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ANALYSIS OF MORPHOLOGICAL COMPOSITION OF WASTES DEPOSITED ON ILLEGAL DUMPING SITES LOCATED IN THE AREA OF OLSZTYN DISTRICT

Dominika Ciura, Maria Łukasiewicz, Mateusz Malinowski
University of Agriculture in Krakow

Abstract

Generated wastes require space and financial outlays on their proper storage and processing, whereas the lack of means usually leads to depositing wastes in places not meant for this purpose. Illegal dumping sites still emerge, despite introducing in Poland the obligatory (common) fee for collection and management of wastes and the obligatory establishing the Selective Waste Collection Points in each district. The aim of the work was conducting a detailed inventory of illegal dumping sites in the area of Olsztyn district (situated in the Silesia province, on the Krakow-Częstochowa Upland) and indicting the morphological composition of the wastes deposited in these places.

The paper presents a detailed analysis of the morphological composition of illegal landfill sites situated in the analyzed district. The investigations located 28 illegal dumping sites, despite the fact that a Selective Municipal Waste Collection Point operates in the district area. The analysis of location, area, mass and composition of the wastes was conducted for each illegal landfill, according to the methodology developed for this purpose. Over a half of the illegal dumping sites was situated in the forest and on 4 of them the estimated mass of dumped waste exceeded 1Mg. Debris constitutes the highest proportion (21.8%) of the waste morphological composition. Recyclable wastes, i.e. glass, plastics, paper and cardboard, used electronic and electric equipment dominated in the morphological composition of wastes on small landfills, situated close to buildings

(less than 250m) and had the smallest area (below 1m^2). The share of debris and construction wastes was growing with increasing landfill area.

Key words: municipal solid waste, illegal dumping sites

INTRODUCTION

Generation of wastes is an inevitable part of human life and activities. Increasing population number, development of technologies and industry, as well as many other factors lead to generation of growing amounts of wastes. Unfortunately, some of them find their way to places unintended for their deposition. Illegal landfill sites are the areas where various kinds of wastes are deposited illegally and in the uncontrolled way. Usually these are sites located close to individual buildings, unfrequented places, but also ditches, watercourses, forests and areas covered with bushes (Dusza *et al.* 2013; Joo and Kwan 2015, Malinowski *et al.* 2015, Szydłowski and Podlasińska 2016, Wojtczak 2015). Illegal dumping sites pose a considerable environmental hazard, constituting a potential source of numerous pollutants (Bartkowiak *et al.* 2016, Golimowski *et al.* 2003, Kanecka-Geszke 2005, Kaszubkiewicz *et al.* 2011). Lack of landfill containment enable migration of toxic substances into the soil profile, whereas chemical, biological and physical transformations occurring in the mass of deposited waste cause formation of many dangerous substances (Filipiak *et al.* 2007, Kulig 2004, Niedźwiecki *et al.* 2004). Illegal dumping sites are created mainly due to the lack of knowledge and civil responsibility, but this phenomenon is also due to the inappropriate supervision of the district authorities over waste management (Pradziadowicz 2013). Removal of illegal dumps bears a cost (Sasao 2015) and makes it necessary to carry out remediation (Ishii *et al.* 2012). Despite the novelization of the Act on Maintaining cleanliness and order in communes (Journal of Law 2016, No. 250), which intended among others to diminish the problem of illegal landfill sites, the problem persists. Estimating the scale of emerging illegal landfill sites by means of the inventory of these places may enable undertaking efficient measures leading to reduction of the amount of wastes deposited on illegal dumping sites. For this purpose, also the knowledge about the morphological composition of wastes dumped on illegal landfills is crucial.

The main objective of research was the inventory of illegal landfill sites in the Olsztyn rural district and determining the relationships between morphological composition of wastes deposited on illegal dumping sites and their total mass deposited there, their area, place and location, as well as the other features in relation to which they were classified during the field research.

AREA AND METHODS OF RESEARCH

The investigations covered Olsztyn district situated in the Częstochowa province, in the northern part of Silesia province. The number of the district inhabitants in 2015 was about 7966. The district area is 10 913 ha, of which agricultural lands make up about 46.5%, whereas forests and forest grounds over 40%. Because of its natural and landscape values, the province has mainly tourist and recreational function. It is located in the "Eagle's Nests" Landscape Park and within its protection zone and many natural monuments, as well as two nature reserves: "Falcon Mountain" and "Green Mountain" are situated there. A Selective Waste Collection Point is located in the district area, where the inhabitants may deposit used batteries, electric and electronic equipment, construction wastes, and bulk waste.

