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# Pilot study of generation and disposal of municipal solid wastes in selected household in rural areas in the south-western Poland

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Pilot study of the composition of wastes was carried out in 15 rural family households engaged in agricultural activity. In the study group the average resident of rural areas generates about 166 kg of municipal wastes annually. The conducted studies showed that the composition of municipal wastes coming from rural households changes seasonally. During the periods of summer and autumn, the quantity of bio-wastes increased distinctly. The average mass of wastes transferred to the companies engaged in the collection of wastes in the analyzed rural households is almost 50 kg · $M^{-1}$ · $year^{-1}$. The studies showed that over 80% of organic wastes (kitchen and garden) is utilized in the place where they are generated. In the studies, organic wastes were collected selectively (in separate bags), which undoubtedly had influence on their humidity (70–90%). Laboratory analysis of these wastes showed that the ratio C:N in it was from 7 to 19, whereas pH lay within the limits from 5.8 to 6.9 indicating its very good properties for the composting process. Therefore composting of organic waste from rural household should be recommended as the best way for its disposal and the weight reduction of biodegradable waste going to landfills. Comparison of the analyzed variants showed that some waste other than kitchen and garden does not leave the holding (it is re-used or burned in home hearths).

**Keywords:** waste management, rural areas.

## INTRODUCTION

In the year 2011 in Poland 9828 thousand tons of municipal wastes was collected, of which about 70% came from households[1]. According to statistical data published by Central Bureau for Statistics (*GUS*) on the basis of, among others, Eurostat, Poland is on the 28 th place with respect to the quantity of municipal wastes generated per 1 resident, among 31 countries analyzed[1]. Since becoming a member of the European Union, Poland was under obligation to undertake a series of actions associated among others with waste management. The basis for realization of these actions will constitute the new legal regulations introducing among others higher responsibility of districts for municipal wastes management on their territories[2]. The statute also assigns the levels of: recycling, and preparation for reuse, or as in the case of biodegradable wastes, limiting the storage of such wastes.

So far the study of mass and composition of municipal waste in Poland has been carried out mainly in the cities. It was conducted for the purpose of monitoring the implementation of the National Plan for Waste Management[3, 4].

For waste management it is important to know the amount of its formation and composition. Factors that may affect the quantity and composition of waste e.g. demographic, geographic should be taken into account.

Rural areas account for approximately 93% of Poland. It has a population of nearly 15.5 million, which represents almost 40% of the Polish population[5]. The number of rural household in Poland amounts to 4422 i.e. 32,6% of the total number of Polish households[6]. Waste management in rural areas in Poland is not well recognized. In the available literature there are no data about waste management activities in rural areas. It is necessary to know different data about waste for proper waste management planning in the community. No such data is available mainly due to the high costs of such research. The rural areas specificity does not let to use the data on the amount and composition of waste generated in cities to organize waste management at rural areas because of prevalence of individual family houses and their scattering, high share of coal furnaces in individual heating systems and kind of rural activity.

The differences in the quantities and composition of wastes depend on many factors, among others on the kind of buildings, season of the year, as well as the accepted methods of conducting the studies. Wastes quantity and composition also change over the period of year[4, 7, 8].

Large differences in the amount and composition of the waste interferes with the planning of a new order for waste management. All decisions of waste management in the region (e.g. timetable of waste reception, type and location of waste treatment installations) should be based on knowledge of the amount and composition of the waste produced in these regions.

For the purpose of reducing the quantities of contaminants channeled into water, soil and atmospheric environments from waste disposal, it is necessary to plan actions and investments connected with waste disposal.

According to the policy of the European Union the member states should establish a waste management system, which is consistent with the principles of sustainable development, which means using in practice 3R Rule (**R**educe, **R**euse, **R**ecycle).

Current problems of waste management in rural areas in Poland and no data were an inspiration to undertake research aimed at the quantity and composition of waste generated in rural households, seasonal variation of these waste, specific waste management in rural households in the context of the possibility of their disposal and the impact on the environment.

In order to pre-estimate the amount and composition of the waste of the typical household in rural areas and factors affecting waste pilot studies was carried out.

## METHODS AND STUDY DESIGN

Inspection of the composition of wastes was carried out in 15 rural family households engaged in agricultural activity, which declared utilization the domestic waste in household. The study included only waste generated by households. The wastes were produced on a continuous basis (typically, daily generated waste).

Chosen farms were located in the south-west, west and central Poland, in four provinces. The studies included a total of 57 people of different ages.

In the study group of people the children under 4 years were 6.5%, older children and adolescents – 20.1%, of working age – 56.9% and seniors – 16.5%.

