ENVIRONMENTAL RANKING CONSIDERATIONS FOR SETTING UP A RECUPERATIVE ENERGY INCINERATOR

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ABSTRACT

The study looks into environmental ranking considerations in setting up a recuperative energy incinerator in Malaysia. Major impacts on the environmental aspects covering land, water and air were put into considerations. Analysis of relative impacts was derived mainly from experiences in setting up such installations in Taiwan and parallel investigations into the scrapped incinerator project in Malaysia were drawn in as comparisons. A case study involving the operations of a sanitary landfill in Malaysia had been observed to determine its suitability to build a recuperative energy incinerator on the existing landfill. The criteria for suitability of such installation were proposed. The ranking analysis to select the most suitable sites with regard to the least potential environmental impacts in constructing a recuperative energy incinerator had also been determined. The appropriate technologies were also incorporated to mitigate the impacts of the by-products on the environment. Finally, the merits and demerits of having such facility in Malaysia in the near future were considered and short to mid terms solutions were also suggested.

Keywords: Environmental ranking; Incinerator; Landfill; Recuperative energy

INTRODUCTION

Incinerator is a container for burning refuse, or plant designed for large-scale refuse combustion. Thus, incineration is one of the best known methods of managing municipal solid waste disposal. Nevertheless, the environmental consideration must be done before setting up a recuperative energy incinerator. The most environmental factors that should be considered are air, water and land. Hence, the EIA (Environmental Impact Assessment) data is one of the main things which will be discussed in this paper. The ranking of potential environmental impacts based on the highest effects that they give to the incinerator also will be seen as well.

Incineration is a waste treatment technology that involves the combustion of organic materials and/or substances. Figure 1 summarizes the key release for the incineration process. It generates emissions, liquid discharges and residues of various types, which are released to the environment of deposited within a landfill in a controlled manner. Incineration involves the combustion, under controlled conditions, of organic wastes (Judith and Gev, 1994) [1].

Incineration with energy recovery is one of several waste-to-energy (WtE) technologies such as gasification, pyrolysis and anaerobic digestion. Incineration may also be implemented without energy and materials recovery. There are many medical queries about air emissions, and local communities still have worries with modern incinerators.

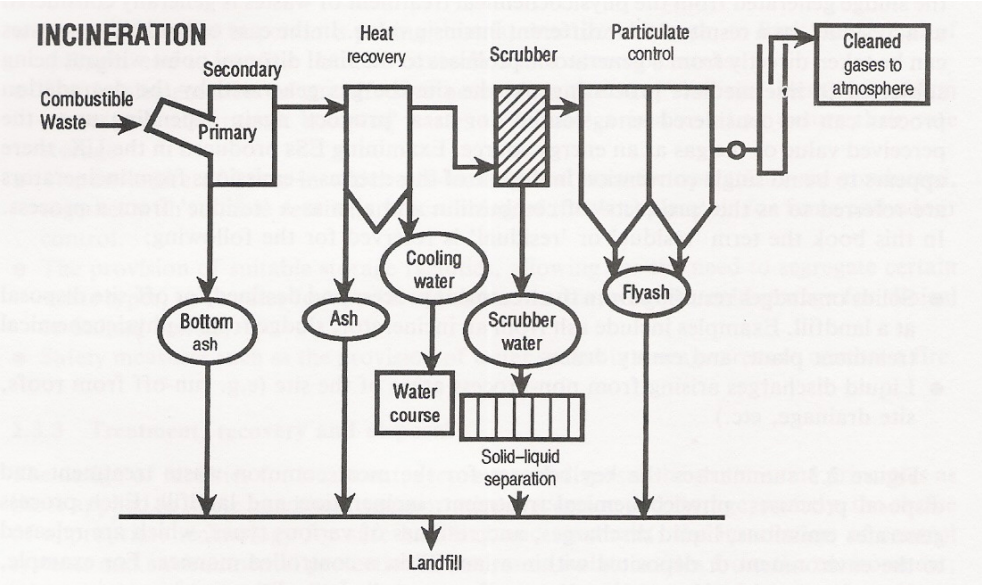

Figure 1: Incineration process and environmental emissions and discharges [1]

The major concerns about the environmental risks of municipal solid waste incinerators are the potential emission of contaminants into the air through exhaust stacks and into water through ash leachate. Proper planning to minimize environmental damage, as well as public education and involvement that directly address these issues, are essential to successful incineration programs (United Nations Environment Programme, 1991) [2].