Currently, modern scanning methods, satellites and GPR systems are used to detect illegal dumps (Ferrara *et al.* 2010, Wu and Huang 2006). In addition, GIS and GPS systems are used for detection and analysis. On site measurements comprised identification of illegal landfills and recording their location by means of handheld GPSmap 76S receiver (GARMIN). An illegal dumping site was considered a group of wastes with an area of more than 0.5m^2. The landfill area (m^2) and its height (m) were determined using a measuring tape. Assuming a mean density of mixed municipal waste equaling 250kg·m^{-3}, an approximate mass of the accumulated wastes was determined for each illegal dump.

A questionnaire for gathering information about illegal dumping sites was used during the field works. The questionnaire (Table 1) was developed on the basis of papers by Kuczek (1987) and Gajda and Plaza (2008). The questionnaire focused in the first place on morphological composition (which was estimated to an accuracy of 5%) of the wastes on the illegal dumping sites, but also contained other data: the location, distance from buildings, area and visibility in the area. The field works were conducted in two series, in July and September 2016.

Data collected in GPS has been linked with the data from questionnaire in Microsfot Excel software. All located waste dumping sites were divided into categories, according to table 1. The morphological composition of the waste (average share of waste groups) was analyzed in each category to determine the differences in this composition and to show the specific characteristics of these sites.

Table 1. The form used during mapping of illegal landfills

Location	in the riverbed on the floodplain/alluvial terrace on a ridge/hump or flat-topped hill in a ravine/gorge/ shrub land/pit on a slope in a hole/depression/cavity in a ditch/channel/gutter on a roadside/on the verge of a path or route on a plain/flat terrain
Relations to water table	in running water in standing water temporarily in direct contact with groundwater in indirect contact no contact
Distance from buildings	long (over 1000 m) medium (500–1000 m) short (250–500 m) very short (to 250 m)
Terrain accessibility	accessible by car/ horse drawn carriage without any hindrances accessible by horse drawn carriage with some obstacles accessible for handcart or wheelbarrow hard to reach even for a wheelbarrow
Area	large (over 10 m^2) medium (5-10 m^2) small (1-5 m^2) very small (do 1 m^2)
Appearance	Clustered dispersed
Visibility in the area	visible from afar hidden
Cover of the illegal landfill area	Forest shrubs humps of grass or clusters of shrubs arable lands other
Mass	large (over 1t) big (over 50 kg) medium (25-50 kg) small (10-25 kg) very small (to 10 kg)

Morphological composition	paper, cardboard wood (timber) natural fabrics organics glass bottles, jars, widow glass PET bottles metal clothes, quilts, pillowcases, curtains wall paints, varnishes, solvents, paint buckets lubricants, oils, oil containers batteries and battery packs medicines plant protection n chemicals, fertilizers, household chemicals rubber (tyres, rubber flooring) debris tiles packaging used electrical equipment furniture, armchairs, sofas, car seats plastics, nets, plastic bags or sacks styrofoam

Source: own studies based on Kuczek (1987); Gajda and Plaza (2008)