In the study households, there were four having 2 person each, three having 3 person, four having 4 person and four having 5 or more person. The selected farms reflect the demographic composition of the rural population in Poland, not only in terms of age as well as the number of people in family[9]. The studies were carried out during 4 seasons (winter, spring, summer and autumn). In every season studies lasted two weeks. In the first week (variant T1), the families accumulated all the wastes created in the household. In the second week (variant T2), the families acted in accordance with their customs and threw into the bags only those wastes, which would in the daily practice so far be dumped into the common container. Terms of waste receipt have been chosen that there were no Christmas (events) that could significantly affect both the quantity and composition of the waste. All the wastes were collected from the households immediately after the period of collection and subjected to analysis of quantity and composition at the Inspection Station of the Institute of Technology and Life Science, Lower Silesian Research Centre at the same day.

For determining the composition of wastes, the method applied was their division into 13 basic material fractions: OR1- organic wastes (OR1 01 – kitchen organic wastes, OR1 02 – garden organic wastes), W2 – wood, PC3 – paper and cardboard, PL4 – plastics, G5 – glass, T6 – textiles, M7 – metals, H8 – hazardous wastes, C9 – composites, IN10 – inerts, U11 – other categories, F12 – minor wastes, P13 – hearth wastes), separated within, which were 34 sub-fractions. Waste samples were collected from fraction OR1 01 along with ashes for the purpose of carrying out chemical analyses.

The pH was measured in the aqueous extracts of the analyzed samples by potentiometry (PN-Z-15011-3:2001)[10]. The content of organic carbon was determined by calcining the dry weight (PN-EN 12879:2004)[11]. Total nitrogen was determined calorimetrically by indophenol reaction using the spectrophotometer UV/VIS 916 of GBC Company according to PN-Z-15011-3:2001[10]. Amount of total phosphorus was determined by calorimetric method using molybdenic blue (PN-76/C-04537/07)[12]. The content of micro- and macro-organic components in the organic waste was determined using ICP spectrometer Integra of GBC Company according to PN-EN ISO 11885:2009 standard[13]. The amount of heavy metals in bottom ash was analyzed by Solaar 6M atomic absorption spectrometer of Thermo Company.

## DISCUSSION OF RESULTS

This results first of all from the specifics of the area covered by the analysis. The wide variation in the results takes place within a much smaller territorial units. Research from 2006 year showed, that test weight of household waste in the country in five small municipalities in Malopolska province (Poland) ranged from 31 do 84,46 kg annually per capita. The estimated size (according to official indicators) was 223.59 kg annually per capita[14]. Older studies at rural areas showed, that weight of waste was ranged from 130–250 kg depending on part of polish rural areas under, which they were made[8]. According to the authors of both works apart from the territorial differentiation the following factors should be taken into account in the planning of waste management in rural areas: reusing of waste in their own farm, incineration the part of waste in the household hearths, abandon waste in prohibited places so called ”illegal dumping”.

In extreme cases, the differences in the amount of waste produced in one country can reach several hundred percent. For example studies conducted in the locality of Sisimiut in Greenland showed, that average quantity of household wastes generated amounts to 133 kg annual on per capita, however the quantity of wastes in statistical data for Denmark amounts to 650 kg annual per capita.

The studies showed that the composition of municipal wastes coming from rural households changes seasonally (Table 1). During the periods of summer and autumn, the quantity of bio-wastes increases distinctly. This results to a considerable extent from growth in the quantity of wastes arising during nurturing of areas around buildings. During winter, a big amount of wastes originating from household hearths whose share in the total mass of wastes may reach almost 20% in case of utilizing coal stoves may pose a problem. These results find confirmation in the studies of other authors conducted on the terrains of various towns in Poland, in which both the share of fractions <10 mm as well as the share of organic wastes in the total mass of wastes underwent very distinct changes depending on the season of the year[4].

In rural areas a lot of wastes are utilized or recycled “at source” in a more or less proper manner. Organic wastes can be used for feeding the animals, composting. Unfortunately sometimes wastes such as wood, color paper and plastics are burned in stoves and ashes coming from them are disposal on site.

The average mass of wastes transferred to firms engaged in the collection of wastes in the analyzed households is almost 50 kg · $M^{-1}$ · $year^{-1}$. This means that almost 70% of the generated wastes does not leave the area of households in the form of mixed municipal wastes (Fig. 1, 4). The total weight of waste generated in the studied households (per capita) changes seasonally (Fig. 3). This applies first of all to organic wastes (OR1), plastics (PL4), fraction U11 composed mainly of disposable diapers and paper (PC3). Significant part of these wastes, excluding fraction OR1, in spite of bans, information and educational campaigns, is frequently burnt in household hearths. As a result of such actions, released into the environment are among others, considerable quantities of dust, aromatic hydrocarbons, carbon

