Title
Management of Household Hazardous Waste: A Review on Global Scenario

Abstract
Generation of Household Hazardous Waste (HHW) has become a challenging problem due to rapid urbanization and lifestyle changes. Even though the fraction of HHW is very low compared to the main residential waste stream, it has the potential to create severe impacts to environmental and public health. Hence, the proper management of HHW is essential. Currently, most countries in the world do not have proper mechanisms or legislation to manage HHW. A small proportion of HHW is separated and recycled whereas the majority is disposed of together with other municipal waste. Main drawbacks for HHW management are lack of awareness, lack of infrastructure and absence of defined legislation. Studies are carried out throughout the world to find measures such as using new technologies to mitigate the impacts of HHW.

Key words: Household hazardous waste, waste management

1. Introduction

Household Hazardous Waste (HHW) encompasses waste material generated from items such as self-care products (hairspray, nail polish, nail polish removers), home maintenance products (adhesives, detergents, cleaning agents, paints, thinners), pesticides, chemical fertilizers, mercury-containing lamps and thermometers, fluorescent lights, automotive maintenance products (oil, grease), medicine and electrical equipment (Thanh et al., 2010). It is obvious that HHW is closely linked with daily household activities. With the globalization and urbanization, generation of HHW is also increased during the past decades. Moreover, the range and number of products which come under HHW have increased (Gu et al., 2014).

Despite HHW accounts for a small proportion of current household solid waste stream, it is the most toxic component of the wastes (Chaves and Silva., 2015). As most of the HHW disposed together with normal trash or poured down into household drains, storm sewers or on the ground, those toxic materials contaminate the environment. This improper disposal leads to adverse impacts of environmental and health hazards. Hence, proper HHW management is essential (Lim-Wavde et al., 2017). Specially, management policies must ensure cost-effective and safe segregation, collection, treatment and disposal of HHW (Diaz et al., 2012).

Given that background, the main aim of this study is to identify generation levels of HHW around the world, identify the impacts of improper management of HHW and prevailing Legislations and Frameworks. Further, the study provides a synthesis of existing HHW management practices, challenges and opportunities for HHW management by reviewing the existing literature.

2. Definitions and Characteristics of Household Hazardous Waste

Household Hazardous Waste is defined in different ways in different countries and/or in different legislation. Table 01 shows some of those definitions which were mentioned in the selected literature.

Table 01: Definitions for Household Hazardous Waste in different regions in the world
<table>
<thead>
<tr>
<th>Region</th>
<th>Definition</th>
<th>Reference</th>
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<tbody>
<tr>
<td>North America</td>
<td><strong>United States</strong>&lt;br&gt;“Leftover household products that contain corrosive, toxic, ignitable or reactive ingredients such as paints, cleaners, oils, batteries and pesticides”&lt;br&gt;&lt;br&gt;Household hazardous waste (HHW) is defined as leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients, such as paints, cleaners, oils, batteries, and pesticides</td>
<td>Lim-Wavde et al. (2017)</td>
</tr>
<tr>
<td>Mexico</td>
<td>Those wastes in Any physical state, that by any Characteristic represent a hazard to the ecological or environmental Balance</td>
<td>Chaves and Silva (2015)</td>
</tr>
<tr>
<td>Europe</td>
<td>Wastes that could Potentially increase the hazardous properties of municipal solid waste when landfilled, incinerated or composted</td>
<td>Gendebien et al., 2002 as cited In Inglezakis, and Moustakas, (2015)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>“a 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 natur</td>
<td>Inglezakis and Moustakas (2015)</td>
</tr>
<tr>
<td>Asia</td>
<td><strong>Thailand</strong>&lt;br&gt;Household hazardous waste (HHW) is a heterogeneous waste category that is usually defined as waste from activities in community excepting industrial, radioactive, or infectious wastes.</td>
<td>Intarasaksit, and Pitaksanurat, (2019)</td>
</tr>
</tbody>
</table>
Household hazardous waste (HHW) is a heterogeneous waste category that is usually defined as “flammable, corrosive, reactive, caustic, and toxic” [Kummar (1999) as cited in Gu et al (2014)].

Waste must be analysed according to National Solid Waste Policy to be identified as hazardous waste [Chaves and Silva (2015)].

