

**REPORT ON QUANTITIES AND MORPHOLOGICAL COMPOSITION OF  
WASTE FOR 16 REPRESENTATIVE MUNICIPALITIES**

*Novi Sad, December, 2015.*

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## 1 DESCRIPTION OF THE METHODOLOGY

The methodology itself consists of two segments:

The **first segment** is measuring the quantities of generated waste in selected municipalities. In cooperation with the utility company from the municipality, the weightings were performed by weighing the tare weight of all waste trucks used for waste collection, i.e. before sending them out to collect waste. This was followed by weighing the same trucks after covering their regular routes in waste collection, and when their capacity is full (gross weight). All weighing was performed by using weighbridge. It is important to underline that the period for weighing was chosen so that waste collection from each household in the municipality was included (mostly one week). The collected waste was then transported to the official disposal site, and the procedure was repeated until every waste truck has finished collection, weighing, and planned disposal for the day according to the regular collection schedule within utility services in the given municipality.



Picture 1.1: Measuring trucks on weighbridge

The key items in the process of determining generated municipal waste quantity can be expressed by the following theses:

1. Utility companies should provide all necessary conditions for weighing of generated waste, monitoring of measurement, recording results;
2. Measurement of truckloads for waste transportation is carried out on the weighbridge;
3. If the PUC doesn't possess weighbridge, they need to provide conditions for measurement of trucks on the weighbridge at third party within the municipality;
4. First, it determines the weight of empty trucks (tare weight).
5. Then trucks collect waste in accordance with their regular routes, for its established program;
6. When a truck for waste collection is filled to its full capacity, it's being transported to the location of the weighbridge;
7. Conducts the measurement of its gross weight and record data on a special form;
8. The form includes date of truck measurement, its tare weight and gross weight obtained by measurement of given trucks that day;
9. After the measurements and data recording have been carried out, the truck is driven to the landfill, where it disposes its contents;
10. The truck then continues waste collection as scheduled, and the measuring cycle is repeated by the previous steps until the truck collects waste from all locations that are planned by daily schedule;
11. The same procedure is repeated for all waste trucks in the Municipality;
12. Weight measuring of municipal waste is carried out for a period of 7 days.

**The second segment** represents sampling and analysis of the morphological composition of waste for the given municipality. For this purpose, it was necessary to bring waste samples of 300-500 kg to the site for analysis (preferably covered). Samples were taken from two types of urban zone (individual and collective housing), as well as rural parts of the municipality.

- 1) Urban zone I – collective housing and commercial areas (settlements with blocks of residential buildings);
- 2) Urban zone II – individual houses (settlements with houses that own yard / garden, situated in the urban zone);
- 3) Rural zones within the municipality (settlements with houses that own yard / garden, situated in a rural zone of the municipality).

Ideally, analysis should be performed on the weekday when the trucks are weighed and total amount of generated waste is determined, to make the timelines similar and data comparable. The samples from each sector were taken randomly, by choosing different streets within the same sector, and then by randomly choosing the bins/containers to be analyzed which will be representative of the selected sector. The desired sample mass of 500 kg is reached by collecting waste from about 50 x 80 l bins, 35 x 120 l bins, or 6-8 x 1.1 m<sup>3</sup> containers. After samples from bins and containers were collected, the waste truck took them to the site determined for sorting and

analysis. It is important to mention that each sample is analyzed individually, depending on the observed sector. The operations of sorting and analysis of the morphological composition of waste were conducted mostly by 3-5 workers, technicians, and an engineer in charge of supervising the process. Waste was separated manually in 15 different fractions, i.e., each fraction was weighed separately, according to the proposed waste catalogue.

Table 1.1: Catalogue of waste, sorted by category with examples

Type of waste	Examples
<b>Garden waste</b>	Cut grass, weeds, flowers, twigs, branches, leaves, remnants of hedges etc.
<b>Other biodegradable waste</b>	Food waste - all kinds (bread, meat, vegetables, fruits, pastries...),
<b>Paper</b>	Old newspapers, advertisements on paper, envelopes, computer prints, diaries, posters, books, notebooks, bus tickets, receipts, letters etc.
<b>Cardboard</b>	All kinds of cardboard boxes, electrical equipment packaging, food packaging, beer packaging carton, boxes of biscuits, toys, flat card etc.
<b>Composite materials</b>	Carton of yogurt, milk, juice, cream etc.
<b>Glass</b>	Bottles (wine, beer, spirits, mineral water, juices, etc.), jars (for pickles, jams, etc.), flat glass, light bulbs, mirrors etc.
<b>Metal - packaging and other</b>	Canned food (sardines, pasta, canned meat), tools, metal car parts, kitchen accessories etc.
<b>Metal - aluminum cans</b>	Beverage cans (beer, coca-cola, energy drinks) etc.
<b>PET bottles</b>	Bottles made of polyethylene terephthalate for water, soft drinks, beer, oil, vinegar, etc.
<b>Plastic packaging waste</b>	Plastic packaging for milk, juice, water bottles, yogurt containers, margarine tubs, take away containers, soft drinks, plates, etc.
<b>Plastic bags</b>	Bags from stores, garbage bags, plastic bags (black, green, gray), bags of chips, sandwich bags, bags of frozen vegetables, bags of cookies, etc.
<b>Hard plastic</b>	Plastic toys, rulers, pencils, toilet lids, toothbrushes, plastic boxes, cleaning supplies, flower pots, etc.
<b>Textile</b>	Natural and man-made fibers: clothing made of natural fibers (cotton, wool, flax) and synthetic fibers (pants, socks, canvas bag, canvas) etc.
<b>Diapers</b>	Baby diapers, sanitary diapers etc.
<b>Construction and demolition materials</b>	Waste generated as a result of construction works (bricks, stones, etc.)
<b>WEEE</b>	All kinds of discarded electrical and/or electronic equipment or its components
<b>Medical waste</b>	Waste materials generated at health care facilities (blood-soaked bandages, discarded needles, culture dishes and other glassware, etc.)
<b>Leather</b>	Leather clothing, wallets, belts, shoes, bags, leather balls etc.
<b>Wood</b>	All wooden items, wooden packaging, parts of furniture etc.
<b>Other special waste streams</b>	Other special waste streams that are not in this table such as car tires, etc.

**Fine elements**

All waste residues, which undergo the last of the 10mm sieve - soil, dust, ash, sand, glass fragments, etc.

Based on the analysis, gained results of waste amounts, divided into categories, are listed in kg, as the total quantity of the sample, and the share of each type of waste in the total amount (given in percentages). It should be noted that each sample was analyzed separately considering the zone where it was collected. This way, the process of determining the quantity and morphological composition of waste per municipality on preferred zone was completed. Obtained data were analyzed and their evaluation was performed.



Picture 1.2: Examples of separate waste categories in the analysis

In short, the methodology can be described as follows:

1. Samples from all three zones that are analyzed should have a mass of 300 - 500 kg;

2. In order to provide appropriate or the most representative waste samples, selection of streets for every zone is performed;
3. In the selected streets waste bins are chosen randomly and their contents are emptied into the truck;
4. After collecting the required weight of the waste sample, trucks from all three sectors are brought to site for sorting and composition analysis;
5. First, the total amount of collected waste in one truck is analyzed;
6. Then for each sample (from three zones), waste should be sorted out according to the fraction from the catalogue.

## 2 OBTAINED RESULTS FOR WASTE QUANTITY AND COMPOSITION WITHIN MUNICIPALITIES

All collected data from conducted analysis and measurements, in each municipality, are shown below. Measurements at weighbridges were conducted from 23/11 – 29/11/2015 in Serbia and Montenegro, and from 30/11 to 06/12/2015 in Macedonia and Bosnia and Herzegovina, all in order to determine the quantity of generated waste. During the fourth campaign, analysis of the waste morphological composition was made for each municipality separately in the period from 24/11 to 04/12/2015 according to the following schedule:

SERBIA		MONTENEGRO	
Vrnjačka Banja	24/11/2015	Pljevlja	24/11/2015
Pančevo	25/11/2015	Berane	25/11/2015
Žitište	26/11/2015	Podgorica	26/11/2015
Apatin	27/11/2015	Kotor	27/11/2015
BOSNIA AND HERZEGOVINA		MACEDONIA	
Cazin	01/12/2015	Bitola	01/12/2015
Prijedor	02/12/2015	Resen	02/12/2015
Tešanj	03/12/2015	Kočani	03/12/2015
Bijeljina	04/12/2015	Ilinden	04/12/2015



## 2.1 MUNICIPALITY OF VRNJAČKA BANJA

For analyzing waste composition in the Municipality of Vrnjačka Banja, three samples according to the proposed methodology were taken from urban zone I - collective housing, urban zone II - individual housing and rural sector. The obtained results are presented in the following table.

Table 2.1: Morphological composition of waste – Municipality of Vrnjačka Banja – autumn campaign

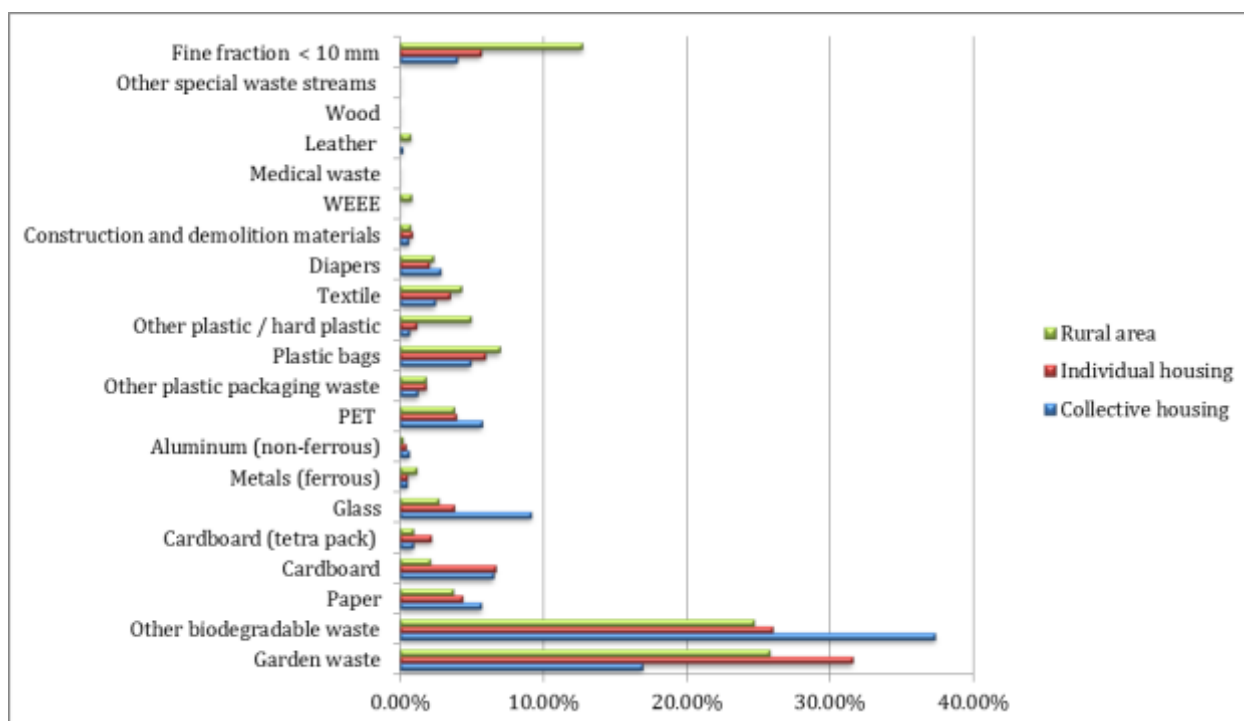
Vrnjačka Banja Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	16.92%	31.55%	25.77%
Other biodegradable waste	37.34%	25.99%	24.66%
Paper	5.68%	4.33%	3.71%
Cardboard	6.51%	6.63%	2.10%
Composite materials	0.91%	2.16%	0.89%
Glass	9.15%	3.75%	2.69%
Metals (ferrous)	0.48%	0.50%	1.12%
Aluminum (non-ferrous)	0.61%	0.39%	0.20%
PET	5.70%	3.92%	3.74%
Other plastic packaging waste	1.22%	1.80%	1.77%
Plastic bags	4.89%	5.95%	6.93%
Other plastic / hard plastic	0.66%	1.11%	4.92%
Textile	2.41%	3.47%	4.24%
Diapers	2.81%	2.01%	2.33%
Construction and demolition materials	0.58%	0.82%	0.72%
WEEE	0.00%	0.00%	0.79%
Medical waste	0.00%	0.00%	0.00%
Leather	0.18%	0.00%	0.72%
Wood	0.00%	0.00%	0.00%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	3.95%	5.61%	12.71%

Dominant fraction for collective housing was "other biodegradable waste" with 37.34% of sample mass, which together with garden waste constitute almost 55% of the sample. From potentially

recyclable components in waste noteworthy were the proportions of paper and cardboard with 5.68%, and 6.51%, respectively, notable was and the amount of the glass with mass share of 9.15%. Plastic with its four subcategories, had proportion of 12.47%. In the analyzed sample, even four components of waste didn't appear at all.

In individual housing, dominant category was garden waste, with 31.55%, which together with other biodegradable waste constitute more than 57% of the sample mass. After this waste category, cardboard and plastic bags also had a notable mass share of 6.63% and 5.95%, respectively. With regard to the previous, it can be concluded that other waste categories have a very low mass share, up to 5%, with the exception of fine elements (5.61%). Five categories of waste had proportion of 0.00%.

Sample from rural area showed a high proportion of organic waste, about 50%, with its two subcategories. Relatively high proportion also had fine elements with mass share of 12.71%. From recyclable categories, plastic with its four subcategories had a notable proportion of 17.36%, among these subcategories the most dominant was plastic bags. Textile had mass share of 4.24%, while all other categories had mass share up to 4%, and three categories of waste didn't appear at all.



Graph 2.1: Comparison of waste composition according to the housing sector – Municipality of Vrnjačka Banja – autumn campaign

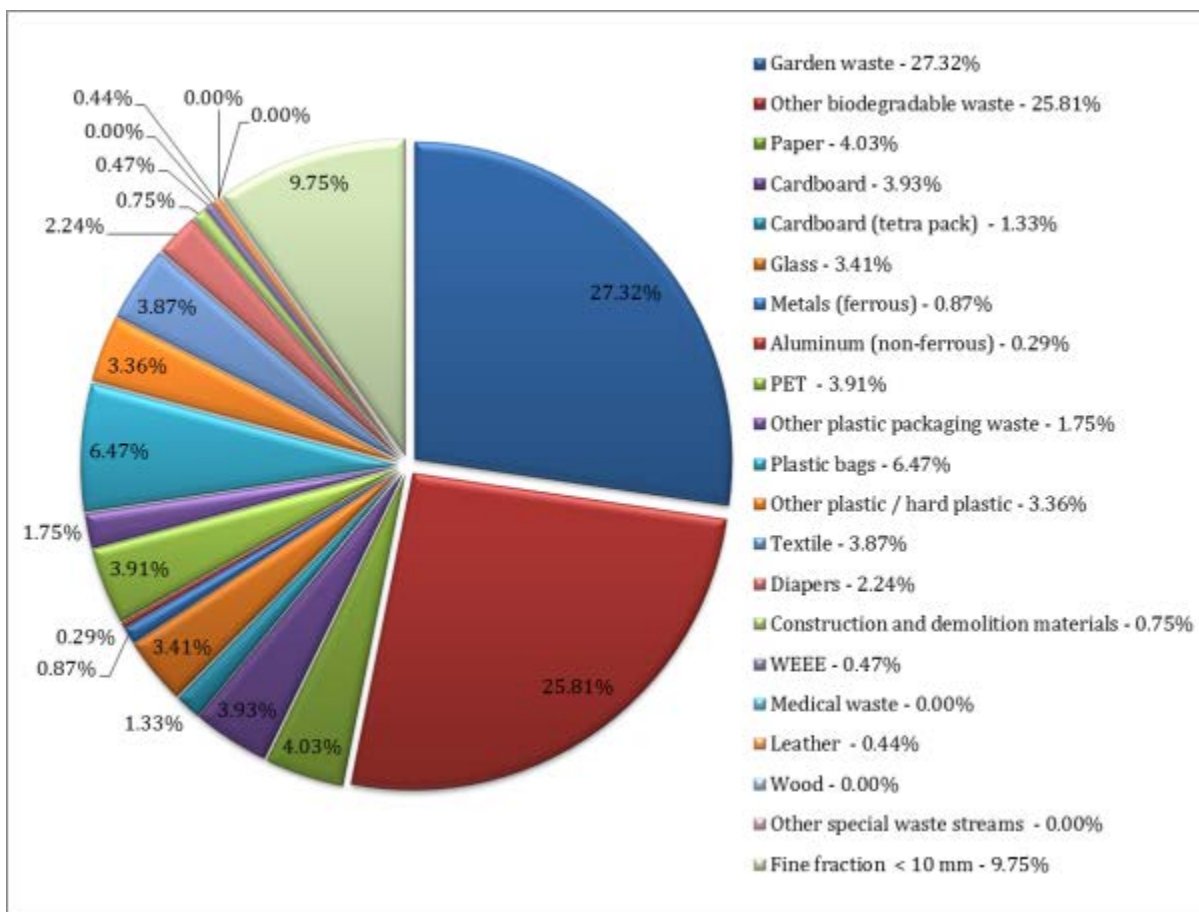
By comparing the results of the waste composition analysis in autumn campaign, from three different living sectors within Municipality of Vrnjačka Banja, it can be concluded that for each living zone, biodegradable waste with its two subcategories, represents the most dominant fraction.

From collective housing sector, potentially recyclable fractions such as paper, glass and PET had a higher mass share in comparison to other two zones, as and for the category of “other biodegradable waste”. Zone of individual housing is characterized by higher mass share of garden waste. Sample from rural area, was characterized by a higher mass share of plastic bags, hard plastic, textile and fine elements, in comparison to other two living sectors. Fractions like medical waste, leather, wood and other special waste streams practically weren’t found in the samples.



*Picture 2.1: Analysis of morphological composition of waste at site – Vrnjačka Banja*

Based on the share, i.e. the total number of people living within the collective (5.37%), individual (35.09%) and rural sectors (59.55%) in the municipality, it is possible to determine the average composition of waste for the entire municipality of Vrnjačka Banja. Taking into account the obtained results, it is evident that the biodegradable fraction, consisted of garden and other biodegradable waste was the most represented, with a proportion more than 53%. Plastic bags and paper, from potentially recyclable fractions, were dominant with 6.47% and 4.03% respectively. Fine fraction also had notable value with mass share of 9.75%. The remaining fraction didn’t have significant values, up to 4%.



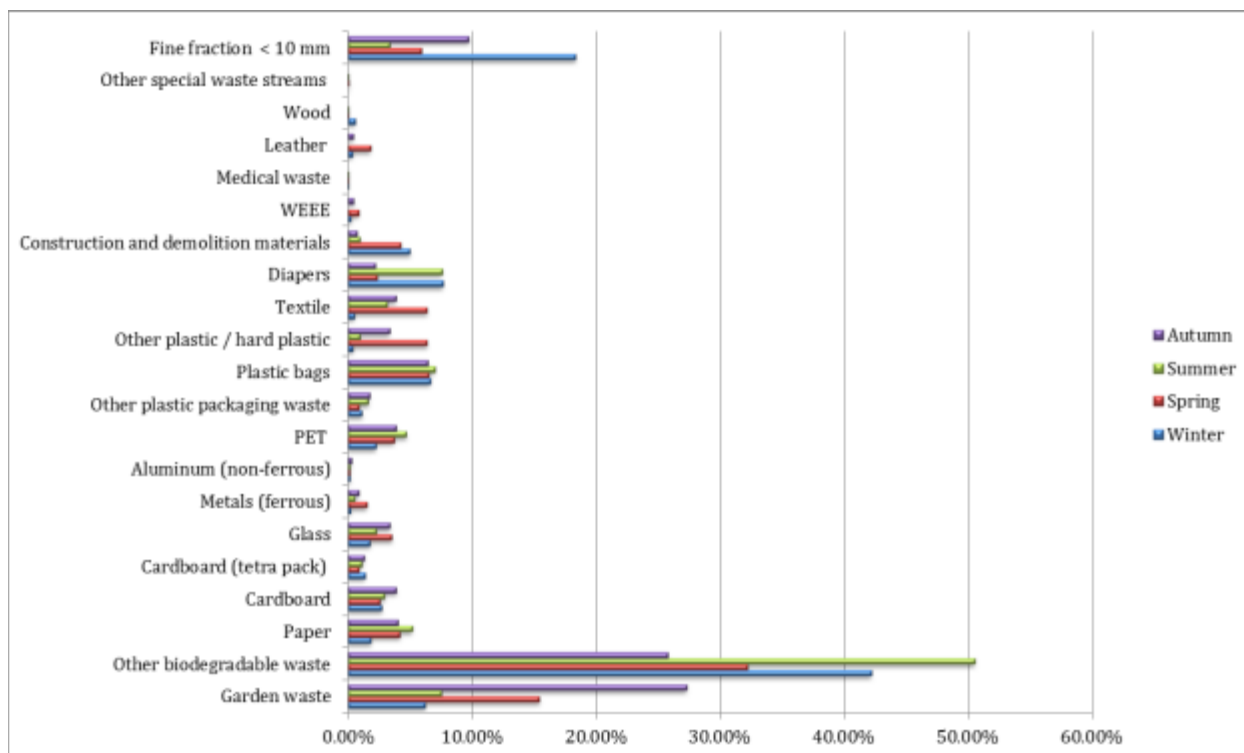
Graph 2.2: Average morphological waste composition (%) for the Municipality of Vrnjačka Banja – for autumn campaign

Morphological composition of waste in the municipality of Vrnjačka Banja was analyzed in four campaigns. Average values from obtained analysis, and annual average for this municipality are presented in the table 2.2.

Variations in the proportion of “garden waste” and “other biodegradable waste” can be observed, also for fine elements are obvious variations, when comparing the average composition of waste per season of sampling within the municipality of Vrnjačka Banja. Garden waste had the lowest value in the winter measurement and the highest value in autumn, while the other biodegradable waste was dominant in the summer measurement, and it had the lowest value in autumn. Hard plastic and textile had higher value in the spring campaign, in comparison to other three. Fine elements, as expected, have the highest proportion in winter season, due to great amount of ash. Other categories of waste didn’t show significant variations.

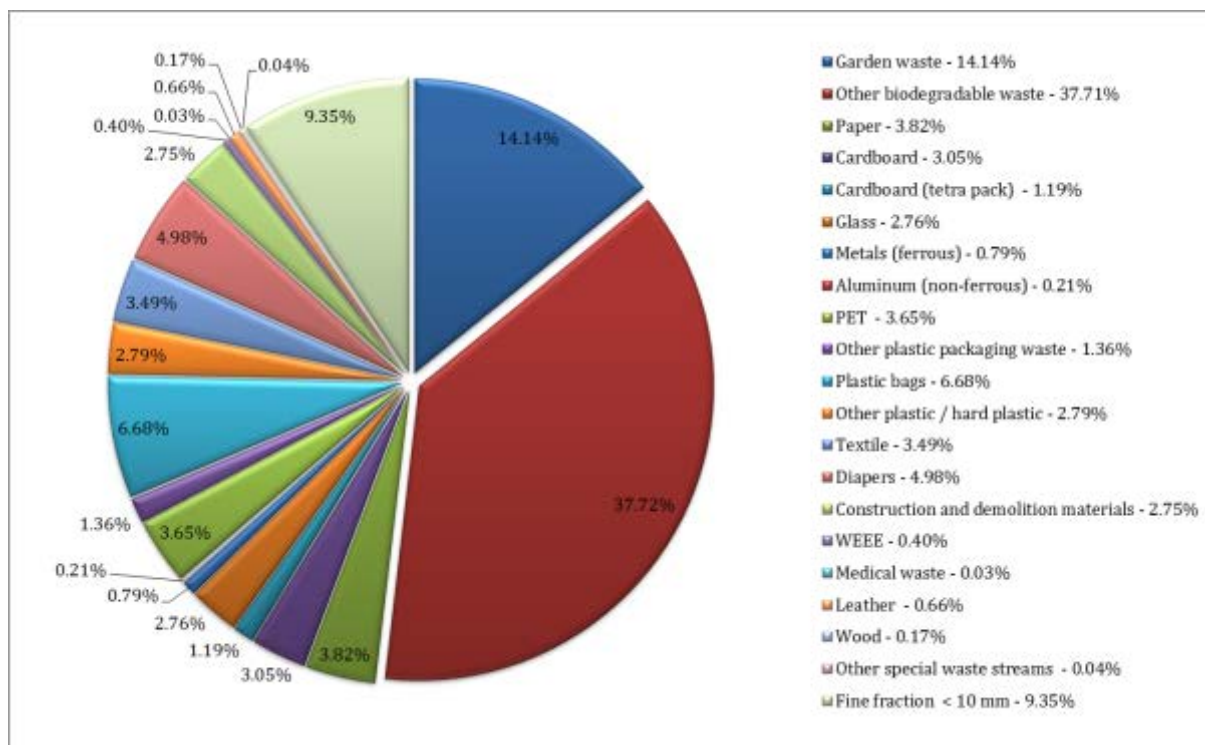
Table 2.2: Composition of municipal waste for four different seasons and the annual average value

Vrnjačka Banja	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	6.26%	15.46%	7.51%	27.32%	<b>14.14%</b>
Other biodegradable waste	42.24%	32.25%	50.56%	25.81%	<b>37.71%</b>
Paper	1.87%	4.19%	5.19%	4.03%	<b>3.82%</b>
Cardboard	2.74%	2.57%	2.95%	3.93%	<b>3.05%</b>
Composite materials	1.38%	0.89%	1.14%	1.33%	<b>1.19%</b>
Glass	1.78%	3.54%	2.30%	3.41%	<b>2.76%</b>
Metals (ferrous)	0.21%	1.54%	0.56%	0.87%	<b>0.79%</b>
Aluminum (non-ferrous)	0.20%	0.15%	0.19%	0.29%	<b>0.21%</b>
PET	2.26%	3.71%	4.70%	3.91%	<b>3.65%</b>
Other plastic packaging waste	1.13%	0.91%	1.65%	1.75%	<b>1.36%</b>
Plastic bags	6.65%	6.56%	7.03%	6.47%	<b>6.68%</b>
Other plastic / hard plastic	0.42%	6.40%	0.99%	3.36%	<b>2.79%</b>
Textile	0.52%	6.40%	3.15%	3.87%	<b>3.49%</b>
Diapers	7.66%	2.38%	7.62%	2.24%	<b>4.98%</b>
Construction and demolition materials	5.02%	4.26%	0.97%	0.75%	<b>2.75%</b>
WEEE	0.27%	0.87%	0.00%	0.47%	<b>0.40%</b>
Medical waste	0.05%	0.02%	0.04%	0.00%	<b>0.03%</b>
Leather	0.37%	1.84%	0.00%	0.44%	<b>0.66%</b>
Wood	0.58%	0.03%	0.06%	0.00%	<b>0.17%</b>
Other special waste streams	0.00%	0.12%	0.03%	0.00%	<b>0.04%</b>
Fine fraction < 10 mm	18.37%	5.91%	3.36%	9.75%	<b>9.35%</b>



Graph 2.3: Comparison of waste composition according to the period of analysis – Vrtnjačka Banja

Based on the measurements during the four seasons, an annual average composition of waste can be calculated for the municipality of Vrtnjačka Banja. Dominant category of waste in the municipality of Vrtnjačka Banja is “other biodegradable waste” with mass share of 37.71%. Next is “garden waste” with mass share of 14.14%. Notable is proportion of fine elements, 9.35%, which is not convenient for waste treatments. From recyclable categories plastic, with its four subcategories, has a proportion of 14.48%, among which the most dominant are plastic bags. Other recyclable materials don’t have significant values, up to 3%, with the exception of paper and cardboard with mass share of 3.82% and 3.05%, respectively. Textile and diapers have mass share of 3.49% and 4.89%, respectively.



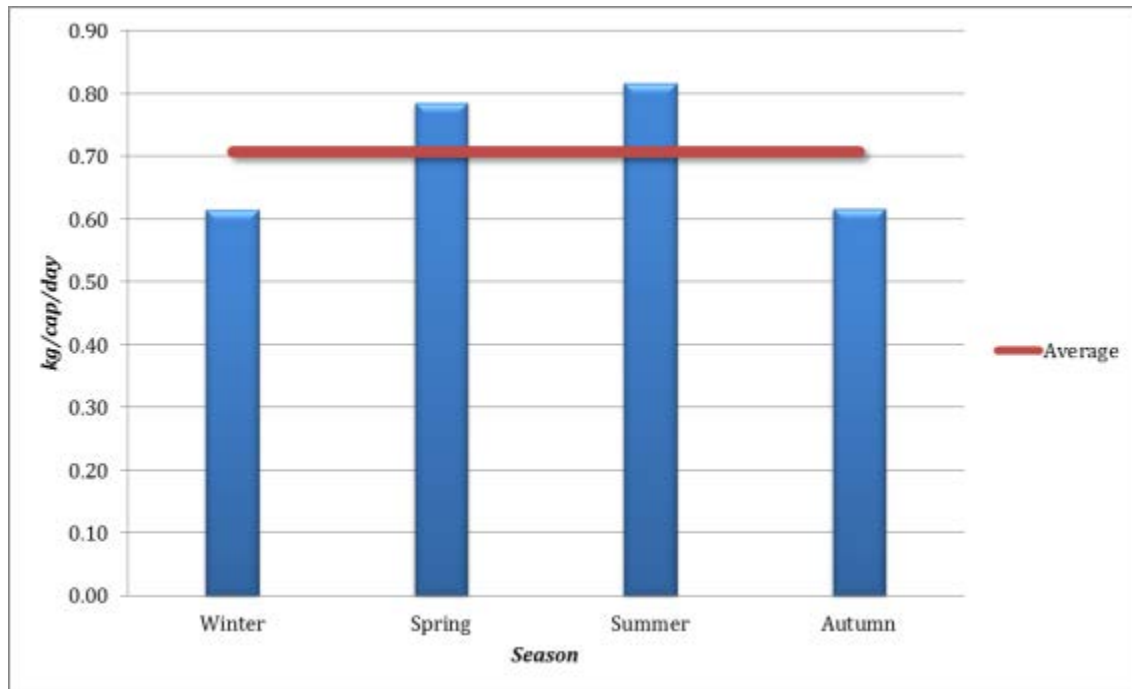
Graph 2.4: Annual average composition of municipal waste – Vrnjačka Banja

In the Municipality of Vrnjačka Banja, during the measurement of waste trucks on weighbridge in the autumn period, 103.04 tons of waste were collected. According to these measurements, results for autumn season expressed in the form of “per capita”, shows that the average resident of Vrnjačka Banja generates 0.62 kg on a daily basis, which is lower than average in Republic of Serbia.

Table 2.3: Projection of obtained results

Municipality of Vrnjačka Banja	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	5346.21	6837.49	7113.33	5372.80	6167.46
Number of residents	27332	27332	27332	27332	27332.00
The population covered by the organized waste collection	23831	23831	23831	23831	23830.77
Share of population under organized waste collection	87.19%	87.19%	87.19%	87.19%	0.87
Waste generation (kg/capita/year)	224.34	286.92	298.49	225.46	258.80
Waste generation (kg/capita/day)	<b>0.61</b>	<b>0.79</b>	<b>0.82</b>	<b>0.62</b>	<b>0.71</b>
Total for whole city (t/year)	6131.67	7842.06	8158.42	6162.17	7073.58

Taking into account four measurements during the year, it can be concluded that the average amount of waste collected by the PUC is 6167.46 tons annually. Percentage of population in the municipality covered by organized collection is about 87%, which leads to the conclusion that one citizen of Vrnjačka Banja generates 258.80 kg per year or 0.71 kg daily. Comparing results per season it can be concluded that generation rate is higher in spring and summer, than in winter and autumn.



Graph 2.5: Comparison of waste generation rate (kg/cap/day) according to the season

Before this project PUC from Vrnjačka Banja conducted one measurement for determination of the municipal waste quantity in March 2013. Measurements were conducted for one week and in that time period 127.47 t of waste was collected.

The benefits of this project are more detailed analysis of generated waste quantity, it was conducted four measurements for four seasons, and it can be observed variations in waste quantity during the year. On the other hand, there wasn't any information about waste composition.



## 2.2 CITY OF PANČEVO

For determining waste composition in the City of Pančevo, three samples according to the proposed methodology were taken from the collective, individual and rural sectors and analyzed for the autumn season. The obtained results are presented in the following table.

Table 2.4: Morphological composition of waste – City of Pančevo – autumn season

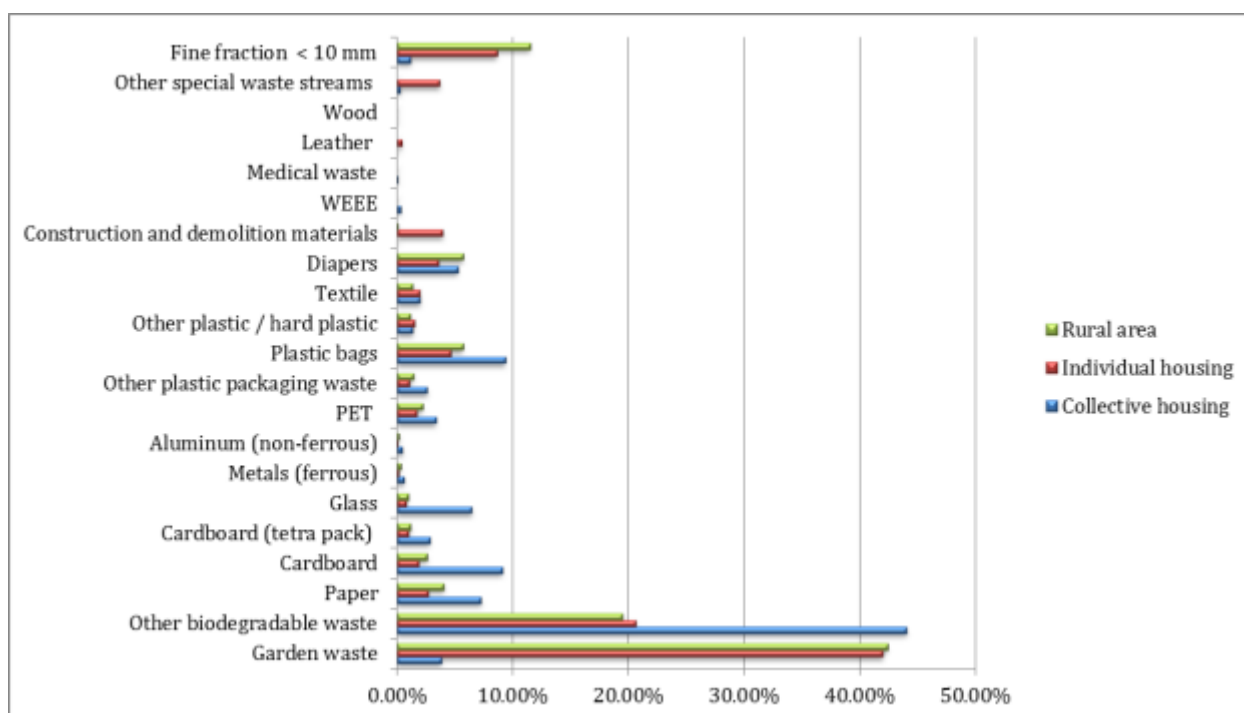
Pančevo Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	3.78%	41.98%	42.36%
Other biodegradable waste	44.03%	20.60%	19.46%
Paper	7.23%	2.69%	4.00%
Cardboard	9.05%	1.85%	2.59%
Composite materials	2.80%	0.98%	1.15%
Glass	6.44%	0.77%	0.96%
Metals (ferrous)	0.57%	0.13%	0.31%
Aluminum (non-ferrous)	0.46%	0.07%	0.19%
PET	3.36%	1.72%	2.18%
Other plastic packaging waste	2.58%	1.03%	1.40%
Plastic bags	9.33%	4.59%	5.68%
Other plastic / hard plastic	1.34%	1.49%	1.11%
Textile	1.98%	1.91%	1.36%
Diapers	5.25%	3.58%	5.68%
Construction and demolition materials	0.00%	3.93%	0.11%
WEEE	0.30%	0.00%	0.00%
Medical waste	0.06%	0.00%	0.00%
Leather	0.00%	0.41%	0.00%
Wood	0.00%	0.00%	0.00%
Other special waste streams	0.28%	3.67%	0.00%
Fine fraction < 10 mm	1.17%	8.61%	11.46%

Sample from collective housing showed that other biodegradable waste constituted more than 44% of the sample. From potentially recyclable fractions dominant were paper and cardboard with mass

share of 7.23% and 9.05%, respectively. Plastic with its four subcategories had proportion of 16.61%, and among them the most dominant were plastic bags with mass share of 9.33%. Notable was an amount of glass and diapers with a proportion of 6.44% and 5.25%, respectively.

In individual housing, dominant category of waste was garden waste with 41.98%, which together with other biodegradable waste (20.60%) constitute more than 60% of sample mass. In addition to this fact, fine elements had mass share of 8.61%. Considering this it's not surprising that all other categories had mass share up to 4%, with expect of plastic bags (4.59%).

Sample from rural area similar as in individual housing showed a high proportion of garden waste with mass share of 42.36%, that together with other biodegradable waste constitute more than 60% of sample mass. Notable amount was recorded for fine elements, with mass share of 11.46%. Among recyclable fractions dominant were paper and plastic bags with mass share of 4.00% and 5.68%, respectively. Noteworthy was proportion for diapers 5.68%, while all other categories didn't have a significant share up to 4%. Even five categories of waste had mass share of 0.00%.



Graph 2.6: Comparison of waste composition according to the housing sector – City of Pančevo – autumn season

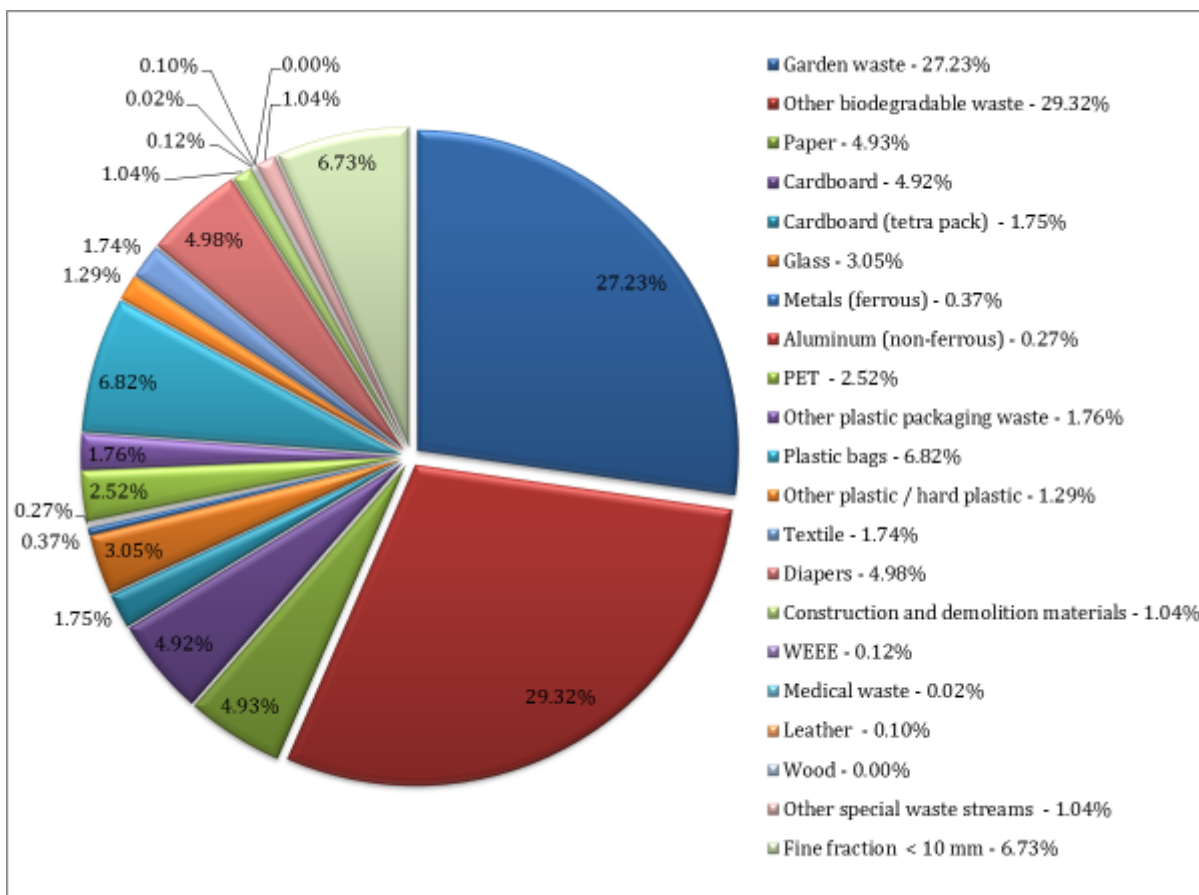
After comparing the results from all three sectors, it can be noticed that within sample from rural area the most dominant category was garden waste, fine fraction also has higher share in this area in comparison to other two living sectors. An increased share of recyclable fractions such are paper, cardboard, glass and plastic bags, characterized waste composition for collective housing and other potentially recyclable fractions had a higher mass share in comparison with the other two housing sectors. Individual housing has greater amounts of C&D materials and for other special waste

streams in comparison to other two living sectors. Fractions such as WEEE, medical waste, wood and leather didn't appear at all or they had a very low mass share.



Picture 2.2: Analysis of morphological composition of waste at site – Pančevo

Based on the share of the population living within collective housing (38.96%), individual housing (25.37%) and rural area (35.67%) in the City of Pančevo, the average composition of the waste for the entire City has been determined. It is evident that the organic fraction, consisted of garden waste (27.23%) and other biodegradable waste (29.32%) has the largest share. From potentially recyclable fractions dominant are plastic bags with mass share of 6.82%. Notable are amounts of paper and cardboard, with mass share of 4.93% and 4.92%, respectively. Plastic with its four subcategories is represented by mass share of 12.39%. From other categories of waste notable are amounts of diapers and fine elements with proportion of 4.98% and 6.73%, respectively.

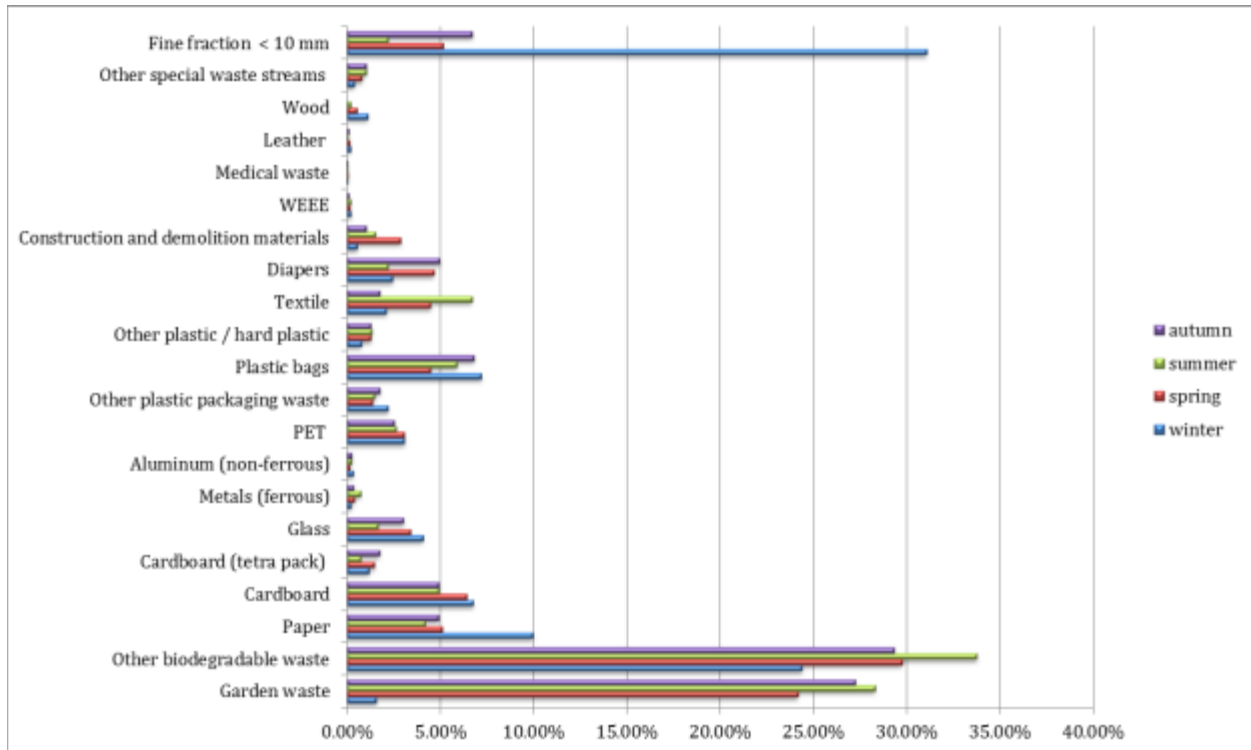


Graph 2.7: Average morphological waste composition (%) for the city of Pančevo – autumn season

Morphological composition of waste in the City of Pančevo was analyzed in four campaigns. According to the population, which living in the collective housing, individual housing and rural areas within the City of Pančevo, the average composition for the entire city, for each season, was made. Average values from four obtained analyses, are presented in the following table, and based on these values the annual average was made for the City of Pančevo.

