ENVIRONMENT AND ENVIRONMENTAL EFFECTS

COMPARISON OF MUNICIPAL SOLID WASTE CHARACTERISTICS AFTER SEPARATION BY STAR AND DRUM SCREEN SYSTEMS

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ABSTRACT

The research provides the results of experimental work in the waste mechanical pre-treatment in Latvia. The goal is to detect and to compare the composition and main parameters of sorted waste components after separation by the star screen and drum screen systems. Samples were taken in three fractions - coarse, medium, fine from the star screen system and coarse and fine from the drum screen system. The parameters – upper, lower heating values, moisture, ash content, S and Cl were determined. Results - the waste content of the fine fraction after the star screen system pre-treatment has less additional material, than after the drum screen system pre-treatment. The coarse fraction after the star screen system pre-treatment contains high calorific energy raw materials for the production of alternative energy materials. However this fraction needs an additional separation if the drum screen system pre-treatment is used for it. The same is necessary for the medium fraction after the star screen system pre-treatment.

Key words: star screen technology, drum screen technology, mechanical pre-treatment, composition of waste, parameters of waste

INTRODUCTION

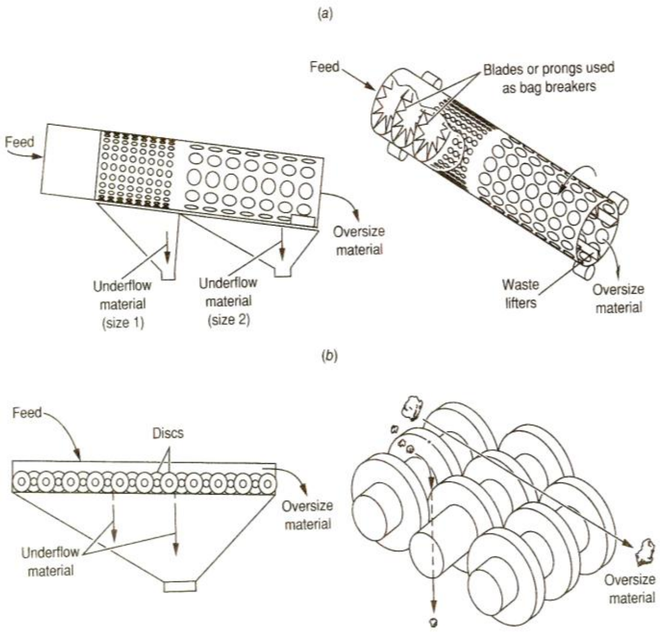
Most of the waste in the Baltic States is not sorted and is landfilled (Eurostat, 2010). According to national statistics the total amount of disposed municipal waste in 2011 was around 572195 tons and the largest part of it - 89%, consisted of unsorted household refuse and similar waste material. The production of alternative fuels is one of the ways to reduce the amount of waste for landfilling. The method used to reduce organic waste disposal is pre-treatment of the unsorted mass before its disposal. The waste separation lines are one of the technological solutions that is planned to be used in all landfills to separate biological waste in Latvia. Automatic sorting by the linear star screen and rotating drum screen sorting lines was investigated as the pre-treatment method. Sorted waste quality as a solid recovered fuel depends on the content, moisture and other factors. The best solutions were found for pre-sorted waste containing small quantities of biodegradable waste and moisture. The mechanical pre-treatment of solid municipal waste was found as a perspective method for improving the sorting properties of waste.

MATERIALS AND METHODS

The effectiveness of two mechanical separation lines has been evaluated – the linear star screen and the rotating drum screen sorting line.

Waste samples were taken from the *Ziemelvidzeme* solid municipal waste landfill *Daibe,* with the first waste mechanical Pre-treatment Centre in Latvia and facilities for mechanical shredding, screening (the star screen system – model of *Komptech Multistar L3-Flowerdisc* – throughput performance of up to 40 t h^{-1}; screen sections: 0/10-25 mm; 10-25 /60-80 mm; >60-80 mm) and the separation of metal of the municipal solid waste (Arina, Orupe, 2012; Arina, Bendere *et.al*, 2012). The operation of the Pre-treatment Centre included separation of a high calorific value fraction prior to landfilling and composting of biodegradable waste. The system of the collection of sorted waste is widely developed in the region unlike in the rest of the territory of Latvia. There is approximately 10 % in source sorted waste.

