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Content and Properties of Mechanically Sorted Municipal Wastes and Their Suitability for Production of Alternative Fuel

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Abstract. The article presents the results of experimental work in the first waste mechanical Pre-treatment Centre in Latvia. The goal – to detect the main parameters for separated waste parts and to compare them with parameters stated for alternative fuels in cement plant in Latvia. Samples were taken in three fractions - coarse, medium, and fine. 132 samples have been taken. The parameters – upper, lower heating values, moisture, ash content, S, Cl, metals were determined. Results - coarse fraction has greater potential of the production of the alternative fuel.

Key words

Parameters of waste, pre-treatment, alternative fuel, cement plant.

1. Introduction

The most part of waste in Baltic States is not sorted and is landfilled as shown by data of the *Eurostat* database [1]. According to national statistics the total amount of disposed solid waste in 2010 was around 634.000 tons and the largest part of it - 94.3%, consisted of unsorted household refuse and similar waste material [2]. Conversion of waste into refuse derived fuel (RDF) or solid recovered fuel (SRF) serves for two purposes: it reduces the volume of waste sent to landfills, and it provides alternative fuels for industries. The used method to reduce the organic waste disposal is pre-treatment of unsorted mass before its disposal.

2. Material and Methods

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 (star screen system) and separation of metal of the municipal solid waste [3]. The operation of the Pre-treatment Centre includes separation of the high calorific value fraction prior to landfilling and composting of biodegradable waste.

The sampling was carried out according to the Standard *LVS CEN/TR 15310-(1-5):2007*. Samples were taken from each fraction (excluding metal) according to the Standard *LVS EN 14899:2011*. The experimental truck loads of the collected unsorted waste were chosen from the city in the four seasons (one truck load per season) – waste from apartments, private houses and small companies; containers are removed 1-2 times per week. 132 samples have been taken. The sample size was ~2 kg.

The samples were weighed in the laboratory, dried and weighed again. The morphological content was determined (sorted parts were weighed and respective weight percentage were calculated) in 10 parts – paper and cardboard (soft paper, journals, packing, wallpaper); plastic (soft and hard plastic); putrescible (kitchen waste, garden waste); small particles (miscellaneous small particles <25 mm); hygiene (diapers and pads); textile; rubber and leather; wood; metal; glass; mineral (stones, ceramics, sand). In order to prepare representative samples for the laboratorial analyses after drying, the samples were manually sorted according to waste type and weighed. Then, according to percentage proportion of the combustible fraction samples of the laboratorial analyses were grained and formed. The following parameters: moisture, heating value, chlorine and sulphur content, ash, amount of heavy metals was determined according to the series of Standards – Characterization of waste.

3. Results and Discussion

The mechanical pre-treatment of unsorted municipal waste has produced following parts:

- Coarse fraction (18-25%);
- Medium fraction (38-43%);
- Fine fraction or putrescible (30-36%);
- Metal (2-3 %).

The average percentage distribution of the waste content of the dry mass is shown in Table I.

Table I. – The Average Content of Waste Fractions after Waste Pre-treatment (%, for dry waste)

CONTENT OF WASTE	COARSE FRACTION (%)		MEDIUM FRACTION (%)		FINE FRACTION (%)	
	MEAN; STD.ERROR	MIN; MAX	MEAN; STD.ERROR	MIN; MAX	MEAN; STD.ERROR	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

The paper and plastic (78 %) are dominating in coarse fraction (both predominantly as packaging). An insufficiently large size of the sample explains the large standard error for paper and plastic. The medium fraction contains all type of waste. The combustible part forms overall about 66 % of the waste of the medium fraction. The fine fraction contain of biologically degradable material: kitchen stuff, green waste from gardens and parks, partly decomposed paper and small particles (as sand and other material), as well as about 38 % of metal, glass, ceramic and rocks.
The income waste and waste fraction after pre-treatment is shown in Figure 1.

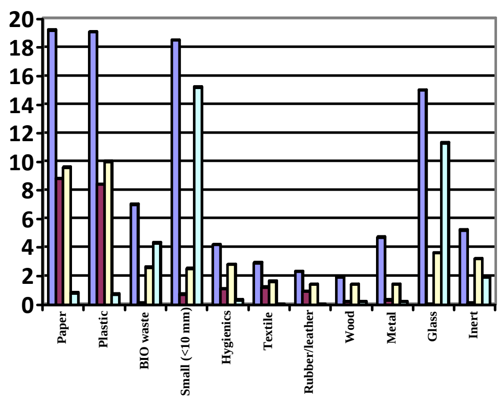

Fig. 1. The income waste and waste fraction after mechanical pre-treatment (% of dry mass). □ – Content of income waste; □ – Coarse fraction; □ – Medium fraction; □ – Fine fraction.

The mean values of the laboratorial analyses for all waste fractions that are compared to requirements of using by cement kiln for SRF material are represented by Table II.