Table 2.5: Composition of municipal waste for four different seasons and the annual average value

Pančevo	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	1.58%	24.17%	28.29%	27.23%	<b>20.32%</b>
Other biodegradable waste	24.39%	29.77%	33.76%	29.32%	<b>29.31%</b>
Paper	9.97%	5.13%	4.19%	4.93%	<b>6.06%</b>
Cardboard	6.78%	6.40%	4.93%	4.92%	<b>5.76%</b>
Composite materials	1.18%	1.48%	0.74%	1.75%	<b>1.29%</b>
Glass	4.07%	3.40%	1.66%	3.05%	<b>3.04%</b>
Metals (ferrous)	0.23%	0.39%	0.73%	0.37%	<b>0.43%</b>
Aluminum (non-ferrous)	0.33%	0.16%	0.24%	0.27%	<b>0.25%</b>
PET	3.08%	3.07%	2.64%	2.52%	<b>2.83%</b>
Other plastic packaging waste	2.21%	1.35%	1.48%	1.76%	<b>1.70%</b>
Plastic bags	7.22%	4.46%	5.90%	6.82%	<b>6.10%</b>
Other plastic / hard plastic	0.78%	1.30%	1.34%	1.29%	<b>1.18%</b>
Textile	2.11%	4.49%	6.69%	1.74%	<b>3.76%</b>
Diapers	2.46%	4.65%	2.18%	4.98%	<b>3.57%</b>
Construction and demolition materials	0.56%	2.89%	1.52%	1.04%	<b>1.50%</b>
WEEE	0.23%	0.17%	0.20%	0.12%	<b>0.18%</b>
Medical waste	0.06%	0.08%	0.02%	0.02%	<b>0.04%</b>
Leather	0.19%	0.14%	0.08%	0.10%	<b>0.13%</b>
Wood	1.12%	0.54%	0.19%	0.00%	<b>0.46%</b>
Other special waste streams	0.38%	0.80%	1.03%	1.04%	<b>0.81%</b>
Fine fraction < 10 mm	31.07%	5.16%	2.20%	6.73%	<b>11.29%</b>

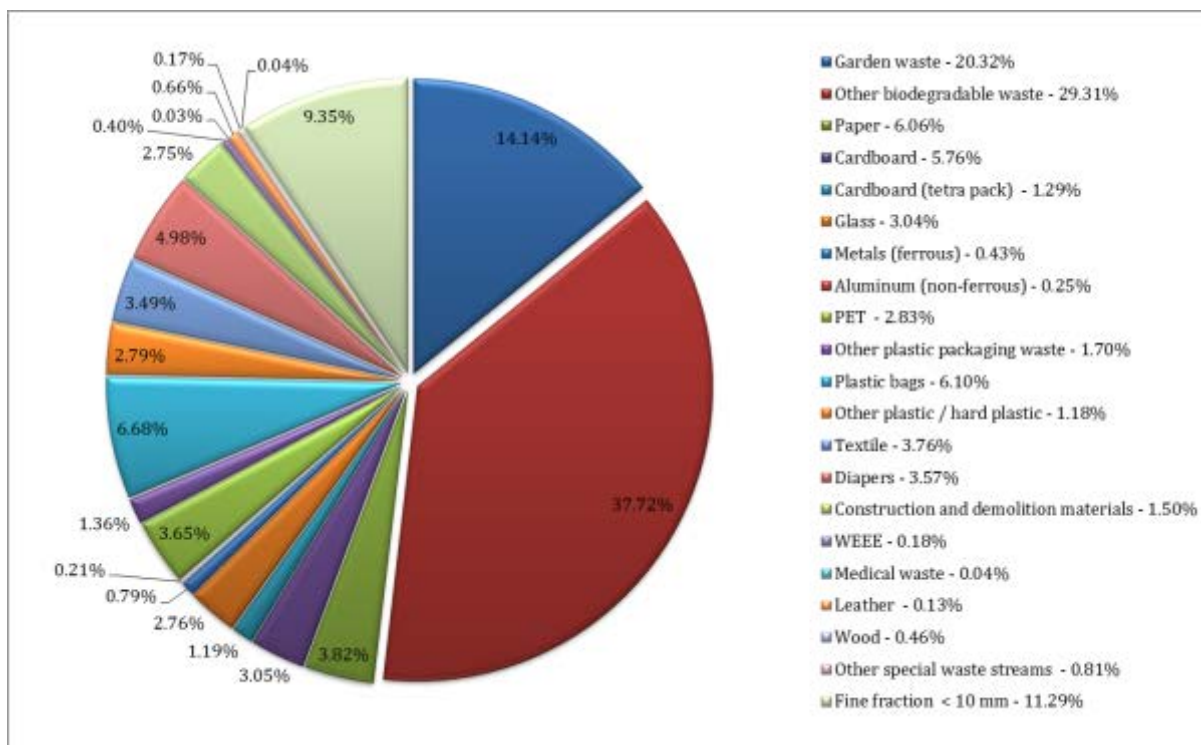


Graph 2.8: Comparison of waste composition according to the period of analysis – Pančevo

Variations in the proportion of “garden waste”, “other biodegradable waste” and “fine fraction” can be observed, when comparing the average composition of waste per season of sampling within the City of Pančevo. Garden waste had the highest value in the summer and the lowest value in the winter period, which is expected. It can be noted higher proportion of fine elements in winter period in comparison to other three periods. The paper had the highest proportion in the winter period, but that is probably due to higher moisture of waste during this period. Other categories of waste show some variations, but they probably are not related to period of sampling.

According to the obtained results from four different seasons of measurements it can be calculated the annual average composition of municipal waste for the City of Pančevo. The annual average composition is represented on graph 2.9.

Dominant category is "other biodegradable waste" with mass share of 29.31%, which together with garden waste constitute almost 50%. Fine fraction has a significant proportion with mass share of 11.29%. Paper and cardboard are dominant from recyclable components, with mass share of 6.06% and 5.76%, respectively. Plastic with its four subcategories has mass share of 11.81%, among these subcategories the most dominant are plastic bags with a proportion of 6.10%. Noteworthy mass share also have textile and diapers with mass share of 3.76% and 3.57%, respectively. Metals with its two subcategories don't have significant proportion, up to 1%.



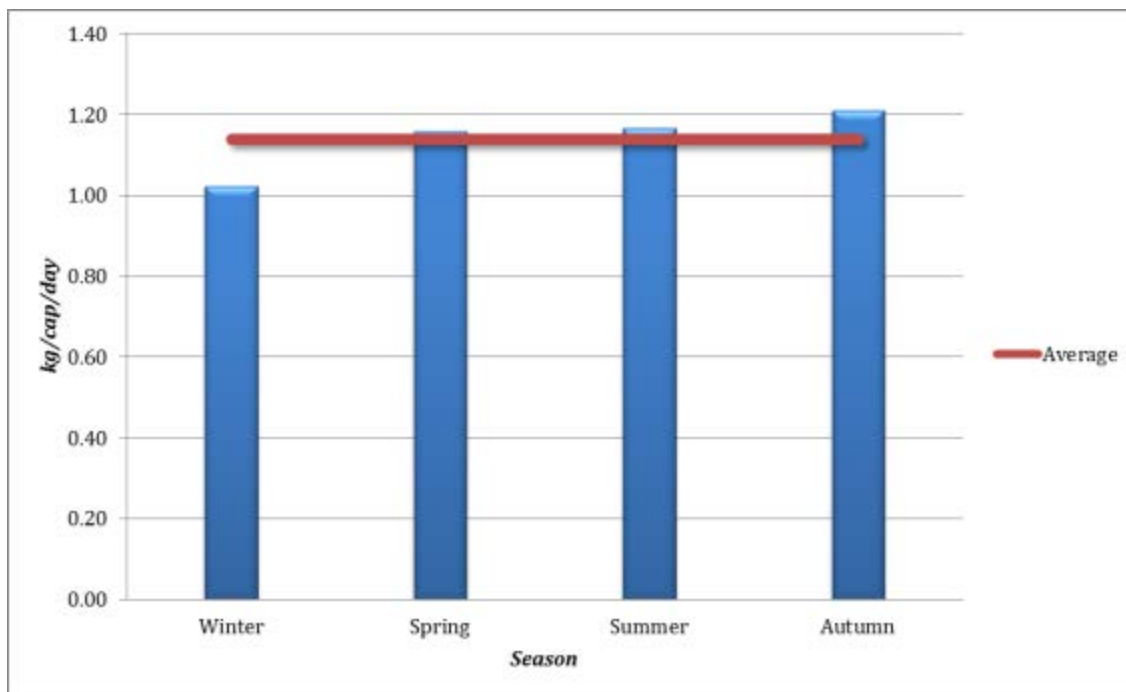
Graph 2.9: Annual average composition of municipal waste – Pančevo

In the City of Pančevo, during one week in autumn period, 572.84 tons of waste was measured. Projection of the results shows that the average amount of waste collected by the PUC from Pančevo per year is 29,870 tons. PUC “Higijena” from Pančevo cover 54.75% of the population with organized collection. According to these data, one citizen of Pančevo generates 1.21 kg of waste per day.

Table 2.6: Projection of obtained results

City of Pančevo	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	25260.09	28611.83	28812.06	29869.51	28138.37
Number of residents	123414	123414	123414	123414	123414
The population covered by the organized waste collection	67569	67569	67569	67569	67569
Share of population under organized waste collection	54.75%	54.75%	54.75%	54.75%	54.75%
Waste generation (kg/capita/year)	373.84	423.45	426.41	442.06	416.44
Waste generation (kg/capita/day)	<b>1.02</b>	<b>1.16</b>	<b>1.17</b>	<b>1.21</b>	<b>1.14</b>
Total for whole city (t/year)	46137.14	52259.05	52624.76	54556.19	51394.29

Based on the results from four obtained campaigns of measurements on weighbridge, it can be concluded that the average amount of waste collected by the PUC "Higijena" from Pančevo is 28,138 tons per year, the greatest amount was collected in the autumn period while the lowest in winter season. Percentage of population covered with the organized waste collection in the city is about 55%. Projection of the aforementioned data indicate that one citizen of Pančevo generates 1.14 kg of waste per day, or 416.44kg annually. These values are little above the republic average.



Graph 2.10: Comparison of waste generation rate (kg/cap/day) according to the season

Before this project PUC from Pančevo already made measurements of waste composition and quantity, and obtained results are similar to values obtained from this project. However, workers got one kind of education, so that in the future will be easier to carry out the above mentioned types of work.



## 2.3 MUNICIPALITY OF ŽITIŠTE

For analyzing waste composition in the Municipality of Žitište, three samples according to the proposed methodology were taken and analyzed. The obtained results from an autumn campaign are presented in the following table.

Table 2.7: Morphological composition of waste – Municipality of Žitište – autumn season

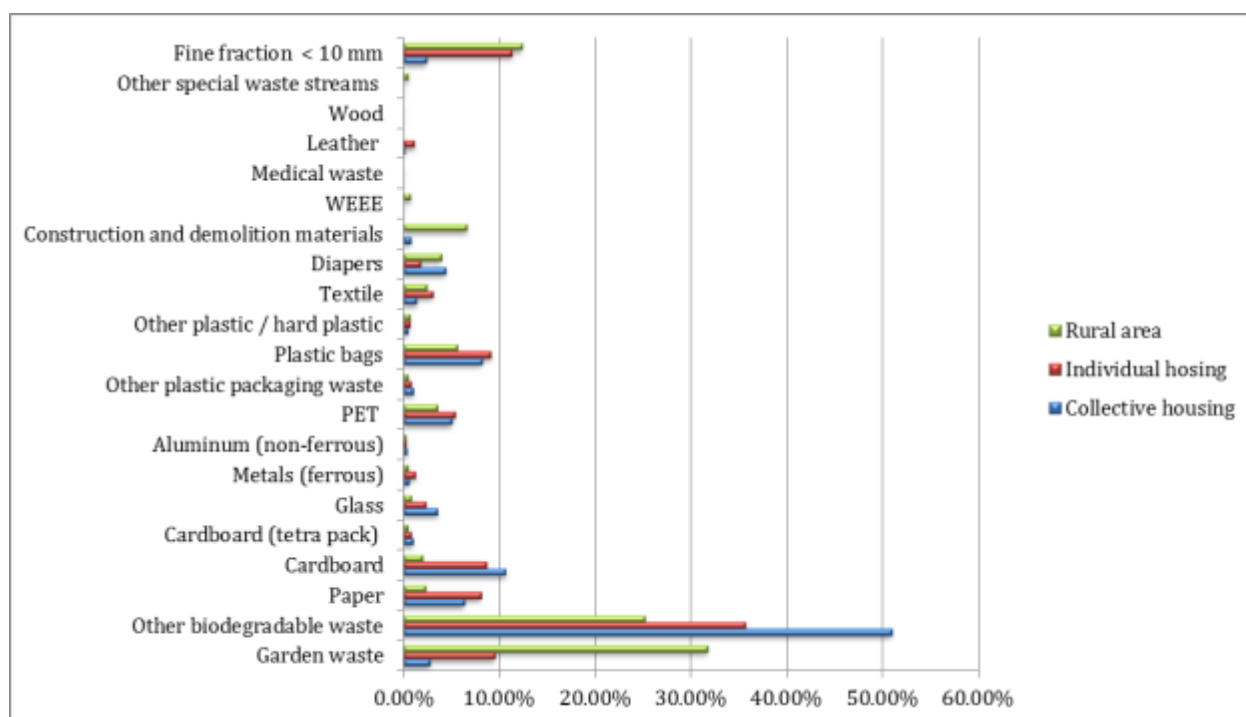
Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	2.75%	9.54%	31.74%
Other biodegradable waste	50.98%	35.70%	25.21%
Paper	6.33%	8.10%	2.29%
Cardboard	10.65%	8.70%	1.94%
Composite materials	1.00%	0.84%	0.42%
Glass	3.56%	2.37%	0.84%
Metals (ferrous)	0.57%	1.26%	0.47%
Aluminum (non-ferrous)	0.40%	0.27%	0.28%
PET	5.02%	5.34%	3.51%
Other plastic packaging waste	1.06%	0.78%	0.49%
Plastic bags	8.22%	9.11%	5.60%
Other plastic / hard plastic	0.44%	0.63%	0.64%
Textile	1.38%	3.06%	2.39%
Diapers	4.36%	1.83%	3.93%
Construction and demolition materials	0.74%	0.00%	6.63%
WEEE	0.00%	0.00%	0.74%
Medical waste	0.00%	0.00%	0.00%
Leather	0.15%	1.14%	0.00%
Wood	0.00%	0.00%	0.00%
Other special waste streams	0.00%	0.00%	0.50%
Fine fraction < 10 mm	2.39%	11.31%	12.38%

Sample from collective housing was characterized with great amount of other biodegradable waste, mass share of 50.98%. Significant mass share from recyclable fractions had cardboard and plastic

bags with 10.65% and 8.22%, respectively. Paper and PET bottles recorded proportions of 6.33% and 5.02%, respectively. Noteworthy was an amount of diapers with mass share of 4.36%, while all other categories were in the range of expected. Even four categories of waste didn't appear at all.

Dominant fraction for individual housing was "kitchen and other biodegradable waste" with 35.70% of sample mass, this value was followed by proportion of fine fraction (11.31%) and garden waste (9.54%). Significant amounts were recorded for paper and cardboard, with mass share of 8.10% and 8.70%, respectively. From potentially recyclable components, notable was also amount of plastic with its four subcategories, mass share of 15.86%. Cardboard with wax and aluminum (tetrapak), as usual recorded small proportion less than 1%.

From rural sector, more than 55% of sample constituted of organic waste with its two subcategories, "garden waste" (31.74%) and "other biodegradable waste" (25.21%). In addition to these, great amount of fine elements (12.38%) and C&D materials (6.63%) were recorded. Considering above mentioned, it can be concluded that other fractions had smaller proportions.



Graph 2.11: Comparison of waste composition according to the housing sector – Municipality of Žitište – autumn season

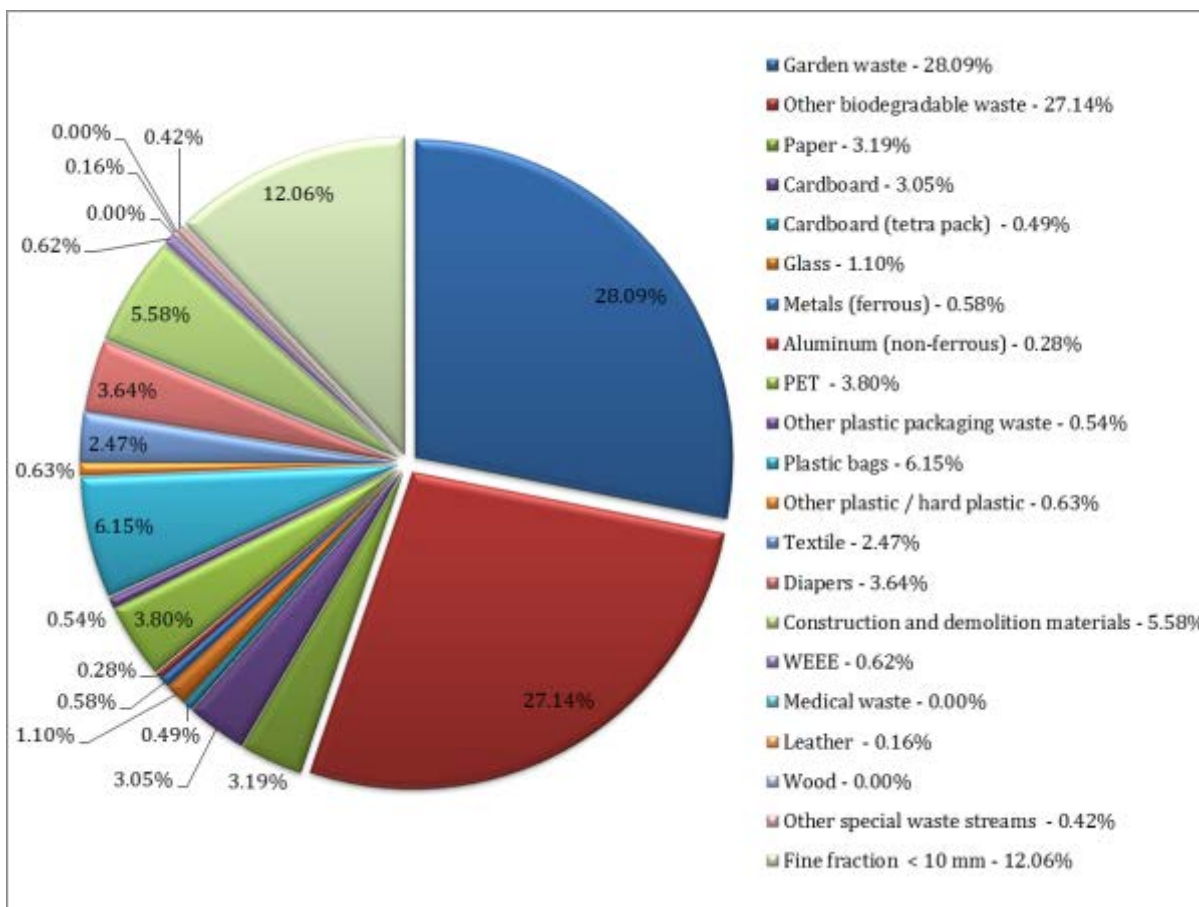
By comparing the results of the waste composition analysis from three different living sectors within Municipality of Žitište, it can be concluded that for each of living zone, organic waste with its two subcategories, represents the most dominant fraction. Composition for collective housing was dominant in comparison to other two living sectors, considering other biodegradable waste, cardboard and glass. Individual housing is dominant in comparison to the other two living sectors regarding waste fractions such as paper, PET and plastic bags. Rural area was dominant regarding garden waste, C&D materials and for fine fraction.



Picture 2.3: Analysis of morphological composition of waste at site – Žitište

Based on the share, i.e. the total number of people living within the collective (1.67%), individual (14.25%) and rural sectors (84.08%) within the municipality, it is possible to determine the average composition of waste, for the autumn season, for the entire municipality of Žitište.

Organic waste, consisted of garden and other biodegradable waste is the most dominant category, with a total mass share of over a 55%. In addition to this great amount of fine fraction was recorded, with a proportion of 12.06%. Plastic bags as one of potentially recyclable categories of waste have a notable proportion of 6.15%. Noteworthy are amounts of diapers and C&D materials with mass share of 3.64% and 5.58%, respectively.



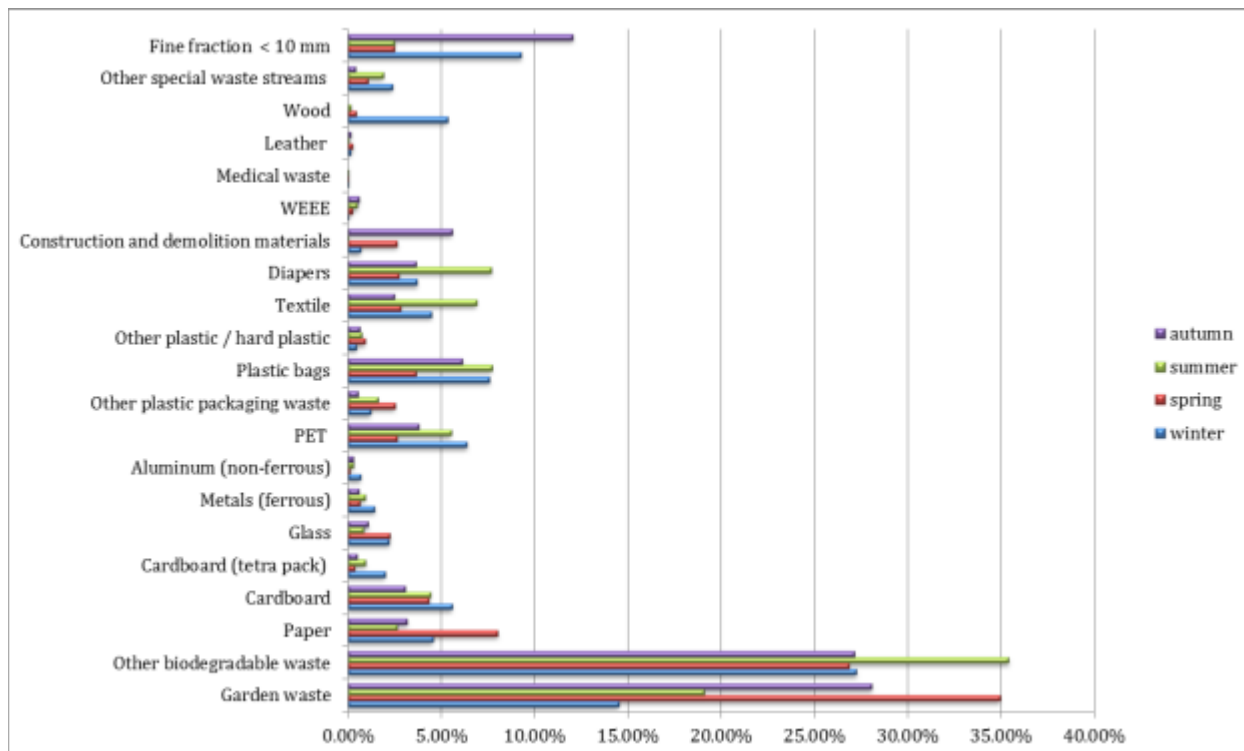
Graph 2.12: Average morphological waste composition (%) for the municipality of Žitište – autumn season

Morphological composition of waste in the municipality of Žitište was analyzed in four campaigns. Taking into consideration proportion of the population which living in the collective, individual and rural parts within the municipality of Žitište, the average composition for the entire municipality, for each season, was made. Average values from obtained analysis, are presented in the following table, and based on these values the annual average for municipality of Žitište was made.

Table 2.8: Composition of municipal waste for four different seasons and the annual average value

Žitište	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	14.52%	34.96%	19.10%	28.09%	<b>24.17%</b>
Other biodegradable waste	27.25%	26.85%	35.41%	27.14%	<b>29.16%</b>
Paper	4.57%	8.03%	2.64%	3.19%	<b>4.60%</b>
Cardboard	5.59%	4.34%	4.41%	3.05%	<b>4.35%</b>
Composite materials	1.98%	0.38%	0.95%	0.49%	<b>0.95%</b>
Glass	2.22%	2.26%	0.84%	1.10%	<b>1.60%</b>
Metals (ferrous)	1.44%	0.64%	0.93%	0.58%	<b>0.90%</b>
Aluminum (non-ferrous)	0.67%	0.11%	0.28%	0.28%	<b>0.34%</b>
PET	6.38%	2.64%	5.54%	3.80%	<b>4.59%</b>
Other plastic packaging waste	1.22%	2.53%	1.60%	0.54%	<b>1.47%</b>
Plastic bags	7.61%	3.65%	7.73%	6.15%	<b>6.28%</b>
Other plastic / hard plastic	0.47%	0.93%	0.74%	0.63%	<b>0.69%</b>
Textile	4.49%	2.82%	6.88%	2.47%	<b>4.17%</b>
Diapers	3.71%	2.75%	7.70%	3.64%	<b>4.45%</b>
Construction and demolition materials	0.69%	2.64%	0.06%	5.58%	<b>2.24%</b>
WEEE	0.00%	0.23%	0.52%	0.62%	<b>0.34%</b>
Medical waste	0.01%	0.01%	0.03%	0.00%	<b>0.01%</b>
Leather	0.15%	0.27%	0.08%	0.16%	<b>0.17%</b>
Wood	5.35%	0.44%	0.17%	0.00%	<b>1.49%</b>
Other special waste streams	2.37%	1.06%	1.90%	0.42%	<b>1.44%</b>
Fine fraction < 10 mm	9.29%	2.47%	2.50%	12.06%	<b>6.58%</b>

Garden waste had the highest value in the spring and the lowest value in the winter period, when comparing values from four different seasons. Variations for “other biodegradable waste” also can be observed, maximum amount was recorded in the summer period, while between three other seasons variations are not so obvious. It can be also noted higher proportion of fine elements in winter and autumn period in comparison to the other two periods. Wood has peak in winter season, with mass share of 5.35%, while in all other three seasons proportion was under 0.5%.

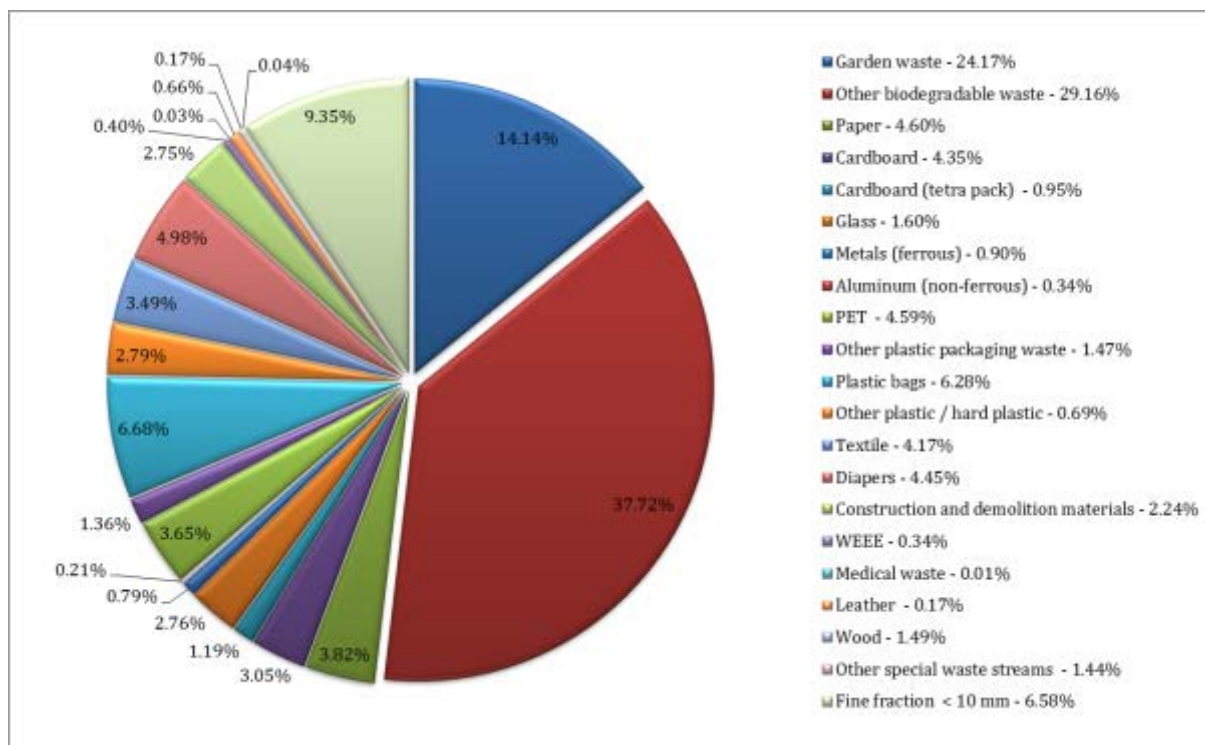


Graph 2.13: Comparison of waste composition according to the period of analysis – Žitište

From other categories of waste, it's an evident variation of paper for spring period, where was maximum proportion. Summer period was dominant regarding to textile and diapers, beside "other biodegradable waste".

Based on the share, i.e. the total number of people living within the collective, individual and rural sectors in the municipality, and based on the obtained results from all four campaigns of measurements, it can be calculated the annual average composition of the waste for the municipality of Žitište.

Dominant categories in the annual average composition of waste are "other biodegradable waste" and "garden waste", these categories together constitute more than 50%. Fine fraction also has a significant proportion with mass share of 6.58%. From potentially recyclable categories dominant are plastic bags with mass share of 6.28%. Paper and cardboard have mass share 4.60% and 4.35%, respectively. Noteworthy proportion also has textile and diapers with mass share of 4.17% and 4.45, respectively. Metals, with its two subcategories, don't have significant proportion, a little above 1%.



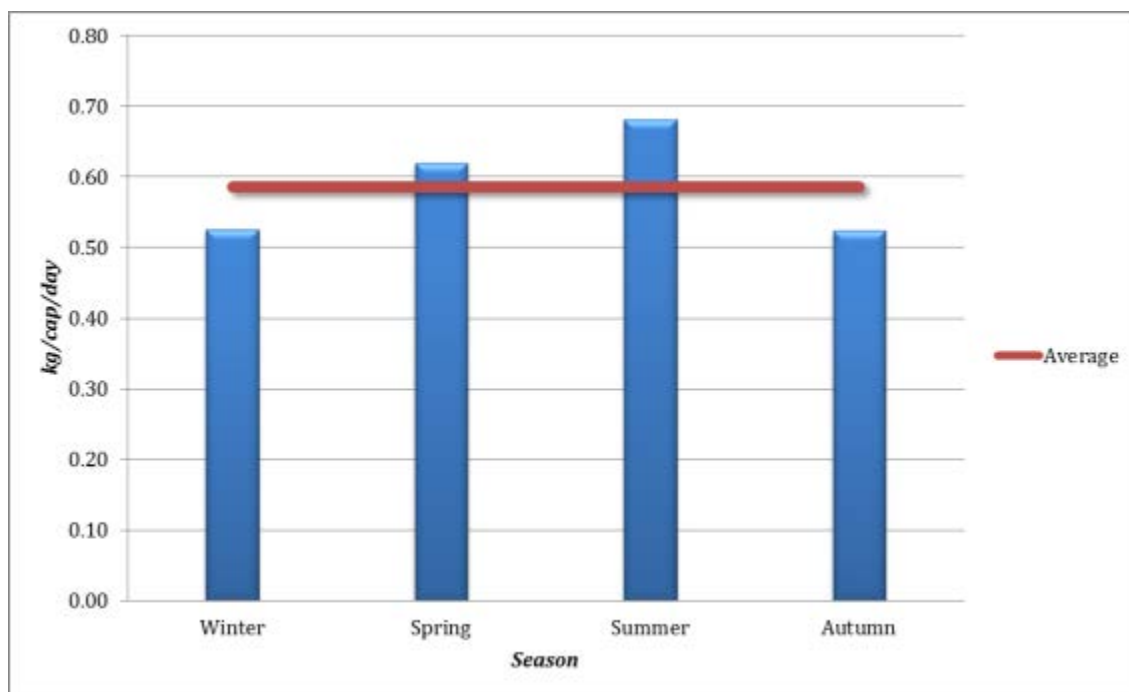
Graph 2.14: Annual average composition of municipal waste – Žitište

Results of measuring the amount of waste in the Municipality of Žitište showed that on a weekly basis PUC “Ekos” collected 47.63 tons in autumn period. According to this data, it can be concluded that the average amount of waste collected by the PUC is 2,483.30 tons annually. Percentage of population in this municipality covered by organized collection is almost 70%, which lead to the conclusion that one citizen of Žitište, in the autumn period, generates 0.59 kg of municipal waste per day.

Table 2.6: Projection of obtained results

Municipality of Žitište	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	2220.24	2617.57	2879.85	2215.55	2483.30
Number of residents	16800	16800	16800	16800	16800
The population covered by the organized waste collection	11579	11579	11579	11579	11579
Share of population under organized waste collection	68.92%	68.92%	68.92%	68.92%	68.92%
Waste generation (kg/capita/year)	191.75	226.07	248.72	191.35	214.47
Waste generation (kg/capita/day)	<b>0.53</b>	<b>0.62</b>	<b>0.68</b>	<b>0.52</b>	<b>0.59</b>
Total for whole city (t/year)	3221.48	3797.99	4178.54	3214.67	3603.17

Projection of obtained results during four campaigns of measurement shows that the average amount of waste collected by the PUC from Žitište per year is 2,483.30 tons. The percentage of the population in the municipality covered by organized collection is 68.92%, according to PUC's data. Results expressed in the form of "per capita", shows that the average resident of Žitište generates 0.59 kg of municipal waste on a daily basis, or 214.5 kg per year. The generation rate per resident is the higher in summer period 0.68 kg/day, and the lowest in autumn period 0.52 kg/day.



Graph 2.15: Comparison of waste generation rate (kg/cap/day) according to the season



## 2.4 MUNICIPALITY OF APATIN

The following table presents the results of waste sampling from all three sectors, in the autumn season, within the Municipality of Apatin, defined by the methodology.

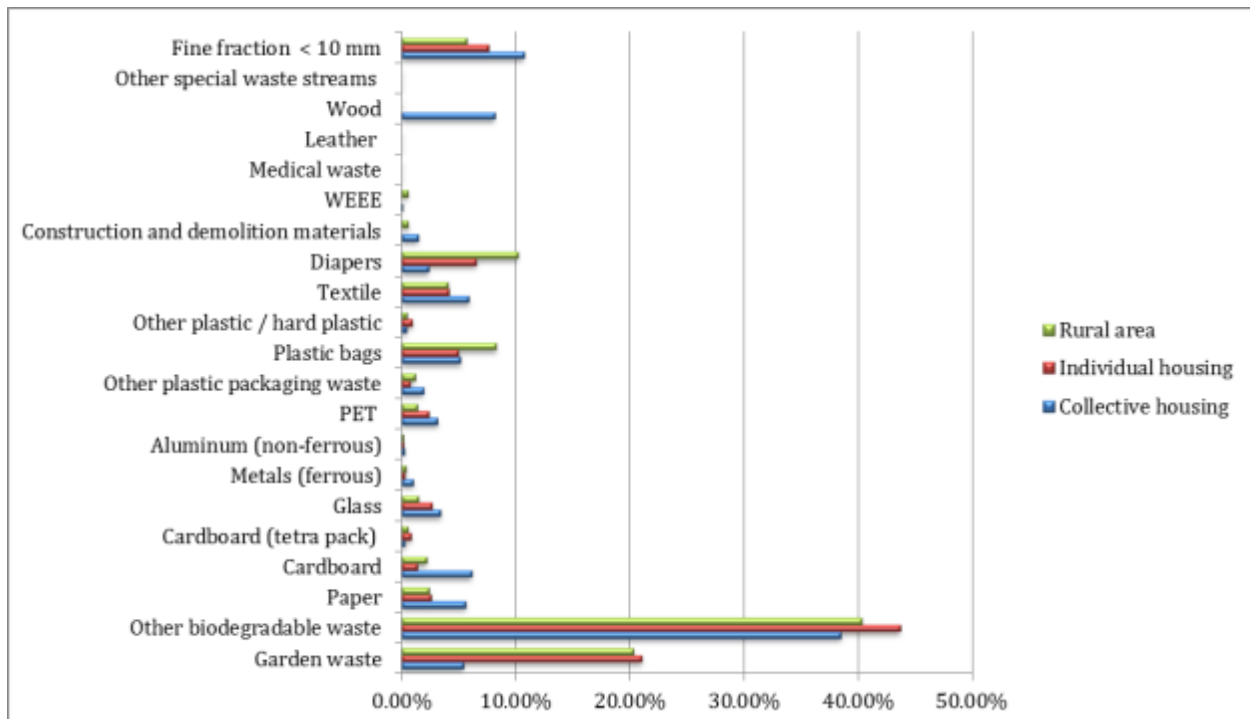
Table 2.10: Morphological composition of waste – Municipality of Apatin – autumn season

Apatin Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	5.38%	21.06%	20.30%
Other biodegradable waste	38.52%	43.71%	40.30%
Paper	5.62%	2.58%	2.43%
Cardboard	6.14%	1.36%	2.17%
Composite materials	0.29%	0.86%	0.53%
Glass	3.40%	2.64%	1.47%
Metals (ferrous)	1.02%	0.30%	0.40%
Aluminum (non-ferrous)	0.26%	0.18%	0.15%
PET	3.16%	2.34%	1.37%
Other plastic packaging waste	1.91%	0.77%	1.16%
Plastic bags	5.17%	4.98%	8.27%
Other plastic / hard plastic	0.42%	0.95%	0.48%
Textile	5.92%	4.12%	4.05%
Diapers	2.35%	6.55%	10.16%
Construction and demolition materials	1.46%	0.00%	0.56%
WEEE	0.13%	0.00%	0.53%
Medical waste	0.00%	0.00%	0.00%
Leather	0.00%	0.00%	0.00%
Wood	8.13%	0.00%	0.00%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	10.71%	7.59%	5.66%

Dominant fraction for collective housing was "other biodegradable waste" with mass share of 38.52%. Great amount of fine elements and wood was recorded, with a proportion of 10.71% and 8.13%, respectively; those were mostly ash, sawdust and wood chips. From recyclable fractions the most dominant were paper and cardboard with mass share of 5.62% and 6.14%, respectively. Significant mass share also had plastic bags with mass share of 5.17%. Noteworthy was also the amount of textile with mass share of 5.92%.

In individual housing, dominant category of waste was "other biodegradable waste" with mass share of 43.71%. This fraction, together with garden waste (21.06%) constituted almost 65% of the sample. In addition to that, fine elements and diapers had proportion of 7.59% and 6.55%, respectively. All other categories of waste constitute about 20% of sample mass. Plastic bags had a noteworthy proportion of 4.98%, while all other categories had mass share up to 3%. Even six categories of waste had mass share of 0.00%.

Sample from rural area showed a higher proportion of organic waste with its two subcategories, more than 60% of the sample mass. After these categories of waste, diapers recorded significant proportion with mass share of 10.16%. From potentially recyclable materials plastic with its four subcategories constitute 11.28% of the sample mass, among these the most dominant were plastic bags with a proportion of 8.27%. All other categories had proportion less than 4%, except textile with 4.05%. Four waste categories didn't appear at all.



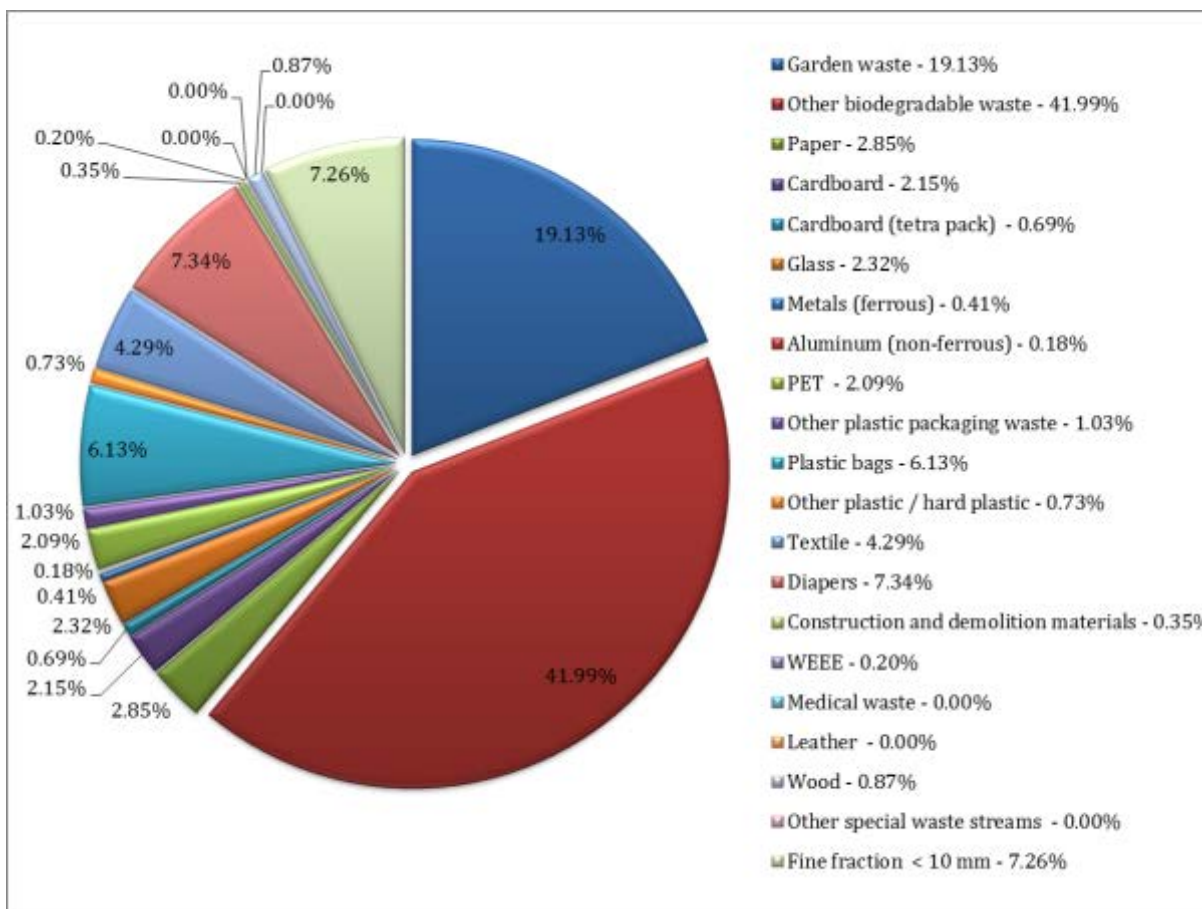
Graph 2.16: Comparison of waste composition according to the housing sector – Municipality of Apatin – autumn season

By comparing the results of the waste composition analysis from three different living sectors within the municipality of Apatin, it can be concluded that other biodegradable waste and garden waste represent the most dominant fractions, and that garden waste had the highest share in individual housing, as other biodegradable waste also. From collective housing sector, waste fractions such as paper, cardboard and glass had a higher mass share in comparison to the other two zones. Surprisingly wood and fine fraction was the most dominant in collective housing, which is not common. Individual housing was a dominant concerning garden waste and “other biodegradable waste”. Plastic bags and diapers were more represented in rural areas compared to other two living sectors. On the other hand, WEEE, medical waste, leather, C&D materials and “other special waste streams” didn’t have any nor had a very small portion in samples.



*Picture 2.4: Analysis of morphological composition of waste at site – Apatin*

Based on the proportion of the total population, which living in the collective (10.67%), individual (55.03%) and rural parts (34.31%) in the municipality of Apatin, projected average composition for the autumn season, for the entire municipality is made. It is evident that “other biodegradable waste” represents the predominant waste category with 41.99% of mass share, which together with garden waste consisted over 60% of waste. There is also a relatively large amount of diapers and fine fraction, with mass share of 7.34% and 7.26%, respectively. From potentially recyclable fractions plastic bags have notable share with 6.13%. Other potentially recyclable fractions have proportion up to 3%. Metals as usual have low proportion, only 0.59%. Three components of waste didn’t appear at all.