In a preliminary comparison, landfill disposal resulted more hazardous either for human health, or for ecosystem quality and or for use of resources. Indeed, from the impacts analysis of the entire process life cycle it is evident that an activity commonly accepted by the average citizen thinking, such as landfill disposal, is far more impacting than municipal solid waste burning in an incineration plant with energy recovery.

Incinerator is actually important for the near future in Malaysia as one of the new facility for managing municipal solid waste, to help the use of landfill and recycling process. However, the mitigation of environmental impacts has to be looked into to reduce the bad affects of using incinerator. Thus, the environmental ranking considerations should be studied in details before setting up an incinerator.

MATERIALS AND METHODS

Search information from internet, journals, books and people related. The examples of incinerator from many countries all over the world also had been found, including its function and merits and demerits of using incinerator. Besides, its operation, waste type, consideration factors and effects also had been covered. The data of typical incinerators are also important so that it could be the reference to build incinerator with minimum impact to environment, especially EIA (Environmental Impact Assessment) data.

Observation on a typical landfill. The observation on chosen typical landfill which was Pulau Burung Sanitary Lnadfill had been done. The purpose of this observation are to study about the EIA for build landfill, its operation system and also the most important is to know the suitable level to build incinerator at the existing landfill. The important of the landfill and incinerator for the future in Malaysia and the comparison between both of them also would be

discussed in details. The information from this landfill would help this project run smoothly in order to choose the best criteria of incinerator.

Study on typical incinerator plants in Taiwan. The study on typical incinerator plants in Taiwan had been done to examine the impact level of different factors in environmental impact assessment for incinerator plants using GM (1, *N*) model. The purpose of this study is to know the environmental impacts level by constructing different environmental impact items such as air quality, hydrology or water quality, solid waste and others. This kind of study would be as the reference in environmental aspects for building incinerator in Malaysia.

Study on scrapped incinerator project in Malaysia. The study on scrapped incinerator project in Malaysia which was Broga Incinerator Project had been done to examine the factors that contributed to its failure, as the main purpose. Above and beyond, the conditions of that site which were physical description and history of site also would be known as well. The environment factor which was one of the main factors of this incinerator project failed had been examined briefly. The suggestions and recommendations for it also could be seen.

Study on Malaysia's situation. The study on Malaysia country situation had been done due to Malaysia Country Situation Report by Consumers' Association of Penang. The report was under International POPs Elimination Project. The purpose of this study is to clarify the Malaysia's condition with focus on Persistent Organic Pollutants (POPs) that gave impact in building incinerator. This country situation report on POPs describes the POPs situation in Malaysia, including known level of POPs and measures planned or underway to address them. Waste incineration had been identified as a major source for unintentional POPs internationally and there were several proposals to install incinerators nationwide as an important solution to the waste disposal problem.

Analyze the potential environmental impacts to build incinerator from typical data and research. The three major potential environmental impacts which are land, air and water were chosen to be observed and discussed in details. Those impacts had been chosen because they are the main environmental aspects that should be considered before setting up recuperative energy incinerator. The comparison between those impacts had been observed. The analysis of those environmental data had been done to examine which potential environmental impacts would give the highest effect to incinerator. The ranking of those potential impacts would be proceeding after all data had been analyzed carefully.

State the pollutant control technology. The availability of suitable technologies to mitigate impacts of the by-products on the environment had been looked into. Day by day, many ways had been found to control the pollutants. From this kind of technology also, the level of pollution released could be found. Besides, the solution of environmental effect to incinerator would be resolute.

Analyze the best-specified incinerator. Many environmental factors were considered in analyzing it, including the potential pollutants and its amount, environmental regulations, risks and others. The analysis of each pollutant impact in Malaysia also would contribute to choose the best-spec incinerator.

Further analysis and rank. The output from all of the research and analysis methods above is the contribution of potential environmental impacts – land, water and air that need to be put into consideration before setting up a recuperative energy incinerator. Thus, the final analysis

had been done for those three major potential environmental impacts to rank them based on the highest effects that they give to the incinerator.

