COMPOSITION ANALYSIS OF MUNICIPAL SOLID WASTE AT A UNIVERSITY DORMITORY

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The paper represents a waste composition study that was conducted at the Mladosť dormitory of the Slovak University of Agriculture (SUA) in Nitra. The aim of the study was to determine the amount and composition of waste generated in the dormitory and to provide recommendations for enhancing the recycling rates and to improve the overall sustainability of waste management in the dormitory. The analysed solid waste was separated into organics, papers, plastics, glass, metals, cardboard beverage packaging (tetrapak), electronic waste (e-waste), and others. The estimated annual average quantity of waste generated per student of the dormitory is 38 kg. The composition of generated solid waste is as follows: paper (6%), glass (26%), plastic (9%), metal (4%), organic (28%), tetrapak (2%), e-waste (1%) and other waste (24%). Potential recycling rate of generated waste is 76%. Composting is the most sustainable method to convert organic waste into valuable compounds and to reduce the waste disposed into landfills.

Keywords: municipal solid waste, waste generation, waste composition analysis, university dormitory

Landfilling is still the most frequent method of municipal waste management in Slovakia. Only 10% of municipal solid waste (MSW) is annually recycled (Lackóová et al., 2013). Effective solid waste management requires a complete understanding of the composition of a waste stream as well as activities that determine its generation in the first place (Smyth et al., 2010).

To enable more efficient separate waste collection at the dormitory Mladosť of the SUA in Nitra, we conducted quantitative composition analyses of the waste generated by accommodated students in 2014. The results of the analyses illustrate the potential for recycling of generated waste and represent basis for drawing up proposals for measures leading to more efficient waste management directly at the originator (Báreková and Kaufman, 2012). They also have an important role in the design of an integrated solid waste management system in particular collecting areas (Gidakaros et al., 2006; Sklenár and Hlavačková, 2005).

A survey which was conducted by Franeková and Báreková (2013) among students accommodated in the dormitory Mladosť showed that the selective collection of waste in the given dormitory has many shortcomings – even 58% of surveyed students expressed dissatisfaction with it. Only 42% of the respondents used containers for collection of paper and plastic and 70% of the surveyed students declared that the containers for separate collection should be placed on each floor. Regarding organic waste, 51% of the respondents would use composters, if they were available nearby the dormitory.

Material and methods

Nitra has a population of 80,524 (as of December 31, 2014). The dormitory Mladosť of SUA in Nitra has 417 rooms, used for accommodation of 1,166 students. In addition, there is also a dining area and a dayroom. Separate waste collection at the dormitory was introduced in April 2012. The containers for the collection are provided by Green Wave Recycling Limited (GWR Ltd.). At present, in the entrance hall of the dormitory there are placed four containers for plastic, two containers for paper and two containers for glass. The capacity of each of them is 240 litres. Collecting of residual municipal waste from the dormitory is provided by the Nitra town. Near the dormitory there are currently located 5 containers for MSW with a volume of 1,100 litres.

After studying several methodologies of quantitative waste analyses, we employed the methodology of The Scottish Environment Protection Agency (SEPA, 2008), which we adjusted for our conditions. The analyses were realized in the calendar year 2014 in all seasons. They illustrate the composition of representative samples of MSW over one reference year. According to the methodology, we collected the samples directly at the source (at the rooms of students) into the indicated bags and then weighted them. Sorting into categories was carried out by the students themselves, but sometimes we had to final-sort them. The analysed waste came from 21 students accommodated in six rooms. All these four seasonal analyses were conducted over one week. It also included weekends, when the number of students in the room usually declined.

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Results and discussion

Summary results of quantitative analyses of waste composition at the dormitory Mladosť (Table 1) show that the total mass of the analysed waste was almost 100 kg while the waste was sorted into eight categories. The sorted components with the highest representation were glass (25.73 kg) and organic waste (27.94 kg). Materials included in the organic waste contain only non-recyclable paper and food waste suitable for composting.

Table 1   Waste composition analysis in 2014 according to total wet weight

Material	Total weight in kg
Paper	6.25
Plastics	8.85
Glass	25.73
Metals	3.54
Tetrapak	1.92
Organic waste	27.94
Electronic waste	0.83
Others waste	23.33
Total	98.36

From the results of the analyses, we calculated the estimated annual quantities of the waste fractions (Table 2) originating in the reporting dormitory. These are the potential weights of the components in the case of complete separation. Since the dormitory is not actively occupied throughout the year, we included only 230 days of the year in the calculation. Operating records of the company GWR Ltd. (which provides a collection of sorted plastic and paper at SUA) indicate that at the dormitory there is annually collected 544.5 kg of paper and 1231 kg of plastics on average. It is only about a quarter of our estimated potential quantities (Table 2).

