Hazardous Waste Management from Garages in Bangkok by Material Flow Analysis (MFA)

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***Abstract*—Hazardous wastes generated from a garage and auto service can cause an adverse impact on the environment. Bangkok has an increasing rate of accumulated car registration. The information from the Department of industrial works indicates that 6,109 garages are registered of which 1,440 sites is located in Bangkok. In this study, 4 types of dataset were used to determine type, quantity and management methods of the hazardous waste from garages in Bangkok, including SK.1 (report 1), SK.2 (report 2), the hazardous waste manifest (report 3) and Questionnaire survey. Report 1, report 2 and report 3 from the year 2015 to 2017 were obtained from DIW. Questionnaires were collected from 62 garages in Bangkok. Material flow analysis or MFA was used to analyze the waste management pathways and identify the potential for improvement. The results show that the amount of hazardous waste generated according to report 1 and report 2 are higher than those of report 3 because report 1 and report 2 were the permission quota which each garage has to request from DIW while report 3 is the actual waste disposal. The amount of hazardous waste generated from garages from report 3 was 11,580, 6,031, and 6,267 tons from 2015 to 2017, respectively. Based on the questionnaires, the waste generation rate, are 1.86 kilograms of contaminated fluids, 1.70 kilograms of waste lubricating oil, 0.97 kilograms of automotive parts, 0.86 kilograms of lead-acid batteries, 0.76 kilograms of organic solvent, 0.61 kilograms of metal packaging, 0.61 kilograms of coolant, 0.37 kilograms of contaminated material, 0.36 kilograms of oil filters, 0.31 kilograms of air filters, 0.24 kilograms of hybrid batteries, 0.23 kilograms of non-metal packaging, 0.15 kilograms of hydraulic oil, 0.10 kilograms of oily sludge, 0.07 kilogram of paint sludge, 0.04 kilograms of tire balance, and less than 0.01 kilogram of fluorescent lamp and alkaline batteries per car in service.**

***Index Terms*—Hazardous wastes from garages, Hazardous wastes management, Garages in Bangkok, Thailand, Material Flow Analysis (MFA)**

I. Introduction

Bangkok is the capital city of Thailand which covering an area of 1,568,737 square kilometers and the population in the year 2015 was more than 5.6 million (Strategy and evaluation department, 2015). The accumulate car registered in Bangkok increased every year and 10,027,464 cars were reported in 2018 (Department of Land Transport, 2018). Consequently, car service and maintenance activities has become a significant source of hazardous waste producers.

DIW reported that 6,109 garages has registered in 2018 and 1,440 of them are located in Bangkok (DIW, 2018). However, only 19.86% to 33.08% of registered garages has reported their types and quantity of the hazardous waste to DIW. The waste disposal report data consist of SK.1 (report 1), SK.2 (report 2), and hazardous waste manifest (report 3)

The hazardous wastes generated from a garage consists of waste oil, oil filters, mixed fuel, brake fluid, antifreeze or coolant, batteries, and other waste. They can cause environmental damages if they are managed improperly. Irish EPA published a smart garage guide in order to encourage the reduction of the environmental impacts from the garage (Clean Technology Centre, Cork Institute of Technology, 2010).

Material flow analysis is an environmental tool which becomes a well-known tool for evaluating the flow and process of wastes or materials (Allesch and Brunner, 2017). Fischer-Kowalski and Hüttler reported a review on the history of MFA from 1860 to 1998 showing the swiftly grow in MFA evaluation (Fischer-Kowalski and Hüttler, 1998).

The aim of this study was to access and evaluate types, quantity, and treatments of hazardous waste generated from the garages in Bangkok, Thailand by Material Flow Analysis (MFA).

II. Hethods and Data

A. Research Boundary

The research boundary covered 1,440 registered garage located in Bangkok, Thailand (DIW, 2018)

B. Sources of Data

This study, 4 sources of dataset is used consisting of SK.1 (report 1), SK.2 (report 2), hazardous waste manifest (report 3) and Questionnaire. The information

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from report 1, report 2 and report 3 was obtained from DIW, Thailand. Questionnaires as primary data were obtained from 62 garages in Bangkok.

III. Results and Discussions

A. The Types of Hazardous Wastes

The hazardous wastes generated from the garages can be separated into 7 types which consists of

1) Engine oil and sludge, which composed of waste engine oil, oily sludge, and engine oil contaminated with fluid.

2) Batteries, which composed of lead-acid batteries, hybrid batteries, and alkaline batteries.

3) Filters and materials, which composed of contaminated materials, oil filters, and air filters.

4) Packaging, which composed of metal and non-metal packaging.

