Analysis of the waste disposal in the context of European standards

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***Abstract* —** for waste treatment exist a number of recommendations arising from the results of scientific research in this area. These theoretical findings are further implemented in legislation and should be practically applied. To what extent are these theoretical findings really applicable, practically being explored within this paper. The comparison is based on examining the theory of the recommended status with the empirical data identified in the framework of the conducted case study.

***Keywords*—** case study, collection yards, waste hierarchy, waste treatment.

I. Introduction

The issue of further use of waste is very wide. Many scientists are concerned with questions of how to continue to use various types of waste [17], [18], [19]. Directive of the European Parliament and Council Regulation (EC) no. 98/2008 on waste introduced the Waste hierarchy* [7].

In practical terms, it is clear that its observance is promoted very slowly. A series of measures required by this theoretical concept is not likely to be maintained [17].
There is a designated sequence of priorities within the waste treatment. The recommended order is as follows:

1) Waste prevention;
2) Reuse - there is a fundamental concern that products do not become waste. This can be achieved through repair or offering of used items for further use;
3) Material recovery - recycling, composting - - If wastes arise, they need to be sorted and used as raw material for new products;
4) Other use – energy use - waste that cannot be recycled or composted can serve as fuel in incinerators for energy production;
5) Elimination - depositing waste in the landfill - and if the waste cannot be used in any of the above-mentioned manner or another, are placed in the landfill [14].

Landfilling is considered the least desirable method of waste disposal, and should it occur only after consideration of all options according to previous levels of hierarchy* [13]. In Addition to environmental impacts, it is necessary to include also security risks associated with some methods of waste management [20]. In case of uncertainties about the optimal sequence in the waste hierarchy and the effectiveness of changes in generally accepted hierarchy for specific waste can be used analysis according to the Lifecycle assessment method (LCA). Combusion of waste can produce a wide range of pollutants. Air pollution is influenced by the emission of pollutants from various sources as a consequence of human activity e.g. nitrogen dioxide concentration analyzed by Kříž (2014) and tropospheric ozone analyzed by Kříž et Šedek [21], [22].

The LCA method examines the different stages of the life cycle - from extracting raw materials to production, through their own manufacturing, distribution, use, up to the stage when the product becomes waste [6], [7].

The LCA method focuses on the environmental impacts caused by waste management where wastes are outputs of each stage of the product lifecycle [6]. This method in practice, among other things, helps in decision making in waste management (such as deciding on the various methods of waste disposal) [7]. Treatment of wastes within the LCA represents the next stage of the product life cycle, which has already become waste. The aim of treatment is to achieve the required consistency, shape or volume of the processed material [15]. This paper focuses on this part of the supply chain according to LCA.

A. Waste management methods

In the Czech Republic the waste is collected, gathered and , shipped to waste collection yards, and then prepared for subsequent use and disposal. Collecting methods are classified according to the technical equipment on the container, sack and container less*. In case of the container method for separate collection the collection containers are used. For container method, emptying differently colored containers are used. Containers for municipal waste have for each waste type its own color [2].

When a bag collecting method is used, separated waste is put into bags which people carry to the front of the house on the day of collection or transport them to the collection yard.

In case of container less collection method people collect waste components at home and at a certain, predetermined date carry them front the home, or at a designated point in the case of a residential buildings. According to the availability of collection points, it can be divided into delivery and carting.

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It depends on the so called delivery distance to a collection point (the distance from collection containers to place of residence).

When there is a delivery collection, one should take already sorted waste components to a place where there are different colored, freely accessible containers. In this collection method the citizens deliver themselves the waste to the designated place, and so the municipality does not have to provide transport of waste from the place of its origin (e.g. households). For this type are used, inter alia, the collection yards which are the subject of further investigation. These are spaces that are used to collect different types of waste. Collection yards are run by municipalities on their territory and are operated by companies engaged in waste management. Citizens of the municipality deposit there waste free (but some kind of waste of a certain amount can be charged).

