HEALTH RISK ASSESSMENT OF HOUSEHOLD HAZARDOUS WASTE IN MALAYSIA

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ABSTRACT

This study was conducted to assess the risk of health hazards of exposure to hazardous waste at home to employees in local authorities in Malaysia. The study was conducted on 40 local authorities (27.8%), using the same method used by Buenrostro *et a*l, 2001 and health risk assessment guidelines of the United States Environmental Protection Agency, 1989. The Four Step Process of Health Risk Assessment is hazard identification, exposure assessment, dose response assessment and risk characterization. In this study, the household hazardous wastes (HHW) were analyzed for their permissible dose level and the existing hazard level, hazard index and cancer index by using Monte Carlo Method. This study estimated that 22,388 tonnes of wastes generated every day in Malaysia and around 2.2 percent out of that amount are HHW, which mean average generation for each person per day was 0.02 kg. The category District Council, show that the HHW generated around 3.7 %, followed by Municipal Council around 3.3 percents then for City Council with 3.0 %. These figures indicate that, the increments of the percentages depend on the status of the local authorities and it was also estimated that the waste generation increment was around 2 to 3 percents per year. The study found that almost 14 percents of the local authorities in Malaysia dumping the HHW into the drains and rivers without considering the proper management and the figures also indicated that the pollution level was at High Risk in Malaysia. Cancer Index for dermal exposure is 5.8×10^{-7} mg/m³, for Inhalation dust $1.4x \times 10^{-1}$ mg/m³, under Low Risk and for Inhalation aerosol is $5 \times x10^{-2}$ mg/m³, under Medium Risk, while if the HHW were improperly managed, it will fall into High Risk in Malaysia if the index rate less than 1:1,000,000 as specified by United States Environmental Protection Agency, 1989 and World Health Organization. Hazard ranking for risk contamination from HHW clearly shows that the district council found 15 % are level High Risk (Rank 1). Municipal council 14 % and City Council 25 % and almost 14 percents the pollution level was at High Risk in Malaysia. For landfill with high-risk pollution potential to water resources, it should be shut in stages. Safety and health are important and should be given priority. So, the employees need to know the permissible dose level of exposure for the handling of HHW and this is the responsibility of employers to increase the level of knowledge and provide personal protective equipment (PPE) to employees in accordance with the provisions under the Occupational Safety and Health Act, 1994. While the separation of HHW should be done at the main source by implementing enforcement and compliance with the provisions of Solid Waste Management and Public Cleansing Act (Act 672) Malaysia, 2007.

