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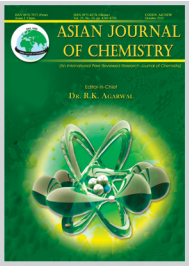

Impact of Landfill Leachate on Water Quality in Langkawi Island Using Management of Environmental System

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Inefficient and/or insufficient solid waste management are one of the principal factors related to the quality degradation of natural environment. This study was conducted at Langkawi Island, which is one of the densely-populated and quite rapidly-growing touristic islands in Malaysia. The study was carried out to understand state of concepts and solid waste management practices in the island as well as their impacts on the local community, problems associated with the waste management practices, landfill leachate affecting water quality of Langkawi geopark. Environmental management system is explored by questionnaire directed towards the island residents and by interviews with personnel of Majlis Perbandaran Langkawi (municipality), key stakeholders in Langkawi Development Authority and Majlis Daerah Langkawi. The aim of this research is to evaluate the effect of landfill leachate in study area based on assessment of the criteria related to economical, social-cultural environment, physical environment and biological environment and survey on water pollution due to landfill leachate and to present some perception and views of local residents on issues related to solid waste management like the aesthetic value of the island environment.

Key Words: Solid waste, Langkawi island, Water pollution, Environmental management system.

INTRODUCTION

The environmental quality is deteriorating rapidly in a multitude of developing countries; especially in urban centers. Incomplete and/or inefficient municipal solid waste management has been determined as one of the main elements contributing to the environment quality degradation; particularly in small areas such as island where there is scarcity of land. Predicting and expanding solid waste collection and disposal services can no longer be resolved singularly. An integrated and holistic effort ought to be applied to control generation of solid wastes.

Environmental pollution is a common phenomenon to urban regions, essentially due to lack of constant waste collection and to haphazard and indiscriminate dumping of the wastes, mostly with no treatment. These factors result in severe environmental pollution, particularly as people tend to get rid of the waste by open-burning when waste accumulates as a result of irregular collection of the wastes, which is a practice that leads to pronounced air pollution[1-3].

An environmental management systems includes a good support from policies, excellent level environmental performance such as: (a) specific quantity and quality of measurable objectives and performance targets; (b) a planning process and strategy to meet the commitment; (c) an organized institutional structure to execute the strategy; (d) implementation programs and support tools to meet objectives; (e) communications and training programs; (f) measurement and review process to monitor progress[4-6].

An integrating environmental management incorporate tools of government intervention, regulation and enforcement with market-based incentives, to attain environmental goals at least cost. An environmental management system combines tools together with consideration of all environmental media (air, water, land). As a result, an integrated, environmental management system could be developed based on data, information and other aspects of concerns of stakeholders.

Environmental management systems have been employed at many levels for solving many challenges related to management of environment. Companies in different states have improved environmental management systems to enhance efficiency and benefits to multiple stakeholders. Environmental management system factors include commitment of policy, goals and targets, planning, structural institution, performance and connection, monitoring and review.

Environmental policy: Environmental policy is the key factor of good environmental management[7-9]. Policy should reflect management commitment with due attention to follow relevant rules and permanent improvement. Policy forms the foundation and organization that builds objects[1]. Policy should be clear and be reviewed periodically. Environmental system should apply also methods for recognition of several environmental to to enhance confidence of stakeholders (Fig. 1).

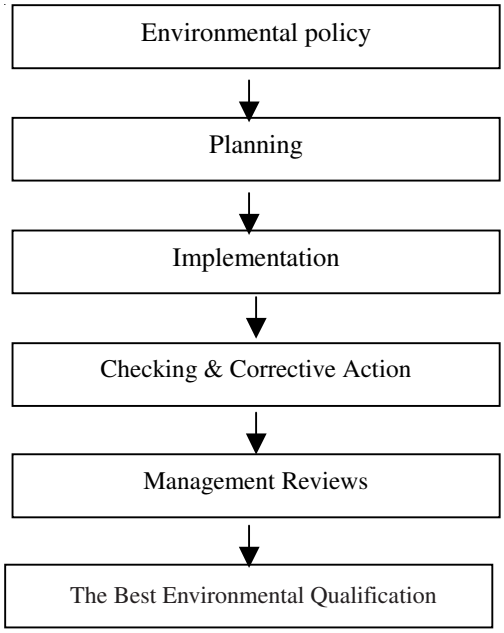

Fig. 1. ISO 14001 environmental management system model, source: environmental management systems a guidebook for improving energy and environmental performance in local government[10]

