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THE STUDY OF SIZE AND COMPOSITION IN SELECTIVELY COLLECTED MIXED PACKAGING WASTE FROM HOUSEHOLDS

ABSTRACT

The basis for our research was provided by the material taken to the manual sorting plant where the packaging wastes selectively collected by the inhabitants is treated. In the course of the measurement, the samples were divided into fractions, first according to size of >350 mm; 350-70 mm; <70 mm, then within those fractions according to the types of material. The material fractions were the following: mixed paper, cardboard, beverage cartons, PET, LDPE, HDPE, mixed plastic, metal, glass and interfering material. 60% of the total waste was in the range of 70 mm – 350 mm preferred by the optical separators, about 20% was bigger and around 20% was smaller than that range. It can be stated from the measurements that about 70% of the waste received at the sorting facility can be recycled and 30% contains not recyclable material.

INTRODUCTION AND AIM

The economic, social and technological development, the growth of the population and the improvement of individual well-being have caused a drastic increase in the amount of the generated solid waste all over the world. [1] Although the amount of the generated municipal waste rose in Hungary over the past years, it is still 100 kg less than the average of the EU-28, that being 487 kg/year per capita. In addition, the amount of dumping was reduced and our recycling rate (with compost) has reached 35%. Unfortunately, the latter rate is still lower than EU's rate of 46%. [2]

To reduce the amount of waste put into landfill, the European Union (EU) has introduced the hierarchy of wastes that has to be applied as a priority order in waste prevention. The following order was stated from the most favoured solution to the least favourable one: prevention, preparation for re-use, recycling, other utilization, such as energetic exploitation and disposal. On this basis, the principle of 3R got into regular use, referring to the initial letters of the words reduce, reuse, recycle and to the first three steps. [3]

Major investments were made in the development of waste management in Hungary from 2001. 39 material recovery facilities were built in 25 regions for the treatment of selectively collected packaging waste by the year of 2012. The system treated the waste of 6.7 residents, that meant 67% of the whole population at that time, and 13 more facilities were planned to be built. [4] According to the early warning reports of the Commission in 2018, Hungary is burdened by the risk of not being able to meet the recycling target of 50% by 2020; and this means that significant efforts would be required to reach the subsequent objectives. [2] [3] The treatment solutions of municipal waste have to be financially sustainable, technically feasible, socially and legally acceptable, and also environmentally friendly, since the GHG emission can only be reduced by effective waste management. [1] The recycling targets defined by the EU do not give enough incentives to the service providers, and the minimum service standards do not require kerbside collection of separated waste. [2]

In most cases, people are more willing to start selective waste collection when kerbside collection is introduced, thus the place of waste collection gets closer to the place of waste generation, and less energy is required for taking waste to the containers. [5] However, these factors are not sufficient to achieve significant changes in recycling and maintaining the model of circular economy. The government should realise that waste management is a complex and long-term process. It should stimulate the market of recycled materials, therefore it has to take an active part in making the decisions necessary for achieving the targets. [6]. Social influence and regulatory factors play an important role in the ways communities develop good recovery habits. [5]

It takes at least 6-8 years to develop and reach the maximum capacity of different selective collection systems; and even if time passed, we can only count on the participation of 70-80% of the population, despite the fact that Act CLXXXV 2012 obliges inhabitants to collect waste selectively. Ideally, a collection rate of 80-90% can be reached in the case of metals, 60-70% of paper, glass, textile and hazardous waste, and 30-40% of plastic that is surprisingly the lowest of the listed material types. [7] [8]

Disposable packaging can make up to half of the environmental impacts of the foodstuff value chain, therefore not only people but also producing companies play a great role in the numbers. Most of the uncollected materials would not be recyclable because of contamination, since clean, homogeneous raw material is needed to get good-quality secondary raw material. [9] However, most of these have good combustion characteristics and they are often treated by energy- and heat generation processes replacing fossil fuels. But this requires additional developed pollution control measures. [10]