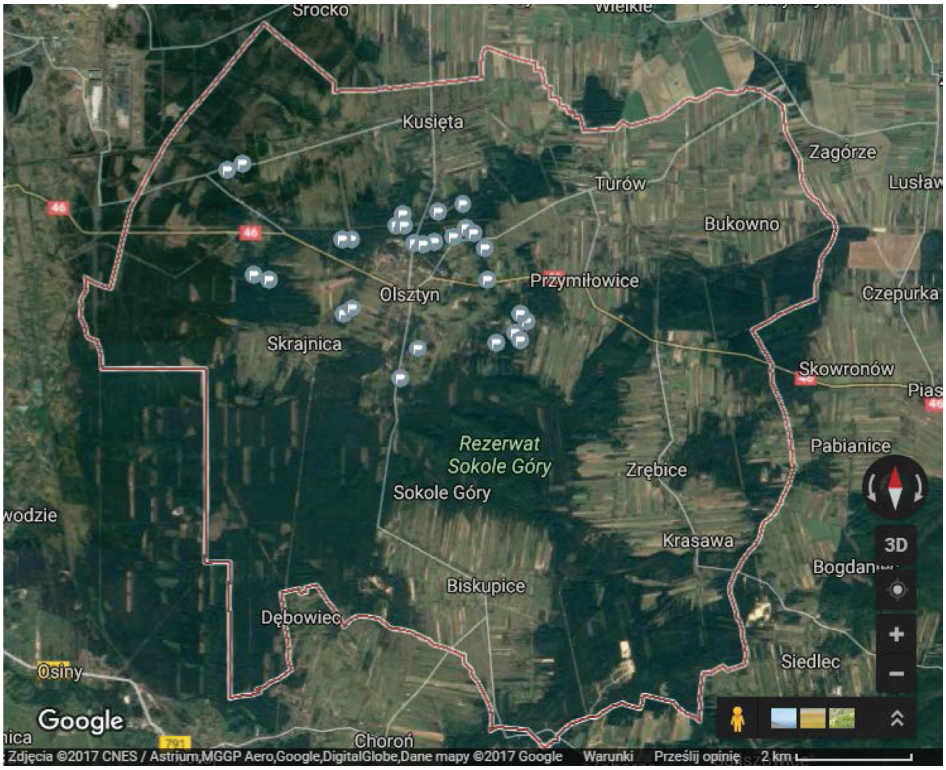
RESULTS

There were 28 illegal landfill sites localized in the area of Olsztyn district (Fig. 1). None of these is in direct contact with water table. Most are situated on a plain or flat terrain. Some of illegal dumping sites were identified in holes or cavities (21.4%), but also on roadsides, on the verge of paths or bike paths (21.4%) (Fig. 2).

Concerning the quality composition of wastes, debris constituted the largest share (Fig. 3). The next wastes considering its proportion were plastics – foils, nets or plastic bags. No medicines were found in the composition of any of the investigated landfills, whereas the wastes such as batteries or accumulators made up only 0.04%.

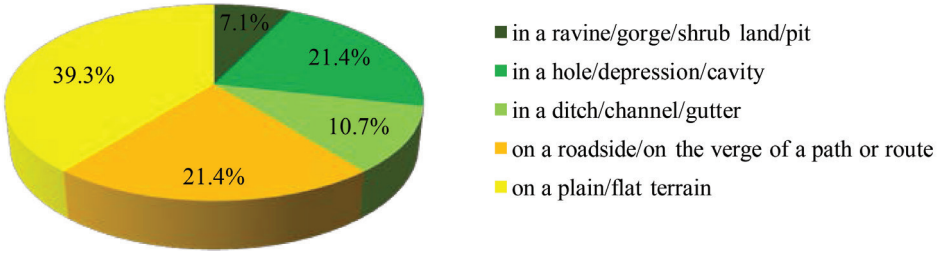
Morphological composition of the wastes deposited on illegal dumping sites in relation to their localization differs between the individual types (Fig. 4). Debris is deposited mainly on flat terrains, in holes and in cavities, respectively (47.4% and 32.3%). Plastics, plastic bags and nets (37.3%) and organic wastes dominate in ditches and channels. The composition of wastes deposited in ravines and gorges is disturbing, as it reveals mainly rubber wastes (45.1%), as

well as wall paints, varnishes and solvents (13.4%). Figure 5 shows the photographs of selected illegal landfill sites in Olszytn district.



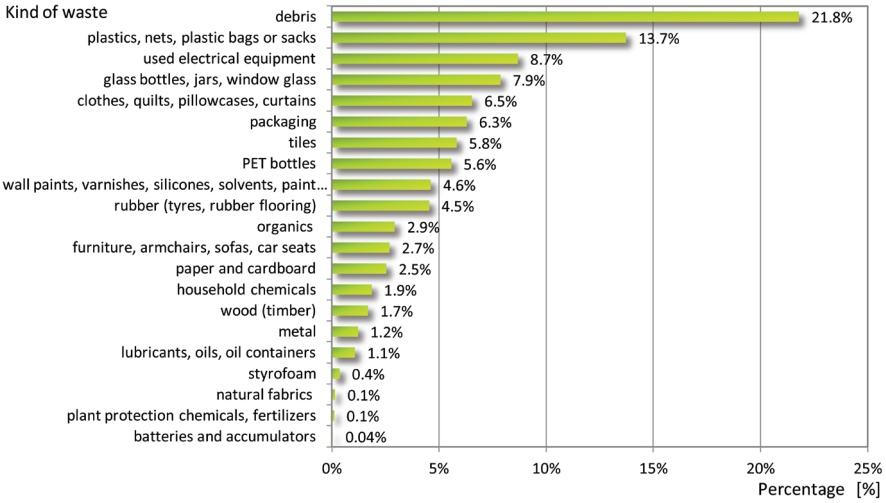
Source: own studies based on www.maps.google.pl

