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Investigation of Seasonal Variation Effects on Household Hazardous Waste Composition and Generation Rate in Tehran and Proposing Environmental Solutions to Prevent and Reduce

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Abstract

Household waste, which is any waste generated from domestic source, represents over two-thirds of the municipal solid waste (MSW) stream. A small portion, typically 1% by weight is defined as household hazardous waste (HHW). Household hazardous waste (HHW) is a heterogeneous waste category that is usually defined as ‘‘flammable, corrosive, reactive, caustic, and toxic’’. Quantification and characterization HHW is an important and meaningful step for the promotion of appropriate HHW management and source separation of this kind of waste in Tehran. In this research, for investigating the effect of seasonal variation on generation rate and composition of HHW, A four-stage systematic tracking survey of 600 households was conducted in 22 municipal districts in Tehran to determine the characteristics of household hazardous waste (HHW) generated by the city. The results indicate that the rate of HHW generation was (6.26– 8.25) g/person/day, which accounted for (1.22-1.58) % of the household solid waste stream. The largest category in this fraction was home cleaning products. The highest rate of HHW generation of 8.25 g/person/day was observed in winter, which was most likely caused by the celebration of Nowruz.

Keywords: Generation rate, Household hazardous waste, Seasonal variation, Special waste, Waste composition.

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Expended Abstract

Introduction

Household waste, which is any waste generated from domestic source, represents over two-thirds of the municipal solid waste (MSW) stream and internationally a large part ends up at landfills. A small portion, typically 1% by weight is defined as household hazardous waste (HHW). In US legislation, HHW is described as ‘‘Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients.’’ In Europe, the term HHW is defined as “Such wastes that could potentially increase the hazardous properties of municipal solid waste when landfilled, incinerated or composted.” A broader definition is provided by the UK National Household Hazardous Waste Forum (NHHWF): “Any material discarded by a household, which is difficult to dispose of, or which puts human health or the environment at risk because of its chemical or biological nature.”

According to Article 2, Paragraph 3 of Iran Waste Management Act, any wastes requiring special care due to containing at least one of the hazardous components of poisonous, pathogenesis, explosiveness, inflammability, corrosiveness and the likes. Those medical wastes, as well as some part of ordinary, industrial, and agricultural wastes which needs to special management, are included as specific wastes. Furthermore, based on Executive Regulation of Waste Management Act, the special component of domestic and agricultural waste, is not considered domestic waste but the responsibility of its executive management is for the domestic waste executive management which is municipality. According to World Bank report in 2018, about 87% of the produced wastes are being buried with different methods in Iran like other Middle Eastern and North African countries. Based on this report, 52.7% is related to open dumping, 14.1% to controlled landfilling, 10.8% to sanitary landfill and 9.4% to unspecified landfill sites. Leachate contains inorganic and organic elements. Xenobiotic organic compounds (XOCs) and heavy metals are generally classified as the hazardous substances occurring in leachate. Hazardous XOCs and heavy metals can be toxic, corrosive, flammable, reactive, carcinogenic, teratogenic, mutagenic and ecotoxic, among other hazards, and can also be bioaccumulative and/or persistent. MSW landfill leachate analyses permit identification of the commonly found XOCs and heavy metals derived from waste with a domestic origin. Moreover, cosmetic wastes, lotions, detergents, batteries and fluorescent lamps which are all categorized as HHW in municipal waste stream, may noticeably increase siloxane and mercury-containing vapors in the gases emitted from the disposal sites and landfills. Apart from the mentioned environmental effects, the significant costs of transportation, pre-treatment and dispose of the HHW can be pointed out as the economic effects of these wastes. Workplace accidents and work-related illnesses of household waste collectors and job dissatisfaction are the social effects of HHW management. Quantification and characterization HHW is an important and meaningful step for the promotion of appropriate HHW management and source separation of this kind of waste

Material & Methods

Sampling

Environmental problems associated with waste generation are among the societal changes in which the household plays an important role. Consumption patterns and life-style influence a household’s waste generation. Therefore, we used the household as the basic unit of analysis, one year as the large cycle, and weeks of various seasons as the small cycles in this study, household’s waste generation. Therefore, we used the household as the basic unit of analysis, one year as the large cycle, and weeks of various seasons as the small cycles in this study. In each season, to obtain statistically significant results, we investigated 600 households in all over the 22 districts of Tehran. All of households participating in the study, 600 (from 22 different districts of Tehran) participated in all four stages of the survey.

Study area

Tehran, the capital city of Iran and the center of the province of Tehran, located in north-central Iran at the foot of the Elburz mountain range. Tehran is Iran’s largest city and one of the most populous cities of the world. The center of the city is on latitude 35°41′ N and longitude 51°26′ E. Tehran is located on the steep southern slopes of the Elburz mountain range, which traces an arc along the coast of the

Caspian Sea in northern Iran. The metropolis of Tehran is divided into 22 municipal districts, each with its own administrative center. 20 of the 22 municipal districts are located in Tehran County's Central District, while the districts 1 and 20 are respectively located in the counties of Shemiranat and Ray. Although administratively separate, the cities of Ray and Shemiran are often considered part of Greater Tehran. According to the last nationwide census in 2016, population of Tehran is 8,693,706 persons and the families living in this city is determined to be 2,911,065. Based on these results, the average size of family in Tehran is about 2.99 persons.

