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Original Research

Household Solid Waste Composition Focusing on Hazardous Waste

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Abstract

Internationally, almost 70% of municipal solid waste is disposed of in landfills and may contain hazardous substances in the form of paints, vehicle maintenance products, mercury-containing waste, pharmaceuticals, batteries, and many other products. The present study has attempted to address the problem of hazardous waste in the context of municipal solid waste generated in a typical urban scenario. The study was conducted in year 2013. The sorting of the waste was performed manually. Determining the quantity of hazardous and potentially hazardous ingredients in household waste was carried out on the 10 samples of the collection from the cities of Kroměříž (City 1) and Brno (City 2). Results revealed that the share of household hazardous waste found in Kuchyňky landfill was 2.047% of the total municipal solid waste stream. The results are based on actual measurements, where the percentage of household hazardous waste has been estimated based on sampling in a municipal landfill.

Keywords: landfill, waste characterization, waste composition

Introduction

Since the beginning of civilization we have produced solid waste. During the earliest periods, solid waste was conveniently and unobtrusively disposed of in large open land spaces, as the density of the population was low. Today, however, rapid urbanization, increasing population, and developing living standards have created large amounts of solid waste all over the world [1-5]. Municipal solid wastes (MSW) coming from activities carried out in homes, places of public and private service, buildings, and commercial and service establishments form an important portion of the solid waste problem [6]. Management and treatment of these wastes is required in order to prevent serious environmental health risks [6]. The disposal of waste in landfills is the most used and cheapest of all waste management techniques [7].

Household waste – any waste produced from a domestic source – represents more than two-thirds of the MSW stream [8]. Internationally, almost 70% of MSW is disposed of in landfills [8, 9]. MSW contains hazardous substances in the form of paints, vehicle maintenance products, mercury-containing waste, pharmaceuticals, batteries, and many other products [10]. To achieve maximum protection of the environment against the

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hazards associated with open dumping, all potential hazards must be identified and assessed properly [7].

Unlike the waste streams originating from industrial sources, hazardous substances in household waste are not strictly controlled under hazardous waste regulations such as the U.S. Resource Conservation and Recovery Act 1976 (RCRA) and the European Hazardous Waste Directive 91/689/EEC [11]. As such, household hazardous waste (HHW) is disposed of in landfills along with general household waste (HW). The amounts and significance of this disposal are poorly understood. Generally, it is assumed that amounts are small and therefore risks of disposal are negligible. Nevertheless, disposal information is lacking or, at best, unreliable and ambiguous. Changes to legislation requiring the separate disposal of MSW, industrial, and other wastes raises the importance of the hazardous element contained in MSW [12].

As concern about chemicals in household products increases [13], the potential consequences to the environment from the disposal of HHW are also moving to the fore. It is therefore important to ascertain the level of risk inherent in the disposal of HHW to landfill, as permitted by current legislation [12].

Hazardous Waste in Municipal Solid Waste

HW may be generated from residential and non-residential sources, hence the need to study the amount and categories of this type of waste. This information is fundamental to the design of appropriate management strategies, to avoid current mixing and co-disposal with non-hazardous waste. However, the variety of products and the heterogeneity of sources make the quantification of this type of waste difficult. Thus, the characterization of containers, packaging, and wrapping materials of products that contained hazardous products by composition might be used as an indicator to estimate the amount of HW mixed and disposed of with the MSW. There are items used regularly in houses, trade centers, administrative centers, and institutions, such as cleaning products, self-care products, medicine, home-care products, automotive maintenance products, electronic equipment, and general maintenance products for machinery. The aforementioned types of products are formulated with substances that, by themselves or when reacting with others, produce additional compounds that when attaining certain concentration levels might be capable of causing severe environmental and public health damage [14].

One of the problems with daily household products is that their chemical formulation is largely unknown, both quantitatively and qualitatively. It is reasonable to expect that the chemical brew produced in a landfill matrix is altogether difficult to stabilize and able to produce substances with stronger damaging effects [14].

There is a wide-reaching discussion about the name and characteristics that should be applied to categorize HHW. The clarification of this topic is essential to determine suitable solid waste management strategies. When discussing the term ‘‘contaminant,’’ Rushbrook and Pugh [15] stated that contaminant waste includes a broad range of products considered hazardous for a variety of factors, one of them being the toxicity grade, where the cumulative effects of sub-products are exerted upon living organisms.

