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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.

Key words: 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 [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.

The heat produced by an incinerator can be used to generate steam which may then be used to drive a turbine in order to produce electricity. The typical amount of net energy that can be produced per ton municipal waste is about 0.67 MWh of electricity and 2 MJ of district heating. Thus, incinerating about 600 tonnes per day of waste will produce about 17 MW of electrical power and 1200 MJ district heating each day.

Incineration, like carbon adsorption, is one of the best known methods of industrial gas waste disposal. Unlike carbon adsorption, however, incineration is an ultimate disposal method in that the objectionable combustible compounds in the waste gas are converted rather than collected. On the other hand, carbon adsorption allows recovery, of organic compounds which may have more value as chemicals than just their heating value. A major advantage of incineration is that virtually any gaseous organic stream can be incinerated safely and cleanly, provided proper engineering design is used [2].

From previous research, recuperative energy incinerators have improved energy efficiency as a result of placing heat exchangers in the hot outlet gas streams [2]. The recuperative incinerator is comprised of the

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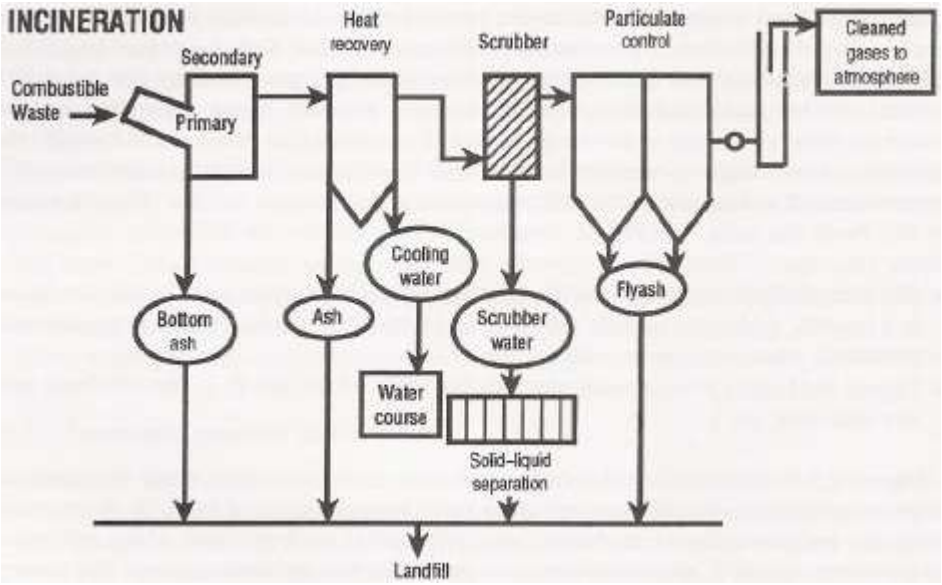

Fig. 1: Incineration process and environmental emissions and discharges [1]

combustion chamber, the waste gas preheater and if appropriate, the secondary, energy recovery heat exchanger.

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 [3].

Incineration has long been and continues to be, one of the most cost-effective technologies for disposing of the world's growing volume of municipal and hazardous waste. Yet anyone who has been involved in an attempt to site an incinerator in recent years knows the political nightmare this process has become. The public has become extremely suspicious of the health and environmental impact of incinerators and not without reason. Incinerators have been known to release unacceptably high levels of toxic substances into the air, including dioxins, furans and other pollutants. Worse, there are no monitoring devices that can continuously measure trace gases in incinerator emissions to allow operators to know exactly what substances are being released and allow for quick corrective action [4].

To address the problems, several teams of university scientists are developing techniques for real-time emissions monitoring that may simultaneously allow industry to operate incinerators in the most efficient manner and assure the public that their health is being protected.

In a preliminary comparison, landfill disposal resulted more hazardous either for human health, or for ecosystem quality and or for use of resources. The effects of POPs on wildlife are reproductive failure and population declines, abnormally functioning thyroids and other hormone system dysfunctions, feminization of males and masculinization of females, compromised immune systems, behavioural abnormalities, tumors and cancers and gross birth defects. 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 relevant people: 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 Environmental Impact Assessment (EIA) data.

Observation on a typical landfill: The observation on chosen typical landfill which was Pulau Burung Sanitary Landfill 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

Fig. 2: Site location map

Table 1: The calorific values at the different spots at pulau burung sanitary landfill [5]

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

of land. Table 1 shows the calorific values at the different spot at this sanitary landfill [5].

