A Review of Composting of Organic Matter in Municipal Solid Waste (MSW)

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Abstract - Solid waste generated in large quantity is creating major issue of solid waste management in developing countries. The major portion of solid waste generated is dumped on land creating an environmental problem. A large amount of organic waste is present in solid waste generated. The organic waste contain in solid waste can be converted in to compost by processing the waste, which will reduce load on landfill. In composting process it reduce volume of waste and convert it to useful end product. The composting is one of good option for treatment of organic waste. The understanding of composting will help to treat organic waste in proper manner and will reduce environmental problems due to improper solid waste management. This review paper contain different method of composting and factor affecting for composting.

***Key Words*:** Solid Waste, Organic Waste, Composting, Solid Waste Management.

1.INTRODUCTION

Rapidly growing population, urbanization and lifestyle change in India has result increase in the generation of solid waste [1, 2 & 4]. In India, MSW generation is about 48 million tons per annum and predicated that it may increase to 300 million tons by the year 2047 [1]. Municipal Solid Waste (MSW) includes domestic, commercial and industrial waste. It includes kitchen and yard waste, street sweeping, construction, and demolition debris, sanitation residues, trade, and non-hazardous industrial refuse and treated biomedical solid waste [2, 3]. MSW is not suitable for refuse-derived fuel (RDF) as it contains high organic waste (40% to 60%) having high moisture content and low calorific value [1, 2 & 5]. The solid waste in India has an old system in which disposal is done by landfills or open dumping which is an inefficient system [1, 2 & 3]. Due to improper management and uncontrolled disposal method create environmental issues like flooding, air, soil, and water pollution and it also has an impact on human health [6]. It is becoming very difficult to manage MSW due to its increasing quantity and varying quality [2]. Composting is one of the best and emerging methods to treat organic waste and convert it into a safe and stable material called compost, which can be used as a soil conditioner. This is also an environmentally friendly and economical method for organic waste treatment [1 – 4, 7 & 9]. Composting is a method to reduce the load on landfills by diverting organic waste and converting to useful products for agriculture purpose [3, 8]. The organic waste decomposition can be done by two major techniques are aerobic decomposition and anaerobic decomposition [9]. The decomposition of organic waste in the presence of oxygen is called aerobic composting [10] and organic waste decomposition in the absence of oxygen is called anaerobic composting [11].

2. Composting of Organic Waste

Composting is defined as the process of decomposition of organic matter to convert waste to stable, humus like product by microorganism under optimum condition [2, 9]. Composting of organic waste is a microbiological process, which stabilizes the waste [13]. In this process, the end product produced is called compost, which is good in nutrients and can be used as fertilizer for providing nutrients for plants [2, 8, & 12]. It is a stable product and free from the pathogen, which is beneficial to increase the productivity of crops. It contains essential nutrients and can improve the physical and chemical properties of soil [13 & 14]. In the composting process carbon and nitrogen are essential for microorganisms for the decomposition of organic matter [5 & 16]. In the composting process decomposition of organic matter can be done by aerobic and anaerobic process [9].

2.1 Aerobic Composting

Aerobic composting is a process that takes place in the presence of oxygen. During this process, it releases CO2, heat and water vapors [10, 17 & 18].

$$Organic\ Waste + O_2 \xrightarrow{Aerobic\ Bacteria} CO_2 + H_2O + Heat$$

In this process for aerobic condition, aeration will be required [19], insufficient aeration will lead to develop the anaerobic condition and it will produce bad odor [20]. Aeration helps to grow an adequate amount of aerobic bacteria and the required temperature for the aerobic process during composting [20]. Aerobic composting takes place in two stages. The first stage is called active decomposition and the temperature is about 65oC to 80oC. In this stage first mesophilic bacteria multiply rapidly and generate heat, which is due to the presence of plenty of food, sugars, and amino acids. The mesophilic temperature range is 20oC to 45oC. In this stage, the temperature continues to rise which develop the thermophilic condition (thermophilic temperature range is 50oC to 70oC). At this phase, thermophilic fungi and thermophilic bacteria grow. This temperature helps to kill the most of pathogens and weed seeds [17 & 22]. The second stage of composting is the curing stage. In this stage there is no further rise in temperature and only active decomposition of plant cell wall material like cellulose and hemicellulose by

fungi is observed. At this stage, the temperature reduces to ambient temperature [17 & 23].

2.1.1 Factors Affecting the Aerobic Composting

The factors affecting the aerobic composting are temperature, pH, moisture content, C/N ratio, particle size and aeration [17, 21]. The temperature range for the process is 40oC to 65oC and the temperature high as 80oC is also reported [17, 21, & 22]. The C/N ratio required is between 20:1 to 40:1. The higher C/N ratio will slow the decomposition process and a lower value will lead to underutilize nitrogen and released in the atmosphere and create an odor problem [17]. The optimum pH range is 6.5 to 7.2 and the aerobic bacteria can tolerate pH 6.5 to 8.0 [21]. The moisture content for process should be in range 40 to 60 percent [17 & 21]. The particle size is also important parameter as fine and dense particle decomposition occurs at a faster rate as it affects oxygen movement [2, 17 & 21]. The average particle size in aerobic composting should be 0.3 to 5.0 cm.