ABSTRAK

Kajian ini dilakukan bagi menilai tahap risiko bahaya kesihatan terhadap pendedahan sisa berbahaya di rumah (SBR) kepada pekerja pihak berkuasa tempatan di Malaysia. Kajian ini dijalankan ke atas 40 pihak berkuasa tempatan (27.8%), menggunakan kaedah yang sama dengan Buenrostro *et al*, 2001 dan garis panduan penilaian risiko bahaya kesihatan daripada Agensi Perlindungan Alam Sekitar United States, 1989. Empat langkah dalam proses penilaian risiko bahaya kesihatan adalah kenalpasti bahaya,menilai tahap pendedahan,penilaian tahap dos dan ciri-ciri bahaya. Dalam kajian ini, Sisa berbahaya dirumah (SBR) dianalisa tahap dos yang dibenarkan dan tahap bahaya yang wujud serta indeks bahaya dan indeks kanser menggunakan Kaedah Monte Carlo. Dianggarkan sebanyak 22,388 tan sampah dijana setiap hari di Malaysia dan daripada jumlah tersebut, kira-kira 2.2 % terdiri daripada SBR dengan purata penjanaan untuk seorang sehari sebanyak 0.02 kg per orang. Kategori Majlis Daerah menunjukkan penjanaan SBR adalah sekitar 3.7 %, diikuti Majlis perbandaran sebanyak 3.3 % manakala kategori Bandaraya sebanyak 3.0 %. Peningkatan ini bergantung kepada taraf pihak berkuasa tempatan dan peningkatan dianggarkan sebanyak 2 hingga 3 % setiap tahun. Kajian menunjukkan hampir 14 % di pihak berkuasa tempatan di Malaysia membuang SBR ke dalam longkang dan sungai tanpa pengurusan yang sempurna, dan perkiraan itu menunjukkan tahap pencemaran pada tahap Risiko Tinggi di Malaysia. Indeks bagi cancer untuk pendedahan kulit ialah 5.8×10^{-7} mg/m³, dan bagi pendedahan pernafasan debu 1.4×10^{-1} mg/m³, ianya dibawah risiko rendah dan bagi pendedahan pernafasan aerosol dibawah risiko sederhana iaitu $5 \times \times 10^{-2}$ mg/m³. Tetapi, jika HHW tidak diuruskan dengan sempurna ianya akan menjadi Risiko Sederhana hingga Risiko Tinggi di Malayisa dengan kadar kurang daripada 1:1,000,000 seperti yang ditetapkan Agensi Perlindungan Alam Sekitar United States, 1989 dan Pertubuhan Kesihatan Sedunia. Tahap bahaya bagi pencemaran daripada SBR jelas menunjukkan bahawa di majlis daerah terdapat 15 % tahap risiko tinggi, majlis perbandaran 14 % dan dewan bandaraya 25 % dan menunjukkan hampir 14 peratus tahap pencemaran dalam tahap risiko tinggi (Rank 1). Tapak pelupusan berisiko tinggi yang berpotensi pencemaran berlaku kepada sumber air ianya perlu di tutup secara berperingkat. Keselamatan dan keselamatan pekerja adalah penting dan perlu diberi keutamaan, oleh itu, pekerja perlu mengetahui tahap dos pendedahan yang dibenarkan terhadap SBR semasa pengendalian dan ini menjadi tanggungjawab majikan dalam meningkatkan tahap pengetahuan serta menyediakan alat perlindungan diri (PPE) kepada pekerja selaras dengan peruntukan di bawah Akta Keselamatan dan Kesihatan Pekerjaan, 1994.Sehubungan dengan itu pengasingan sisa berbahaya di rumah perlu dilakukan di peringkat sumber dengan penguatkuasaan dan pematuhan kepada peruntukan Akta Pengurusan Sisa Pepejal dan Pembersihan Awam (Akta 672), Malaysia, 2007.

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LIST OF ABBREVIATIONS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ADD	-	Average Dailly Dose
AIEC	-	Acute inhalation exposure criteria
ALARA	-	as low as reasonably achievable
CSDS	-	Chemical Safety Data Sheet
CR	-	Cancer Risk
CPSC	-	Consumer Product Safety Commission
CSF	-	Cancer slope factor
CEL	-	Ceiling Exposure Limit
CSDS	-	Chemical Safety Data Sheet
DOE	-	Department of Environmental
DW	-	Domestic Waste
HW	-	Hazardous Waste
HHW	-	Household Hazardous Waste
HHP	-	Household Hazardous Products
HQ	-	Hazard quotient
HI	-	Hazard index
HHRA	-	Human Health Risk Assessment
IARC	-	International Agency for Research on Cancer
IRIS	-	Integrated Risk Information System
EC	-	Exposure Concentration
LA	-	Local Authority
LD_{50}	-	Lethal Dose 50% killing
LC_{50}	-	Lethal Concentration 50% killing

LADD	-	Lifetime average daily dose (mg/kg-day)
LFL	-	Lower Flammable Limit
LOEAL	-	Lowest Observable Effect Level
MCL	-	maximum contaminant level
MSDS	-	Material Safety Data Sheet
mg/m^3	-	Milligrams of chemical substance per cubic meter
mg/kg	-	Milligrams per kilogram
mm Hg	-	Millimeters of mercury
MHLG	-	Ministry of Housing and Local Government
MW	-	Municipal Wast
NOAEL	-	no-observed-adverse-effect level
NAC	-	National Academic Centre
OSHA	-	Occupational Safety and Health Act
PPE	-	Personal Protection Equepment
Ppm	-	Parts per million
PB-PK	-	physiologically-based pharmacokinetic
PEL	-	Permissible Exposure Limit
RA	-	Risk Assessment
SDWA	-	Safe Drinking Water Act
TLV	-	Threshold Limit Value
TWA	-	Time Weight Average
SBR	-	Sisa Bahaya Rumah
STEL	-	Short Term Exposure Limit
S	-	Skin
SF	-	Slope Factor
UFL	-	Upper Flammable Limit
URF	-	Unit risk factor
VOC	-	Volatile organic compound
WHO	-	World Health Organization
WM	-	Waste Minimization
3R	-	Reduce,Reused and Recyling

