



Assessment of Mixing Potential of Sewage Sludge, Green Waste and Food Waste for Co-Composting in Sharjah, UAE

Md Maruf Mortula^{1*}, Aqeel Ahmad¹, and Syed Ali Shah²

¹Department of Civil Engineering, American University of Sharjah, Sharjah, UAE

²Compost Plant, Sharjah Municipality, Sharjah, UAE

Abstract. The generation of large amounts of solid waste is a big challenge for large cities like Sharjah, UAE. A major portion of this waste is organic in nature. There are different types of organic wastes produced in different operations within the municipalities. Instead of having separate composting facilities, working with the major types of organic waste for co-composting can add value. Sewage sludge, green waste and food waste are major sources of organic wastes in many municipalities. Currently, the compost facility within Sharjah Municipality uses sewage sludge and green waste as their raw material. There is no separate composting provision for food waste. The objective of the paper was to characterize different organic wastes and assess the suitability of co-composting in Sharjah, UAE. The results indicated that sewage sludge, green waste and food waste had very diverse characteristics suitable for compost. Mixing these wastes in the appropriate proportion can generate good quality compost. When it comes to maintaining a mixing proportion of these three different organic wastes, there are several combinations that can work.. Optimal moisture content was also investigated in the study.. A laboratory-based experimental study identified the mixing potential of these three types of organic waste for the municipality of Sharjah, UAE.

Keywords. *Green Waste, Sewage Sludge, Food Waste, Co-composting*

*Correspondence:
mmortula@aus.edu

1. Introduction

Due to rapid growth of the municipalities, solid waste and sewage sludge generation has been on the rise (generated) over the past few years. Environmental pollution caused by these wastes is a major obstacle that deters municipal growth. It is therefore crucial to find the effective methods of reusing these wastes and reducing their adverse impact on the surroundings (Lu et al., 2009).

There are significant amounts of municipal waste generated within the municipalities. In the City of Sharjah, UAE, approximately 2500 tonnes of solid waste is produced every day (Abu Rashed et al., 2013). The organic fraction of the waste is typically considerable for developing countries (Faverial and Sierra, 2014). In the City of Sharjah, UAE, municipal waste consists of 40% organic waste on top of the 14% papers and cardboards (Beeh, 2013).

Consequently, valuable reuse of the organic waste can contribute to significant diversion from the solid waste disposal of landfill (Körner et al., 2008, Zurbrügg et al., 2004, Zurbrügg et al., 2005). Therefore, Sharjah Municipality needs a strong self-sustaining approach in dealing with all these organic wastes (Mortula et al., 2015).

There are different management approaches to organic waste. Composting is considered to be a simple and low-investment method (Hsu and Lo, 1999). The physical and chemical properties of individual organic waste (food waste or green waste) often do not support efficient composting processes. Co-composting of two or more types of organic materials is expected to overcome the drawbacks of composting a single waste (Kumar et al., 2010). The capability of decaying through the action of living organisms

and steadiness during the composting process have a major influence on the quality of the compost produced (Grigatti et al., 2011 and De Guardia et al., 2010).

Different kinds of unprocessed waste have different characteristics that high-quality compost needs. The required quality of efficient compost can be acquired by optimizing the suitable proportions of different types of organic waste in the compost (De Guardia et al., 2010).

Urban untreated waste is usually not dense with a relative superior carbon-to-nitrogen (C/N) ratio, whereas the sewage sludge has a dense structure with high moisture content and low (C/N) ratio (Bernai et al., 1998). Therefore, sewage sludge needs a bulking agent to soak up the moisture. Green waste is absorbent in nature and has a required carbon-to-nitrogen ratio (Hogland et al., 2003).

The objective of the paper was to assess the potential mixing of sewage sludge, green waste and food waste for effective co-composting for the municipality of Sharjah, UAE. Characteristics of these wastes were used to investigate the potential mixing proportions.

Compost Plant, Sharjah Municipality

The compost plant in Sharjah Municipality uses treated sewage sludge and green waste for composting. The plant mixes these two wastes with equal volume in a windrow composting process. The composting process takes approximately four weeks. The compost is used throughout the green spaces within the Sharjah Government.

