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Full Length Research Paper

Integrated scheduled waste management system in Kuala Lumpur using expert system

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Over the past decade, Malaysia has enjoyed tremendous growth in its economy. This has brought about a population growth together with a great influx of foreign workforce to the cities. This resulted in an increase in the amount of scheduled waste generated. Furthermore, scheduled waste management has long been a problem for local authorities in Kuala Lumpur. Continued illegal dumping by waste generators is being practiced at large scale due to lack of proper guidance and awareness. This report reviewed and discussed service provided for scheduled waste management by an authority and international scenario of scheduled waste management. An expert system was developed to integrate scheduled waste management in Kuala Lumpur. The knowledge base was acquired through journals, books, magazines, annual report and web sites. An object oriented expert system shell, Microsoft Visual Basic 2005 Express Edition was used as the building tool for the prototype development. The overall development of this project was carried out in several phases which are problem identification, problem statement, literature review, identification of domain experts, prototype development, knowledge acquisition, knowledge representation and prototype development. Scheduled waste expert system is developed based on five types of scheduled waste management which are label requirements, packaging requirements, impact of scheduled wastes, recycling of scheduled wastes and recommendations. Besides, it contains several sub-modules by which the user can obtain a comprehensive background of the domain. The output is to support effective integrated scheduled waste management.

Key words: Expert system (ES), scheduled wastes, management.

INTRODUCTION

Even though the use of information technology plays a major role in application of technology nowadays, application of artificial intelligence (AI) is still in its early stages in Kuala Lumpur. During the last decade, AI was developed to be a major aspect of research in computer science. Varieties of AI-based application programs have been developed to address real life problems and have been successfully field-tested (Jayawardhana et al., 2003). As Kuala Lumpur still lack proper systems of information assimilation, archival and delivery, AI tool can effectively be employed to improve the management of scheduled waste.

Scheduled wastes are defined as wastes or combination of wastes that pose a significant or potential hazard to human health or living organisms. This definition specifically excludes municipal solid waste and municipal sewage. Scheduled wastes are broadly classified into the categories of chemical wastes, biological wastes, explosives and radioactive wastes (Chapter 5 Waste Disposal). The objectives of this study were: (1) to study scheduled waste generated in Kuala Lumpur (KL) and service provided for scheduled waste management by the authority which is Department of Environment (DOE), (2) to develop an expert system on integrated scheduled waste management system in KL by using Visual Basic Expert System (VBES) and (3) to recommend a new approach for integration of scheduled waste management system in KL.

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Scheduled wastes

Scheduled wastes are defined as wastes or combination of wastes that pose a significant or potential hazard to human health or living organisms. Scheduled waste management has long been a problem for local authorities in Kuala Lumpur. Continued illegal dumping by waste generators is being practiced at large scale due to lack of proper guidance and awareness. In 2007, the Department of Environment (DOE) was notified that 1698.118 metric tones were generated. In addition, Kuala Lumpur has enjoyed tremendous growth in its economy. This has brought about a population growth together with a great influx of foreign workforce to the cities. It resulted in an increase in the amount of waste generated. The main reason attributable to this deficiency is the lack of expertise in the scheduled waste management field. The aim of this research was to address scheduled waste management in Kuala Lumpur by providing an expert system called Scheduled Waste Expert System (SWES). Currently, various facilities have been approved for management of scheduled wastes in Malaysia. These include 211 licensed waste transporters, 76 recovery facilities (non e-waste), 85 partial recovery e-waste facilities, 35 on-site incinerators, 3 clinical waste incinerators and 2 secured landfills. In Kuala Lumpur, in 2007, there were 11 licensed waste transporters and 6 local off-sites recovery facilities (Laporan Tahunan Jabatan Alam Sekitar Wilayah Persekutuan, Kuala Lumpur, 2002-2007). However, there are many other potential sites which can be used as illegal dump area. To guide the proper implementation of scheduled waste management, the need of expertise, in the form of human expert or a written program such as an expert system is a crucial factor. In order to convey the expert knowledge to the operational level personnel, the most convenient and cost effective means is an expert system (Berry and Hart, 1990). Most of these wastes are classified under hazardous waste (HW) because of their physical characteristics that are suitable with HW. HW can be classified on the basis of their hazardous nature which includes toxicity, flammability, explosively, corrosively and biological infectivity (Chiemchaisri, 2007). According to Chinese law, solid waste is classified into three types: Industrial solid waste (ISW), municipal solid waste (MSW) and hazardous waste. According to the environmental statistics for the whole country in 2002, the quantity of ISW generated in China was 945 million tons, of which 50.4% was reused as source material or energy, 16.7% was disposed of simply, 30.2% was stored temporarily and 2.7% was discharged directly into the environment. In recent years, the quantity of ISW generated in China has been increasing continually. When compared with 1989, the quantity of ISW generated in 2002 had increased by 66%. The categories of ISW are closely related to the industrial structure in China. The largest component of ISW is mining gangue, which is 27.5% of the total amount. The other major components of ISW are coal gangue (15.8%), coal ash (14.4%), boiler slag (11.5%) and iron blast-furnace slag (6.73%) (Coad, 2007).