5) End-of-life vehicles, which composed of tire balance, brake pads, and coolant

6) Paints and organic solvents, which obtain from paint activity such as paint sludge and contaminated thinner.

7) Electronic parts, which composed of a fluorescent lamp

B. Hazardous Waste Generation

1) Report 1 and report 2

The amount of hazardous waste from garages located in Bangkok was examined from report 1 and report 2 from year 2015 to 2017 are 73,336, 67,713, and 50,7856 ton, respectively, or 35.27-50.93 ton per garage per year

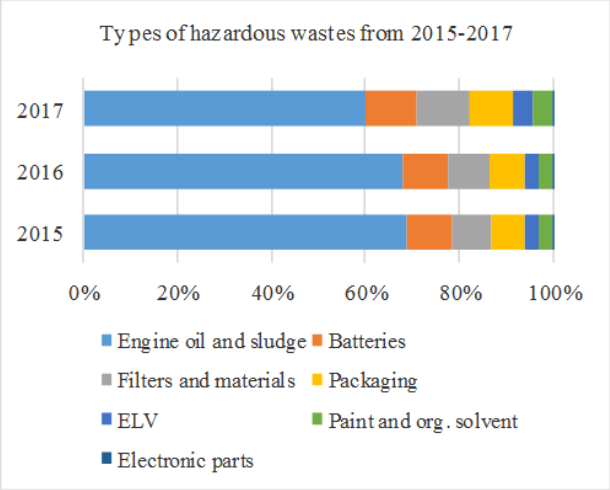

Figure 1. Types of hazardous wastes generated from from 2015 to 2017

The type of hazardous waste consisted of 60.13-68.81% of engine oil and sludge, 9.71-10.91% of batteries, 8.39-11.15% of filters and materials, 6.75-9.32% of packaging, 2.87-4.27% of ELV, 2.99-4.22% of paint and organic solvents, and less than 1% of electronic parts. (Fig. 4).

2) Report 3

The amount of garage hazardous waste in Bangkok predicted from report 3 from the year 2015 to 2017 are 11,581.07, 6,031.37, and 6,266.88 ton, respectively, or 4.19-8.05 ton per garage per year

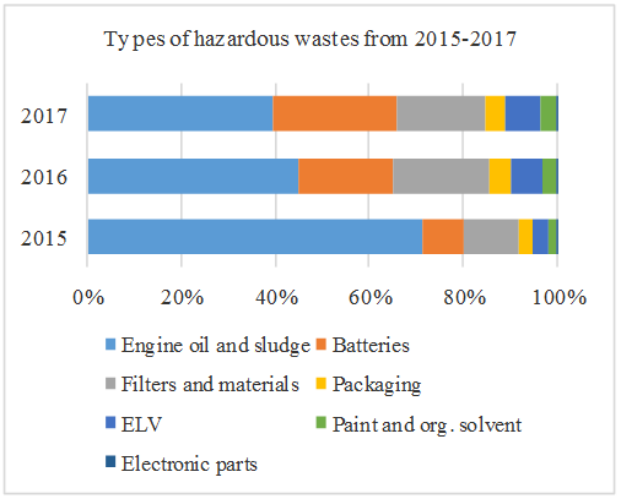

Figure 2. Types of hazardous wastes generated from garages and their fraction from report 3 in 2015 to 2017

The type of hazardous waste consists of 39.57-71.25% of engine oil and sludge, 12.14-20.35% of filters and materials, 8.69-26.14% of batteries, 3.44-7.58% of packaging, 2.69-4.69% of ELV, 1.78-3.35% of paint and organic solvents, and less than 1% of electronic parts. In 2015, filters and materials are more than batteries which is different from 2016-2017. Moreover, quantity of engine oil and sludge decreased while batteries, paint and organic solvent, and electronic part increased (Figure 5).

3) Questionnaires

The amount of garage hazardous waste in Bangkok determined from the questionnaire are 11,568.3 kilogram or 11.56 ton which consists of 51.63% of engine oil and sludge, 17.60% of batteries, 14.02% of filters and materials, 6.13% of packaging, 7.16% of ELV, 3.39% paint and organic solvents, and less than 1% of electronic parts

The amount of hazardous waste generated according to report 1 and report 2 are higher than report 3 because report 1 and report2 were the permission quota which each garage have to report the quota of the waste that they generated to DIW while report 3 is the actual transported waste. Therefore, report 3 is the most reflect to the actual waste generated than other data in respect of the amount of hazardous. Although, the waste gathered from report 3 was different to the survey questionnaires but the proportion of the waste type is comparable.