Figure 1. Spatial location of illegal landfill sites in the area of Olsztyn district



Source: own studies

Figure 2. Localization of illegal landfill sites situated in the area of Olsztyn district



Source: own studies

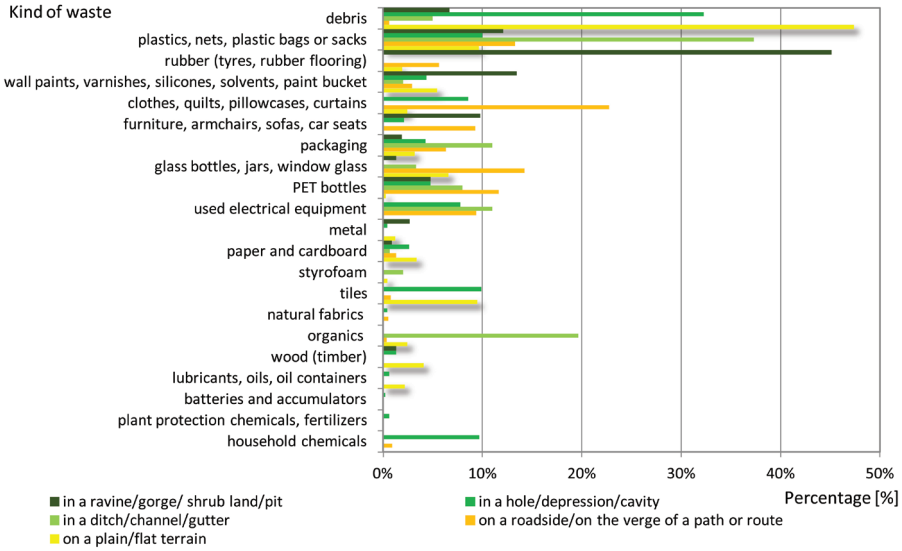
Figure 3. Morphological composition of wastes from illegal dumping sites total (n=28)

Source: own studies

Figure 4. Selected illegal dumping sites located in the area of Olsztyn district

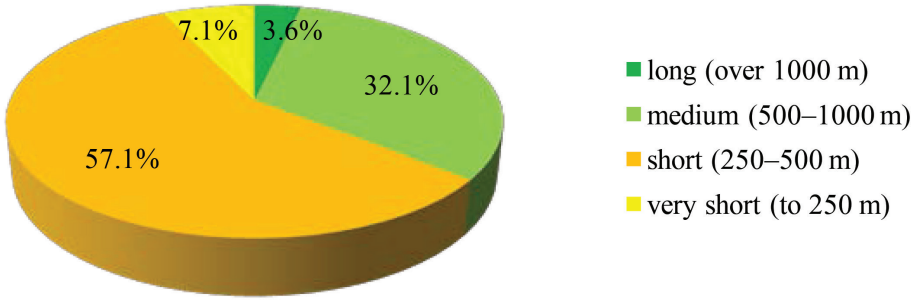
A definite majority of illegal landfill sites is situated between 250 and 500 m or between 500 and 1000 m from buildings (Fig. 6). The studied dumping sites were situated at a considerably longer distance from buildings that similar

objects presented in the research of Gajda and Plaza (2008), Malinowski *et al*. (2015) or Szydłowski and Podlasińska (2016).