Waste samples were taken from the separation and reloading waste station of *Vibsteri* in *Broceni* (*Viduskurzeme* waste management organization) with the first facilities for alternative fuel (refuse derived fuel and solid recovered fuel) production in Latvia. *Vibsteri* is equipped with a mechanical shredder, screener, magnetic separator of metal, manual sorting line (places for 8 people), a metal detector and cutting mill (30x30 mm). The screener (drum screen) – model of *Technobalt DS-6000* – with screen: 60x60 mm. The typical scheme of screening technologies (Tchobanoglous *et.at*, 1993) and pictures are shown in Fig.1.



(a) The drum screen in *Vibsteri* (photo: Arina)

(b) The disc screen in *Daibe* (photo from: www.komptech.com)

Figure 1. Typical screens used for the separation of solid wastes: (a) rotary drum screen, (b) disc screen

The mass of household refuse waste was screened to the following components in average firstly using pre-shredding:

- After the star screen technology: coarse fraction ~22% (18-25%), medium fraction ~40% (38-43%), fine fraction (putrescible) ~35% (30-36%), metal ~3 % (2-3%);
- After the drum screen technology: coarse (combustible) fraction (size >120mm) ~53% (50-55.5%), fine fraction or putrescible (size <60mm) ~45% (43-47%), metal ~2 % (1.5-3%). Afterwards the coarse fraction is forwarded to the manual sorting line where about 5-8% of it is separated: biodegradable (food) waste ~1%, inert (glass, rocks) ~3%, aluminum cans ~1%. About 45-50% of refuse derived fuel is generated after shredding.

The sampling was carried out according to the Standards *LVS CEN/TR 15310-(1-5):2007* and *LVS EN 14899:2011*. Samples were taken from each fraction: coarse, medium and fine (excluding metal) from the landfill *Daibe* and coarse (refuse derived fuel) after cutting mill and two fine fractions (excluding metal) from *Vibsteri*. The samples of the fine fraction were taken separately from both the start and the end of the drum screen, because of the visual difference between them after their fall out from the drum from it`s start and end respectively. The experimental truckloads of the collected refuse waste were chosen from the city in the four seasons in *Daibe* and only in the summer season in *Vibsteri* (one truck load per season) – waste from apartments, private houses and small companies; containers were removed 1-2 times a week.

About 150 samples were taken. The sample size was 1-2 kg. The samples were weighed in the laboratory, dried and weighed again. The composition was determined manually (sorted components were weighed and the respective weight percentage was calculated) in 11 parts – paper and cardboard (soft paper, journals, packing, wallpaper); plastic (soft and hard plastic); putrescible (kitchen waste, garden waste); small particles (miscellaneous small particles); hygiene (diapers and pads); textile (fabric); rubber and leather; wood; metal (ferrous, non-ferrous); glass; mineral (stones, ceramics). In order to prepare the representative samples for laboratory analyses after drying, the samples were grained and formed. The following parameters: moisture, heating value, chlorine and sulphur content, ash, amount of metals in ash were determined according to the series of Standards (from Latvian National Organization for Standardisation) – *Characterization of waste* and *Solid recovered fuels*. Data were evaluated statistically using the SPSS 17.0 computer program. A One-Way ANOVA was used to analyze the effects of the variables.

RESULTS AND DISCUSSIONS

The average percentage distribution of the waste composition of dry mass after the star screen technology is shown in Table 1 and after the drum screen technology in Table 2.