Here takes place separated collection, where usable waste components are separated in order to allow their use as a secondary raw material [16]. For recycling it is important to sort the waste, while waste sorting means is one of the main activities for collecting yards. In the collecting yards are graded recyclable components and other components of the waste. The recycled components mainly include paper, glass, plastics, beverage cartons, metals, textiles and some types of wood [13], [9].

Many of the collecting yards receive, among others, also biodegradable waste for composting [7].

Another possibility is thermal treatment of waste. There's a waste incineration in waste incineration facilities known as energy recovery for electricity and heat production [1].

The extent to which the waste is used and how this use is correlated with the requirements of the waste management hierarchy* is subject to the following case study.

B. Collection Yards

For the analysis of the operation of collecting yards have been selected collection yards in the Statutory city of Pardubice in the Czech Republic. A more detailed analysis focused on the degree of implementation hierarchy* of waste management was carried out in two of these devices, where were for the latest year (2014) collected the biggest amount of waste. Table 1 summarizes the collection yards in city of Pardubice and it`s suburbs. In italics are indicated those to which the study focuses.

Table 1. List of collection yards in the city of Pardubice

Collection yard	Acreage	Share of total amount of waste
Dražkovice	15 239 m^2	22,51 %
Svítkov	3 103 m^2	18,33 %
Nemošice	2 508 m^2	17,66 %
Pardubičky	1 799 m^2	14,99 %
Rosice nad Labem	1 065 m^2	11,52 %
Ohrazenice	865 m^2	7,36 %
Hůrka	779 m^2	5,86 %
Polabiny	Not Identified	1,77 %

Source: [3], [8], [10]

At collection yards in Pardubice are deposited variable types of waste, the inventory of them varies for each yard. Basic overview of the types of waste accepted at the collection yards are given in Table 2.

Table 2. List of accepted types of waste at collection yards in Pardubice.

Types of waste	**Collection yeard**
Paper, glass, plastics, metals	All collection yards
Construction rubble, ceramics	All collection yards
Bulky waste (furniture, carpets, linoleum, mattresses,…)	All collection yards
Discarded electronics (refrigerators, TVs, computers, fluorescent lamps, …)	All collection yards
Tyres (diskless)	All collection yards
Edible oils, fats (enclosed in disposable containers)	All collection yards
Car batteries, other batteries	All collection yards – except collection yeard Polabiny
Foliage, branches	All collection yards – except collection yeard Polabiny
Hazardous wastes (acids, bases, pesticides, paints, adhesives, resins, oils, solvents, oil filters, drugs,…)	All collection yards – except collection yeard Polabiny
Eternit, cardboard	Just collection yeard Dražkovice

Source: [11]

As the table shows, collection yards received, sorted and sent away for further processing or disposal a broad spectrum of waste. Figure 1 shows the proportion of the most commonly occurring waste at all collection yards in Pardubice by weight in 2014 [3].

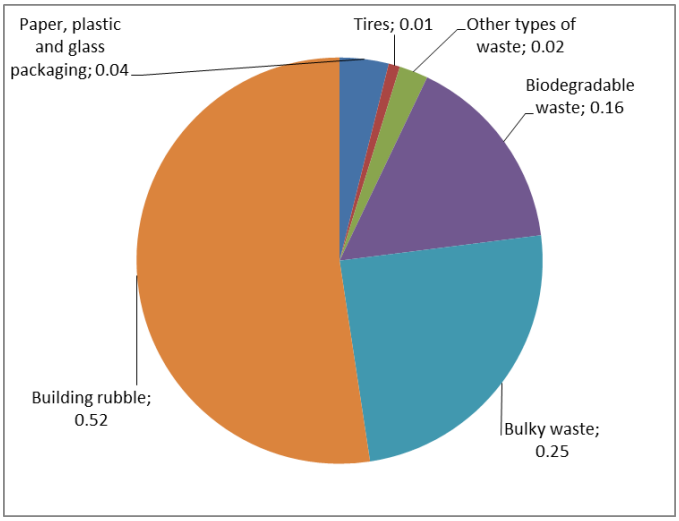

Figure 1. The most frequent types of waste at collection yards in Pardubice (2014).