LIST OF SYMBOLS

bw	-	*bodyweight*
c	-	Confidence interval
D, d	-	diameter
F	-	Force
g	-	Gram
Kg	-	Kilogram
HI	-	Hazard Index
m^3	-	meter square
m	-	Mess
mg	-	milligram
mg/kg-day	-	milligram per kg per day
n	-	No of sample
P	-	Pressure
r	-	Radius
sf	-	slope factor
ss	-	Sample size
t	-	*Time*
µg	-	microgram
µg/kg-day	-	microgram per kg per day
x	-	*Displacement*
z	-	Value of 1.96 for 95% confidence level

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CHAPTER 1

INTRODUCTION

1.1 Background of the research

The growing problem of solid waste management has resulted in the Health Risk Assessment of Household Hazardous Waste (HHW) at Local Authorities in Malaysia. Malaysia has 144 Local Authorities which divided to three categories; city council, municipal council and district council (Appendix A). Formerly known as Ministry of Local Government and Housing, it was established on 24th May 1964. After reshuffling of Cabinet and merging of Ministry of Housing and Rural Development and the Department of Local Government which earlier part of the Ministry of Local Government and the Federal Territory, it was renamed to Ministry of Housing and Local Government (MHLG,2004).

According to MHLG, solid waste generation in Malaysia is expected to grow as Malaysia moves towards a fully developing country status. Without doubt, human activities especially in energy and resource utilization will results in the generation of wastes. There are approximately 19,000 tonnes of solid waste was generated per day in Malaysia in 2007 by a population of about 26 million people, and only 70% tonnes/day were collected. The remaining of 30 % that was not collected is probably

due to illegal dumping and diversion of waste during the collection for recycling purposes, and part of those waste are HHW (MHLG, 2007).

Malaysia is facing acute environmental public health, and HHW is considered to be one of the main causes. Many of the household products today would be classified as hazardous waste if they were being used in an industrial setting. Paints, pesticides, arsenic treated wood and fluorescent lamps are among the household products that significantly contribute to the input of priority hazardous substances. It was then identified as the most problematic for the current waste management and disposal route. People seldom realize on the need to use and dispose of these products in ways that are specific to hazardous chemicals. Thus, it is important for us to take appropriate measures to protect ourself by acknowledging the dangers that will cause by the hazardous chemicals in our home. Proper used of the household products will not pose a threat to human health. Nevertheless, improper use of the products may cause contamination to soil, air, groundwater and surface water. It may as well cause injury to the users or solid waste workers and damage the septic systems. (GDHR, Guide, 2002 and Agamuthu, 2004).

The widespread use of chemicals in the market contributes to the generation of waste, particularly the carcinogenic chemical. A number of 1500 substances have been reported carcinogenic in animal test with some of the studies are questionable, but less than 30 agents are positively linked with cancer in human. Over 5 million known carcinogenic substances, only 7,000 of the substances been tested for carcinogenicity. Yet, the knowledge on the chronic health effects is still lack except for cancer. This is because ethical considerations prevent deliberate human experimentation with potentially dangerous chemicals, and the length of the latent period for cancer and some other effects greatly complicated epidemiologic studies of uncontrolled human exposures. Animal model must be used to investigate whether exposure to chemical is related to the incidence of health effects, and the results must be extrapolated to human. To make judgements amid such uncertainty, risk assessors must rely on a series of assumptions (Maugh, 1978 and Zalina ,2008).

Hazardous waste at home is increasing and it is disposed of directly into the trash and is well managed by local authorities in Malaysia.(MHLG,2006) In contrast with hazardous industrial wastes, HHW are not regulated by law in Malaysia. However, the contents of chemical ingredients are nearly the same. Thus, it still needs to be handled with care. Any product labeled toxic, poison, corrosive, flammable and combustible or irritant that is disposed of are HHW. A typical HHW can contained a vast array of household hazardous products (HHP) used for cleaning, painting, lubricating, and disinfecting the house, yard, workshop and garage. When HHPs are no longer usable or wanted, they become HHW.