EXPERIMENTAL

Study area: The Langkawi Geopark comprises all 99 Islands of Langkawi under the Kedah State and it was declared on Legislative Council on 31 May 2006 and was later endorsed by the board of the Langkawi Development Authority (LADA) on 6th October 2006. The total area of Langkawi consists of 6 sub-districts, namely Kuah, Padang Mat Sirat, Ayer Hangat, Kedawang, Ulu Melaka and Bohor. The latitude of Langkawi is 6º 19' 47" N (deg min sec), 6.3297º (decimal), 0619.78 N (LORAN) and the longitude of the area is 99º 43' 43" E (deg min sec), 99.7287º (decimal), 09943.72 E (LORAN). The establishment of the Langkawi Geopark was initiated by the Malaysian Geological Heritage Group (MGHG) since 2001, has identified the potential of Langkawi Island as a world class geopark[11,12].

Methodology: The solid waste management system should be integrated and developed with the ultimate aim of protect Geopark of Langkawi Island (Fig. 2). Instead of focusing on individual elements an integrated synthesize a waste management system involving the whole waste stream of viewpoints of environmental and economic perspectives is recommended. Selection and application of appropriate management programs, technologies and techniques are keys to achieve the objectives of waste management.

The data in this research were collected *via* a survey using a set of questionnaire and personal interviews; the 'face to face' data collection from relevant agencies. Environmental management system encourages mitigation, control and education as ways to reduce the negative impacts and increase positive impacts. Determination of the status of ecosystem of landfill is important to protect the Geopark and rivers and ecosystem.

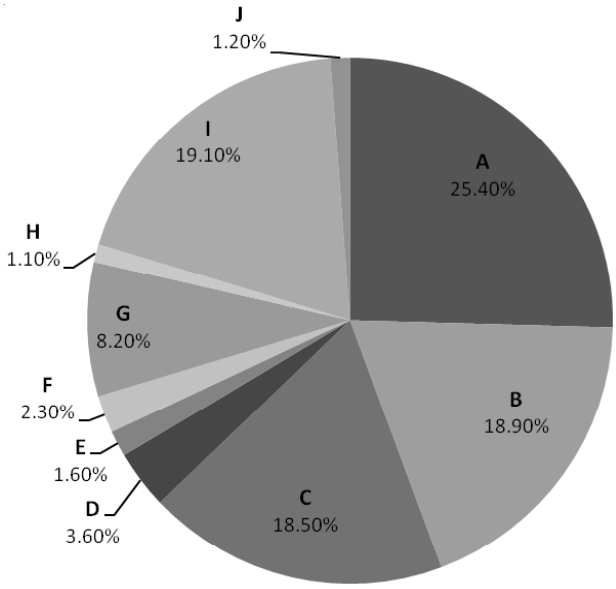

Fig. 2. Solid waste composition of Langkawi Island

Measurement and evaluation is necessary to indicate environmental impacts and regular monitoring is needed to prevent pollution of water in Langkawi. Matrix of (+, -) impact comparisons with factors considered on axis scale provide some indication of importance and intensity of the different factors.