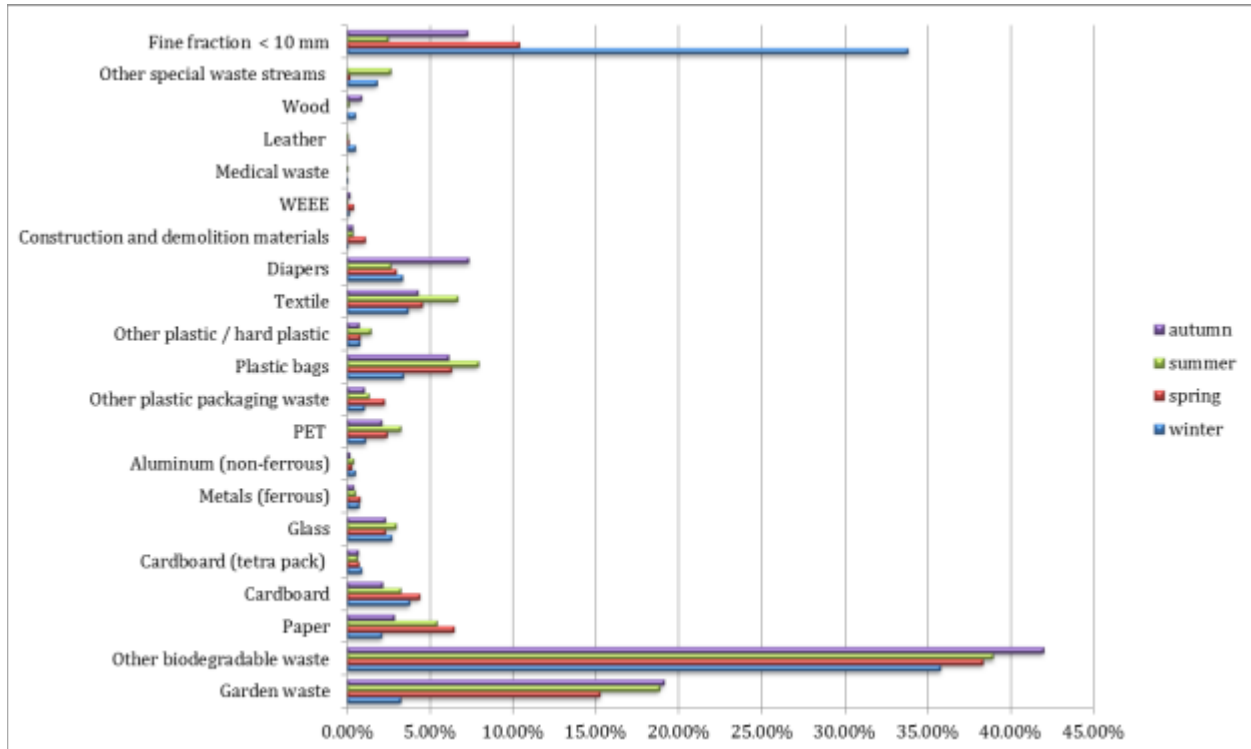
Graph 2.17: Average morphological waste composition (%) for the municipality of Apatin – autumn season

In the municipality of Apatin, for the purpose of determination of the morphological composition of municipal waste, four campaigns were conducted. Taking into account proportion of the population which lives in collective housing, individual housing and rural area average composition for each season is determined, and based on these results annual average composition of municipal waste for the municipality of Apatin was calculated.

Table 2.11: Composition of municipal waste for four different seasons and the annual average value

Apatin	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	3.26%	15.26%	18.84%	19.13%	<b>14.12%</b>
Other biodegradable waste	35.79%	38.37%	38.98%	41.99%	<b>38.78%</b>
Paper	2.12%	6.43%	5.42%	2.85%	<b>4.20%</b>
Cardboard	3.76%	4.36%	3.22%	2.15%	<b>3.37%</b>
Composite materials	0.89%	0.72%	0.63%	0.69%	<b>0.73%</b>
Glass	2.72%	2.33%	2.95%	2.32%	<b>2.58%</b>
Metals (ferrous)	0.71%	0.80%	0.50%	0.41%	<b>0.60%</b>
Aluminum (non-ferrous)	0.48%	0.27%	0.39%	0.18%	<b>0.33%</b>
PET	1.13%	2.40%	3.25%	2.09%	<b>2.22%</b>
Other plastic packaging waste	1.04%	2.26%	1.31%	1.03%	<b>1.41%</b>
Plastic bags	3.43%	6.31%	7.91%	6.13%	<b>5.94%</b>
Other plastic / hard plastic	0.76%	0.81%	1.44%	0.73%	<b>0.94%</b>
Textile	3.69%	4.57%	6.68%	4.29%	<b>4.81%</b>
Diapers	3.37%	2.97%	2.66%	7.34%	<b>4.09%</b>
Construction and demolition materials	0.08%	1.11%	0.37%	0.35%	<b>0.47%</b>
WEEE	0.13%	0.38%	0.04%	0.20%	<b>0.19%</b>
Medical waste	0.02%	0.00%	0.07%	0.00%	<b>0.02%</b>
Leather	0.51%	0.11%	0.09%	0.00%	<b>0.18%</b>
Wood	0.49%	0.00%	0.14%	0.87%	<b>0.37%</b>
Other special waste streams	1.81%	0.15%	2.64%	0.00%	<b>1.15%</b>
Fine fraction < 10 mm	33.84%	10.40%	2.48%	7.26%	<b>13.50%</b>

Comparing the average composition of waste according to the period of sampling within the municipality of Apatin it can be observed significant variations in the proportion of organic waste and fine fraction. Garden waste had the highest value in the autumn and the lowest value in the winter period, as expected. "Other biodegradable waste" didn't have such obvious variations, and it was dominant in each season. Fine fraction had the highest share in the winter period, great amount of ash as consequence of heating season, and the lowest share was recorded in summer season. Paper and cardboard had the highest mass share in the spring and the lowest proportion in winter.

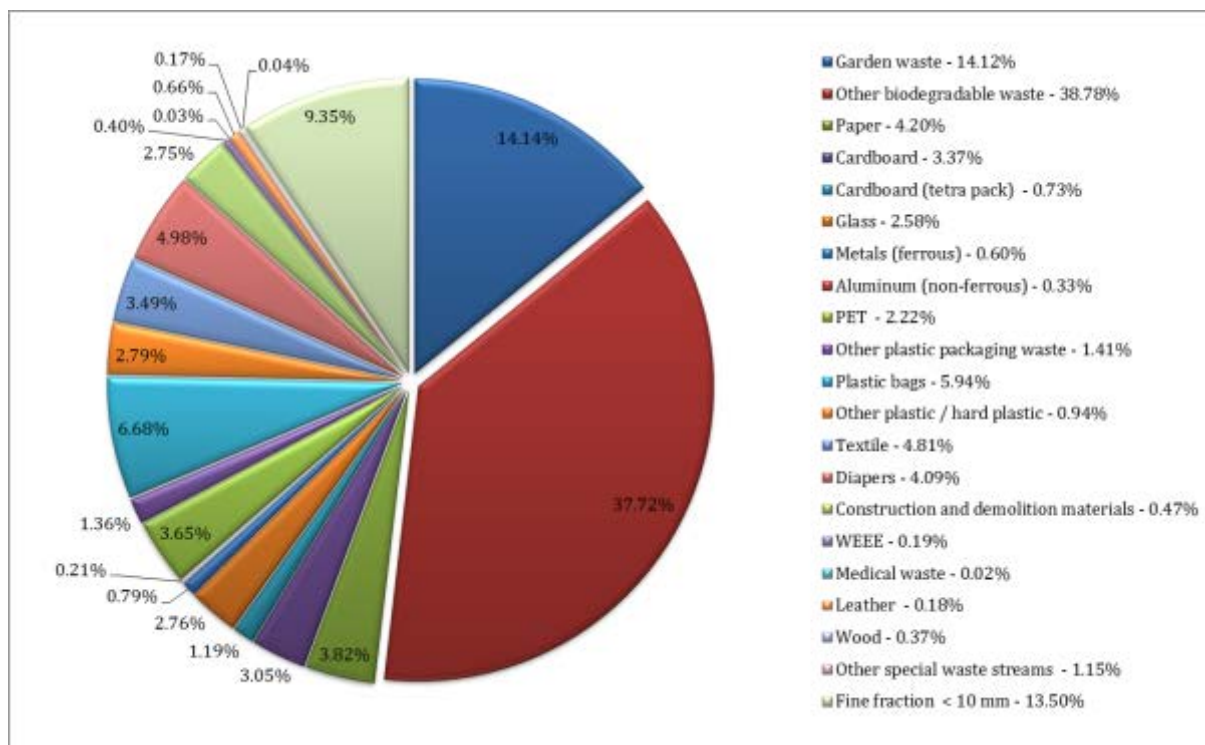


Graph 2.18: Comparison of waste composition according to the period of analysis – Apatin

Plastic bags, textile and “other special waste streams” were more represented in summer period comparing to other three seasons. Glass, metals didn’t have significant variations. Diapers had the greatest mass share in autumn, and the lowest in summer period. Other categories didn’t have significant variations, comparing the composition from different seasons of analysis.

According to the four obtained campaigns of measurements and taking into account proportion of the population, which live in collective housing, individual housing and rural areas, it can be calculated the annual average composition of municipal waste for the municipality of Apatin.

“Other biodegradable waste” is a dominant waste category with mass share of 38.78% that together with garden waste constitute over a 50% of waste. Fine fraction also has significant mass share with 13.50%, which is not convenient for waste separation, and some other waste treatments. From potentially recyclable categories paper and cardboard have proportions of 4.20% and 3.37%, respectively. Metals and tetra pack have, as usual, small proportions up to 1%. Plastic with its four subcategories is represented with mass share of 10.51%. From other categories of waste, noteworthy are amount of textile and diapers, with mass share of 4.81% and 4.09%, respectively.



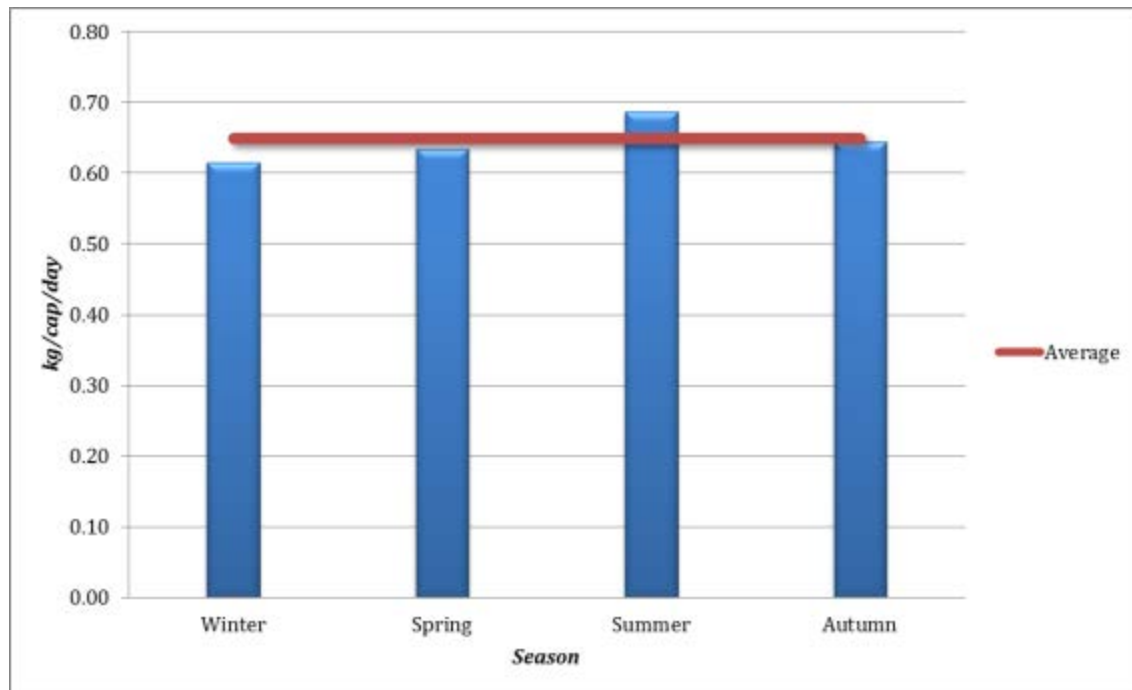
Graph 2.19: Annual average composition of municipal waste – Apatin

Based on the results of measurements on the weighbridge, it can be concluded that the amount of waste collected by the PUC "Naš dom" in autumn period was 4,521.70 tons per year. Percentage of population covered by the organized waste collection in the municipality is about 67%. Projection of the aforementioned results indicate that one citizen of Apatin generates 0.65 kg of waste per day, or 235.46 kg per year, in autumn period. Also on the basis of the foregoing, it can be concluded that about 2200 tons of waste per year end up on illegal dumps.

Table 2.12: Projection of obtained results

Municipality of Apatin	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	4313.26	4444.66	4811.22	4517.66	4521.70
Number of residents	28654	28654	28654	28654	28654
The population covered by the organized waste collection	19187	19187	19187	19187	19187
Share of population under organized waste collection	66.96%	66.96%	66.96%	66.96%	66.96%
Waste generation (kg/capita/year)	224.80	231.65	250.76	235.46	235.67
Waste generation (kg/capita/day)	<b>0.62</b>	<b>0.63</b>	<b>0.69</b>	<b>0.65</b>	<b>0.65</b>
Total for whole city (t/year)	6441.54	6637.78	7185.22	6746.80	6752.83

Projection of the results obtained from four campaigns of measurements, show that the average amount of waste collected by PUC „Naš Dom“ from Apatin, is about 4,522 tons annually. Taking into account the percentage of the population covered by the organized waste collection (about 67%), the entire municipality generates about 6,750 tons per year. Observing the results in the form of „per capita“, it is calculated that the average resident of Apatin generates 0.65 kg per day.



Graph 2.20: Comparison of waste generation rate (kg/cap/day) according to the season

Before this project PUC from Apatin didn't conduct this type of measurement for determination of the municipal waste quantity. According to their estimates they collect 6500 tons of municipal waste measured values.

The benefits of this project are detailed analysis of generated waste quantity and also for waste composition, it was conducted four measurements for four seasons, it can be observed variations in waste quantity and composition during the year.



## 2.5 MUNICIPALITY OF PLJEVLJA

Analyzing waste composition of the municipality of Pljevlja, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

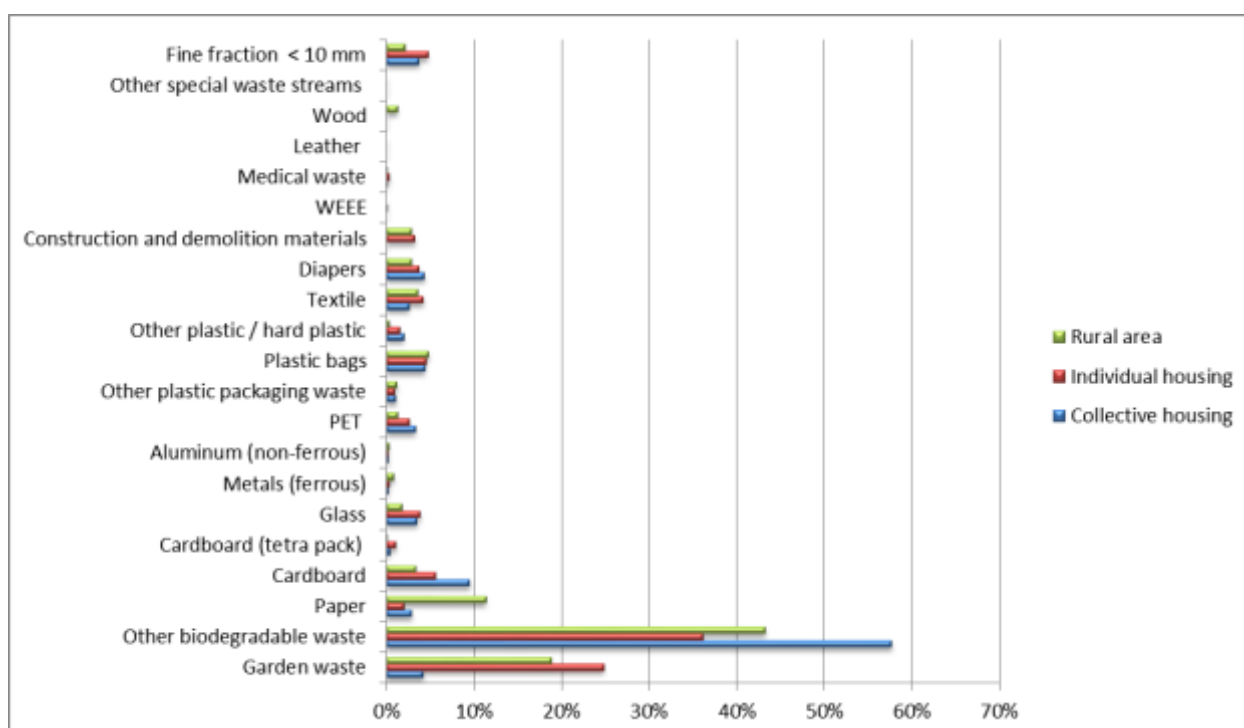
Table 2.13: Morphological composition of waste in the municipality of Pljevlja

Pljevlja Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	4.20%	24.81%	18.78%
Other biodegradable waste	57.68%	36.20%	43.25%
Paper	2.89%	1.94%	11.37%
Cardboard	9.47%	5.56%	3.36%
Composite materials	0.40%	1.07%	0.10%
Glass	3.47%	3.85%	1.73%
Metals (ferrous)	0.25%	0.33%	0.85%
Aluminum (non-ferrous)	0.22%	0.21%	0.27%
PET	3.31%	2.65%	1.24%
Other plastic packaging waste	1.05%	0.94%	1.20%
Plastic bags	4.36%	4.51%	4.81%
Other plastic / hard plastic	2.00%	1.57%	0.32%
Textile	2.59%	4.20%	3.58%
Diapers	4.35%	3.74%	2.85%
Construction and demolition materials	0.00%	3.26%	2.85%
WEEE	0.00%	0.08%	0.00%
Medical waste	0.05%	0.33%	0.10%
Leather	0.00%	0.00%	0.00%
Wood	0.00%	0.00%	1.22%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	3.71%	4.74%	2.12%

Collective housing sector sample showed the highest share of biodegradable waste, followed by garden waste. Cardboard had the highest share among all potentially recyclable materials (9.47%), and it was followed by plastic bags and paper). Other plastic sub fractions had small shares.

In individual housing sector, other biodegradable fraction was dominant, and it is followed by garden waste. Cardboard was dominant fraction among potentially recyclable materials, while plastic bags had the highest share among plastic sub-fractions. This sample showed notable amounts of construction and demolition materials, textile and fine fraction.

In the rural sector, two dominant fractions of biodegradable waste had more than 50% of total waste mass. Second highest shares had paper, and combined with cardboard it made up to 14.73%. Plastic bags had the highest share out of all plastic fractions (4.81%).



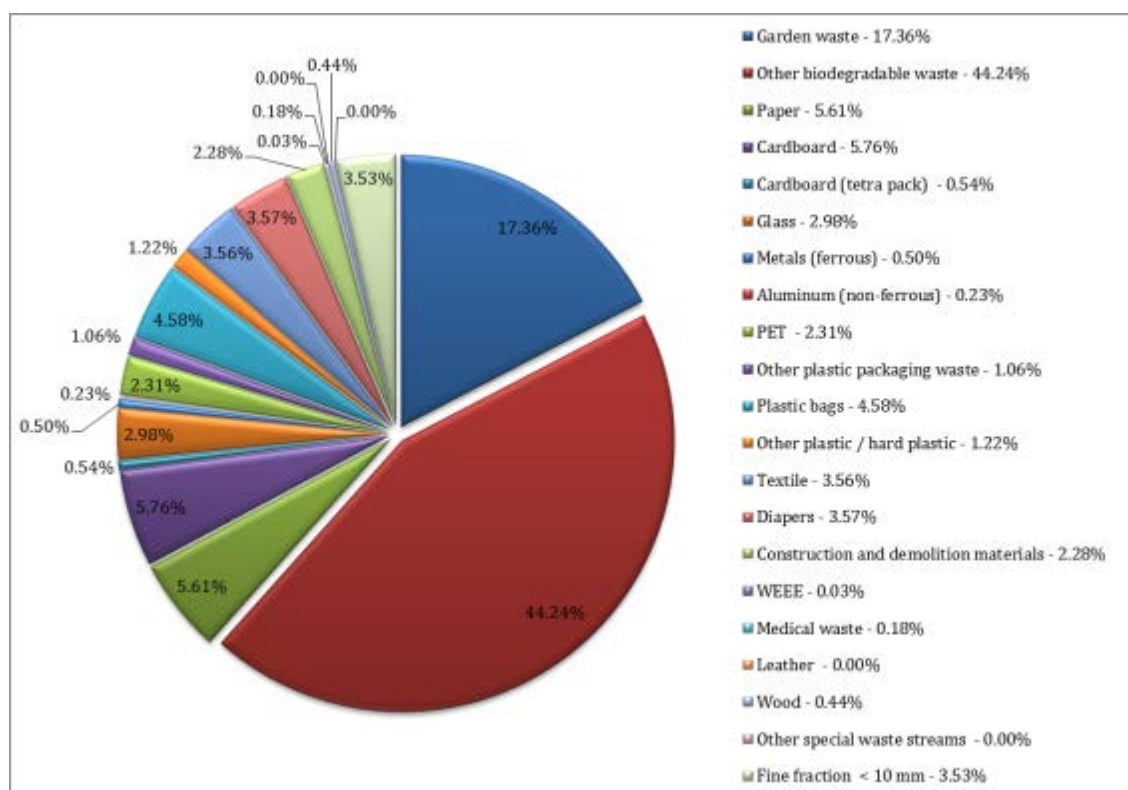
Graph 2.21: Comparison of waste composition according to the housing sector – municipality of Pljevlja, autumn analysis

By comparing the results of the waste composition analysis from three different living sectors within the municipality of Pljevlja, it can be concluded that for each of living zone, other biodegradable waste and garden waste, represent the most dominant fractions. Sample from individual housing sector showed highest share of garden waste, while other biodegradable waste had highest share in collective housing.

Paper had the highest share in rural area sample, while cardboard had the highest share in the collective housing. Fractions like diapers, textile, plastic bags, packaging waste, and PET to some extent had similar shares in all samples.

Medical waste, wood and WEEE showed extremely small shares, while leather was not presented in any of samples.

Overall morphological composition of waste in Pljeva municipality shows that more than 50% of waste is biodegradable waste. Potential recyclables with notable share are paper (5.61%), cardboard (5.76%). On the other side, plastic bags had share of 4.58% while all other materials have shares under 4%. Exact percentages are shown in the following figure.

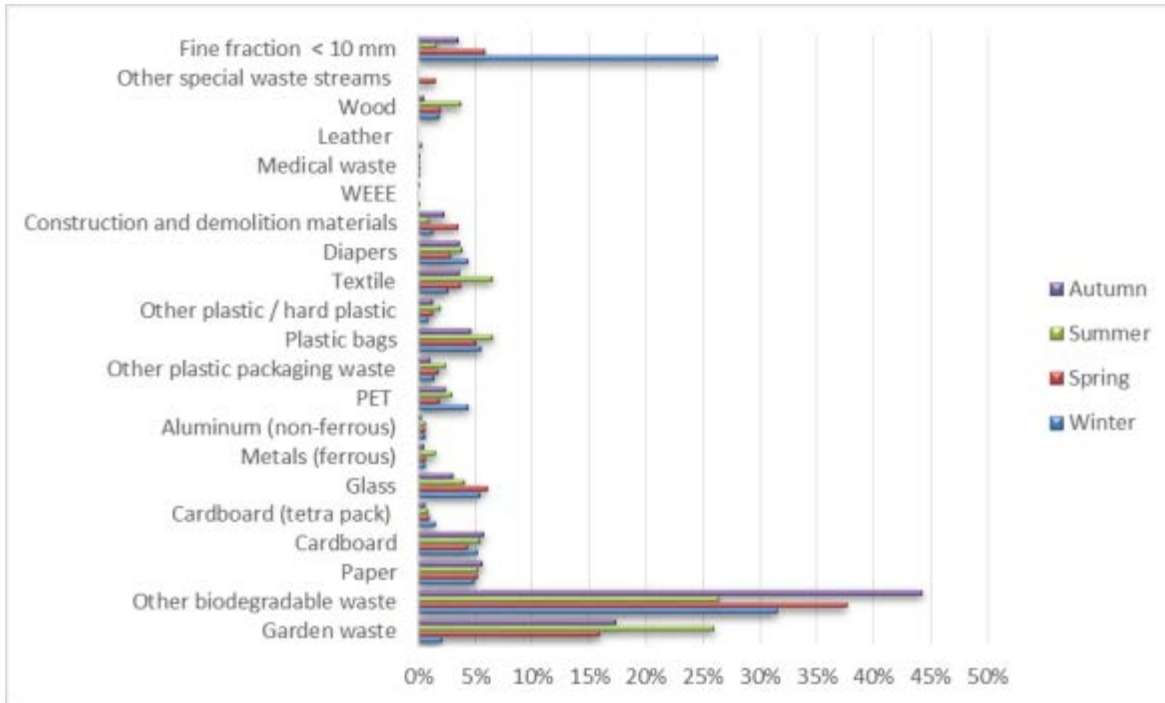


Graph 2.22: Morphological composition of waste in the Municipality of Pljevlja for autumn analysis

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

Table 2.14: Composition of municipal waste for four different seasons and the annual average value

Pljevlja Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	2.01%	15.89%	25.96%	17.36%	<b>15.31%</b>
Other biodegradable waste	31.50%	37.60%	26.34%	44.24%	<b>34.92%</b>
Paper	4.85%	5.16%	5.15%	5.61%	<b>5.19%</b>
Cardboard	5.16%	4.27%	5.38%	5.76%	<b>5.14%</b>
Composite materials	1.46%	0.93%	0.83%	0.54%	<b>0.94%</b>
Glass	5.33%	6.01%	4.03%	2.98%	<b>4.59%</b>
Metals (ferrous)	0.63%	0.54%	1.49%	0.50%	<b>0.79%</b>
Aluminum (non-ferrous)	0.52%	0.54%	0.59%	0.23%	<b>0.47%</b>
PET	4.38%	1.83%	2.86%	2.31%	<b>2.85%</b>
Other plastic packaging waste	1.30%	1.70%	2.37%	1.06%	<b>1.61%</b>
Plastic bags	5.52%	4.99%	6.49%	4.58%	<b>5.40%</b>
Other plastic / hard plastic	0.82%	1.27%	1.90%	1.22%	<b>1.30%</b>
Textile	2.53%	3.74%	6.49%	3.56%	<b>4.08%</b>
Diapers	4.32%	2.80%	3.82%	3.57%	<b>3.63%</b>
Construction and demolition materials	1.27%	3.43%	0.95%	2.28%	<b>1.98%</b>
WEEE	0.03%	0.00%	0.00%	0.03%	<b>0.02%</b>
Medical waste	0.04%	0.15%	0.09%	0.18%	<b>0.11%</b>
Leather	0.27%	0.00%	0.00%	0.00%	<b>0.07%</b>
Wood	1.84%	1.88%	3.69%	0.44%	<b>1.96%</b>
Other special waste streams	0.00%	1.46%	0.00%	0.00%	<b>0.37%</b>
Fine fraction < 10 mm	26.22%	5.82%	1.54%	3.53%	<b>9.27%</b>



Graph 2.23: Comparison of seasonal fluctuations of fractions in Pljevlja municipality

Biggest seasonal fluctuations were presented in fine material fraction. These materials showed the highest share during the winter period, rather small amount during summer, and middle values during spring and autumn. Reasoning behind this is that there is a coal mine near the city of Pljevlja, so the whole city and villages in the proximity of city use coal for heating. Small quantities of fine fraction materials during the autumn campaign could be associated with relatively high temperatures which are not characteristic for the Pljevlja municipality and late November. Garden waste had the highest share during the summer and the lowest share during the winter, while other biodegradable fraction had the highest share during autumn. Other fractions showed small deviation.

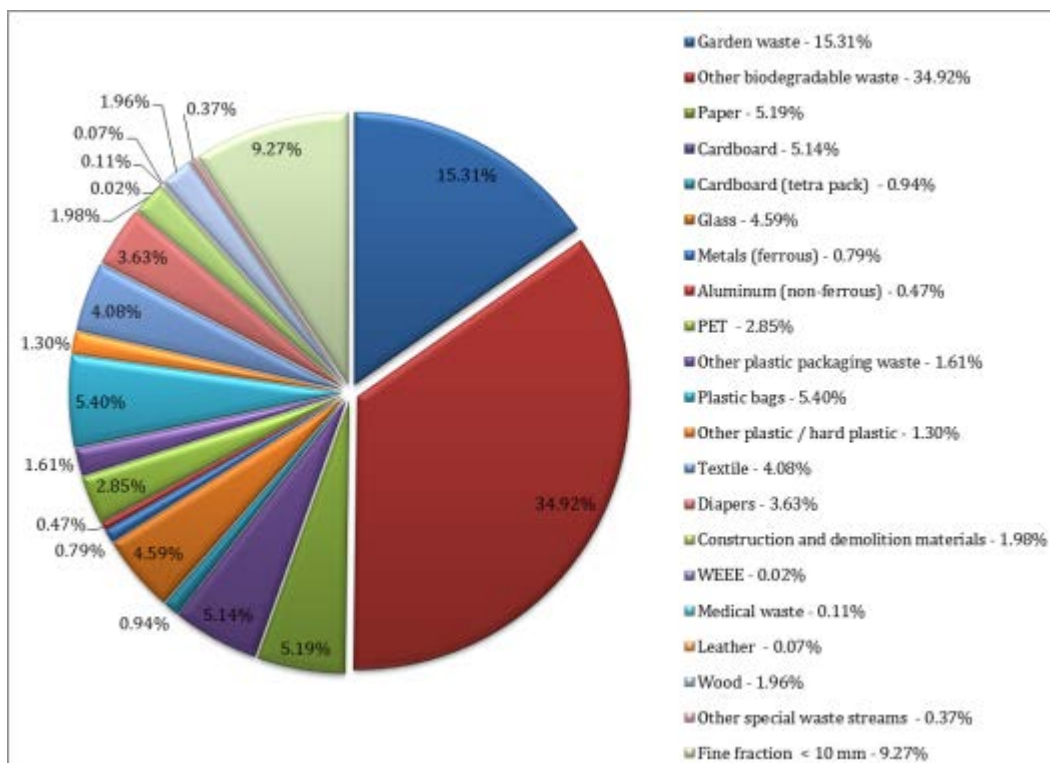


Figure 2.24: Average annual morphological composition for the whole municipality of Pljevlja

Overall composition showed that around 50% of total waste is biodegradable. There was relatively high amount of potentially recyclable materials – paper (5.19%), cardboard (5.14%) and glass (4.59%). Among all plastic sub fractions, plastic bags had the highest share – 5.40%. Fine fraction materials, because of previously stated reasons, have a notable share of 9.27%.

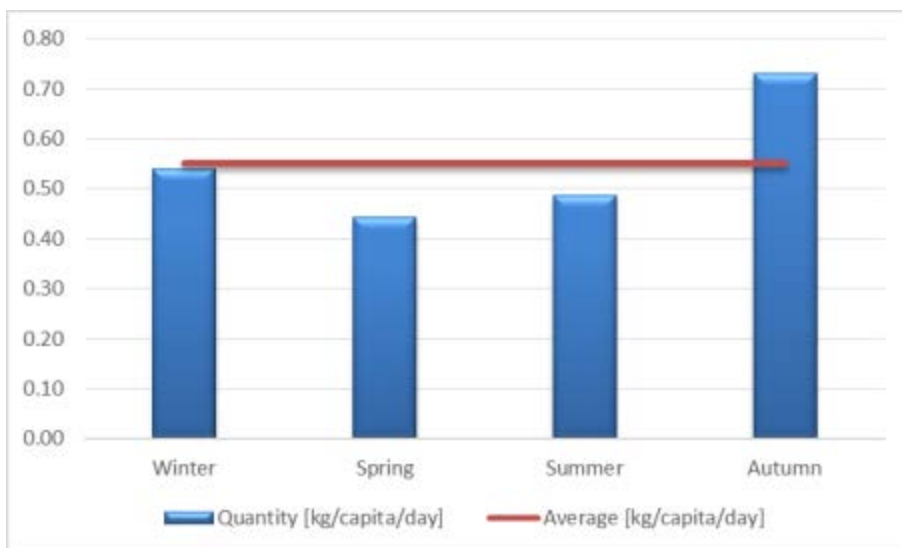


Picture 2.5: Analysis of morphological composition of waste at site – Pljevlja

The municipality of Pljevlja measured amounts of collected waste on the weighbridge. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount are shown in table 2.15.

Table 2.15: Projection of obtained results

Municipality of Pljevlja	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	6,082.99	4,984.60	5,469.26	8,232.31	6,192.29
Number of residents	30,844	30,844	30,844	30,844	30,844
The population covered by the organized waste collection	30,844	30,844	30,844	30,844	30,844
Share of population under organized waste collection	100.00%	100.00%	100.00%	100.00%	100.00%
Waste generation (kg/capita/year)	197.22	161.61	177.32	266.90	200.76
Waste generation (kg/capita/day)	<b>0.54</b>	<b>0.44</b>	<b>0.49</b>	<b>0.73</b>	<b>0.55</b>
Total for whole municipality (t/year)	6,082.99	4,984.60	5,469.26	8,232.31	6,192.29



Graph 2.25: Overall annual fluctuations of generated waste expressed in kg/capita/day

Highest amount of waste was presented during the last (autumn) campaign, while waste generation had low values during spring and summer. End value (average value) is similar to the winter value, and amounts 0.55 kg/capita/day.



## 2.6 MUNICIPALITY OF BERANE

Analyzing waste composition of the municipality of Berane, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

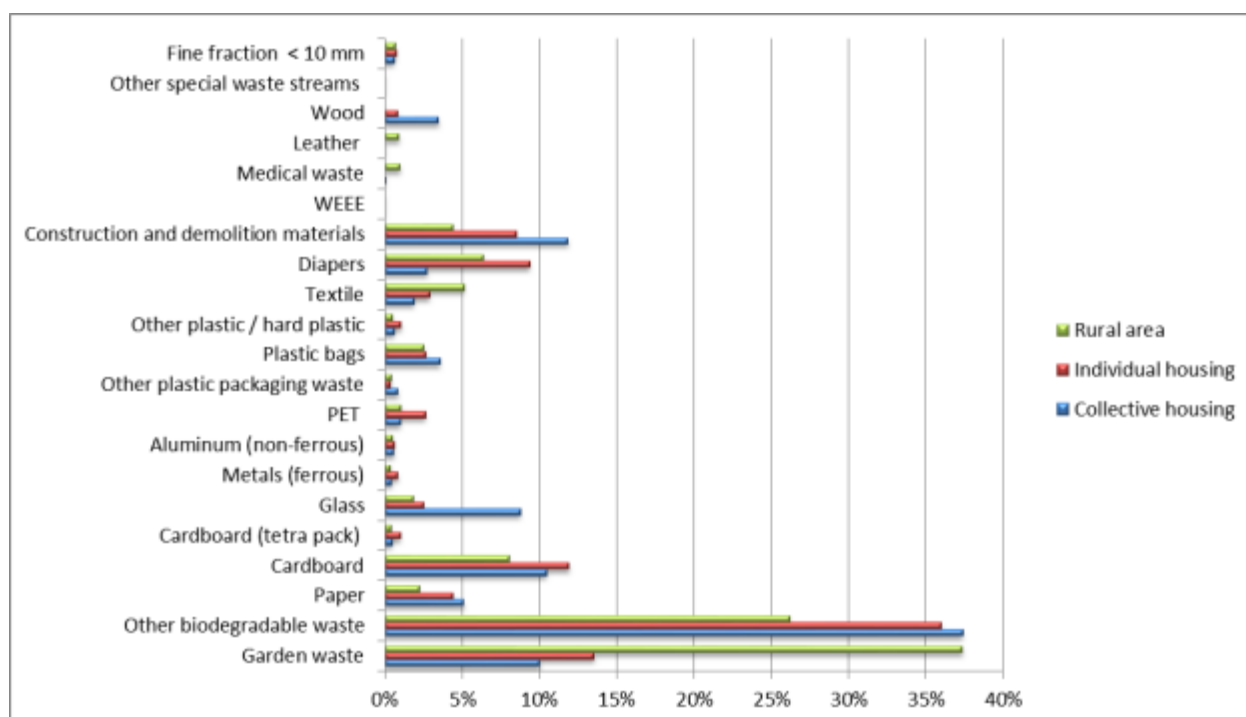
Table 2.16: Morphological composition of waste in the municipality of Berane

Berane Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	10.02%	13.53%	37.35%
Other biodegradable waste	37.38%	36.02%	26.19%
Paper	5.09%	4.41%	2.23%
Cardboard	10.46%	11.91%	8.03%
Composite materials	0.49%	1.02%	0.40%
Glass	8.76%	2.49%	1.84%
Metals (ferrous)	0.44%	0.86%	0.36%
Aluminum (non-ferrous)	0.59%	0.61%	0.52%
PET	1.01%	2.64%	1.05%
Other plastic packaging waste	0.86%	0.38%	0.42%
Plastic bags	3.59%	2.67%	2.55%
Other plastic / hard plastic	0.61%	1.06%	0.52%
Textile	1.91%	2.91%	5.14%
Diapers	2.74%	9.40%	6.38%
Construction and demolition materials	11.86%	8.50%	4.41%
WEEE	0.00%	0.00%	0.00%
Medical waste	0.08%	0.00%	0.99%
Leather	0.00%	0.00%	0.92%
Wood	3.48%	0.85%	0.00%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	0.62%	0.76%	0.69%

Biodegradable waste is dominant fraction in collective housing sector and it made up to 47.4% of total sample weight. Potentially recyclable materials had notable shares – cardboard 10.46%, glass 8.76% and paper had 5.09%. Another fraction with notable share was construction and demolition materials with 11.86% share.

Beside the two sub fraction of biodegradable waste, which had the highest share, individual housing sector showed high share of cardboard – 11.91%. This sample showed notable share of diapers (9.4%) and construction and demolition materials (8.5%), while all other fractions had share of less than 5%.

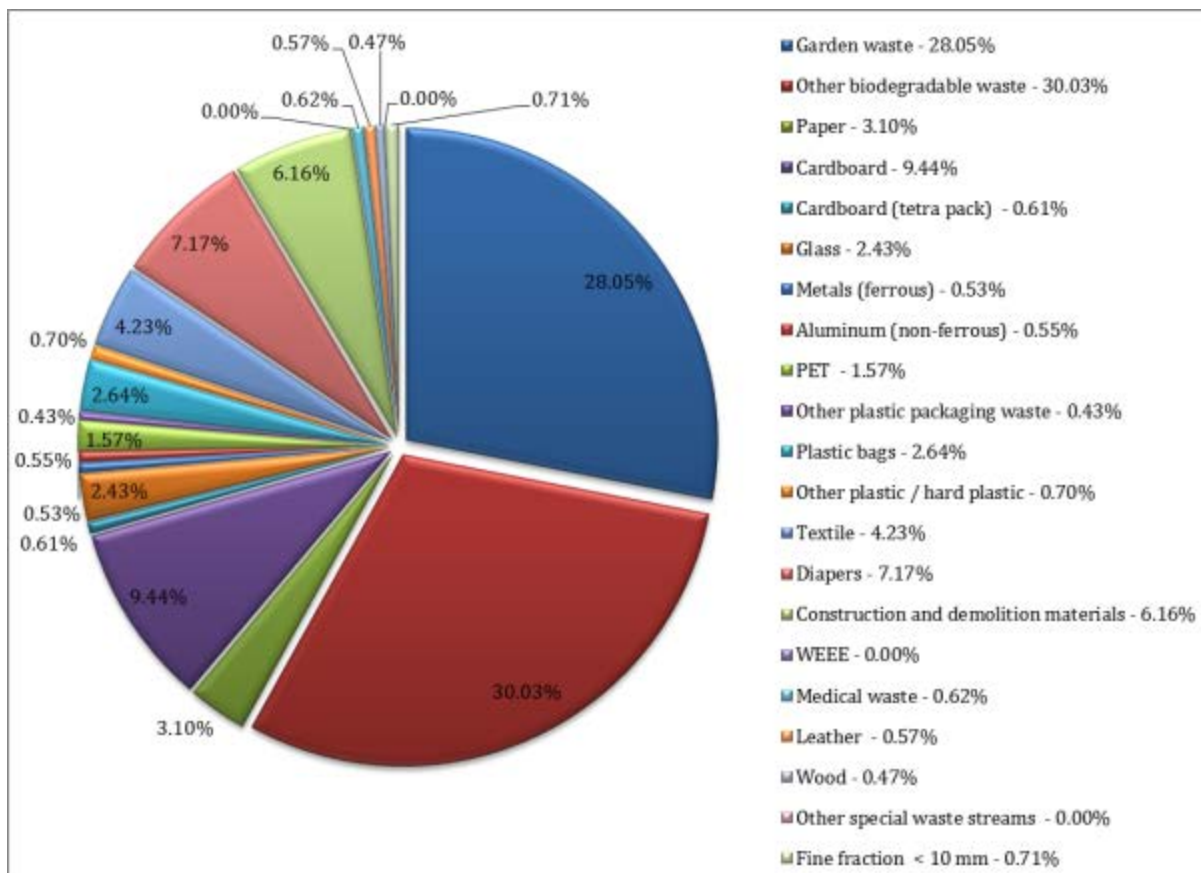
Most dominant fraction in rural area sample was biodegradable waste, with garden waste (37.35%) and other biodegradable waste (26.19%). On the other hand, cardboard, paper and composite materials had a combined share of 10.63%, while plastic sub categories had combined share of 4.54%. Among all other fraction, diapers had the highest share of 6.38%, and textile had a share of 5.14%.



Graph 2.26: Comparison of waste composition according to the housing sector - the municipality of Berene, autumn analysis

Collective housing sector had the highest share of fraction like other biodegradable fraction, glass, construction and demolition materials, wood and plastic bags, comparing to other two sectors. The biggest amount of cardboard and diapers was found in the individual housing sector, while rural area sample showed the biggest amount of garden waste and textile. Small amounts of leather and medical waste was found in rural area sample only, while WEEE was not presented in any of samples.

In order to get the morphological composition of waste, which represents the whole municipality of Berane, waste composition of separate sector was multiplied by corresponding population share. Similarly to other municipalities, biodegradable waste makes more than half of total waste (58.08% in this case). Cardboard had notable share in all three analyzed samples so it influenced overall composition of waste for whole municipality, and cardboard makes up to 9,44% of total waste. Besides cardboard, notable shares have diapers and construction and demolition materials.