**Table 1.** Mass of selected material fractions of wastes from rural households during separate seasons of the year in kg per capita

| Season | Variant | Value | Material fraction | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | OR1 | PC3 | PL4 | G5 | M7 | C9 | U11 | P13 |
| Winter | T1 | Min | 2.95 | 0.21 | 0.39 | 0.00 | 0.10 | 0.10 | 0.00 | 0.00 |
| | | Max | 33.10 | 7.80 | 9.10 | 13.08 | 2.10 | 3.33 | 18.70 | 30.00 |
| | | **Average** | **20.04** | **2.11** | **2.92** | **3.98** | **0.77** | **1.01** | **3.31** | **8.07** |
| | | SD | 9.52 | 1.93 | 2.29 | 4.74 | 0.51 | 0.80 | 5.66 | 9.75 |
| | T2 | Min | 0.98 | 0.00 | 0.11 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | Max | 8.17 | 1.22 | 2.60 | 4.55 | 0.22 | 0.71 | 21.00 | 15.51 |
| | | **Average** | **3.50** | **0.30** | **1.10** | **1.65** | **0.06** | **0.34** | **2.05** | **2.83** |
| | | SD | 2.83 | 0.43 | 0.84 | 1.45 | 0.07 | 0.26 | 6.29 | 5.91 |
| Spring | T1 | Min | 6.00 | 0.00 | 1.26 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | Max | 38.79 | 1.85 | 5.19 | 13.20 | 1.15 | 1.93 | 15.00 | 7.60 |
| | | **Average** | **22.09** | **0.96** | **2.74** | **3.54** | **0.44** | **1.04** | **2.61** | **1.13** |
| | | SD | 9.17 | 0.60 | 1.44 | 4.08 | 0.36 | 0.47 | 4.53 | 2.52 |
| | T2 | Min | 1.68 | 0.13 | 0.61 | 0.84 | 0.01 | 0.19 | 0.15 | 0.00 |
| | | Max | 8.62 | 2.91 | 6.30 | 3.56 | 0.98 | 1.35 | 6.13 | 2.10 |
| | | **Average** | **3.94** | **0.88** | **2.19** | **1.88** | **0.28** | **0.70** | **1.30** | **0.34** |
| | | SD | 2.30 | 0.87 | 1.64 | 1.07 | 0.27 | 0.44 | 1.84 | 0.76 |
| Summer | T1 | Min | 11.31 | 0.24 | 0.37 | 0.40 | 0.10 | 0.70 | 0.03 | 0.00 |
| | | Max | 39.24 | 5.30 | 5.63 | 11.70 | 2.00 | 3.00 | 10.80 | 6.50 |
| | | **Average** | **25.30** | **2.11** | **2.97** | **4.48** | **0.93** | **1.55** | **1.57** | **0.61** |
| | | SD | 10.83 | 1.65 | 1.70 | 4.22 | 0.70 | 0.58 | 2.84 | 1.73 |
| | T2 | Min | 1.70 | 0.23 | 0.53 | 0.15 | 0.03 | 0.00 | 0.00 | 0.00 |
| | | Max | 10.30 | 2.47 | 4.39 | 2.15 | 0.96 | 1.92 | 0.95 | 2.10 |
| | | **Average** | **4.09** | **0.97** | **2.45** | **0.80** | **0.29** | **0.63** | **0.22** | **0.28** |
| | | SD | 3.18 | 0.69 | 1.07 | 0.67 | 0.31 | 0.60 | 0.37 | 0.70 |
| Autumn | T1 | Min | 13.97 | 0.17 | 1.40 | 1.97 | 0.05 | 0.53 | 0.66 | 0.00 |
| | | Max | 53.62 | 6.54 | 5.61 | 9.12 | 2.78 | 5.32 | 17.00 | 25.00 |
| | | **Average** | **27.42** | **1.83** | **2.99** | **3.87** | **0.62** | **1.55** | **2.96** | **3.90** |
| | | SD | 11.18 | 1.89 | 1.23 | 1.96 | 0.73 | 1.25 | 4.54 | 7.25 |
| | T2 | Min | 1.00 | 0.37 | 0.96 | 0.40 | 0.07 | 0.09 | 0.05 | 0.00 |
| | | Max | 14.10 | 3.60 | 4.86 | 5.98 | 1.13 | 2.96 | 6.70 | 15.27 |
| | | **Average** | **4.72** | **1.32** | **2.28** | **2.10** | **0.42** | **1.06** | **1.34** | **1.91** |
| | | SD | 4.31 | 0.96 | 1.20 | 1.90 | 0.36 | 0.87 | 2.28 | 4.81 |
| Year | T1 | Min | 39.54 | 2.39 | 5.25 | 3.80 | 0.57 | 2.46 | 1.38 | 0.00 |
| | | Max | 130.31 | 15.47 | 23.61 | 39.26 | 6.34 | 9.73 | 54.80 | 60.35 |
| | | **Average** | **94.85** | **7.00** | **11.63** | **15.86** | **2.76** | **5.15** | **10.46** | **13.72** |
| | | SD | 29.33 | 4.58 | 5.09 | 10.71 | 1.64 | 1.94 | 13.79 | 16.87 |
| | T2 | Min | 6.50 | 1.13 | 4.71 | 2.72 | 0.18 | 1.83 | 0.35 | 0.00 |
| | | Max | 26.31 | 7.12 | 14.99 | 13.72 | 1.92 | 4.12 | 23.98 | 18.97 |
| | | **Average** | **16.25** | **3.48** | **8.02** | **6.43** | **1.04** | **2.73** | **4.9** | **5.36** |
| | | SD | 6.32 | 1.84 | 3.14 | 3.62 | 0.58 | 0.75 | 6.72 | 6.81 |

Explanation: SD – standard deviation.

oxides, nitrogen and sulfurs. This has a considerable effect on the pollution not only of air but also water, soil and plants particularly in the direct vicinity of the sources where the pollution is created.