Consideration of carbon dioxide dissolved in water was

$$CO_2\ (Mg/L) = A*N*4400/VW \text{ normality} \quad (1)$$

Measurement of dissolved hydrogen sulphide (or sulfide) in water for assessment of leachate is:

$$H_2S\ (Mg/L) = MI2*VI2*34*1000/VW \quad (2)$$

Soil structure determination is used to estimate the leachate flow:

$$\%\ (Silt + Clay) = R1/W*100 \quad (3)$$

$$\%\ (Clay) = R2/W*100 \quad (4)$$

RESULTS AND DISCUSSION

Results of researches and questionnaire are summarized and showed in Tables 1-5. All data collection were done in April 2009 until Feb 20011 on Langkawi island (Table-1).

The assessment carried out show that many of the residents were not satisfied about landfill area, and these are as follow: A) 76 % unsatisfied; B) 16 % satisfied; C) 8 % not aware of this problem.

Dislikes of residents to landfill in Langkawi Island are : A) 51 % unsanitary landfill; B) 27 % bad odor (smell); C) 16 % not beautiful landscape of island; D) 3 % damage for ecosystem; E) 3 % damage to ecotourism industry.

The main cause of problems of solid waste identified is low enforcement of waste laws and regulations (Table-2).

About 38 % of people believe that poor collection is a cause to indiscriminate dumping of solid wastes on Langkawi Island (Table-3).

TABLE-1
THE RESPONDENT'S DEMOGRAPHICS OF LANGKAWI ISLAND

Variable		Respondents	
		f	%
Gender	Male	184	46.1
	Female	215	53.9
Occupation	Self employed	21.0	5.30
	Trader	16.0	4.00
	Business	53.0	13.3
	Civil servant-government	189	47.4
	Private employee	82.0	20.6
	Other	38.0	9.50
Age	16-26	174	43.6
	27-37	152	38.1
	38-48	50.0	12.5
	49-59	20.0	5.00
	60 and above	3.0	0.80
Nationality	Malay	383	96.0
	Foreigner	16.0	4.00
Education Level	Primary	16.0	4.00
	Secondary	174	43.6
	College or University	203	50.9
	Others	6.00	1.50
Income	500-1000	107	26.8
	1001-2000	147	36.8
	2001-3000	105	26.3
	3001-4000	20.0	5.00
	4001-5000	6.00	1.50
	5000 and above	14.0	3.50

TABLE-2
IDENTIFIED SWM PROBLEMS IN LANGKAWI ISLAND

Variable	Respondents	
	f	%
Poor urban planning	49	12.3
Lack of enough funding	74	18.54
Bad infrastructure	36	9.02
Low enforcement of waste laws & regulations	87	21.80
Low public awareness on waste issues	121	30.32
Lack expertise	32	8.02

TABLE-3
FACTORS LEADING TO THE INDISCRIMINATE DUMPING OF SOLID WASTES ON LANGKAWI ISLAND

Variable	Respondents	
	f	%
Poor Collection	153	38.34
Long distance to community bins/dumps	104	26.06
Laziness of the people	39	9.77
People's attitude	98	24.56
No bins available in the area	5.0	1.25

A high percentage of residents indicated their low awareness on waste issues as a reason of solid waste problems in Langkawi Island (Table-4).

TABLE-4
IDENTIFIED SWM PROBLEMS OF LANGKAWI ISLAND

Variable	Respondents	
	f	%
Poor urban planning	49	12.3
Lack of funding	74	18.54
Bad infrastructure	36	9.02
Low enforcement of waste laws & regulations	87	21.80
Low public awareness on waste issues	121	30.32
Lack expertise	32	8.02

TABLE-5
MINIMUM, MEAN AND MAXIMUM CONCENTRATIONS OF HEAVY METALS CONTENTS IN MSW SAMPLES FROM LANGKAWI ISLAND. (SOURCE: JABATAN PENGURUSAN SISA PEPEJAL NEGARA JUN 2008)