MATERIALS AND METHODS

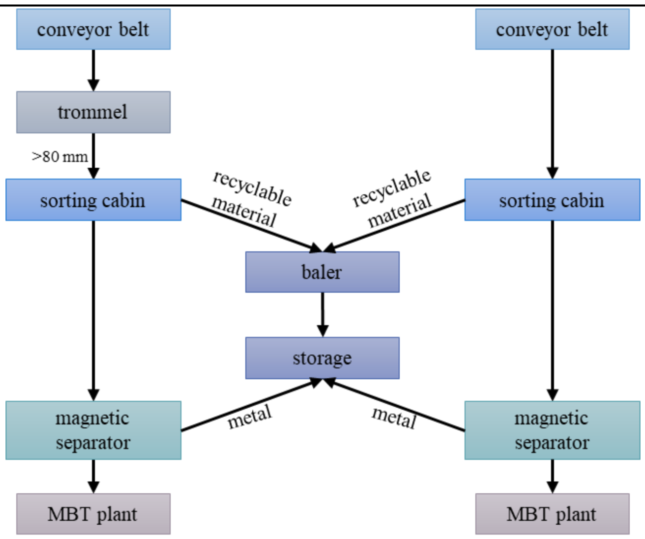

Figure 1.

The schematic drawing of the waste sorting facility.

Our research was carried out in the waste sorting plant of Pécs-Kökény, where the packaging waste selectively collected by the inhabitants is treated. The collected selective waste is sorted here by types and transported from this location to other waste recovery facilities. Most of the sorting is carried out manually, supplemented by a trommel and two magnetic metal separators. The separated waste is baled and taken to waste processing and recovery facilities. The detailed process of the treatment can be seen in Figure 1.

In our research, 12 samplings were taken within 3 months. In the course of each sampling, a container of 1100 litres was filled with selectively collected packaging waste taken to the sorting facility. The samples were taken from the waste received on the previous day, as an average of different point samples during the day. These samples contained mixed packaging waste (different types of paper, plastic and metal) selectively collected by the inhabitants. According to the regional rules of waste collection, glass waste is not collected in the same containers, but there are separate collecting points with this purpose, therefore, in theory, no glass waste could have been found in our samples. After ripping up the bags, the selection of these was done manually in the hall of the material recovery facility, in a covered working area with concrete floor.

When defining the separation limits of size, the ideal size range of the optical sorting facilities was used as a basis. The fraction bigger than 350 mm was selected first from the samples because these can hide a lot of waste during the mechanised technology and that would downgrade the output material quality. In these fraction, only cardboard, LDPE and interfering material was found. The next separation limit was the fraction smaller than 350 mm but bigger than 70 mm. This is the size range, where the optical separators are capable of working with the highest efficiency, so we separated this fraction into 10 different types of material: mixed paper, cardboard, beverage carton, PET, LDPE, HDPE, mixed plastic, metal, glass and interfering material. In the case of the fraction smaller than 70 mm, practical experience showed that it predominantly contained contaminated waste that cannot be recycled, and that their picking was economically not recoverable.

RESULTS AND DISCUSSION

Material composition

The results of material composition are shown in Table 1.

Table 1.

Material composition of the samples taken from the waste received at the waste sorting facility. [m/m%]

	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	SPL 6	SPL 7	SPL 8	SPL 9	SPL 10	SPL 11	SPL 12
mixed paper	22.3%	18.1%	26.6%	30.7%	23.1%	13.7%	16.3%	30.9%	18.3%	17.3%	20.6%	15.1%
cardboard	18.2%	13.1%	8.6%	13.6%	34.2%	32.1%	7.6%	12.2%	10.6%	22.5%	11.7%	20.0%
beverage carton	3.4%	2.2%	4.2%	3.4%	3.1%	2.5%	3.3%	3.5%	4.2%	3.8%	3.6%	3.6%
PET	13.2%	10.6%	9.1%	10.8%	11.2%	11.6%	12.7%	12.2%	11.4%	9.0%	11.3%	11.2%
LDPE	3.4%	2.8%	2.9%	4.3%	2.7%	4.3%	6.5%	2.6%	6.4%	2.4%	4.3%	3.0%
HDPE	2.4%	0.6%	3.6%	2.0%	1.4%	2.5%	2.5%	3.0%	1.7%	2.4%	1.9%	1.7%
mixed plastic	3.0%	0.9%	4.7%	3.1%	2.7%	6.5%	4.3%	3.9%	2.8%	2.8%	3.0%	3.0%
metal	2.0%	0.6%	2.1%	2.6%	1.7%	2.2%	5.1%	4.8%	3.3%	2.8%	3.0%	2.8%
glass	3.0%	3.4%	2.3%	2.6%	1.0%	1.4%	7.2%	3.9%	1.4%	1.0%	0.9%	0.6%
interfering material	9.8%	19.3%	13.0%	11.1%	8.5%	6.9%	13.4%	9.1%	11.1%	13.5%	19.4%	12.3%
unsorted	19.3%	28.3%	22.9%	15.9%	10.5%	16.2%	21.0%	13.9%	28.9%	22.5%	20.4%	26.7%

According to Figure 2. showing the average results, it can be stated that 41% of the incoming waste is made up of paper (mixed paper, cardboard, beverage carton), 20% is plastic (PET, LDPE, HDPE, mixed plastic), 3% is metal, 3% is glass and 33 % is not recyclable material (interfering material, unsorted).