2. Materials and Methodologies

Materials

Sewage sludge, food waste and green waste were used in this study for co-composting. Representative food waste samples were collected from the various sources at the American University of Sharjah campus. The green waste is normally collected in the city of Sharjah and stored in the compost plant. Green waste was collected from the compost plant. The activated sludge was produced at the Sharjah Municipality's wastewater treatment plant and its treated bio solids were collected from the compost plant for this study. Waste samples were characterized based on standard analytical methods (Table 1). Samples were tested at the compost plant laboratory of Sharjah Municipality.

Table 1

Standard test methods (Agricultural Analytical Service Laboratory, 2015)

Analyte	Method	Reference
% Solids, % Moisture	SM 2540 G (Dried at 105°C)	Standard Methods for the Examination of Water and Wastewater. 1992. 18th Edition, American Public Health Association, 1015 Fifteenth Street, NW, Washington, DC 20005.
pH	TMECC 4.11-A (1:5 w:w slurry)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Soluble Salts	TMECC 4.10-A (1:5 w:w slurry)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Organic Matter	TMECC 05.07-A (Loss on Ignition)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Total Nitrogen	TMECC 4.02-D (Combustion)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Total Carbon	TMECC 4.02-D (Combustion)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Phosphorus	TMECC 4.03-A	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.
Ammonium-N	TMECC 4.02-C (1:5 w:w slurry)	Test Methods for the Examination of Composting and Compost, USDA and U.S. Composting Council. 2002.

Assessment of Mixing Potential

Mixing potential was investigated mathematically based on mixing sewage sludge, green waste and food waste. Different proportions of mixing of these wastes were investigated. The target was set to achieve optimal moisture content and a C/N ratio of 20-25:1. Considerations were also made on the amount of solid waste generated within the municipality of Sharjah.

Experimental Approach

One of the potential mixing proportions identified in the previous section was used in the bench scale experiment. The Naturemill setup was used for the bench scale experiment. It is a decentralized composting machine (Figure 1). They aerate the waste mixture to optimize the composting process. There are two chambers in the Naturemill. The top lid opens directly to the first chamber where the food is discarded, and the flappers at the bottom of this tray or chamber are slanted so that small enough pieces are produced once the compost is decomposed enough and can pass through the flappers. The flappers can be dislodged using a mechanical lever. The model is fitted with an activated carbon air filter to remove any odours.

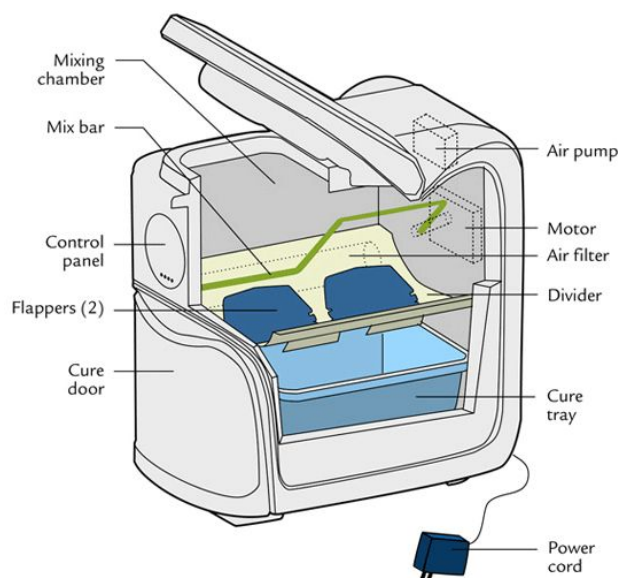


Figure 1: Naturemill schematic (Naturemill 2015)

The experiment was conducted using a mixture of sewage sludge (30%), green waste (50%) and food waste (20%). The setup was operational for six weeks. Samples were collected using standard procedures and tested for compost quality.

3. Results and Discussion

Composting Potential for Organic Waste Mixture

Waste characterization analysis showed that sewage sludge had very high moisture content, a low salinity and low C/N ratio (Table 2). On the other hand, green waste had very low moisture content, a high salinity and high C/N ratio. Food waste had a moderate moisture content, moderate salinity and low C/N ratio. Different types of waste had different characteristics. Green waste often had a very high void ratio, indicating suitability to be operated as a bulking agent during the composting process. Therefore, appropriate mixing among the different types of waste has good potential for production of good quality compost.