Table II. – The mean values of the laboratorial analyses for all waste fractions in four seasons

Fraction	Moisture (%)	Lower Heating Value (as received) $MJ\ kg^{-1}$	Ash content (dry basis) (%)	S (%)	Cl (%)
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
Requirements for SRF	< 25	>16	< 15	<1	<0.8

The moisture of spring significantly differs from moisture amount for summer coarse fraction, for summer, autumn and winter medium fraction and for summer, autumn and winter fine fraction (at the $\alpha=0,05$ level; at analyze of ANOVA).
The large amount of moisture of the waste influences the calorific value. The amount of moisture depends on weather conditions, on proportion of biologically degradable food waste, on storage of waste and on the waste capacity to absorb the moisture. It is characteristic of Latvia that rainfall exceeds evaporation. As paper, cardboard and some hygienic waste and textiles as absorbing moisture and plastic being relatively dry forms largest part of coarse fraction. In that way moisture is

greater if the largest part of the sample is formed of moisture absorbing waste. The average amount of moisture for each fraction is similar to amount of moisture for unsorted waste, mentioned in literature: 31 %, 42%, 44% and 25-35% [4, 5, 6].

The large amount of paper and cardboard within the coarse and medium fraction explains it`s high proportion of ash. But fine fraction contains more sand and other incombustible material.

The large amount of cardboard explains the content of chlorine for samples of coarse fraction. There was relatively less chlorine within medium fraction nevertheless this fraction contained influential part of plastic with chlorine as well as paper and cardboard.

The amount of sulphur corresponds to requirements for all three fractions.

The amount of chemical elements in the fractions is given in the Table III.

Table III. – The quantity of the chemical elements in the dry ash material of coarse, medium and fine fraction of municipal solid waste after pre-treatment by star screen system in seasons

Chemical elements	Coarse fraction				Medium fraction				Fine fraction				Requirements for SRF
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	
Mercury mg kg^{-1}	0.50	0.68	0.23	0.57	0.45	0.97	0.98	0.60	0.66	1.90	1.96	3.97	< 1.5
Cadmium mg kg^{-1}	0.84	1.14	0.38	0.95	0.75	1.62	1.63	1.2	1.11	3.17	3.27	3.97	< 9
Thallium mg kg^{-1}	0.34	0.46	0.15	0.4	0.30	0.65	0.65	0.36	0.44	1.27	1.31	1.59	< 2
Bromine M.-%	0.023	0.002	0.0001	0.005	0.006	0.003	0.003	0.001	0.002	0.001	0.001	0.001	< 0.25
Iodine M.-%	0.001	0.001	0.0005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	< 0.25
Antimony mg kg^{-1}	5.38	0.46	0.15	28.5	5.81	21.3	26.1	4.44	0.66	10.78	1.31	5.55	< 150
Arsenic mg kg^{-1}	0.5	0.5	0.2	1.1	0.4	0.6	20.9	1.20	1.33	1.27	1.31	2.38	< 20
Chromium mg kg^{-1}	11.76	6.84	8.25	26.6	13.41	6.46	117.4	63.6	13.3	221.9	176.6	5654	< 150
Cobalt mg kg^{-1}	1.68	11.4	1.50	9.5	1.49	16.15	16.30	6.00	2.21	31.7	32.7	39.6	< 20
Copper mg kg^{-1}	28.56	59.28	18.0	45.6	35.76	106.6	61.94	32.4	24.3	158.5	130.8	237.9	< 500
Lead mg kg^{-1}	60.48	5.02	2.85	17.5	62.58	27.13	108.9	241.2	16.4	71.0	34.0	199.8	< 200
Manganese mg kg^{-1}	47.04	47.88	360	64.6	87.91	126.0	453.1	74.4	112.7	279.0	595.1	1983	< 150
Nickel mg kg^{-1}	5.04	2.28	3.37	28.5	4.47	19.4	16.3	8.4	8.84	50.7	19.6	39.6	< 70
Tin mg kg^{-1}	1.68	4.56	0.75	15.2	35.76	3.23	9.78	2.4	4.42	6.3	6.5	55.5	< 50
Vanadium mg kg^{-1}	8.4	22.8	7.50	19.0	7.45	32.3	32.6	12.0	22.1	63.4	65.4	79.3	< 100

The amount of Manganese exceeded the pollution limit one time in winter coarse fraction, two times in winter medium fraction, one time in autumn fine fraction, three times in winter fine fraction and 12 times in spring fine fraction.

The amount of Lead (241 mg kg^{-1}) of the spring medium fraction exceeds requirements (200 mg kg^{-1}) for the SRF as an alternative fuel.

The amount of Mercury exceeded the pollution limit for 0.4 mg per kg in autumn fine fraction, for 0.46 mg per kg in winter fine fraction and 1.5 times in spring fine fraction.

The amount of Chromium exceeded the limit for 71.9 mg per kg in autumn fine fraction, for 26.6 mg per kg in winter fine fraction and 36 times in spring fine fraction.

The amount of Cobalt exceeded the limit for 11.7 mg per kg in autumn fine fraction, for 12.7 mg per kg in winter fine fraction and for 19.6 mg per kg in spring fine fraction.

The amount of Tin exceeded the limit for 5.5 mg per kg in spring fine fraction.

4. Conclusion

1. The fine fraction can not be used for production of quality compost, but after bio-treatment and stabilization it can be used as covering material.
2. The coarse fraction is most suitable for the production of alternative fuel.
3. The medium fraction can be used as fuel in waste incineration facilities or landfilled.
4. It is not possible to prepare the qualitative material for fuel production from a wet (in Latvia like wet waste circumstances) unsorted

household waste by pre-shredding and screening only.

5. To decrease the amount of the 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 the biowaste (including kitchen waste) – thus it is possible to obtain a qualitative mass of the biowaste that can be used for production of the compost or biogas.

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