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Waste characterization at mixed municipal solid waste composting and recycling facility units

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ABSTRACT

The waste characterization for the Istanbul Metropolitan Municipality Composting and Recycling Facility, which is one of the four composting facilities in Turkey, has been investigated in this study. Main units of the facility include Waste Receiving, Ø80 mm Trommel Screen, Hand Sorting Unit, Composting Unit and Ø15 mm Trommel Screen. The changes of waste profile in the units of the facility and its effects on the compost product were determined by monthly for one year period. In addition, the inert content (glass, plastic, metal and textile) of the compost product, which is important for marketing, was determined and certain strategies were proposed for the reduction of these materials. Food waste (49.5%) was the biggest percentage in the incoming mixed municipal solid waste. The other main constituents were paper-cardboard (16.4%), plastic bag (8.3%), diaper (5.1%), textile (4.6%), glass (3.5%), and plastic (2.7%). The maximum percentage of the components for the Ø80 mm undersize material, which goes into composting process, were food waste (73.9%), paper-cardboard (9.6%), textile (3.9%), and glass (4.2%). In comparison to the incoming waste, a significant increase was determined in the food waste (from 49.5% to 73.9%) and glass (from 3.5% to 4.2%) for the Ø80 mm undersize material. In contrast, the percentage of the paper-cardboard, plastic bag, and diaper remarkably declined for the Ø80 mm undersize material. The inert content of compost product was approximately 5.6% (glass: 4.2%, textile: 0.8%, plastic: 0.6%, and metal: 0.1%). It is determined that if the additional screening is applied to the fine compost through Ø4 mm trommel screen, the inert content could be decreased to 1.02% which meets the criteria of less than 2% inert content set by the related regulation in Turkey.

Keywords: Composting; Glass; Inert matter; Waste characterization

1. Introduction

There are four composting facilities in Turkey located in Istanbul, Izmir, Antalya and Denizli which produce compost from municipal solid waste. The European Union (EU) Landfill Directive sets 25%, 50% and 65% reduction targets for disposal of biodegradable municipal waste (BMW) at landfills by 2006, 2009 and 2016, respectively, compared to the total generation of such waste in 1995 [1]. Consequently, biodegradable waste in Europe will be composted, anaerobically digested or incinerated instead of landfilling. Turkey as a candidate country also has to meet these targets. According to National Solid Waste Master Plan prepared by Ministry of Environment and Forestry, composting will be one of main alternative technologies for treatment of biodegradable waste suggesting more than 100 new municipal solid waste composting facilities in the coming years [2].

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There is a very limited information in the literature about the operational parameters at full-scale composting facilities. In order to better design and operate new composting facilities in Turkey, significant information such as waste profile in the units, effects on products and inert content is needed from existing municipal waste composting facilities. The objectives of this study were to determine waste characterization at mixed municipal solid waste composting facility units and to determine its effects on the compost product. In addition, the inert content, which includes glass, plastic, metal and textile, of the compost product which is important for marketing was investigated and relevant strategies were proposed for the reduction of these materials.

2. Istanbul metropolitan municipality composting and recycling facility

Waste characterization study was carried out at Istanbul Metropolitan Municipal Solid Waste Composting and Recycling Facility located in Kemerburgaz. The facility was constructed in 2001 with a capacity 1000 t/d. The flow chart of the Composting and Recycling Facility is shown in Fig. 1. Main units of the facility are listed below:

2.1. Waste receiving

In this unit, mixed municipal solid wastes from European side transfer stations are unloaded onto a tipping floor where easily identifiable bulky items such as mattresses and large pieces of wood are pushed aside with a front end loader and sent to Odayeri Sanitary Landfill. The remaining material is moved with a front end loader onto conveyor belts.

2.2. Ø80 mm trommel screen

Conveyor belts transfer wastes to two parallel Ø80 mm trommel screens. These screens are equipped with knifes to open the closed plastic bags.

2.3. Hand sorting

Oversize materials from the Ø80 mm trommel screen are directed to the hand sorting unit in order to separate recyclable materials such as metal, aluminum, plastic, paper and cardboard. After the hand sorting unit, the remaining materials are processed and pelletized at refuse derived fuel (RDF) unit. The RDF product is used in the cement kilns as a secondary fuel.