C. Estimation of Hazardous Waste from Car Service and Maintenance Activities

The generation of hazardous waste per car in service was estimated from 62 garages by questionnaires, it was found that the waste generated per car service activity in a year consists of 1.86 kilograms of contaminated fluids, 1.70 kilograms of waste lubricating oil, 0.97 kilograms of automotive parts, 0.86 kilograms of lead-acid batteries, 0.76 kilograms of organic solvent, 0.61 kilograms of metal packaging, 0.61 kilograms of coolant, 0.37 kilograms of contaminated material, 0.36 kilograms of oil

filters, 0.31 kilograms of air filters, 0.24 kilograms of hybrid batteries, 0.23 kilograms of non-metal packaging, 0.15 kilograms of hydraulic oil, 0.10 kilograms of oily sludge, 0.07 kilogram of paint sludge, 0.04 kilograms of tire balance, and less than 0.01 kilogram of fluorescent lamp and alkaline batteries.

D. Hazardous Waste Treatments

1) Report 1 and report 2

Report 1 is defined by permited waste storage in a garage so, this amount of waste is considered to be a stock in the material flow analysis study.

Hazardous waste treatment data which investigated from report 2 shows 9 types of treatment consisting of recycling, fuel blending, regeneration, sorting for resale, storage, collect and export, burn for energy recovery, incineration, and landfill. From 2015 to 2017, it was found that mainly hazardous wastes were treated by recycling, fuel blending, and storage. Other treatments were a discrepancy in each year. Incineration, collection and export did not used for waste treatment in 2015. Burn for energy recovery and collection and export were not used for waste treatment in 2017. In addition, the amount of waste was decreased from 2015 to 2017

2) Report 3

Hazardous waste data from report 3 was used for the material flow analysis study. The results of hazardous waste flow and treatment from 2015 to 2017 are presented in the following figures

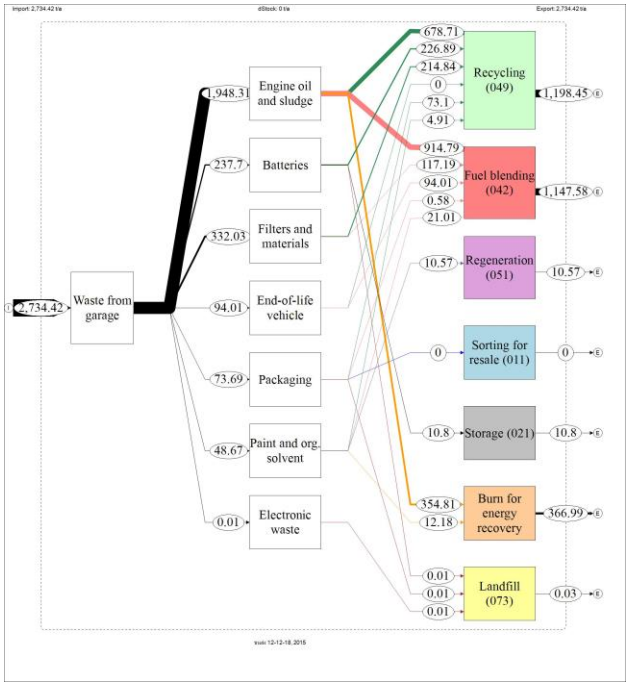

Figure 3. Material flow analysis of report 3 in 2015

Hazardous waste treatment data which investigated from report 3 shows 7 types of treatment consist of recycling, fuel blending, regeneration, sorting for resale, storage, burn for energy recovery, and landfill. From 2015 to 2017. It was found that mainly hazardous waste was treated by recycling and fuel blending. Regeneration, sorting for resale, and storage was a discrepancy in each year. However, the wastes which is treated by burning for energy recovery was decreasing every year from 2015 to 2017 and the wastes which is treated by landfill was increasing every year (Fig. 3-5).

