TREATMENT OF ORGANIC SOLID WASTE FOR REUSE: A STEP TOWARDS ZERO WASTE

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ABSTRACT

Large amounts of organic solid wastes are being generated from municipal, industrial and agricultural activities. After necessary processing, the organic solid waste can be reused for agriculture not only as a nutrient supplement for plant growth, but also as a conditioner for seedbed soil. Processed organic wastes may improve soil structure and enhance water and nutrient-holding capacity of the soil, as well as increase the microbial activity within the soil, thereby increasing soil fertility. In this study, problems like undesirably high moisture contents and large volumes per unit weight of the processed organic solid wastes have been addressed through pelletization. Physical properties like durability, percent of fines content, and bulk and particle density of the processed and pelletized organic waste have been investigated, and the optimum values for storage, handling and transportation of the pelletized organic waste have been determined. Three different sizes of extruding sieve (4.35, 6.35 and 7.9 mm) and three different waste-mixing ratios (1:1:2, 1:2:2 and 1:3:3) of farmyard waste, wastewater sludge and sugar industry press mud were used respectively for the production of bio-solid pellets. The physical properties of the palletes show that durability increases by increasing the amount of sewage sludge while fines content, bulk density and unit density decrease. The large sieve size has more durability and less fine content. The results showed that the pelletization technique can be efficiently used by the farmers and appears to be a good option for sustainable management and re-use of organic solid wastes.

Keywords: *Farmyard Manure, Sewage Sludge, Pellets, Sieve Size, Durability*

1. INTRODUCTION

Today, the management and proper disposal of huge amount of solid wastes is a serious challenge faced by Pakistan. As the potential of the solid waste reuse goes untapped, inappropriate dumping practices of solid waste not only pose threat to local environment but also lead to wastage of resource. The organic component of solid waste contains sufficient amounts of nutrients that can be used as biological fertilizer. In the last few decades, Pakistan, however, has shifted to intensive agriculture, whereby excessive synthetic chemical fertilizers are used that are environmentally unsafe [1]. While on the other hand, organic wastes have the potential to be used not only as a source of nutrient supply but also as soil conditioners to improve the characteristics of the soil. Organic wastes improve the soil structure and enhance the water and nutrient-holding capacity of the soil. It also increases the microbial activity within the soil thereby increasing the soil fertility [2-5].

Slurry originating from the municipal wastewater treatment plant as a byproduct is known as sludge, and biosolids if stabilized [6-7]. The most common way to treat sludge is composting [8]. Use of industrial wastes, such as sugar-press mud, is gaining attention because of their rich nutrient content. Sugar-press mud provides sufficient supply of organic matter, major nutrients and some main micronutrients. It is recognized for its physical properties and significance in enhancing crop production and soil fertility [9]. Farmyard manure is also a valuable organic waste that has been traditionally used as a soil conditioner in agricultural fields [10].

This paper is based on an investigation that aimed at determining the optimum mixing proportion of these wastes and their physical properties for safe and more productive reuse of organic solid wastes (sewage sludge, sugar-press mud, farmyard manure) in agriculture through pelletization.

2. MATERIALS AND METHODS

The organic solid wastes used in this study included sugar-press mud, sewage sludge and farmyard manure. These wastes usually contain some portion of inorganic solids, like dust particles, sand, silt and small pebbles, which cause abrasion and blocking problems during pelletization process. Removal of such impurities is important and which was achieved through mechanical vibrating sieve of pelleting machine having 10 mm opening size (Figure-1). After separation, the material was conveyed to the hammer mill, where it was grinded in fine powder like form.

After grinding, all waste materials were mixed up manually in required proportions. Mixing ratio among the wastes (farmyard manure, wastewater sludge and sugar-press mud) were: 25:25:50, 20:40:40 and 14:43:43, respectively. Aerobic composting of these mixed wastes was done for four weeks to render it environmentally safe and agronomically more productive. Moisture was maintained in the range of 40-60 %.