Source: own studies

Figure 5. Morphological composition of wastes deposited on illegal dumping sites versus their localization in the area

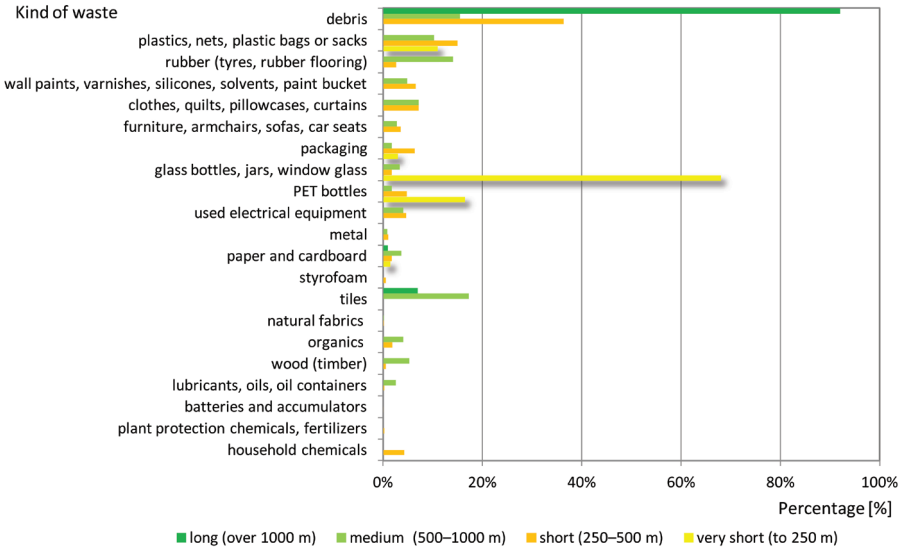


Source: own studies

Figure 6. Distance of illegal dumping sites situated in the area of Olsztyn district from buildings

It was found that morphological composition of wastes differs in relation to the distance from buildings. Illegal dumping sites situated closest to buildings (less than 250 m) contained mainly packaging (potential recyclable materials)

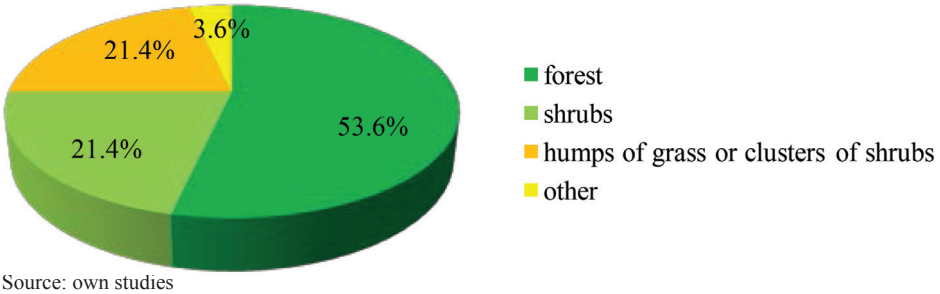
suitable for recycling. The dominant are: glass (68.0%) and plastics, i.e. PET bottles (16.5%), plastics and nets (11.0%), as well as other packaging (3.0%), paper and cardboard (1.5%). Morphological composition of wastes on illegal landfill sites located at the distance shorter than 500 m, contained the highest proportion of debris (36.4%), followed by plastics and plastic bags (15.0%). No kind of waste dominated on illegal dumping site situated at the distance of between 500 and 1000 m from buildings. Comparable shares of construction wastes, like tiles (17.3%) or debris (15.5%), but also rubber wastes (14.1%) or plastics (10.3%) were registered. The landfills situated furthest from buildings, more than 1000 m, contained mainly debris, which made up over 90% (Fig. 7).



Source: own studies

Figure 7. Morphological composition of wastes deposited on illegal dumping sites versus their distance form buildings

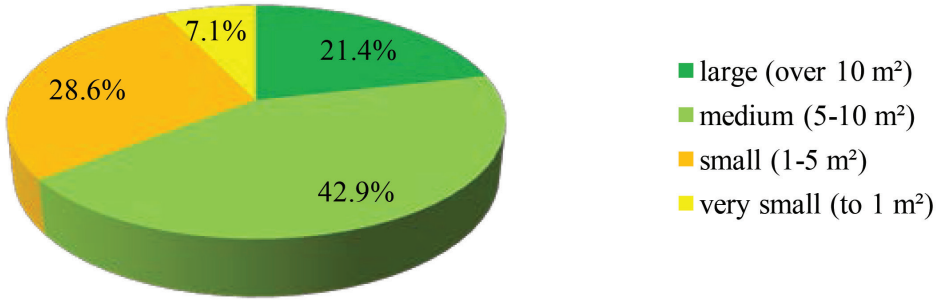
Considering visibility, field research revealed equal share of "hidden" illegal landfills and these "visible from afar". The feature did not diversify morphological composition of the wastes. Identified illegal dumping sites were mostly in the forest area (Fig. 8), but their presence was also observed in the areas covered by clumps of grass or cluster of bushes and in shrubs.