RESULTS AND DISCUSSION

Case study 1: Pulau Burung Sanitary Landfill, Seberang Perai. The real average value of tonnage at this sanitary landfill now is about 2 200 tonnes per day. Roughly, the disposal wastes are divided into two categories which are domestic waste (60%) and industrial waste (40%). The estimated closing operation of this landfill is on end of year 2009. In different spot of the landfill, the calorific value also different. This is because its contents have changed according to the use of land. Table 1 shows the calorific values at the different spot at this sanitary landfill [3].

Table 1: The calorific values at the different spot at Pulau Burung Sanitary Landfill

Spot	Average calorific value (MJ/kg)	Net calorific value (MJ/kg)
1	8.56	7.19
2	1.41	1.24
3	1.17	0.98
4	11.38	8.69

The purpose of building the incinerator at the existing landfill is to reduce the waste that is dumped to the land so that the landfill operation will be longer. Besides, the waste also can be disposed in two methods at the same time. The types of waste disposed also can be separated according to its suitable disposal method. The incinerator ash also can be easily disposed at the landfill. To build incinerator here, the EIA requirement is almost same with the EIA for that landfill. The construction cost also can be reduced because of the area already exists. So it is easier to build incinerator at the existing landfill.

Case study 2: Incinerator plants in Taiwan. The impact level of different factors in environmental impact assessment for incinerator plants has been determined using GM (1, *N*) model. GM (1, *N*) is effective in predicting the environmental impact and analyzing the reasonableness of the impact. In this study, the impact levels in EIA reports of 10 incinerator plants were quantified and discussed. The relationship between the quantified impact levels and the plant scale factors of BeiTou (BT), LiZe (LZ), BaLi (BL), LuTsao (LT), RenWu (RW), Ping-Tung (PT), SiJhou (SJ) and HsinChu (HC) were constructed, and the impact levels of the GangShan (GS) and YongKong (YK) plants were predicted using grey model GM (1, *N*). Finally, the effects of plant scale factors on impact levels were evaluated using grey model GM (1, *N*) too. In order to calculate and predict the impact level, the range of impact levels is from 1 (lowest) to 7 (highest). The impact levels prediction of 10 incineration plants were quantified as shown in Table 2 [4].

Case study 3: Broga Incinerator Project, Hulu Langat, Selangor. Broga incinerator was the proposed thermal treatment plant for solid waste management with designed capacity to treat 1,500 tonnes of municipal solid wastes per day. Municipal solid waste incinerators are typically fed a mixed waste stream and the combustion of such waste leads to hazardous substances originally present within the waste being mobilized into releases from the incineration plant. All types of incineration result in releases of toxic substances in ashes and in the form of gases/particulate matter to air. These substances include heavy metals,

numerous organic compounds, such as dioxins, furans, and gases, such as nitrogen oxides, sulphur oxides, hydrogen chloride, hydrogen fluoride, together with carbon dioxide. The proposed incinerator would be constructed in an environmentally-sensitive area despite objection and protest from concerned citizens.

Table 2: Impact levels of different environmental items for 10 incinerator plants [4]

Assessment items	BT	LZ	BL	LT	RW	PT	SJ	HC	GC	YK
Topography/ geology/soil	6	6	5	5	5	5	5	5	5	5
Air quality	5	5	6	5	6	6	6	6	6	5
Hydrology/ water quality	5	4	6	6	6	6	6	6	6	6
Solid waste	4	5	6	5	5	6	5	6	6	5
Noise	4	5	5	4	5	5	5	6	4	5
Terrestrial fauna/flora	5	5	5	5	6	4	6	5	6	5
Aquatic fauna/flora	5	5	5	5	5	6	5	5	6	4
Traffic	5	5	6	4	5	5	5	5	6	5

It contravened laws and policies, and imperiled the society with enormous environmental, health, safety and financial costs. Those factors were the main factors that failed this incinerator project. The EIA report recognized that water pollution might arise both during the development and operational phases of the proposed incinerator plant. The main contributor of water pollution during development came from sediment transported to streams resulting from soil erosion and the disposal of sewage and sullage from construction camps and site office. Upon completion of construction and commissioning of the plant, sewage from plant areas and wastewater stream such as wastewater from cooling water blow down, washing and seepage storage pit expected to be the main sources of water pollution.