The present study has attempted to address this concern in the context of MSW generated in a typical urban scenario. The primary objective was to develop the profile of specific compounds and to quantify the predominant hazardous pollutants possible in MSW. For this purpose, both fresh MSW and that mined from an open landfill in Kuchyňky (Czech Republic) were extracted and screened for hazardous compounds. Results of this study could be useful in the decisions of appropriate solid waste disposal methods and modifying present methods.

Material and Methods

Location: Basic Characteristic of the Kuchyňky Landfill

The Kuchyňky landfill (Fig. 1) is situated in a triangular space delimited by main roads connecting the villages of Zdounky, Nětčice, and Troubky-Zdislavice at a distance of ca. 1,800 m NNW of the church in Zdounky, 750 m NNW of the built-up area limits in Zdounky, and 450 m SW of the boundary line of Nětčice. In terms of maintenance, the landfill is classified in the S-category (other waste, sub-category S-OO3). The designed area of the landfill is 70,700 m^2 in five stages with a total volume of 907,000 m^3, i.e., ca. 1,000,000 10^3 kg of waste. Up to now, Stage I of 19,200 m^2 has been constructed together with parts of Stage II (5,500 m^2) and Stage III (7,500 m^3). Planned service life of the facility is up to year 2018.

The facility receives waste (category of other waste) from a catchment area with a population of ca. 75,000 residents. The annually deposited amount of waste is ca. 40,000 10^3 kg, of which 50% are from the communal sphere. The approved landfill sector for waste of sub-category S-OO1 has not yet been opened. The sector will be intended for the disposal of waste (category of other waste) with the low content of organic biologically degradable substances. A sector of the landfill will be intended largely for the disposal of asbestos-containing wastes, gypsum-based waste, stabilized waste, waste with high sulphur content, and waste with increased metals content. Waste with the substantial content of organic biologically degradable substances must not be stored in that sector [16].

Sorting the Waste

The present study was conducted between May 2013 and September 2013. Waste sorting was performed by a team of three. The crew was carefully introduced to the purpose and importance of the scientific work and each crew member was instructed regarding the sorting

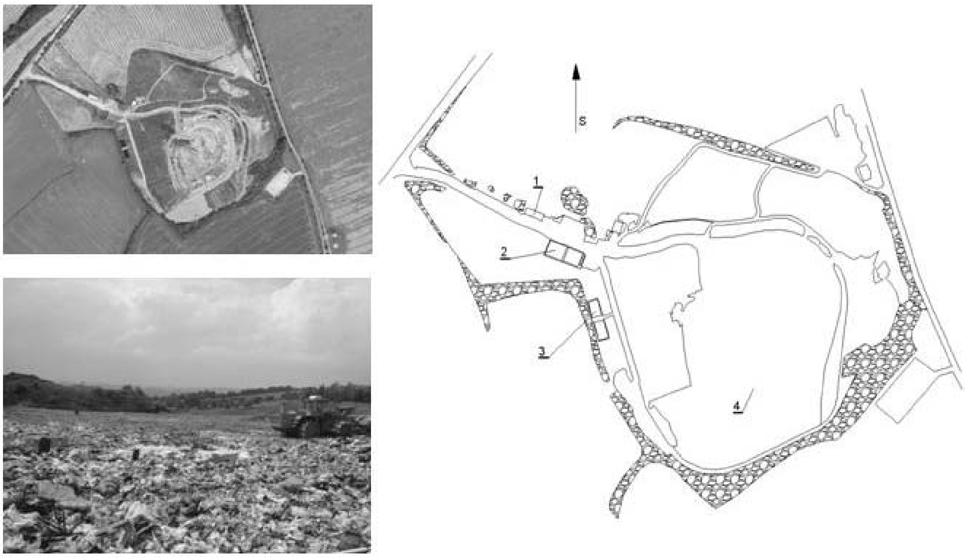

Fig. 1. Kuchyňky landfill and landfill surroundings.

procedures. Written sorting instructions were available. In case of doubt, the team leader was called to identify the correct type of fraction.

Determination of the quantity of hazardous and potentially hazardous ingredients in HW was always carried out on the 10 samples of the collection from City 1 and City 2. The minimum required weight of one sample was 500 kg (the exact weight of the samples is listed in Table 1). The average weight of samples of MSW imported from City 1 amounted to 508.37 kg, and from City 2 507.78 kg.

The individual samples were manually sorted according to dangerous waste potential HW. HW and sorted components were separately stored. Sorted components and the remaining municipal waste was weighed and the results recorded.

Table 1. Weights of the examined samples.