2.4. Composting unit

Ferrous metals within the undersize materials that pass through Ø80 mm trommel screen are removed by a magnetic separator, and then the remaining wastes are transferred to the Composting Unit. The composting unit is designed as an agitated tunnel system with eight week residence time. The piles are formed in an enclosed building, on an aerated floor and are turned. Within the composting unit, temperature and moisture levels are monitored to control the process.

2.5. Ø15 mm trommel screen

After composting process is completed, the material is passed through a Ø15 mm trommel screen that separates compost from oversized, inorganic materials. The oversize materials (coarse compost) are sent to Odayeri sanitary landfill to be used as a daily cover. The undersize fraction (fine compost) is used as a soil conditioner and fertilizer at the parks and green areas by the Municipality.

3. Materials and methods

A detailed waste characterization at the Composting Facility Units was performed monthly for a year period. Samples were obtained from seven main units which are listed below and shown in Fig. 1.

1. Waste Receiving,
2. Ø80 mm Undersize,
3. Ø80 mm Oversize,
4. Hand Sorting Output,
5. Composting Unit Output,

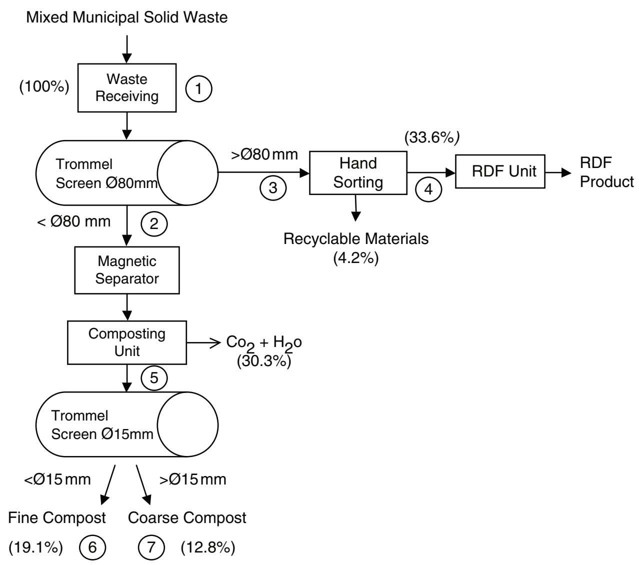

Fig. 1. The flow chart of the Istanbul Metropolitan Municipality Composting and Recycling Facility (numbers in circles show the sampling points and percentages in the parenthesis show the mass balance).

6. Ø15 mm Undersize (Fine Compost), and
7. Ø15 mm Oversize (Coarse Compost).

The ASTM method (D 5231–92) was used for sampling and sorting process [3]. Using quartering and coning technique, about 90 kg representative sample was obtained. Then, the material was classified to 20 different categories and the amount of each category was determined by a balance.

In order to determine the effects of additional screening to remove inert matter, sieve analyses for fine compost (Ø15 mm undersize) was conducted according to Test Methods for the Examination of Composting and Compost (TMECC) [4]. 250 cm^3 aliquot of sample was sieved for <2 mm, 2–4 mm, 4–9.5 mm, 9.5–15 mm size fractions. Then plastic, metal, glass and textile were sorted and classified for each size fractions. The mass of inert materials were obtained by a lab-scale balance.

Some specific analyses for the glass fraction, which was the highest inert component in the fine compost, were carried out to investigate the sources of contamination and possibility of separation. Glass samples were further classified for colour (white, green and brown) and physical condition (broken, unbroken).

Important physical and chemical parameters such as pH, moisture content, electrical conductivity and organic matter for the sub-samples obtained from waste characterization study were analyzed according to TMECC.

4. Results and discussion

The results of waste characterization study at the Composting and Recycling Facility units are given in Tables 1 and 2 as an average of 12 mo. Food waste was the biggest percentage in the incoming waste (waste receiving unit). The other main constituents were paper-cardboard (16.4%), plastic bag (8.3%), diaper (5.1%), textile (4.6%), glass (3.5%), and plastic (2.7%). The maximum percentage of the components within the Ø80 mm undersize material, which goes into composting process, were food waste (73.9%), paper-cardboard (9.4%), glass (4.2%) and textile (3.9%). In comparison to the incoming waste, a considerable increase was determined in the food waste (from 49.5% to 73.9%) and glass (from 3.5% to 4.2%) for the Ø80 mm undersize material. In contrast, the percentage of the paper-cardboard (from 16.4% to 9.4%), plastic bag (from 8.3% to 1.1%) and diaper (from 5.1% to 0.4%) significantly declined within the Ø80 mm undersize material.