The total volume of hazardous waste generated in Thailand in 2001 was 1.65 million tons, of which 1.29 million tons (78%) were generated by the nonindustrial (community) sector. Together with the industrial and nonindustrial sectors, a main source of hazardous waste generation is the transport of hazardous wastes from foreign countries into Thailand. The hazardous waste production levels in Dar es Salaam (Tanzania) can be estimated at 95 000 tonne per year or 3.8 kg per capita per year. The per capita waste generation rate is about 60% of that of Japan, 17% of Denmark and 3.8% of the Netherlands (Jitti, 2005).

There are many computer techniques in managing the waste worldwide. For example, for Sri Lankan solid waste composting, BESTCOMP is used. BESTCOMP is one of the Expert System. BESTCOMP is the short form of 'Born to guide for Solid waste COMPosting'. This system is based on several phases including problem identification, knowledge acquisition, knowledge representation, programming, testing and validation. It is composed of several basic components such as the user interface, knowledge base, inference mechanism and the database (Jayawardhana et al., 2003).

Another Sri Lankan alternative is BESTFill for landfilling applications. An expert system was developed to assist proper implementation of landfill technology in Sri Lanka. This system contains several sub modules by which the user can obtain comprehensive background of the domain. The output is expected to support effective integrated solid waste management.

METHODOLOGY

Expert system (ES) has been used to organize part of the knowledge domain in scheduled waste management from all data collected to non-expert users. This knowledge should support them in terms of label and packaging requirements, impact and recycling of scheduled wastes, recommendations, besides predicting the scheduled waste generated and population in Kuala Lumpur (Meng-Shiun and Weber, 1995).

Visual basic expert system development

Problem identification, problem statement, literature review and identifications of domain experts were done. Several entities in the integration of scheduled waste management system in KL is shown. Five different entities of this process, each of which has many sub entity are:

1. Label requirements
2. Packaging requirements
3. Impact of scheduled waste
4. Recycling of scheduled waste
5. Recommendation