The studies showed that over 80% of organic wastes (kitchen and garden) are not given out from the place they have been generated in (Table 1). The share of organic fraction in the total mass of wastes amounts to approx. 57% (Fig. 2) and its quantity undergoes significant seasonal changes. During the summer and autumn periods, the quantity of garden wastes increases decidedly. Most frequently, these wastes are composted along with selected kitchen wastes. For the proper course of the composting process, it is necessary to apply composting parameters to the kind of materials composted[16]. Components for composting containing large quantities of carbon form, which_is the source of energy in the undergoing process, whereas components rich in nitrogen provide appropriate quantity of proteins for microorganisms.

As recommended in literature, the ratio C:N contained in the components composted should not be greater than 30:1 and moistness approx. 60%[17, 18, 19]. The ratio of carbon to phosphorous C:P should not exceed 100,

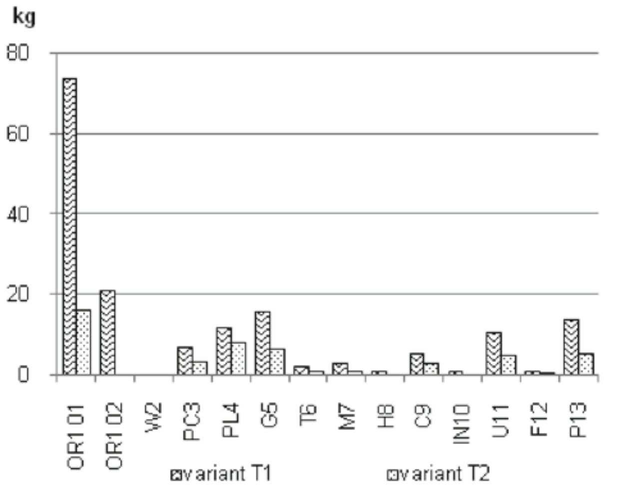


**Figure 1.** Morphological composition of wastes from rural households (T1 – wastes generated, T2 – wastes transferred to firms collecting wastes)