Malaysia's situation. POPs are chemicals that are toxic, persistent, mobile, accumulate in fatty tissue, and magnify in the food chain. Their high mobility makes them a global issue, while their other properties mean that POPs are hazardous to animal and human health even at low levels of exposure. Hence, it is essential that action is taken globally for the minimization and ultimate elimination of POPs. The main by-product of incineration is dioxins and furans. Dioxins and furans are POPs that are emitted as secondary pollutants and produced unintentionally primarily through industrial and chemical processes and thermal processes [5].

List of potential environmental impacts. The focusing potential environmental impacts in this paper to build incinerator are land, air and water. The analysis of them has been done according to typical data and research from the case studies and others. Figure 2 summarizes the key potential impacts of the releases on the environment by incineration process [1].

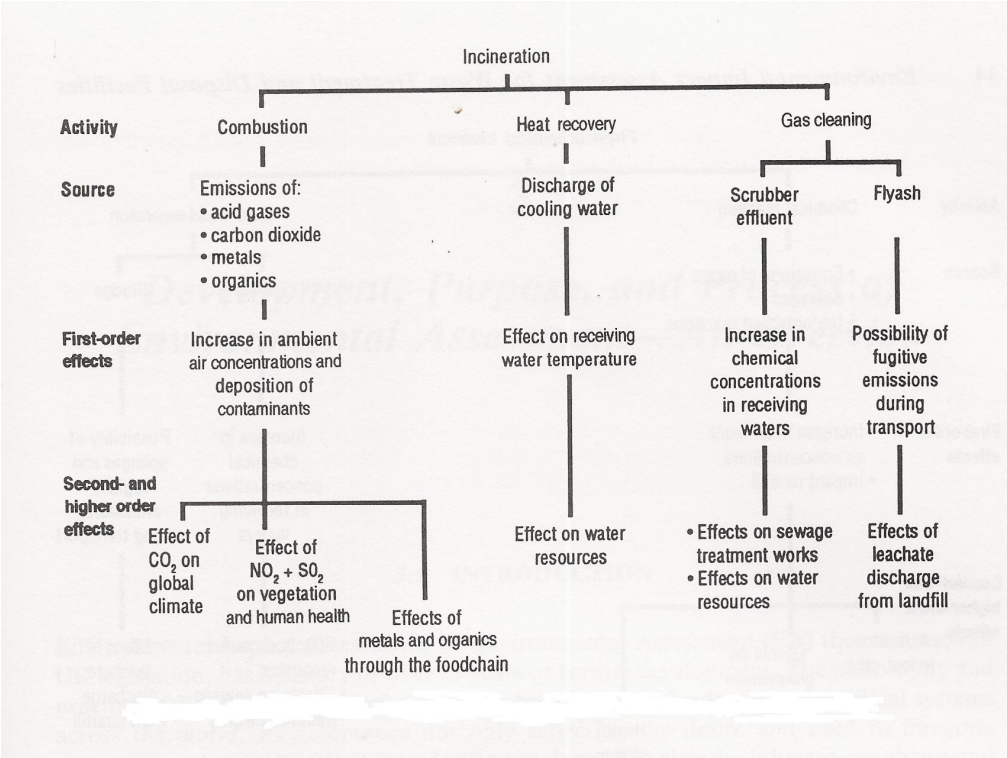

Figure 2: Incineration – sources of impacts and effects on the environment [1]

Pollutant control technology. The pollutants that give the highest impact from incinerator to the environment are air emission and residual incinerator ash. The major air emission control technologies available for incinerators are fabric filters, electrostatic precipitators, and scrubbers. Incinerator ash is usually disposed of in a municipal solid waste landfill, the environmental controls typically installed for environmentally sound sanitary landfills (e.g., liners and leachate collection/treatment) become all the more important. Ash can be stabilized and solidified by encasing in concrete prior to disposal, thereby significantly reducing the potential for the contaminant to migrate. Some individuals also advocate managing fly ash and bottom ash separately, with additional stabilization of the fly ash through vitrification or pyrolysis, because fly ash can contain higher concentrations of metals. In addition to landfilling, incinerator ash has been used in the production of road bedding, concrete, brick, cinder block, and curbing.