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Description of Pelleting Unit

1 Waste sump
2 Bucket elevator
3 Screening chute
4 Vibrating sieve
5 Grinding mill
6 Mixer chute
7 Mixer hopper
8 Mixer
9 Extruder
10 Dryer drum
11 Burner
12 Conveyer

Figure-1: Pelleting Machine

Composted material was homogenized in the mixer assembly. During mixing, appropriate amount of water was added to increase the binding property of the material. The homogenized material then found its way into the extruder via the hopper, where the material was transformed into pellets by extruding it through the sieves of required size. These soaked pellets were then subjected to a dryer drum, where hot burnt gas was passed into a rotating drum. To achieve the class-A pellets with desired moisture and hardness, they were dried at a temperature range of 70 to 80°C for a time period of 65 to 75 seconds, which is recommended by US-EPA [11]. The treated pellets were then moved into a collecting hopper, which is the inflow point of the conveyer carrying a final product for stockpiling. The pellets were stacked up in the plant vicinity where natural curing took place. The pellets were then ready to be bagged and transported to commercial markets.

3. PHYSICAL CHARACTERISTICS OF PELLETS

i. Bulk Density

Bulk density of pellets was determined according to the ASABE Standard method S269.4 [12]. Pellets were transferred into a cylindrical container up to the top level. The extra material was removed and weight of the pellets was calculated by deducting the weight of empty container from the collective weight of pellets and container. Bulk density was calculated by dividing the mass by the container volume.

$$\rho b = M/V \qquad \text{... Eqn. (1)}$$

Where:
ρb = Bulk Density of pellets (kg/m^3),
M = Mass of pellets in container (kg), and
V = Volume of container (m^3).

ii. Unit Density

Unit density of the pellets was determined by calculating the weight and volume of a few pellets individually. The volume of each pellet was determined by using the following formula:

$$V_t = \pi/4D^2L \qquad \text{... Eqn. (2)}$$

Particle or unit density was calculated by:

$$\rho U = M_t/V_t \qquad \text{... Eqn. (3)}$$

Where:
ρU = Bulk Density of pellets (g/cm^3),
M_t = Total mass of individual pellets (g), and