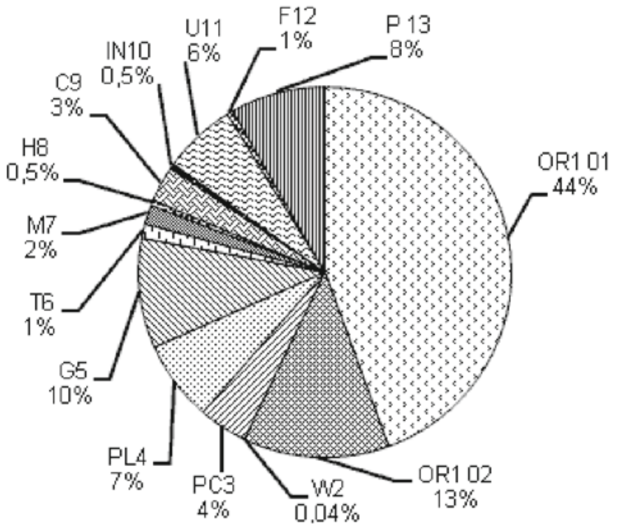


**Figure 2.** Share of separate material fractions in total mass of wastes from rural households

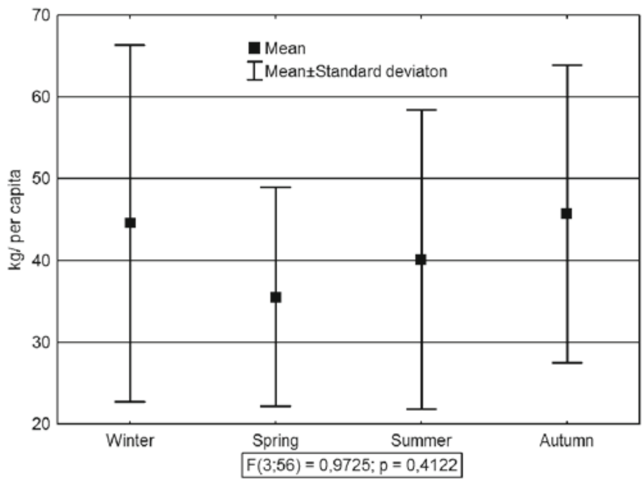


**Figure 3.** Mass of municipal waste generated in the analyzed households seasonally in kg per capita

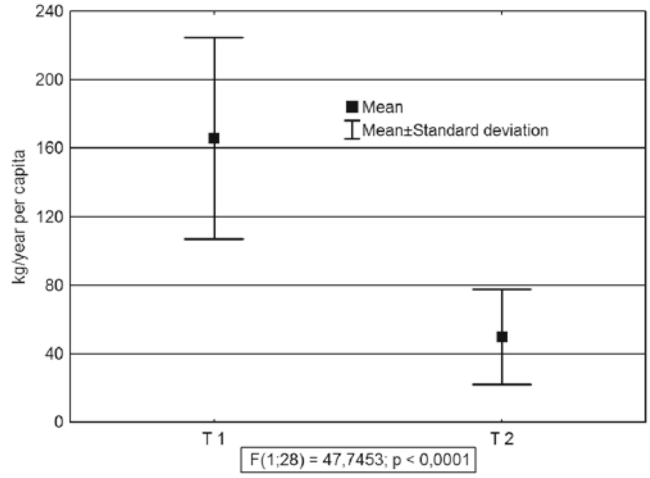


**Figure 4.** Mass of municipal waste generated in rural households (T1) and mass of wasted transferred to firms engaged in collection of them (T2) in kg · year$^{-1}$ per capita

whereas the reaction should be almost neutral (6–8). Also affecting the composting process is the structure of the mass composted (fragmented components), moistness and aeration (oxygen access). Having a negative influence on the course of the composting process is the presence of substances limiting the development of microorganisms, which may be available, for example in citruses. Wastes containing considerable quantities of items decomposing with difficulty, such as lignin or tannin also weaken the process of composting.

In the studies, organic wastes were collected selectively (in separate bags), which_undoubtedly had an influence on their humidity (70–90%).

Laboratory analysis of these wastes showed that the ratio C:N in them was from 7 to 19, whereas pH lay within the limits from 5.8 to 6.9 indicating their very good properties for the composting process. To improve the composting conditions, such wastes were enriched with phosphorous because the ratio C:P was decidedly too high and amounted to 242.

The average content of mineral substances in the studied wastes amounted to 174 mg/g whereas organic to approx. 825 mg/g. Table 2 shown average content of micro and macro components. Some samples also contained traces of Cr and Pb.

One of the oldest and cheapest procedure with organic wastes in rural areas is their composting. The wastes are most often composted in prisms, in the open air. The mass of the composted waste is greatly reduced. The resulting compost can be used on the farm for use as fertilizers.

This paper shows the analysis of composts from 7 households. The ratio C:N in the studied composts amounted from 5.6 to 12.2 indicating high degree of mineralization

**Table 2.** Contents of main macro-components as well as Zn and Cu in kitchen organic wastes

| Symbol | Unit | Fraction | | | | |
|---|---|---|---|---|---|---|
| | | >100 mm | 40–100 mm | 20–40 mm | 10–20 mm | <10 mm |
| $pH_{H20}$ | – | 5.8 | 6.7 | 6.2 | 6.2 | 5.9 |
| Corg | mg/g | 359.7 | 339.7 | 357.6 | 357.6 | 380.5 |
| $Ntotal_k$ | mg/g | 19.71 | 17.73 | 18.88 | 21.39 | 22.89 |
| Ptotal | mg/g | 1.74 | 0.97 | 1.51 | 2.24 | 1.47 |
| Na | mg/g | 6.4 | 2.1 | 2.5 | 3.8 | 5.2 |
| K | mg/g | 7.4 | 6.8 | 6.9 | 8.1 | 8.1 |
| Mg | mg/g | 2.2 | 2.3 | 1.9 | 1.9 | 2.0 |
| Ca | mg/g | 23.5 | 70.4 | 25.0 | 34.0 | 33.8 |
| Zn | mg/g | 0.027 | 0.051 | 0.051 | 0.167 | 0.234 |
| Cu | mg/g | 0.018 | 0.020 | 0.019 | 0.045 | 0.025 |
| s.m.l. | mg/g | 861.2 | 779.8 | 841.8 | 832.4 | 808.6 |
| s.m.m. | mg/g | 138.9 | 212.7 | 158.2 | 167.6 | 191.3 |
| Humidity | % | 90.3 | 78.3 | 81.6 | 80.2 | 70.1 |

Explanation: s.m.l. – dry weight of organic matter, s.m.m. – dry weight of mineral matter.

**Table 3.** Basic parameters of composts generated from organic wastes

| Symbol | Unit | Kind of compost | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | M* | M* | O** | Z*** | O** | Z*** | M* |
| $pH_{H20}$ | – | 7.40 | 7.47 | 7.73 | 7.45 | 7.16 | 7.67 | 7.46 |
| Corg | mg/g | 65.4 | 72.0 | 44.1 | 90.0 | 17.7 | 83.8 | 87.0 |
| $Ntotal_k$ | mg/g | 7.51 | 5.74 | 4.61 | 9.25 | 2.56 | 8.98 | 8.8 |
| $N_{NH3}$ | mg/g | 0.07 | 0.12 | 0.1 | 0.11 | 0.07 | 0.09 | 0.12 |
| $N_{Nox}$ | mg/g | 0.086 | 0.184 | 0.293 | 1.8 | 0.610 | 0.142 | 0.174 |
| Ptotal | mg/g | 0.92 | 1.31 | 1.3 | 1.74 | 0.43 | 2.7 | 1.76 |
| s.m.l. | mg/g | 157.3 | 191.6 | 102.6 | 267.3 | 41.4 | 221.3 | 227.1 |
| s.m.m. | mg/g | 842.7 | 808.4 | 897.4 | 732.7 | 958.6 | 778.7 | 772.9 |