The main components for the Ø80 mm oversize material, which is sent to hand sorting unit, were paper-cardboard (23.8%), food wastes (16.9%), textile (%15.7), and plastic bags (15.4%). While paper-cardboard, plastic bags and textile increasing, food wastes and glass decreased within the Ø80 mm undersize material in comparison to the incoming waste. During the study, it was determined that Ø80 mm oversize material still

Table 1
Waste characterization results for waste receiving, Ø80 mm undersize, Ø80 mm oversize and hand sorting output (Mean ± std. dev.) (n = 12)

Components	Waste receiving (%)	Ø80 mm Undersize (%)	Ø80 mm Oversize (%)	Hand sorting output (%)
Paper-cardboard	16.35 ± 4.03	9.35 ± 3.21	23.82 ± 4.52	24.78 ± 9.25
Glass	3.49 ± 1.98	4.21 ± 1.69	1.18 ± 1.17	0.97 ± 0.93
Pet	0.90 ± 0.50	0.10± 0.17	1.85 ± 0.84	0.60 ± 0.47
Plastic bag	8.25 ± 1.41	1.08± 0.70	15.43± 3.82	15.59 ± 3.47
Plastic	2.74 ± 0.98	1.54 ± 0.77	4.08± 1.51	2.69 ± 1.06
Sack	0.11 ± 0.21	0	1.13 ± 1.23	0.34 ± 0.59
Aluminium	0.24 ± 0.25	0.29 ± 0.54	0.68 ± 0.52	0.37 ± 0.33
Ferrous	1.04 ± 0.96	0.40 ± 0.54	2.20 ± 2.24	0.66 ± 0.46
Food waste	49.54 ± 7.78	73.85 ± 7.93	16.88 ± 5.27	19.67 ± 6.47
Diaper	5.07 ± 2.41	0.43 ± 0.59	4.49 ± 1.39	7.79 ± 2.98
Wood	1.01 ± 0.86	0.68 ± 0.69	1.92 ± 1.61	1.82 ± 1.25
Electric-Electronic Waste	0.18 ± 0.39	0.00 ± 0.00	0.18 ± 0.47	0.07 ± 0.25
Battery	0.01 ± 0.03	0.17 ± 0.55	0.02 ± 0.03	0
Textile	4.63 ± 1.74	3.93 ± 2.34	15.72 ± 4.13	16.86 ± 4.39
Milk and juice box (container)	0.61 ± 0.28	0.05 ± 0.08	1.14 ± 0.64	1.27 ± 0.68
Other combustibles	2.30 ± 1.04	1.82 ± 1.80	5.35 ± 4.25	3.77 ± 2.13
Park and garden waste	0.67 ± 1.21	0	0.53 ± 1.14	0.78 ± 1.65
Stone	1.37 ± 1.64	1.57 ± 1.07	2.30 ± 2.99	1.45 ± 1.82
Bone	0.85 ± 1.44	0.53 ± 0.93	1.11 ± 1.77	0.54 ± 0.69
Others	0.65 ± 1.94	0	0	0

Table 2
Waste characterization results for composting unit output, Ø15 mm oversize, Ø15 mm undersize (Mean ± std. dev.) (n = 12)

Components	Composting unit output	Ø15 mm Oversize (coarse compost)	Ø15 mm Undersize (fine compost)
Paper-cardboard	9.67 ± 3.70	14.57 ± 2.85	–
Glass	11.61 ± 2.04	18.95 ± 2.86	4.20 ± 1.43
Plastic Bag	1.87 ± 1.10	3.47 ± 1.61	–
Plastic	3.13 ± 0.57	4.37 ± 0.70	0.58 ± 0.21
Aluminium	0.06 ± 0.07	0.27 ± 0.25	–
Ferrous	1.22 ± 1.32	0.80 ± 0.21	0.08 ± 0.04
Diaper	0.58 ± 0.70	0.18 ± 0.13	–
Wood	1.97 ± 0.33	4.52 ± 1.50	–
Battery	0.08 ± 0.17	0.18 ± 0.36	–
Textile	6.53 ± 2.88	12.14 ± 3.87	0.75 ± 0.25
Milk and juice box (container)	0.22 ± 0.25	0.35 ± 0.26	–
Other combustibles	1.75 ± 0.80	3.17 ± 1.21	–
Stone	8.00 ± 0.62	16.49 ± 2.93	5.84 ± 0.67
Bone	1.31 ± 1.45	1.85 ± 1.56	–
Others	0.21 ± 0.25	1.28 ± 1.51	–
Compost	51.78 ± 3.90	17.40 ± 3.03	88.54 ± 2.46