Source: [3]

The chart shows that the most widespread kind of waste, in terms of tonnage is waste or mixtures of concrete, bricks, tiles and ceramics, or building rubble, belonging to construction waste. This type of waste consists of 52.4%. Even here the collection yards do not detract from the situation in the Pardubice region nor in Pardubice, where always the highest produced type of waste is construction and demolition waste, where this kind of waste belongs. Therefore neglecting the mixed municipal waste, which belongs to the largest share in the produced waste in Pardubice (but this waste is not accepted at the collection yards) [3].

Another most popular type of waste is the bulky waste, which constitute 24.6% of the total amount.

Bulky waste with biodegradable waste, which are on third place in the overall amount, make up the largest portion of municipal waste collected by these collection yards.

The most other common types of waste are, but with a far smaller percentage of recyclable components, glass, paper and plastic packaging (3.9% of the total amount of waste collected at all collection yards in Pardubice in 2014) [3].

These municipal waste types constitute a group with the largest number of accepted types of waste on researched collection yards.

In the context of municipal waste the largest groups this year were bulky waste 59.58% (2,080 tons) and biodegradable waste 38.44% (1,342 tons) [3].

The total amount of waste collected through collection yards in Pardubice represents 0.75% in the total production of waste in the Pardubice Region (2013) and 27.55% in the total waste generated in the city Pardubice itself (for 2014) [3], [4], [12].

These municipal wastes constitute a group with the largest number of accepted waste types in researched collection yards.

This waste was collected in 2014 a total of 3,491 tons, that is 41.28% of the total amount of waste collected in collection yards.

C. Collection Yard Dražkovice

Waste on collection yard Dražkovice is accepted only within the opening hours. The opening hours are Monday, Tuesday, Thursday and Friday 6:30 a.m. to 3:00 p.m. and Wednesday 6:30 a.m. to 5:00 p.m. [11]. The amount of waste received at the collection yard in years 2010-2014 is presented in the graph in Figure 2.

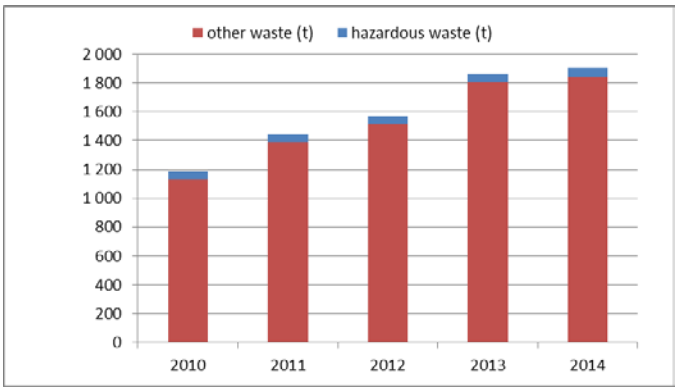

Figure 2. The amount of waste collected at recycling center in Dražkovice

Source: [3]

From this graph it is clear, that the total amount of waste collected at the collection yard in the period, grew steadily. In 2010 the amount of waste occupied 14.64% of the total amount of waste collected by all collecting yards in Pardubice and in 2014 it was already 22.51%.

Hazardous waste had accepted 3.31% (2014) of the total amount of waste to the recycling center, which is 2.15% more than the level of the collection yards in Pardubice. Hazardous waste accounted for 3.31% of the total waste received in 2014 to the collection yard, which is 2.15% more than the average level of collection yards in Pardubice [3], [4], [12].

In 2014, to the total amount of waste collected in this collection yard contributed mixtures of concrete, bricks, tiles and ceramics, or building rubble, belonging to construction waste. Ranking categories of waste in terms of quantity is similar at all collection yards, where in first place it is also building rubble, in second bulky waste, as well as biodegradable waste and paper, plastic and glass packaging. This collection yard is unlike all other collection yards, a larger share of building materials containing asbestos (2.71% of the total amount of waste at the facility in 2014) belonging to the category of hazardous waste. This kind of waste was in 2014 (but also throughout the period 2010-2014) collected only at this collection yard. The same applies to insulation material that was accepted only in collection yard Dražkovice in 2015 [3].