Table 1

The average composition of waste fractions after waste pre-treatment by the star screener (%, for dry waste)

Composition of waste	Coarse fraction (%) Mean; Std.error	Coarse fraction (%) Min; Max	Medium fraction (%) Mean; Std.Error	Medium fraction (%) Min; Max	Fine fraction (%) Mean; Std.Error	Fine fraction (%) Min; Max
Paper and cardboard	39.5±2.90	2.0; 92.1	23.9±1.73	7.6; 48.3	2.4±0.16	0; 4.8
Plastic	38.7±2.84	4.8; 77.9	24.5±1.55	5.4; 44.3	2.1±0.19	0; 5.6
Putrescible, green	0.7±0.17	0; 3.9	6.6±0.85	0; 23.6	12.3±1.38	2.6; 30.0
Small particles (<10mm)	3.2±0.63	0; 16.0	6.3±0.69	0; 18.5	43.7±2.01	21.5; 71.8
Hygiene (diapers, pads)	5.1±0.99	0; 30.6	7.1±1.06	0; 24.6	0.7±0.12	0; 2.9
Textile	5.5±1.27	0; 37.5	4.0±0.81	0; 19.4	0.1±0.03	0; 0.8
Rubber/ leather	4.1±1.32	0; 41.9	3.4±1.34	0; 43.9	0.1±0.02	0; 0.4
Wood	1.1±0.47	0; 19.1	3.6±0.86	0; 20.9	0.5±0.10	0; 2.3
Metal	1.5±0.35	0; 10.3	3.5±0.66	0; 23.4	0.5±0.15	0; 3.3
Glass	0.2±0.08	0; 2.6	9.1±1.17	0; 25.3	32.1±1.86	1.9; 52.0
Inert, mineral	0.4±0.33	0; 13.4	8.1±1.66	0; 36.7	5.5±0.52	0; 14.2

Table 2

The average composition of waste fractions after waste pre-treatment by the drum screener in summer (%, for dry waste)

Composition of waste	Coarse (refuse derived fuel) fraction (%) Mean; Std.error	Coarse (refuse derived fuel) fraction (%) Min; Max	Fine fraction (from the start of the drum) (%) Mean; Std.Error	Fine fraction (from the start of the drum) (%) Min; Max	Fine-2 fraction (from the end of the drum) (%) Mean; Std.Error	Fine-2 fraction (from the end of the drum) (%) Min; Max
Paper and cardboard	25.8±1.69	17.0; 36.5	6.2±0.53	4.4; 9.8	18.5±2.41	6.0; 31.4
Plastic	24.8±2.23	16.4; 44.9	4.3±0.56	2.4; 9.2	9.9±1.38	3.6; 18.2
Putrescible, green	0.6±0.32	0.0; 3.3	13.6±1.55	2.9; 19.5	17.2±2.60	8.6; 35.3
Small particles (<10mm)	26.0±2.16	10.0; 33.9	40.1±3.59	27.1; 58.2	15.6±2.34	5.4; 29.7
Hygiene (diapers, pads)	2.4±0.56	1.0; 7.7	1.8±0.42	0.0; 4.5	10.3±1.55	2.6; 18.7
Textile	8.9±1.72	0.0; 17.0	1.4±0.30	0.0; 3.1	5.4±1.35	0.0; 13.5
Rubber/ leather	3.9±0.93	0.0; 10.1	0.9±0.38	0.0; 4.0	2.2±0.84	0.0; 9.5
Wood	5.3±0.99	0.9; 11.5	1.1±0.27	0.0; 2.5	3.1±0.68	0.4; 8.6
Metal	0.7±0.26	0.0; 2.9	2.1±1.26	0.0; 14.5	2.2±0.65	0.0; 6.5
Glass	0.4±0.12	0.0; 0.9	21.5±3.24	2.3; 37.9	11.1±1.90	1.9; 22.7
Inert, mineral	1.3±0.66	0.0; 7.4	7.1±1.09	1.4; 13.4	4.4±1.84	0.0; 21.9

The fine fraction from the start of the drum screen was used to compare fine fractions from both screening technologies, because the fine fraction from the start of the drum differs significantly from the fine fraction from the end of the drum.

The drum screener produces more heterogenic mass than the star system screener within fine fraction – there is about three times more paper after drum screening as shown by the data. There is more glass in the separated fraction after the star

screening, because glass is reduced to a smaller size during this process and therefore reaches a fine fraction as smaller and heavier parts. Whereas there are larger pieces of glass (even whole bottles) after drum screening, therefore arriving at a combustible fraction (afterwards separated manually).
The mean values of the parameters for all waste fractions are represented in Table 3.

