RESEARCH ARTICLE

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Comparative Analysis of Household Hazardous Waste in Different Seasons of Year (Case Study)

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Background & Aims of the Study: Household Hazardous Waste (HHW) are the wastes can potentially increase the hazardous properties of municipal solid waste in the landfill, incineration, or composting. The lack of information about their generation and composition hinders the creation of special programs for their collection and treatment, making these wastes a potential threat to human health and the environment. Therefore the aim of this study was to determine the quantity, quality and to be able to compare the results of four seasons, regarding consumption patterns and solid waste generation rates.

Materials & Methods: A cross-sectional study was done in 2015-2016 years in Isfahan compost plant (waste receipt place) and the analyses were performed on household hazardous waste in four seasons of the year. The Shapiro–Wilk test was used to evaluate the normality of the quantitative data.

Results: HHW comprised 0.6% of municipal solid waste (MSW). The largest percentage of HHW in total HHW were home cleaners in spring (37.53%), summer (26.82%), and fall (39.78%), because home cleaners are the daily necessities of residential households but in winter medical products (34.70%) were more than others. Probably cause of the high percentage of medical products is disease outbreaks in winter. Generally, the most hazardous materials in MSW included home cleaning (0.2%), medical products (0.19%) and self-care equipment (0.11%) and the lowest were biological infection materials.

Conclusions: This study demonstrated that the production of HHW in Isfahan is independent of different seasons of the year. Household cleaners and personal protective equipment and medicine had formed the highest percentage of household hazardous waste.

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Background

According to the United States of America (USA) definition of hazardous waste due to the amount or concentration of materials that feature physical, chemical, and infectious causes an increase in infectious diseases and ultimately lead to death. Now because of the treatment, storage, transportation, disposal, and improper management of this waste, there are potential risks to human health and the environment (1). The risk of dangerous waste is dependent on various factors, including the physical form, the reactivity, quantity, composition of matter, the biological and ecological effects, the degree of volatility after entering the environment, its stability in the environment, indirect effects on health humans, and the environment (2). According to Chinese law, hazardous waste is divided into three categories: industrial hazardous waste (IHW), medical waste (MW), household hazardous waste (HHW) (3). Any waste that is discarded by residential areas called household waste. It forms more than two-thirds of municipal waste and a large part of the waste that buried in the landfill. In Europe and the United Kingdom (UK) based National Household Hazardous Waste Forum (NHHWF), HHW is defined as garbage that when composting, disposal, and burning increases the potential risks also because of the physical and chemical nature is a serious risk to human health and the environment (4-5). HHW characteristics include combustible, flammability, spontaneous combustion, reactivity, toxicity, and corrosion (6-9). HHW is an important part of the household waste that amount and quality of its depend on people's life (10). Household hazardous waste included paint, gardening pesticides, pharmaceuticals, photographic chemicals, cleaners special, personal protective equipment, fluorescent lamps, oil, and heavy metals such as batteries, electronic waste, and equipment that have chlorofluorocarbons (CFCS) (11). Although studies have shown that HHW makes up only 0.5-5 percent of municipal waste, but causing significant damage to the environment when buried (8). The impact of HHW is evaluated in three stages of garbage collection and transportation and treatment. When transferring the HHW to disposal sites one gallon of leachate can contaminate a million liters of drinking water. Suitable management in collection and transportation stage prevent of serious events. In the final compost treatment step if household solid waste (HSW) and HHW mix together, cause aggression of heavy metal and reduce of biogas extraction (10). One of the causes of global warming, greenhouse gas emissions and contamination of soil and groundwater is increasing HHW in a landfill (12,13). Rainfall in waste collected site causes waste decomposition and leachate production. If the leachate of MSW contacts with dangerous contaminants in landfills, HHW will be toxic. It is the first cause of groundwater pollution (5, 11). If HHW toxins enter in the human food chain, accumulate in the body and cause cancer, genes mutagenic, and congenital diseases (12). In recent decades, some researchers have studied the characteristics of HHW stream in various regions around the world. Otoniel et al. (2007) found that HHW concentrations of 3.7% and 1.7% were detected in the northern region (Mexicali) and in the CB area, respectively (14). Gu et al. (2014) reported that the rate of HHW generation was 6.16 (g/person/day), which accounted for 2.23% of the household solid waste stream (10). Also, Otoniel et al. (2008) indicated that approximately 1.6% of the waste stream consists of HHW (15). Ojeda-Benitez et al (2013) attempted to quantify the levels of HHW generated in Mexicali, Mexico. In this study, HHW comprised 3.49% of the total generated waste (8).