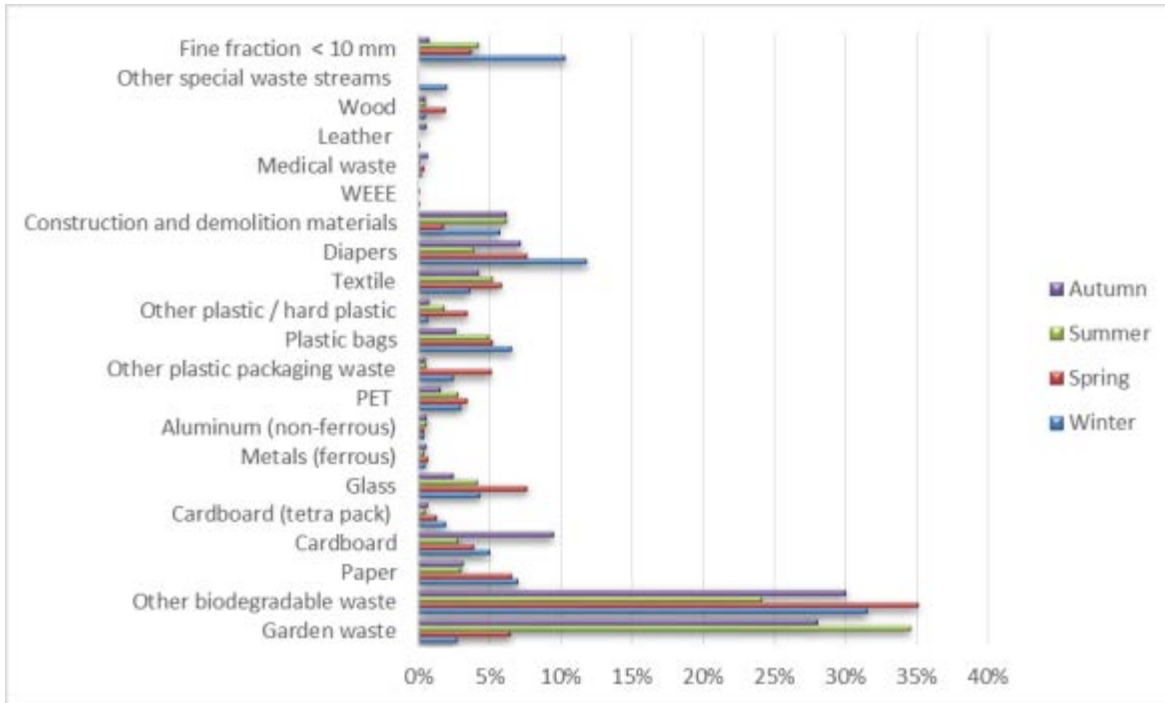


Graph 2.27 – Morphological composition of waste in the Berane municipality for autumn campaign

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

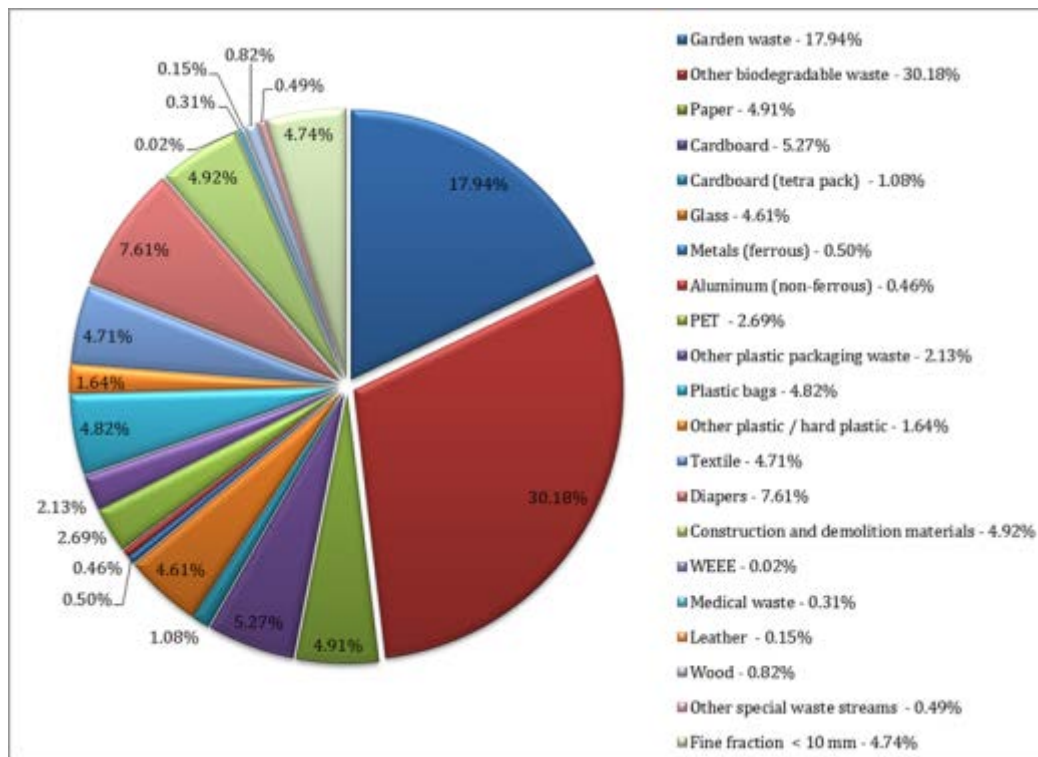
Table 2.17: Composition of municipal waste for four different seasons and the annual average value

Berane Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	2.68%	6.47%	34.55%	28.05%	<b>17.94%</b>
Other biodegradable waste	31.51%	35.09%	24.11%	30.03%	<b>30.18%</b>
Paper	6.99%	6.55%	2.98%	3.10%	<b>4.91%</b>
Cardboard	4.99%	3.86%	2.80%	9.44%	<b>5.27%</b>
Composite materials	1.92%	1.30%	0.50%	0.61%	<b>1.08%</b>
Glass	4.30%	7.61%	4.09%	2.43%	<b>4.61%</b>
Metals (ferrous)	0.44%	0.64%	0.38%	0.53%	<b>0.50%</b>
Aluminum (non-ferrous)	0.35%	0.38%	0.56%	0.55%	<b>0.46%</b>
PET	3.00%	3.38%	2.83%	1.57%	<b>2.69%</b>
Other plastic packaging waste	2.46%	5.08%	0.54%	0.43%	<b>2.13%</b>
Plastic bags	6.54%	5.16%	4.94%	2.64%	<b>4.82%</b>
Other plastic / hard plastic	0.67%	3.41%	1.78%	0.70%	<b>1.64%</b>
Textile	3.58%	5.82%	5.19%	4.23%	<b>4.71%</b>
Diapers	11.84%	7.60%	3.84%	7.17%	<b>7.61%</b>
Construction and demolition materials	5.73%	1.67%	6.14%	6.16%	<b>4.92%</b>
WEEE	0.07%	0.00%	0.02%	0.00%	<b>0.02%</b>
Medical waste	0.18%	0.41%	0.03%	0.62%	<b>0.31%</b>
Leather	0.03%	0.00%	0.00%	0.57%	<b>0.15%</b>
Wood	0.45%	1.87%	0.49%	0.47%	<b>0.82%</b>
Other special waste streams	1.95%	0.00%	0.00%	0.00%	<b>0.49%</b>
Fine fraction < 10 mm	10.32%	3.71%	4.22%	0.71%	<b>4.74%</b>



Graph 2.28: Comparison of seasonal fluctuations of fractions in Berane municipality

In Berane municipality, general fluctuations of fractions are rather small. Garden waste had high differences in share – it had rather small shares during the winter and spring period, rather high shares during summer period, and little smaller values during autumn (compared to summer). Besides that, fine fraction materials were highest during winter. Other than that, cardboard showed the highest values during the autumn period. Paper had two similar high (during winter and spring), and two similar low values (during summer and autumn). Glass, packaging waste, hard plastic and wood had their highest shares during spring. Construction and demolition materials had strangely high (and almost equal) shares during three seasons (winter, summer and autumn).



Graph 2.29: Average annual morphological composition for the whole municipality of Berane

In the municipality of Berane, total biodegradable waste made little less than 50% (48.12%). Potentially recyclable materials (paper, cardboard and glass) had high shares, when compared to other fractions (excluding biodegradable waste). The municipality of Berane had small shares of plastic materials (plastic bags had the highest overall share among other plastic sub categories - 4.82%). As previously stated, construction and demolition materials had high shares during three out four analysis, and because of this end result is relatively high – 4.92%. Besides this, diapers had a notable share of 7.61%, while fine fraction materials had almost the same share (4.74%).

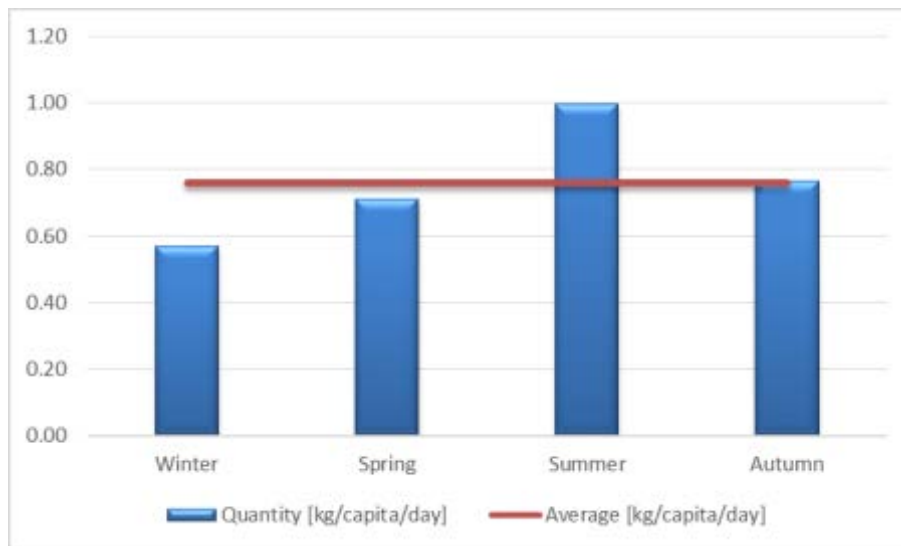


Picture 2.6: Analysis of morphological composition of waste at site – Berane

Measurement of waste quantities on a weighbridge before landfilling is applied in Berane. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount for whole year are shown in table 2.18.

Table 2.18: Projection of obtained results

Municipality of Berane	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	4,777.33	5,960.45	8,365.80	6,397.93	6,375.38
Number of residents	34,034	34,034	34,034	34,034	34,034
The population covered by the organized waste collection	22,966	22,965	22,965	22,965	22,965
Share of population under organized waste collection	67.48%	67.48%	67.48%	67.48%	67.48%
Waste generation (kg/capita/year)	208.02	259.54	364.28	278.59	277.60
Waste generation (kg/capita/day)	<b>0.57</b>	<b>0.71</b>	<b>1.00</b>	<b>0.76</b>	<b>0.76</b>
Total for whole municipality (t/year)	7,079.62	8,833.17	12,397.82	9,481.50	9,447.80



Graph 2.30: Overall annual fluctuations of generated waste expressed in kg/capita/day

Graph above shows differences in waste generation during four campaigns of measurements. During the winter campaign, waste was landfilled at the landfill in the city of Podgorica. Waste weight was measured at the mentioned landfill, and this amount is the smallest when compared to other values. During the other three campaigns, waste was transported to local site for landfilling, to reduce transportation and landfilling costs, and its weight was measured on local weighbridge. Results from summer campaign showed highest values, while results from spring and autumn campaign had close results. Overall average value is also close to the values which are results of spring and autumn campaign, and it amounts 0.76 kg per capita daily. It should be noted that share of population under the organized waste collection is only 67.48%.



## 2.7 CITY OF PODGORICA

Analyzing waste composition of the city of Podgorica, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

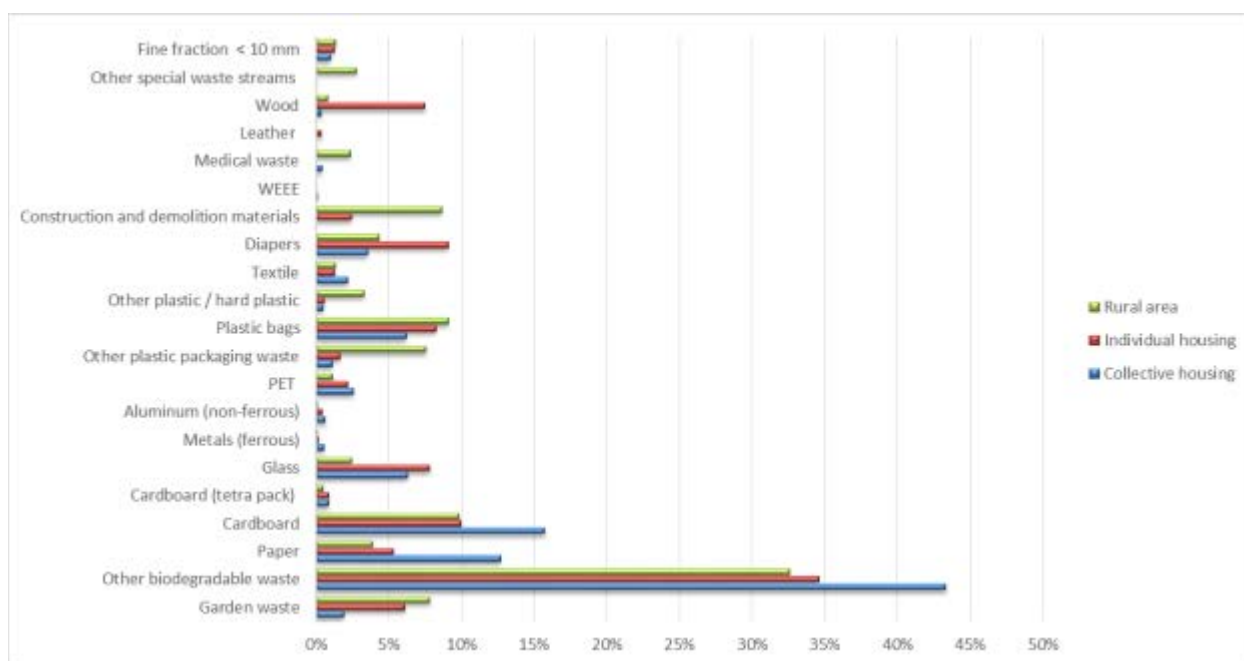
Table 2.19: Morphological composition of waste in the city of Podgorica

Podgorica Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	1.91%	6.14%	7.84%
Other biodegradable waste	43.33%	34.60%	32.58%
Paper	12.68%	5.32%	3.91%
Cardboard	15.75%	9.98%	9.84%
Composite materials	0.87%	0.91%	0.51%
Glass	6.29%	7.83%	2.44%
Metals (ferrous)	0.55%	0.18%	0.06%
Aluminum (non-ferrous)	0.63%	0.44%	0.12%
PET	2.57%	2.17%	1.16%
Other plastic packaging waste	1.12%	1.64%	7.56%
Plastic bags	6.22%	8.23%	9.09%
Other plastic / hard plastic	0.47%	0.56%	3.31%
Textile	2.17%	1.29%	1.32%
Diapers	3.55%	9.11%	4.32%
Construction and demolition materials	0.00%	2.44%	8.65%
WEEE	0.11%	0.00%	0.00%
Medical waste	0.40%	0.00%	2.37%
Leather	0.00%	0.38%	0.00%
Wood	0.37%	7.51%	0.79%
Other special waste streams	0.00%	0.00%	2.78%
Fine fraction < 10 mm	1.00%	1.26%	1.35%

Collective housing sector showed big amount of other biodegradable waste, but rather small amount of garden waste. On the other hand, potentially recyclable materials – paper, cardboard and glass all have notable shares (12.68, 15.75 and 6.29% respectively). All plastic sub fractions, combined, make up to 10.38%.

Similarly to collective housing sector, sample taken from individual housing sector showed that biodegradable waste had the highest share. In this sample, two sub fractions formed little over a 40% of total mass, while other biodegradable waste alone made 34.6%. Cardboard had the highest share of 9.98%, it is followed by diapers (9.11%), plastic bags (8.23%), glass (7.83%), wood (7.51%) and paper 5.32%.

Biodegradable waste was dominant fraction in rural area sample. Cardboard had notable share in this sample – 9.84%. Strangely for the sample from rural area, plastic bags and other packaging waste had high shares in this sample – 9.09 and 7.56% respectively. Besides mentioned fractions construction and demolition materials had shared of 8.65%.



Graph 2.31.: Comparison of waste composition according to the housing sector - the city of Podgorica

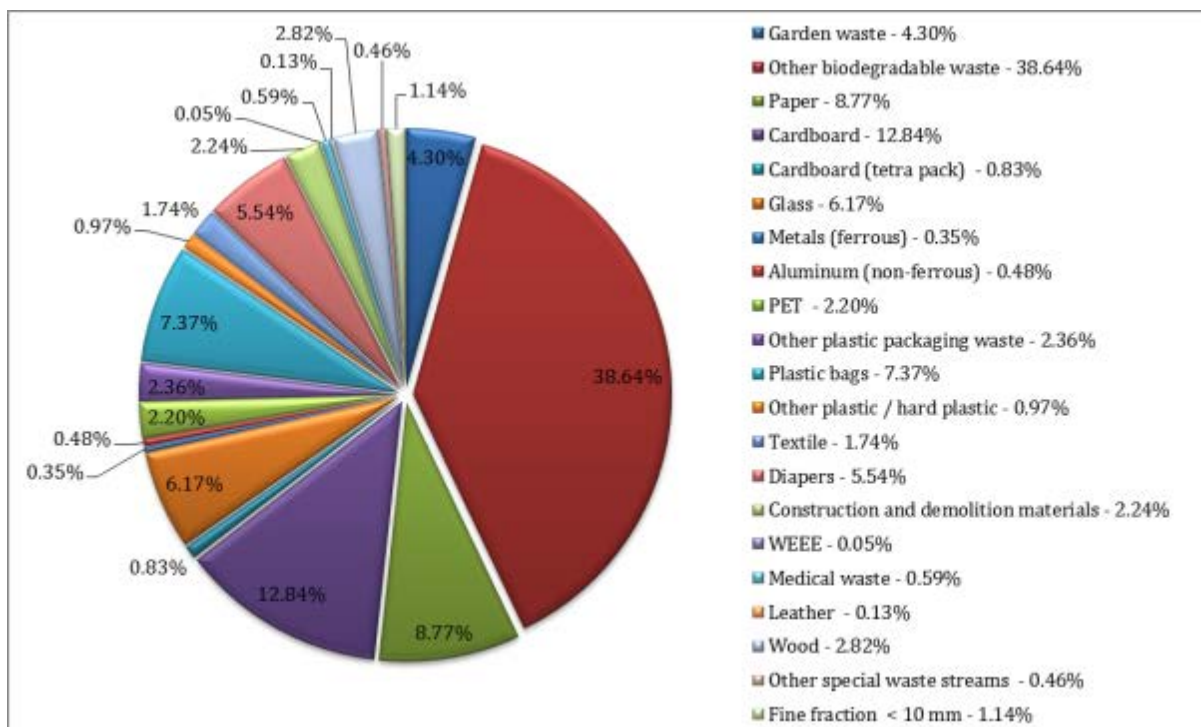
As it was previously stated, other biodegradable waste fraction is dominant one in all three of living sectors. It could be noted that garden waste had rather small share in all of samples, comparing to other biodegradable waste.

Cardboard had high shares in all three sectors, but it had the highest share in collective housing sector. Besides this, collective sector showed highest amount of paper as well.

Individual housing sector showed higher amount of glass and wood, when compared to other sectors.

Rural area strangely had higher amount of packaging waste, plastic bags, hard plastic, construction and demolition materials and medical waste, when compared to other sectors.

In order to get the whole municipality's morphological composition for this campaign, morphological composition of separate sector and share of people living in the corresponding sector were combined, and following graph was obtained. It shows that dominant fractions are "other biodegradable waste" 38.64%, garden waste 4.3%, cardboard 12.84%, paper 8.77%, glass 6.17% and diapers 5.54%. All other fractions have shares under 5%.

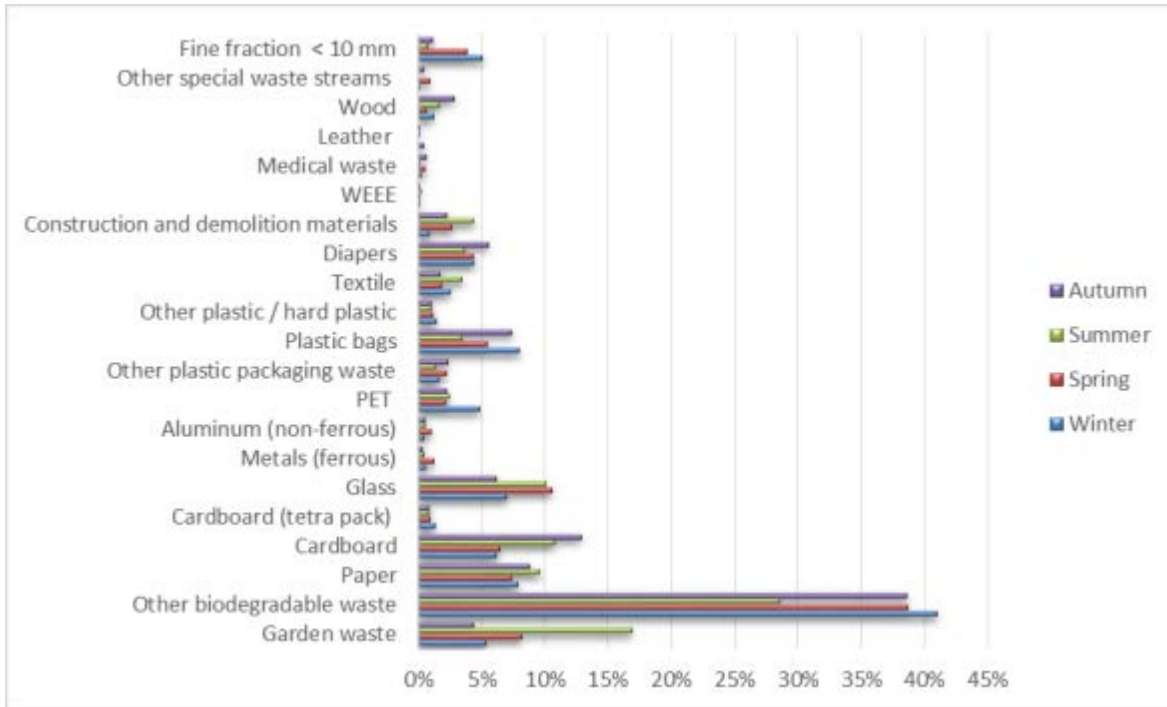


Graph 2.32: Morphological composition of waste in the city of Podgorica, for the autumn analysis

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

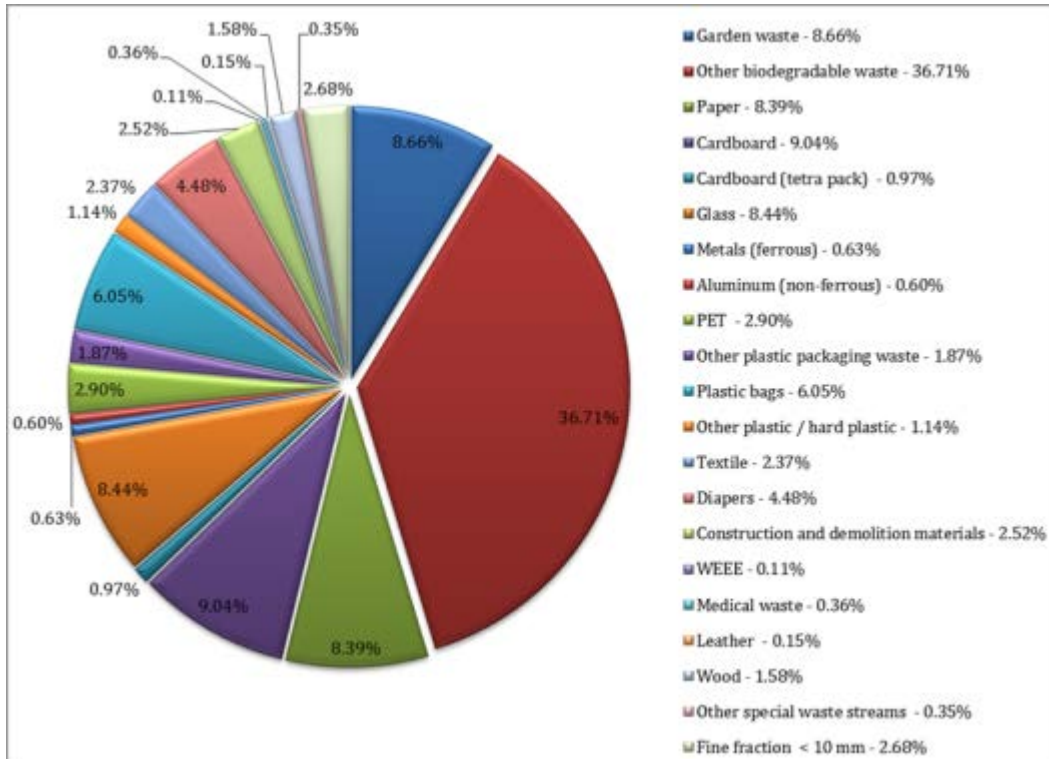
Table 2.20: Composition of municipal waste for four different seasons and the annual average value

Podgorica Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	5.31%	8.13%	16.88%	4.30%	<b>8.66%</b>
Other biodegradable waste	40.96%	38.68%	28.56%	38.64%	<b>36.71%</b>
Paper	7.86%	7.35%	9.57%	8.77%	<b>8.39%</b>
Cardboard	6.17%	6.42%	10.73%	12.84%	<b>9.04%</b>
Composite materials	1.30%	0.95%	0.83%	0.83%	<b>0.97%</b>
Glass	6.96%	10.55%	10.07%	6.17%	<b>8.44%</b>
Metals (ferrous)	0.56%	1.20%	0.43%	0.35%	<b>0.63%</b>
Aluminum (non-ferrous)	0.40%	0.97%	0.56%	0.48%	<b>0.60%</b>
PET	4.79%	2.17%	2.42%	2.20%	<b>2.90%</b>
Other plastic packaging waste	1.58%	2.18%	1.35%	2.36%	<b>1.87%</b>
Plastic bags	7.97%	5.42%	3.46%	7.37%	<b>6.05%</b>
Other plastic / hard plastic	1.41%	1.16%	1.00%	0.97%	<b>1.14%</b>
Textile	2.50%	1.78%	3.46%	1.74%	<b>2.37%</b>
Diapers	4.37%	4.38%	3.62%	5.54%	<b>4.48%</b>
Construction and demolition materials	0.82%	2.64%	4.35%	2.24%	<b>2.52%</b>
WEEE	0.12%	0.10%	0.19%	0.05%	<b>0.11%</b>
Medical waste	0.22%	0.55%	0.07%	0.59%	<b>0.36%</b>
Leather	0.40%	0.00%	0.08%	0.13%	<b>0.15%</b>
Wood	1.18%	0.66%	1.67%	2.82%	<b>1.58%</b>
Other special waste streams	0.06%	0.88%	0.00%	0.46%	<b>0.35%</b>
Fine fraction < 10 mm	5.04%	3.81%	0.71%	1.14%	<b>2.68%</b>



Graph 2.33: Comparison of seasonal fluctuations of fractions in the city of Podgorica

Comparison of the seasonal fluctuations showed the highest amount of garden waste during summer period by a significant margin. Other biodegradable waste had close values between different seasons, with an exception of summer campaign. Cardboard had slightly higher shares during the autumn and summer seasons. PET bottles had almost the same amount during all seasons, but during winter, when it had a slightly higher share. Glass had higher share during the summer and spring, while plastic bags had the share between 5 and 10% during three seasons (with exception of summer). Fractions like paper, cardboard, metals, packaging waste, hard plastic, textile, diapers, and even C&D materials, and so on..., had really close shares between four different analyses.



Graph 2.34: Average annual morphological composition for the whole city of Podgorica

Overall composition of waste in Podgorica showed that the other biodegradable waste made up to 36.71%, which is the one of the lesser values. Combined with the 8.66% of garden waste, total amount of biodegradable waste is 45.37%. Besides this, recyclables had a notably high shares - cardboard, paper and glass – 9.04, 8.39 and 8.44% respectively. Plastic bags had share of 6.05%, which is highest of all other sub fractions. Other than this, diapers had share of 4.48%, while all other fractions had a share under 4%.

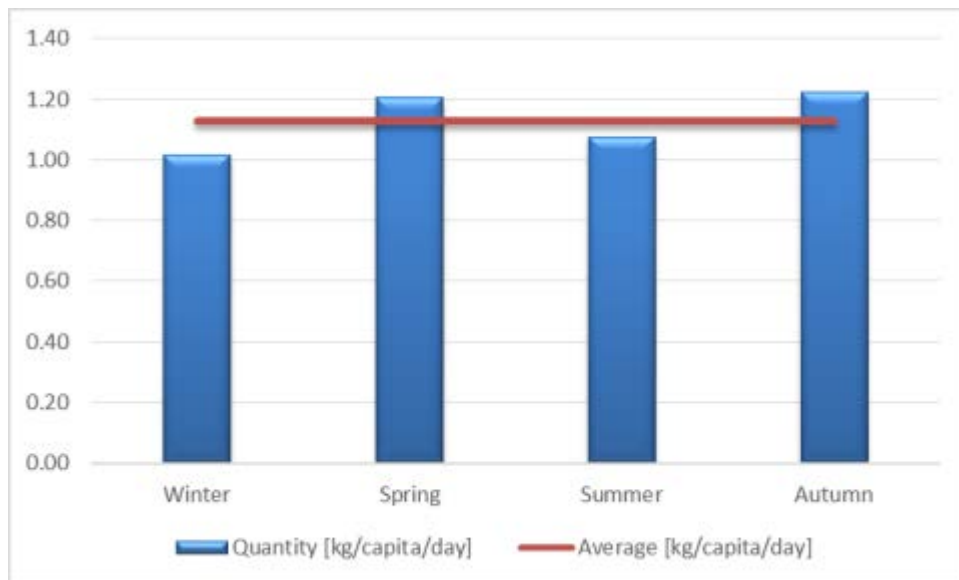


Picture 2.7: Analysis of morphological composition of waste at site – Podgorica

Continuous system of measurements of generated waste quantities is implemented in the city of Podgorica. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount for whole year are shown in table 2.21.

Table 2.21: Projection of obtained results

City of Podgorica	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	59,498.13	70,707.90	63,117.89	71,693.30	66,245.30
Number of residents	186,290	186,290	186,290	186,290	186,290
The population covered by the organized waste collection	160,694	160,692	160,691.61	160,691.61	160,694
Share of population under organized waste collection	86.26%	86.26%	86.26%	86.26%	86.26%
Waste generation (kg/capita/year)	370.26	440.02	392.79	446.15	412.30
Waste generation (kg/capita/day)	<b>1.01</b>	<b>1.21</b>	<b>1.08</b>	<b>1.22</b>	<b>1.13</b>
Total for whole city (t/year)	68,975.34	81,971.77	73,172.65	83,114.14	76,807.68



Graph 2.35: Overall annual fluctuations of generated waste expressed in kg/capita/day

Amount of generated waste in the city of Podgorica showed small deviations. The resulting end value after calculations was 1.13 kg/capita/day, while the highest amount was 1.22 kg/capita/day (autumn measurement campaign), while the lowest was 1.01 kg/capita/day (during winter measurement campaign).



## 2.8 MUNICIPALITY OF KOTOR

Analyzing waste composition of the municipality of Kotor, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

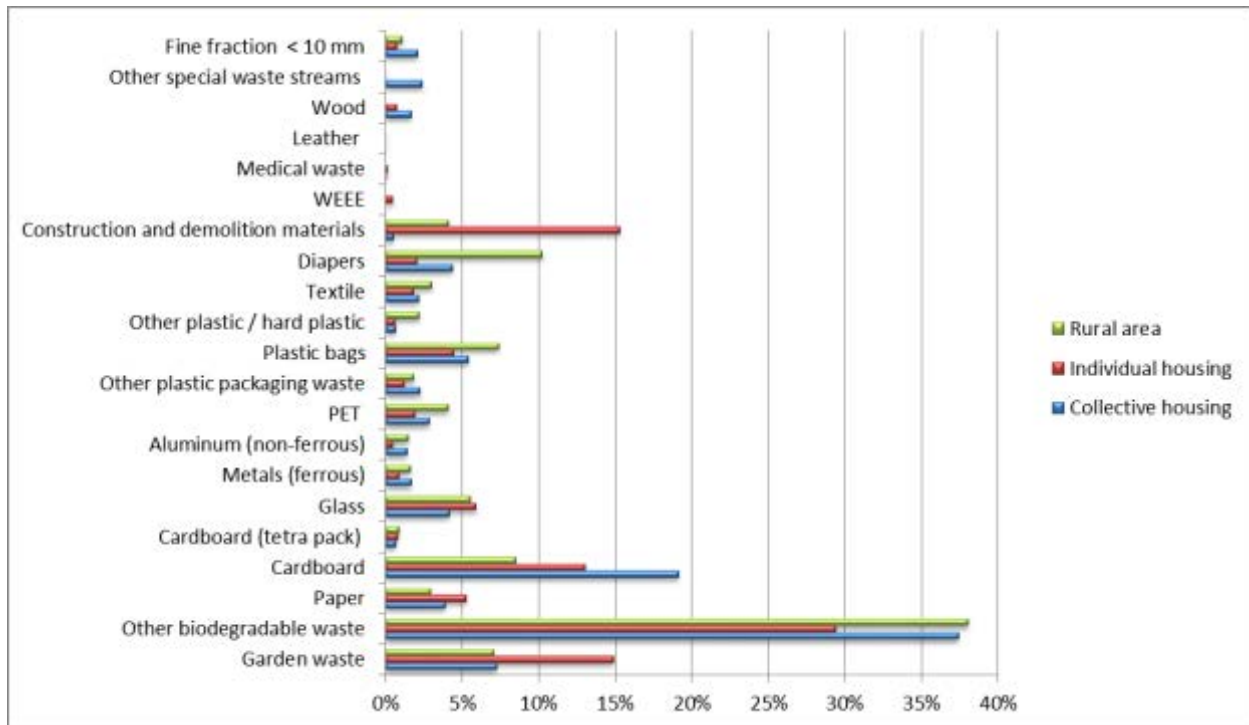
Table 2.22: Morphological composition of waste in the municipality of Kotor

Kotor Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	7.23%	14.88%	7.08%
Other biodegradable waste	37.40%	29.41%	38.02%
Paper	3.89%	5.27%	2.95%
Cardboard	19.13%	13.03%	8.47%
Composite materials	0.66%	0.79%	0.88%
Glass	4.14%	5.91%	5.54%
Metals (ferrous)	1.67%	0.87%	1.61%
Aluminum (non-ferrous)	1.42%	0.47%	1.46%
PET	2.86%	1.91%	4.08%
Other plastic packaging waste	2.26%	1.25%	1.85%
Plastic bags	5.40%	4.45%	7.37%
Other plastic / hard plastic	0.66%	0.61%	2.20%
Textile	2.18%	1.81%	3.03%
Diapers	4.35%	2.02%	10.25%
Construction and demolition materials	0.51%	15.27%	4.12%
WEEE	0.00%	0.47%	0.00%
Medical waste	0.08%	0.15%	0.00%
Leather	0.00%	0.00%	0.00%
Wood	1.67%	0.71%	0.00%
Other special waste streams	2.41%	0.00%	0.00%
Fine fraction < 10 mm	2.08%	0.73%	1.10%

In collective housing sector, garden waste (with rather small share) combined with other biodegradable waste had a total share of 44.63%. Among all other fractions, cardboard had extremely high share of 19.13. Plastic bags fraction had the highest share among all plastic sub fractions. Glass fraction had drastic decrease in quantity when compared with its share during summer period, and it notes share of only 4.14%.

Individual sector had high share of both garden and other biodegradable waste (14.88 and 29.41%). Among the recyclables, similarly to collective housing sample, cardboard had the highest share – 13.03%. This sample, on the other hand, showed very high amount of C&D materials (15.27%). Besides glass and paper, all other fractions had shares under 5%.

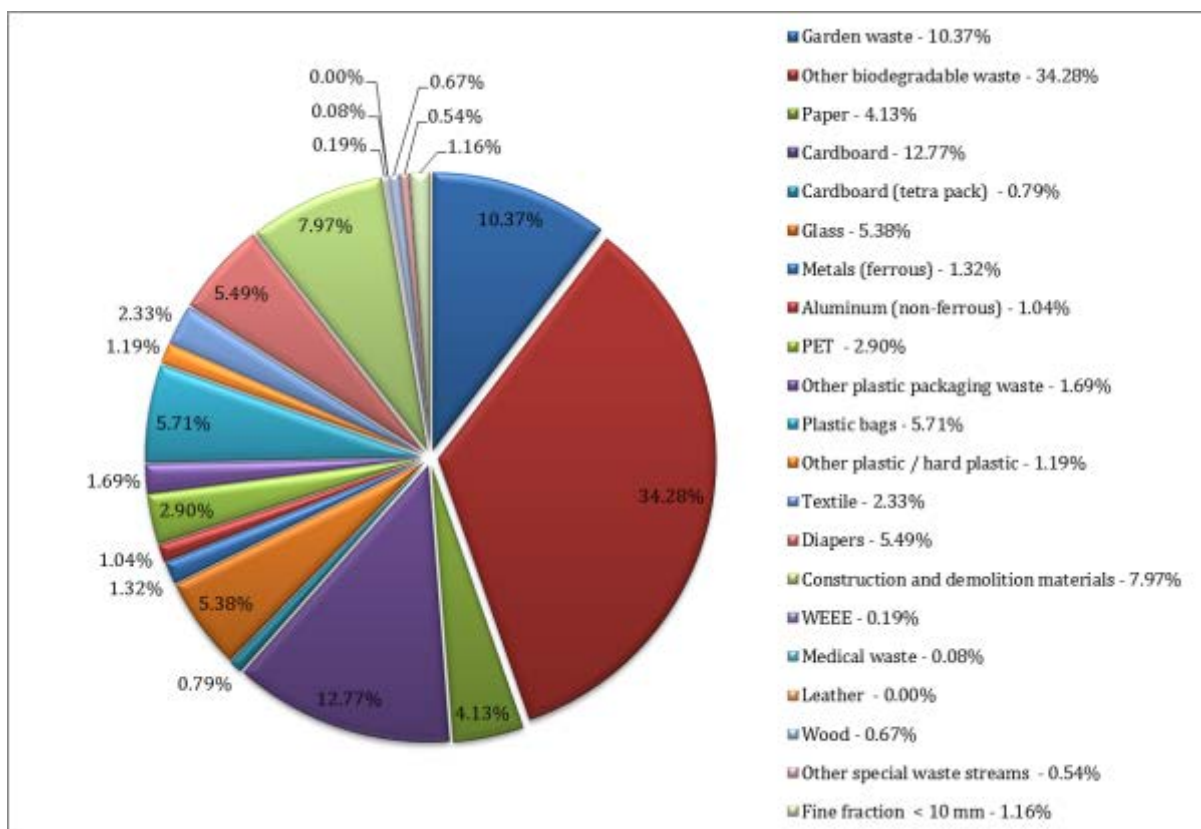
Rural area sample showed that nearly half of total weight was biodegradable waste, with its two sub categories (45.1%). This sample had lesser shares of potentially recyclables, so paper and cardboard make little over 10%. Plastic bags and PET bottles had the two highest shares among other plastic categories, with 7.37 and 4.08%. Other than this, diapers had notable share of 10.25%.



Graph 2.36: Comparison of waste composition according to the housing sector - the municipality of Kotor, autumn measurement

Among all three samples, “other biodegradable waste” fraction had the highest mass share. Certain fractions (which would be noted afterwards) have higher share in different housing sectors, but fractions like textile, plastic bags, packaging waste, PET, metals, glass, tetra pack, paper have similar shares in all three sectors. Collective housing sector had highest shares of cardboard and wood, comparing to other sectors. The biggest amount of C&D materials and garden waste was presented in individual housing sector, while rural area sector had the highest amounts of diapers.

Total morphological composition of waste for Kotor municipality is shown on following figure. The figure shows a high amount of biodegradable waste (close to 45%). It is interesting that waste composition in Kotor is highly heterogeneous (meaning that numerous fractions have rather high shares). Among those fractions cardboard is predominant with 12.77% share. Other fractions with notable share are glass 5.38%, plastic bags (5.71%) and fine fraction materials 7.97%.

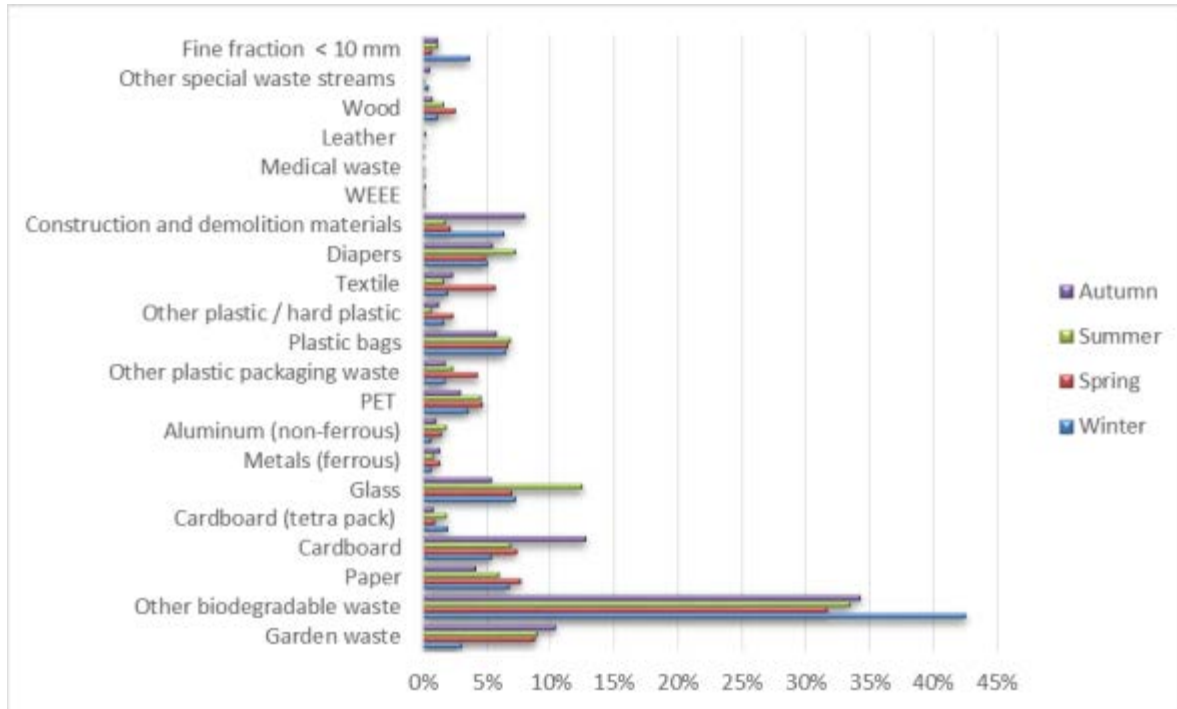


Graph 2.37: Morphological composition of waste in the Kotor municipality, autumn analysis

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

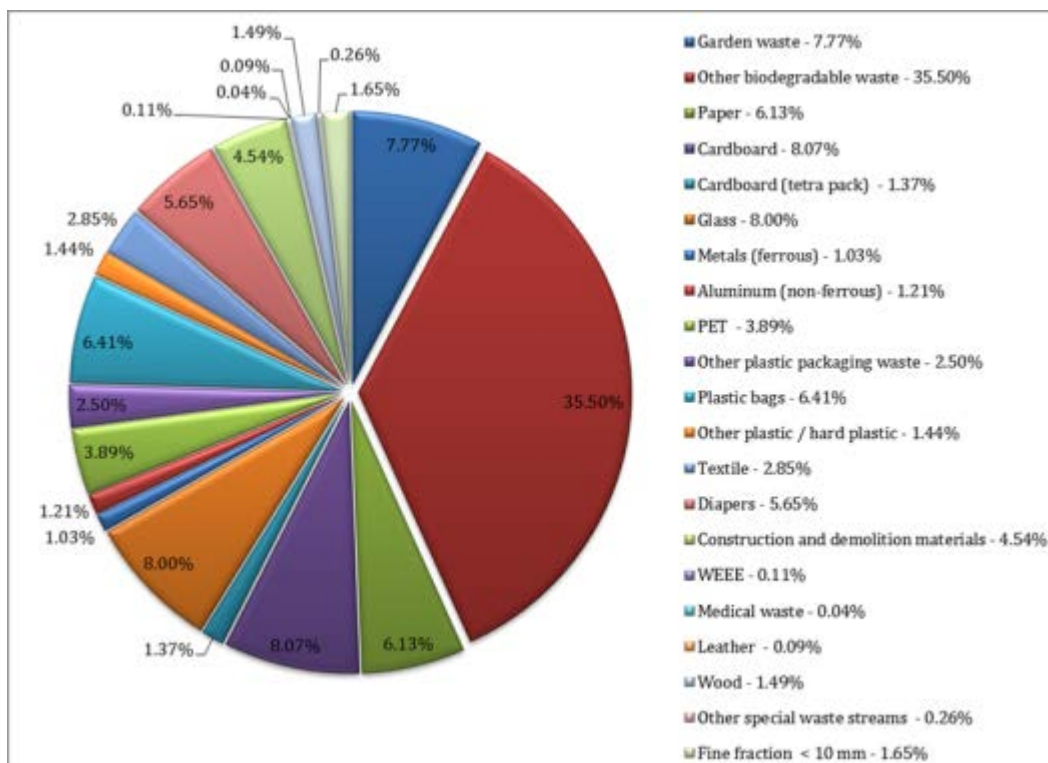
Table 2.23: Composition of municipal waste for four different seasons and the annual average value

Kotor	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	3.01%	8.80%	8.92%	10.37%	7.77%
Other biodegradable waste	42.54%	31.68%	33.48%	34.28%	35.50%
Paper	6.78%	7.67%	5.92%	4.13%	6.13%
Cardboard	5.30%	7.32%	6.87%	12.77%	8.07%
Composite materials	1.96%	0.88%	1.84%	0.79%	1.37%
Glass	7.23%	6.90%	12.50%	5.38%	8.00%
Metals (ferrous)	0.63%	1.31%	0.85%	1.32%	1.03%
Aluminum (non-ferrous)	0.58%	1.42%	1.80%	1.04%	1.21%
PET	3.52%	4.64%	4.50%	2.90%	3.89%
Other plastic packaging waste	1.72%	4.28%	2.29%	1.69%	2.50%
Plastic bags	6.42%	6.69%	6.84%	5.71%	6.41%
Other plastic / hard plastic	1.63%	2.36%	0.59%	1.19%	1.44%
Textile	1.88%	5.62%	1.58%	2.33%	2.85%
Diapers	5.05%	4.84%	7.23%	5.49%	5.65%
Construction and demolition materials	6.31%	2.17%	1.71%	7.97%	4.54%
WEEE	0.12%	0.08%	0.04%	0.19%	0.11%
Medical waste	0.02%	0.08%	0.00%	0.08%	0.04%
Leather	0.11%	0.00%	0.25%	0.00%	0.09%
Wood	1.15%	2.51%	1.62%	0.67%	1.49%
Other special waste streams	0.43%	0.07%	0.00%	0.54%	0.26%
Fine fraction < 10 mm	3.61%	0.64%	1.17%	1.16%	1.65%



Graph 2.38: Comparison of seasonal fluctuations of fractions in Kotor municipality

Fluctuations between waste fractions are interesting in the Kotor municipality, mainly because the municipality is located on the Montenegro seaside, and because it is one of the most attractive tourist destinations. This fact waste influences generation rates per capita daily during different seasons, as well as the waste compositions. One of better examples is big quantity of glass during the summer period. Cardboard also had a notable increase in its share during the autumn campaign, while plastic packaging waste had the highest value during the spring season measurements. On the other hand fractions like diapers, plastic bags and PET had small fluctuations. Winter period had the highest amounts of fine fraction materials, other biodegradable waste, while it had the smallest amount of garden waste. Garden waste had the highest share during the autumn campaign analysis, while C&D materials had the highest shares during autumn and winter season.



Graph 2.39: Average annual morphological composition for the whole municipality of Kotor

Overall waste composition is shown on the graph above. 35.58% of waste is “other biodegradable waste”. Garden waste makes up to 7.77%. Recyclables had reasonable high shares during all four analyses, so the average values are pretty high were well. Highest share of recyclables had cardboard (8.07%), and it is followed by glass and paper (8.00 and 6.13% respectively). Plastic bags fraction had the highest share among all the other sub fractions (6.41%), but in this case, PET and plastic packaging waste fractions had notable high shares (3.89 and 2.50%). Besides this, diapers and construction materials should be mentioned with 5.65 and 4.54%. Both sub fractions of metals have relatively high shares when compared to other municipalities from the region.

