mineral nutrients, or readily available forms of carbon, enzymes and pH-balancing compounds that are meant to enhance microbial activity when the additive is in contact with the waste material [39, 40]. The effects chemical additives such as coal fly ash, wood ash, green liquor dregs, bauxite, natural zeolites, and kaoline on composting of municipal solid waste, green waste, sludge, catering waste have been extensively studied by different researchers [41]. Inoculation of MSW with specific organisms can also enhance the speed of composting [42].

CONCLUSION
Due to the increase in the generation of municipal solid wastes, proper management has to be adopted in order to minimize the generation.

- Managing waste at source is more important than the conventional way of handling waste. Composting is one of the methods to manage the waste at source.
- Since a place like India has higher composition of organic wastes, composting has become a convenient and effective method to treat the municipal solid waste.
- It has been found throughout the world that the use of chemical fertilizers and other chemicals is harmful to soil productivity and also a cause of water and air pollution. On the other hand, compost causes no harm to environment and provides suitable nutrients to soil.
- Adding additives can also help to speed up the biodegradation of wastes and enhance the quality of the finished compost as well. Hence, more research has to be done on additive aided composting.

Therefore, composting technique is an attractive method of municipal solid waste management, in addition to being environmental friendly, wealth creating and a sustainable method.

REFERENCES