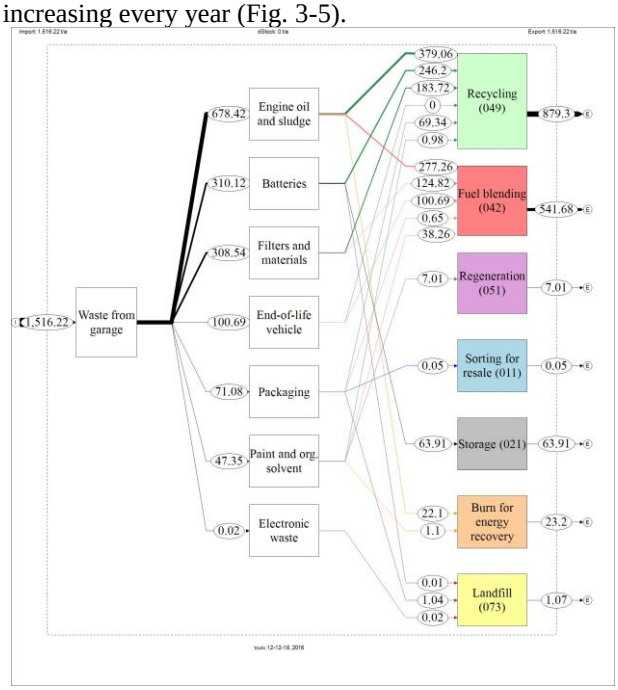

Figure 4. Material flow analysis of report 3 in 2016

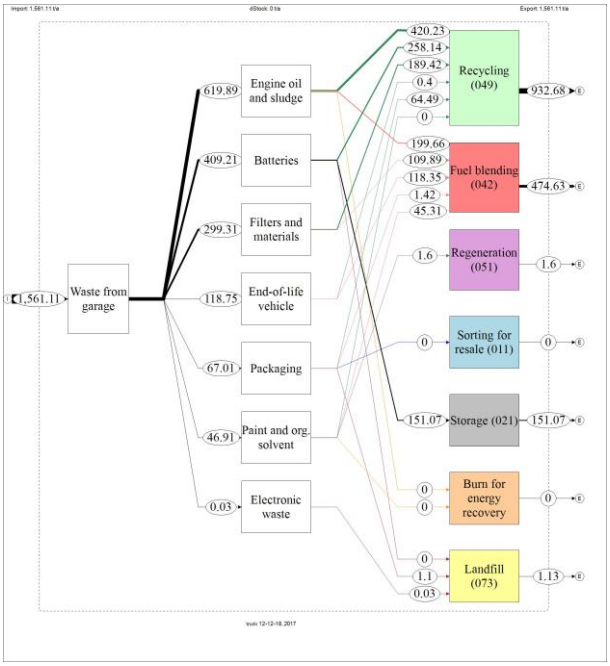

Figure 5. Material flow analysis of report 3 in 2017

3) Questionnaires

The results from the questionnaires indicated that some garages still improperly managed their hazardous waste. Most of the garages in Bangkok are small-size and the amount of waste generated are too small to be economically feasible to manage by a waste processor. Many of them disposed their waste with municipal waste and/or mixing their some hazardous waste such as oil

filters, air filters, contaminated materials, packaging, alkaline batteries, and fluorescent lamps with non-hazardous waste. This result is similar to the study of garage waste in Ireland, it was found that most of the hazardous waste was disposed in general garbage pails (The Clean Technology Centre, 2009)

IV. Conclusions

In summary, using material flow analysis (MFA) in order to evaluate the amount of hazardous waste which are generated by the garage and their treatments can be concluded in following issues

1. Hazardous waste generated from garage consists of engine oil and sludge batteries, filters and materials, packaging, end-of-life vehicles, paints, and organic solvents and, electronic parts

2. The amount hazardous waste in Bangkok which calculated from report 3 is the suitable data. The amount of garage hazardous waste in Bangkok estimated from report 3 during the year 2015 to 2017 are 11,581, 6,031, and 6,2667 ton, respectively. The proportion of hazardous waste consists of 39.57-71.25% of engine oil and sludge, 12.14-20.35% of filters and materials, 8.69-26.14% of batteries, 3.44-7.58% of packaging, 2.69-4.69% of ELV, 1.78-3.35% of paint and organic solvents, and less than 1% of electronic parts

3. The results from questionnaires showed that the generation of hazardous waste per car in service consists of 1.86 kilograms of contaminated fluids, 1.70 kilograms of waste lubricating oil, 0.97 kilograms of automotive parts, 0.86 kilograms of lead-acid batteries, 0.76 kilograms of organic solvent, 0.61 kilograms of metal packaging, 0.61 kilograms of coolant, 0.37 kilograms of contaminated material, 0.36 kilograms of oil filters, 0.31 kilograms of air filters, 0.24 kilograms of hybrid batteries, 0.23 kilograms of non-metal packaging, 0.15 kilograms of hydraulic oil, 0.10 kilograms of oily sludge, 0.07 kilogram of paint sludge, 0.04 kilograms of tire balance, and less than 0.01 kilogram of fluorescent lamp and alkaline batteries.

4. Many treatments were used to manage a hazardous but the most mainly hazardous waste was treated by recycling and fuel blending. Moreover, recycling and fuel blending were increasing from 2015 to 2017. Although, landfill was the smallest treatment but hazardous waste which management by landfill was increasing every year.

5. The result suggest evaluating the recycling process and other management methods for wastes which management by landfill in order to improve waste management which has the lowest environmental impact in the further study.

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