According to European Environmental Protection Act (1990), "Waste is any substance, which constitutes scrap material or any effluent or other unwanted surplus substances arising from the application of a process, or any substances or article, which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled." It poses a highly complex and heterogeneous environmental and health problem. The health effects can cause harm to the refuse collection workers as well as those at the landfill if they are continually exposed to the chemicals contained in the hazardous waste.

Waste characteristics are highly dependent on the content of the material. Its existences especially its treatment, can cause environmental damage as well as health risks. Waste-related problems are varies depends on its categories. Thus, it may be necessary to have different legal regulations for different type of waste in order to control the effect of waste treatment to environment and human.

In Malaysia, many local authorities did not managed household hazardous waste properly. The wastes are directly disposed to the landfill openly and no sanitary. According to US EPA (1993), HHWs are sometimes disposed of improperly by individuals such as pouring wastes down the drain, on the ground, into storm sewers, or putting them out with the trash. The dangers of such disposal methods may not be immediately obvious, but certain types of HHW have the

potential to cause physical injury to sanitation workers; contaminate septic tanks or wastewater treatment systems if poured down drains or toilets; and present hazards to children, workers, and pets if left around the house.

Improper and uncontrolled management of HHW will lead to health effect to workers and publics. According to statement from US Environmental Protection Agency, 1989 has recorded thousands of hazardous material accidents in United State of America. These incidents resulted in over 10,000 injuries and hundreds of deaths. Hazardous material is defined as any substances in a quantity or form that poses a substantial present or potential hazard to health, safety, or the environment when improperly treated, stored, transported, or disposed due to its quantity, concentration, or physical, chemical, or infectious characteristics (US EPA, 1989).

Public also concerned that disposal of Household Chemical Products (HCPs) in the solid waste stream is a health threat to sanitation workers. All liquid products are flammable, corrosive, reactive, or highly toxic and hazardous to group of workers and equipments. Many of these materials were contained in household products and dispersed widely in the environment and can cause hazard to humans.

Growth development of lifestyle changes, especially in the city increased the use of HHP. Various products that are used daily at home have potential to harm human health and environment. Paints, thinners and solvents, cleaning products, pesticides, aerosol cans, motor oil, antifreeze, lead/acid batteries, smoke alarms, fluorescent lights and some personal care items are examples of common hazardous materials that can be found in homesand (UOM,1991 and PCC,1992) In the past, the potential dangers of these products and their wastes were not well understood. Today, we know that improper handling of HHPs and HHW can cause contamination to air, groundwater, surface water and soil. In addition, it can poison the food chain thus affects human and animals' health (Boyland, 1969 and Higginson, 1969). Other dreadful effects from improper disposal of HHWs and HHPs are, it can trigger explosions and fires (GOY, 2006). The chemical-based

household products from a single home may seem insignificant, but when millions of homes in Malaysia are using similar products, the combined effect of improper handling, storage and disposal becomes a major problem. Berry and Bove (1997) revealed a convincing increase in proportion of low birth weight babies (<2.5kg) and lower average birth weight in the population that live close to the landfill (within radius 1 km) as compared to a control population. Martine, (2000) also reported that disposal of wastes in landfill sites has increasingly caused concern about possible adverse health effect for population living nearby, particularly in relation to those sites where hazardous waste is dumped.

Waste is generated in every human activity at rural or urban area. Urban waste in the form of solid, semi solid, liquid and gases could be in the formed of organic or inorganic. It could be listed into six types of waste such as household waste, city waste, commercial waste, industrial waste, liquid waste and gaseous waste. Techniques used for waste management should have minimal impact on the health and environment, since it can cause groundwater contamination (Agamuthu, 2001 and Kuma, 2004).

Day by day, the generations of wastes are increasing in Malaysia due to development and increasing in population. These also give effect to the HHP consumption and HHW generation, and according to Agamuthu (2008), approximately Malaysia generates 19,000 tons of solid waste every day. HHW make up one to two per cent of this figure, which equates to 380 tonnes a day and 136,000 tonnes annually. This is a serious problem for a small country like Malaysia and it will continue as the population and standard of living increase. Some of the house wastes are HHW, which if not properly managed can risk human and environment. HHW disposal is a growing nationwide concern. As HHW chemicals were dumped into the storm and household drains, disposed of on the ground or buried in a landfill, they may contaminated our streams and ground water and give health effect to humans. When things like insecticides or medicines end up in the landfill, it can dissolve in rainwater and leach into our water system. “If you drink a glass of water now, you will not feel anything. But 20 years in the future you may get cancer

because you have been drinking contaminated water all that time!"(Agamuthu, 2008). In the meantime, Noor Zalina (2008) from the Institute of Biological Sciences, University Malaya, described HHW as the garbage from households that are "harmful to humans and environment because of their chemical or biological nature". HHW makes up a small percentage estimated around 3 to 5 percentage of household waste, but they are a serious problem.

