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ARAŞTIRMA MAKALESİ (Research Article)

EFFECTS of BIOMASS FLY ASH IN MUNICIPAL SOLID WASTE COMPOSTING

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ABSTRACT

In this study, the effect of biomass fly ash (BFA) as co-amendment was assessed on compost maturity and reduction of N loss during municipal solid waste (MSW) composting. Composting experiments were conducted using three ratios of BFA (0, 5 and 10%) in three in-vessel composting reactors for 105 days. MSW showed lower C/N ratio and higher moisture content for composting. Thermophilic temperatures could not be reached in MSW treatment. However, co-amendment of BFA and MSW extended the thermophilic stage and promoted compost maturity. Nitrogen loss from reactors co-amended by BFA and MSW were reduced by compared with the control. While nitrogen loss was 62.75% in MSW treatment, it was 31.58% in 5% BFA treatment and 28.09% in 10% BFA treatment. The results demostrated that 10% BFA could be a suitable additive to improve the quality of MSW composting.

Keywords: *Biomass fly ash, Municipal solid waste, Composting*

1. INTRODUCTION

Recently, large quantities and various characteristics of wastes have been generated as a result of the changes in consumption habits with the increasing population [1]. The correct management of solid wastes is of great importance in order not to endanger human health and the life of other living things, not to pollute the air, water, and soil, and to use the raw material and energy potential [2]. Living standards of the societies are not affected and sustainable development is ensured with the selection and implementation of the necessary/appropriate method, technology, and management programs (Integrated solid waste management) towards a specific waste management objective [3]. The solid wastes in general consist of organic wastes, metal, paper, plastic, glass and other wastes. The distribution of solid wastes on a globally are 44% organic wastes, 17% paper, 12% plastic, 5% glass, 4% metal and 18% other wastes. It is known that the income level changes the shares in the waste content, and it is observed that the amount of organic waste in the waste composition increases with the decrease in the income level [2].

In the disposal of organic wastes, which have a high share in the solid waste composition, landfilling and incineration ways that are not sustainable are generally applied due to limited space. Composting is gaining importance day by day due to gas and liquid wastes generated in landfills and incineration processes [4]. Composting is a disposal and recovery method that biodegrades organic materials into a final product called compost [5]. Material mixture and process management factors such as temperature, pH, nutrient content, moisture content, and oxygen content affect the composting process. The nutrient balance, expressed by the C/N ratio, must be between 25 and 35 for the growth and activity of microorganisms [6, 7]. To achieve a good microbial activity, the pH value should be in the range of 5.5 - 8.0 [6, 8]. With regular aeration, the temperature is controlled, while the increase in moisture content and CO_2 content is removed. It is also a source of oxygen for microbial activities. The desired O2 content in the composting process is 15 -20% [8, 9]. At the beginning of the composting process, the moisture content is expected to be between 50-60% [10]. An increase in moisture content weakens the O2 transfer between the materials, while its decrease reduces the rate of degradation of organic substances [11]. In the composting process, thermophilic temperatures should be reached to destroy pathogens. However, this temperature must not exceed the tolerance limit (52-60°C) of microorganisms in order to continue microbial activities [6, 8].

By the use of additives in the composting process, it is possible to fast the activity of microorganisms and improve the content of the final compost. Several additive materials have been the focus of research such as hazelnut kernel [12], vermiculite [13], poultry waste [14], zeolite [15], and fly ash [16], etc. Fly ash is a solid waste formed during the combustion of solid fuels, containing metal oxides, unburned carbon, and other inorganic matters [17]. It is known that the use of fly ash in the composting process will improve the quality of the final compost formed due to the carbon in its structure [18].

In the present study, composting of fly ash and municipal solid waste for 105 days was investigated. The scope of the present study is to (i) examine the composting of municipal solid wastes with fly ash, (ii) evaluate the effects of MSW and fly ash mixtures on the physicochemical properties such as temperature, pH, and TN, and (iii) determine the optimum material mixing ratio.

