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Characterization of bulking agents and its effects on physical properties of compost

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ABSTRACT

Objective was to enquire the attributes of regionally obtainable BA (bagass, paper, peanut shell, sawdust) to inscribe the efficacy of BA at (10–40%) for moisture reduction. Sawdust was prominent in moisture reduction capability in 5–7 days. The prime physical changes in BA under various compression forces were as; by increasing compression force, BD rise and FAS decline, whereas PD had not exhibit any discrepancy. Proficient compost production entails meticulous understanding the process dynamics in terms of correlation between moisture reduction; FAS, BD and PD. FAS and moisture were negatively where as BD and moisture positively correlated.

1. Introduction

Environmental pollution from agricultural wastes and inflation of fertilizers prices, composting has acquired widespread usage as biodisposal method in Pakistan. Composting is the process whereby thermophilic, aerobic microorganisms transform organic materials into hygienic, biostable product (Agnew and Leonard, 2003).

Composting process is affected by some environmental conditions like (temperature, moisture contents pH, and aeration) and substrate characteristics (C/N ratios, particles size, nutrients contents and free air space) (Diaz et al., 2002; Kulcu and Yaldiz, 2004). Moisture content; greatly influence the changes in physical and chemical properties of waste material in course of degradation of organic matter. MSW comprises high proportion of moisture (80–90%) and organic matter (70–80%) that give raise the odor during decomposition (Jolanun et al., 2008). When the optimum moisture level 60%, is not easily accessible to the microorganism, their microbial activity abate the composting process and temperature 40–70 °C will not be accomplished (Haug, 1993). Most favorable moisture level for biodegradation of different compost mixture varied from 50% to 70% (Richard et al., 2002). Excessive moisture content of MSW, results in significant leachate formation during composting and collapse of the composting matrix leading to reduction in porosity and oxygen availability. If the oxygen apportioning is not homogenous, it causes CO_2 accumulation and bringing forth anaerobic condition inside the piles. According to Haug (1993) oxygen concentration within the composting matrix should not be lower than 5–7% and proper aeration of the composting material will only be possible if enough porosity and FAS are around 30% in composting piles. FAS, porosity and BD are intimately related to airflow resistance in compost piles. Airflow purveys the oxygen supply as to remove CO_2, excess moisture and to limit excess heat accumulation (Haug, 1995). Controlling the moisture contents and to optimize the C/N ratio, bulking agents (BA) are added in composting process for an effective disposal of MSW. BA also demote ammonia emission and others volatiles during the composting process (Sanchez-Monedero et al., 2001).

A bulking agent is the material that provides the optimum FAS and regulates the water contents of the waste to be composted. Bulking agents are commonly fibrous with carboneous material with low moisture contents to provide optimal FAS for composting process (Miner et al., 2001; Eftoda and McCartney, 2004).

The free air space is an important factor in determining the quantity and movement of air through the composting matrix. Jeris and Regan (1973) examined the effect of FAS on oxygen consumption rates in mixed refuse samples, and approximately 67% moisture and 30% FAS were found to be optimum. By this about 95% of the maximum oxygen consumption rate was maintained. Schultz (1962) also concluded that minimum of 30% FAS should be maintained in composting of garbage and sludge mixture. Kulcu and Yaldiz (2003) found optimum FAS 33.62% for grass and leaf wastes.

Jolanun et al. (2008) concluded that the ratio of BA sawdust to waste material has greatly influenced the percentage of FAS in fed batch composting. Kulcu and Yaldiz (2007) determined the optimum ratio of pinecones 10%, goat manures 45% and wheat straw 45% to obtain FAS 32.8% in the composting mixture.

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Nomenclature

BA	bulking agents	MC	moisture content
BD	bulk density	MSW	municipal solid waste
C	carbon	OW	organic waste
C/N	carbon nitrogen ratio	PD	particle density
FAS	free air space		
H	hydrogen		

Most of the bulking agents act as a buffer against the organic acids produced during the early stages of composting and thus help to maintain the mixture, pH within a range from 6 to 8 (Haug, 1993). Selection of bulking agents for composting are typically inexpensive of the waste materials that are readily available, with little consideration of what type and shape of bulking agent are used. Naturally using more bulking agent may provide more FAS (McGuckin et al., 1999). For the successful composting, different types of bulking agents available in the region were used, because they have different properties due to their carbon source, physical shape, particle size and BD.