Aims of the study: Due to the adverse effects of hazardous waste and the lack of sufficient information on the quantity and quality of household hazardous waste in Isfahan, so in this study, the quantity and quality of HHW were

analyzed. The results of this study will provide a benchmark for the discussion of and will also help officials plan strategies designed to manage Isfahan's HHW.

Materials & Methods

Description of the study area

Isfahan is located in the center of Iran. This city is located in center of Isfahan, at north latitude 32°63′ and east longitude 51°65′. Isfahan's weather is semi-desert- Mild and dry with very little annual precipitation. Temperatures range from −5°C in the winter to 40°C, in the summer. In 2011, according to official statistics, the population of this city obtained 2243249 (Fig. 1).

Sampling method

The cross-sectional study was descriptive in 2015 – 2016. Sampling was performed in four different seasons of the year. Every season one day was selected for sampling. In waste receiving a place, the samples were collected randomly by Bobcat machine (KOMATSU). The waste was mixed completely and was selected one ton of it for analysis. According to Table 1 hazardous waste was separated from the selected sample and their weights were measured by small carriage scales (OHAUS, capacity: 2610, USA) and big carriage scales (Fixed measure, precision: 50 g, capacity: 200kg, IRAN)(7).

Figure 1) Location of Isfahan City, Iran.

Table 1) Household hazardous waste categories(14)

Household hazardous waste	waste categories
Home cleaning	Laundry detergent, powder or liquid, Dishwashing detergent, powder or liquid, Laundry aids, Bleach, Fabric softener, Oven cleaners, Soap bars, All-purpose cleaners, Wood protectors, Drain openers, Air fragrances
Automotive maintenance	Oil, Antifreeze agents, Brake fluid, Lubricants, Windshield wiper solution, Transmission, fluid
Batteries and small home appliances	Car batteries, Batteries, electronic equipment
Medicines	Oral, Injections, Syrup, Lotion, Suppositories, Food supplements
Biological-infectious	Dialysis, Latex gloves, Syringes, Condoms, Gauze bandages
Gardening	Insecticide, Pesticides, Soil fertilizers
Self-care	Beauty products and cosmetics, Hair Care, Lotion, Perfume, Deodorant, Soap bar, Talcum powder, Ketone, Tooth paste, Acrylic nails
Others	Oil base paint, Water base paint, Solvents, Shoe polish, Printer toner, Photography material, CD, Glue

HHW classification

Once the generation analysis was obtained, materials, packages, and containers were separated according to the classification suggested by Delgado (14). As shown in Table 1 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) miscellaneous. The last category included all containers and packaging that could not be categorized in the other seven.

Data analysis

The Shapiro–Wilk test was used to evaluate the normality of the quantitative data. Data were presented as median, range (R), and percentage.

ANOVA test was used to compare weight average of wastes among different seasons. Data analyses were performed using Statistical Package for Social Sciences version 21(SPSS Inc., Chicago, IL, U.S.A.).