contained some food waste because of the non-opened plastic bags.

Plastic, metal, aluminum and paper-cardboard are separated and recycled at hand sorting unit. The main constituents of hand sorting output, which are transferred to RDF unit, were paper-cardboard (24.8%), food waste (19.7%), textile (16.9%), plastic bag (15.6%) and diaper (7.8%).

At composting unit output, compost was the biggest component (51.8%) which was followed by paper (9.7%), stone (8.0%), glass (11.6%) and textile (6.5%). Despite high temperature during composting process, the material still had very high levels of paper. Glass percentage increased from 4.2% at the beginning of the composting process to 11.6% at the end of the process because of the mass loss due to biodegradation.

Coarse compost (Ø15 mm oversize), which is obtained by screening composted material through Ø15 mm trommel screen, included mainly glass (19.0%), compost (17.4%), stone (16.5%), paper-cardboard (14.6%) and textile (12.1%). Fine compost (Ø15 mm undersize) had the highest fraction of compost (88.5%). The other main components were stone (5.8%) and glass (4.2%). Textile (0.8%), plastic (0.6%) and metal (0.1%) in the fine compost were low levels. Because stone is not regulated, the overall inert content of fine compost was 5.6%. This level is higher than the maximum allowable limits of 2% set by Turkey Solid Waste Regulation [5]. However, it is lower than the inert content of the mixed MSW composts in the United States, especially for metal, plastic, and textile components [6]. Brinton (2003) found that US MSW composts contained 10.96%, 6.22% and %3.78 inert matters for <25 mm, 4–10 mm and 1–4 mm fractions, respectively with the highest contamination of glass. Mass balance in the facility units for 100 kg waste input is given in Table 3.

According to sieve analyses results, most of the fine compost was less than 2 mm size (47.6%) (Table 4). The 2–4 mm, 4–9.5 mm and 9.5–15 mm fractions were 24.1%, 24.8% and 3.5%, respectively. Total inert materials in fine compost were ~0%, 1.02%, 3.34%, 1.26% for <2 mm, 2–4 mm, 4–9.5 mm and 9.5–15 mm size fractions, respectively. These results show that if the additional screening is applied to the fine compost using Ø4 mm trommel screen, the inert content could be decreased to 1.02% which meets the criteria of less than 2% level set by the national regulation. The material loss due to additional screening will be only 28.3% and this material can be applied for low quality use such as mine sites rehabilitation, etc.

The glass component in incoming waste contained 30.9% green (mainly mineral water bottles), 60.3% white (mason jars, soft drink bottles) and 8.9% brown (mainly drug bottles) glass. While 80% of glass passed through Ø80 mm trommel screen, 20% of glass stayed in the oversize fraction. Most of the glass in incoming waste was unbroken (60%) and 80% of these unbroken glasses were broken at Ø80 mm trommel screen resulting only 7% of the unbroken glass entering to the composting unit. These results suggest that glass could be removed by hand sorting at the beginning of facility with the maximum efficiency of 60%. Although hand sorting of