	Parameter	Concentration (mg/kg)		
		Minimum	Mean	Maximum
1	Sodium (Na)	246.5	1,279.3	3,008.0
2	Potassium(K)	76.2	615.1	1,978.0
3	Calcium (Ca)	36.51	374.37	1,726.0
4	Cadmium (Cd)	ND	0.105	0.238
5	Copper (Cu)	ND	3.072	10.920
6	Aluminium (Al)	0.519	3.227	9.040
7	Nickel (Ni)	ND	1.588	5.610
8	Iron (Fe)	48.14	410.60	1,364.00
9	Lead (Pb)	0.53	12.56	45.04
10	Mercury (Hg)	0.013	0.106	0.218
11	Tin(Sn)	ND	0.071	0.110
12	Zinc (Zn)	ND	0.297	1.020
13	Chromium (Cr)	ND	3.651	11.030
14	Arsenic (As)	ND	0.082	0.124
15	Cobalt (Co)	ND	0.069	0.142
16	Manganese (Mn)	0.109	2.546	9.240

Surveys show that amount of some elements is more than specific standards and it is necessary to prevent entrance of landfill leachate into water bodies to protect the Langkawi Geopark (Table-6).

TABLE-6
COMPOSITION OF LEACHATE SAMPLE FROM MSW IN LANGKAWI ISLAND (SOURCE : JABATAN PENGURUSAN SISA PEPEJAL NEGARA JUN 2008)

Test Parameter	Langkawi Island
Temperature (ºC)	30.2 (ºC)
pH	8.65 at 30.02 (ºC)
Colour, Hazen	Black
BOD5 at 20(°C) (mg/L)	11,460
COD(mg/L)	40,400
Total nitrogen (mg/L)	1,265
Ammoniacal nitrogen (mg/L)	903.2
Phosphate (mg/L)	32.1
Sulphate as SO_4^{2-} (mg/L)	135.4
Sulphide (mg/L)	1.70
Alkalinity as $CaCO_3$ (mg/L)	297.2
Chromium hexavalent (mg/L)	0.161
Chromium trivalent (mg/L)	0.064
Sodium (mg/L)	1620
Silver (mg/L)	<0.01
Mercury (mg/L)	<0.05
Magnesium (mg/L)	170.6
Cadmium (mg/L)	<0.01
Arsenic (mg/L)	<0.01
Cyanide (mg/L)	2.85
Lead (mg/L)	0.125
Copper (mg/L)	<0.01
Manganese (mg/L)	0.214
Zinc (mg/L)	0.457
Nickel (mg/L)	0.205
Cobalt (mg/L)	<0.01
Phenol (mg/L)	0.94
Total chromium as Cr (mg/L)	0.225

The inorganic pollutants detected in the groundwater samples from the boreholes and river water sample are nickel,

copper, chromium, silver, cadmium, lead, barium, selenium, mercury and arsenic. The average nickel concentration in the groundwater samples from boreholes of landfill site (Fig. 3) were 0.025 mg/L but are below the intervention value of 0.075 mg/L of environmental impact guidelines for groundwater and/or surface water supply project (DOE 1977). The average copper concentration in ground water samples from the boreholes of Langkawi was < 0.01 mg/L. The concentration value is below the intervention value of the Malaysian EIA guideline (source: Jabatan Pengurusan Sisa Pepejal Negara 2008).

Fig. 3. A snapshot of condition of landfill and leachate in Langkawi Island (2010)

The average cadmium concentration in the groundwater samples from boreholes of Langkawi landfill site[13] was 0.08 mg/L. The average cadmium concentration in the groundwater samples from boreholes of Langkawi landfill site exceeded the intervention value of 0.006 mg/L of the Malaysian EIA Guideline. This indicated that the groundwater from the boreholes of Langkawi landfill is considered to be contaminated with cadmium and therefore require treatment prior to be used as potable water supply source.

Moisture content: The moisture contents of solid waste samples from Langkawi Island are shown in Fig. 4. It was observed that the moisture levels showed high fluctuations, ranging from a low of 35.8 % to a high of 75 %. The amount of moisture content in solid waste has effect on leachate generation and water pollution in Langkawi Island.