Results

The results showed that the rate of HHW generation was 6.15 kg/ton/day. In fact, HHW comprised % 0.6 of municipal solid waste (see Table 2). Also by 2243249 inhabitants and 366727 ton municipal solid waste produced in Isfahan, 2.74 gr/person/ day HHW generated. Waste related to home cleaning products accounted for the largest portion of spring (37.53%), summer (26.82%), and fall (39.78%) of total HHW generation but in winter medicines products accounted for (34.70%) of the total HHW generation (Fig 2). Generally, the three largest categories were home cleaning (0.20%), medical products (0.19%) and Self-care equipment (0.11%) of total MSW generation, respectively. Quantity of HHW contributing to total MSW were in fall (0.75), winter (0.75), spring (0.56), summer (0.40). According to the Table 3, there was not a significant difference between the four seasons in terms of weight average of wastes (P-Value=0.325).

Table 2) Weight (g ton^{-1}day^{-1}) and percentage of household hazardous waste in per season

	Spring		Summer		Autumn		Winter				
HHW	g	%	g	%	g	%	g	%	Total (g)	% HHW HHW^{-1}	% HHW MSW^{-1}
Home cleaning	2093.5	37.53	1079	26.82	2990	39.78	1732	23.14	7894.5	32.09	0.20
Automotive maintenance	0	0.00	960	23.87	0	0.00	631.5	8.44	1591.5	6.47	0.04
Batteries & electronic equipments	452.3	8.11	87.55	2.18	502.5	6.69	272	3.63	1314.35	5.34	0.03
Medicines	1876.3	33.64	834.2	20.74	2441	32.48	2597.2	34.70	7748.7	31.50	0.19
Biological-infectious	108.5	1.95	0	0.00	0	0.00	0	0.00	108.5	0.44	0.00
Self-care	728.1	13.05	920.4	22.88	1014	13.49	1555.5	20.78	4218	17.14	0.11
Gardening	0	0.00	0	0.00	100	1.33	0	0.00	100	0.41	0.00
Others	319.5	5.73	141.3	3.51	469	6.24	696.7	9.31	1626.5	6.61	0.04
Total HHW (g)	5578.2		4022.45		7516.5		7484.9		24602.05		
Total MSW (g)	1000000		1000000		1000000		1000000				
% HHW MSW^{-1}	0.56		0.40		0.75		0.75				
%average of HHW generation	0.62										

Table 3) The relationship between HHW and different seasons.

	Spring	Summer	Autumn	Winter	sig
Median	127	162	108.5	113.5	0.325
Minimum	7	29.2	6.5	7.8	
Maximum	2080	1900	1820	960	
IQR	43.25-290.75	84.2-415	27.25-212	31.76-314.25	