Household hazardous waste (HHW) refers to the products used in and around the home that are flammable, toxic, explosive or corrosive [Waste Authority, Western Australia].

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HHW products</th>
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<tbody>
<tr>
<td>toxicity</td>
<td>oil-based paints, nonhalogenated degreasers, thinners and solvents (petroleum distillates), stripping agents, epoxy resins, adhesives, rubber cements and glues</td>
</tr>
<tr>
<td>flammability</td>
<td>alkaline degreasers, corrosive cleaning solutions, rust removers, waste acids, and bleach compounds (peroxide and chlorine compounds)</td>
</tr>
<tr>
<td>corrosiveness</td>
<td>bleaches and hypochlorites from water treatment processes or swimming pool sanitizing operations and discarded munitions or explosives.</td>
</tr>
<tr>
<td>reactivity</td>
<td>inks and sludges containing certain heavy metals, bat-teries containing lead, certain pesticides, and paint wastes containing heavy metals, such as chromium or lead</td>
</tr>
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</table>

Most of the components of these products create dangerous environmental and health hazards by themselves or when mixed with others [Delgado et al., 2007]. Unfortunately, the chemical composition in most daily household products is unknown. Hence, it is difficult to prevent the mixing and co-disposal of HHW with other Municipal Hazardous Waste [Adamcova et al., 2016].
3. Generation of Household Hazardous Waste

Long-term studies done in nearly 20 European countries, Canada, United States of America, Mexico, Japan, India, Pakistan, Nepal and Hong-Kong show that generation of Household Hazardous Waste (HHW) percentage is very low compared to overall Municipal Waste. For example, in the European Union and in the United States of America, the quantity of HHW is only 1% in MSW (Adamcova et al., 2016). However, these figures may vary even within the same country as most of the data are based on estimations. Hazardous household waste generation amounts in different countries which are mentioned in the selected literature are given in table 02.

Table 02: Hazardous household waste generation in different countries

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Waste amount</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>United Kingdom</td>
<td>7000 tons per month</td>
<td>Slack et al. (2007)</td>
</tr>
<tr>
<td>North America</td>
<td>Mexicali, Mexico</td>
<td>3.7% of total household waste</td>
<td>Delgado et al (2007)</td>
</tr>
<tr>
<td>Asia</td>
<td>Vietnam</td>
<td>0.2 % of total household waste</td>
<td>Thanh et al., 2010</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>2.5 to 4.3 kg of HHW per ton of household waste</td>
<td>Yasuda and Tanaka (2006)</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>3 million tons per year</td>
<td>Gu et al., 2014</td>
</tr>
<tr>
<td></td>
<td>Karnataka, India</td>
<td>0.9% of total household waste</td>
<td>Lakshmikanth and Lakshminarasimaiah (2007)</td>
</tr>
</tbody>
</table>

There are several factors which impact on the generation of HHW. They are income level, household structure, consumer preference, customs and culture and waste management policies (Delgado et al., 2007; Gu et al., 2014; Yasuda and Tanaka, 2006). However, previous studies suggest that the effect of income is not similar in every country. For example, In Mexicali city, Mexico, HHW waste generation is high in the low-income sector (3.2%) while it is low in the high-income sector (1.06%). In contrast, in high-income North American cities such as California, New Orleans and Louisiana, generation of HHW is nearly similar and low at 0.3 to 0.4% compared to Mexico (Delgado et al., 2007).

4. Impacts of Improper Management of Household Hazardous Waste

Health issues

Most of the HHW are identified as toxics (Ziaee et al., 2012). The HHW contains a wide range of chemicals which can cause adverse health effects through ingestion, inhalation or absorption. Moreover, some products emit hazardous gases which cause headaches, rashes,
fatigue and burning eyes. Long-term exposure to household hazardous products such as oil-based paints, pesticides and solvents may develop chronic health issues (Chaves and Silva, 2015). For instance, these toxins can accumulate through food chains can cause illnesses such as gene mutations and cancers (Ziaee et al., 2012). Children are highly susceptible to such health issues which are caused by exposure to HHW. They may experience asthma, allergies or severe neurological effects (Chaves and Silva, 2015). Specially, home maintenance products like insecticides and pesticides can be absorbed through the skin, digestive and respiratory system. In addition, most personal care products contain chemical composition similar to detergents. They are harmful to both humans and animals when accumulated in high amounts (Delgado et al., 2007).