Local authorities are responsible for carrying out the work of waste management. Refuse collection workers and those who works in landfills are directly exposed to the HHW. Employers need to take security measures to protect these workers and to carry out the Human Health Risk Assessment for the guarantee of employees' safety and health when working. Human Health Risk assessment of HHW has been done to estimate the increasing risks on peoples' health problem results from the exposure to toxic pollutant. Risk assessment method can be use to estimate the increasing risk on adverse ecological effects due to toxic pollutant in the environment. There are four steps to risk assessment which is hazard identification, exposure assessment, dose-response assessment, and risk characterization (US.EPA, 1989).

Thus, health risk assessment of HHW at Local Authority in Malaysia was conducted to estimate quantities of HHW and calculate the level of risk and HHW characteristics to human. Results obtained rendered the health impacts and HHW's risks level, protection methods and the information can be use as a guideline to a proper disposal of the HHW and thus, improved the management of solid waste above all HHW.

1.2 Objectives of this study

The objectives of this study are as follows:

(i) To identify HHW generated by household based on hazard classification such base on Categories of HHW.

(ii) To determine the risk characterization of HHW managed by Local Authority according to Guideline from US. EPA

(iii) To develop a model of HHW ranking of significance hazard model.

1.3 Scope of the Study

The focused of this study was mainly on the HHW generated from household that can possibly cause toxicity, flammable, corrosiveness and reactiveness to human (workers, scavengers and contractors) managed by Local Authority (LA) in Malaysia. This study was carried out through surveys, site visits, meetings, questionnaires and observations at 144 LA. The segregation of waste was conducted at 40 dumping grounds based on categories of HHW according to hazardousness, weight and volume.

1.4 Significance of the study

The increasing scale of economic activity, urbanization, industrialization, rising standard of living and population growth, has led to a sharp increase in the quantity of wasted generated. In 1997, the total solid waste generated throughout Malaysia was 5.6 million tons or 15,000 tons/day and of this 80 % was domestic waste (about 12,100 ton/day) and the rest (about 3,100 tons/day) was commercial waste (Gamut, 2001). HHW is part of the portion from domestic waste and although many people may not realizing it, almost every household producing hazardous wastes. Some products used around the home contained ingredients that can pose threats to human health if not handled properly. Related to disposal of HHW, according to Agamuthu, 2008, more than 64.7% end up in the garbage bin, 12.7% are poured down the drain, 2.4% are burnt and 20.2% are disposed of by other methods like burying or are just arbitrarily dumped.

The chemical based household product from a single home may seem insignificant, but when millions of homes in Malaysia use similar products, the combined effect of improper handling, storage and disposal becomes a major problem and has potential to get cancer due to drinking contaminated water. Noor Zalina, (2008) described HHW as the garbage from households that are "harmful to humans and the environment because of their chemical or biological nature".

However, improper use, storage and disposal of HHPs can potentially harm humans, contaminate the environment, and if thrown in with regular trash, it can injure sanitation workers and may end up in landfill. While dumping of HHW to the street or back yard will only cause pollution to the water collection area.(Agamuthu,2004).

Health problems can be caused by chemicals in some of the products in your home if product warnings and directions for proper use are not heeded. Health

effects can range from minor problems, such as irritated skin or watery eyes, to more serious problems such as burns, poisoning or even cancer. We can be exposed to a hazardous product ingredients through ingestion, including accidental ingestion by drinking, eating or smoking when a substance is on your hands, breathing dust or fumes (inhalation) or contact with skin or eyes.

Researches and efforts regarding the HHW risks are numbered in Malaysia. Hence, results from health risk assessment of HHW can be used and be a references and guideline to control risk and proper management of HHW at Local Authority in Malaysia. Results from this study can be used for decision making in improving the management of solid waste especially in HHW administration, safety and health and engineering control.

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