Building tools

For the development of Scheduled Waste Expert System (SWES),

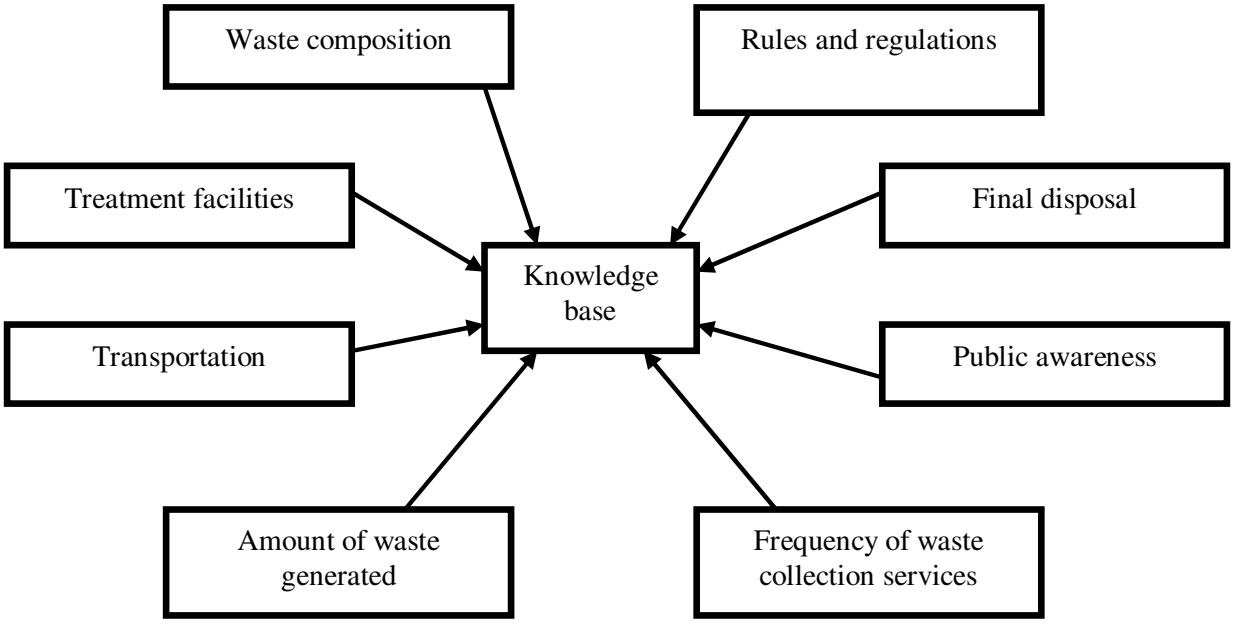

Figure 1. Knowledge base content.

an expert system shell, Microsoft Visual Basic 2005 Express Edition, was preferred over conventional programming languages.

Knowledge aquisition

Knowledge acquisition is the lengthiest process in building an expert system. However, it is the single most important process of the engineer's knowledge upon which quality of the expert system depends. The central core of the knowledge base was acquired from the published text books, journals, magazines and pamphlet. This knowledge consists of well established facts, rules, theory and guidelines that had been practiced over many years. Annual Report of Department of Environment (DOE) related that statistics of scheduled waste generated have provided very valuable sources of information. This source of information provided a means to build a unique knowledge base for SWES. All the sources are from Department of Environment, Kuala Lumpur (DOE), Kuala Lumpur City Hall (DBKL) and Alam Flora Sdn. Bhd (AFSB) (Alam Flora Sdn Bhd., 2006).

Knowledge acquisition has now become relatively easy than how it was two decades ago, due to the advancement of internet facilities. Much valued information about management of scheduled waste of Kualiti Alam and Radicare, organizations, companies, recycling procedure and so on, were acquired through the internet. These were helpful in building the sub-modules of the SWES.

RESULTS AND DISCUSSION

Knowledge base

Knowledge base in expert system is presented as set of rules that are checked against the collection of facts or knowledge about current situation. For developing the solid waste expert system, it is important to identify the knowledge base content which represents the purpose of system (Suciu and Tartiu, 2008). As illustrated in Figure 1, the solid waste management area may consists of waste composition, rules and regulations, final disposal, public awareness, frequency of waste collection services, amount of waste generated, transportation and treatment facilities.

User interface

User interface is part of the expert system where the system can interact with the user. The user interface controls the way the user interacts and performs tasks with the expert system. It also provides varying opportunities for the user to follow the inference process and to provide explanation features. The interface that is designed by using visual basic is called Form. The main user interface or the main form as illustrated in Figure 2 could offer the capacity to interact with the system through text, pictures and graphics.