*M- compost generated from garden and kitchen wastes; **O- compost generated mainly from garden wastes; ***Z- compost generated from kitchen and garden wastes along with admixture of animal faeces.

of components (Table 3). As for composts, the low content of organic substance results from the high content of soil in the composted plant wastes. The considerable losses of nitrogen while composting in small prisms by the house result from the emission of ammonia nitrogen into the atmosphere and washing away by atmospheric precipitation. In the studied composts, the total nitrogen content ranged from 0.3 to 1.1% whereas phosphorous from 0.1 to 0.3%. Although the composts generated in compost prisms by the house are not rich in nutritional components, or organic substances, they can be utilized successfully in the private area. The content of nitrogen in these composts is comparable with the content of this element in manure. Fertilizer properties of composts depend mainly on the components.

The wastes of fractions PC3, PL4, G5, M7 and C9 are mainly the packaging wastes. The average share of packaging wastes in these fractions is about 80% of the total mass of the said fraction. The consecutive fraction of large share in the total mass of wastes from rural households is constituted by glass wastes. These wastes are most often periodically accumulated in the household area and thrown into containers meant for selective accumulation of wastes or collected as segregated directly from the property. Found in this fraction are mainly packaging items after alcoholic drinks and fruit-vegetable industry products. The problem constitutes fraction U11 found in which are mainly disposable diapers. Its share in the total mass of wastes amounts to 6%. In households, where the stoves are used for heating, wastes are incinerated during colder months. Sometimes flammable wastes (paper and cardboard, wood) are stored on the farm and burned during the heating season. These wastes are unfortunately frequently burnt in household hearths.

In own research plastics (PL4) and paper (PC3) constitute the next 13% of the total mass of wastes. Packaging wastes dominate in these fractions. Due to their properties they are readily used for food packaging in many branches in food industry[20, 21, 22]. Foods are a major part of everyday shopping and therefore a significant part of packaging wastes in the total volume of wastes coming from households is not surprising.

In recent years, the amount of plastic packaging placed on the market has steadily increased. Due to its characteristics (low specific weight, high strength, facility of molding and coloring) plastic packaging displace other packaging materials. Their wide application results in accumulation of significant quantities of plastic wastes in households.

A burdensome problem with waste management in rural areas is their uncontrolled burning in household hearths or in the open area.

One of the biggest sources of air pollution in rural areas is called "low emission" of pollutants from small and unorganized sources, domestic stoves and small boilers[23]. Author found, that_80.5% of farmers burn substances (gums, plastics, films) in household stoves. Household hearths are not suitable for thermal treatment of waste because they do not achieve a sufficient temperature and domestic chimneys do not have the filters. Fly ashes from the household combustion are poorly dispersed by the wind, that is why they mainly pollute surroundings. Such actions result in releasing into the environment the items harmful for the health such as dioxins, furans and other chloroorganic compounds as well as heavy metals[24, 25, 26]. These compounds, in particular dioxins, are extremely dangerous because of their ability for long-term accumulation in the body, resulting in disturbances of various homeostatic mechanisms[27].

**Table 4.** Heavy metal content in ashes from domestic hearths

| Symbol of household | Cd | Pb | Cu | Zn | Cr | Ni |
|---|---|---|---|---|---|---|
| | [mg/kg s.m.] | | | | | |
| D1 | 0.879 | 109 | 220 | 688 | 219 | 41.5 |
| B1 | 1.036 | 38.2 | 157 | 556 | 17.0 | 12.4 |
| M1 | <0.5 | 49.2 | 908 | 8921 | 128 | 148 |
| W1 | <0.5 | 197 | 239 | 192 | 35.7 | 19.9 |
| N1 | <0.5 | 41.8 | 105 | 668 | 59.9 | 59.8 |
| M2 | <0.5 | 21.3 | 489 | 1084 | 114 | 133 |
| W2 | <0.5 | 75.8 | 171 | 682 | 106 | 143 |
| B2 | 2.835 | 157 | 165 | 4396 | 40.8 | 20.1 |
| Wi1 | <0.5 | 30.2 | 108 | 190 | 25.9 | 70.3 |
| N2 | <0.5 | 104 | 226 | 3378 | 180 | 212 |
| W3 | 0.554 | 23.8 | 104 | 326 | 18.9 | 9.4 |
| Wi2 | <0.5 | 48.5 | 68.0 | 601 | 29.6 | 22.9 |
| Wi3 | <0.5 | 52.4 | 122 | 481 | 21.8 | 70.2 |

Waste arising from the use of individual heating in households are hearth wastes. In the total weight of waste from the analyzed households, hearth wastes varied according to the season from 1.5% in summer to 18.1% in winter (8% yearly).