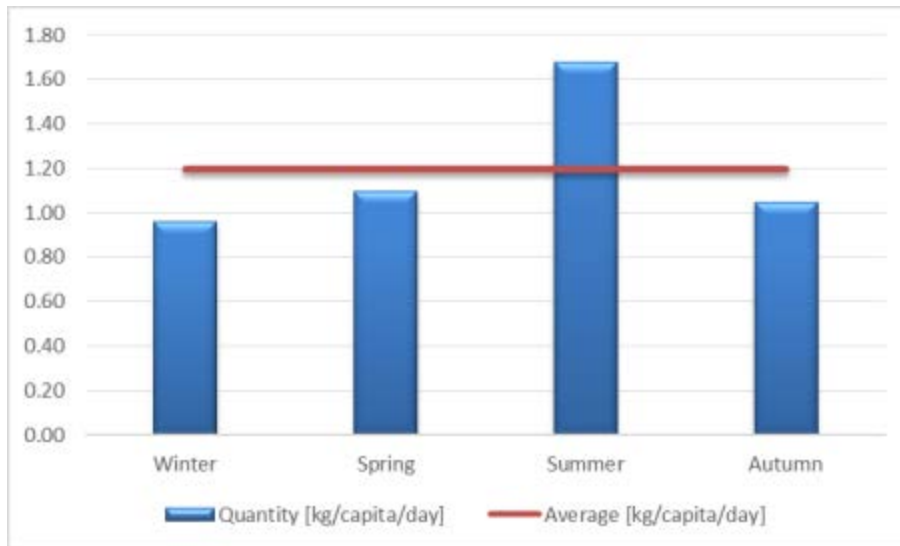


Picture 2.8: Analysis of morphological composition of waste at site – Kotor

Municipality of Kotor has a continuous measurement of waste quantities on the weighbridge. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount for whole year are shown in table 2.24.

Table 2.24: Projection of obtained results

Municipality of Kotor	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	7,949.70	9,046.79	13,843.41	8,667.19	9,876.77
Number of residents	22,644	22,644	22,644	22,644	22,644
The population covered by the organized waste collection	22,644	22,644	22,644	22,644	22,644
Share of population under organized waste collection	100.00%	100.00%	100.00%	100.00%	100.00%
Waste generation (kg/capita/year)	351.07	399.52	611.35	382.76	436.18
Waste generation (kg/capita/day)	<b>0.96</b>	<b>1.09</b>	<b>1.67</b>	<b>1.05</b>	<b>1.20</b>
Total for whole municipality (t/year)	7,949.70	9,046.79	13,843.41	8667.19	9,876.77



Graph 2.40: Overall annual fluctuations of generated waste expressed in kg/capita/day

As it was previously stated, municipality of Kotor, with the city of Kotor, is located on the seaside. It is one of the most visited cities of Montenegro during the summer season. Because of increased number of people who reside in the municipality of Kotor, higher waste amounts are generated. It can be seen that the summer quantities of generated waste per capita daily during summer are nearly 1.75 times higher than the quantities generated during winter. Spring and autumn quantities are nearly the same. Overall amount of generated waste amounts 1.20 kg/capita/day.

Municipality of Kotor reported that the quantities of waste were measured before this project. Total amount of waste for municipality Kotor was 11,820 t for year 2013. On the other hand, for the year 2013 there are data of quantities of specific waste fractions that were separated and exported market. However, exported amount of waste was not only from the municipality of Kotor only – this amount comes from municipality of Kotor and the municipality of Tivat. Amounts of exported waste fractions are:

- ✓ Paper and cardboard - 383.12 t
- ✓ Plastic – 85.11 t
- ✓ Plastic packaging waste – 111.34 t
- ✓ Metal packaging waste – 2.84 t
- ✓ Other metals – 18.4 t

It was stated that morphological composition analysis was conducted during the year 2013, by the “Aptisa” agency, but these data were not presented.



## 2.9 MUNICIPALITY OF CAZIN

Analyzing waste composition in the Municipality of Cazin, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results from an autumn campaign are presented in the following table.

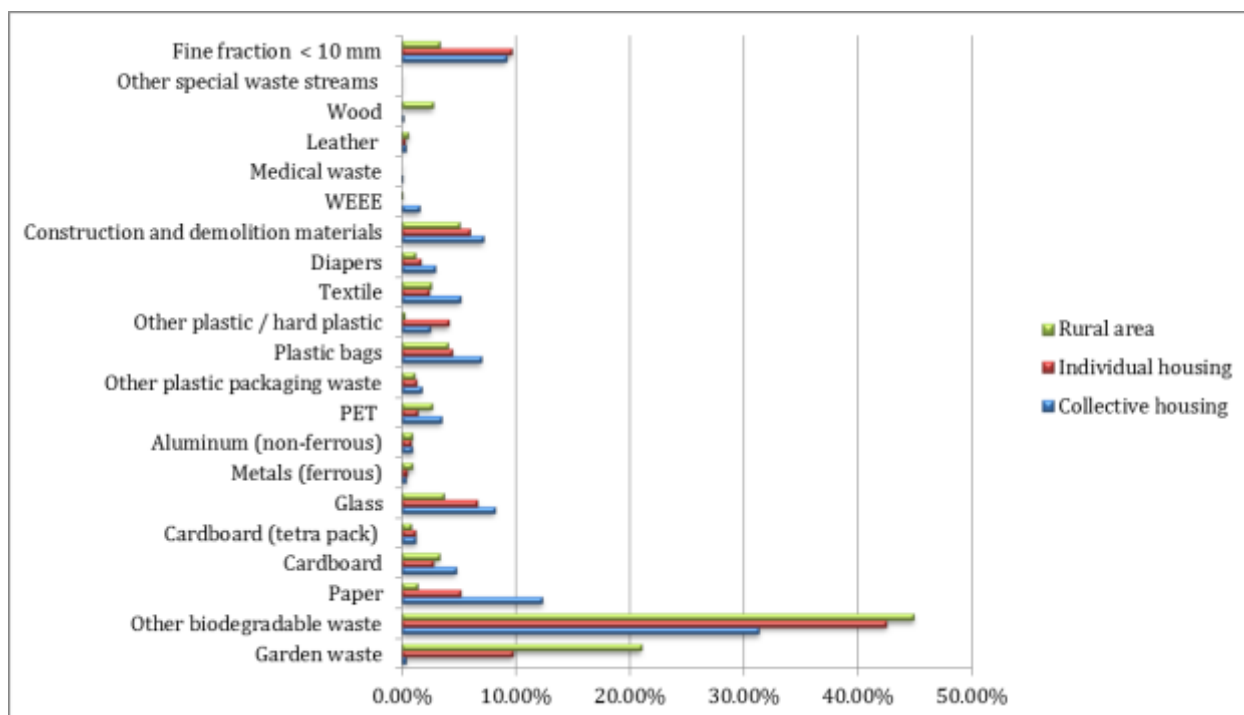
Table 2.25: Morphological composition of waste – Municipality of Cazin – autumn campaign

Cazin Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	0.32%	9.72%	21.00%
Other biodegradable waste	31.33%	42.54%	44.91%
Paper	12.30%	5.09%	1.32%
Cardboard	4.71%	2.74%	3.27%
Composite materials	1.18%	1.19%	0.78%
Glass	8.11%	6.62%	3.66%
Metals (ferrous)	0.34%	0.44%	0.93%
Aluminum (non-ferrous)	0.89%	0.78%	0.88%
PET	3.45%	1.34%	2.62%
Other plastic packaging waste	1.70%	1.27%	1.09%
Plastic bags	6.93%	4.40%	3.99%
Other plastic / hard plastic	2.47%	4.06%	0.23%
Textile	5.09%	2.33%	2.54%
Diapers	2.90%	1.63%	1.14%
Construction and demolition materials	7.13%	5.92%	5.03%
WEEE	1.52%	0.00%	0.05%
Medical waste	0.06%	0.00%	0.00%
Leather	0.32%	0.28%	0.54%
Wood	0.11%	0.00%	2.72%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	9.14%	9.65%	3.29%

Dominant fraction for collective housing was "other biodegradable waste" with mass share of 31.33%. Potentially recyclable components in waste with relatively large share were paper and glass with proportions of 12.30% and 8.11%, respectively. Plastic with its four subcategories had a notable share with 14.55%. Noteworthy were amounts of fine fraction (9.14%) and construction and demolition materials (7.13%).

In individual housing, dominant category of waste also was an organic waste with its two subcategories, with a proportion of 52.26%. From the recyclable categories significant proportion had paper (5.09%) and glass (6.62%). Metals with its two subcategories constitute 1.22% of the sample mass. From other categories of waste significant were the proportions of fine elements (9.65%) and C&D materials (5.92%). Four categories of waste didn't appear at all.

Sample from rural area showed a higher proportion of organic waste, with its two subcategories, more than 65% of the sample mass. From potentially recyclable fractions, cardboard (3.27%) glass (3.66%) and plastic bags (3.99%) had a proportion above 3%. In the analyzed sample notable was an amount of C&D materials, with mass share of 5.03%.



Graph 2.41: Comparison of waste composition according to the housing sector – Municipality of Cazin – autumn campaign

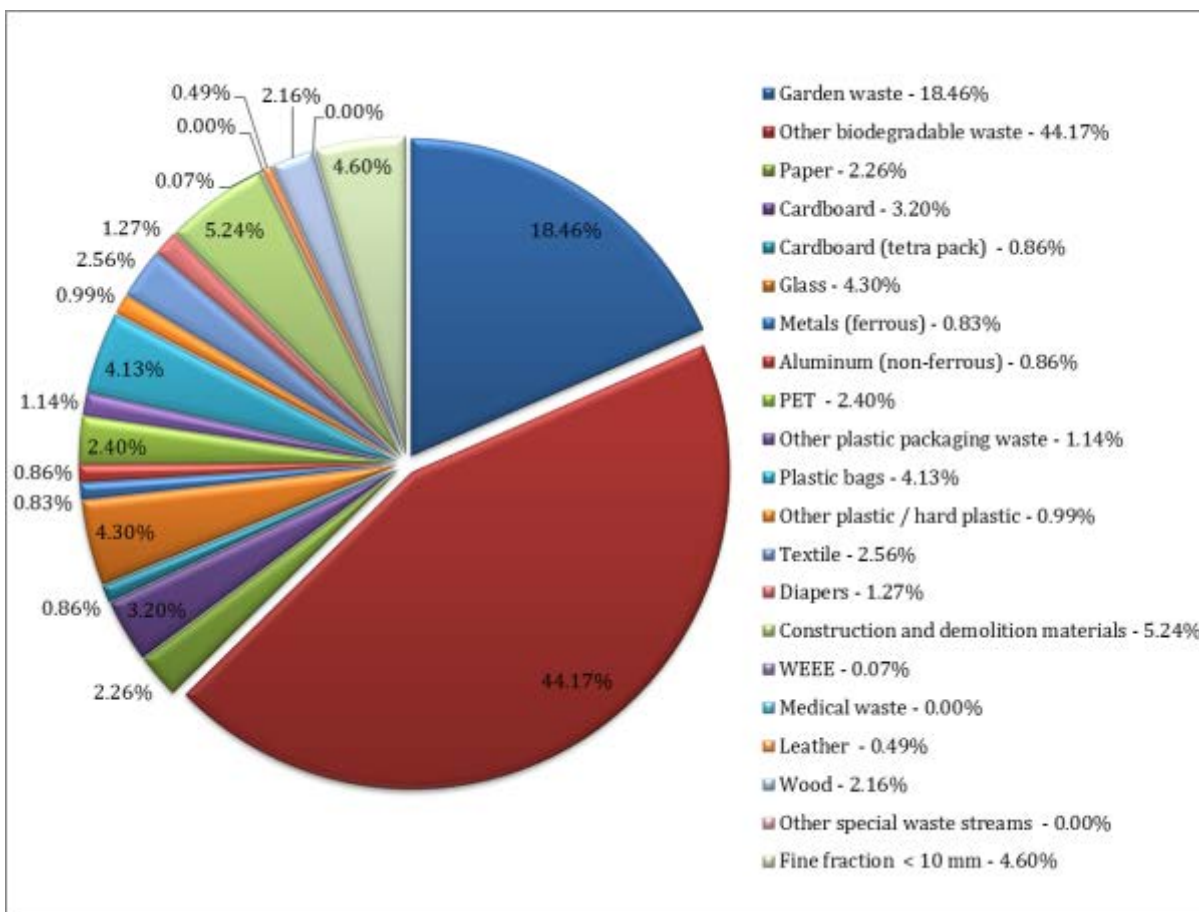
"Other biodegradable waste" represents the most dominant fraction for each of living zones within municipal of Cazin, and mass share is the lowest in the collective housing. Collective housing was dominant regarding paper, cardboard, glass, plastic waste, textile and C&D materials. Individual housing had greater amounts of fine elements in comparison to other two living sectors. Rural area recorded greater amounts of garden waste and wood in comparison to other two living sectors.

Medical waste, leather and other special waste streams practically didn't have any portion in analyzed samples.



Picture 2.9: Analysis of morphological composition of waste at site – Cazin

Taking into account the share, i.e. the total number of people living within the urban I sector (2.16%), urban II (18.57) and rural sector (79.27%) within the municipality, it is possible to determine the average composition of waste for the entire municipality of Cazin. It is evident that the biodegradable fraction, consisted of garden and other biodegradable waste was the most represented, with a total mass share of 62.63%. There was also a relatively large amount of construction and demolition waste and fine elements with mass share of 5.24% and 4.60%, respectively. From potentially recyclable fractions glass and plastic bags had mass share of 4.30% and 4.13%, respectively. Remaining fractions didn't have significant values and were in the range of expected, with proportions up to 4%.



Graph 2.42: Average morphological waste composition (%) for the municipality of Cazin – autumn campaign

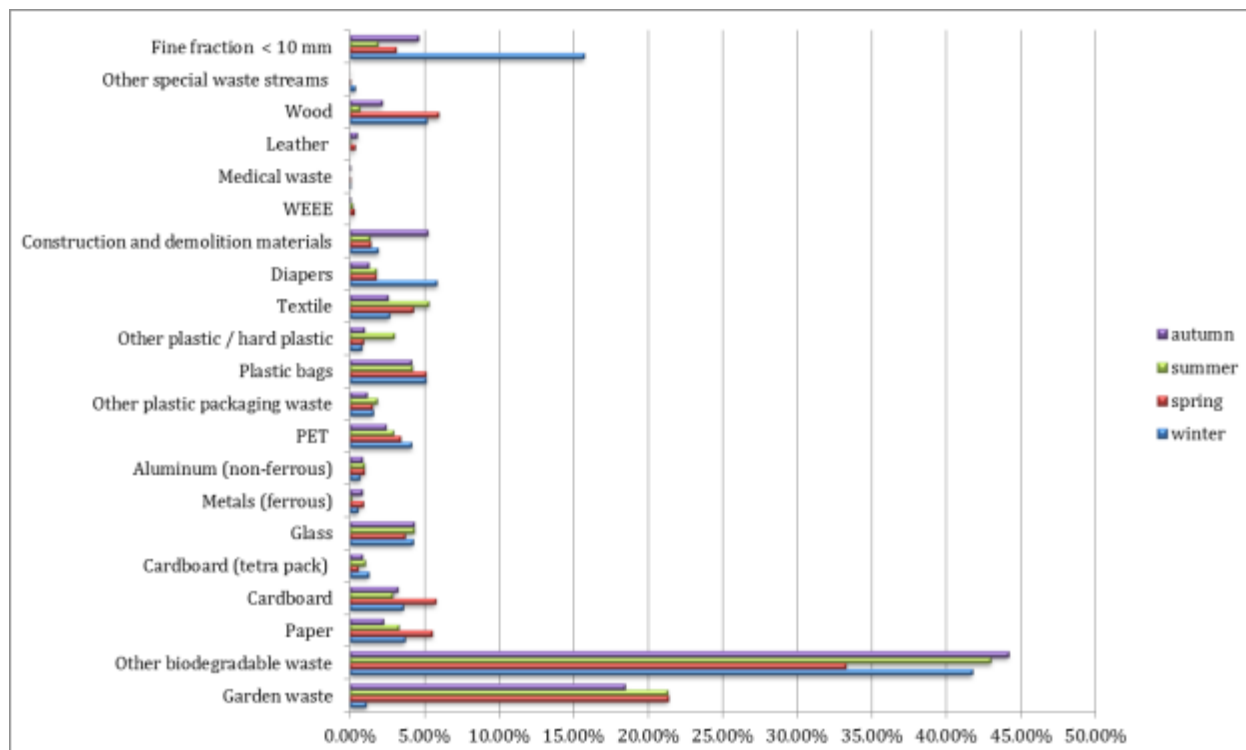
Obtained results from waste composition analysis, for four different seasons are presented in the following table. Based on the share of the population living within the collective, individual and rural parts of the municipality of Cazin, average composition of the municipal waste for each campaign of measurement has been determined. Annual average composition of municipal waste has been also determined.

Table 2.26: Composition of municipal waste for four different seasons and the annual average value

Cazin Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	1.11%	21.35%	21.31%	18.46%	<b>15.56%</b>
Other biodegradable waste	41.73%	33.25%	42.98%	44.17%	<b>40.53%</b>
Paper	3.70%	5.54%	3.27%	2.26%	<b>3.69%</b>
Cardboard	3.56%	5.76%	2.86%	3.20%	<b>3.85%</b>
Composite materials	1.25%	0.55%	1.05%	0.86%	<b>0.93%</b>
Glass	4.24%	3.70%	4.31%	4.30%	<b>4.14%</b>
Metals (ferrous)	0.53%	0.91%	0.14%	0.83%	<b>0.60%</b>
Aluminum (non-ferrous)	0.68%	0.97%	0.99%	0.86%	<b>0.88%</b>
PET	4.14%	3.42%	2.94%	2.40%	<b>3.22%</b>
Other plastic packaging waste	1.56%	1.50%	1.84%	1.14%	<b>1.51%</b>
Plastic bags	5.10%	5.09%	4.17%	4.13%	<b>4.62%</b>
Other plastic / hard plastic	0.80%	0.90%	2.97%	0.99%	<b>1.42%</b>
Textile	2.64%	4.22%	5.30%	2.56%	<b>3.68%</b>
Diapers	5.84%	1.73%	1.76%	1.27%	<b>2.65%</b>
Construction and demolition materials	1.90%	1.41%	1.36%	5.24%	<b>2.48%</b>
WEEE	0.00%	0.29%	0.21%	0.07%	<b>0.14%</b>
Medical waste	0.00%	0.01%	0.00%	0.00%	<b>0.00%</b>
Leather	0.00%	0.36%	0.03%	0.49%	<b>0.22%</b>
Wood	5.17%	5.95%	0.64%	2.16%	<b>3.48%</b>
Other special waste streams	0.35%	0.02%	0.00%	0.00%	<b>0.09%</b>
Fine fraction < 10 mm	15.69%	3.09%	1.87%	4.60%	<b>6.31%</b>

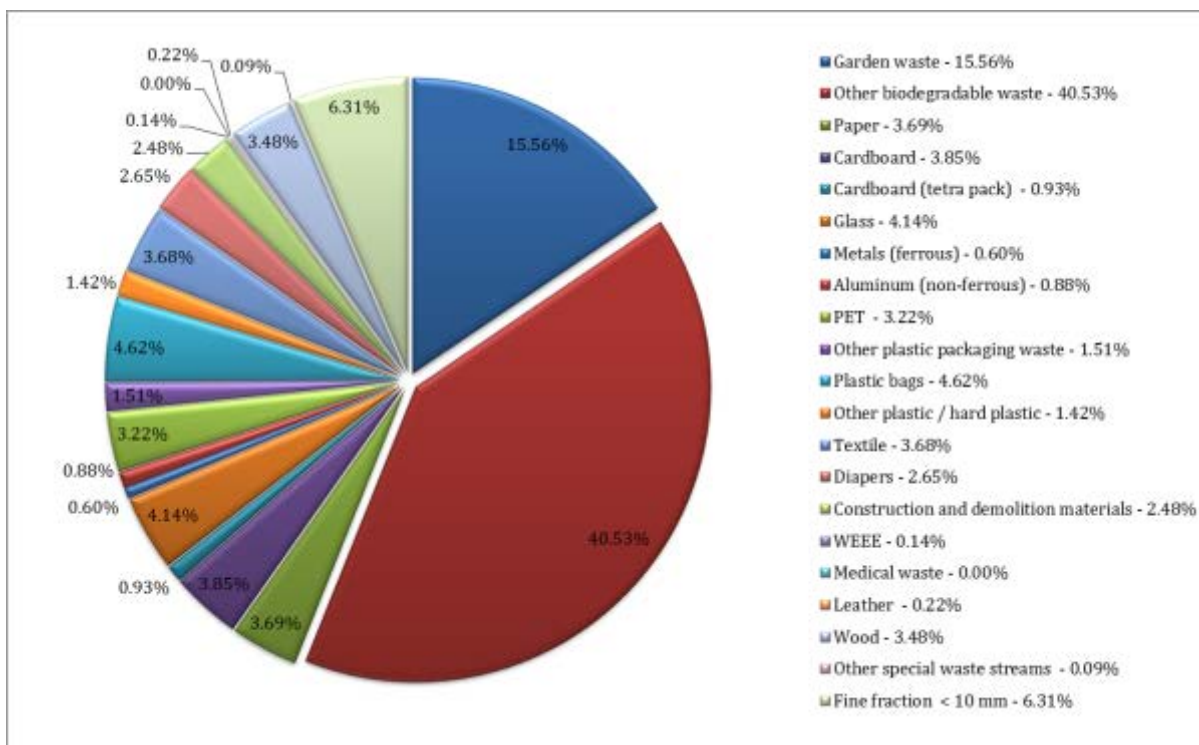
Comparing the average composition of waste according to the period of sampling within the municipality of Cazin it can be observed significant variations in the proportion of organic waste and fine fraction. Garden waste recorded proportion of only 1% in winter period while in other three campaigns proportion was about 20%. "Fine fraction" recorded the greatest amount in winter period as a consequence of heating seasons, great amount of ash. Paper and cardboard had a higher mass share in the spring season, while glass had the lowest value in spring. Plastic with its four subcategories didn't show significant variation. Textile had the greatest amount in summer period

and diapers had the greatest proportions in winter campaign of measurement. In autumn campaign was recorded a higher mass share of C&D materials in comparison to other three campaigns. Wood had higher proportions in winter and spring.



Graph 2.43: Comparison of waste composition according to the period of analysis – Cazin

Based on the measurements during the four seasons, an annual average composition of waste can be calculated for the municipality of Cazin. "Other biodegradable waste" is the dominant waste category with mass share of 40.53% that together with garden waste constitute more than 55% of the municipal waste. After these categories of waste "fine fraction" has the highest proportion with 6.31%. From potentially recyclable categories, notable is the amount of plastic bags and glass that have a proportion of 4.62% and 4.14%, respectively. All other categories of waste are represented by mass share up to 4%.



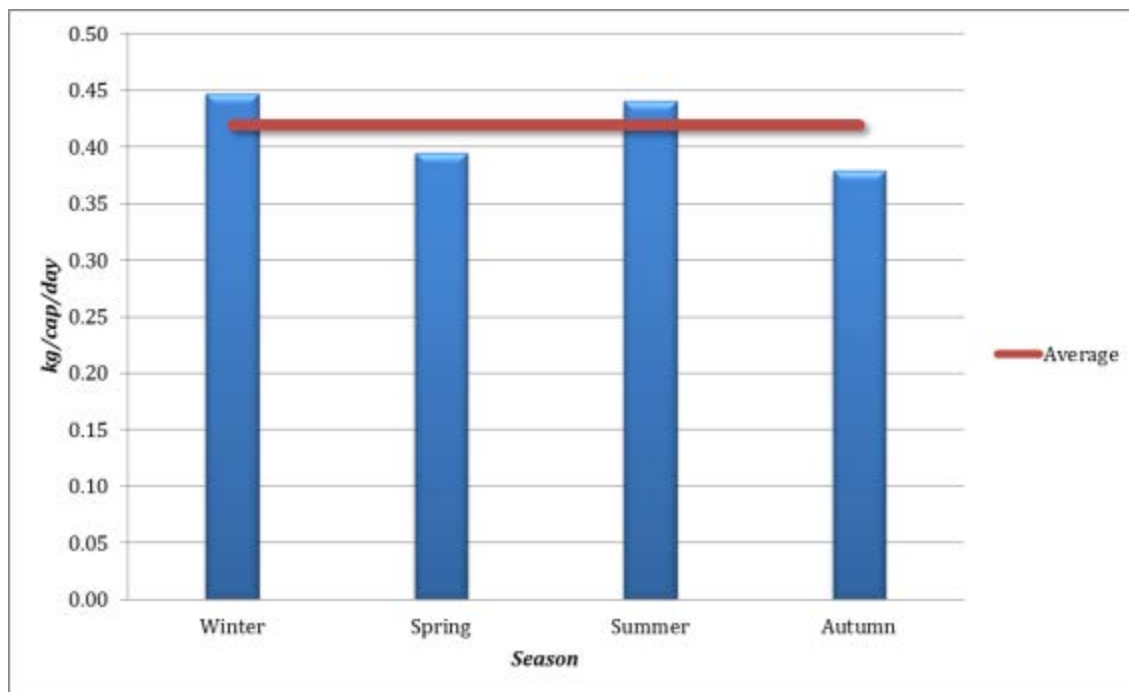
Graph 2.44: Annual average composition of municipal waste – Cazin

In the Municipality of Cazin, during the measurement of waste trucks on weighbridge in the autumn period, 153.07 tons of waste were collected. According to these measurements, results for autumn season expressed in the form of “per capita”, shows that the average resident of Cazin generates only 0.38 kg on a daily basis, which is quite low.

Table 2.27: Projection of obtained results

Municipality of Cazin	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	9397.71	8312.61	9276.21	7981.51	8742.01
Number of residents	69411	69411	69411	69411	69411
The population covered by the organized waste collection	57632	57632	57632	57632	57632
Share of population under organized waste collection	83.03%	83.03%	83.03%	83.03%	83.03%
Waste generation (kg/capita/year)	163.06	144.24	160.96	138.49	151.69
Waste generation (kg/capita/day)	<b>0.45</b>	<b>0.40</b>	<b>0.44</b>	<b>0.38</b>	<b>0.42</b>
Total for whole city (t/year)	11318.45	10011.58	11172.12	9612.80	10528.74

Taking into account four measurements during the year, it can be concluded that the average amount of waste collected by the PUC is 8742 tons annually. Percentage of population in the municipality covered by organized collection is about 83%, which leads to the conclusion that one citizen of Cazin generates 151.69 kg per year or 0.42 kg daily. Comparing results per season it can be concluded that generation rate is higher in winter and summer, than in spring and autumn.



Graph 2.45: Comparison of waste generation rate (kg/cap/day) according to the season

Before this project in the municipality of Cazin was some estimates about municipal waste volume, so this project was very useful for PUC, so they have basic data about waste composition and quantity.

The benefits of this project are detailed analysis of generated waste quantity and also for waste composition, it was conducted four measurements for four seasons, it can be observed variations in waste quantity and composition during the year.



## 2.10 MUNICIPALITY OF PRIJEDOR

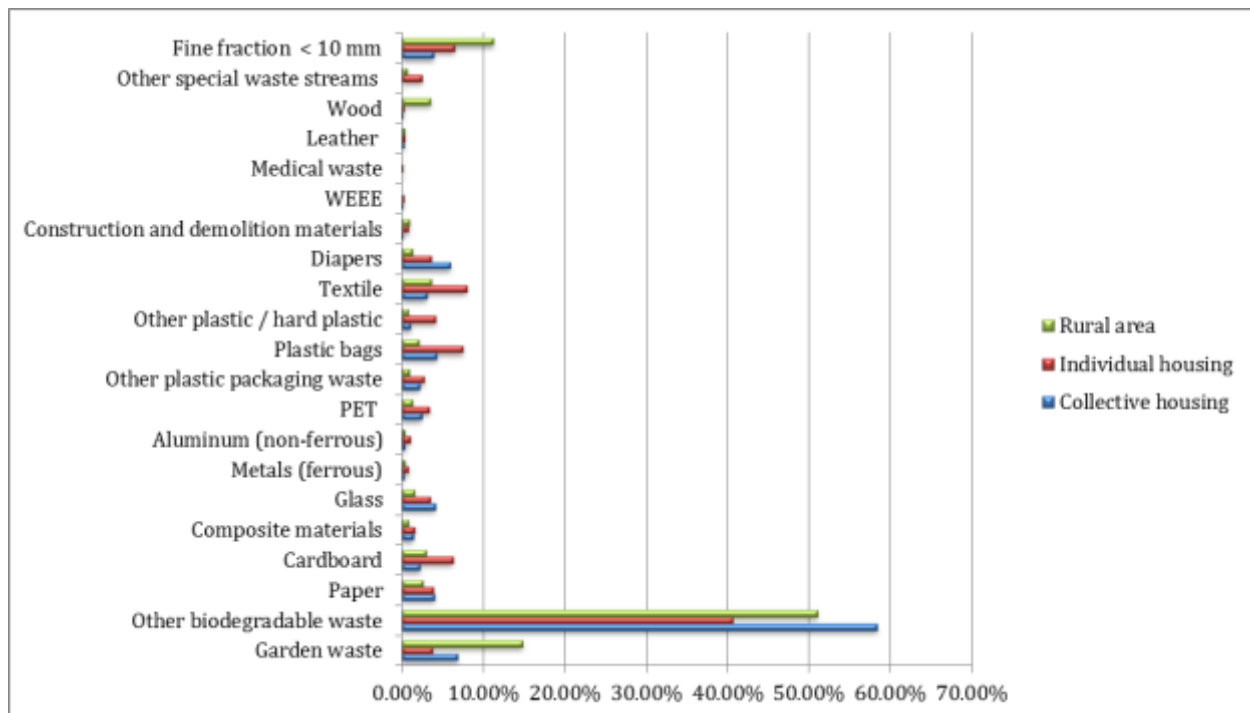
In Municipality of Prijedor, three samples were taken and analyzed, in accordance with the methodology, for purpose of autumn campaign. Organic fraction (consisted of garden and other biodegradable waste) represented about 65% of sample mass for a zone of collective housing. In analyzed sample was a great amount of diapers, with a proportion of 5.86%. From recyclable categories of waste, notable were the proportions of plastic bags (4.21%) and glass (4.05%), paper had a mass share of 3.95%. Fine fraction had mass share of 3.86%. All other categories of waste were in the range of expected, with proportion up to 3%.

Table 2.28: Morphological composition of waste – Municipality of Prijedor – autumn campaign

Prijedor	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	6.78%	3.61%	14.77%
Other biodegradable waste	58.35%	40.55%	51.05%
Paper	3.95%	3.82%	2.51%
Cardboard	2.19%	6.20%	2.90%
Composite materials	1.34%	1.50%	0.72%
Glass	4.05%	3.40%	1.48%
Metals (ferrous)	0.26%	0.75%	0.36%
Aluminum (non-ferrous)	0.33%	0.96%	0.31%
PET	2.33%	3.31%	1.22%
Other plastic packaging waste	2.07%	2.65%	0.84%
Plastic bags	4.21%	7.46%	2.03%
Other plastic / hard plastic	1.01%	4.06%	0.67%
Textile	2.99%	7.85%	3.59%
Diapers	5.86%	3.52%	1.17%
Construction and demolition materials	0.05%	0.75%	0.89%
WEEE	0.05%	0.21%	0.00%
Medical waste	0.00%	0.06%	0.00%
Leather	0.26%	0.30%	0.29%
Wood	0.07%	0.24%	3.45%
Other special waste streams	0.00%	2.41%	0.60%
Fine fraction < 10 mm	3.86%	6.38%	11.15%

In the individual housing, dominant category of waste was other biodegradable and kitchen waste, with mass share of 40.55%. From potentially recyclable category, dominant were cardboard and plastic bags with mass share of 6.20% and 7.46%, respectively. Plastic with its four subcategories constitute 17.48% of sample mass. Metals as usual, had a proportion up to 1%. Notable proportion had textile and “fine fraction” with 7.85% and 6.38, respectively.

Sample from rural area showed that almost 65% of the sample represents an organic fraction, with its two subcategories. Considering this it's not surprising, that all other categories of waste had smaller proportions. Noteworthy was an amount of fine elements 11.15%. Above 3% of mass share were wood (3.45%) and textile (3.59%), while all other categories had proportion up this value.



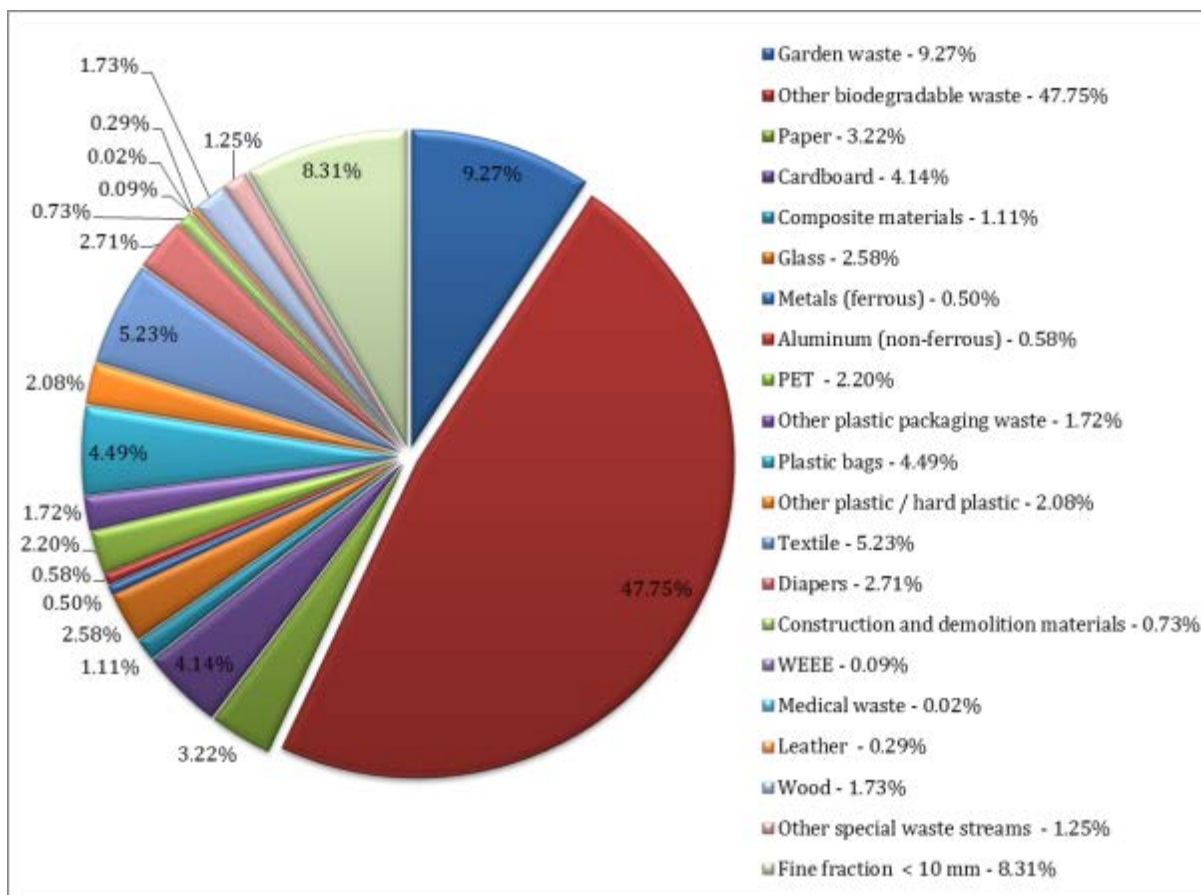
Graph 2.46: Comparison of waste composition according to the housing sector – Municipality of Prijedor – autumn campaign

Comparing the results obtained by the analysis of samples from all three sectors, it can be seen that the sample from a rural area is dominant regarding garden waste, wood and fine fraction. Collective housing is characterized by an increased share of “other biodegradable waste” and diapers in comparison to the remaining two residential zones. Cardboard and all four subcategories of plastic recorded the highest proportions in the zone of individual housing. Other categories of waste didn't have significant values, and significant variations haven't been observed with respect to the zone of residence.



Picture 2.10: Analysis of morphological composition of waste at site – Prijedor

Taking into consideration proportion of the population, which living in the collective (12.60%), individual (40.24%) and rural parts (47.15%) within the municipality of Prijedor, the average composition for the entire municipality was made. The organic fraction consisted of garden and other biodegradable waste as expected was the most dominant category, and constitute about 55% of the waste sample. From potentially recyclable fractions cardboard (4.14%) and plastic bags (4.49%) had mass share greater than 4%, while other fractions were lower than this value. Notable proportions were recorded for textile and “fine fraction”, with mass share of 5.23% and 8.31%, respectively. Metals and composite materials as usual had small proportions about 1%.



Graph 2.47: Average morphological waste composition (%) for the municipality of Prijedor – autumn campaign

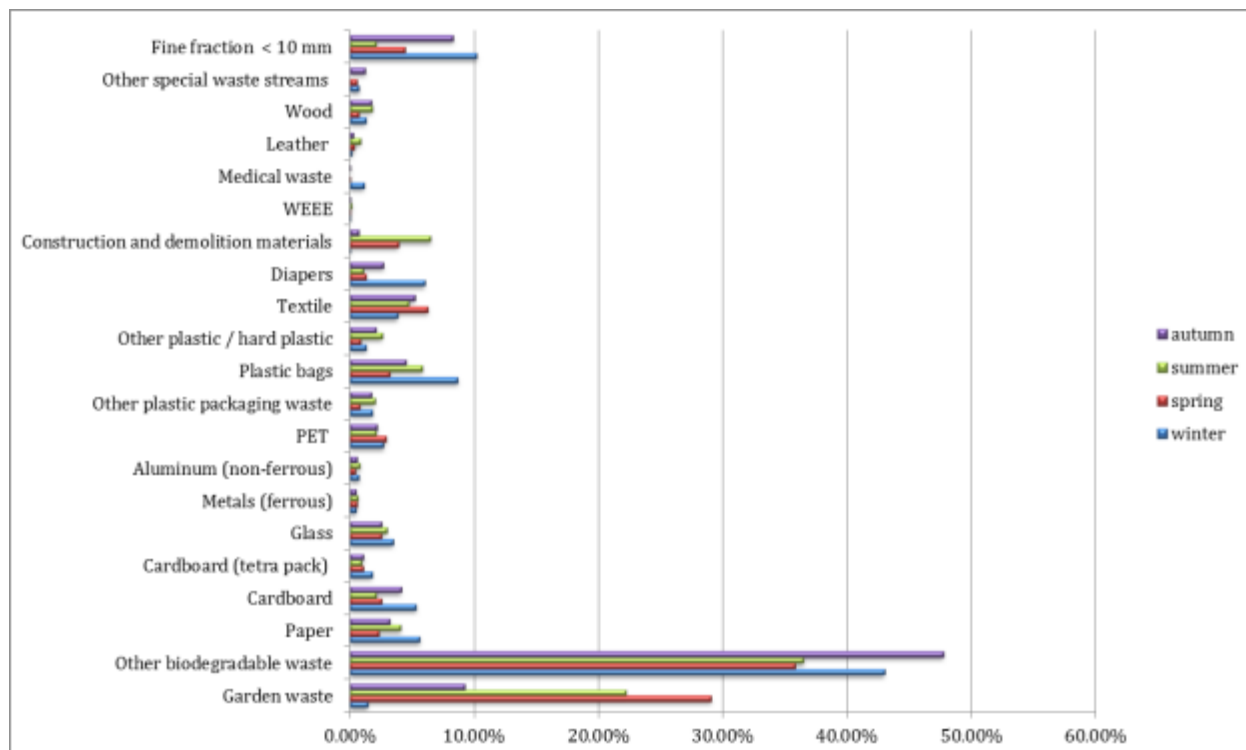
In the Municipality of Prijedor, three samples were taken for analysis of morphological composition of waste, four times, for each season. Samples were from collective and individual housing sector, as well as from the rural sector. Based on the share of the population that lives within these three living sectors average composition of the waste for each season has been determined. The obtained results are presented in the following table, as well an annual average.

Table 2.29: Composition of municipal waste for four different seasons and the annual average value

Prijedor	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	1.45%	29.06%	22.17%	9.27%	<b>15.49%</b>
Other biodegradable waste	43.00%	35.81%	36.51%	47.75%	<b>40.77%</b>
Paper	5.63%	2.35%	4.08%	3.22%	<b>3.82%</b>
Cardboard	5.34%	2.55%	2.12%	4.14%	<b>3.54%</b>
Composite materials	1.79%	1.08%	0.91%	1.11%	<b>1.22%</b>
Glass	3.48%	2.53%	2.98%	2.58%	<b>2.89%</b>
Metals (ferrous)	0.51%	0.61%	0.64%	0.50%	<b>0.57%</b>
Aluminum (non-ferrous)	0.75%	0.47%	0.83%	0.58%	<b>0.66%</b>
PET	2.71%	2.94%	2.09%	2.20%	<b>2.48%</b>
Other plastic packaging waste	1.82%	0.84%	2.04%	1.72%	<b>1.60%</b>
Plastic bags	8.68%	3.18%	5.83%	4.49%	<b>5.55%</b>
Other plastic / hard plastic	1.32%	0.88%	2.61%	2.08%	<b>1.72%</b>
Textile	3.85%	6.27%	4.72%	5.23%	<b>5.02%</b>
Diapers	6.02%	1.32%	1.06%	2.71%	<b>2.78%</b>
Construction and demolition materials	0.07%	3.93%	6.49%	0.73%	<b>2.80%</b>
WEEE	0.05%	0.06%	0.17%	0.09%	<b>0.09%</b>
Medical waste	1.13%	0.01%	0.00%	0.02%	<b>0.29%</b>
Leather	0.18%	0.38%	0.85%	0.29%	<b>0.42%</b>
Wood	1.28%	0.74%	1.79%	1.73%	<b>1.39%</b>
Other special waste streams	0.74%	0.59%	0.00%	1.25%	<b>0.64%</b>
Fine fraction < 10 mm	10.20%	4.42%	2.10%	8.31%	<b>6.25%</b>

Significant variations in the proportion of garden waste and fine fraction can be observed within the municipality of Prijedor, comparing the average composition of waste for different periods of sampling. Garden waste recorded the smallest amount in the winter period that is expected only 1.45%, also in this period was recorded the greatest amount of fine elements, possible as a consequence of heating seasons, great amount of ash, mass share of 10.20%. In the spring season was recorded the greatest amounts of garden waste, PET and textile. "Other biodegradable waste" was dominant in all four campaigns and the highest proportion was recorded in autumn. Paper, cardboard and plastic bags had higher proportions in winter season that could be a consequence of

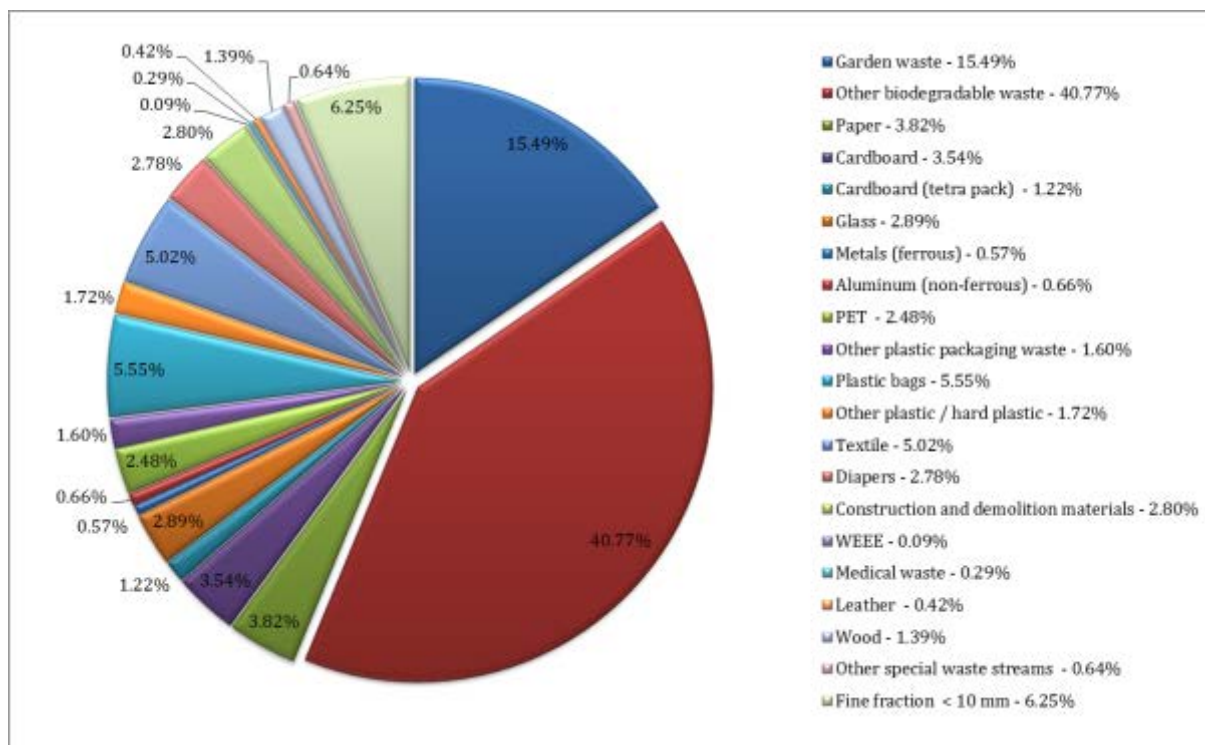
higher moisture content of the waste in sampling period. Construction and demolition materials were dominant in summer period. Other variations in proportions of waste categories didn't were so notable.