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. Some important parts of EIA approval conditions for this sanitary landfill site that related to this paper project are as below [6]:

- The area identified for stockpiling the cover material should be located far from the mangrove area. The design of the landfill is to follow the suitable phases of the project
- Vehicles used for transporting solid waste and cover material area to be fully covered while transporting the material
- Vehicles transporting solid waste, cover material and prima movers are to be maintain in good order so as to avoid noise disturbances when work is carried out
- Leachate, groundwater and gas emissions from the landfill site is to be monitored throughout the life span of the project

Table 2: Impact levels of different environmental items for 10 incinerator plants [7]

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
Terrestrialfauna/flora	5	5	5	5	6	4	6	5	6	5
Aquaticfauna/flora	5	5	5	5	5	6	5	5	6	4
Traffic	5	5	6	4	5	5	5	5	6	5

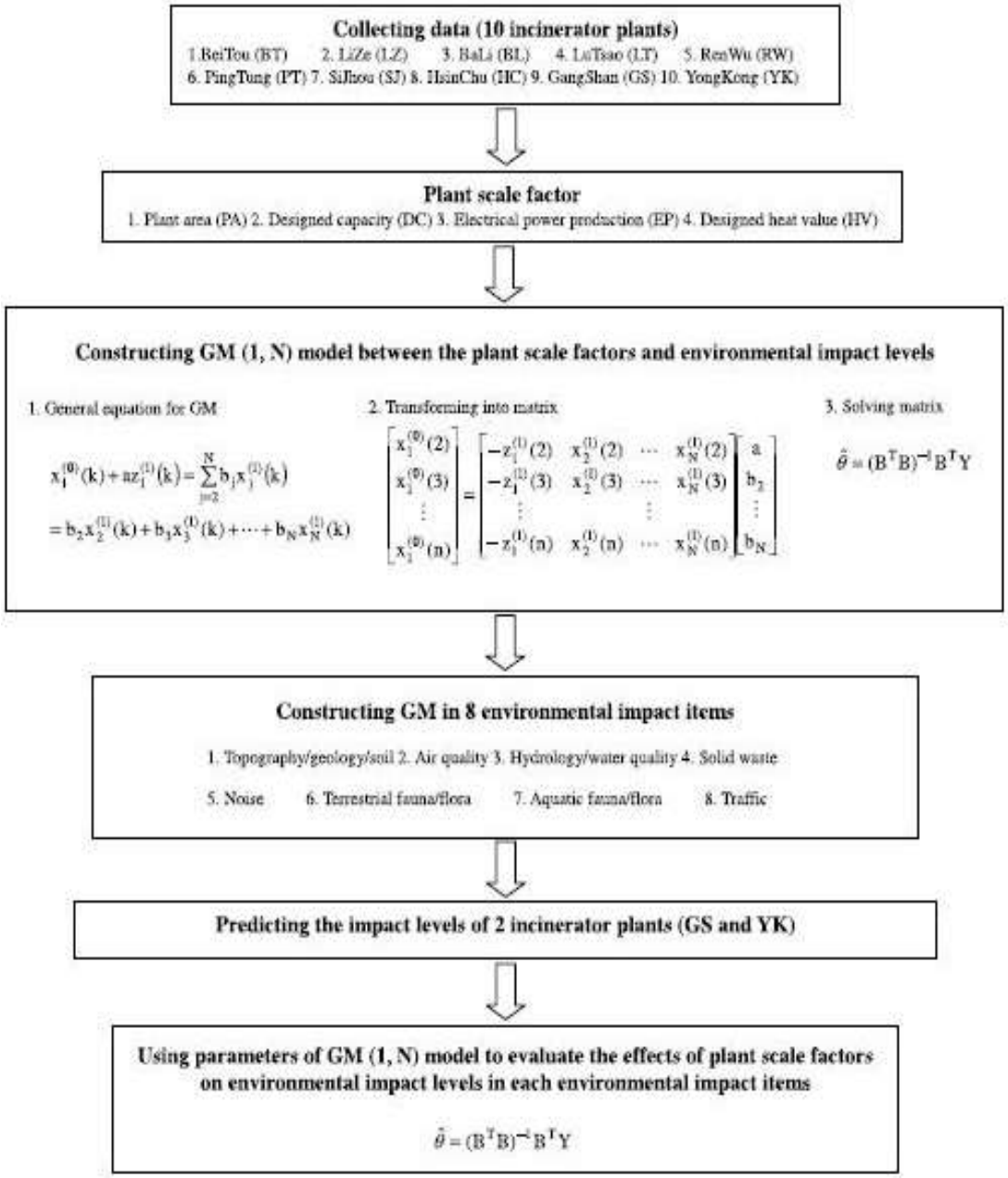

Chart 1: Structure diagram of GM (1, *N*) model [7]

- Parameters to be analyzed for water quality monitoring include BOD, SS, O&G, Ammoniacal Nitrogen, E. Coli, pH, pesticide and heavy metals
- Open burning of solid waste at the site and source for cover material is not allowed

Apart from that, Pulau Burung landfill site also follows the environmental standards, which is Environmental Quality Act, 1974. The act is relating to the prevention, abatement, control of pollution and enhancement of the environment and purposes connected therewith. It is an enabling act that allows the formulation of relevant regulations for the protection of the environment. Thus, one of the ideas to delay the closing date for this landfill site is by constructing a recuperative energy incinerator for municipal solid waste at this existing landfill. Day by day, the amount of wastes increases because of the development of lifestyle nowadays. The map of site location is shown in Fig. 2.

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*). The structure diagram of GM (1, *N*) model can be seen at Chart 1.

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 [7].