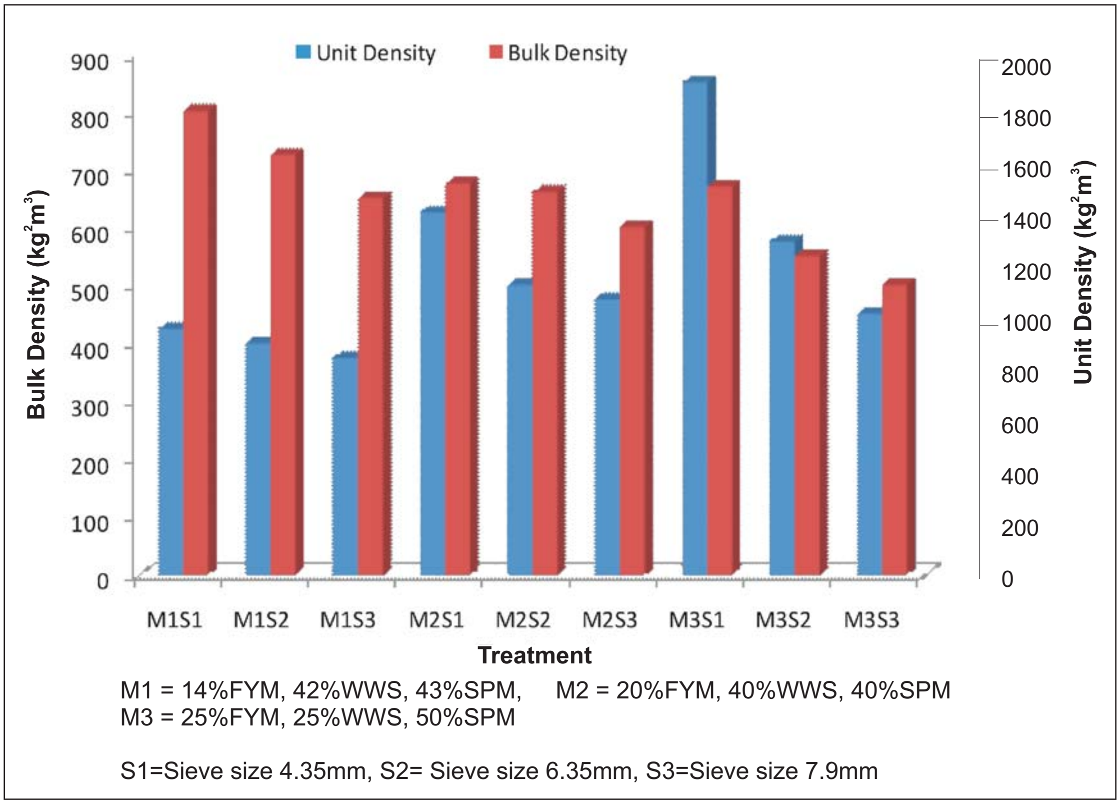

Figure-2: Relation of Mixing Ratio and Sieve Size on Bulk and Unit Density of Ppellets

V_t = Total volume of pellets (cm^3).

iii. Fines Content

Fines content means the formation of fine particles during pellet manufacturing. This is due to factors like temperature of sieve or amount of moisture present in material and the cohesive force in material [16]. Fines content was determined by the method described by Lui, et al. [13], using a 3.15 mm sieve. Pellet sample weighing 300 gms were taken and each sample was placed on a vibrating sieve for 30 seconds. The final mass was weighted again.

Fines content was calculated using the following formula:

$$P_f = (m_i \; m_f)/m_i * 100\% \qquad \text{... Eqn. (4)}$$

Where:
P_f = Fines of sample (%),
m_i = Initial weight of sample (g) and
m_f = Final weight of sample (g).

iv. Durability

Durability was determined by the drop-testing method given by Oveisi, et al. [14]. A sample mass of 300 g of pellets filled in a 250x300 mm fabric bag having a zip lock on its one side was used. Before each test, pellets were sieved mechanically by using sieve analysis apparatus with 3.15 mm sieve size to separate the broken pellets. After the separation of broken pieces, pellets were put in the bag. The loosely filled bag was dropped from a height of 8 m building onto a marble floor. The pellets were once again passed through a 3.15 mm sieve and the unbroken pellets were weighed [14]. Percent breakage was determined using the following formula:

$$D = M_f/M_i * 100 \qquad \text{... Eqn. (5)}$$

Where:
D = Durability (%),
M_i = Initial mass of pellets before drop (g),
M_f = Final mass of pellets after drop (g).