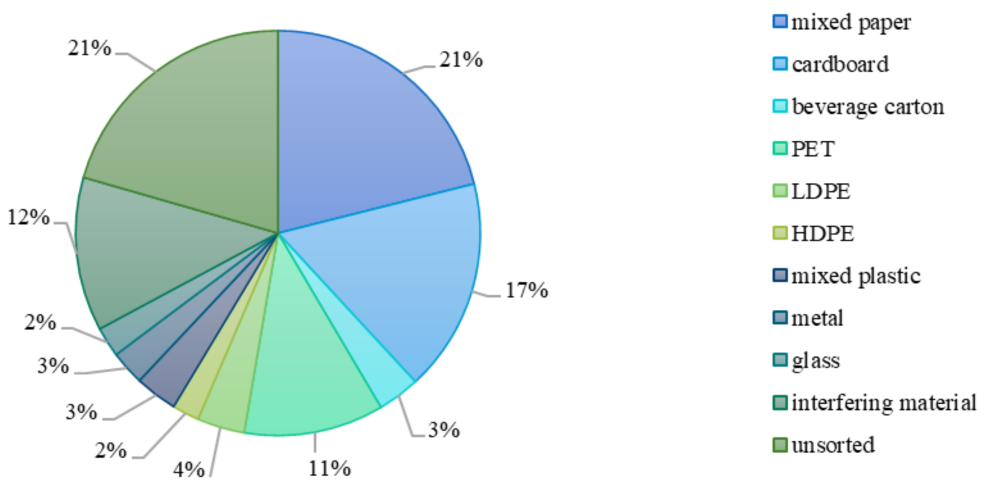

Figure 2.

Material composition of the waste received at the waste sorting facility. [m/m%]

However, Figure 3. clearly shows that we also got values significantly different from the average values. The main cause of it can be found in the two main characteristics of the studied material: we examined waste that was taken from residual collection. Since our samples were taken from residual collection, the measured values were highly affected by human attention and negligence. There can be significant differences between waste material coming from an urban or rural area. Since it is about waste, the outliers cannot be ignored in any case; it can be proved later over a longer measurement period that they are caused by some external influence and so these measurement results occur on the basis of a trend or pattern from time to time, and this way they can lose their outlying character.

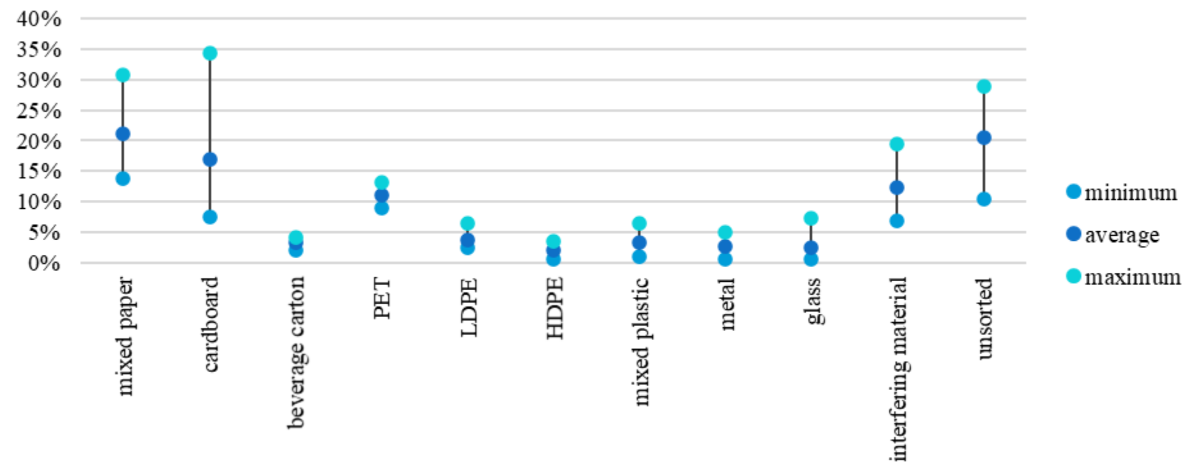

Figure 3.