Source: own studies

Figure 8. Cover of the areas where illegal dumping sites were identified

The areas where illegal landfills are situated are characterized by a good accessibility. Over a half of them (57.1%) may be reached by car without any hindrances. The other sites are the areas with some terrain difficulties connected with, among others densely wooded area or sandy ground. Almost a half of illegal landfills has the area between 5 and 10 m^2, described as medium (Fig. 9). Small landfills, whose area ranged from 1-5 m^2 constituted 28.6%, whereas the landfills with the area exceeding 10 m^2 made up 21.4%.Considering the appearance of the landfill, a definite majority – 67.9% were clustered, whereas the other 32.1% were dispersed landfills.

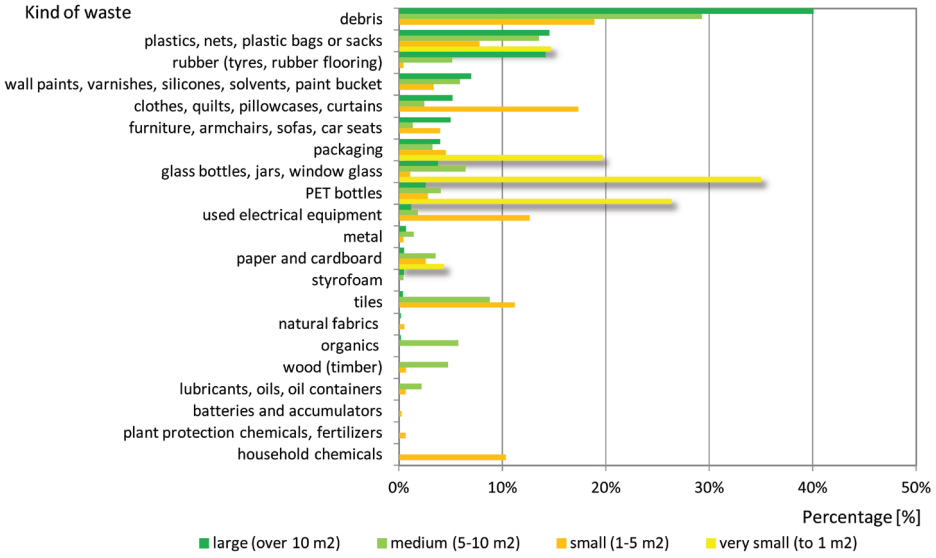


Source: own studies

Figure 9. Area of illegal dumping sites in the rea of Olsztyn district

Morphological composition of the wastes on landfills whose area did not exceed 1 m^2 contained the wastes which should get to a selective waste collection. There were mainly glass (35.0%) and PET bottles (26.3%). The rest was packaging waste (19.7%), plastics (14.7%) and small amounts of paper and cardboard (4.3%). Debris (18.9%), textile wastes (17.3%), as well as used electrical equipment (12.6%) and domestic chemicals (10.3%) constituted a similar

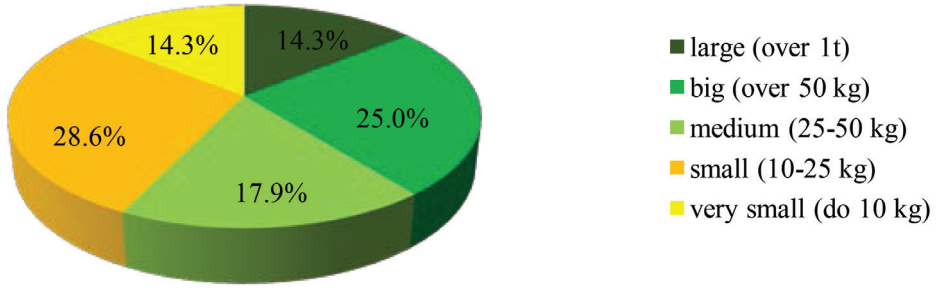
proportion on small area illegal landfills. Debris was mainly found on landfills with the area exceeding 5 m^2 (Fig. 10).