Sample	MSW, City 1 (kg)	MSW, City 2 (kg)
1	514.78	517.43
2	507.98	500.82
3	512.29	511.20
4	504.53	506.82
5	502.10	515.57
6	506.00	504.57
7	508.40	510.70
8	503.00	505.10
9	506.20	505.30
10	518.40	500.30

Results

Charts were created based on the results. Fig. 2 compares the weights of the MSW (kg) and mass of Total HW (kg) for City 1. In MSW total HW was identified ranging from 7.10-42.73 kg during the reported period.

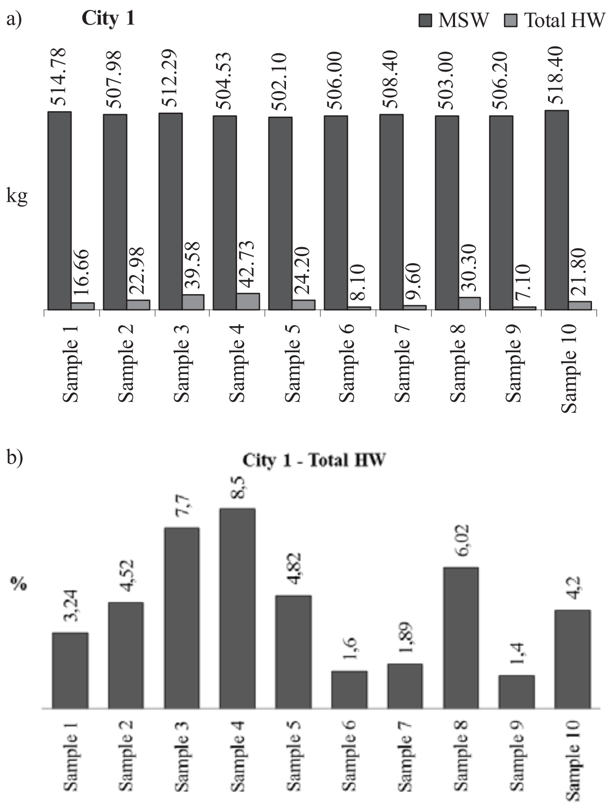

Fig. 2. Comparison of: a) MSW weights, total weight of HW, b) total weight of the HW expressed as a percentage for City 1.

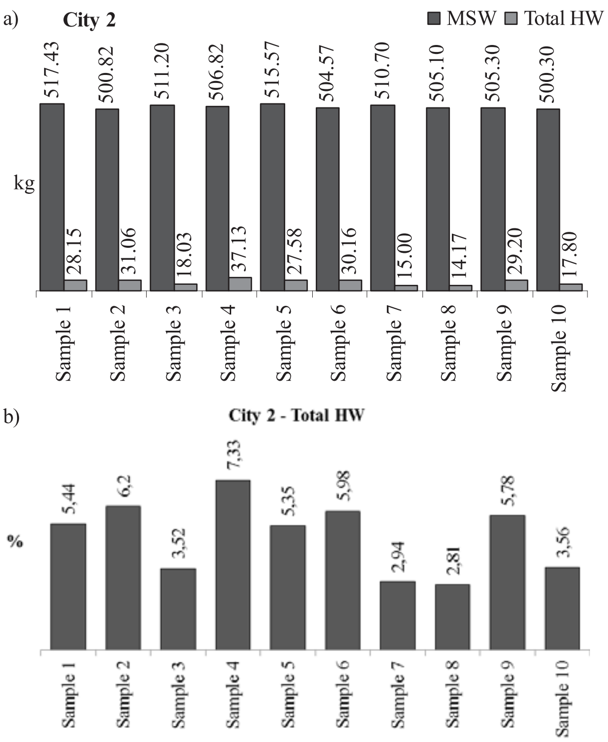

Fig. 3. Comparison of: a) MSW weights, total weight of HW, b) total weight of the HW expressed as a percentage for City 2.