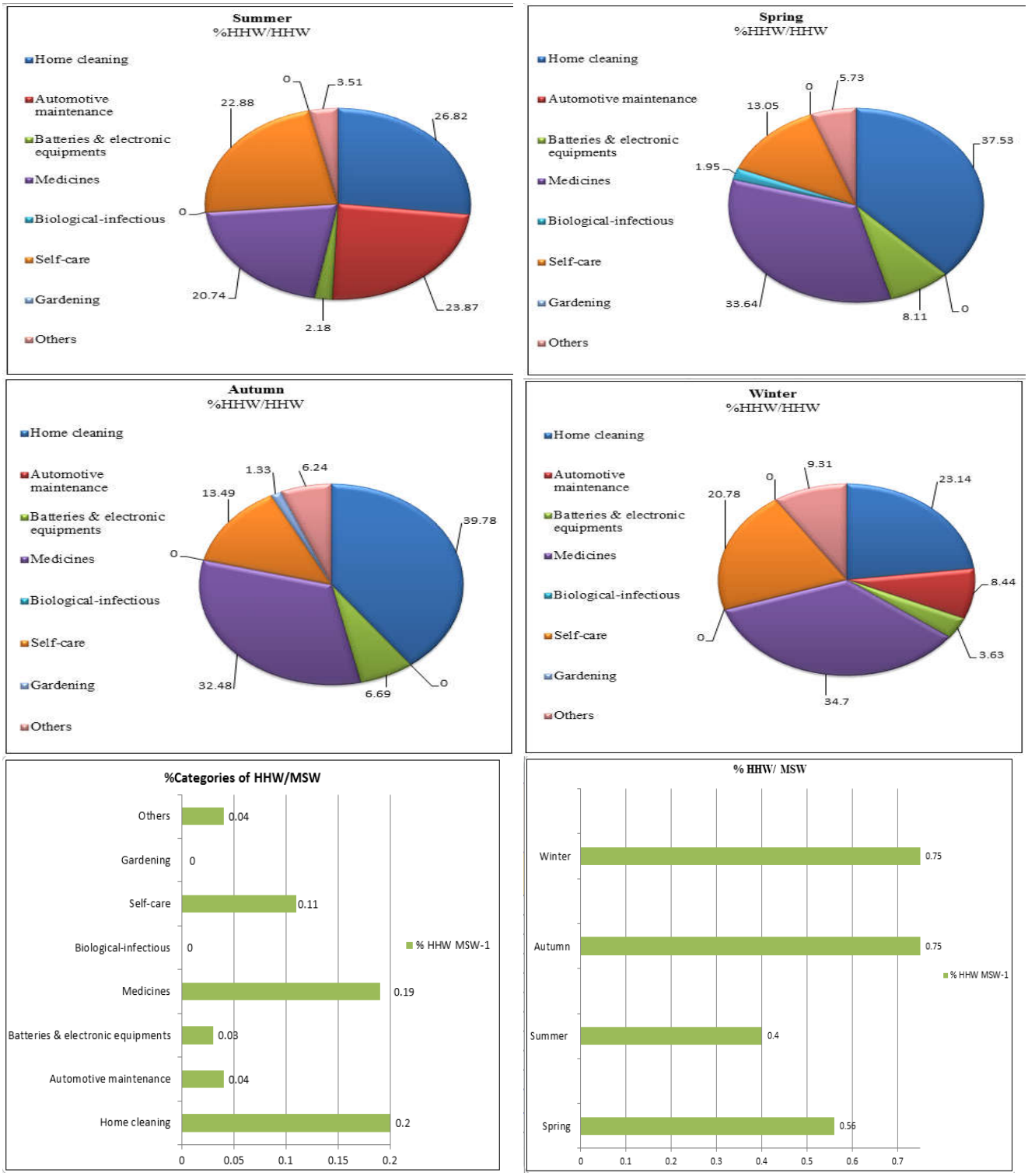

Figure 2) Composition distributions of HHW in Isfahan

Table 4) Comparison of household hazardous waste and other countries

Country and/or city	Type of the largest HHW categories	The largest HHW categories (%)	Average HHW generation %	References
Isfahan, Iran	-home cleaning -medical products -Self-care	32.09 31.50 17.14	0.6	This study
Northern Mexico	-home maintenance products -cleaning products -batteries and electro domestics	29.2 19.5 15.7	3.7	(14)
Southern Mexico	-cleaning products -self- care products -insecticides	39 27.3 14.4	1.7	(14)
Mexico	-home cleaning -Self-care -medical products	34.9 26.6 15	1.6	(15)
Mexico	-Cleaning products -Personal care and beauty products	45.86 22.45	3.49	(8)
Suzhou, China	-home cleaning -medical products -Self-care	21.33 17.67 15.19	6.16 g/person/day	(10)