The minimum, average and maximum values of the measured values of material composition of the waste received at the sorting facility.

Size composition

The results of size composition are shown in Table 2.

Table 2.

Size composition of the samples taken from the waste received at the sorting facility. [m/m%]

	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	SPL 6	SPL 7	SPL 8	SPL 9	SPL 10	SPL 11	SPL 12
>350 mm	23.6%	28.7%	8.3%	13.1%	36.6%	24.5%	6.2%	11.7%	12.5%	21.5%	19.2%	13.3%
70 mm - 350 mm	57.1%	43.0%	71.4%	71.0%	52.9%	59.2%	72.8%	74.3%	58.6%	56.1%	55.2%	60.0%
<70 mm	19.3%	28.3%	20.3%	15.9%	10.5%	16.2%	21.0%	13.9%	28.9%	22.5%	25.6%	26.7%

According to Figure 4. representing the average results, it can be stated that 60% of the incoming waste belongs to size range 70 mm – 350 mm preferred by optical separators, about 20% of it is bigger and around 20% is smaller than that range. In practice, this means that 60% of the incoming waste is suitable for being sorted by the optical separators. To this size range belong newspapers, advertising magazines,1.5 litre PET bottles, cardboard and beverage cartons, which give a significant part of this fraction. In order to be able to improve the sorting effectiveness of the machines, the waste bigger than that size should be separated manually and the smaller ones by machines.

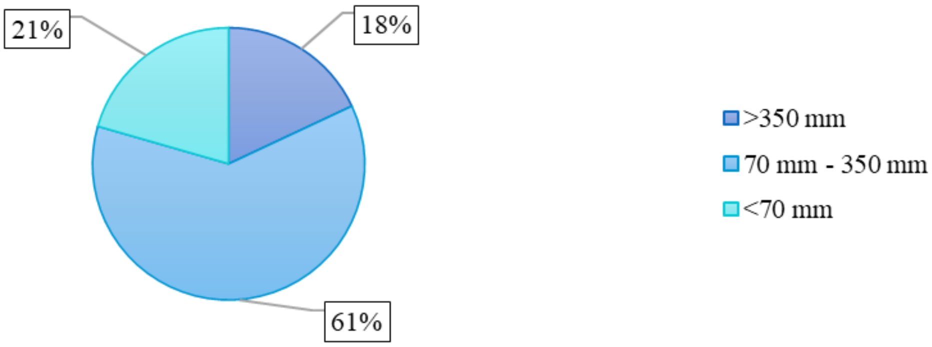

Figure 4.

Size composition of the waste received at the sorting facility. [m/m%]

Material composition split into size fractions

Table 3 and 4 show material composition split into size fractions.

Table 3.

The rates of material types in the samples of >350 mm size range taken from the waste received at the sorting facility. [m/m%]

>350 mm	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	SPL 6	SPL 7	SPL 8	SPL 9	SPL 10	SPL 11	SPL 12
cardboard	64.3%	35.9%	38.9%	69.6%	80.6%	91.2%	70.6%	48.1%	28.9%	67.7%	34.7%	85.9%
LDPE	7.1%	2.2%	5.6%	13.0%	3.7%	8.8%	11.8%	0.0%	26.7%	1.6%	13.9%	0.0%
interfering material	28.6%	62.0%	55.6%	17.4%	15.7%	0.0%	17.6%	51.9%	44.4%	30.6%	51.4%	14.1%

Table 4.

The rates of material types in the samples of 70 mm - 350 mm size range taken from the waste received at the sorting facility. [m/m%]

70 mm - 350 mm	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	SPL 6	SPL 7	SPL 8	SPL 9	SPL 10	SPL 11	SPL 12
mixed paper	39.1%	42.0%	39.2%	43.2%	43.6%	23.2%	22.4%	41.5%	31.3%	30.9%	32.1%	25.2%
cardboard	5.3%	6.5%	7.3%	6.4%	9.0%	16.5%	4.5%	8.8%	11.8%	14.2%	9.9%	14.3%
beverage carton	5.9%	5.1%	6.2%	4.8%	5.8%	4.3%	4.5%	4.7%	7.1%	6.8%	5.6%	5.9%
PET	23.1%	24.6%	13.5%	15.2%	21.2%	19.5%	17.4%	16.4%	19.4%	16.0%	17.5%	18.7%
LDPE	3.0%	5.1%	3.5%	3.6%	2.6%	3.7%	8.0%	3.5%	5.2%	3.7%	3.3%	5.0%
HDPE	4.1%	1.4%	5.4%	2.8%	2.6%	4.3%	3.5%	4.1%	2.8%	4.3%	3.0%	2.8%
mixed plastic	5.3%	2.2%	6.9%	4.4%	5.1%	11.0%	6.0%	5.3%	4.7%	4.9%	4.6%	5.0%
metal	3.6%	1.4%	3.1%	3.6%	3.2%	3.7%	7.0%	6.4%	5.7%	4.9%	4.6%	4.7%
glass	5.3%	8.0%	3.5%	3.6%	1.9%	2.4%	10.0%	5.3%	2.4%	1.9%	1.3%	0.9%
interfering material	5.3%	3.6%	11.5%	12.4%	5.1%	11.6%	16.9%	4.1%	9.5%	12.3%	17.9%	17.4%