2. MATERIALS and METHOD

2.1. Composting Materials

BFA was obtained from a Biomass Power Plant in Çarşamba, Samsun. Municipal solid waste was collected from a wholesale market hall in Samsun. Organic fraction of municipal solid waste was seperated and shredded before the composting. The initial properties of the composting materials were summarized in Table 1.

Table 1. Characteristics of composting materials used in the experiments.

Parameter	BFA	MSW
pH	5.14	7.26
EC (mS/cm)	2.47	2.04
MC (%)	6.13	71.50
Total N (%)	0.11	2.84
TOC (%)	6.29	61.51
C/N	57.18	21.66

2.2. Composting Procedure and Sampling

The composting experiments were carried out in-vessel reactors. The reactors had a volume of 30 L. Air was pumped into each reactor at a rate of 10 L min^{-1} during the process. A total of three reactors were used in the experiments. The organic fraction of MSW and BFA were mixed at two different ratios. A reactor was filled with only MSW and compared with co-composting reactors. The mixture ratios in reactors are given in Table 2.

Table 2. Mixture ratios in reactors.

Reactor no	Mixture ratio
T1	100% MSW
T2	5% BFA + 95% MSW
T3	10% BFA + 90% MSW

Each composting mixture was turned before every sampling. Temperature was measured daily using a digital dry bulb thermometer within the pile. pH was measured in the aqueous extract (1:10 w/v sample: water extract) using a pH meter with a glass electrode. Moisture content (MC) was determined by drying the sample at 105 ^oC for 24 h in an oven. All measurements were conducted at least in triplicate, and data are presented as the mean.

3. RESULTS AND DISCUSSION

During the composting process, organic materials are degraded by microorganisms and carbon dioxide and water are formed as aerobic decomposition products. A large amount of energy is released in the form of heat with microbial decomposition. The self-decomposition property of the composting material leads to heat build-up which causes the temperature to rise. The resulting heat ensures the removal of disease-causing microorganisms that are undesirable in the compost. The temperature values observed in the three composting systems examined during the process are shown in Figure 1. Temperature values in all systems increased during the first two weeks. After the second week, the temperature values decreased. There was no significant change was observed in the temperature values after reaching ambient temperature. The pathogenic organisms are generally eliminated at temperatures above 55◦C for 1 or 2 days [5]. In MSW treatment the maximum temperature reached to 41.5◦C in the thermophilic phase. However, both of the co-amendment treatment reached the required temperature for forced aeration (>55◦C). Similar results have been reported by Kabak et al. [14], who indicated that MSW treatment without the addition of any additives failed to reach sufficient thermophilic temperatures in composting.

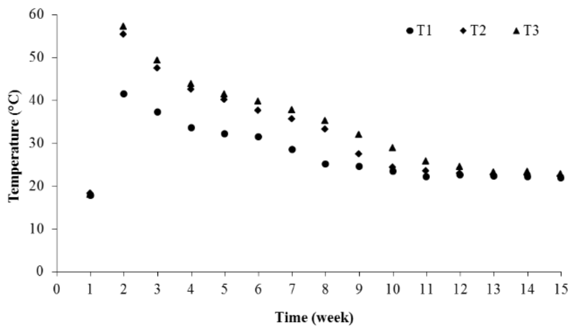

Figure 1. Changes of temperature during the composting process.

The pH values of BFA and MSW were 5.14 and 7.26, respectively. As a result of mixtures of BFA and MSW, the pH values changed between 6.26 and 6.89. The pH change in all systems during the process is graphically shown in Figure 2. In all systems, pH values showed a rapid decrease when the temperature peaked. It is stated that these decreases occur due to the rapid decomposition of organic matter forming CO_2 and organic acids in the thermophilic phase. The pH value increased again in all systems after the second week. The pH changes did not show much oscillation in the last weeks. Optimum pH value for the final compost is between 6.5 and 7.2 [19]. At the end of the composting process, pH value was measured as 8.25, 7.14 and 6.99 in MSW treatment, containing 5% BFA treatment and containing 10% BFA treatment, respectively. Co-amendment treatments provided the optimum pH range in final products. However, pH value of final compost of MSW treatment was not in the optimum range. Similar results have been reported by Turan and Ergun (2008) for MSW composting without any amendment material [15].