Source: own studies

Figure10. Morphological composition of wastes deposited on illegal dumping sites versus their area

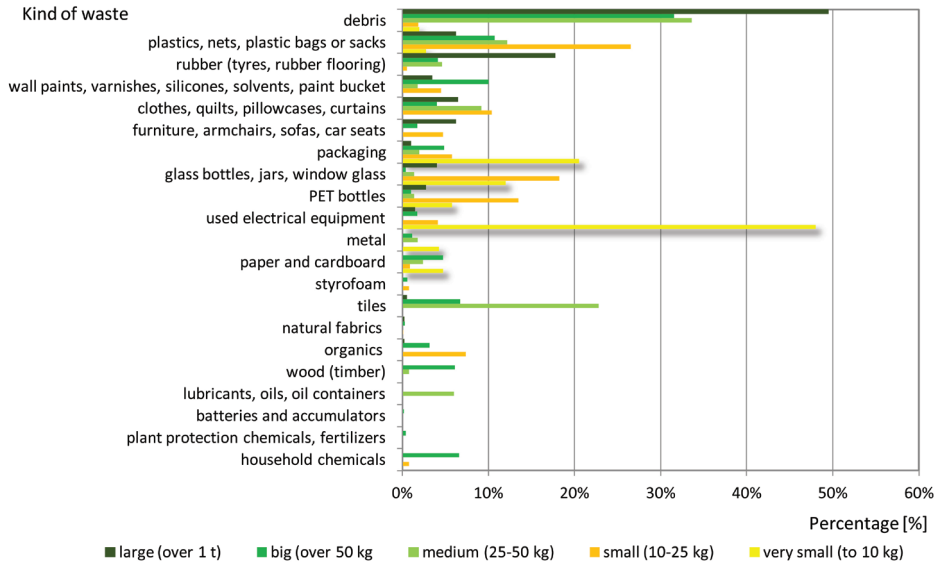
Small illegal dumping sites, with a mass ranging from 10 to 25 kg (Fig. 11), constituted a majority. There were 4 landfills, whose mass exceeded 1Mg, localized in the area of Olsztyn district.



Source: own studies

Figure 11. Estimated mass of illegal dumping sites situated in the area of Olsztyn district

On the landfills with a mass below 10 kg, used electric equipment constitutes almost a half (48.0%) of wastes, whereas the rest is mainly packaging. Morphological composition of wastes on illegal dumping sites, where over 25 kg was deposited is approximate, with dominating debris (Fig. 12). Conducted analysis confirms observations of Zabłocki *et al.* (2011) and Malinowski *et al.* (2015), who found that mainly PET bottles, glass bottles and metal cans are deposited on small illegal landfills, whereas debris, construction and post-renovation wastes are found on larger landfills.



Source: own studies

Figure 12. Morphological composition of wastes on illegal dumping sites versus the mass of deposited wastes

CONCLUSIONS

The research demonstrated, that despite a common fee for collection and management of wastes and despite the Selective Municipal Waste Collection point operating in the area of Olsztyn district, the wastes are still dumped illegally. Over a half of illegal dumping sites was located in forests, which poses a serious hazard to the environment and negatively affects landscape values of the district. The following most important conclusions may be drawn from the work:

1. debris constitutes the largest share (21.8%) in the waste morphological composition, followed by plastics. Dangerous wastes had the lowest share,

2. a definite majority of illegal landfills is situated at the distance between 250 and 500 m and between 500 and 1000 m from buildings. Recyclable wastes, i.e. glass, plastics, paper and cardboard, used electronic and electric equipment dominated on the landfills situated closest to buildings (less than 250 m) and with the smallest area (less than 1 m^2),
3. the proportion of debris and construction wastes was growing with increasing landfill area,
4. illegal dumping sites are situated in the generally accessible places and over a half of them may be reached by car.

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Corresponding author: Mateusz Malinowski, PhD, Eng
Maria Łukasiewicz, MSc, Eng.
Dominika Ciura, Eng.
Institute of Agricultural Engineering and Computer Science
University of Agriculture in Krakow
Balicka 116b, 30-149 Krakow
Phone: +48 (12) 662 46 60
e-mail: mateusz.malinowski@urk.edu.pl

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