Table 3

The mean values of the parameters for all waste fractions

Fraction	Moisture (%)	Lower Heating Value (as received) MJ kg^{-1}	Ash content (dry basis) (%)	S (%)	Cl (%)
After star screen system					
Coarse f.					
Summer	43±3.0	13	17	0.2	1.1
Autumn	36±2.7	13	19	0.2	2.2
Winter	36±4.2	20	8	0.1	0.2
Spring	24±1.6	14	9	0.3	0.3
Medium f.					
Summer	49±1.6	11	15	0.3	4.1
Autumn	48±1.7	8	32	0.2	0.7
Winter	43±1.3	11	33	0.3	1.7
Spring	30±1.7	15	12	0.9	0.5
Fine f.					
Summer	49±2.5	7	46	0.2	2.0
Autumn	44±2.8	3	63	0.2	0.2
Winter	49±1.0	5	65	0.2	0.3
Spring	28±1.2	7	79	0.2	0.1
After drum screen system					
Coarse f., Summer	33±1.1	14	13	0.4	0.7
Fine f., Summer	43±1.7	4	63	0.3	0.5
Fine-2 f., Summer	50±1.6	6	29	0.3	0.4

The moisture of spring significantly differs from the moisture amount for summer coarse fraction, for summer, autumn and winter medium fraction and for summer, autumn and winter fine fraction after the star screen technology (at the α=0,05 level; at analyze of ANOVA).
There is a significant difference ($P<0.01$) of moisture between all three summer fractions obtained from the drum screen technology.
There is no statistically significant difference ($P\geq0.01$) between moisture of the fine fractions from the star and the drum screening technologies in summer.
The lowest calorific value for the coarse fraction was not significantly different between both screening technologies.
The large amount of moisture in the waste influences the calorific value. The amount of moisture depends on the weather conditions, on the proportion of biologically degradable food waste, on the storage of waste and on the waste capacity to absorb moisture. It is characteristic of Latvia that rainfall exceeds evaporation. As paper, cardboard and some hygienic waste and textiles absorb moisture, plastic being relatively dry, forms the largest part of the coarse fraction. In that way moisture is greater if the largest part of the sample is formed from moisture absorbing waste.
The amount of ashes for summer coarse fraction differs significantly between both screening technologies ($P<0.05$). There are more ashes after star screening. The large amount of paper and cardboard within the coarse and medium fraction explains its high proportion of ash. But fine fraction contains more sand and other incombustible materials.
The large amount of cardboard and paper explains the content of chlorine for samples of the coarse fraction. There was relatively less chlorine within the medium fraction, nevertheless this fraction contained an significant part of plastic with chlorine as well as paper and cardboard.
The amount of sulphur was significantly different only for the spring medium fraction, being relatively small for all other fractions.

CONCLUSIONS

1) The drum screening technology (screens of 60x60mm) separates more mass of waste than the technology of the star screen. This is useful if the aim of the screening is to separate biologically degradable waste from the waste to be landfilled.
2) To obtain more material (fine-2 fraction) for the production of refuse derived fuel, it would be

advisable for this case to have smaller screens for the distal part of the drum.
3) The qualitative material for the production of fuel cannot be obtained from wet unsorted household waste (typical of Latvia's circumstances) by only pre-shredding and screening either with the drum or star screen.
4) Depending on financial resources both technologies (star or drum) of the screening can be used if the aim is not to produce fuel.
5) The waste fractions separated by the star screen technology can be used more widely in landfills. As the fine fraction can be composted and used as a cover material for landfills or can be used for the production of biogas. The medium fraction can be landfilled or used for direct combustion and the coarse fraction can be used to produce fuel.
6) Mechanical sorting lines do not give the possibility to fully separate biological waste.
7) To decrease the amount of moisture in the waste and to increase the amount of waste for RDF or SRF production it is advisable to introduce the source separation system for biowaste (including kitchen waste) – thus it is possible to obtain a qualitative mass of biowaste that can be used for the production of compost or biogas (Bendere, 2012).

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