The content of heavy metals in ashes varies and depends among others on the materials burnt. Fireplace/hearth wastes are most frequently utilized to sprinkle pathways during winter or go to the composting heaps.

Such procedure may lead to spot pollution of the environment with heavy metals or dioxins. The latter are characterized by high mobility in soil environment especially when the soil is devoid of organic material[28].

Referring the value obtained to the limiting value denoting admissible value of heavy metals in municipal sewage residues in agriculture and also rehabilitation of soil for agricultural purposes (2500 mg/kg), it can be stated that utilization of these ashes in household areas constitutes pollution hazard to soil and groundwater[29]. The content of heavy metals in the ashes examined differed considerably. Literature data indicate that composition of ashes depends mainly on the composition of the material (fuel) burnt[30]. An average pH value of the examined ashes amounted to 9.21. Long-term dumping of such ashes in specific places may lead to alkalization of the environment.

Waste management should be based on limiting the amount of waste generated, increasing the amount of waste collected selectively and increasing the amount of waste recycled. Among the municipal wastes collected in Poland, hardly 10% are waste segregated "at source" at the place of their origin; however growth ratio of such wastes amounts to 19% annually[7]. Segregation of wastes "at source", including separation of organic wastes, enables obtaining secondary raw materials, which can be subjected to retrieving processes or recycling. A considerable part of society in rural areas is aware of the necessity of introducing solutions aimed at reducing the quantity and volume of wastes. It was confirmed by research conducted by Hadryjańska[31] in rural areas, which showed that 90% of respondents observe a positive effect of good practice in waste management. Therefore it is necessary to enhance awareness and correct attitudes of people associated with waste management and to introduce appropriate financial incentives.

## CONCLUSIONS

The conducted studies showed that the composition of municipal wastes coming from rural households changes seasonally especially with respect to organic fraction from 20,0 kg per capita in winter to 27,42 kg per capita in autumn and ashes 1.5% in summer to 18.1% in winter. In study rural households generated average of 166 kg of waste annual per capita. The results of research are lower than those given by other sources (literature). In own research 70% of household wastes were reused "at source".

The basis for waste management should be segregation of waste at the place where they are generated. Separating the organic fraction of waste, which is suitable for composting and reusing on farm effectively reduces the amount of waste going to landfill. Segregation of the remaining fractions "at source" is to achieve better results in obtaining of secondary raw materials from waste. It is necessary to raise the awareness of the residents with respect to the harmful effects of bad practices in waste management including uncontrolled burning of wastes.

Knowledge of the quantity and composition of waste generated in a given area should be the planning basis of the whole waste management system at these area. Starting from the receipt of the waste from the producers to the design of investments related to their management. Until now people planning waste management systems in rural areas used the statistical data. The results obtained in our own pilot studies differ significantly from the statistical data. Therefore there is a need for realignment of these data by means of extensive research conducted in rural areas throughout the country.

The studies were carried out within the framework of the long-term program for the years 2011–2015 "Standardization and monitoring of the environmental undertakings, agricultural technique and infrastructural solutions for safety and balanced development of agriculture and rural areas" – Resolution No. 202/2011 of the Council of Ministers dated 14 October 2011.

## LITERATURE CITED

1. Environment 2012. (2012). Statistical information and elaborations. Central Statistical Office, from http://www.stat.gov.pl/cps/rde/xbcr/gus/se_ochrona_srodowiska_2012.pdf

2. Journal of laws. (2011). Dz.U 2011 nr 152 poz. 897. Act amending the Act of 1st of July 2011 on maintaining cleanliness and order in municipalities and other acts., from http://isap.sejm.gov.pl/DetailsServlet?id=WDU20111520897, (in Polish).

3. Sieja, L. (2006). Characteristics of municipal wastes based on research carried out in selected towns in Poland. *Protection of air and waste problems*, 40(1). 28–33, (in Polish).

4. Den Boer, E., Czarnecka, W., Kowalski, Z., Kulczycka, J. & Szpadt, R. (2009, October ). A review of municipal solid waste composition and quantities In Poland. *Waste Management* 30, 369–377. DOI:10.1016/j.wasman.2009.09.018.

5. The results of the national census of population and housing (2011). Central Statistical Office, from http://www.stat.gov.pl/gus/5840_12766_PLK_HTML.htm

6. Households in Poland in 2011. (2013). Central Statistical Office, from http://www.stat.gov.pl/cps/rde/xbcr/gus/LU_Gospodarstwa_domowe_w_2011r_wyniki_NSP2011.pdf

7. Kaca, E. & Kaca, G. (2012). Mass indices of the wastes in Poland in light of the statistical data. *Problems of Agricultural Engineering.* PIR 2012 (VII–IX): 3(77), 123–134, (in Polish).

8. Żygadło, M. (2001). *Strategy of municipal waste management*. (1 st ed.). Poznań – Poland. Polish Association of Engineers and Technicians of Sanitary, (in Polish).