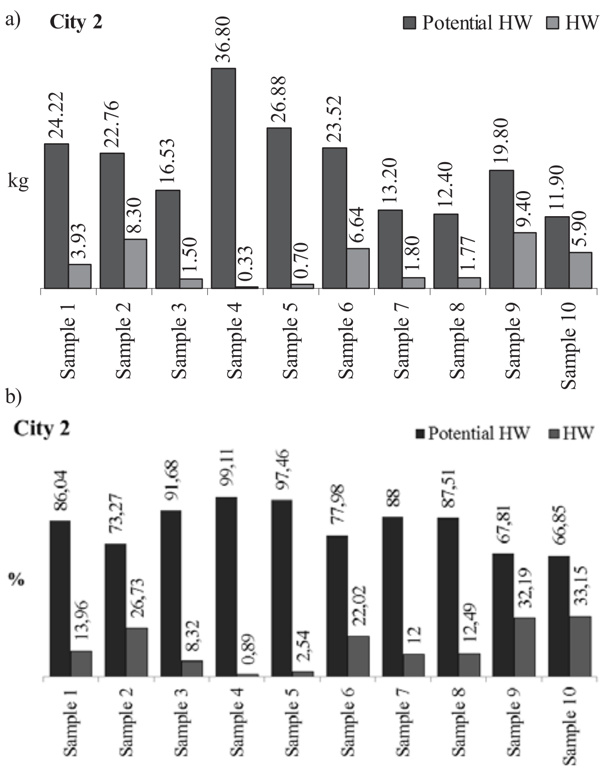

Fig. 5. The weight of: a) potential HW and HW, b) potential HW and HW expressed as a percentage for City 2.

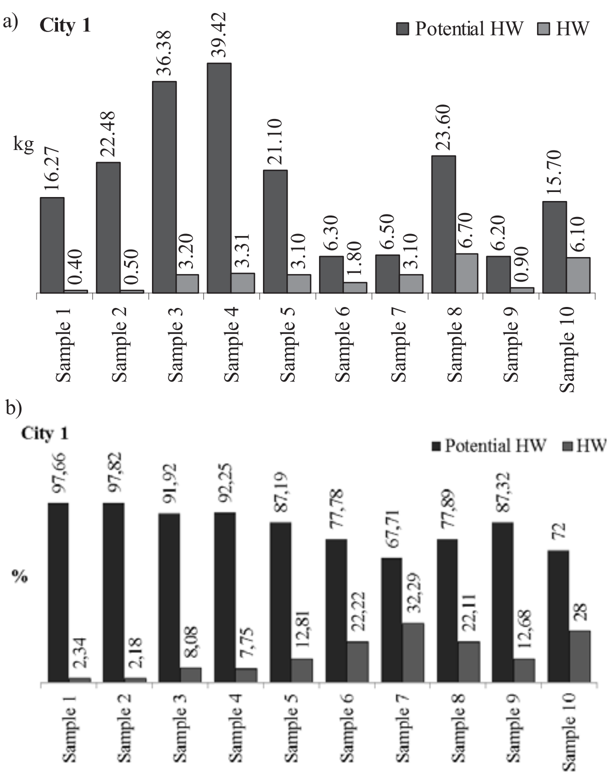

Fig. 4. The weight of: a) potential HW and HW, b) potential HW and HW expressed as a percentage for City 1.

Fig. 3 shows the comparison of the weight of MSW (kg) and the total mass of the Total HW (kg) for the City 2. In MSW we identified total HW ranging from 14.17-37.13 kg during the reporting period. City 2 levels reached higher total HW values than for City 1.

Since in the course of research HW was identified, these wastes were divided into potential HW and HW. The weight of the waste for City 1 for each of the samples taken are listed in Fig. 4. The weight of potential HW in the period considered ranged 6.20-39.42 kg. The weight of HW in the given period in the investigated samples ranged from 0.40-6.70 kg.

The weight of potential HW and HW for City 2 for each of the samples taken are listed in Fig. 5. The weight

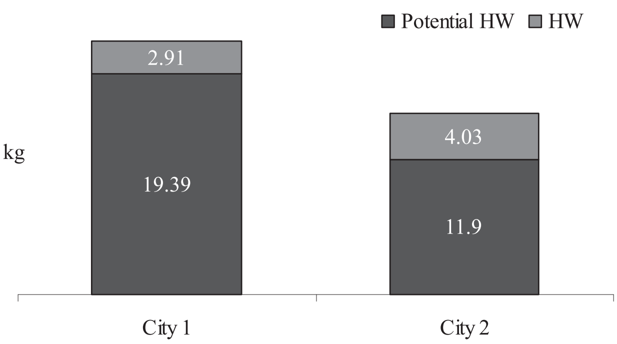

Fig. 6. Average values of Potential HW and HW in Cities 1 and 2.

of potential HW in the period considered ranged from 6.20-39.42 kg, and the weight of the HW ranged from 0.33-9.40 kg.

Fig. 6 shows comparison of average stated values of Potential HW and HW in Cities 1 and 2. The MSW from City 1 included on average 3.8% potential HW and 0.57% HW. MSW in City 2 included potential HW of 2.34% and 0.79% HW. MSW from City 1 showed much higher values of potential HW (19.39 kg) than City 2, but in MSW from City 2 we found more HW (4.03 kg) than in City 1.