Graph 2.48: Comparison of waste composition according to the period of analysis – Prijedor

As is mentioned before based on the share of the population living within the collective housing, individual housing and rural parts within the Municipality of Prijedor, and according to results from four obtained campaign of measurements an annual average composition of the waste for the entire municipality has been determined.

"Other biodegradable waste" is a dominant waste category with mass share of 40.77% that together with garden waste which also have a high proportion (15.49%) constitute more than 55% of waste. After mentioned categories of waste fine fraction also has notable proportion, mass share of 6.25%. Plastic bags and textile were represented by 5.55% and 5.02%, respectively. Taking into consideration above mentioned, it is not surprising the fact that all other categories of waste are represented by mass share less than 5%. From potentially recyclable categories, paper and cardboard have proportions of 3.82% and 3.54%, respectively.



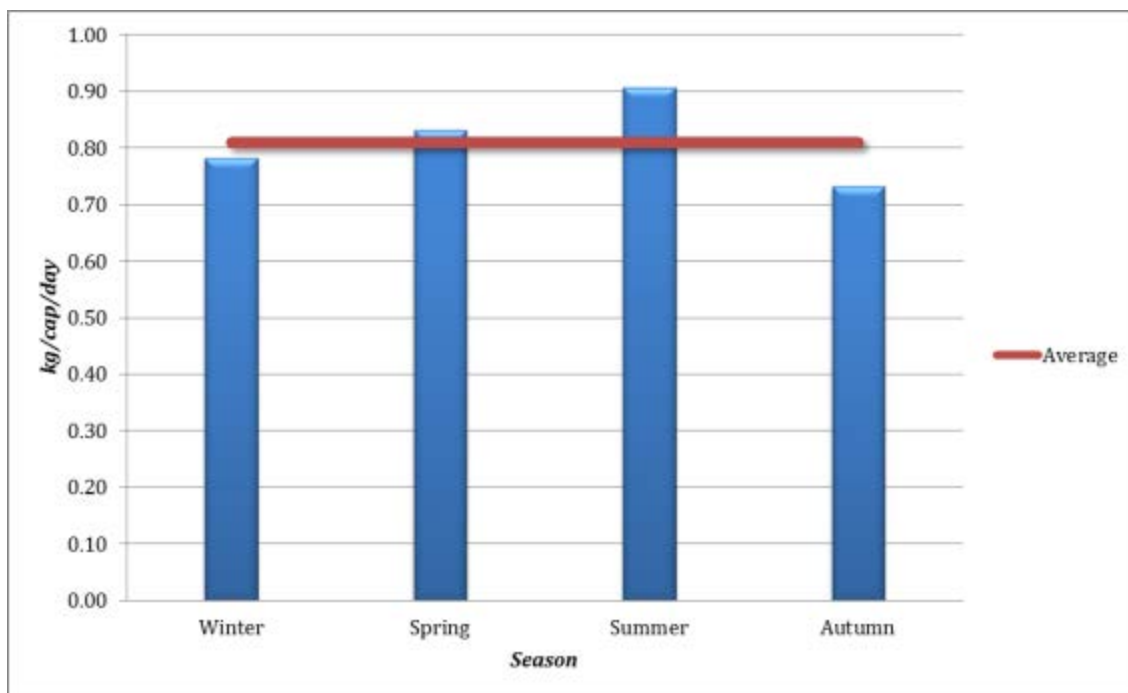
Graph 2.49: Annual average composition of municipal waste – Prijedor

Results of waste amount measurements on weighbridge in the municipality of Prijedor for one week, in autumn season, show that 291.92 tons of waste were collected. Projection of the results shows that the amount of waste collected by PUC „Komunalne usluge“ is about 15,220 tons annually. Taking into account the percentage of the population covered by the organized waste collection (about 58%), the entire municipality generates about 26,086 tons per year. Observing the results in the form of „per capita“, it is calculated that the average resident of Prijedor generates 0.73 kg per day, or 367.31 kg per year, in autumn period.

Table 2.30: Projection of obtained results

Municipality of Prijedor	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	16265.44	17277.01	18868.41	15221.54	16908.10
Number of residents	97588	97588	97588	97588	97588
The population covered by the organized waste collection	56943	56943	56943	56943	56943
Share of population under organized waste collection	58.35%	58.35%	58.35%	58.35%	58.35%
Waste generation (kg/capita/year)	285.65	303.41	331.36	267.31	296.93
Waste generation (kg/capita/day)	<b>0.78</b>	<b>0.83</b>	<b>0.91</b>	<b>0.73</b>	<b>0.81</b>
Total for whole city (t/year)	27875.65	29609.28	32336.61	26086.62	28977.04

Measurements for determining quantities of generated waste were conducted in the Municipality of Prijedor, during a one week period, four times per year. Obtained results from four campaigns were used in order to calculate data, such as total collected amount of waste or waste generation per capita, annual and per day. According to obtained results PU from Prijedor annually average collect 28,977.04 tons of municipal waste. Looking at the results in form per capita, it is obtained that the average resident of the Municipality of Prijedor generates 296.93 kg per year or 0.81 kg daily. Comparing values according to the season of measurement, it can be observed that in summer period was generated the greatest amount of waste, and lowest value was in autumn.



Graph 2.50: Comparison of waste generation rate (kg/cap/day) according to the season



## 2.11 MUNICIPALITY OF TEŠANJ

For analyzing waste composition in the Municipality of Tešanj, three samples according to the proposed methodology were taken from urban I (collective housing), urban II (individual housing) and rural zone. The obtained results from autumn season are presented in the following table.

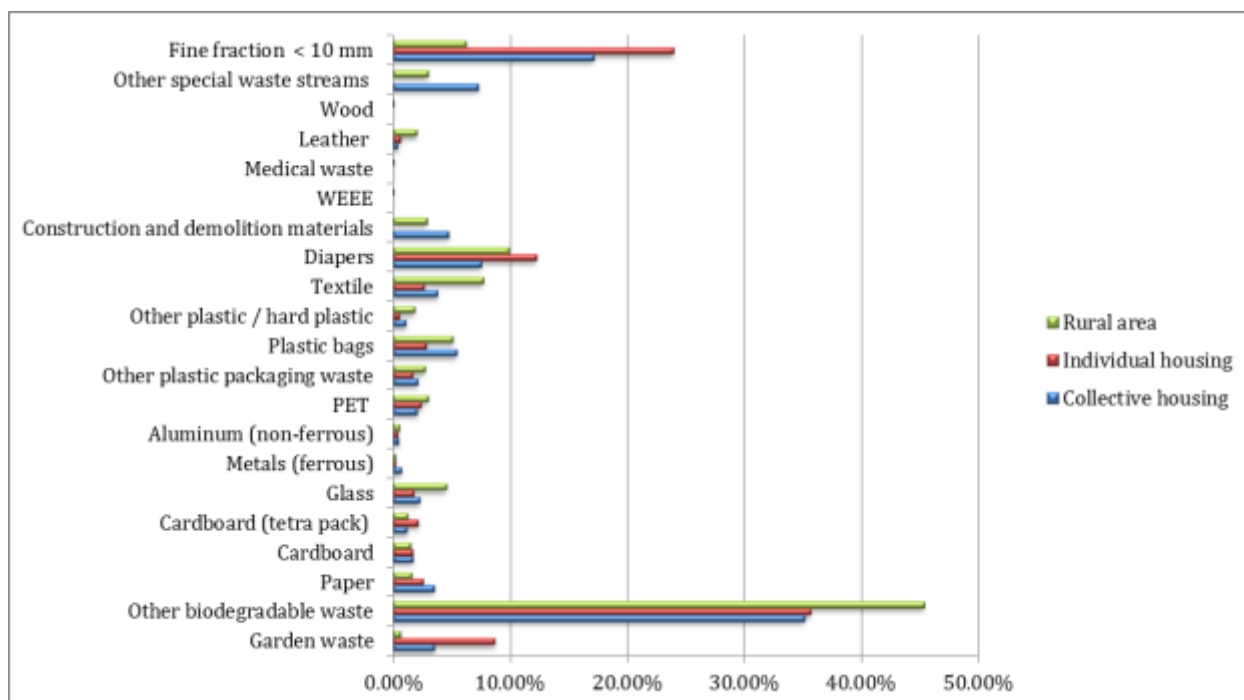
Table 2.31: Morphological composition of waste – Municipality of Tešanj – autumn campaign

Tešanj Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	3.55%	8.70%	0.64%
Other biodegradable waste	35.15%	35.69%	45.38%
Paper	3.48%	2.59%	1.56%
Cardboard	1.71%	1.63%	1.46%
Composite materials	1.19%	2.14%	1.26%
Glass	2.27%	1.74%	4.53%
Metals (ferrous)	0.67%	0.20%	0.22%
Aluminum (non-ferrous)	0.47%	0.38%	0.51%
PET	2.05%	2.39%	2.98%
Other plastic packaging waste	2.10%	1.66%	2.70%
Plastic bags	5.41%	2.82%	5.11%
Other plastic / hard plastic	1.10%	0.53%	1.81%
Textile	3.81%	2.67%	7.67%
Diapers	7.49%	12.25%	9.88%
Construction and demolition materials	4.77%	0.00%	2.88%
WEEE	0.00%	0.00%	0.08%
Medical waste	0.00%	0.00%	0.06%
Leather	0.36%	0.65%	1.98%
Wood	0.00%	0.00%	0.06%
Other special waste streams	7.27%	0.00%	2.98%
Fine fraction < 10 mm	17.14%	23.97%	6.25%

Sample from urban zone I (collective housing) in the Municipality of Tešanj, indicates that dominant category was “other biodegradable waste” with 35.15%. After this value fine fraction had a significant mass share of 17.14%. From potentially recyclable fraction paper (3.48%) and plastic bags (5.41%) had mass share above 3%. Among other categories of waste, larger amounts of diapers (7.49%) and “other special waste streams” (7.27%) were noted. Three categories of waste didn’t appear at all.

In the sample from urban zone II dominant was “other biodegradable waste” with mass share of 35.69%, followed by “fine fraction” that recorded proportion of 23.97%. In addition to that garden waste and diapers recorded significant proportions of 8.70% and 12.25%, respectively, so other categories had smaller amounts, up to 3%. Even five categories of waste had proportion of 0.00%.

Sample from rural area was characterized with a higher share of other biodegradable waste, 45.38%. Diapers and textile had noteworthy proportions, 9.88% and 7.67%, respectively. From potentially recyclable fraction noteworthy proportions are noted for glass (4.53%) and plastic bags (5.11%). Other categories of waste didn’t have significant values.



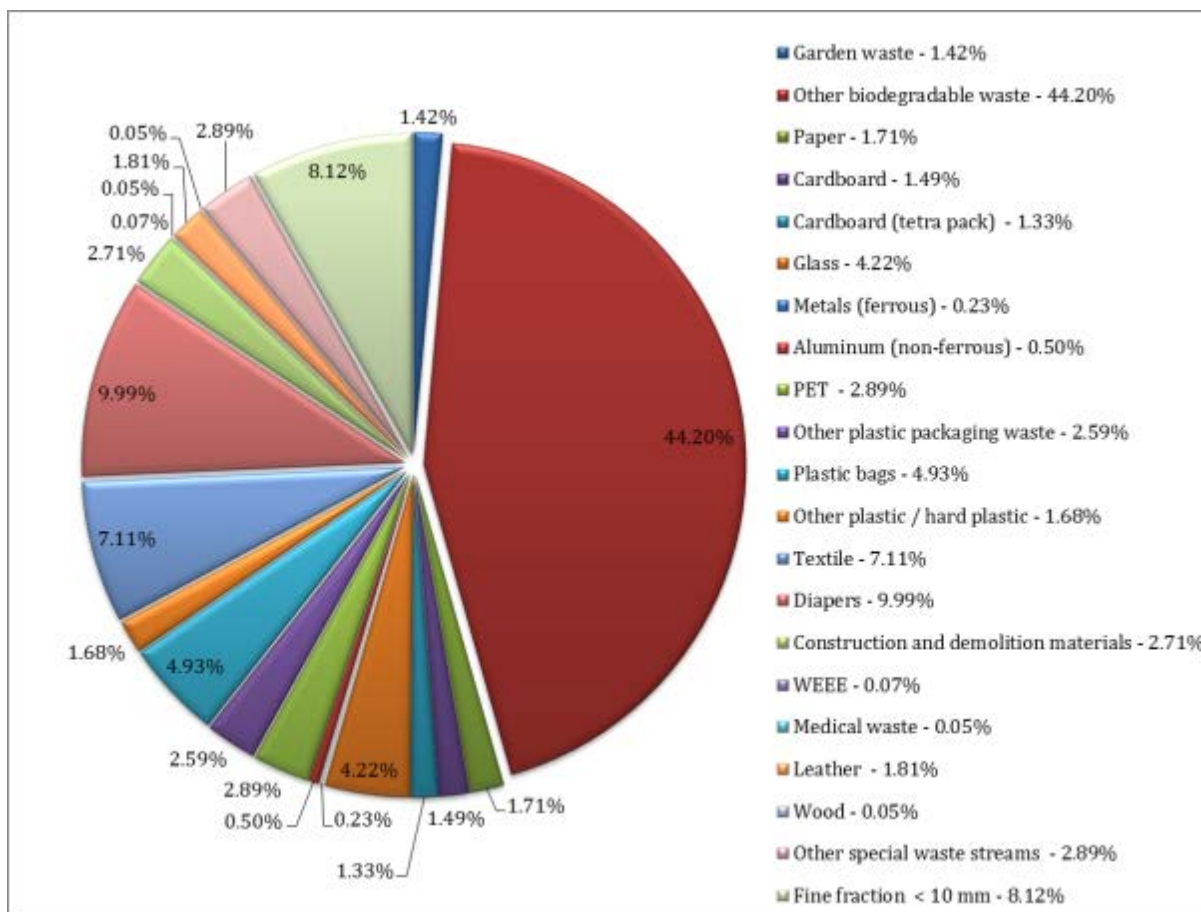
Graph 2.51: Comparison of waste composition according to the housing sector – Municipality of Tešanj – autumn campaign

Comparing the results from analyzed samples, it can be noticed that in all three zones “other biodegradable waste” was the most dominant category of waste. Garden waste, diapers and fine fraction were more presented in individual housing comparing to other two living sectors. Rural area was dominant regarding categories of waste such as “other biodegradable waste”, glass, textile and leather. Other categories of waste didn’t show significant differences regarding the housing sector, and all values were in the range of expected, more or less.



Picture 2.11: Analysis of morphological composition of waste at site – Tešanj

Taking into account proportion of the population, which live in collective housing (3.68%), individual housing (8.30%) and rural area (88.01%) average composition for whole municipality is determined. It is evident that other biodegradable waste represents a predominant waste category with 44.20% of mass share. There is also a significant amount of textile and diapers with 7.11% and 9.99% respectively. Fine fraction also recorded notable proportion of 8.12%. From potentially recyclable fractions only glass (4.22%) and plastic bags (4.93%) had mass share above 4%, while all other categories were below this value.



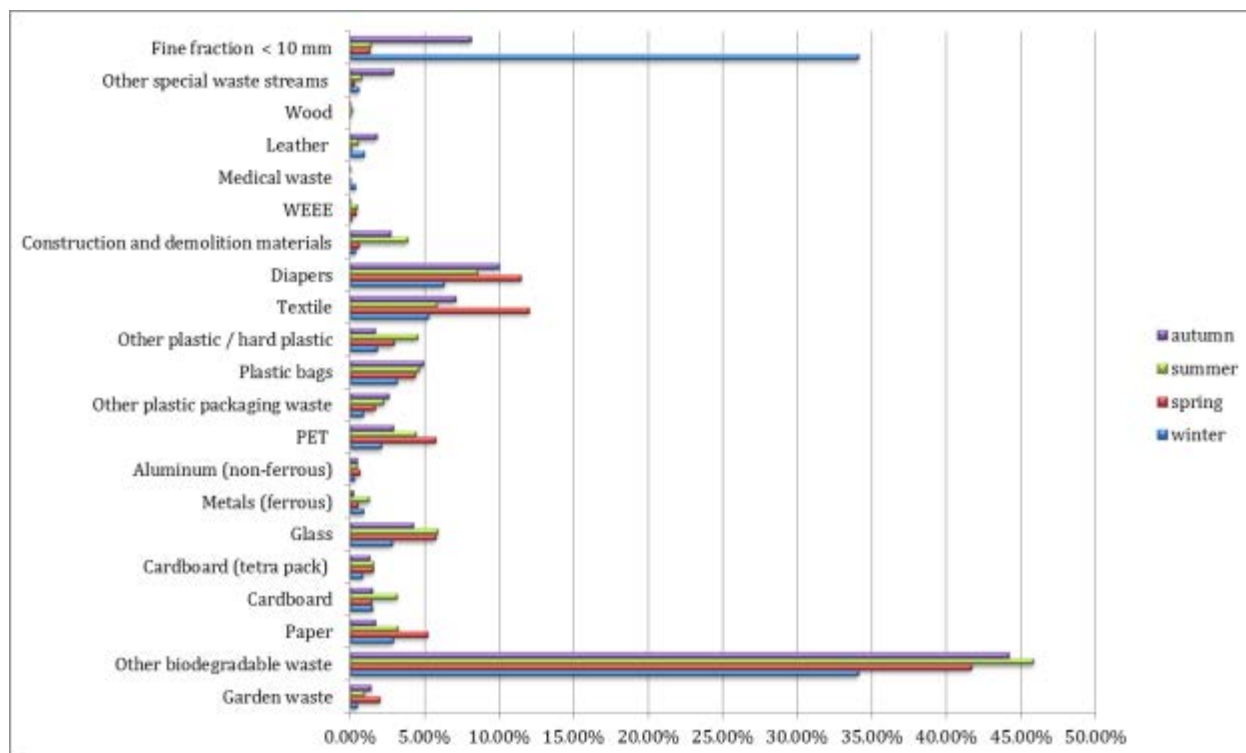
Graph 2.52: Average morphological waste composition (%) for the municipality of Tešanj – autumn campaign

In the Municipality of Tešanj three samples were analyzed, in accordance with the proposed methodology, four times, for each season. Average composition of waste for each season was determined based on the proportion of people that live within specified housing sectors. The obtained results are presented in the following table, and an annual average composition.

Table 2.32: Composition of municipal waste for four different seasons and the annual average value

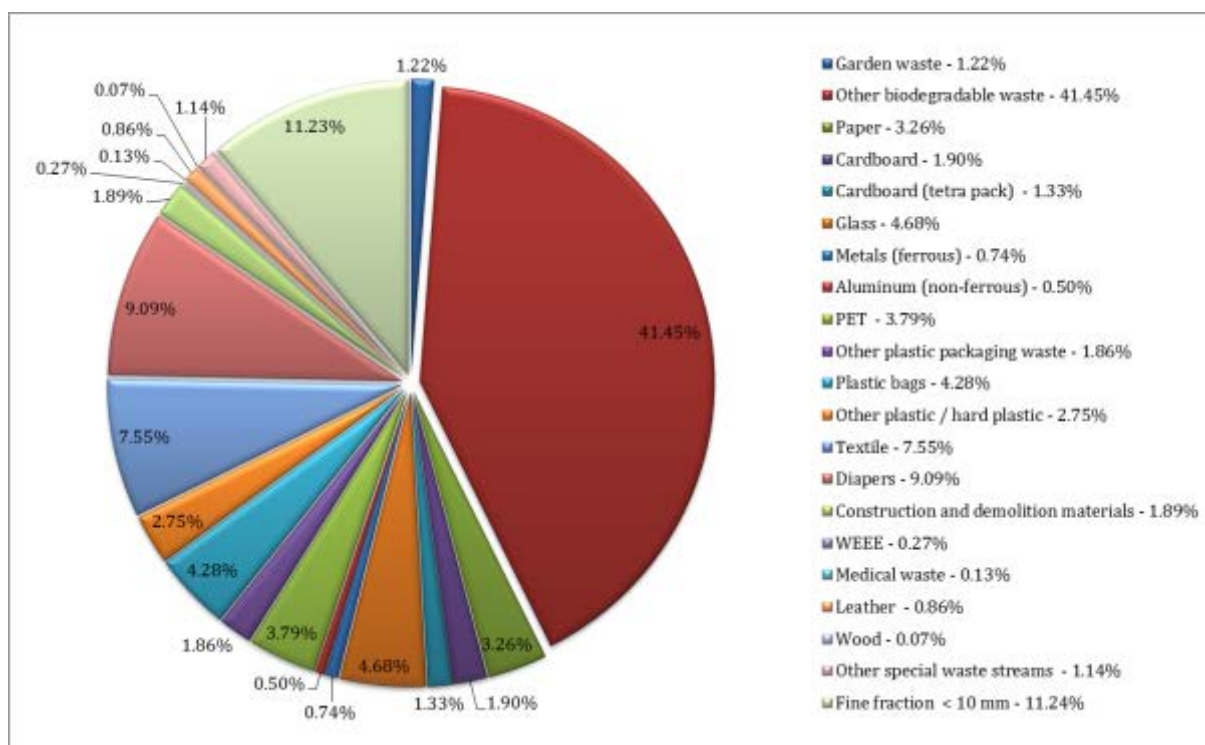
Tešanj	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	0.48%	2.03%	0.96%	1.42%	<b>1.22%</b>
Other biodegradable waste	34.10%	41.68%	45.84%	44.20%	<b>41.45%</b>
Paper	2.89%	5.21%	3.21%	1.71%	<b>3.26%</b>
Cardboard	1.53%	1.44%	3.15%	1.49%	<b>1.90%</b>
Composite materials	0.86%	1.56%	1.57%	1.33%	<b>1.33%</b>
Glass	2.85%	5.76%	5.91%	4.22%	<b>4.68%</b>
Metals (ferrous)	0.93%	0.52%	1.30%	0.23%	<b>0.74%</b>
Aluminum (non-ferrous)	0.33%	0.67%	0.51%	0.50%	<b>0.50%</b>
PET	2.10%	5.76%	4.41%	2.89%	<b>3.79%</b>
Other plastic packaging waste	0.90%	1.67%	2.26%	2.59%	<b>1.86%</b>
Plastic bags	3.16%	4.38%	4.64%	4.93%	<b>4.28%</b>
Other plastic / hard plastic	1.83%	2.97%	4.54%	1.68%	<b>2.75%</b>
Textile	5.25%	12.03%	5.82%	7.11%	<b>7.55%</b>
Diapers	6.31%	11.50%	8.57%	9.99%	<b>9.09%</b>
Construction and demolition materials	0.36%	0.60%	3.88%	2.71%	<b>1.89%</b>
WEEE	0.11%	0.42%	0.49%	0.07%	<b>0.27%</b>
Medical waste	0.39%	0.08%	0.00%	0.05%	<b>0.13%</b>
Leather	0.96%	0.10%	0.55%	1.81%	<b>0.86%</b>
Wood	0.00%	0.02%	0.19%	0.05%	<b>0.07%</b>
Other special waste streams	0.59%	0.29%	0.78%	2.89%	<b>1.14%</b>
Fine fraction < 10 mm	34.08%	1.32%	1.42%	8.12%	<b>11.24%</b>

Comparing the average composition of waste according to the period of sampling within the municipality of Tešanj it can be observed significant variations in the proportion of fine fraction. "Fine fraction" recorded the greatest amount in winter period as a consequence of heating seasons, great amount of ash. Winter season recorded the smallest amounts of garden waste and "other biodegradable waste". In summer period were recorded more of "other biodegradable waste", cardboard and C&D materials, in comparison to other three seasons. Paper, PET, textile and diapers recorded greater amounts in the spring campaign of measurement.



Graph 2.53: Comparison of waste composition according to the period of analysis – Tešanj

According to the four obtained campaigns of measurements it can be calculated the annual average composition of the waste for the municipality of Tešanj. "Other biodegradable waste" is a dominant waste category with mass share of 41.45%. After the mentioned category of waste "fine fraction" has proportion more than 11% of waste. From potentially recyclable categories paper and glass have proportion of 3.26% and 4.68%, respectively. Plastic waste, with its four subcategories, is represented by mass share of 12.68%. Significant are proportions of textile and diapers with mass share of 7.55% and 9.09%, respectively. All other categories of waste are represented in proportions up to 3%.



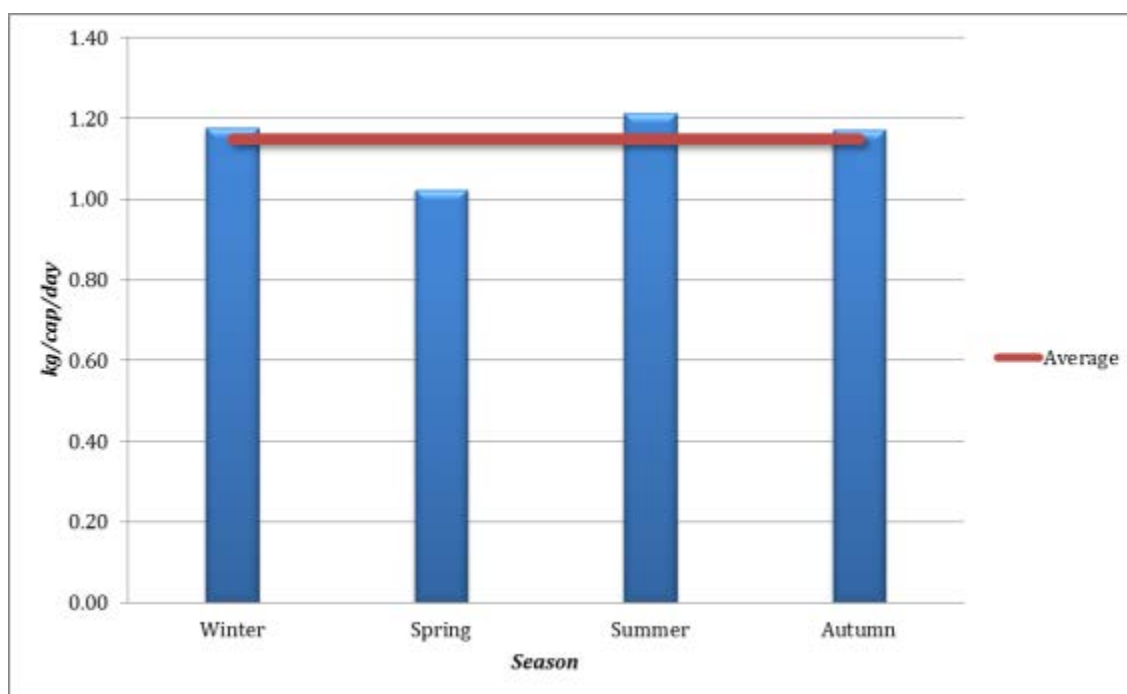
Graph 2.54: Annual average composition of municipal waste – Tešanj

Results of measuring the amount of waste in the Municipality of Tešanj showed that on a weekly basis PUC "Rad", in the autumn period, collected about 140 tons of municipal waste. Percentage of population in this municipality covered by an organized collection of waste is about 37%, which leads us to the conclusion that the whole municipality generates 19,725.56 tons per year, and PUC collects only 7,326.07, so a great amount (about 13,000 tons) of waste ends up on illegal dumps. Looking at the results per capita, it is obtained that the average resident of the Municipality of Tešanj generates 1.17 kg of municipal waste per day, in autumn season.

Table 2.33: Projection of obtained results

Municipality of Tešanj	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	7369.87	6400.01	7588.87	7326.07	7171.21
Number of residents	46135	46135	46135	46135	46135
The population covered by the organized waste collection	17135	17135	17135	17135	17135
Share of population under organized waste collection	37.14%	37.14%	37.14%	37.14%	37.14%
Waste generation (kg/capita/year)	430.12	373.52	442.90	427.56	418.52
Waste generation (kg/capita/day)	<b>1.18</b>	<b>1.02</b>	<b>1.21</b>	<b>1.17</b>	<b>1.15</b>
Total for whole city (t/year)	19843.49	17232.13	20433.15	19725.56	19308.58

Taking into account measurements from all four campaigns, it can be concluded that the average amount of waste collected by PUC from Tešanj is 7,171.21 tons annually. Taking into account percentage of the population covered by organized collection, lead to the conclusion that whole municipality generated about 19,310 tons of waste per year. Considering these data, it can be concluded that the difference between collected and generated amount of waste, about 12,000 tons was deposited uncontrolled. Looking at the results per capita, it is obtained that the average resident of the municipality of Tešanj generates 418.52 kg per year or 1.15 kg daily.



Graph 2.55: Comparison of waste generation rate (kg/cap/day) according to the season

Before this project in the municipality of Tešanj were two campaigns of waste quantity measurements in 2008 and 2014, both in winter period. According to these measurements, collected amount of waste was 6494.8 tons/year and 6526 tons/year, respectively. In this project projection of conducted results showed that the collected amount of waste in 2015 is greater than mentioned values, 7171.21 tons annually.

The benefits of this project are detailed analysis of generated waste quantity and also for waste composition, it was conducted four measurements for four seasons, so it also possible to observe variations in waste quantity and composition during the year.



## 2.12 CITY OF BIJELJINA

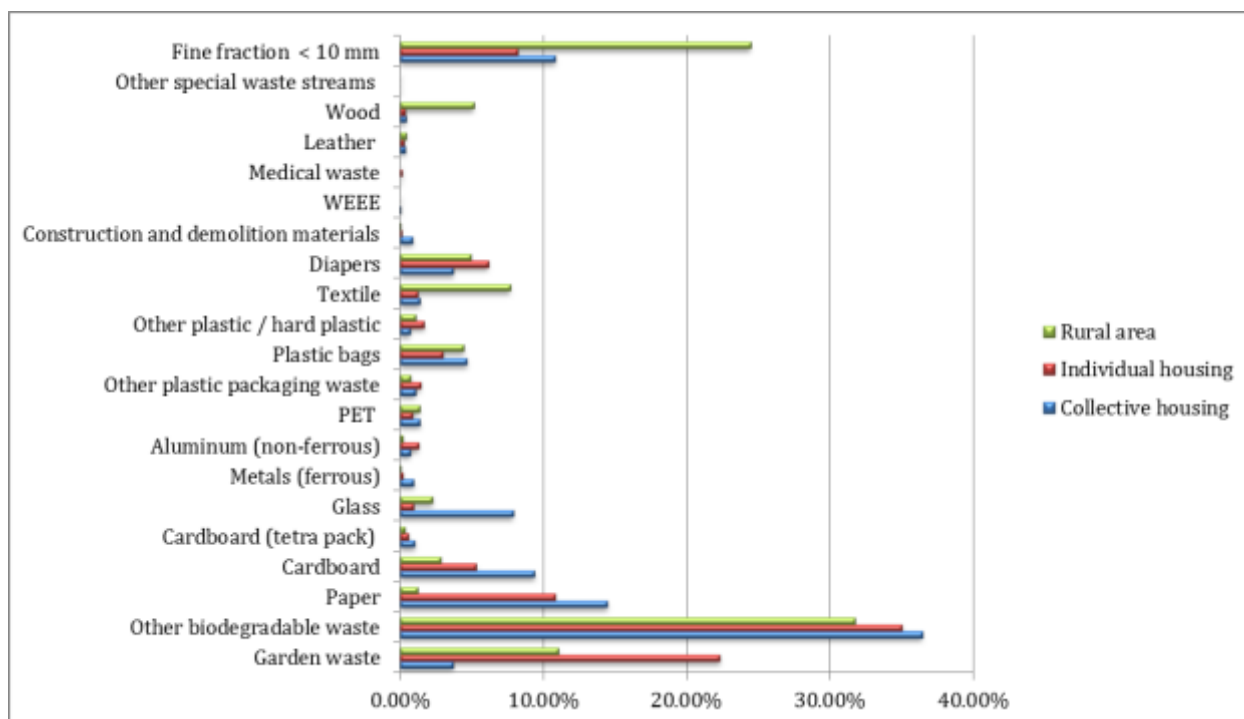
In the City of Bijeljina in autumn season three samples were analyzed, in accordance with the proposed methodology. In the sample from collective housing, dominant category was “other biodegradable waste” with mass share of 36.44%. From recyclable categories of waste, paper and cardboard had significant share with 14.48% and 9.37%, respectively. Plastic with its four subcategories was represented with mass share of only 7.79%. Notable was an amounts of glass with proportion of 7.89%. “Fine fraction” had notable amount with mass share of 10.83%.

Table 2.34: Morphological composition of waste – City of Bijeljina – autumn campaign

Bijeljina Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	3.70%	22.32%	11.06%
Other biodegradable waste	36.44%	35.04%	31.71%
Paper	14.48%	10.81%	1.21%
Cardboard	9.37%	5.30%	2.82%
Composite materials	1.02%	0.58%	0.33%
Glass	7.89%	0.96%	2.25%
Metals (ferrous)	0.94%	0.21%	0.10%
Aluminum (non-ferrous)	0.72%	1.29%	0.20%
PET	1.38%	0.88%	1.37%
Other plastic packaging waste	1.05%	1.42%	0.72%
Plastic bags	4.67%	3.00%	4.44%
Other plastic / hard plastic	0.69%	1.67%	1.10%
Textile	1.40%	1.25%	7.67%
Diapers	3.70%	6.13%	4.91%
Construction and demolition materials	0.87%	0.13%	0.06%
WEEE	0.05%	0.00%	0.00%
Medical waste	0.00%	0.17%	0.00%
Leather	0.38%	0.25%	0.41%
Wood	0.41%	0.38%	5.15%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	10.83%	8.22%	24.47%

Organic waste, with its two subcategories, was a dominant category of waste within a sample from individual housing, with mass share of 57.36%. Paper and cardboard have recorded proportions of 10.81% and 5.30%, respectively. From other potentially recyclable materials plastic bags recorded noteworthy proportion with mass share of 3.00%. From other categories of waste diapers and “fine fraction” recorded significant proportions, 6.13% and 8.22%, respectively.

Sample from rural area showed that “other biodegradable waste” was dominant with mass share of 31.71%. In addition to this, more than 35% together represent garden waste (11.06%) and fine fraction (24.47%), so potentially recyclable fractions had smaller proportions. Notable was only mass share of plastic bags, 4.44%, while others had mass share up to 3%. Noteworthy was proportions of textile and diapers, with mass share of 7.67% and 4.91%, respectively. In the analyzed sample even three categories of waste didn’t appear at all.



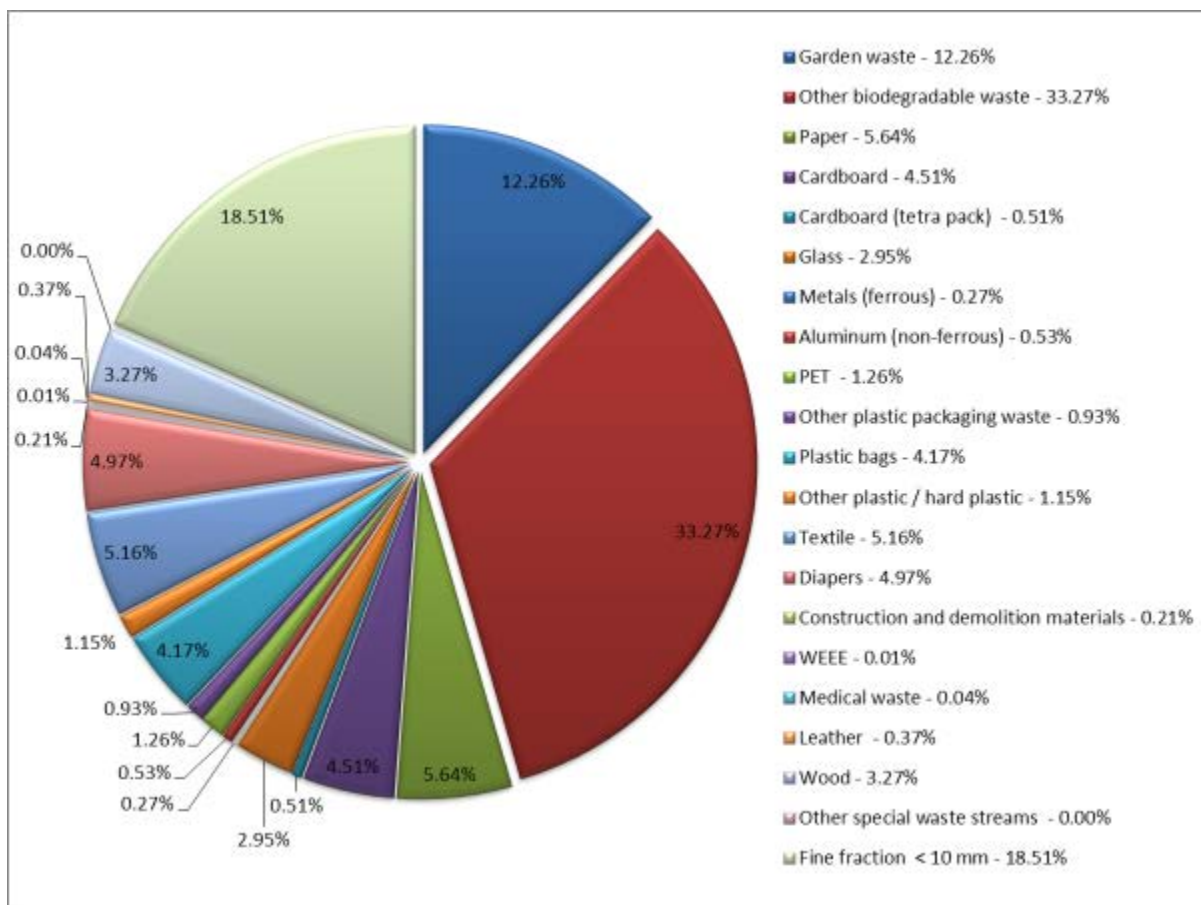
Graph 2.56: Comparison of waste composition according to the housing sector – City of Bijeljina – autumn campaign

Comparing the results obtained by the analysis of samples from all three sectors in the autumn season, it can be seen that the sample from an individual housing was dominant when it comes to the category of garden waste and diapers. Composition of waste for collective housing showed greater amounts of paper, cardboard, glass and “other biodegradable waste” in comparison to other two living sectors. Rural area was dominant in categories such as textile, wood and fine fraction. Other waste categories didn’t show notable variations.



Picture 2.12: Analysis of morphological composition of waste at site – Bijeljina

Based on the share of the population living within the collective (17.44%), individual (22.06%) and rural parts (60.50%) in the city of Bijeljina, the average composition of the waste to the entire city has been determined. Organic fraction was dominant, consisted of garden waste (12.26%) and other biodegradable waste (33.27%). After these categories of waste, significant is mass share of “fine fraction” by 18.51%. From recyclable fractions dominant were paper, cardboard and plastic bags with mass share of 5.64%, 4.51% and 4.17%, respectively. Notable were amounts of textile and diapers, with a proportion of 5.16% and 4.97%. All other components are represented by mass share less than 4%, and one category of waste had proportion of 0.00%.



Graph 2.57: Average morphological waste composition (%) for the city of Bijeljina – autumn campaign

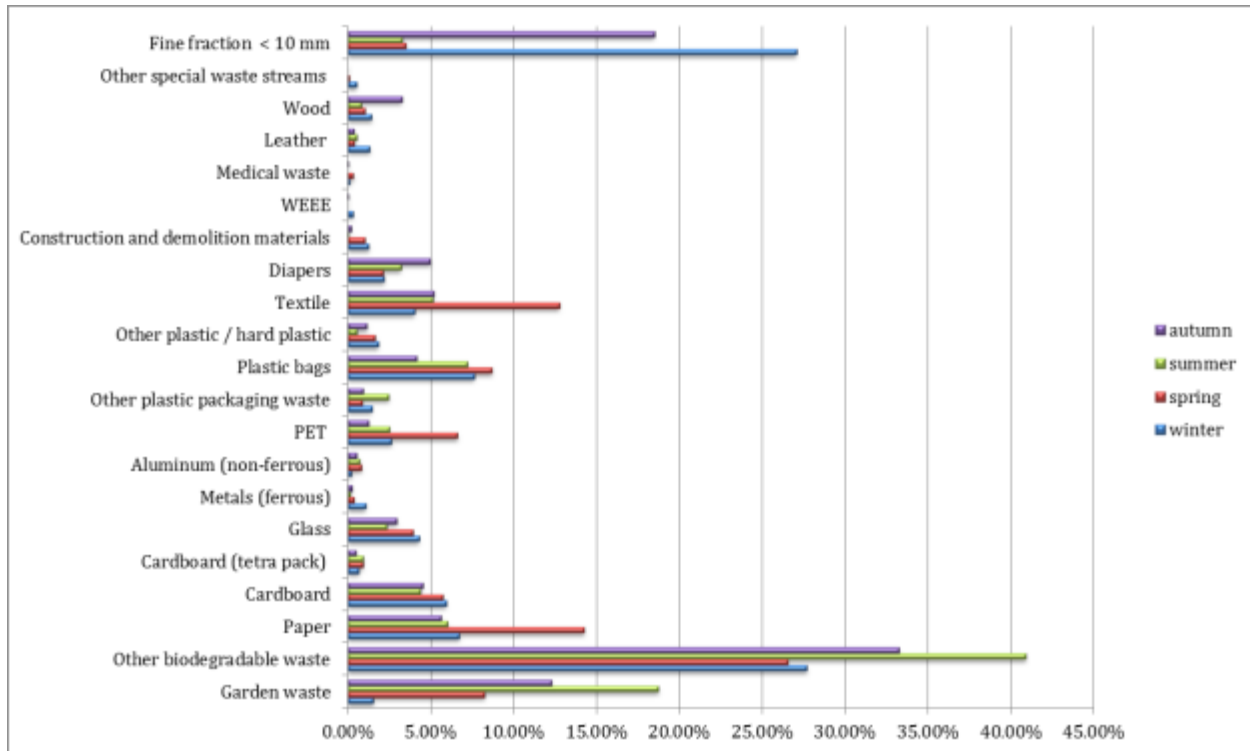
Morphological composition of waste in the city of Bijeljina was analyzed in four campaigns. Taking into consideration proportion of the population, which living within the collective, individual and rural parts of the city, the average composition for each season, was made. Average values from obtained analysis, are presented in the following table, and based on these values was made the annual average for the city of Bijeljina.

Table 2.35: Composition of municipal waste for four different seasons and the annual average value

Bijeljina	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	1.53%	8.27%	18.75%	12.26%	<b>10.20%</b>
Other biodegradable waste	27.69%	26.54%	40.93%	33.27%	<b>32.11%</b>
Paper	6.73%	14.26%	6.01%	5.64%	<b>8.16%</b>
Cardboard	5.94%	5.75%	4.39%	4.51%	<b>5.15%</b>
Composite materials	0.67%	0.90%	0.93%	0.51%	<b>0.75%</b>
Glass	4.31%	3.93%	2.34%	2.95%	<b>3.38%</b>
Metals (ferrous)	1.08%	0.37%	0.15%	0.27%	<b>0.47%</b>
Aluminum (non-ferrous)	0.24%	0.82%	0.73%	0.53%	<b>0.58%</b>
PET	2.63%	6.63%	2.48%	1.26%	<b>3.25%</b>
Other plastic packaging waste	1.47%	0.89%	2.48%	0.93%	<b>1.44%</b>
Plastic bags	7.62%	8.69%	7.21%	4.17%	<b>6.92%</b>
Other plastic / hard plastic	1.83%	1.65%	0.55%	1.15%	<b>1.30%</b>
Textile	4.02%	12.77%	5.15%	5.16%	<b>6.77%</b>
Diapers	2.18%	2.12%	3.22%	4.97%	<b>3.12%</b>
Construction and demolition materials	1.26%	1.02%	0.02%	0.21%	<b>0.63%</b>
WEEE	0.32%	0.00%	0.00%	0.01%	<b>0.08%</b>
Medical waste	0.13%	0.33%	0.00%	0.04%	<b>0.12%</b>
Leather	1.33%	0.41%	0.54%	0.37%	<b>0.66%</b>
Wood	1.44%	1.05%	0.81%	3.27%	<b>1.64%</b>
Other special waste streams	0.52%	0.09%	0.00%	0.00%	<b>0.15%</b>
Fine fraction < 10 mm	27.06%	3.50%	3.30%	18.51%	<b>13.09%</b>

Variations in the proportion of “garden waste” and “fine fraction” are the most obvious, comparing the average composition of waste per season of sampling within the city of Bijeljina. Garden waste had the lowest value in the winter season, about 1.5%, and the greatest value was recorded in summer period. Fine fraction had the greatest share in the winter and the lowest in summer, which is expected. Other biodegradable waste had the greatest proportion in summer and the lowest in spring. Paper had almost constant mass share except in spring when proportion was twice as high as in other three campaigns. PET waste had also the greatest amount in spring, while other subcategories of plastic didn’t show significant variations. From notable variations it’s evident

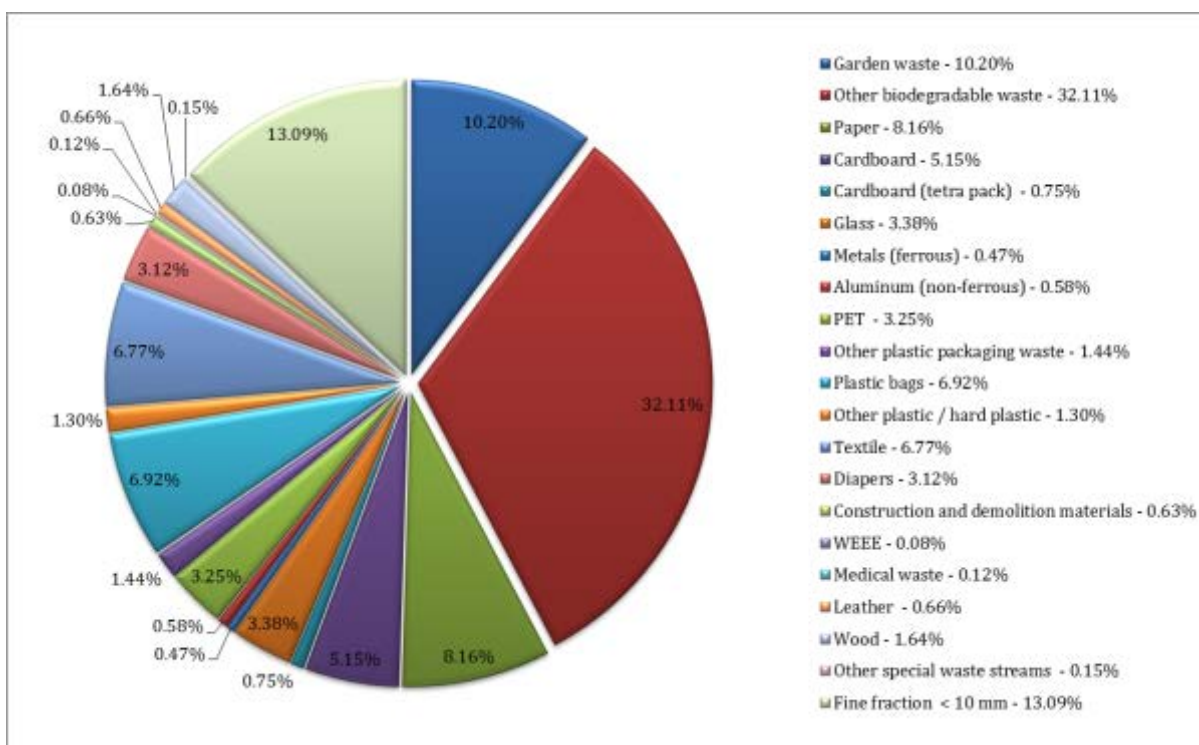
greater amount of textile in spring, while other categories of waste show some not so significant variations.