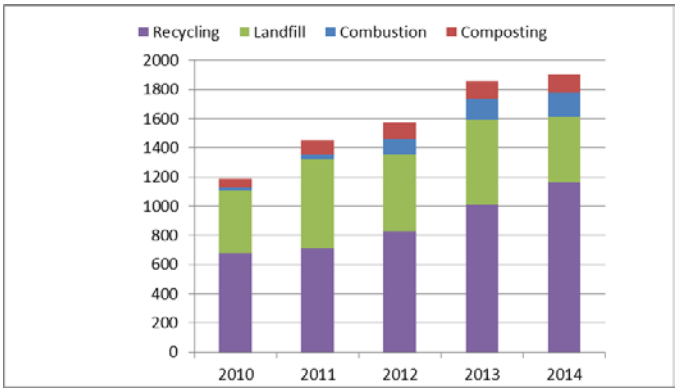

Figure 3. Waste disposal methods of collection yard in Dražkovice

From the graph in Fig. 3,it is also clear that waste concerning collection yard Dražkovice predominates over the other methods of recycling. For this type of waste disposal also grew processed amount of waste in the reporting period. In 2010 was processed 56.77% in this way of the waste from the collection yard, in 2014 it was already 61.17%. In second place was ranked landfill and in third composting.

Comparison of these empirical data with the theoretical concept of waste disposal hierarchy allows to make an interim conclusion that the structure of the theoretical concept of the waste disposal hierarchy does not correspond. Positively may be evaluated the considerable proportion of recycled waste. Worse results are for the landfill, which would be, according to the mentioned theory, used as little as possible, this way of disposal now occupies second place in the ranking according to the amount of waste. Variants of waste disposal leading to reuse for the same or a different purpose are not noticeable here [3], [5], [14].

D. Collection Yard Svítkov

Waste at the collection yard in Svítkov is accepted only within the opening hours. The opening hours are Monday, Wednesday and Friday 1:00-5:00 pm and Saturday 8:00 to 12:00 am. [11].

The amount of waste received at the collection yard in individual years 2010-2014 is shown in the chart in Figure 4.

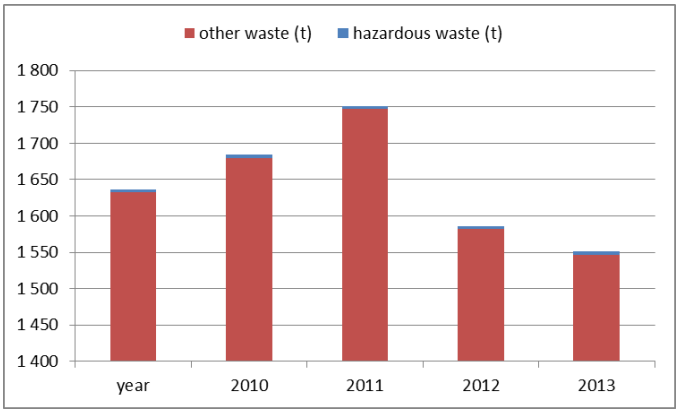

Figure 4. The amount of waste collected at collection yard in Svítkov

Source: [3]

Like the waste from the collection yard in Dražkovice and at all collection yards in Pardubice, the recycling waste dominates. In 2014 it dealt with 64.3% waste of all waste received at the collection yard. In second place alternately take the position - landfill and composting. In 2012 and 2014, outran the composting landfill, in terms of the volume of waste. In 2014 the biggest difference was in the amount of composted waste and the amount of landfilled waste was biggest, 159 tons. [3], [5].

Even the data concerning waste going from the collection yard according the graph of Figure 5 shows, that in 2012 started part combustion and part recycling of bulky waste. Also here this fact is reflected by increase of the incinerated waste amount and reduction of the waste deposited amount in the landfill between 2011 and 2012. This trend is also evident in the years 2013 and 2014. [3], [5]. The graph in Figure 5 shows the proportions of the various methods of waste treatment in years 2010-2014.