9. Population status and demographic and social structure (2013). Central Statistical Office, from http://www.stat.gov.pl/gus/5840_14076_PLK_HTML.htm

10. Polish Committee for Standardization. (2001). Polish Standard: Determine of dry matter, organic matter, pH. PN-Z-15011-3:2001, (in Polish).

11. Polish Committee for Standardization. (2004). Polish standard: Mineral and organic dry mass of sludge. PN-EN 12879:2004, (in Polish).

12. Polish Committee for Standardization. (1976). Polish Standard: Research of content of phosphorus compounds. PN-76/C-04537/07, (in Polish).

13. Polish Committee for Standardization. (2009) Polish Standard: Determine of metals by using method ICP-OES. PN-EN-ISO 11885–2009, (in Polish).

14. Christensen, T.H. (2011, March). Characterization of household waste in Greenland. *Waste Management* 31(7), 1461–1466, DOI: 10.1016/j.wasman.2011.02.018.

15. Bergel, T., Kaczor, G. (2006). Estimated and real quantity of municipal wastes collected in rural districts *Infrastructure and Ecology of Rural Areas*. 32, 5–16, (in Polish).

16. Czyżyk, F. & Kozdraś, M. (2004). Chemical properties and composting of sludge from rural waste water treatment plant. *Water -Environment- Rural Areas*. 4(11), 559–569, (in Polish).

17. Kasprzak, K. (1998). Theoretical and practical requirements for organic waste composting. In :Municipal Enterprise and the Environment. IX Conference Poland-Poznań (p. 125–238). Abrys, (in Polish).

18. Rosik-Dulewska, C. (1996). Desirability and economic viability of the construction of composting methods, organization and methods. In: Municipal Enterprise and the Environment, III International Conference January 1996, Wisla, Poland (p. 63–83), Abrys, (in Polish).

19. Sebastian, M. & Szpadt, R. (1999). Individual composting of garden biowaste at home composting facility. In: Composting and disposal of compost. I Technical Sciences Conference 1999 (p. 117–124). Pulawy-Warsaw-Poland. IOŚ, IUNG, PTIE, (in Polish).

20. Steinhoff-Wrześniewska, A. & Strzelczyk, M. (2011) Structure of packaging wastes in production of alcoholic beverages. *Journal of Ecological Engineering*. 27, 202–209, (in Polish).

21. Steinhoff-Wrześniewska, A., Strzelczyk, M. & Czyżyk, F. (2011). Material and waste management in brewing industry. *Science, Nature, Technologies.* 5,4,#47, from http://www.npt.up-poznan.net/pub/art_5_47.pdf, (in Polish).

22. Strzelczyk, M. & Steinhoff-Wrześniewska, A. (2010, September). Formation and disposal of wastes and determination of wastefulness indicators in sugar industry. *Polish Journal of Chemical Technology* 12 (3), DOI: 10.2478/v10026-010-0035-9.

23. Michalik, P. (2009). Awareness of the risk factors of the low emission among social groups: Plock and Sierpic district farmers sample. *Environment and Natural Resources* (40), 617–622, from http://www.ios.edu.pl/pol/pliki/nr40/nr40_73.pdf, (in Polish).

24. Brzeski, Z. (2011). Dioxins and furanes in the environment and their effect on the human body. *General Medicine and Health Sciences*. 17(3), 161–164.

25. Biłyk, A. (2000). Dioxines and furane in the environment. *Environment* 2(77), 9–13.

26. Wyrzykowska, B., Hanari, N., Orlikowska, A., Yamashita, N. & Falandysz, J. (2009, April). Dioxin-like compound compositional profiles of furnace bottom ashes from household combustion in Poland and their possible associations with contamination status of agricultural soil and pine needles. *Chemosphere* 76(2), 255–263. DOI: 10.1016/j.chemosphere.2009.03.019.

27. Żukiewicz-Sobczak, W., Chmielewska-Badora, J., Krasowska, E., Wojtyła, A. & Piątek, J. (2012). Effect of dioxins in the environment and the human body. *General Medicine and Health Sciences*. 18(1), 59–63. (in Polish).

28. Czerniak, A., Grochowalski, A. & Poszyler-Adamska, A. (2006). Dioxin content in touristic forest bonfire ashes (preliminary test). *Infrastructure and Ecology of Rural Areas* 3(1), 183–194, (in Polish).

29. Journal of laws. (2012). Regulation of the Minister of the Environment, the 13 th July 2012 on municipal sewage sludge. DzU No 137, Poz. 924, (in Polish).

30. Ciesielczuk, T., Kusza, G., Nemś, A. (2011). Fertilization with biomass ashes as a sourceof trace elements for soils. *Environmental Protection and Natural Resources*. 49, 219–227, (in Polish).

31. Hadryjańska, B. (2006). Segregation of wastes in rural areas as an element of the environmental protection in Poland. *Water -Environment- Rural Areas.* 6, 2(18), 77–8. (in Polish).