Graph 2.58: Comparison of waste composition according to the period of analysis – Bijeljina

According to the obtained results from four different seasons of measurements it can be calculated the annual average composition of the waste for the city of Bijeljina.

Dominant category is "other biodegradable waste" with mass share of 32.11%, which together with garden waste constitute more than 40%. Fine elements have a significant mass share of 13.09%. Paper and cardboard have noteworthy proportions of 8.16% and 5.15%, respectively. Metals and tetra pack, with its two subcategories, don't have significant proportion, up to 1%. Plastic with its four subcategories has mass share of 12.91%. Significant is an amount of textile that in average has mass share of 6.77%.



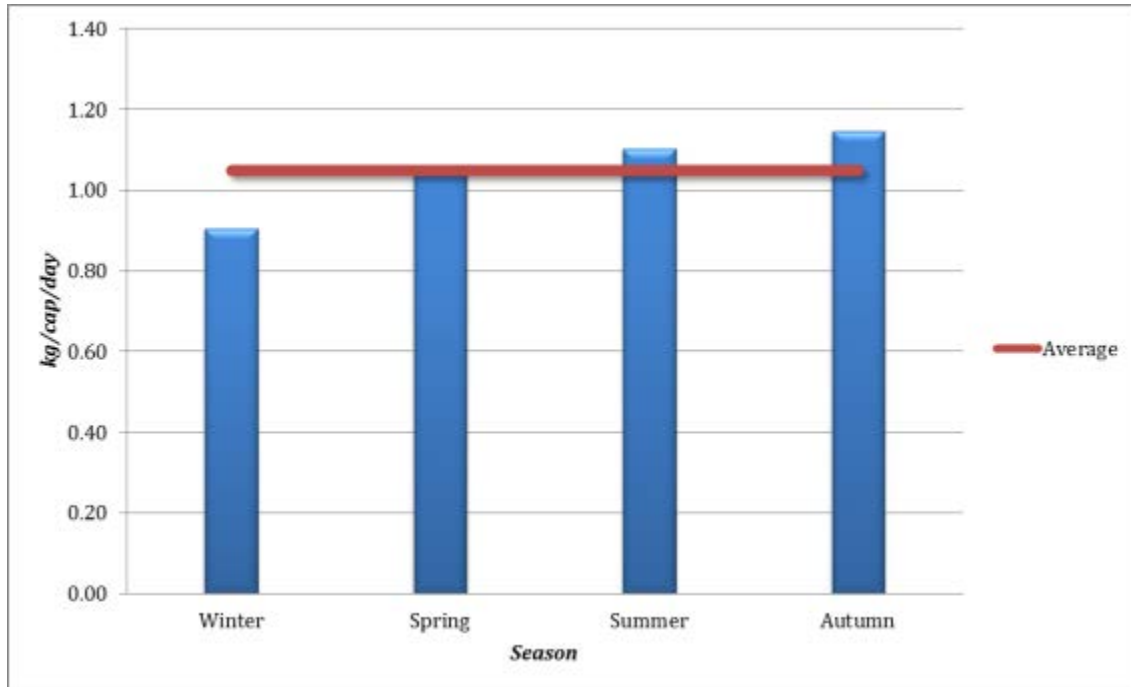
Graph 2.59: Annual average composition of municipal waste – Bijeljina

Results of measured waste amount on weighbridge in Bijeljina for one week in autumn showed that about 515 tons of waste was collected. Projection of the results showed that the amount of waste collected by PUC „Komunalac” from Bijeljina is 26,811.86 tons annually. Taking into account the percentage of the population covered by the organized waste collection (about 56%), it may be concluded that one citizen of the City of Bijeljina generates 1.15 kg of municipal waste per day for the autumn season.

Table 2.36: Projection of obtained results

Municipality of Bijeljina	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	21163.74	24844.51	25802.89	26811.86	24655.75
Number of residents	114663	114663	114663	114663	114663
The population covered by the organized waste collection	64039	64039	64039	64039	64039
Share of population under organized waste collection	55.85%	55.85%	55.85%	55.85%	55.85%
Waste generation (kg/capita/year)	330.48	387.96	402.92	418.68	385.01
Waste generation (kg/capita/day)	<b>0.91</b>	<b>1.06</b>	<b>1.10</b>	<b>1.15</b>	<b>1.05</b>
Total for whole city (t/year)	37893.90	44484.35	46200.35	48006.91	44146.37

Based on the results of measurements on weighbridge, it can be concluded that the average amount of waste collected by the PUC is 24,655.75 tons per year, the greatest amount was collected in autumn period while the lowest in winter season. Projection of the aforementioned data indicate that one citizen of Bijeljina generates 1.05 kg of waste per day, or 385 kg annually



Graph 2.60: Comparison of waste generation rate (kg/cap/day) according to the season



## 2.13 MUNICIPALITY OF BITOLA

Analyzing waste composition of the municipality of Bitola, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

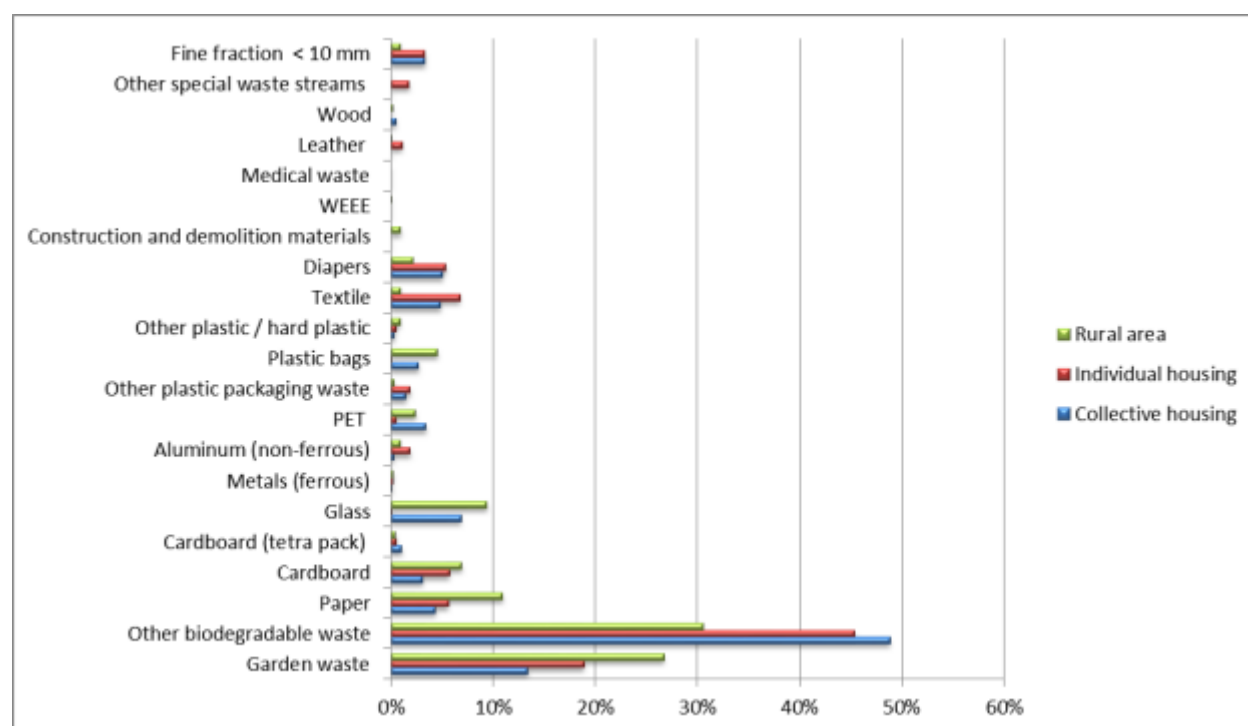
Table 2.37: Morphological composition of waste in the municipality of Bitola

Bitola Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	13.40%	18.91%	26.76%
Other biodegradable waste	48.85%	45.41%	30.57%
Paper	4.39%	5.63%	10.96%
Cardboard	3.14%	5.75%	6.93%
Composite materials	1.07%	0.54%	0.45%
Glass	6.88%	0.13%	9.41%
Metals (ferrous)	0.14%	0.22%	0.28%
Aluminum (non-ferrous)	0.32%	1.91%	0.94%
PET	3.43%	0.52%	2.41%
Other plastic packaging waste	1.49%	1.91%	0.34%
Plastic bags	2.75%	0.12%	4.57%
Other plastic / hard plastic	0.34%	0.53%	0.91%
Textile	4.90%	6.79%	0.99%
Diapers	5.08%	5.38%	2.18%
Construction and demolition materials	0.00%	0.00%	0.95%
WEEE	0.00%	0.00%	0.12%
Medical waste	0.00%	0.00%	0.00%
Leather	0.00%	1.11%	0.08%
Wood	0.49%	0.00%	0.20%
Other special waste streams	0.00%	1.80%	0.00%
Fine fraction < 10 mm	3.33%	3.35%	0.93%

Other biodegradable waste had the highest share in collective housing sector (48.85%), and it is followed by garden waste (13.4%). Glass followed these two fractions with share of 6.88%. Paper, cardboard and tetra pack fractions have a combined share of 8.7%, while all plastic sub fractions have a share of 8.01%. Besides this, diapers and textile have shares of 5.08 and 4.9%.

Other biodegradable waste in individual housing sector alone showed extremely high share of 45.41%. When that is combined with garden waste, total share of biodegradable waste goes up to 64.32%. Paper and cardboard (potentially recyclable fractions) had shares of 5.63 and 5.75%. On the other hand, notable shares had the fractions like textile and diapers.

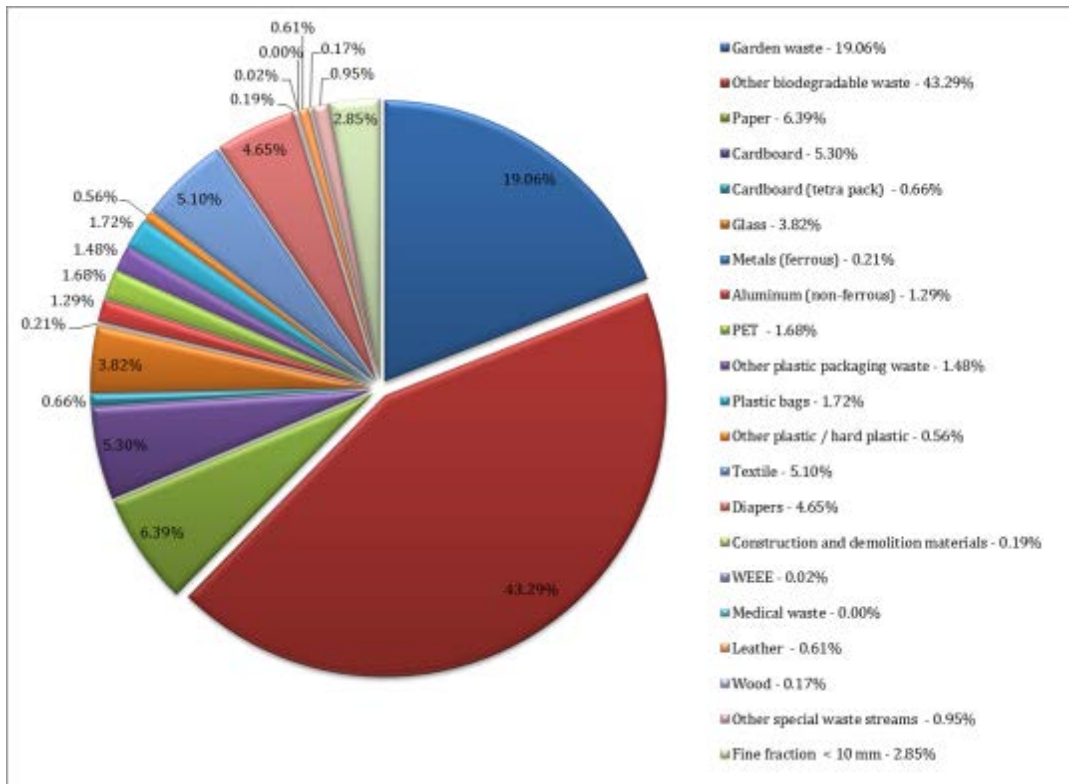
Besides high amount of biodegradable waste in rural sector (57.33%), sample from this sector showed



Graph 2.61: Comparison of waste composition according to the housing sector - the municipality of Bitola, autumn analysis

Collective housing sector, strangely, showed the highest amount of other biodegradable waste. Individual housing sector showed had the highest amount of textile, while it showed rather low amount of glass. Garden waste, glass, plastic bags and construction and demolition materials fractions had the highest shares in rural area sample.

Total waste composition for Bitola municipality for autumn analysis is shown on following figure. Because of high amounts of biodegradable waste in all three sectors, resulting total composition has extremely high share of these fractions. Other fractions with notable shares are paper, cardboard and textile.

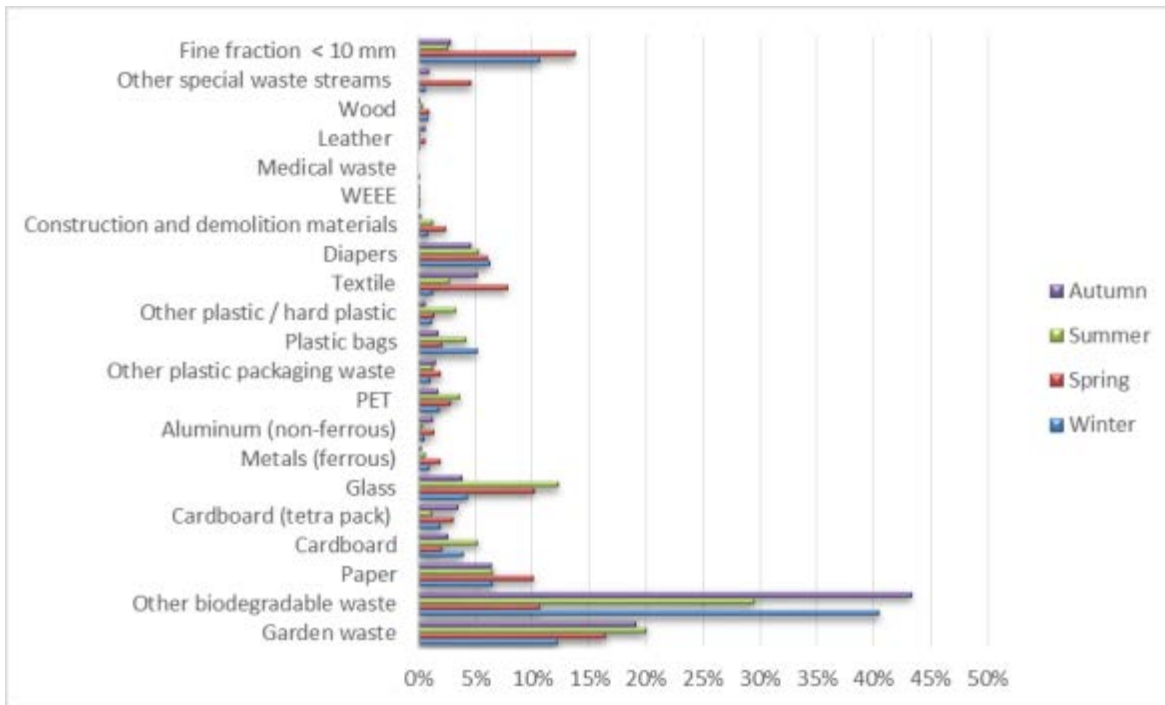


Graph 2.62: Morphological composition of waste in the Bitola municipality (autumn analysis)

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

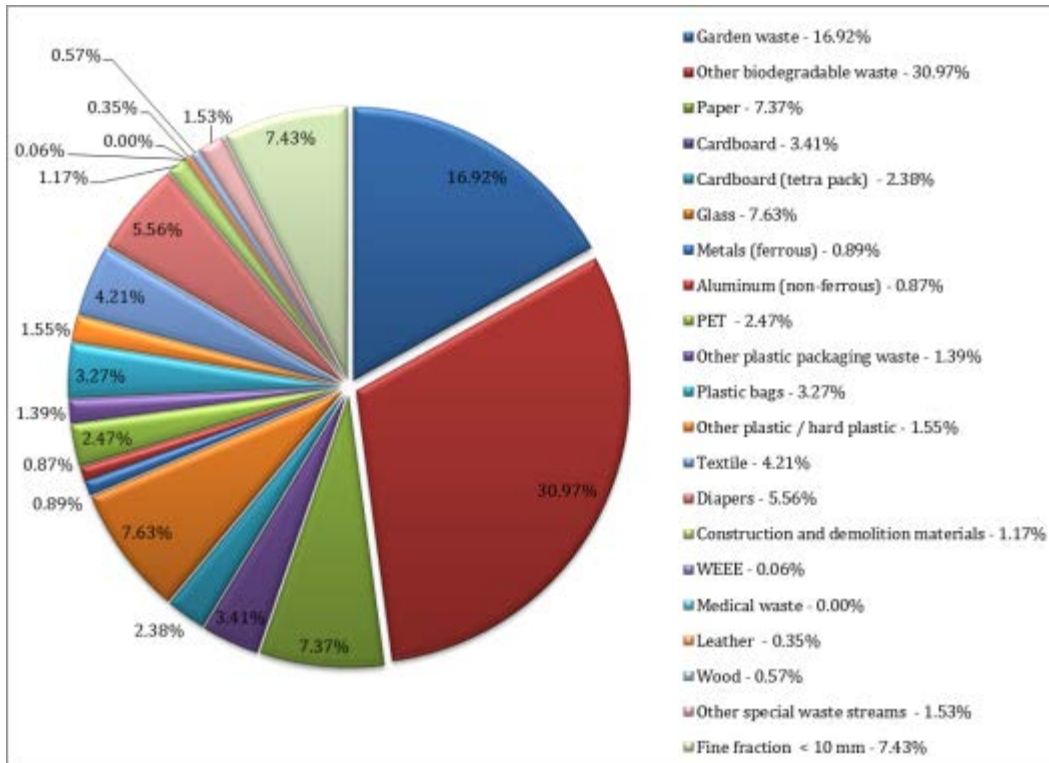
Table 2.38: Composition of municipal waste for four different seasons and the annual average value

Bitola Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	12.19%	16.44%	20.00%	19.06%	<b>16.92%</b>
Other biodegradable waste	40.44%	10.64%	29.49%	43.30%	<b>30.97%</b>
Paper	6.53%	10.09%	6.47%	6.39%	<b>7.37%</b>
Cardboard	3.88%	2.05%	5.18%	2.54%	<b>3.41%</b>
Composite materials	1.95%	3.05%	1.11%	3.43%	<b>2.38%</b>
Glass	4.30%	10.16%	12.25%	3.82%	<b>7.63%</b>
Metals (ferrous)	0.91%	1.89%	0.54%	0.21%	<b>0.89%</b>
Aluminum (non-ferrous)	0.48%	1.35%	0.35%	1.29%	<b>0.87%</b>
PET	1.83%	2.78%	3.60%	1.68%	<b>2.47%</b>
Other plastic packaging waste	0.99%	1.92%	1.19%	1.45%	<b>1.39%</b>
Plastic bags	5.11%	2.03%	4.20%	1.73%	<b>3.27%</b>
Other plastic / hard plastic	1.09%	1.33%	3.21%	0.56%	<b>1.55%</b>
Textile	1.22%	7.81%	2.69%	5.10%	<b>4.21%</b>
Diapers	6.22%	6.08%	5.30%	4.65%	<b>5.56%</b>
Construction and demolition materials	0.81%	2.40%	1.28%	0.19%	<b>1.17%</b>
WEEE	0.02%	0.15%	0.03%	0.02%	<b>0.06%</b>
Medical waste	0.01%	0.00%	0.00%	0.00%	<b>0.00%</b>
Leather	0.07%	0.57%	0.16%	0.61%	<b>0.35%</b>
Wood	0.78%	0.93%	0.40%	0.17%	<b>0.57%</b>
Other special waste streams	0.55%	4.61%	0.00%	0.95%	<b>1.53%</b>
Fine fraction < 10 mm	10.62%	13.72%	2.54%	2.85%	<b>7.43%</b>



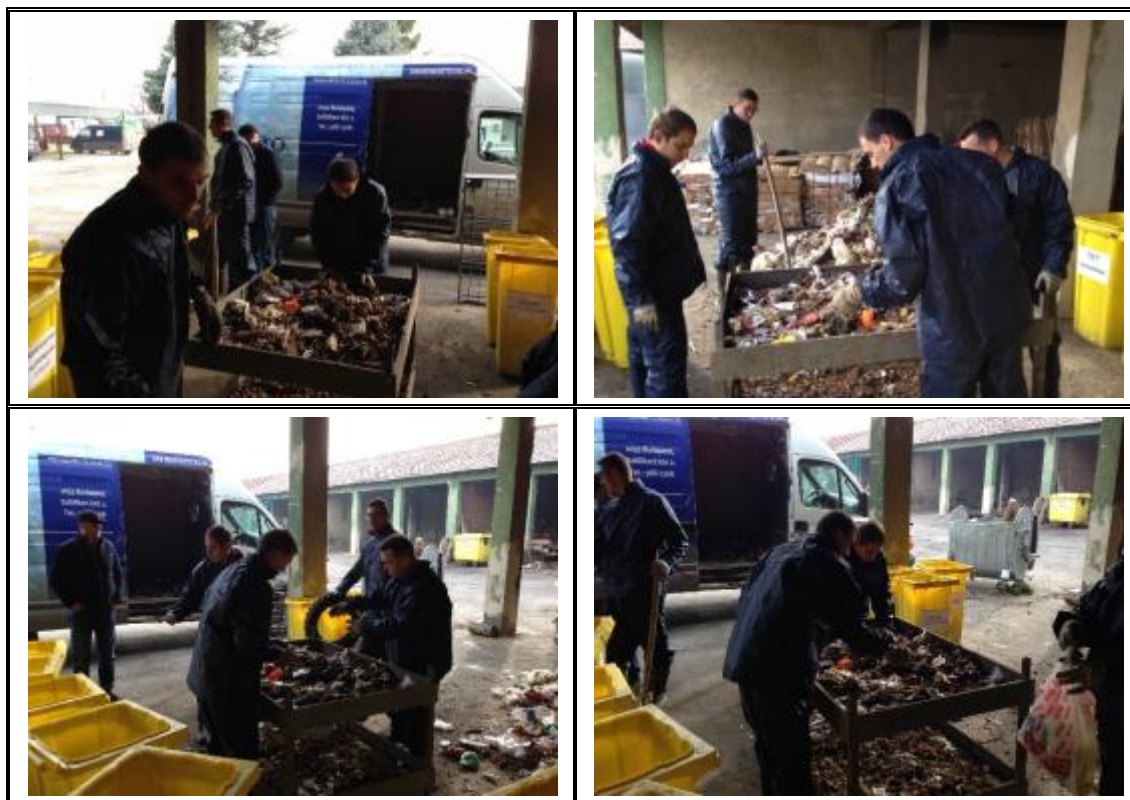
Graph 2.63: Comparison of seasonal fluctuations of fractions in Bitola municipality

Comparison of seasonal fluctuations of fractions show that there are significant seasonal variations in fractions like other biodegradable waste, glass, textile and fine fraction materials. Amount of biodegradable materials had the highest share during autumn and winter campaign, glass had the highest share during the summer and spring campaign. The highest amount of fine fraction materials was presented in spring and winter samples, mostly because of presence of ashes in the samples. Textile and paper had the highest shares in spring sample. Other fractions also had fluctuations in different campaigns, but those were not significant.



Graph 2.64: Average annual morphological composition for the whole municipality of Bitola

Average morphological composition, as previously stated, took into account measurements of three different samples (from three different housing sectors) and corresponding number of people living in those sectors. Overall morphological showed the biggest amount of biodegradable waste. Both biodegradable sub fractions had a combined share of 47.89%. Other than this, paper and glass (fractions that can be recycled), had a decent share of 7.37%. On the other hand, fine fraction materials and diapers also had a notable share of 7.43 and 5.56%. Beside all other fractions, which have a share under the 4%, only textile had a share of 4.21%, mainly because of high amount of textile during the spring analysis.

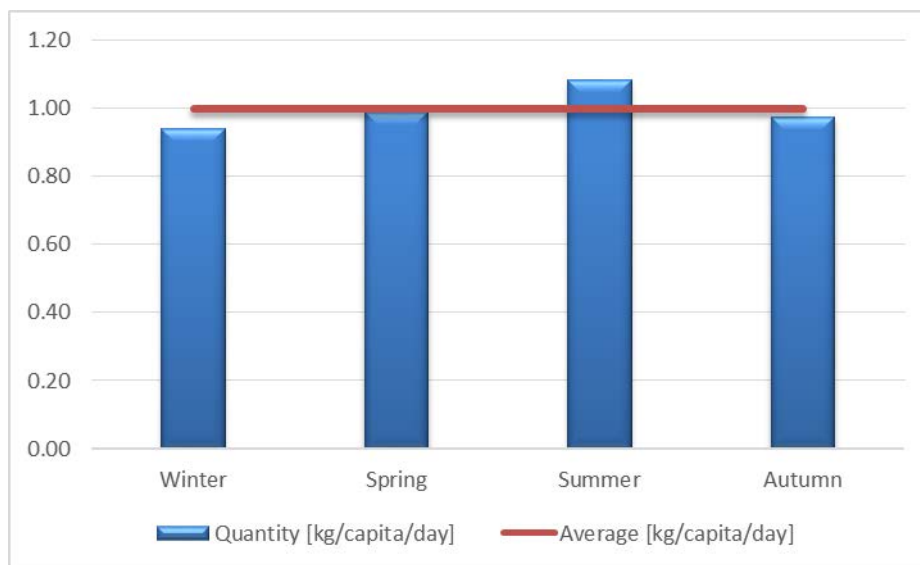


Picture 2.13: Analysis of morphological composition of waste at site – Bitola

Municipality of Bitola has implemented a system of continuous measurements of waste collecting trucks on a weighbridge before landfilling, in order to determine quantity of generated waste. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount for whole year are shown in table 2.10.

Table 2.39: Projection of obtained results

Municipality of Bitola	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	26979.76	28,373.54	31062.02	27924.06	28,584.84
Number of residents	92,777	92,777	92,777	92,777	92,777
The population covered by the organized waste collection	78,536	78,536	78,536	78,536	78,536
Share of population under organized waste collection	84.65%	84.65%	84.65%	84.65%	84.65%
Waste generation (kg/capita/year)	343.53	361.27	395.50	355.55	363.97
Waste generation (kg/capita/day)	<b>0.94</b>	<b>0.99</b>	<b>1.08</b>	<b>0.97</b>	<b>1.00</b>
Total for whole municipality (t/year)	31872.13	33,517.83	36,693.76	32,986.87	33,768.27



Graph 2.65: Overall annual fluctuations of generated waste expressed in kg/capita/day

Graph that shows annual fluctuations of generated waste shows that the highest amount of waste in the Bitola municipality was generated during the summer period and it was 1.08 kg/capita/day. All other three campaigns showed that amount of waste per capita and day was not higher than 1.00 kg/capita/day, and because of those three lower values, end amount of generated waste per capita and day was 1.00 kg.

PUC from Bitola municipality conducted measurements for determination of the quantity of waste two times before this project.

First measurement was conducted during the period 24.07.2011. – 01.08.2011. Those measurements reported total of 492880 kg (492.88 t) of municipal solid waste and 49080 kg (49.08 t) of industrial non-hazardous waste. The total amount of waste during the period of one week was 541.96 t, and at the end of this report next values were stated: 253-313 kg/capita, 122-127 kg/m<sup>3</sup> per household and 96 kg/m<sup>3</sup> of commercial waste.

Second measurement conducted during the period 22.07.2013. – 27.07.2013. Weekly quantities were 495.37 t of municipal solid waste and 75.99 t of industrial non-hazardous waste. When calculated on annual basis those quantities are 25759.44 t of municipal solid waste and 3951.48 t of industrial non-hazardous waste (29710.92 t in total).

The benefits of this project are more detailed analysis of waste quantity generated on the territory of municipality, mostly because, for the first time, four seasonal measurements were conducted. Besides from that, morphological waste composition was determined.



## 2.14 MUNICIPALITY OF RESEN

In the municipality of Resen, only three samples for analysis of morphological composition of waste were taken. The obtained results are presented in the following table.

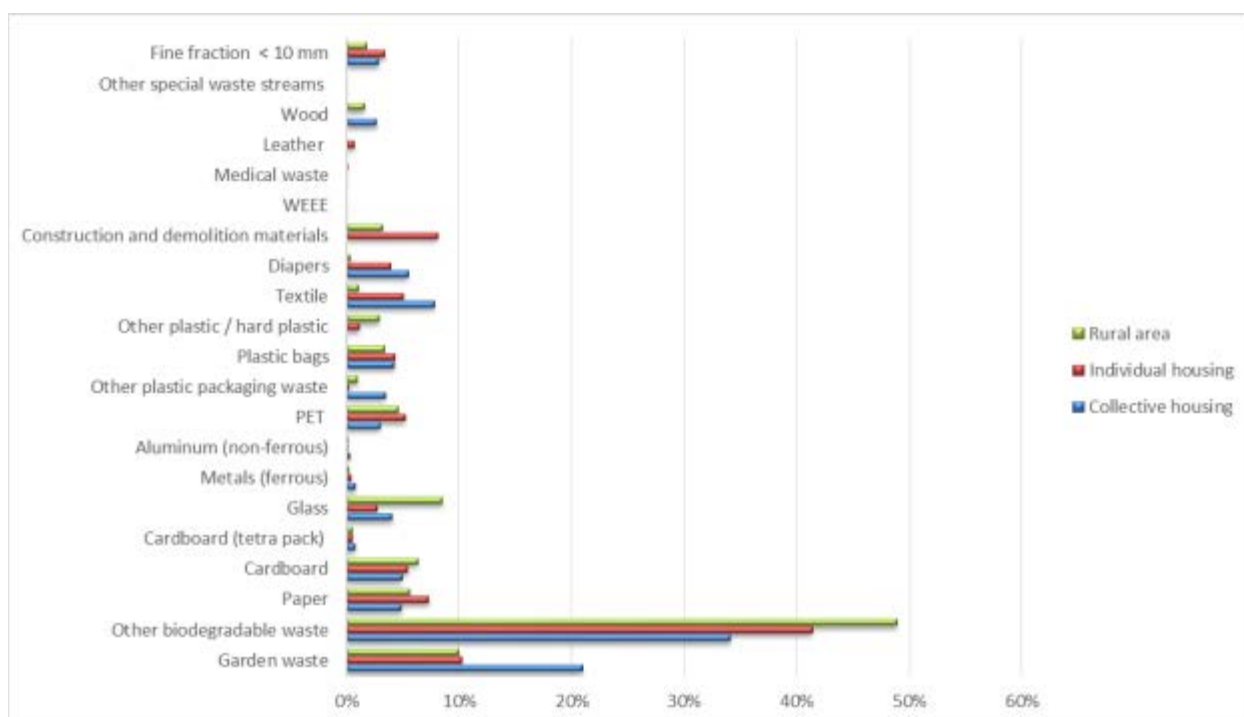
Table 2.40: Morphological composition of waste in the municipality of Resen

Resen Waste category	Mass share [%]		
	Collective housing	Individual housing	Rural sector
Garden waste	20.98%	10.25%	10.00%
Other biodegradable waste	34.10%	41.38%	48.91%
Paper	4.88%	7.30%	5.62%
Cardboard	4.93%	5.45%	6.31%
Composite materials	0.73%	0.51%	0.53%
Glass	4.03%	2.69%	8.49%
Metals (ferrous)	0.74%	0.38%	0.18%
Aluminum (non-ferrous)	0.27%	0.10%	0.08%
PET	2.96%	5.20%	4.59%
Other plastic packaging waste	3.42%	0.19%	0.97%
Plastic bags	4.24%	4.25%	3.39%
Other plastic / hard plastic	0.00%	1.13%	2.87%
Textile	7.82%	5.07%	1.09%
Diapers	5.46%	3.91%	0.33%
Construction and demolition materials	0.00%	8.10%	3.22%
WEEE	0.00%	0.00%	0.00%
Medical waste	0.00%	0.00%	0.04%
Leather	0.00%	0.70%	0.00%
Wood	2.64%	0.00%	1.59%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	2.82%	3.40%	1.77%

Dominant fraction in collective housing sector was biodegradable waste. Other biodegradable section had much higher share, comparing to garden waste, and in total those two fractions make up to 55.08%. Paper and cardboard, as well as glass, as a potentially recyclable materials had notable shares (4.88, 4.93 and 4.03% respectively), comparing to other fraction. Four types of plastic in total made a share of 10.62%. Textile fraction also had a notable share of 7.82%

Individual sector, similarly to collective housing sector, had the highest share of biodegradable waste. In this sample, garden waste had about one fourth of other biodegradable waste mass. Construction and demolition materials had a share of 8.1%, while paper and cardboard, as recyclables shares of 7.3 and 5.45%. PET bottles showed rather high share in this sample – 5.2%.

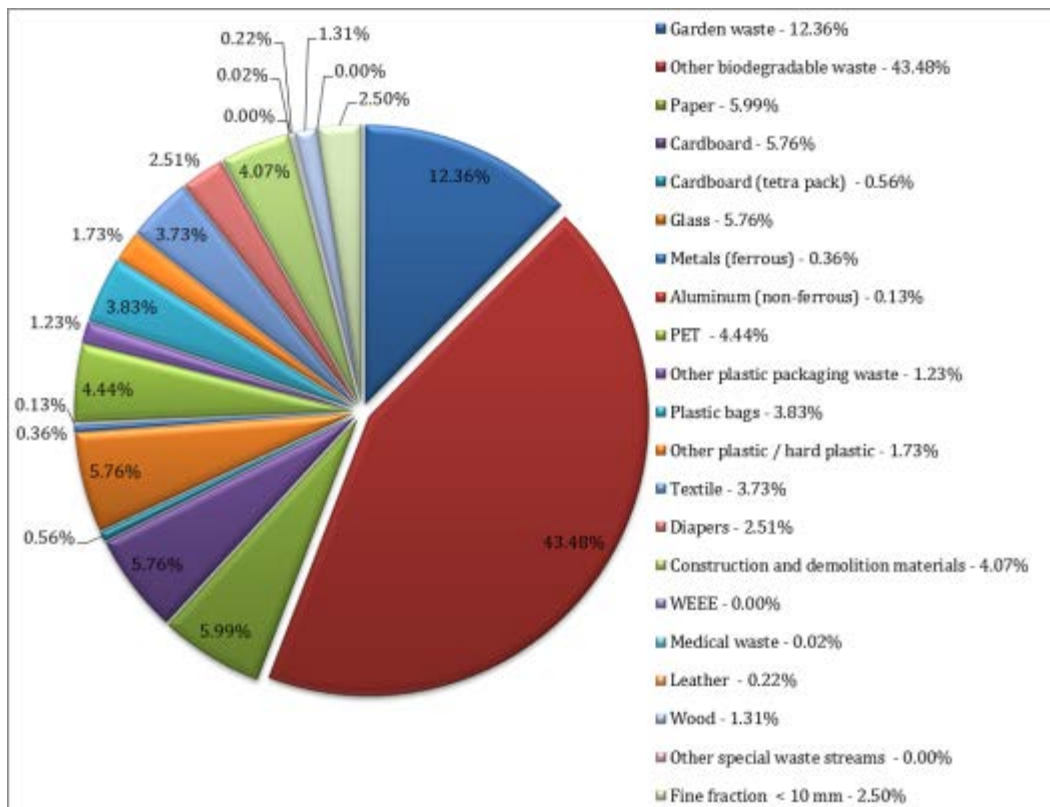
Rural sector sample showed that about a half of a total sample mass was other biodegradable waste alone. When garden waste is added to it, total biodegradable waste from rural area made up to 58.91%. Glass fraction also had big amount of 8.49%, and it is followed by cardboard (6.31%) and paper (5.62%).



Graph 2.66: Comparison of waste composition according to the housing sector - the municipality of Resen, autumn measurement

Collective housing sector had highest amount of garden waste. Besides this, in this sectors' sample, the biggest amount of textile and diapers was found, in comparison to other two samples. Individual housing sector had highest amount of construction and demolition materials, as well as paper PET and fine fraction materials (by small margin). Rural area sample showed highest amount of other biodegradable waste as well as highest amount of glass. Other fraction had slight differences in quantities among samples, while WEEE was not found in any of samples.

Final waste composition for the whole municipality is shown on a figure 2.28. It can be seen that biodegradable waste makes 55.84% in total. Many other fractions have notable shares in the municipality of Bitola. Highest and most notable of them all are paper (5.99%), cardboard (5.76%) and glass (5.76%).

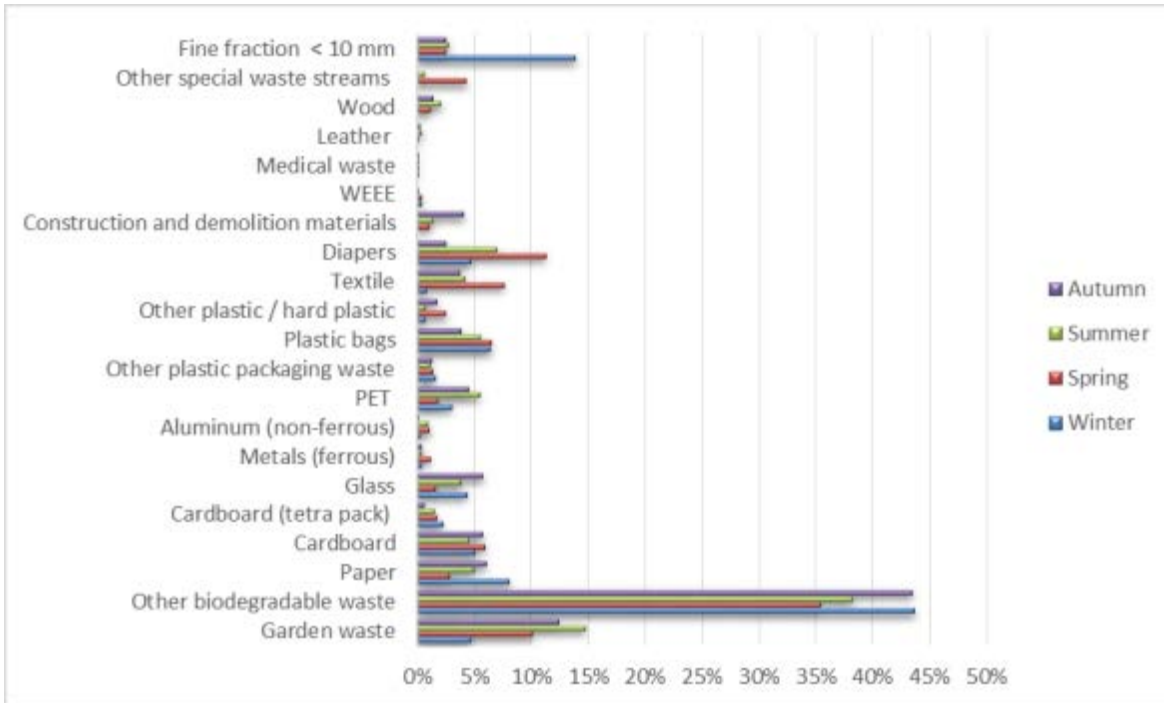


Graph 2.67: Morphological composition of waste in the Resen municipality for autumn analysis

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

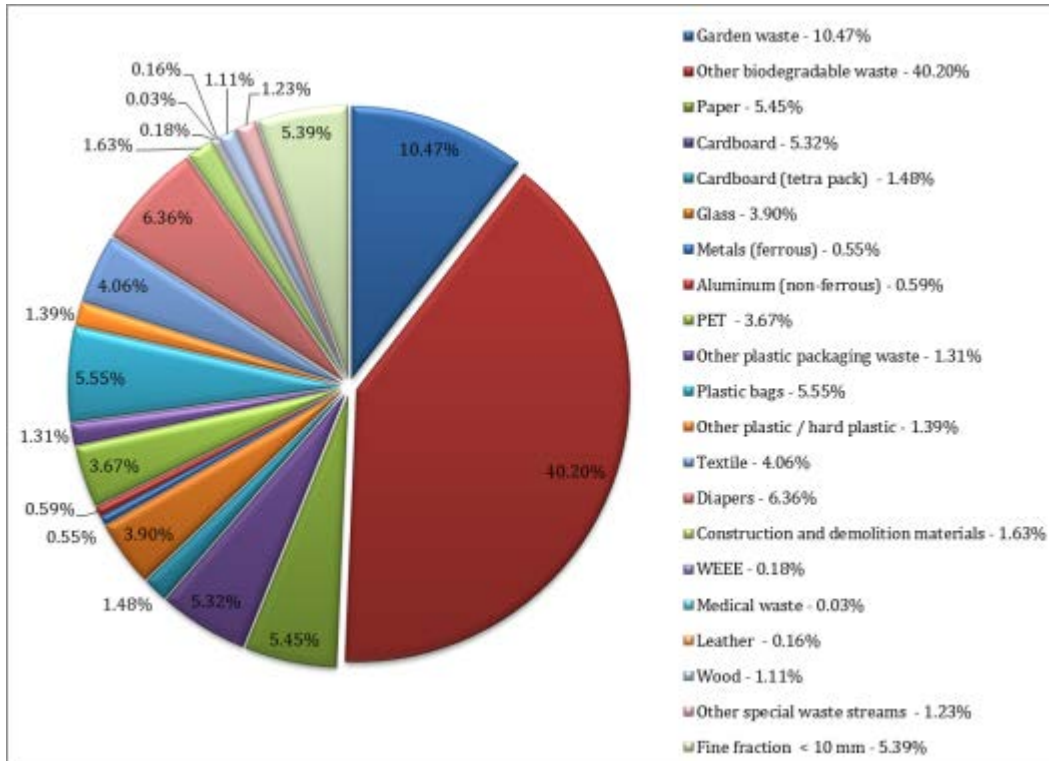
Table 2.41: Composition of municipal waste for four different seasons and the annual average value

Resen	Mass share				
Waste category	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	4.70%	10.07%	14.74%	12.36%	<b>10.47%</b>
Other biodegradable waste	43.70%	35.39%	38.22%	43.48%	<b>40.20%</b>
Paper	8.08%	2.82%	4.89%	5.99%	<b>5.45%</b>
Cardboard	5.06%	5.95%	4.50%	5.76%	<b>5.32%</b>
Composite materials	2.24%	1.67%	1.44%	0.56%	<b>1.48%</b>
Glass	4.37%	1.62%	3.84%	5.76%	<b>3.90%</b>
Metals (ferrous)	0.35%	1.10%	0.40%	0.36%	<b>0.55%</b>
Aluminum (non-ferrous)	0.20%	1.06%	0.96%	0.13%	<b>0.59%</b>
PET	3.00%	1.80%	5.45%	4.44%	<b>3.67%</b>
Other plastic packaging waste	1.57%	1.37%	1.09%	1.23%	<b>1.31%</b>
Plastic bags	6.40%	6.47%	5.49%	3.83%	<b>5.55%</b>
Other plastic / hard plastic	0.65%	2.47%	0.68%	1.73%	<b>1.39%</b>
Textile	0.75%	7.59%	4.17%	3.73%	<b>4.06%</b>
Diapers	4.70%	11.28%	6.94%	2.51%	<b>6.36%</b>
Construction and demolition materials	0.00%	1.05%	1.39%	4.07%	<b>1.63%</b>
WEEE	0.33%	0.38%	0.01%	0.00%	<b>0.18%</b>
Medical waste	0.04%	0.04%	0.01%	0.02%	<b>0.03%</b>
Leather	0.00%	0.02%	0.39%	0.22%	<b>0.16%</b>
Wood	0.00%	1.08%	2.04%	1.31%	<b>1.11%</b>
Other special waste streams	0.00%	4.29%	0.62%	0.00%	<b>1.23%</b>
Fine fraction < 10 mm	13.88%	2.48%	2.71%	2.50%	<b>5.39%</b>



Graph 2.68: Comparison of seasonal fluctuations of fractions in Resen municipality

Graph shows that the highest amount of waste in all seasons is biodegradable waste. Other biodegradable fraction had differences in shares between 35 and 45%, while garden waste had shares between 5 and 15%. Spring sample had the highest shares of materials like diapers and textile. Fine fraction materials had shares under 5% in three samples, while the share of this fraction in winter was nearly 15% probably due to heating. Construction and demolition materials had small quantities in all samples with an exception of autumn one. Other than this, rather small fluctuations in different waste samples for fractions like cardboard, packaging waste, plastic bags, hard plastics, etc...