**Environmental degradation**

The toxins in HHW mixed with groundwater or surface water bodies and create adverse impacts on everyone including ecosystems, human and animals (Fikri et al., 2015). In addition, improper storage of HHW can lead to accidental spills specially during emergencies such as earth quacks, floods or fires which may increase the level of severity of the environmental and public health problems (Chaves and Silva, 2015).

Another possible risk of improper dispose of HHW is the accumulation of hazardous and toxic material. This happens even in controlled landfills (Fikri et al., 2015). For instance, a previous study which evaluated the impact of disposal of used batteries in landfills in countries such as Italy, Thailand, Iran and Florida confirms there is a strong correlation between health and environmental damage and battery disposal. Because these batteries contain a high amount of heavy metals such as Mercury (Hg) and Cadmium (Cd) (Fikri et al., 2015).

**5. Management of Household Hazardous Waste**

**5.1 Existing Management Practices for Household Hazardous Waste around the World**

Due to the absence of strict laws and regulations, collection and further management of Household Hazardous Waste (HHW) is mainly depend on a voluntary basis. In general, people must sort and separate their HHW, store them properly and then transfer them to a collection point. The studies suggest that curbside collection is the most convenient method for households. But it has found that off-site drop off points help the authorities to collect more HHW because the curbside collection is comparatively expensive and time-consuming (Inglezakis and Moustakas, 2015). Additionally, collection and recycling of HHW in different countries or regions is largely depending on variances in household income levels, demographic factors, financial and technical feasibility and presence of regulations and laws (Lim-Wavde et al., 2017).

Inglezakis and Moustakas (2015) have summarized types of HHW collection systems present in different countries as below.

- Delivery by people: drop-off points, recycling centres, retailer take backs, mobile or temporary collection vehicles which are available at a specific site or specific date

- Collection by the municipal council: curbside collection, special container collected with other general waste, mobile collection vehicle
• Combination of above-mentioned methods

However, a survey by Asari and Sakai (2011) revealed that many people keep used and end-of-life batteries, fluorescent lamps, spray cans and pesticides in their homes due to lack of awareness on HHW products. Moreover, the results revealed most people discard those with other normal MSW and do not follow HHW programs if presence any. On the contrary, knowledge of people about the collection, recycling and risks of HHW were high. Especially when information on risks was mentioned, people participate in HHW programs actively (Asari and Sakai, 2011).

In most developing countries, HHW is disposed improperly to dumping sites, street gutters or added to open burning sites along with other MSW. Some data shows that automotive oil and tires are the main wastes which reach collection centres (Chaves and Silva, 2015). It has found that mixing of non-hazardous waste and hazardous waste reduce the recycling and reusing ability of waste. Moreover, they release toxic chemicals to the environment creating severe risks (Krook & Eklund, 2010). Another survey revealed that only around 20% of people dispose HHW into recycling centres or mobile collection centres while nearly 50% of people dispose HHW into normal street-side bins (Diaz et al., 2012).

Furthermore, studies state that in general, household waste streams around the world consist of 63% of the compostable material and 20% of the recyclable material. Unless these wastes are properly sorted at the sources, both these compostable and recyclable waste amounts are contaminated by HHW which only account for 2.3%. Hence, proper segregation and collection of HHW at the household level is essential for energy recovery from waste as well as for the environmental and community well-being (Gu et al., 2014). Some developed countries have taken measures towards HHW management, but many developed and most of the developing countries do not have any mechanism to treat HHW. However, practices mentioned in the existing literature show that successful management of HHW is possible (Inglezakis and Moustakas, 2015).

According to previous findings, existing HHW management systems can be divided into three main categories. They are developed national systems, local systems and improper management systems (Inglezakis and Moustakas, 2015).