2.1.2 Aerobic Composting Techniques

The windrow aerated static pile, and in-vessel composting are the three composting techniques that are available to compost organic waste [12 & 24]. Aerated Windrows is a periodically turned elongated piles used to decomposed a large quantity of organic waste [12, 24 & 25]. The turning is essential for aerating the organic waste it can be done either manually or mechanically. The size of windrow depends on the turning mechanism available, which varies from 1.5 to 2-meter height and 3 to 6-meter width [24]. Aerated Static Pile is a mechanically aerated controlled process for homogenous mix and the large quantity of organic waste. The land requirement reduced due to mechanical controlled air supply [12, 24 & 25]. The bulking agent like wood chips and shredded newspaper are used for proper aeration of the pile [25]. In-Vessel Aerobic Composting is a process in which composting is done in a closed chamber or vessel under controlled environmental parameters [12, 24 & 25]. In this system due to the controlled parameter composting process is faster [24 & 25].

2.2 Anaerobic Composting

Anaerobic composting is a process that takes place in the absence of oxygen. During the anaerobic process, it releases Methane, CO2, NH3, trace amount of other gases and organic acids [11 & 21]. In this process, anaerobic bacteria use nitrogen, phosphorus and other nutrients to decompose the organic waste. The hydrolysis, fermentation, acetogenesis, and methanogenesis are the four stages of anaerobic composting [21].

The first stage of digestion in anaerobic decomposition is hydrolysis as shown in figure 1[21 & 26]. Hydrolysis is a process of breaking the chain of macromolecular of organic waste to convert to chemical energy for anaerobic bacteria [26]. In this stage complex compounds like cellulose are converted into fatty acid, amino acids and sugars [21]. The second stage is the fermentation process in this the breakdown of the remaining complex compounds by acidogenic (fermentative) bacteria. At this stage, it generates ammonia, carbon dioxide, hydrogen sulfide with other by-products. In the third stage, a simple molecule are converted to acetic acid, carbon dioxide, and hydrogen by acetogenesis bacteria. The final stage of decomposition convert to methane, carbon dioxide, and water is called methanogenesis [21 & 26].

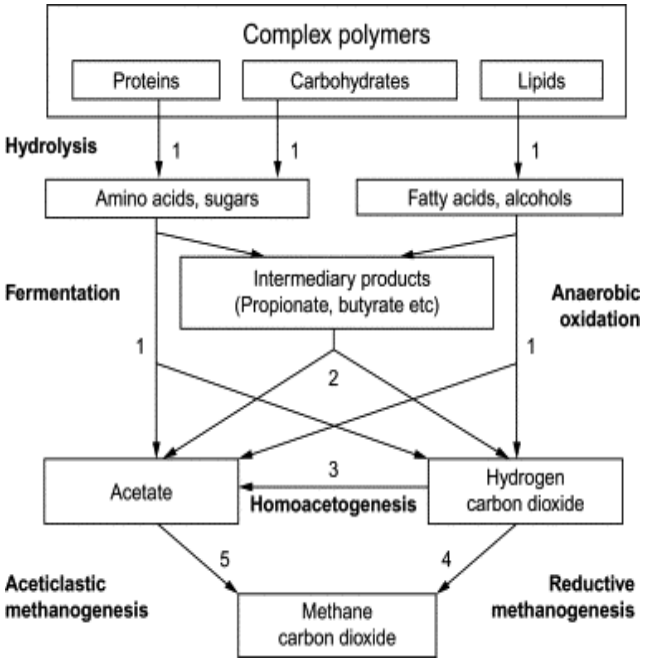

Fig -1: Anaerobic Composting Pathway [21]

2.2.1. Factors Affecting the Anaerobic Composting

The factors affecting the anaerobic process are temperature, pH, C: N ratio, substrate, and pathogens [21 & 26]. The optimum temperature for anaerobic decomposition is 35oC. The temperature is an important factor in this process as it was observed in the previous study that the metabolism rate of bacteria was decreased by 50% for drop of 10oC [21 & 27]. The optimum pH range for the process is 6.5 to 7.5 and it can tolerate up to 8. If the pH value decreases below 6.5 it leads to process failure [26]. The C/N ratio and C/P ration in the substrate should be in the range of 20-30:1 and 140-200:1respectively. The C/N ratio higher than 30:1 shows the bacteria metabolism process and at a lower C/N ratio of 3:1 shows the good results of decomposition [21 & 26]. In this process, the pathogens bacteria are not destroyed as in aerobic process due to high heat release during the aerobic process. The six month maturation period is required for the complete destruction of pathogens in the anaerobic process [26].

2.2.2 Anaerobic Composting Techniques

The Indian Bangalore method, Bokashi Composting, Submerged Composting, and Container Composting are the anaerobic composting method for decomposition of organic waste. In the Indian Bangalore method, the decomposition is done in a pit filled in a layer in such a way that night soil is sandwiched between the two layers of solid waste. The top layer of solid waste is kept 25 to 30 cm and sometimes the top layer of soil is laid to avoid fly breeding [28 & 29]. Bokashi composting is a fermentation of food waste in a closed container. It takes 4 to 6 weeks to decompose organic matter. The acid formation helps to destroy the pathogens. In the submerged composting method the composting container are submerged in water to reduce odor by 80%. In the closed container composting method the composting is carried out under a controlled environment.

3. Conclusion

The environmental issue created due to solid waste is because of its large quantity. The solid waste contains organic and inorganic component. The proper waste management system requires the segregation process for proper disposal of waste. Due to large quantity of waste the segregation of waste is difficult. The decentralized waste management is one of good option for proper waste management. The decentralized system is the method of handling and treating waste generated at source. The composting is one of option for treatment of organic waste at source. The composting help to reduce the waste generated and reuse the waste in form of compost. The composting can be done by aerobic or anaerobic process.

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