Table 2

Waste Characteristics

Parameter	Sewage Sludge	Green Waste	Food Waste
pH	7.1	6.05	4.33
Conductivity, ms/cm	0.779	11.38	5.28
Salinity, %	0.4	6.5	2.8
Moisture Content, %	80.82	7.9	58.91
Organic matter at 550 C, %	72.14	70.8	93.72
Organic Carbon, %	41.84	41.06	54.35
C:N Ratio	7.48	36.99	15.71
Total Nitrogen, %	5.56	1.11	3.46
Phosphorus as P2O5, %	2.59	0.34	0.71

Several combinations of waste mix were analysed (Table 3). Based on the mass analysis of the appropriate mix proportions, C/N ratios were estimated. It indicated the C/N ratio of 20-25 can be achieved.

Table 3

Mix proportion to C/N ratio

Mix No.	Sewage Sludge (%)	Green Waste (%)	Food Waste (%)	Mix C/N Ratio
1	20	40	40	22.6
2	30	40	30	21.8
3	40	40	20	20.9
4	20	50	30	24.7
5	30	50	20	23.9
6	40	50	10	23.1
7	20	45	35	23.7
8	30	45	25	22.8
9	40	45	15	22.0

Moisture contents for different combinations of mix proportions were also analysed (Table 4). The majority of the combinations had a moisture content of 40%-50%. Typically a moisture content of 40%-60% is preferred as part of compost quality. Therefore, it is an indication that the mix proportions can produce acceptable moisture levels as well.

Table 4

Mix proportion to moisture content

Mix No.	Sewage Sludge (%)	Green Waste (%)	Food Waste (%)	Mix Moisture Content (%)
1	20	40	40	42.9
2	30	40	30	45.1
3	40	40	20	47.3
4	20	50	30	37.8
5	30	50	20	40.0
6	40	50	10	42.2
7	20	45	35	40.3
8	30	45	25	42.5
9	40	45	15	44.7

Experimental Results

Experimental results of Mix No. 5 indicated that mixing sewage sludge, green waste and food waste can produce acceptable qualities of compost (Table 5). The majority of the characteristics were acceptable by the government. The salinity level observed was high due to high salinity levels in the green waste. Based on the mathematical analysis, the

observed C/N ratio was expected to be 23.9:1. The experimental results revealed the C/N ratio of 25. Even though the number was higher than that accepted by the ministry, it is close to the values expected during the mixing. Therefore, having a higher portion of sewage sludge might reduce the salinity level and decrease the C/N ratio.

Table 5

Compost Quality

Parameter	Mix Quality	Ministry Requirement
pH	5.49	≤ 7.5
Conductivity, ms/cm	9.7	≤ 10
Salinity, %	5.4	< 2%
Moisture Content, %	9.9	< 25%
Organic matter at 550 C, %	84.19	≥ 40%
Organic Carbon, %	48.83	Around 54%
C:N Ratio	25.04	≤ 20:1
Total Nitrogen, %	1.95	From less than 1% to 5%
Phosphorus as P ₂ O ₅ , %	0.6	NA

4. Conclusions and Recommendations

Conclusions

The study investigated the potential for mixing sewage sludge, green waste and food waste. Mathematical analysis based on the characteristics of the individual waste collected from Sharjah Municipality was investigated. Laboratory-based analysis was conducted on the viability of mixing the three different types of organic waste for generation of a suitable compost.

The results indicated three different types of waste had three different types of characteristics required for suitable compost. Therefore, a suitable mixing can provide the basis for creating good quality compost. Experimental results also indicated that co-composting by mixing different types of waste in appropriate proportions can provide good quality compost for the municipality of Sharjah.

The study revealed that the co-composting of sewage sludge, green waste and food waste in appropriate proportions produced a good

quality compost within the acceptable limits specified by the ministry.

Recommendations

The study was limited in its scope to identify the suitable mixing proportions for producing suitable compost for use in the municipality of Sharjah. Therefore, further experimental studies are required for estimation of different types of waste in the laboratory-based experiment to assess the effectiveness of co-composting for the municipality of Sharjah.

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