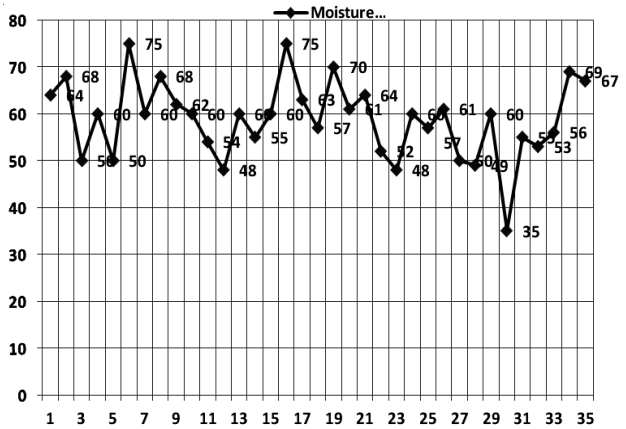

Fig. 4. Moisture contents of solid waste samples from Langkawi island (Source: Jabatan Pengurusan Sisa Pepejal Negara April 2008)

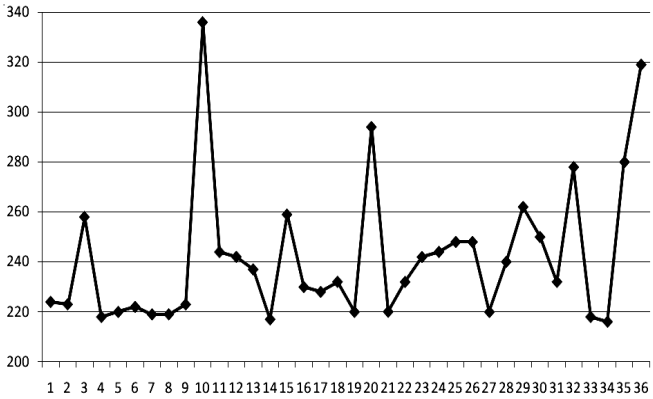

Fig. 5. Bulk density of Langkawi Island solid waste (source: Jabatan Pengurusan Sisa Pepejal Negara 2008)

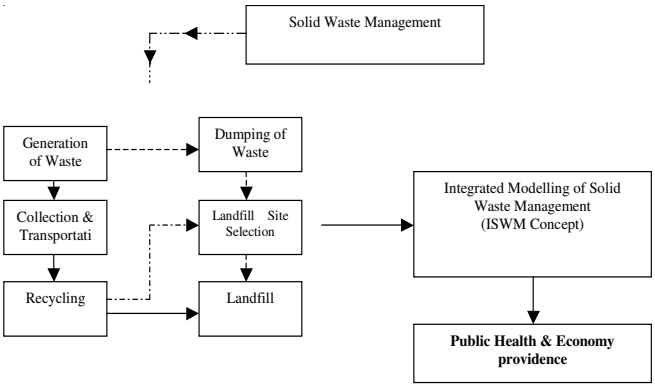

Fig. 6. Proposed structure of integrated solid waste management for Langkawi Island

Bulk density of Langkawi Island: The bulk densities of all fourteen samples were shown in Fig. 5. It was observed that the density difference amongst all samples were quite high, where the difference between the maximum and minimum value is at approximately 120 kg/m^3.

Conclusion

Environmental monitoring and control with regards to collection and other effective actions for proper management of solid wastes including the leachate of landfills are important in ensuring good environmental health for human health[1,3,12].

Important elements of the environment require good monitoring and assessment in the design of modern landfill with consideration of protecting quality of water and soil near the area. Another important point in environmental monitoring design is the special attention that need be given to educating the personnel needs and public. Environmental management system includes aspects of environmental control, economic activities, safety, applying policy and suitable implementation strategies.

Recommended use of appropriate filtration membrane, flocculation, chemical and ammonium stripping methods, adsorption of activated carbon or exchange of ion and treatments of electrochemical treatments must be suitable to the characteristics of landfill leachate and ecological conditions of the affected area.

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