The percentage of the analysed components of the waste (Figure 1) shows that only 24% of the generated waste cannot be materially recovered on average (i.e. other waste). The collection and subsequent recycling for all other
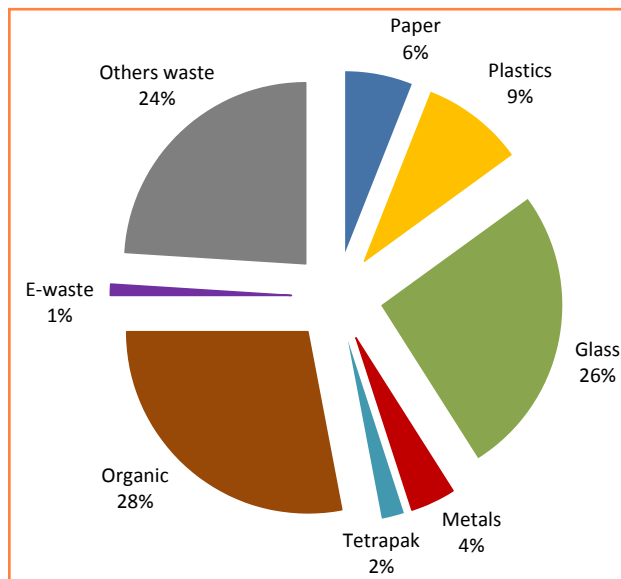

Figure 1   Waste composition analysis (2014), wet weight

classified components are ensured by the town of Nitra. Organic waste has the highest proportion (28%), confirming our belief that it is necessary to ensure separate collection or processing of this waste fraction (previously landfilled) at the dormitory. In these given conditions, two variants are available:

- To establish a community composting nearby the dormitory.
- To request containers for organic matter to engage in its collection system in the town of Nitra with subsequent treatment in municipal composting plant.

Both solutions mean conversion of food waste into compost.

Benefits of composting (Tiew et al., 2011) are shown below:

- Reduced landfill space.
- Reduced surface and groundwater contamination.
- Reduced methane emissions.
- Reduced transportation costs.
- Reduced air pollution from burning waste.
- More flexible overall waste management.
- Enhanced recycling of materials.
- Little capital and operating costs.

Table 2   Annual waste production estimation for the dormitory Mladosť in kg

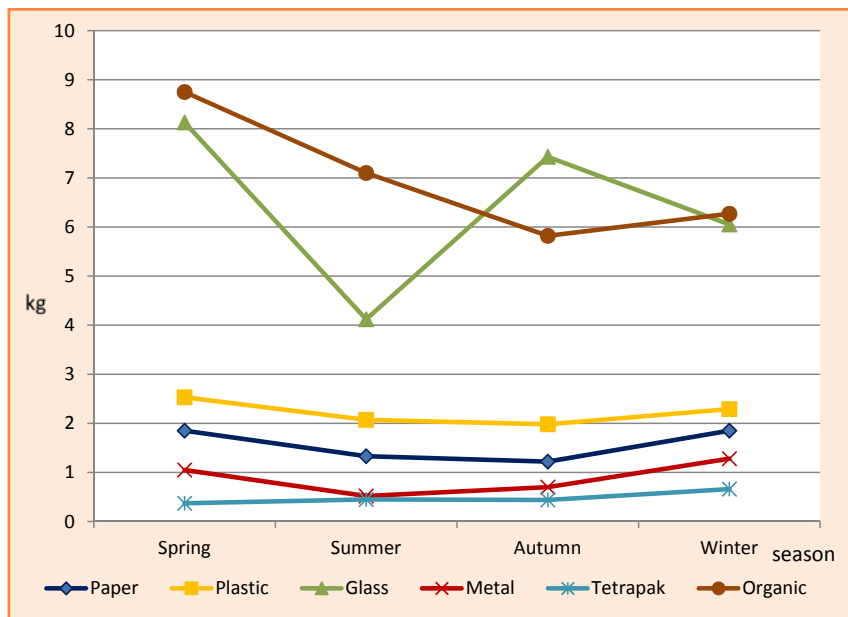| Waste material	Estimated production per resident in kg per year	Estimated production per dormitory in kg per year
Paper	2.44	2845
Plastics	3.46	4032
Glass	10.06	11733
Metals	1.39	1619
Tetrapak	0.75	872
Organic waste	10.93	12748
Electronic waste	0.33	383
Others waste	9.13	10641
Total	**38**	**44872**

Figure 2   Waste composition analysis shows seasonal variation of recyclable fractions, wet weight