First one is developed national systems of HHW management. These are present in countries such as Austria, Germany, Netherland, Sweden, Belgium and Denmark. California, USA is taking many initiatives towards the management of HHW. There is an HHW collection program which includes permanent, temporary, mobile and periodic facilities, door-to-door and curbside programs. It also includes clean-up programs. Permanent facilities collect over 50% of HHW while temporary facilities and recycling-only facilities collected 10-20% and 6% respectively (Lim-Wavde et al., 2017). San Luis Obispo County, California is the first city in the USA to start a mandatory retail-back program for HHW such as household batteries, latex paints, medical sharps and fluorescent lamps. This program was highly effective and successful in managing HHW (Wagner et al., 2013). In addition, several other countries such as Japan, Switzerland and Germany have initiated retail-take back programs. However, these programs do not specifically target all the HHW and limited to some products only (Wagner et al., 2013). In Canada, the number of waste which considered as HHW are less. But according to the regulations on HHW, manufactures are financially responsible for the waste they produce (Okoye and Elbeshbishy, 2019).
Secondly, local systems which are implemented in countries such as France, Hungary, Italy, the UK and Spain. In Madrid, Spain, legislation was implemented to increase public access to appropriate HHW management systems. Municipal councils established Fixed recycling centres (FRC) and mobile recycling centres (MRC) for the purpose of selective collection of HHW. The FRCs were situated at fixed locations whereas MCs were established at alternative collection locations (Diaz et al., 2012). In Sweden, municipalities have given sole authority by the waste management regulations to collect, transport and treat HHW. Meanwhile, households are obliged for proper segregation of HHW from other wastes. People can deliver these HHW to recycling centres at free of charge (Bernstad, la Cour Jansen & Aspegren, 2011). Most local governments and City Councils in Australia encourage people for proper disposal of HHW. There are free collection sites and special free drop-off days are assigned to collection centres in many areas (Brisbane City Council, 2018). In some states, i.e. Western Australia, HHW programs are funded by the Waste Authority through the Waste Avoidance and Resource Recovery Levy while they are administered by the Western Australian Local Government Association (WALGA). Moreover, online resources such as WasteNet are available for updated information on HHW management actions specially by Local Governments (Waste Net, 2018). Despite the lack of governing legislation, many Chinese cities encourage citizen the proper sorting and separation of HHW prior to disposal with other MSW (Tai et al., 2011).

Finally, improper HHW management systems especially in Asian and African countries. The main reason for such management is lack of finance and infrastructure (Inglezakis and Moustakas, 2015). Similar to many South Asian countries, most of the HHW in India is either poured out to drainage, ground or dumped into open landfills together with other Municipal waste (Lakshmikantha and Lakshminarasimaiah, 2007). There is no proper method of handing HHW in Vietnam too. All the HHW generated is disposed to landfills. However, as some municipalities conduct bio-waste recycling, it is essential to prevent contaminations form HHW to maintain the quality of compost (Thanh, Matsui & Fujiwara, 2010). Most of the HHW waste (85%) in Sleman regency, Indonesia is dumped in to rivers and barren lands or open burned (Iswanto et al., 2019). A study done in Iranian urban settlement reveals that only 10% of the residents separate HHW from other household wastes (Amouei et al., 2016). Open burning, land filling and incineration is the widely used methods of managing HHW in most sub-Saharan countries (Edokpayi et al., 2017).

### 5.2 Legislations and Frameworks for Household Waste Management

There is a number of regulations to control industrial waste such as US Resource Conservation and Recovery Act 1976 (RCRA) and the European Hazardous Waste Directive 91/689/EEC. In contrast, household hazardous waste (HHW) is not strictly controlled in most of both developed and developing countries. As a result, most HHW is disposed to landfills with other wastes. Even though the amount of generated HHW is small compared to MSW, the risks of untreated disposal of HHW to landfills and other open areas cannot be underestimated. Moreover, the existing knowledge on impacts of such incidents is insufficient to make any predictions or to form a basis for proper regulation (Adamcova et al., 2016; Fikri et al., 2015).

As state-wise, California in the USA has several regulations for HHW. According to California law, an electronic waste recycling fee is charged form consumers when they buy
new or refurbished electronic equipment. Moreover, Paint Stewardship Program which is regulated under the California Paint Stewardship Statute of 2010, manages the leftover oil-based and latex paints. Additionally, the California Oil Recycling Enhancement Act of 1991 states that oil manufacturers pay a fee for lubricating oil sold in California (Lim-Wawde et al., 2017).