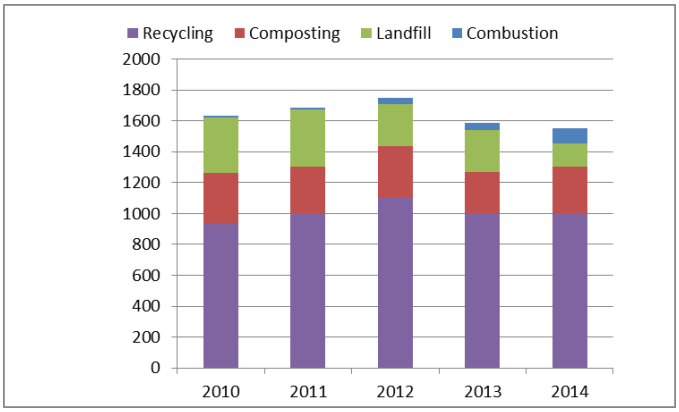

Figure 5. Waste treatment methods of collection yard in Svítkov

Source: [3], [5]

Given the predominance of waste recycled, it is possible to say that in this case there is a partial match with the concept, of waste management hierarchy. Waste management at the collection yard in Svítkov begins to approach this concept also that the landfill, which at the beginning of the researched period was in second place, was overtaken by composting in 2014. If there were only 54 tons more waste incinerated in 2014, there would come landfill in last place, which would already have much better fit to aforementioned theoretical concept. [3], [5], [14]

Reuse of the same or another purpose, however, is also practically absent here.

II. The Results of Analysis

Carrying out a comparative analysis and comparison of the theoretical concept of the waste managerial hierarchy with the empirical data it was possible to formulate the following conclusions:

In the period 2010-2014 all collection yards accepted annually over 8000 tons of waste in the last reporting year, it was 8,457 tons, representing 27.55% in the total production in the city Pardubice itself. Furthermore, for each year during this period collection yards recycled the largest amount of waste. In 2014, it was 63.34% of the total amount of waste at all collection yards.

The advantage of this type of waste treatment can be seen in the fact that here it has been dealt with, inter alia, types of waste which have the largest share in the total amount at the collection yards - building rubble, part of bulky waste and recyclable waste such as paper, plastic and glass packaging.

In second place was ranked landfilling, composting and also in last place was combustion. In 2010 and 2011, bulky waste was just landfilled, but because in 2012 it started to be incinerated, part of the waste was combusted and part recycled, reducing the amount of landfilled waste and conversely increasing the amount of waste incinerated.

We carried out the comparison of empirically obtained data with the theoretical concept of the waste treatment hierarchy*. Analysis revealed that according to the assumptions of the hierarchy* within the collection yards in Pardubice was fulfilled only in terms of recycling, that waste treatment in these facilities prevailed. Landfilling in terms of quantity of the treated waste was in second place, while the hierarchy of waste management should be the last resort, because it is the least desirable way to deal with the waste.

The analysis also showed a positive trend, which in 2014 recorded a larger amount of composted waste than those placed in the landfill, suggesting a shift in dealing with waste in accordance with recommendations of the waste treatment hierarchy.

The results show that within the collection yards they do not apply the reuse of wastes, which should precede all other levels of waste treatment. The question arises here, whether the collection yards are a good place to analyze the possibilities for reuse, because for this purpose they are designed primarily for custodian-refund systems. Due to the variety of different wastes that come to collection yards, it can be assumed that here too it is possible to apply this method of waste disposal.

E.g. household electronics can be used to further provide either still functional pieces, or dismantle the various functional components such as transformers, speakers, etc., and offer them for further use.

III. Conclusion

The analysis performed, confirmed the positive trend in waste management. Over a relatively short period of 4 years there has been a visible shift to the state that recommends the theoretical concept of the waste management hierarchy.

However, it is still noticeable, that there exists deficit in the utilization of the waste at the higher levels of the waste treatment hierarchy. As the recommendations may therefore be noted, in addition to maintain the current trend to expand ways to waste treatment, there is the opportunity to reuse the still functional or repaired products. Relevant workshops that would carry out repairs, could often be placed directly into the complex of collection yards.

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