Table 3
Mass balance in the facility units for 100 kg waste input

Components	Waste receiving	Ø80 mm undersize	Ø80 mm Oversize	Hand sorting output	Composting unit output	Ø15 mm Oversize	Ø15 mm Undersize
Paper-cardboard	16.35	5.82	9.0	8.32	3.09	1.86	0.7
Glass	3.49	2.62	0.45	0.33	3.71	2.420.8	
Pet	0.9	0.06	0.7	0.2	0	0	0
Plastic bag	8.25	0.67	5.83	5.23	0.6	0.44	0
Plastic	2.74	0.96	1.54	0.9	1.0	0.56	0.11
Sack	0.11	0	0.43	0.12	0	0	0
Aluminium	0.24	0.18	0.26	0.12	0.02	0.03	0
Ferrous	1.04	0.25	0.83	0.22	0.39	0.1	0.02
Food waste	49.54	45.93	6.38	6.6	16.52	2.22	16.24
Diaper	5.07	0.26	1.7	2.62	0.19	0.02	0
Wood	1.01	0.42	0.73	0.61	0.63	0.58	0
Electric-Electronic Waste	0.18	0	0.07	0.02	0	0	0
Battery	0.01	0.11	0.01	0	0.03	0.02	0
Textile	4.63	2.44	5.94	5.66	2.08	1.55	0.14
Milk and juice box (container)	0.61	0.03	0.43	0.43	0.07	0.050	
Other combustibles	2.3	1.13	2.02	1.27	0.56	0.41	0
Park and garden waste	0.67	0	0.2	0.26	0	0	0
Stone	1.37	0.97	0.87	0.49	2.55	2.11	1.12
Bone	0.85	0.33	0.42	0.18	0.42	0.24	0
Others	0.65	0	0	0	0.07	0.16	0
Total	100.0	62.18	37.81	33.58	31.93	12.77	19.13

Table 4
The results of sieve analyses for the fine compost

Sieve fraction	Glass	Stone	Textile	Plastic	Metal	Compost	Total
< 2 mm	0	0	0	0	0	47.60	47.61
2 mm–4 mm	0.86	1.69	0.01	0.13	0.02	21.34	24.05
4 mm–9.5 mm	2.62	3.86	0.29	0.38	0.05	17.61	24.81
9.5 mm–15 mm	0.71	0.29	0.45	0.08	0.02	1.98	3.53
Total	4.20	5.84	0.75	0.58	0.08	88.54	100.00

glass is possible before the composting unit, only 7% maximum efficiency could be achieved. The removal of glass at the beginning of the facility and before the composting unit would result 30% and 3.5% decrease in the glass content of the fine compost due to about 50% mass loss during composting. If the additional screening through Ø4 mm trommel is applied to the fine compost as suggested above, 80% of the glass in fine compost could be removed. Deposit system for soft drink and mineral water bottles would also help to reduce glass content of fine compost. But, the most effective system would be the source separation of glass at homes.

Moisture content of incoming waste and fine compost were 50.9% and 31.5%, respectively. Organic matter contents were 72.9%, 60% and 45% for the incoming waste, at the beginning of composting unit and in the fine compost, respectively. While the pH in the incoming waste was in the range of 6–7, there was no change at the beginning of composting process. But pH increased to 7–8 levels in the fine compost. Electrical conductivity of incoming waste was in the range of 2000–4000 µS/cm. It was more stable in the fine compost having concentrations of between 3000–4000 µS/cm.

5. Conclusion

In this study, the waste characterization for the Istanbul Metropolitan Municipality Composting and Recycling Facility units was determined by monthly for one year period. Food waste (49.5%) was the biggest percentage in the incoming mixed municipal solid waste. In comparison to the incoming waste, a serious increase was determined in the food waste and glass for the Ø80 mm undersize material. In contrast, the percentage of the paper-cardboard, plastic bag, and diaper significantly declined for the Ø80 mm undersize material. Ø80 mm oversize material still contained some food waste due to non-opened plastic bags, so it was suggested to add more knifes to the Ø80 mm trommel screen to increase plastic bag opening efficiency. The high paper-cardboard levels in hand sorting output showed the inefficiency of hand sorting for paper-cardboard separation. The inert content of the fine compost product was approximately 5.6% which is higher than 2% set by the national regulation. If the additional screening is applied to the fine compost through Ø4 mm trommel screen, the inert content could be decreased to 1.02% which meets the criteria of the legislation. The main sources of glass (the maximum inert in the fine compost product) were mason jars, soft drink and mineral water bottles. It has been proposed that when the additional sorting process is applied in the beginning of the facility, before the composting process and for the compost product, the glass removal efficiencies in the fine compost could be achieved as 30%, 3.5%, 80%, respectively. However, deposit system for soft drink & mineral water bottles and source separation of glass at homes are needed to reduce further glass contamination.

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