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Implementation of Decision Support System for Scheduled Waste Management in Malaysia

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Abstract: Malaysia is today a model of economical success, attaining growth rates in Southeast Asia today. The country continues to take big strides in its industrialization nation by the year 2020. An ever-expanding population and high rates of economic development in Malaysia resulted in the generation of vast amount of waste. Nevertheless, public has not yet realized that the industrial growth normally proportion with scheduled waste generation. Currently, there are legislative and policies regarding the waste management have been enforced and new technology has been introduced in this country. However, the efforts disable to completely solve the problem as the waste management is complicated and unique. This is due to mainly insufficient key parameters employed in the integrated system developed. This study introduces a model that could be applied or considered in the scheduled waste management. Most of waste planners or waste generators do not have enough resources needed to manage all relevant data, assist in waste management and to make optimization analysis leading to incomplete consideration and uncontrolled collection. In addition, the existing system tool cannot comprehend with the current generation of waste and waste management because only used as database and assessment viz. E-Consign and E-Swiss. Thus, the implement of DSS that encompass all aspect in waste management is prior needed under the present circumstances. The DSS model could be used in assisting decision makers and able to give robust prediction despite the inherent uncertainties of waste generation and the plethora of waste characteristics and gives optimal allocation of waste stream for recycling, incineration, landfill and composting of solid waste in an economic and environmentally sustainable way.

Key words: DSS, scheduled waste, incineration, landfill

INTRODUCTION

Solid waste management is a high priority issue for all societies around the world and owing to major complexity problem nowadays. Increasing the solid waste generation rates, disposal cost, environmental and health concern, limited landfill space, legislative changes, political climate and social attitudes have significant effect on waste management efforts (Chambal *et al*., 2003). Malaysia has a problem to manage the Scheduled Waste (SW) regarding on collection, transportation, treatments and disposal. Finding acceptable strategies to cope such a problem cause the development of strategic waste management, pollution control technologies and to more rigorous legislation on waste handling and disposal, to minimize the environmental impact associated with waste management (Fiorucci *et al*., 2003). The inefficient collection and treatments of SW contributes adverse impact to health and environmental especially on landfill which does not provide a sustainable solution as more land is required to cater for the increase in waste generation and finally outpacing the lifespan of current landfills capacity. Without an effective and efficient solid-waste management program and the better technology treatment facilities, the waste generated from various human activities; both industrial and domestic, can result in health hazards and pose a negative impact on the environment such as illegal dumping, odour pollution, open burning, leachate contamination on drainage system, global warming and groundwater contamination.

The definition of scheduled wastes varies from one country to another. In the international level it's called a toxic and hazardous waste. In Malaysia, under the Environmental Quality (Scheduled Wastes) Regulations 2005 (amendment 1989) defined scheduled wastes is any waste falling within the categories of waste listed in the first schedule, which is included 77 scheduled waste code categories (Akta, 1974). The United States Resources Conservation and Recovery Act (RCRA) of 1976 considers wastes toxic and/ or hazardous if they 'cause or significantly contribute to an increase in serious irreversible, or an incapacitating reversible illness; or pose

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a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed off, or otherwise managed (Michael *et al*., 2001; Linder and McBride, 1984). Currently there are five (5) sets of regulations and order is directly can be use in managing the scheduled wastes in Malaysia. The regulations cover the management of the potentially toxic and hazardous wastes from their sources through to treatment and disposal under a 'cradle to grave' approach. However, the successful of the implementation of the regulation will require the participation and commitment of all levels of the society including the researchers, industrial sectors, academicians and government and private sectors.

Besides, the Department of Environment 4 years ago has already started an electronic reporting system called E-SWIS (Electronic Scheduled Waste Information system) and Electronic Consignment (E-Consign) which involves less paperwork and quicker tracking of waste movements, but its effectiveness is unproven. The system failed to discern and comprehend the material in- flow and out-flow of such complex successive scheduled wastes generators, transporters, recoveries and recyclers, within the boundary system (country, state, unit operation, facilities). The anticipated prediction accuracy with regard to the generation trends facing many fast-growing regions is quite challenging. The lack of complete historical records of quantity and quality due to insufficient budget and unavailable management capacity has resulted in a situation that makes the long-term system planning and/or short-term expansion programs intangible (Boyle and Baetz, 1998). The system is not effective and used as a database without considering the other functional element to be used in prior function such as optimization analysis, prediction and identification in term of characteristic of waste, amount generation, cost analysis, storage collection, transportation, treatment and disposal. Thus, need a comprehensive system or tool that can assist Waste Generators (WG) to determine or identify the characteristic of scheduled waste with the current situation of waste in Malaysia to sustainable the environmental soundness.

All this issue owing to development and application of Decision Support System (DSS) in overall waste management and environmental issues from both economic and environmental standpoints. DSS as a computer integrated tools systems is capable to assist the planner or decision makers in various steps of design procedures (Marek and Roger, 2008). Initially, DSS acknowledge as an expert system or smart system to suggest the best decisions or alternatives based on the analysis and collected data. Adenso-Diaz *et al*. (2005) defines the DSS as a new generation of information system, the goal of which is to try to discover what would happen if a series of decision are taken, or going further, by automatically providing the decision or suggestions that assist the users (Adenso-Diaz *et al*., 2005).