Discussion

Aghalari et al. (16) Investigated the household hazardous wastes production in Tabriz(Iran) and found that the amounts of HHW generated in summer and winter were 2.75 and 2.43 g for each person in per day respectively, that were similar with our research. The Morelia (15) research estimated that a total amount of 442 ton/day of domestic waste are produced, including 7.1 ton of HHW per day. In other words 16 kg/ton/day HHW are produced. HHW generation rate and characteristics deepened on variables factors, some of these variables include culture and geographic location (17), seasonal variations (18), climate changes, as they might determine the acquisition of products such as insecticides and education level and the community type (14). Although the quantities are small, the risks of disposal are not negligible due to the hazardousness of this waste stream (19). Furthermore, as household waste recycling levels increase, the residual waste fraction may contain a greater concentration of hazardous waste, presenting additional management problems (4). Studies showed that a positive correlation between generation and income. For instance, the production of household cleaning products waste was directly related to the socioeconomic stratum (15). Studies have shown that household cleaners can have adverse effects on humans and the environment, including air generally, pollution, endocrine disorders, and chronic bronchitis (20) Therefore, proper management of these products is very important in a landfill. Binxian et al. (2014) reported that the major waste categories contributing to total HHW were home cleaning products (21.33%), medicines (17.67%), and personal care products (15.19%) (10). Also, Otoniel et al. (2008) indicated that home cleaning (34.9%), self-care product (26.6%), and medical products (15%) constitute the most part of HHW (15). According to our research in winter medicines products accounted for (34.70%) of the total HHW generation. The highest percentage of HHW in winter was medicines products, such as glass syrup, pill, thermometer, and syringe. Probably cause of the high percentage of medical products is disease outbreaks in winter. According to Yousefi et.al study the containers of laundry and dishwashing liquid are the largest amount of HHW generated

by families and the lowest amount of those belonged to batteries and electrical components (21). The results of this study were compared with other countries in Table 4. In studies conducted in Mexico and China as well as household cleaners, personal protective equipment, and medicine had formed the highest percentage of household hazardous waste (15). Studies have shown that household cleaners can have adverse effects on humans. Results from ANOVA test (P-Value=0.325) showed there was not a significant difference between the four seasons in terms of weight average of wastes (Table 3). In another study of Delgado et al. (2007) were done a comparative analysis of HHW in two Mexican regions. In the northern region (Mexicali city), HHW comprised 3.7% of municipal solid waste, the largest categories in this fraction were home cared products (29.2%), cleaning products (19.5%), batteries and electronic equipment (15.7%). In the central region, HHW comprised 1.03% of municipal solid waste; the main categories in this fraction were represented by cleaning products (39%), self -care products (27.3%), and insecticides (14.4%) (14). Ojeda-Benítez et al. (2013) attempted to quantify the levels of HHW generated in Mexicali, Mexico. Cleaning products represent 45.86% of the HHW generated (8). As shows in table 2 the average of HHW obtained.62 %, although it has been considered that HHW at 1.6% (w/w) of total waste does not constitute a serious risk(15), because generation rate of HHW are increasing the HHW management is important. In Isfahan, HHW is collected and managed along with MSW, management of hazardous waste is the most difficult, because in the process of treatment, heavy metals and dioxins are obtained. These elements are dangerous for the environment and public health (22). For waste management, it needs information about family structure, consumption patterns, population growth, society, parameters of income, geographical location, and culture of society (12). Finally this article supposes strategies include the training of families to reduce and elimination of waste, separation, and elimination in the source for HHW management.

Conclusion

The study was descriptive in 2015 – 2016. Sampling was performed in four different seasons of the year. In every season one day was selected for sampling. This survey of the HHW generation and characteristics in Isfahan city enables us to make the following conclusions:

1. The rate of HHW generation was 6.15 kg/ton/day. In fact, HHW comprised 0.6% of municipal solid waste
2. The largest percentage of HHW was home cleaners in spring (37.53%), summer (26.82%), and fall (39.78%), but the largest percentage of HHW in winter was medical products (34.70%).
3. There was not a significant difference between the four seasons in terms of weight average of wastes (P-Value=0.325).
4. Generally, the three largest categories of HHW in a year were home cleaning (32.09%), medical products (31.50%) and self-care equipment (17.14%).
5. Although the average of HHW generation was lower than 1.6% and does not constitute a serious risk but also due to the increasing of HHW rate and prevention of adverse environmental effects of hazardous wastes, management of these waste are important.

Footnotes

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Conflict of Interest:
The authors declared no conflict of interest.

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