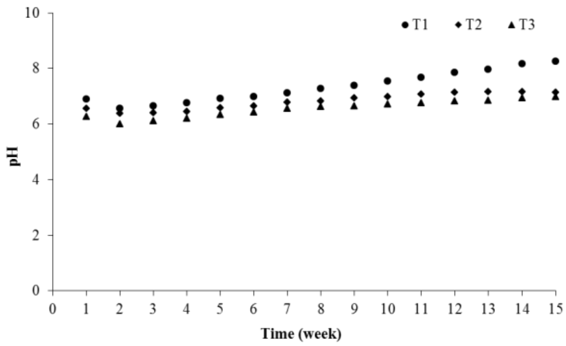

Figure 2. Changes of pH during the composting process.

Nitrogen has an important place in the composting process since it is necessary for the activities and reproduction of microorganisms. Other nutritive elements, which are necessary for the reproduction of microorganisms, are mostly found in organic materials at sufficient levels. Nitrogen content is among the parameters examined in composting processes, since it requires more than inorganic nutrients. The total nitrogen content of MSW and BFA were 2.84 and 0.11, respectively. MSW contains a higher amount of nitrogen than BFA. Total nitrogen content in all treatments decreased during the process.

The most notable reductions were observed at high thermophilic temperatures. The variation of the total nitrogen content observed in the treatments during the composting process is shown in Figure 3.

At the end of the process, the nitrogen loss in each system was calculated. Nitrogen losses are very important due to the potential to pollute underground and surface water resources, to create odor and to reduce the nutrient content of the compost. Approximately 20-77% of the nitrogen contained in animal wastes is lost in the composting process [20] Nutrient losses during composting occur mainly in the form of gas emissions. Martins and Dewes (1992) stated that approximately 47-77% of nitrogen losses are in the gaseous state. An important part of this is in the form of NH_3, and a small part is in the form of N_2O. Nitrogen losses occur in the form of NH_3 evaporation, especially when the temperature is quite high and the pH is above 7. Low C/N ratio also increases NH_3 losses in poultry waste [21].

The highest nitrogen loss occurred in the system containing 100% MSW with 62.75%. It is thought that nitrogen loss in MSW is due to the high pH and moisture content. Nitrogen loss is reduced by about half in co-amendment treatments compared to control treatment. The nitrogen losses were 31.58% and 28.09% and in the treatments containing 5% and 10% BFA, respectively.

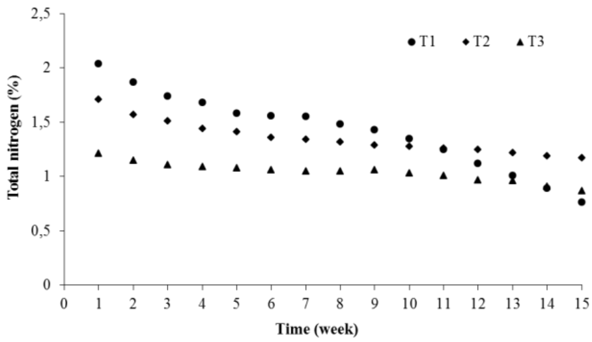

Figure 3. Changes of total nitrogen content during the composting process.

4. CONCLUSIONS

Composting is one of the recommended treatment methods for MSW. However, MSW requires amendments to adjust process conditions for composting. In this study, the effects of BFA as an amendment were investigated in MSW composting. The results showed that BFA as an amendment was obviously effective in improving compost quality and maturity. In addition, it reduced nitrogen loss during the composting process and provided higher thermophilic temperatures. Among different BFA and MSW treatments, 10% BFA treatment obviously decreased TN losses during the composting process.Hence, BFA can be recommended in MSW composting because it both improves the compost properties and does not cost as a waste.

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