The BA absorbs part of the leachate produced during the decomposition process; to keep the mixture moist and sustain an active microbial activity. When a wet substrate is mixed with a bulking agent it provides the structural support to create inter particle voids with the wet substrate occupying a portion of those voids. When a wood chips porous bulking agent is used air will also be contained in the intraparticles voids. Peat also absorbed excess water from slurry waste resulting in solid matrix mixture that can compost easily under passive aeration condition (Sartaj et al., 1997).

A long list of waste materials have been used as the bulking agents but sawdust is one of the most widely used material (Larsen and McCartney, 2000). Besides in few studies sugarcane bagass, rice hull and woody residues have also been used as BA in composting. Being of low biodegradability due to lignin contents woodchips was found to require minimum free air space 26% as opposed to the generally recommended free air space of 30% (Eftoda and McCartney, 2004). Gea et al. (2007) reported that optimal results were obtained with artificial bulking agents with the particle size of 5 mm mixed at volumetric ratio of 1:1. Cardboard and newspaper are occasionally used as bedding on dairy farm composting piles. It provides carbon but not much air space. Leaves can also be used as carbon source and have relatively low porosity than wood chips.

Recently Adhikari et al. (2009) investigate the effectiveness of three bulking agents namely Chopped wheat straw, chopped mature hay and wood shaving in different ratios in composting. In addition to the type of bulking agent used its particle size and the proportions of bulking agent in the final mixture have also been emphasized as an important factor in sludge composting process (Larsen and McCartney, 2000) as well as in the modeling of the process (Haug, 1993). Eftoda and McCartney (2004) found that a volumetric ratio of biosolids to woodchips of 1:2.5 provided the best aeration level for the least BA. Furthermore woodchips with a small particle size of 5.2 mm resulted in a lower moisture loss as compared to a large particle size of 40 mm because of greater resistant to ventilation (Raichura and McCartney, 2006).

Particle size distribution determine the availability of surface area to microbes for degradation and by decreasing the particle size, a great surface area is exposed to microbial attack (Gray and Biddlestone, 1993). Raichura and McCartney (2006) found that that a low particle size of bulking agent is preferred to give the material an adequate porosity instead of using large quantity of bulking agent. Bulking agent of small particles create a real porous structure and the homogenous porous size distribution inside the material that act as efficient oxygen consumer.

Pakistan has a population of 160 million peoples living in urban areas. Solid waste generated in urban areas of Pakistan is estimated at 55,000-tones/day (Jica, 2005).

The objective of this paper was to monitor the quantity of MSW produce under study area in summer and winter season and to examine the effect of different percentages of BA on the moisture reduction and availability of FAS in composting matrix. Further more the locally available BA was also characterized to formulate the recipe for composting.

2. Methods

MSW collected from the Sunday Bazaar Lahore was halted to the PCSIR labs complex Lahore and samples were analyzed after segregation into biodegradable and non-biodegradable material. BA (bagass, peanut shell, paper, sawdust, rice husk and corn pith) available in the region were selected for the evaluation of moisture reduction from MSW, because they are commonly used in composting (Alburquerque et al., 2006)

Sawdust and peanut shell having the particle size, less than1.5 mm was collected from PCSIR workshop and Punjab University Cafeteria, respectively. The newspaper was manually cut with the width of 2.5 mm and length of 16 mm. The rice husk was collected from the Abass Rice mill where as bagass, corn pith was taken from the Punjab University Lahore Cafeteria and was chopped to the length of 10–50 mm and placed on the concrete floor.

The dry BD of all BA was determined by using four different levels of forces, loose or without force, manually compressed and by imposing a force of 4900 N (500 g), 9800 N (1000 g) and 14,700 N (1500 g) for 15 min for the change in depth (cm) with reference to their compression force was noted.

The moisture reduction level of all BA in different percentages (10%, 20%, 30%, 40%) was determined by adding the each BA separately with MSW in plastic container to note the absorption capacity under laboratory conditions for seven days with the following formula:

$$\text{Moisture reduction } (\%) = B - C = D = A - D = G = G/A = F \times 100 \quad (1)$$

MSW moisture as control $= A$

Moisture of mixture of BA and MSW $= B$

Bulking agent moisture $= C$

Difference between A and $D = G$

BD, PD and FAS of bagass, peanut shell, paper, and sawdust of different percentages was determined during the moisture absorption process. All parameters were noted three times in a day and reported as an average in both summer and winter season.

The BD was determined by dividing the total mass of sample by its volume occupied. The Free air space (FAS) was determined from the bulk density (wet/dry) and particle density of the BA and MSW