It can be seen clearly in Figure 5 that more than half of the fraction of >350 mm is made up of cardboard waste and an additional 10 % is LDFE foil. These packaging materials are often used in the case of bigger products needed in the households; this is why they can be found in such a large quantity in the selectively collected residual packaging waste. In the fraction of 70 mm – 350 mm mixed paper, beverage cartons, metals, LDPE and HDPE plastic, and also glass could be found in almost the same quantities. In this fraction, the amount of cardboard and interfering material was twice as much, PET was four times as much and mixed paper was seven times as much as in the first observed fraction.

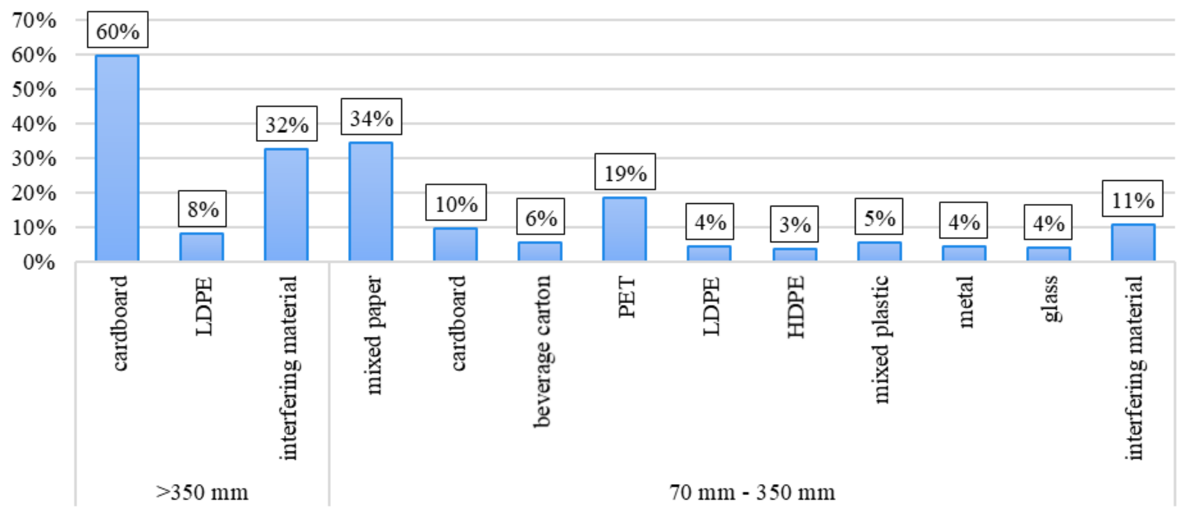

Figure 5.

Material composition split into size fractions. [m/m%]

The rates of material types in the different particle sizes is shown in Figure 6. The size distribution of the sorted cardboard shows that the rate was 40%-60% between the fractions of 70 mm - 350 mm and >350 mm, and in the case of LDPE foil the rate was the other way round. This means that cardboard is favoured at the packaging of large size products. Interfering substances were to be found at the same rate in both fractions.