Therefore, objective of the study is introduced a systematic approach to the management of scheduled waste that combines and integrates source reduction, reuse, recycling, composting, energy recovery and landfilling in order to conserve and recover resources and dispose of waste in a manner that protects human health and the environment.

PROBLEMS OF SCHEDULED WASTE MANAGEMENT IN MALAYSIA

In Malaysia, based on notification received by the Department of Environment (DOE), a total of 1,103,457.06 metric tonnes of scheduled wastes were generated in 2006 as compared to 548,916.11 metric tonnes in 2005 (Department of Environment, 2006).The sharp increase of waste quantity in 2006 was due to new waste categories such as e-waste introduced and controlled under the Environmental Quality (Scheduled Wastes) Regulations 2005 which came into force on 15 August 2005 (Department of Environment, 2006). In addition, the quantity of gypsum wastes managed on-site by two main generators which were not reported in previous Environmental Quality Reports (EQR) is included in 2006 and these amounted to 511,929.38 metric tonnes (Department of Environment, 2006). Several issues recently become extremely more important are the problem of managing and forecasting of the scheduled wastes including identification of waste, illegal dumping of scheduled wastes, E-waste, contaminated land and disposal of hazardous waste.

Identification of scheduled waste: With the implementation of Environmental Quality (Scheduled Wastes) Regulations 2005 (amendment 1989) which came into force on 15 August 2005, 77 scheduled waste code categories and new electronic waste (e-waste) have been introduced (Department of Environment, 2006). As changed in the waste categories has give difficulty for WG to identify the kind of waste in term of time consuming, economic cost and waste management. Most solid waste planners do not have the resources needed and systematic system to manage all relevant data, leading to incomplete consideration or satisfying in identifying the waste categories.

Illegal dumping of scheduled wastes: Generally there seems to be an increase in the number of illegal dumping cases detected by the Department in the last five years, which is from 3 cases in 2001 to 31 cases in 2005 (Abdul-Rashid *et al*., 2007). The types of wastes dumped were mainly waste paint, mineral oil and dross. These activities were mostly carried out in secluded areas to avoid detection. There were also factories that buried their wastes within their premises. This does not mean that we can treat this issue lightly because these wastes can contaminate groundwater and nearby rivers as well as affect public health. It was reported that there is an average of 97 cases of illegal toxic waste disposals in the last five years (2001-2006) (Cheremisinoff, 2003). The new cases happened on 23 June 2006, an illegal dumping site in Labis, Johor, 5,000 tonnes of aluminium dross was buried at Kg Sungai Gatom and 3,000 tones at the two other sites (Abdul-Rashid *et al*., 2007).

Electronic waste (E-waste): There will be a new waste category known as e-wastes, which are defined as electrical wastes or electronic assemblies containing components such as accumulators, mercury-switches, glass from cathode ray tubes and other activated glass or polychlorinated biphenyls-capacitors or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyl (Bhatia, 2007). Electrical and electronic waste is intrinsically has become a serious impact to the environment and health because of these two key reasons:

- It is potentially hazardous and
- It is being generated at an alarming rated

This growth has created additional wastes and it is a challenge to ensure waste emanating from this source does not end up in the landfills, thus realizing toxic substances to the environment (Abdul-Rashid *et al*., 2007).

Status of collection of scheduled waste: The current collection of solid waste is uncontrolled management in which solid waste could be collected by any collector, transported by any firm or vehicle, treated by any other party and disposed of in any location (Department of Environment, 2005). Although a lot of treatment facilities existed in Malaysia, most Waste Generators (WG) still sent their waste to Kualiti Alam, Trieneken Sdn Bhd or disposed to landfill, without knowing the best alternatives to treat the waste. No tool or system can assist or advice the WG to manage the waste properly and efficiently and coincidentally can preserve the natural resources, environmental and human health.

IMPLEMENTATION OF DSS FOR SCHEDULED WASTE MANAGEMENT

Since 1996, rapidly growing of DSS by researchers for waste management was achieved and successfully established to conquer the critical issue pertaining on rising waste generation, insufficient waste management, conventional waste management and losses of landfill. The main objective of developed DSS for waste management is depending on the critical issue or problems that are faced by the region, country, industry and societies in the world. Many researchers has applied and adopted the Waste Management Hierarchy (Prevention, material recovery/recycling/reuse, incineration and landfill) which is introduced by Sakai *et al*. (1996), Cheremisinoff (2003), Ekvall (2005) and Bhatia (2007) as a main goal for developing the waste management (Sakai *et al*., 1996; Cheremisinoff, 2003; Ekvall, 2005; Bhatia, 2007).