Solid waste expert system (SWES)

A unique feature of Solid Waste Expert System is that it contains several subforms by which the user can obtain a comprehensive background understanding regarding current solid waste management in Kuala Lumpur. The subforms were named as literature, photo gallery, legislations, training tools, waste management, and finally the solid waste expert system itself. Solid waste expert system also enable user to browse the concept of expert system by clicking the About button. Help button is also

Figure 2. Main user interface.

provided for the user to get an overview content of each button so that they can easily understand the function of each button. In addition, for further information, user can find the authors' contacts at About Us button.

Legislation form

Legislations were incorporated in order for the user to obtain background knowledge on legal framework associated with solid waste management. Legislation form was divided into two categories which are Environmental Quality Act, 1974 and Environment Impact Assessment (Figure 3).

Waste management form

Waste management form has been designed in order to give the user an overview on current solid waste management in Kuala Lumpur. As illustrated in Figure 4, it consists of programs, collection, waste flow, transfer station, disposal and maintenance. Each button provides a brief introduction of solid waste management handled by Alam Flora and Dewan Bandaraya Kuala Lumpur (DBKL). For example, when the user click the waste flow button, a picture of waste flow will appear and brief information explaining the picture is also provided.

Rules for waste estimation

The waste estimation form consists of data taken from the literature review and DBKL. This is a very important knowledge where the user is able to know the amount of waste to be generated in the future. The amount of waste that is predicted until year 2023 is shown in Table 1 where user can make a comparison with the previous data. The prediction of total solid waste generation in Kuala Lumpur is by taking assumption that the rate population increase is 4% and the rate of increase of solid waste generation per person is 2% per year.

Figure 3. Legislations form.

Figure 4. Waste management forms.

Table 1. Prediction of total MSWG of Kuala Lumpur.

Year	Population of KL city (million)	MSWG (kg/cap.day)	MSWG (tonnes/day)	MSWG (tonnes/year)
2009	2.43	1.66	4029.85	1470895.25
2011	2.63	1.72	4534.78	1655194.70
2013	2.85	1.79	5102.97	1862584.05
2015	3.08	1.87	5742.35	2095957.75
2017	3.33	1.94	6461.85	2358575.25
2019	3.60	2.02	7271.50	2654097.50
2021	3.90	2.10	8182.59	2986645.35
2023	4.21	2.19	9207.84	3360861.60

Mohamed, 2000. MSWG, municiple solid waste generation.