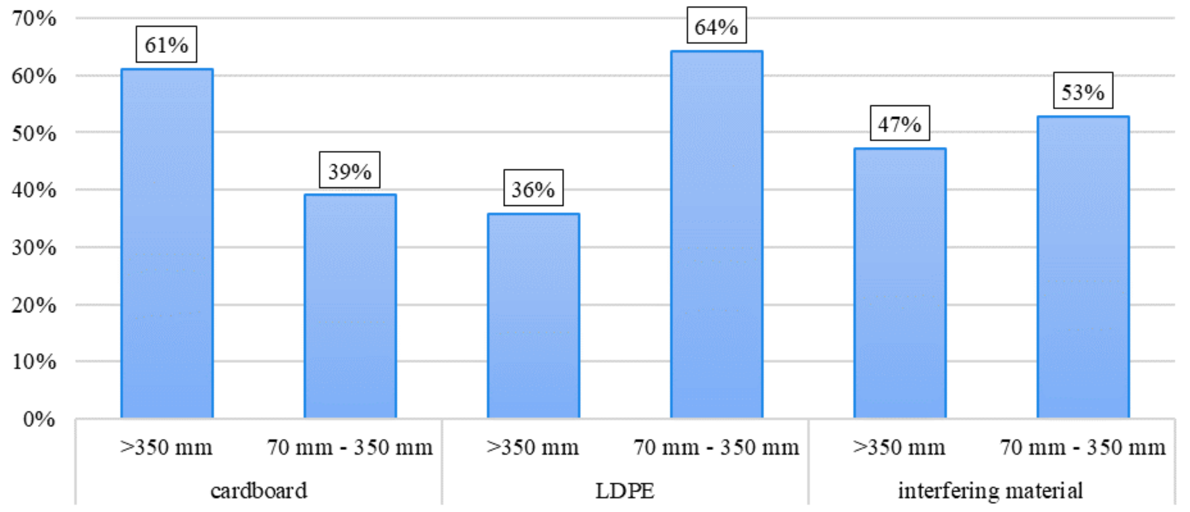

Figure 6.

The rates of material types in the different particle sizes. [m/m%]

CONCLUSION

70% of the material taken to the waste sorting plant is useful material and 30% of it is not recyclable material. 60% of it belongs to size range 70 mm – 350 mm, 20% to size range <70 mm and 20% to size range >350 mm. At the breakdown of the fraction 70 mm – 350 mm into material types, it has been found that mixed paper, PET and cardboard is present in the largest percentage of the useful materials, making up 60% of the fraction. In the fraction >350 mm only cardboard and LDPE foil can be found of the recyclable materials, which make up 60% of the fraction.

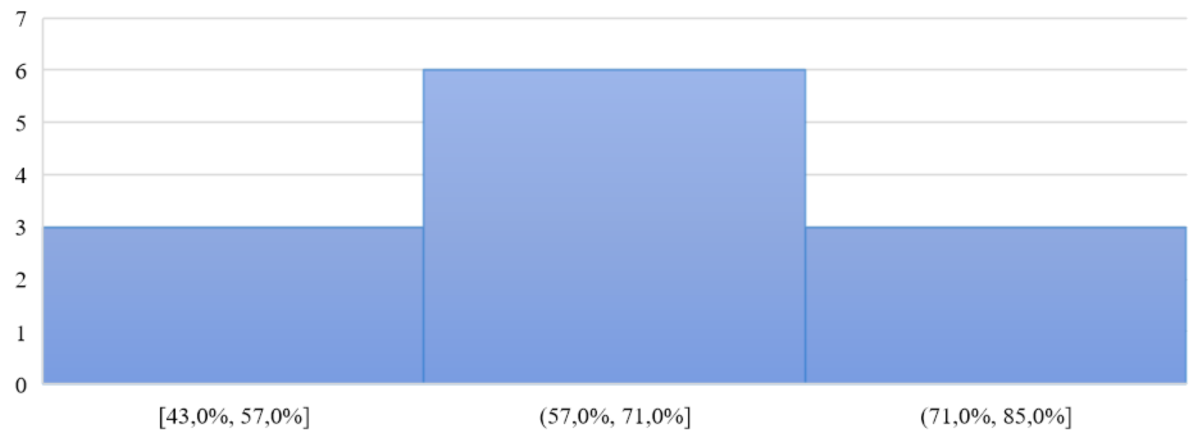

Figure 7.

The histogram of the results measured in the range of 70 mm – 350 mm.

During the measurements it was observed that on average 60% of the received waste would be ideal for automatic sorting. However, when looking at the values of the samples it can be seen that the measured values are most frequently between 60-70% (Figure 7), hence it would be even better to design setting the technology to 70%. To be able to define the technological design more precisely, more samplings would be needed; in an ideal case, exact definitions could be taken from a sampling line covering a whole year.

The measurement results clearly show that despite the rules of waste collection - which state that glass waste must not be put into containers used for residual kerbside collection - almost 2.5% of the incoming material is glass waste. It may also be worth factoring this fact into the technological designs.

ACKNOWLEDGEMENT

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