HHW classification

Once the generation analysis was obtained, materials, packages, and containers were separated according to the classification suggested by literature. Waste categories were: (1) home cleaning, (2) automotive maintenance, (3) batteries, (4) medicines, (5) biological-infectious (syringes, dialysis equipment, used bandages, and etc.), (6) gardening, (7) self-care products, (8) home maintenances, (9) fluorescent lamps, (10) miscellaneous. The last category included all containers and packaging that could not be categorized in the other nine. The HHW classification included the number of packages or containers found in each category. Also, the total weight of each category was recorded, and whether the container still had some material left in it or not. According to previous studies, to mark any leftover as positive, it should represent at least 1% of the product.

Sample size determination

Since covering the whole metropolitan area with 9 million people is almost impossible, a representative sample with similar characteristics to Tehran's population is randomly selected and studied. Therefore, Cochran Equation is used to determine the size of a finite sample from the infinite society of Tehran. Assuming the maximum variability, which is equal to 50% (p=0.5) and taking 95% confidence level with ±4% precision, and the population size is 2,948,446. So sample size is calculated 600 households in all over the 22 districts in Tehran.

Determination of domestic solid waste generation rate and HHW composition

Solid waste sampling was carried out during the summer of 2018. Bags were collected daily for seven consecutive days. Once the bags were gathered from the area, each bag was individually weighed. Refuse was hand sorted and individual components were also weighed. Categories and sub-categories corresponded to the format described elsewhere. Once each part was categorized, each tray was weighed, taking care to note if the final sum corresponded to the total weight (kg) of the bin bag. The procedure was performed for each individual bin bag. For each household, the weight of solid waste was averaged throughout the whole period. The result indicated the average solid waste generation per household (kg/ household). Parallel to the solid waste generation analysis, packaging and containers of hazardous wastes were selected and sorted, according to the classification proposed by previous studies. HHW was classified according to ten categories, as mentioned before. After categorization, each group was weighed, including the weight of the containers per product plus any product remaining inside the container. Finally, average generation rate and the composition of HHW in different seasons was calculated which will be presented in this paper.

Statistical analysis

SPSS Statistics 25© software was used for statistical analysis of the data. Skewness and kurtosis of the graphs of data are utilized as the criteria for normalization evaluation using Shapiro-Wilk techniques of normalization evaluation.

Discussion of results

Shapiro-Wilk analysis showed that the household hazardous waste generation in different season in Tehran are normally distributed with no significant statistical deviation (sig>0.05). During the sampling period, 6473.56, 6863.05, 6530.29, and 6097.61 kg mixed solid wastes were collected from 600 households in Tehran in Spring, Summer, Autumn and, Winter, respectively. The most tendency for producing HHW is in summer with 105.33 kg and the less is for autumn by 79.98 kg. The results

indicate that the rate of HHW generation was 6.26– 8.25 g/ person/ day, which accounted for 1.22-1.58% of the household solid waste stream. The largest category in this fraction was home cleaning products.

Conclusions

The results of the present study, which determine the composition and production rate of hazardous household waste in Tehran, indicate that the per capita rate of hazardous domestic waste production in Tehran is higher than the per capita values obtained in all domestic studies such as Isfahan, Amirkola. Based on the comparison HHW generation in Japan, Switzerland, China, Indonesia, Malaysia, Mexico, and Denmark, indicating generation HHW in Tehran higher than in the country of Japan, Switzerland, China, and Indonesia, but is smaller when compared to the generation HHW in Malaysia, Mexico, and Denmark. Indeed, a notable difference exists among the results, which can be explained by differences in the time the investigations were conducted, country characteristics, methodology and proposed objectives. Seasonal rates of HHW generation are summarized in this paper. On average, a higher rate of HHW generation of 8.25 g/ person/ day was observed in winter, which was most likely caused by the celebration of Iranian ancient Nowruz. Most household follow the custom of cleaning their houses to give a warm welcome to their family members, relatives and friends before the new year Festival. Finally, this study found a high disposal rate for used home cleaning containers in the winter survey period (e.g., oven cleaners, all-purpose cleaners, laundry detergent, powder or liquid). Generally, most Iranian households do not throw low value items away except when important events. As noted above, it can be concluded that the most part of the household's hazardous waste can be significantly reduced by increasing the awareness of citizen to consume the product entirely and also clean the containers. Given the results of the present study and the possible effects of these substances on landfill sites, further studies on leachate compounds and emitted gas from landfill sites are strongly recommended.