Suggestion of best-specified incinerator. According to Malaysia's situation, the suggestions of best-spec incinerator are as below:

- the area of site is at existing landfill, so that the place is already far from society and will not disturbed them because it is same as landfill's operation before and reducing the cost
- besides at existing landfill, the area of incinerator site also can be in town, so that the wastes will be carried in small area and the transportations will not disturbed other places
- the levels of land, air and water quality should accurate with Malaysia's standards
- the pollutant control technology should be applied to control the amount of emissions contain, based on POPs regulations
- the amount of wastes for burning in incinerator would not as much as dumping in landfill, however, it would be about 1 000 tonnes per day so that the impacts will be reduced

- the incinerator also can be build for specific wastes (clinical or medical waste, industrial waste, municipal solid waste and others) and not burning all in one
- the hazardous waste should be separate before the waste burning in the incinerator

However, the best value of basic details for typical municipal solid waste incinerator also can be used for reference which is as in Table 3 [6].

Table 3: Basic details of the municipal solid waste incinerator (Wang *et al*, 2007)

Basic details	Value
Capacity (ton/day)	1350
Capacity of furnace, three sets (t/h/set)	18.75
Stack emission flow rate (Nm^3/min)	1 600
Stack emission velocity (m/s)	160
Stack emission temperature (°C)	150
Stack height (m)	120
Stack diameter (m)	2

Ranking of potential environmental impacts to incinerator. From all of the research and analysis methods before, the ranking of potential environmental impacts to incinerator can be done as point of view. Hence, the ranking is:

1. *air impact* – the emissions of stack gases produced by incinerator gives the major effects to environment and society which will cause air pollution and dangerous to people's health (oxygen in air as the main source for people to live)
2. *water impact* – the chemical concentrations in water resources produced by incinerator gives the second major affect to environment and society which will cause water pollution (river and sea as the water and food sources for people)
3. *land impact* – the change of physical properties of land by the soil chemical produces by incinerator gives the third major affect to environment and society which will cause land pollution and disturb the structure of land or earthquake (land as the place where people live)

Merits and demerits of having incinerator in Malaysia. The merits of using incinerator in Malaysia for solid waste management in the near future are as below:

- solve the deficiency of land problem to build landfill: in densely populated areas, finding space for additional landfills is becoming increasingly difficult
- convert waste to energy: incineration plants generate electricity and heat that can substitute power plants powered by other fuels at the regional electric grid and steam supply for industrial customers
- avoid the release of carbon dioxide and methane: every ton of municipal solid waste incinerated, prevents about one ton of carbon dioxide equivalents from being released to the atmosphere
- produce good by-product: incineration of medical waste and sewage sludge produces an end product ash that is sterile and non-hazardous, while the bottom ash residue remaining after combustion has been shown to be a non-hazardous solid waste that can be safely landfilled or possibly reused
- as one of the good solid waste management

The demerits of using incinerator in Malaysia for solid waste management in the near future are as below:

- health affects: dioxin and furan emissions spread into the atmosphere from incinerators
- management of by-product: fly ash must be safely disposed of
- emit varying levels of heavy metals: vanadium, manganese, chromium, nickel, arsenic, mercury, lead and cadmium can be emitted by incinerator, which can be toxic at very minute levels
- produce fine particles in the furnace: even with modern particle filtering of the flue gases, a fraction of these are emitted to the atmosphere
- require long contract periods of building and operating: recover initial investment costs and causing a long term lock-in
- the site location problem: local communities are often unpleased with the idea of locating incinerators in their own vicinity

CONCLUSIONS

The conclusion of this study can be summarized as below:

1. The major potential environmental impacts which are land, water and air have different required criteria that should be fulfilled before setting up a recuperative energy incinerator
2. The ranking of the potential environmental impacts based on the effects that they give to the incinerator, from lowest to highest are:
   land impact $\longrightarrow$ water impact $\longrightarrow$ air impact
3. Although there are some demerits of incinerator, Malaysia should have the incinerator for managing municipal solid waste in the near future to overcome the problem of finding space for landfill
4. One of the suggestion area to build incinerator in Malaysia is at existing landfill such as Pulau Burung Sanitary Landfill

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