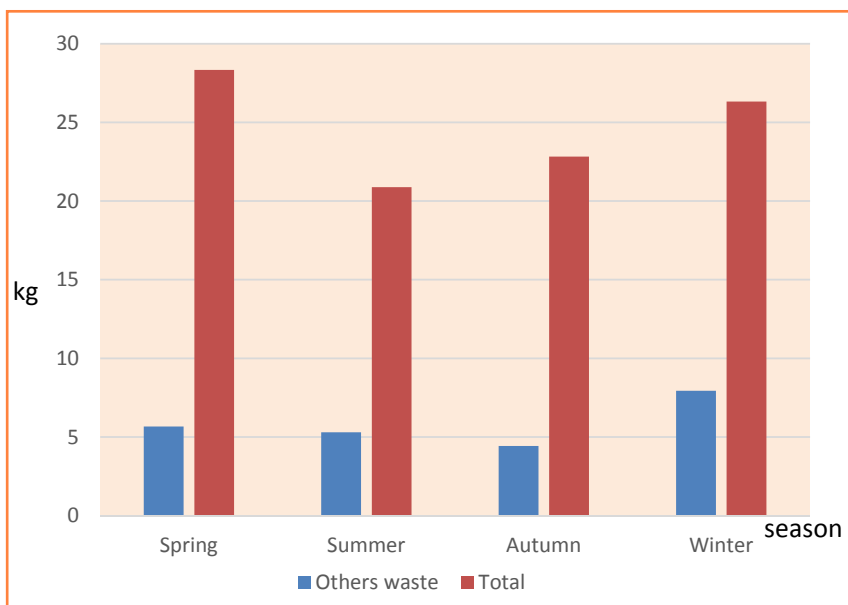**Figure 3**   Waste composition analysis shows seasonal variation of non-recyclable fraction and total amount of waste, wet weight

remains of meat and bones (Stejskal, 2010). Therefore, of bio-waste more attention must be paid to raising awareness and to public education of waste producers (in this case of students) during implementation of the collection.

Evaluation of the results of analyses allows us to estimate the anticipated seasonal changes in the amount of individual components produced at the dormitory (Figure 2 and 3). The highest variability is demonstrated precisely in the components with the highest representation, i.e. organic waste and glass. For other recyclable materials, there was an insignificant seasonal change in the resulting amount. However, it must be noted that analysed glass waste consisted primarily of alcoholic beverages packaging. This is probably also the cause of a significant decrease in this component in the summer analysis that was conducted during the examination period.

The graph in Figure 3 shows the evolution of total amount of waste produced in the course of weekly analyses compared to the amount of non-recyclable fraction. The highest proportion of this component in the total waste was in winter (30%), and in autumn was its representation in the analysed waste the lowest (19.4%). Thus, we can conclude that the share of materially recoverable waste in the total waste production at the dormitory ranges from 70 to 80% during the year.

Our results confirm the data from Table 3, where we compare them with the waste characterization studies that were conducted at dormitories of the University Kebangsaan Malaysia (UKM) and at the Prince George campus of the University of Northern British Columbia (UNBC) in Canada. To simplify, waste was classified into three waste streams (recyclable,

Existing risk of high contamination (over 2%) of separated organic waste can cause difficulties in the composting process. Undesirable ingredients are often non-compostable plastic bags and organic waste such as

Table 3   Percentages (by weight) of the recyclable and compostable waste components (comparison with other universities)

Waste stream	Dormitory Mladosť of the SUA	Dormitories **of the UKM***	Prince George campus of the UNBC**
Recyclable	48%	22.2%	49.97%
Compostable	28%	51.6%	21.61%
Non-recyclable	24%	26.2%	28.42%
Total	100.0%	100%	100%

Source: *Tiew et al., 2011; **Smyth et al., 2010

compostable and non-recyclable waste). In all three universities, a non-recyclable fraction was represented by 20 to 30%. The difference was only in the proportion of recyclable and compostable materials, which probably reflects climatic conditions, food habits and living standard of students in the compared states.

Conclusion

In summary of the study of waste composition, it can be said that the SUA campus could restructure its waste management in the dormitories because almost 76% of the produced waste is recyclable or compostable (Figure 1). There is a high potential (28%) for converting the waste into fertilizers that can be used for landscaping at the SUA rather than dumped into landfills.

Our main recommendations are:
- To introduce the collection of organic waste at the dormitories (according to our estimated annual production of organic waste is about 4000 kg of compost in the dormitory Mladosť).
- To improve the availability of containers for separate collection (to place containers for components that have a high percentage on each floor – glass, organic waste, plastics, paper).
- To ensure understandable indicating of containers.
- To take care of public education (regularly inform students about the importance of waste separation at the dormitory and about its practice).

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