Table 1 shows the application of DSS for three types of waste and it revealed none of DSS or model was developed to be used for scheduled waste management. From 1996 to 2008 a lot of applications and model was developed to manage the waste and improvised the existing system to become more practicable and successful. It discovered that all researchers know the important and the functionality of DSS for waste management in current situation and how it give beneficially to development country in term of economic, politic and social. Figure 1 shows the simplification of DSS for scheduled waste in Malaysia and no DSS or systems was developed in Malaysia because the DSS using today is still not compatible in term of functional

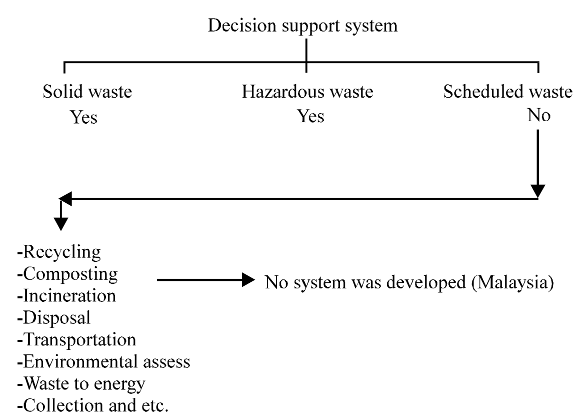

Fig. 1: General application area of DSS for waste management

Table 1: Application of DSS models

Solid waste	Hazardous waste	Scheduled waste
Chang *et al.* (2008) -DSS, Fuzzy Multicriteria analysis, GIS. -Selection of landfillsite, display map and location of landfills.	Musee *et al.* (2008) -DSS, FUZZY logic set. -Classify the status of composite waste and waste classification.	-
Gomesa *et al.* (2008) -MCDA, DSS -Evaluating, priotising alternative of disposing plastic waste, construction and demolition waste recycling facilities	Amouzegar and Jacobsen (1998), Amouzegar and Moshirvarziri (2001) -DSS,GAMS, Hierarchical model, Matlab, Bilavel programming -Assess the impact of various policy makers. -To cope environmental issue of solid waste treatment and disposal. -Waste generation (information), treatment capacity (alternatives), costs of treatments (optimization)	-
Repoussis *et al.* (2009) -DSS,GIS, Random yield model, Grasp -Estimate production, inventory, collection and distribution. -only to waste lube oil.	Boyle and Baetz (1998) - DSS, software Paradox. - Determine the treatment option for the industrial waste.	-
De Oliveira Simonetto and Borenstein (2007) -SCOLDSS,ARENA -Allocation of separate collection vehicle, determine the daily amount of solid waste to be sent to each sorting unit.		-
Costi *et al.* (2004) -DSS, Lingo 6.0, spreadsheet file, ORACLE, INFORMIX, DBASE. -Plan solid waste management to define the waste flow (incineration, recycling, disposal)		-
Fiorucci *et al.* (2003) - DSS, linear programming. -Optimize number of landfill and treatment plant. -Determine the optimal quantities and characteristic refuse.		-
-Included cost transportation, maintenance, recycling, incinerator and lifespan of landfilling.		-
Cheng *et al.* (2003) -DSS, MCDA, IMILP. -To select the best landfill location for solid waste management.		-
Haastrup *et al.* (1998) -DSS, Optimization algorithm, MCDA, GIS. -Evaluate general policies of collection and identify suitable area for locating waste treatment and disposal plants.		-
Chang *et al.* (1997) -Visual Basic, C++, Excell, Stastica. -Forecasting solid waste generation -Analysis waste collection, treatment, and disposal. -Optimal routing and cost benefit.		-
Chang and Wang (1996) -SAS package, regression model, SCL, GIS and DSS. -Prediction and optimal collection of waste stream for recycling and incineration.		-

model from region to other region, from country to other country because the complexity of waste characteristics itself is heterogeneous and depending on weather, different community lifestyle, industrial activities and policy and country legislative. This is synchronize with statement by Bhargava and Tettelbach (1997) that waste characteristic effect or influence the structuring of waste management model Bhargava and Tettelbach (1997). Therefore, to create a DSS model; it must consider all that matter and all alternative to treat the waste. This is reliable with statement based on review of DSS for municipal solid waste management by Barlishen and Baetz (1996).

CONCLUSION

Therefore, a systematic approach must be introduced to the management of scheduled waste that combines and integrates source reduction, reuse, recycling, composting, energy recovery and landfilling in order to conserve and recover resources and dispose of waste in a manner that protects human health and the environment. Also, the legislation and policy regarding waste management must be revolutionizing to improve the effectiveness of waste management and strengthen the rules and regulation of environmental issue. These include scheduled waste collection, treatment and disposal; public health and environmental cleanliness; landscaping; planning and other responsibilities such as licensing and enforcement of by-laws. Because of the increasing demand on integrated solid waste management, development of system tools and environmental DSS on integrated solid waste management and holistic approach to manage the waste subsequently become a need. Using a tool as DSS can help the user in identification of waste in which can be applied in forensic as waste fingerprint and use for optimization analysis,-cost economic.

Thus, the implement of DSS that encompass all aspect in waste management is prior needed under the present circumstances. This is to give the best optimization and best option of waste management by reducing the uncertainty and constraints in which the increasing complexity and number of options cause the challenging for engineer or planner to make a decision and educate the user such as recycling program. In addition, the complex environmental problems can be dealt with effectively in the future.

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