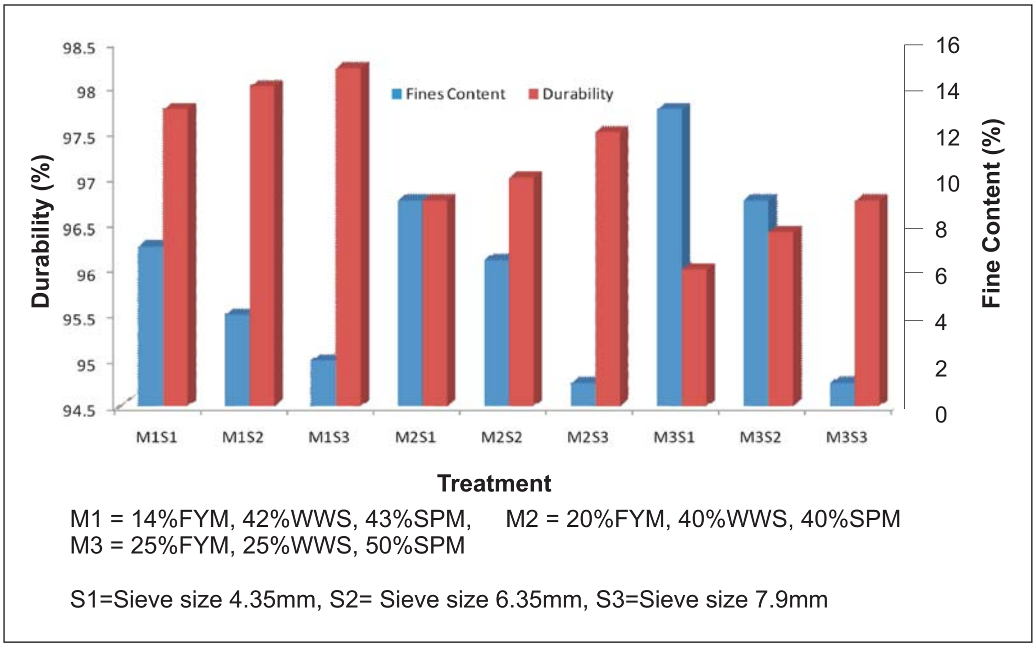

Figure-3: Relation of Sieve Size and Mixing Ratio on Durability and Pellets Fines Content

4. RESULTS AND DISCUSSION

4.1 Effect of Mixing Ratio and Sieve Size on Bulk and Unit Density of Pellets

Unit density of pellets depends on raw organic waste, size of sieve used, and moisture content. Conveyance, handling efficiency and storage space provisions depend on density of pellets. Sufficient storage is needed in order to safely handle a huge supply of pellets stock. Low storage space for high bulk density of pellets is required with greater efficiency [13]. Figure-2 shows the interaction of sieve size and mixing ratio on bulk and unit density of pellets. At constant mixing ratio, bulk density decreased with an increase in the size of sieve opening size. So the sieve size 4.35 mm gave the maximum bulk density at same waste composition. The mixing ratio with less sugar-press mud and sewage sludge portion showed less bulk density of pellets. Waste that comprised of 14 % farmyard manure, 43 % waste water sludge and 43 % sugar-press mud, and passed through 4.35 mm size sieve, gave maximum bulk density.

Unit density increased with decreasing quantity of sugar-press mud and wastewater sludge. Maximum unit density was observed in waste having ratio of 1:1:2, i.e., 25 % farmyard manure, 25 % sewage sludge and 50 % sugar-press mud.

4.2 Effect of Mixing Ratio and Sieve Size on Durability and Fine Content of Pellets

Durability is considered high if it is above 80 %, intermediate when it varies from 70-80 % and low when it is less than 70 % [15]. Low durability is not desired as it troubles the pellet storage and handling. Figure-3 shows the interaction between sieve size and mixing ratio for durability and fines content of pellets. Results showed that durability of pellets increases with increase in sieve size because larger pellets are more compact and dense than smaller ones. Durability of pellets decreases with decreasing amount of wastewater sludge and sugar-press mud. It might be due to the fact that sludge is a sticky material that tightly binds with other materials. Highest durability was achieved with the mixing ratio of 1:3:3, i.e., 14 % farmyard manure, 43 % wastewater sludge and 43 % sugar-press mud, with sieve size of 7.9mm. Pellets with low durability might cause storage and transportation problems because these tends to crumble due to moisture adsorption or due to drop or resistance. Less durability increases the possibility of fracture in pellets [14].

Fines content decrease with increase in sieve size. Fines content was highest in the 4.35 mm sieve. With respect to mixing ratio, fines content increased with increasing the amount of farmyard manure and decreasing wastewater sludge and sugar-press mud. Mixing ratio 1:1:2 (25 % farmyard manure, 25 % waste water sludge and 50 % sugar-press mud), gave maximum fines content. Maximum fines content was produced in treatment of waste material having ratio 1:1:2 (25 % farmyard manure, 25 % wastewater sludge and 50 % sugar-press mud) with a sieve size of 4.35 mm.

5. CONCLUSIONS

Reusing organic waste is the need of the hour as it not only reduces load on landfills, but also cuts down the depletion of fresh resources. The study showed that organic solid wastes can be reused as soil conditioner using pelletization technique, which not only densified the waste but also improved its other physical properties. The outcome showed that treated pellets can be used as nutrient-supply source, as well as soil conditioner. The pallets have the potential to be used on commercial scale for sustainable solid waste management.

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