Graph 2.69: Average annual morphological composition for the whole municipality of Resen

Figure above shows that the biodegradable waste is just slightly over the 50% mark, when overall annual composition is observed. Other fractions with relatively high shares are potentially recyclable paper and cardboard (with 5.45 and 5.32%). It should be noted that Resen municipality has a working composting facility, which mainly uses garden and biodegradable waste which is generated on local field in apple production, so biodegradable waste stream (or even paper and cardboard) could be directed there (facility may need capacity expansion). Besides this, relatively high amount of plastic bags, fine fraction materials and diapers was recorded – 5.55, 5.39 and 6.36%.

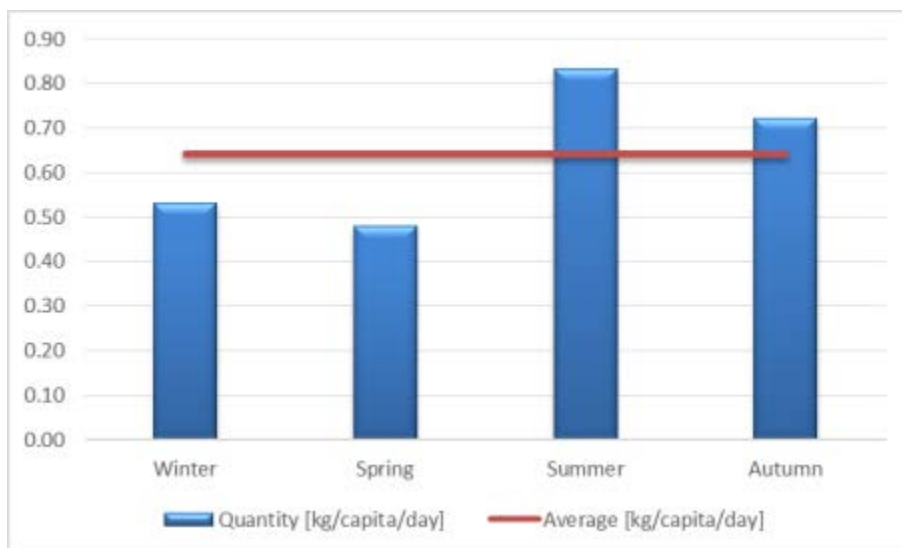


Picture 2.14: Analysis of morphological composition of waste at site – Resen

In the municipality of Resen, measurements of waste quantities were conducted. Results were obtained during four campaigns over a period of one week. Those results for each of campaigns and the projection of the average amount for whole year are shown in table 2.42.

Table 2.42: Projection of obtained results

Municipality of Resen	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	2,558.65	2,304.71	4,009.79	3,468.54	3085.42
Number of residents	16,345	16,345	16,345	16,345	16,345
The population covered by the organized waste collection	13,186	13,185	13,185	13,185	13,185
Share of population under organized waste collection	80.67%	80.67%	80.67%	80.67%	80.67%
Waste generation (kg/capita/year)	194.05	174.79	304.11	263.06	234.00
Waste generation (kg/capita/day)	<b>0.53</b>	<b>0.48</b>	<b>0.83</b>	<b>0.72</b>	<b>0.64</b>
Total for whole municipality (t/year)	3171.75	2,857.02	4970.70	4299.75	3824.75



Graph 2.70: Overall annual fluctuations of generated waste expressed in kg/capita/day

Analysis of generated waste in the Bitola municipality showed that higher quantity was generated during the summer and autumn. The lowest amount of generated waste per capita daily was 0.48 kg, it was obtained during the spring campaign, while the highest quantity was noted during summer campaign – 0.83 kg/capita/day. Average value is 0.64 kg/capita/day. Higher amount of waste during the summer and autumn periods can maybe be linked to enhanced activities due to apple production. Besides this, it should be noted that only around of 80% of municipality is covered with PUC's services.

PUC "Proleter" from Resen municipality reported measurements of waste quantity before the start of this project. Total annual quantities were 3798 t, and it was stated that 3456 t was municipal solid waste, 190 t was waste from town marketplace, 75 t were collected from streets and 52 t was commercial waste while 25 t of waste were collected from parks and graveyard area.

It is clear that the benefits of this project are new data about the morphological composition of waste in the municipality, as well as the most certain and recent data about the waste quantity.



## 2.15 MUNICIPALITY OF KOČANI

Analyzing waste composition of the municipality of Kočani, three samples according to the proposed methodology were taken from collective housing, individual housing and rural sector. The obtained results are presented in the following table.

Table 2.43: Morphological composition of waste in the municipality of Kočani – autumn analysis

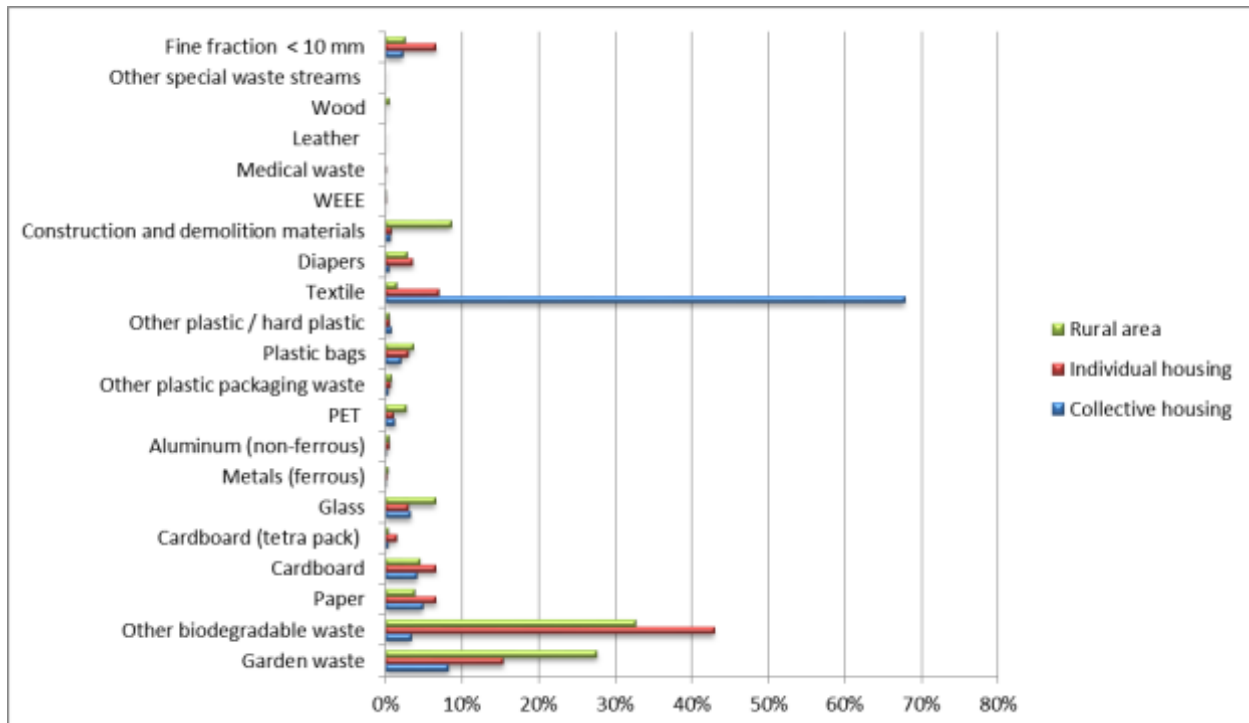
Kočani Waste category	Mass share		
	Collective housing	Individual housing	Rural sector
Garden waste	8.23%	15.37%	27.63%
Other biodegradable waste	3.38%	42.97%	32.64%
Paper	4.87%	6.62%	3.86%
Cardboard	4.12%	6.62%	4.44%
Composite materials	0.32%	1.47%	0.40%
Glass	3.31%	2.94%	6.53%
Metals (ferrous)	0.07%	0.20%	0.32%
Aluminum (non-ferrous)	0.16%	0.49%	0.49%
PET	1.26%	1.04%	2.79%
Other plastic packaging waste	0.34%	0.69%	0.82%
Plastic bags	1.98%	2.93%	3.66%
Other plastic / hard plastic	0.74%	0.53%	0.48%
Textile	67.84%	6.93%	1.47%
Diapers	0.46%	3.58%	2.80%
Construction and demolition materials	0.65%	0.78%	8.58%
WEEE	0.00%	0.18%	0.04%
Medical waste	0.00%	0.02%	0.00%
Leather	0.00%	0.00%	0.00%
Wood	0.00%	0.00%	0.50%
Other special waste streams	0.00%	0.00%	0.00%
Fine fraction < 10 mm	2.27%	6.64%	2.54%

Sample from collective housing sector in municipality of Kočani showed rather strange composition. Textile had the highest sharer in this sample – 67.84%. Reasoning behind this is that there are several clothing manufactures and shops in the collective housing sector of the

municipality. Besides this huge amount of waste, there was notable amount of garden waste, and paper and cardboard.

Sample from individual housing sector had more than 55% biodegradable waste. There also was a notable amount of paper (6.62%) and cardboard (6.62%), textile (6.93%) and fine fraction (6.64%). All other fractions had a share under 4%.

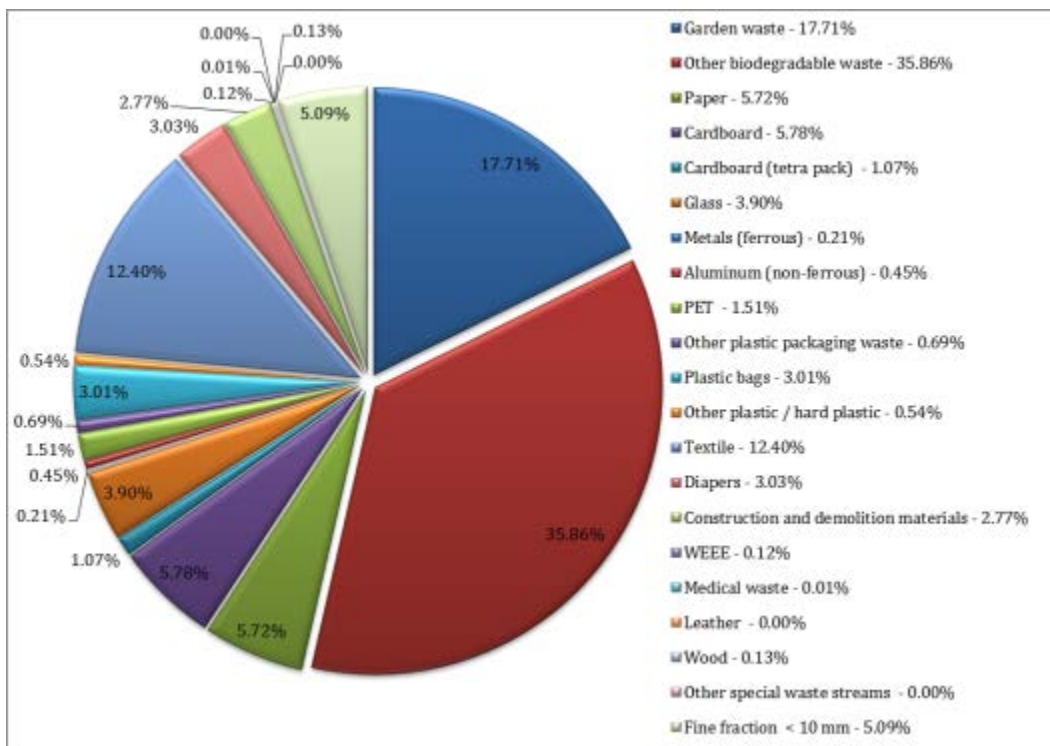
Rural area sample beside big amount of biodegradable waste, which was more evenly distributed between two sub fractions, had the most notable amount of construction and demolition materials (8.58%). This sample showed big amount of glass, cardboard and paper with shares of 6.53, 4.44 and 3.86% respectively.



Graph 2.71: Comparison of waste composition according to the housing sector - Municipality of Kočani, autumn analysis

Because of big amount of textile in collective housing sector, all other fractions from this sector have small shares. Individual housing sector had notable higher share of other biodegradable waste, fine fraction, and slightly higher share of paper, cardboard and tetra pack, comparing to rural area sample. On the other hand, rural area sample had higher share of garden waste, glass and C&D materials, comparing to individual housing sector.

Total waste composition for whole municipality was affected with the huge amount of textile in the collective housing sector. Because of this, projection of total composition shows that 12.4% of waste is textile. On the other hand, even beside this, more than 50% of waste is biodegradable. Paper, cardboard and fine fraction materials have shares slightly over then 5%.

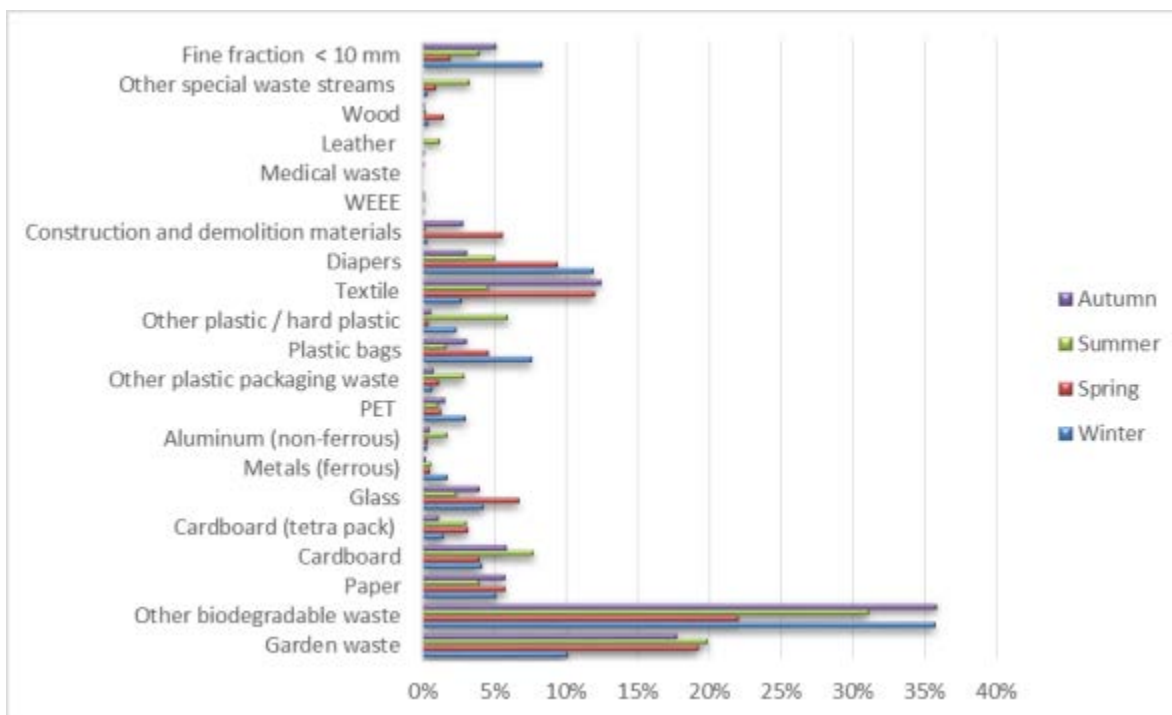


Graph 2.72: Morphological composition of waste in the Kočani municipality, autumn measurement

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

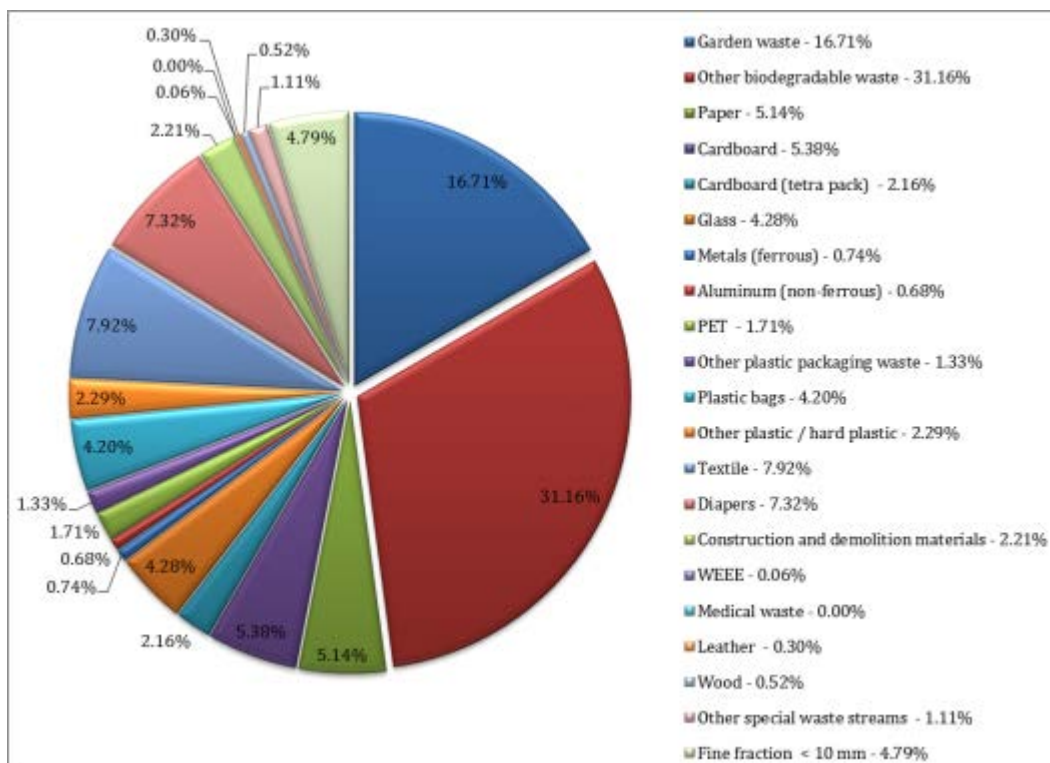
Table 2.44: Composition of municipal waste for four different seasons and the annual average value

Kočani Waste category	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	10.10%	19.20%	19.85%	17.71%	<b>16.71%</b>
Other biodegradable waste	35.73%	21.99%	31.07%	35.86%	<b>31.16%</b>
Paper	5.15%	5.76%	3.93%	5.72%	<b>5.14%</b>
Cardboard	4.12%	3.93%	7.70%	5.78%	<b>5.38%</b>
Composite materials	1.42%	3.14%	3.02%	1.07%	<b>2.16%</b>
Glass	4.19%	6.70%	2.31%	3.90%	<b>4.28%</b>
Metals (ferrous)	1.67%	0.48%	0.59%	0.21%	<b>0.74%</b>
Aluminum (non-ferrous)	0.26%	0.30%	1.70%	0.45%	<b>0.68%</b>
PET	2.97%	1.27%	1.08%	1.51%	<b>1.71%</b>
Other plastic packaging waste	0.67%	1.12%	2.85%	0.69%	<b>1.33%</b>
Plastic bags	7.56%	4.60%	1.61%	3.01%	<b>4.20%</b>
Other plastic / hard plastic	2.33%	0.36%	5.92%	0.54%	<b>2.29%</b>
Textile	2.72%	11.97%	4.60%	12.40%	<b>7.92%</b>
Diapers	11.86%	9.42%	4.98%	3.03%	<b>7.32%</b>
Construction and demolition materials	0.29%	5.56%	0.21%	2.77%	<b>2.21%</b>
WEEE	0.01%	0.00%	0.11%	0.12%	<b>0.06%</b>
Medical waste	0.00%	0.00%	0.00%	0.01%	<b>0.00%</b>
Leather	0.05%	0.00%	1.14%	0.00%	<b>0.30%</b>
Wood	0.34%	1.46%	0.16%	0.13%	<b>0.52%</b>
Other special waste streams	0.27%	0.89%	3.27%	0.00%	<b>1.11%</b>
Fine fraction < 10 mm	8.29%	1.85%	3.91%	5.09%	<b>4.79%</b>



Graph 2.73: Comparison of seasonal fluctuations of fractions in Kočani municipality

Waste in municipality of Kočani had an unusual composition, mainly because there was big amount of textile during spring and autumn analysis, and the amounts of these fractions were smaller during the other two campaigns. There was a significant variation in amounts of other biodegradable waste among different seasons, and this fraction ranged between 21.99% during spring season, to 35.86% during winter. Other fractions, beside fine fraction materials, glass, plastic bags, diapers and C&D materials had rather small deviations (less than 5%). Fine fraction materials had the highest share during winter, C&D materials had the highest share during spring (there was a lesser amount during autumn, while during other two seasons amounts were really small). There was the highest amount of diapers during winter, while textile had the highest share during spring. Plastic bags fraction had close amounts for all seasons beside winter (this season showed higher amount in comparison to other measurement results). Glass had high share during the spring, while it had close amount values for other periods.



Graph 2.74: Average annual morphological composition for the whole municipality of Kočani

Overall composition of waste for the municipality of Kočani shows quite high amount of biodegradable waste. Two sub fractions combined make up to 47.87%. The highest share after those two fractions have textile and diapers fraction. It should be noted that there was a big amount of textile in at two collective housing sector samples during the spread of four campaigns. Potentially recyclable materials like paper, cardboard and glass have relatively high shares, while plastic bags have the highest share among other plastic sub fractions.

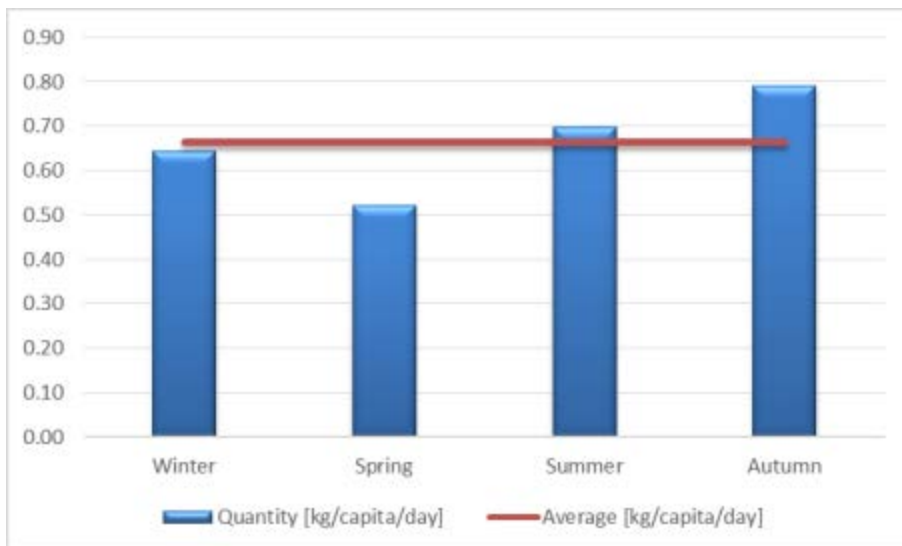


Picture 2.15: Analysis of morphological composition of waste at site – Kočani

Municipality of Kočani has implemented a system of continuous measurement of waste quantities on a weighbridge before landfilling. Obtained results for one week campaign show values represent in table 2.30.

Table 2.45: Projection of obtained results

Municipality of Kočani	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	8,455.49	6,824.46	9,135.95	10,367.56	8,695.86
Number of residents	38,004	38,004	38,004	38,004	38,004
The population covered by the organized waste collection	35,914	35,914	35,914	35,914	35,914
Share of population under organized waste collection	94.50%	94.50%	94.50%	94.50%	94.50%
Waste generation (kg/capita/year)	235.44	190.02	254.39	288.68	242.13
Waste generation (kg/capita/day)	<b>0.65</b>	<b>0.52</b>	<b>0.70</b>	<b>0.79</b>	<b>0.66</b>
Total for whole municipality (t/year)	89,47.60	7,221.68	9,667.71	10,971.01	9,201.97



Graph 2.75: Overall annual fluctuations of generated waste expressed in kg/capita/day

Municipality of Kočani had almost same amounts of generated waste per capita daily for winter and summer period, while amounts were the highest during autumn and the lowest during the spring. Average value is 0.66 kg/capita/day, and this value is very close to winter waste generation value.



## 2.16 MUNICIPALITY OF ILINDEN

In the municipality of Ilinden, two samples for analysis of morphological composition of waste were taken. Samples were from individual housing sector, as well as from the rural sector. Reason for this is that there is no collective housing sector in Ilinden. The obtained results are presented in the following table.

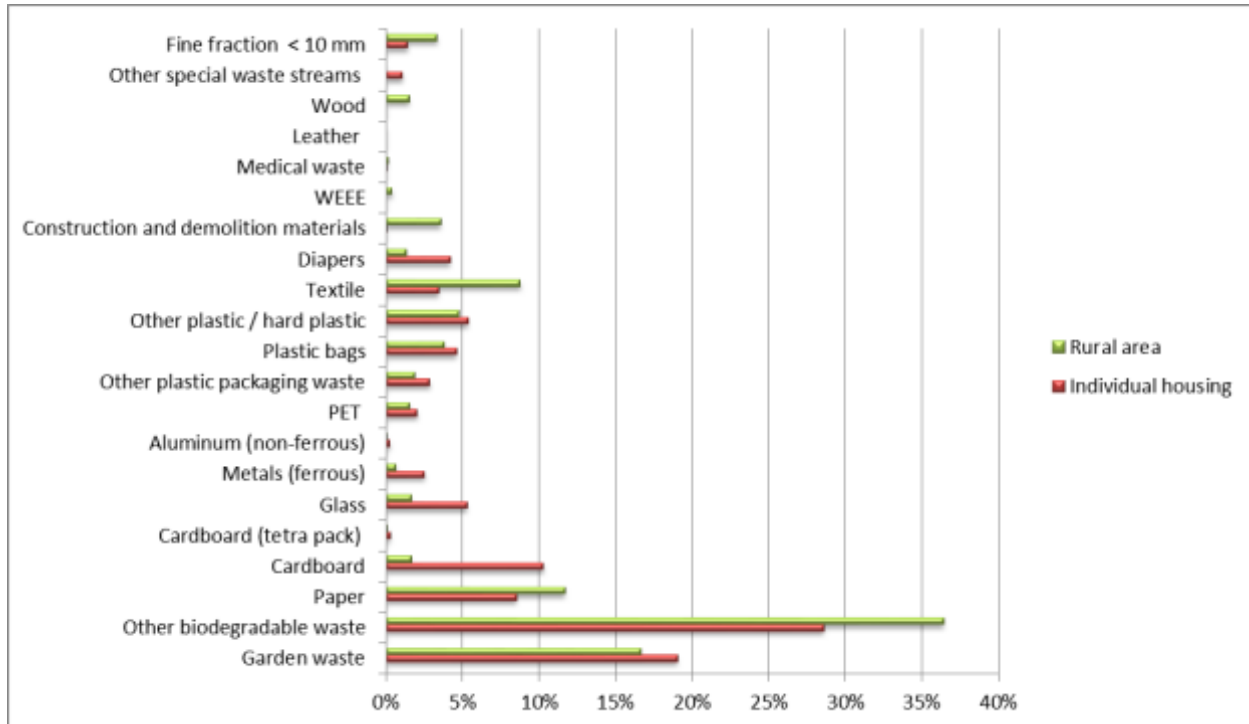
*Table 2.46: Morphological composition of waste in the municipality of Ilinden*

Ilinden Waste category	Mass share	
	Individual housing	Rural sector
Garden waste	19.05%	16.63%
Other biodegradable waste	28.59%	36.43%
Paper	8.52%	11.70%
Cardboard	10.30%	1.66%
Composite materials	0.29%	0.11%
Glass	5.30%	1.65%
Metals (ferrous)	2.54%	0.66%
Aluminum (non-ferrous)	0.27%	0.05%
PET	2.05%	1.56%
Other plastic packaging waste	2.87%	1.88%
Plastic bags	4.60%	3.78%
Other plastic / hard plastic	5.37%	4.76%
Textile	3.44%	8.77%
Diapers	4.21%	1.34%
Construction and demolition materials	0.07%	3.60%
WEEE	0.00%	0.39%
Medical waste	0.02%	0.16%
Leather	0.00%	0.00%
Wood	0.00%	1.53%
Other special waste streams	1.09%	0.00%
Fine fraction < 10 mm	1.42%	3.34%

In individual housing sector, dominant fraction was other biodegradable waste. Fraction with second highest sharer was garden waste. Those two fractions had shares of 28.59 and 19.05%.

Cardboard had the highest share out of all recyclables – 10.3%; while paper also had high share of 8.52%. Plastic fractions also had notable shares. Hard plastic had the highest share of all sub fractions, and it is followed by plastic bags.

Rural sector showed more than 50% of biodegradable waste. Paper had highest share out of all recyclable materials – 11.7%. Similarly to individual housing sector, hard plastic and plastic bags had higher shares than PET and packaging waste. Besides this, this sample showed high amount of textile – 8.77%.



Graph 2.76: Comparison of waste composition according to the housing sector - the municipality of Ilinden, autumn analysis

When comparing two sectors, it can be seen that biodegradable waste had the biggest share in both sectors, while garden waste had slightly higher share in individual housing sample, while other biodegradable waste had higher in rural area sample. Individual housing sector showed higher amount of cardboard, glass and diapers, while rural area had higher amount of paper, textile, C&D materials and fine fraction materials. Wood was only presented in rural area sample, and all other fraction had small deviations between samples.

The overall composition in this municipality is shown on the following figure. About half of total waste was biodegradable waste. Besides this, notable shares had paper and cardboard, while textile and hard plastic had shares slightly over 5%. All other fraction had smaller shares.

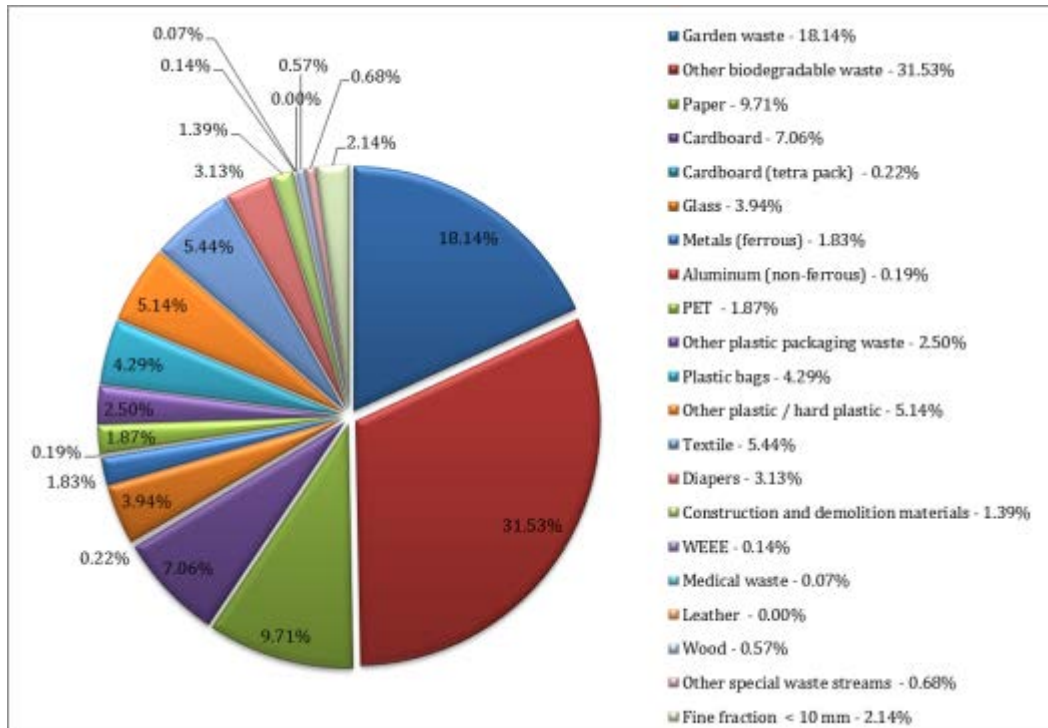
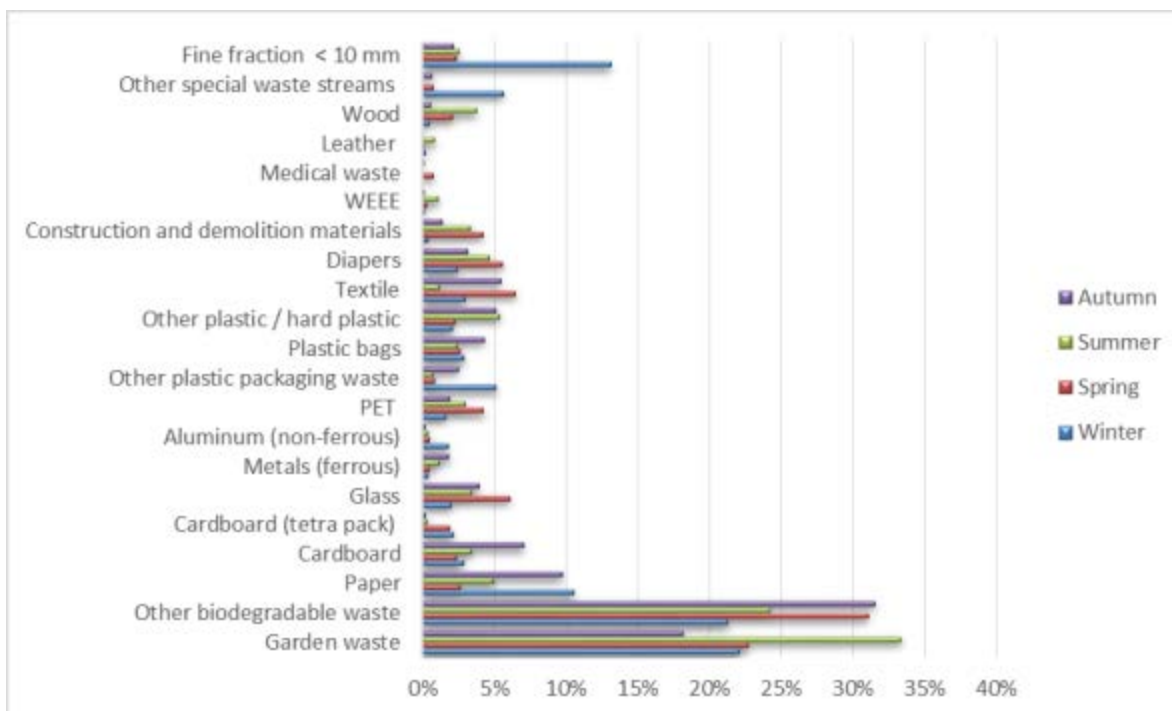


Figure 2.77: Overall morphological composition of waste in the Municipality of Ilinden for the autumn analysis

Four seasonal measurements were conducted after each season. After each of measurements, seasonal results were presented. Those results took into account morphological composition of samples taken from three housing sectors and the number (percentage) of people living in corresponding sector. Following table shows the average value of morphological composition over the all seasonal measurements.

Table 2.78: Composition of municipal waste for four different seasons and the annual average value

Ilinden	Mass share				
	WINTER	SPRING	SUMMER	AUTUMN	AVERAGE
Garden waste	22.09%	22.74%	33.35%	18.14%	<b>24.08%</b>
Other biodegradable waste	21.29%	31.07%	24.18%	31.53%	<b>27.02%</b>
Paper	10.51%	2.61%	4.94%	9.71%	<b>6.94%</b>
Cardboard	2.85%	2.34%	3.42%	7.06%	<b>3.92%</b>
Composite materials	2.14%	1.85%	0.32%	0.22%	<b>1.13%</b>
Glass	1.98%	6.06%	3.38%	3.94%	<b>3.84%</b>
Metals (ferrous)	0.36%	0.46%	1.15%	1.83%	<b>0.95%</b>
Aluminum (non-ferrous)	1.79%	0.49%	0.39%	0.19%	<b>0.71%</b>
PET	1.62%	4.23%	2.99%	1.87%	<b>2.68%</b>
Other plastic packaging waste	5.11%	0.84%	0.70%	2.50%	<b>2.29%</b>
Plastic bags	2.88%	2.63%	2.45%	4.29%	<b>3.06%</b>
Other plastic / hard plastic	2.05%	2.21%	5.36%	5.14%	<b>3.69%</b>
Textile	2.96%	6.47%	1.14%	5.44%	<b>4.00%</b>
Diapers	2.45%	5.58%	4.65%	3.13%	<b>3.95%</b>
Construction and demolition materials	0.35%	4.21%	3.36%	1.39%	<b>2.33%</b>
WEEE	0.14%	0.24%	1.09%	0.14%	<b>0.40%</b>
Medical waste	0.00%	0.77%	0.00%	0.07%	<b>0.21%</b>
Leather	0.23%	0.02%	0.85%	0.00%	<b>0.28%</b>
Wood	0.45%	2.09%	3.75%	0.57%	<b>1.72%</b>
Other special waste streams	5.62%	0.77%	0.00%	0.68%	<b>1.77%</b>
Fine fraction < 10 mm	13.12%	2.33%	2.55%	2.14%	<b>5.04%</b>



Graph 2.78: Comparison of seasonal fluctuations of fractions in Ilinden municipality

Share of garden waste in the Ilinden municipality had closer value to the value of other biodegradable waste share, in comparison to some other municipalities. Amount of garden waste was highest during the summer period, while it had the lowest value during the autumn period. On the other hand other biodegradable had the highest share during the autumn, and the lowest share was presented during the winter. Paper and cardboard had the highest shares during the autumn period, as well. Fine fraction materials have increased amount during the winter period. Construction and demolition materials were presented in all seasonal measurements, but had higher values during spring and summer. Hard plastic had higher shares during summer and autumn period, compared to other two seasons. Packaging waste had small amount during three seasons, while it had the highest share during the winter. All other waste fractions have either small total shares or small deviations among different seasons.

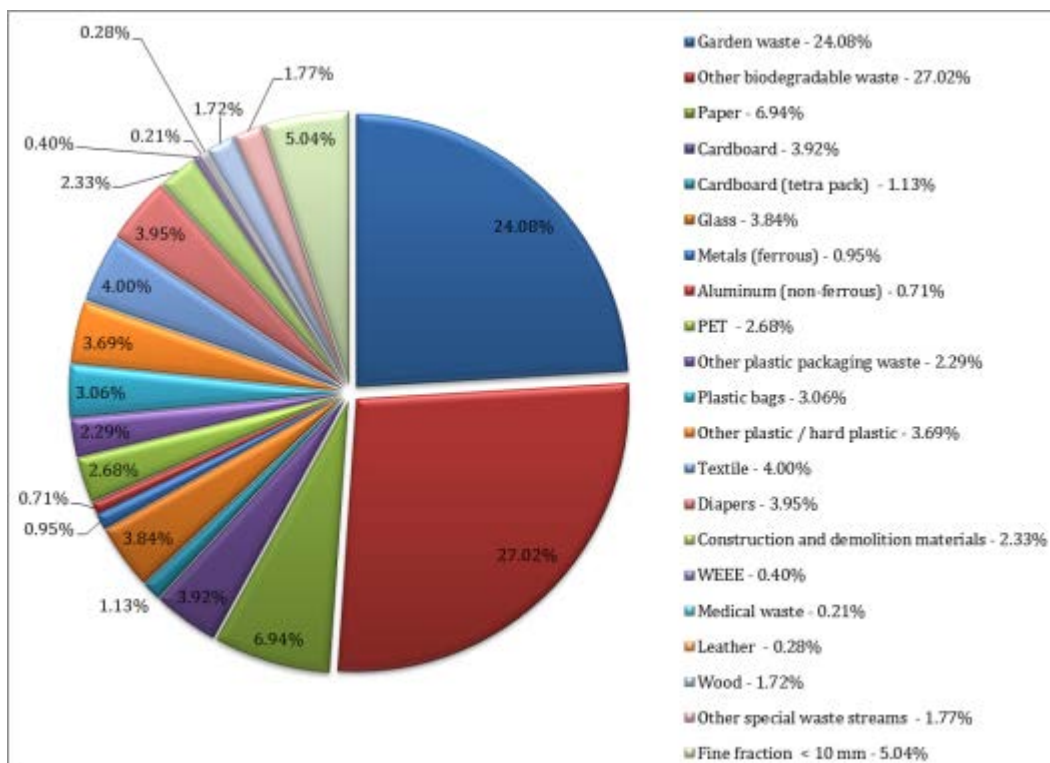


Figure 2.79: Average annual morphological composition for the whole municipality of Ilinden

Biodegradable waste, with its two sub fractions makes nearly 50% of total waste mass. It is followed by paper – 6.94%, and fine fraction materials – 5.04%. All other material fractions have lesser shares, but, interestingly, there are numerous fractions that have shares between 2 – 5% (cardboard, glass, PET, packaging plastic, plastic bags, textile, diapers, C&D materials).

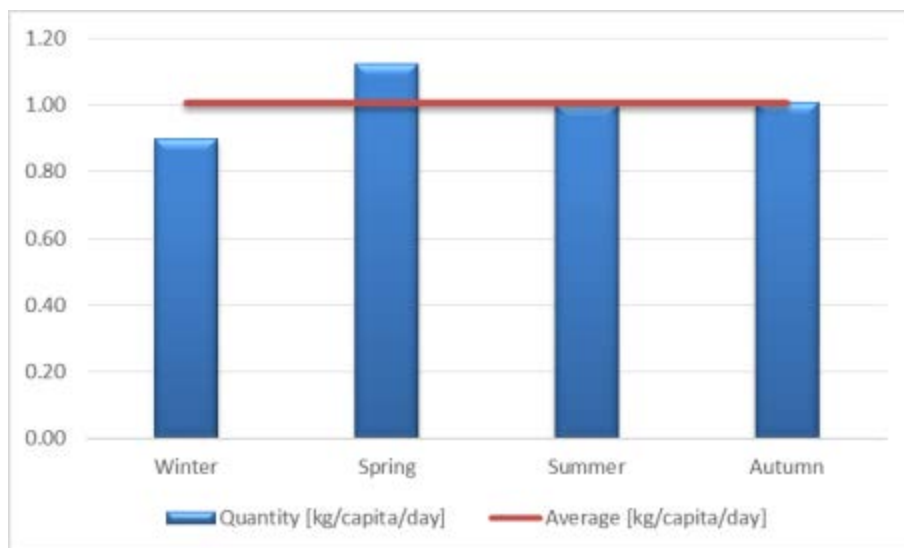


Picture 2.16: Analysis of morphological composition of waste at site – Ilinden

Measurements for determination of the quantities of generated waste were conducted in the municipality of Ilinden, during a period of one week. The weighting was conducted on the weighbridge, and the obtained results were used in order to obtain data such as the total collected amount of waste or waste generation per capita and day. Those results are shown in following table.

Table 2.48: Projection of obtained results

Municipality of Ilinden	Winter	Spring	Summer	Autumn	Average
Total collected waste amount (t/year)	5481.26	6,855.22	6120.01	6153.38	6152.47
Number of residents	16736	16,736	16,736	16,736	16,736
The population covered by the organized waste collection	16736	16,736	16,736	16,736	16,736
Share of population under organized waste collection	100.00%	100,00%	100,00%	100,00%	100,00%
Waste generation (kg/capita/year)	327.51	409.61	365.68	367.67	367.62
Waste generation (kg/capita/day)	<b>0.90</b>	<b>1.12</b>	<b>1.00</b>	<b>1.01</b>	<b>1.01</b>
Total for whole municipality (t/year)	5481.26	6,855.22	6120.01	6153.38	6152.47



Graph 2.80: Overall annual fluctuations of generated waste expressed in kg/capita/day

Processed data about waste generation per capita daily show similar end values of amount of generated waste to Bitola municipality (end value for Bitola is 1.00 kg/capita/day; while end value for Ilinden is 1.01 kg/capita/day). Fluctuations between different seasonal measurements are rather small – end value is maximally 0.11 kg/capita/day away from end value (four seasons with highest differences then the end value).