Discussion

Certain categories of HW are generated within households containing remnants of chemical fertilizers, pesticides, herbicides, cleaning products, etc., and are usually found in dump sites or even landfills [17]. A small portion (typically 1% by weight) is defined as HHW.

A review of 20 European counties, the USA (several states), Mexico, Canada, Greenland, Japan, India, Pakistan, Hong-Kong, and Nepal from 1992-2013 showed that the HHW quantities represent just a small percentage of overall MSW. In EU and the USA it is generally reported that the quantities of HHW arising represent 1% w/w of municipal waste [18-20]. Inglezakis and Moustakas [21] collected 36 values of HHW percentage (w/w) in MSW [22-36]. The values are presented in Fig. 7. The average value is 0.90±0.39% (range 0.12-1.88). As shown in Fig. 7, there is a scattering of values, but the majority is concentrated between 0.4 and 1.2%. It is important to mention that these figures are rough approximations and are not based on actual measurements, with exceptions, as in the cases of Canada and Greece, where the percentage of HHW has been estimated based on sampling in a municipal landfill [21]. Other quantitative data present higher percentages of w/w content of HHW within MSW, exceeding 1% and even reaching 4% [21, 37]. Such variations can also take place within different areas of the same country and can be explained on the basis of different facts, including the different terms of HHW used and the different existing consumer patterns and ways of life around the world.

Our results revealed that the share of HHW found in Kuchyňky landfill was 2.047% of the total MSW stream. The results are based on actual measurements as in the cases of Canada and Greece [21], where the percentage of HHW has been estimated based on sampling in a municipal landfill. It is of crucial importance to be able to recognize solid waste composition (content of HW and Potential HW) when designing waste management and disposal strategies, and to decide about sanitary, public health, and environmental impact policies [37].

Conclusions

In many countries of the world MSW is landfilled without any sorting and, moreover, without proof of contents. Domestic waste contains certain percentage of dangerous substances that are potentially harmful, in amounts of 1% of MSW. There was a significant development when it comes to waste treatment and its regulation laid down by laws, such as, for example, setting objectives for recycling and preliminary treatment of biodegradable organic substances before adding it to the landfill, which now limit the speed of expansion of the landfill sites [38].

The present study was conducted in 2013. Determining the quantity of hazardous and potentially hazardous contents of household waste was always carried out on samples from Kroměříž (City 1) and Brno (City 2). In the MSW, despite considerable public awareness and

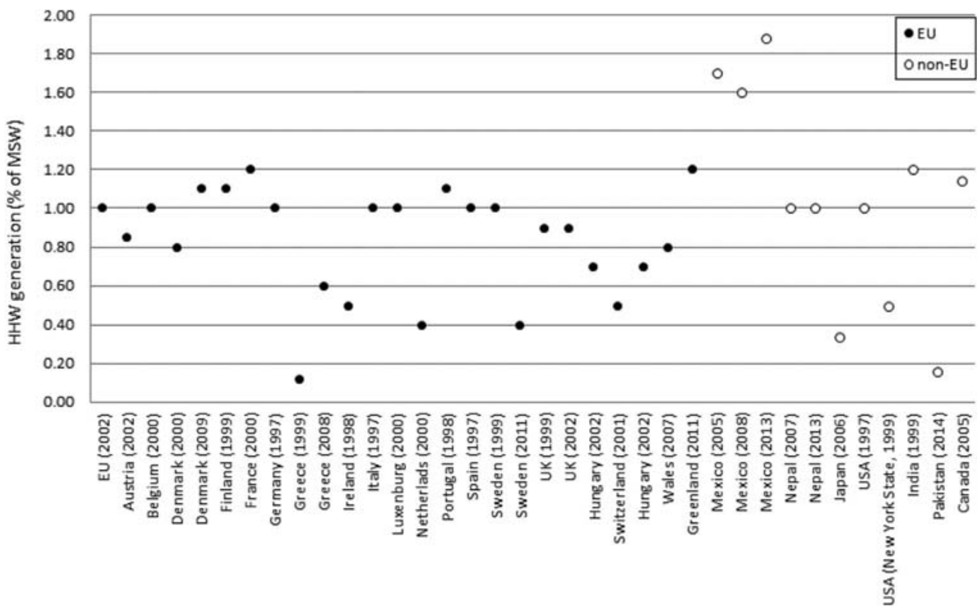

Fig. 7. HHW generation (% of MSW) [19].

education of the population, we found and identified about 2.047% potential HHW.

The experiment was carried out in real conditions for the first time and its repetition is planned to be carried out again in the landfill in order to verify our initial experimental results.

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