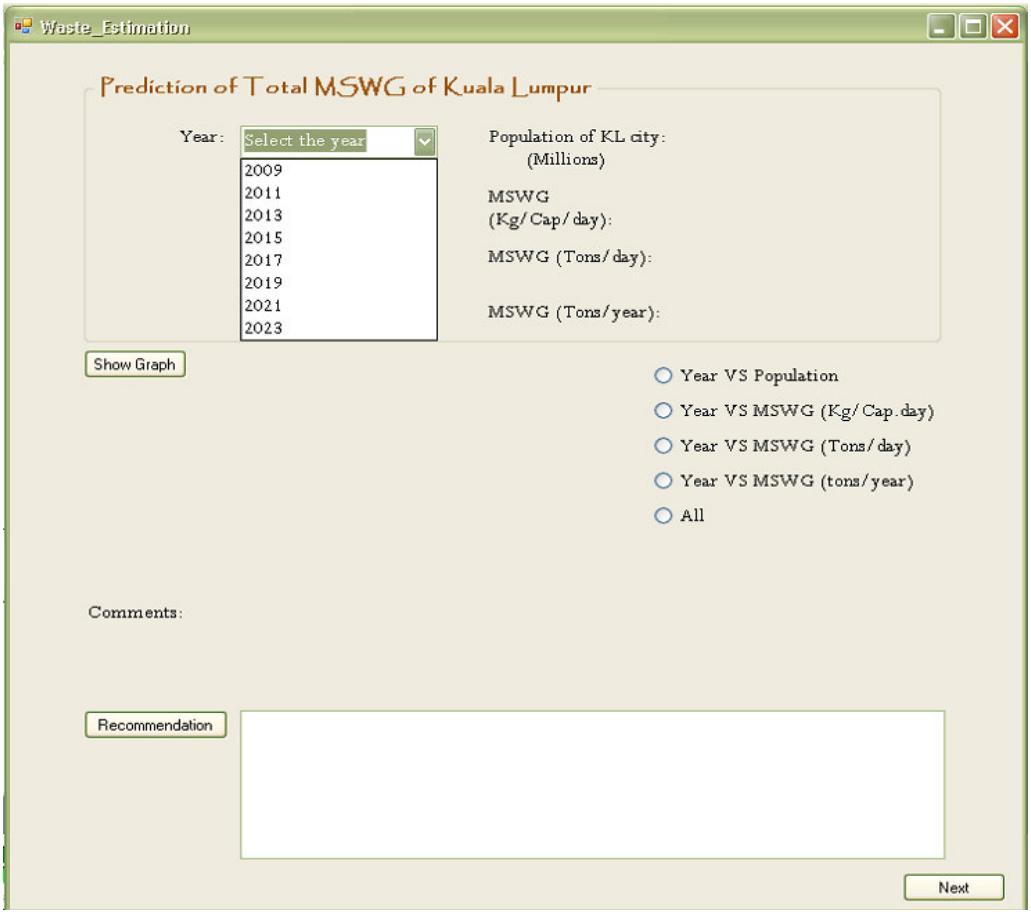

Figure 5. The choices for waste estimation year.

The selection of year is made in the form of dropdown list of combobox. The rule behind this method is:
Select Case ComboBox1.SelectedIndex: Case 0, 'if year is selected then results will be shown. Me.Label11.Text = ("2.43"); Me.Label14.Text = ("1.66"); Me.Label15.Text = ("4029.85"); Me.Label16.Text = ("1470895.25"), Case 1.

The rule will be in the form of combobox and the meaning of the rule is:

Assuming that the user want to know the amount of waste generated in year 2015; If he/she select 2015 which is case 3, then the population, municiple solid waste generation (MSWG) in (kg/cap/day), (tons/day) and (tons/year) are displayed. Similar rule is applied for other choices. Figure 5 shows the illustration of the rule of choices in form of combobox using Visual Basic.

System validation

The forecasting for waste estimation in SWES was done by comparing it with the data from a research study done by Mohamed et al. (2007). The amount of waste (per day and per year) that was estimated for year 2011, 2013, 2015, 2017, 2019, 2021 and 2023 is similar to previous data from DBKL. For instance, if the current waste generation trends continue increasing at 2% rate per year and 4% rate increase in the population, the waste generation will follow the same trends as previous data. These trends are used to predict the future tendency and also help with the design of the treatment facility and landfill size. As a result, the output data in graphical form that is chosen by the user for a certain year is matched with the trend of previous data from DBKL.

System maintenance

It was observed that other rules can be added to the rules in the knowledge base, and they can be changed or deleted without worrying about how the changes will affect the overall system.

Conclusion and recommendation

The expert system tool in developing the solid waste expert system is using Visual Basic Express Edition 2005. It is an ideal programming language for developing sophisticated professional applications for Microsoft Windows. The overall development of expert system has been carried out in several phases, including problem definition, knowledge acquisition, knowledge base, prototype development, prototype validation and implementation. Although, the expert system at this stage is useful among the potential users such as local authorities, consulting forms, researchers and students, it can be improved for the choices of proper management of solid waste for more efficient expertise. The expert system can be improved by adding an assessment tool with technical details such as terminology, calculations and examples. A related website regarding solid waste management and power point presentation could also be included in future study.

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