In the European Union, there is no separate legislation for the management of HHW. Hence, HHW is must be managed along with other industrial hazardous waste under the European Hazardous Waste Directive 91/689/EEC. But as there are no specific rules and definitions, proper management of HHW is difficult (Inglezakis and Moustakas, 2015).

In the context of China, even though industrial and medical waste is properly treated according to the law, there is no active legislation or framework for HHW (Gu et al., 2014). Similarly, in Indonesia, management of HHW is not getting sufficient attention of regulatory bodies compared to industrial hazardous waste. The Government Regulation No. 18 Jo 85 Year 1999, Chapter III, article 9 verse VI, mention about HHW management about is has been identified that no continuing actions are taken to implement any program or regulation (Fikri et al., 2015). Many countries in Sub-Saharan African region have different regulations and legislation for solid waste and wastewater management but do not have specific legislation for HHW management. Hence, HHW is managed in broader terms with industrial hazardous waste and other residential waste (Edokpayi et al., 2017).

6. Challenges and Opportunities for Household Hazardous Waste Management

The biggest challenge in managing Household Hazardous Waste (HHW) is that it only belongs to a small fraction of Municipal Solid Waste through the impacts are very high. As a result, proper segregation and treatment are time-consuming and not cost-effective. Most household hazardous products do not contain enough qualitative or quantitative information in their labels. A study has shown that people give positive responses to HHW separation and recycling when are given sufficient information (Asari and Sakai, 2011). Hence, informative labelling on household hazardous products must be encouraged for producers.

Moreover, the awareness of managing HHW should be given to common people. Hence, knowledge of risks and potential impacts must be given through local information systems and awareness programs (Inglezakis and Moustakas, 2015). Additionally, educational programs must consider the socio-economic and environmental constraints of the community (Díaz et al., 2012). People must be encouraged for proper waste segregation sorting practices. Furthermore, disposal of HHW to landfills should be avoided to prevent potential harmful impacts. The relevant authorities must design proper waste disposal schemes which encourage people for proper management of HHW (Inglezakis and Moustakas, 2015). In addition, the cooperation of multiple stakeholders is essential for the success of HHW related regulations and use of collection and recycling centres.

Lack of infrastructure is the main challenge for managing HHW, particularly in developing countries in South Asia and Sub-Saharan Africa (Edokpayi et al., 2017; Lakshmikantha and Lakshminarasimaiah, 2007). Most countries do not even have proper MSW management procedures. Lack of proper collection bins or vehicles, lack of trained staff, insufficient technology to process waste, reduce the attention of both authorities and community for HHW management (Lakshmikantha and Lakshminarasimaiah, 2007). Moreover, as there are more pressing concerns in these countries such as poverty and malnourishment and
unemployment, the government is reluctant to invest in matters like HHW management (Edokpayi et al., 2017).

Another major challenge in managing HHW is lack of proper definition and clarification. It is essential to provide a proper explanation for the hazardousness of household waste to increase awareness as well as to develop management strategies (Adamcova et al., 2016). Limited knowledge of chemical reactions of HHW and their impacts on human and environmental health hinder the identification of possible prevention and mitigation measures. Hence, further research is necessary to identify synergistic, antagonistic interactions and the chemical nature of HHW (Chaves and Silva, 2015).

As landfills remain to the most popular method of disposal, new technologies can be applied to minimize the impact hazardous leachate generated due to co-dispose of HHW with MSW. For example, Alumur and Kara (2007) developed a new model for hazardous waste location-routing problem in Turkey which mainly focused on identifying the best locations for collection and recycling centres. This model target on reducing the transportation cost and risk which are the main obstacles in HHW management.

7. Conclusion

The available literature state that the fraction of household hazardous waste (HHW) is very less compared to municipal waste. But HHW is becoming a pressing problem due to its high toxicity and ability to cause severe damages to the environment and human health. In most countries worldwide, there is no specific defined legislation to manage HHW. Some developed countries manage HHW through municipalities and voluntary approach of residents while most of the developing countries dispose of HHW with other residential waste. Lack of awareness, inadequate infrastructure, lack of proper legislation are the major challenges for HHW management. However, initiation of new recycling programs and implementing new technologies would help to establish effective HHW management systems.

Reference