Since the impact level was quantified based on the opinion of reviewers, no unit was given for the impact level. The assessment items included topography/geology/soil, air quality, hydrology/water quality, solid waste, noise, terrestrial fauna/flora, aquatic fauna/flora and traffic. The relationship between the quantified impact levels and the plant scale factors of the BT, LZ, BL, LT, RW, PT, SJ and HC incinerator plants were constructed; and the impact levels of the GS and YK incinerator plants were predicted using grey model GM (1, *N*). The impact levels of eight incinerator plants (BT, LZ, BL, LT, RW, PT, SJ and HC) were used to construct GM with plant area, design capacity, electrical power and heating value. After the construction of GM, the impact levels of the GS and YK incinerator plants were predicted using the constructed GM. The impact levels of observed values and model values of different environmental items are shown in Fig. 3. GM (1, *N*) was applicable to predict the environmental impact and analyze the reasonableness of the impact.

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. 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. The anti-incinerator committee had campaigned on this issue since 2002 [8]. This shows majority people did not agree with this incineration construction especially because of environmental issue.

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

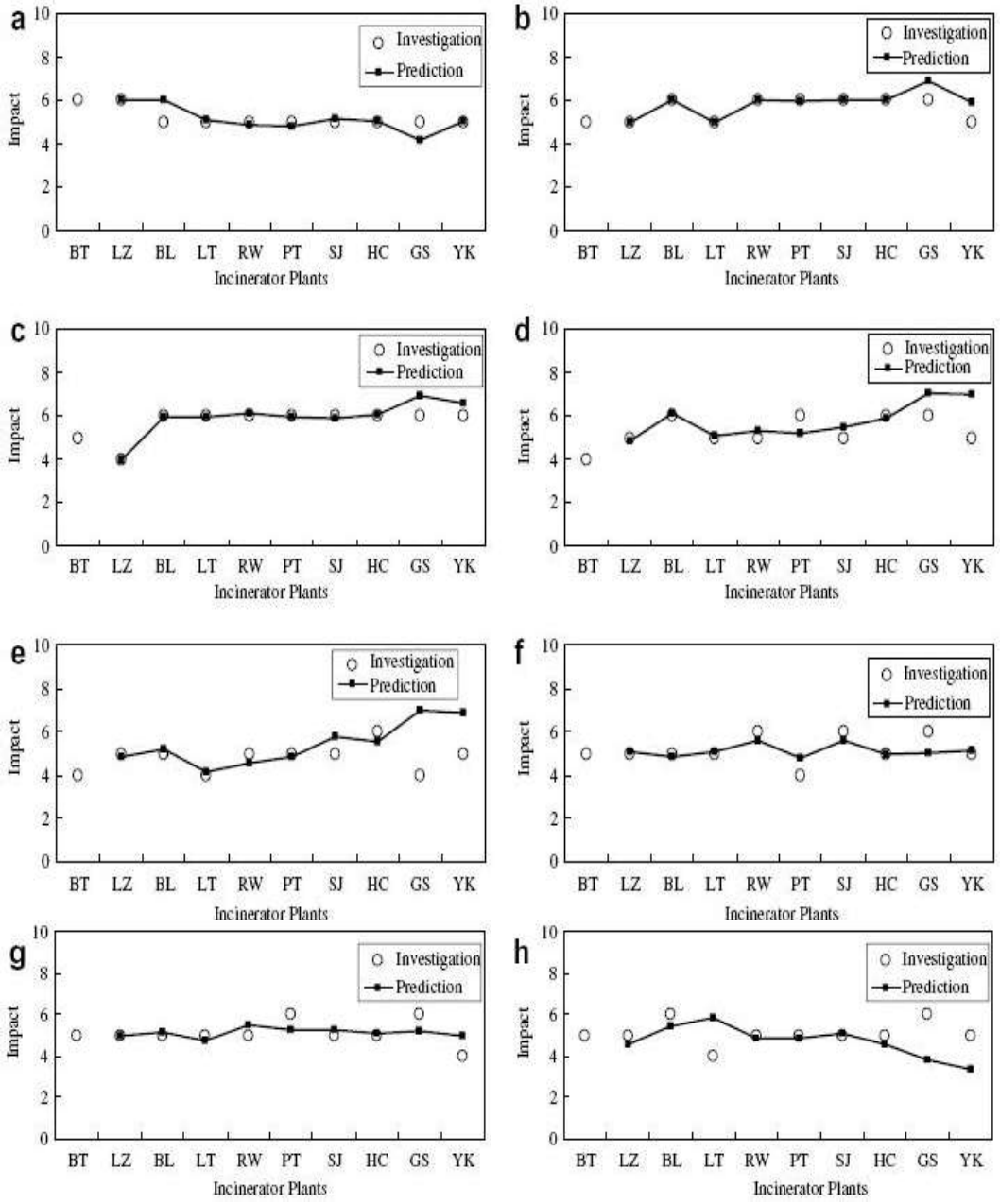

Fig. 3: The impact levels of observed values and model values of different environmental items: (a) topography/geology/soil, (b) air quality, (c) hydrology/water quality, (d) solid waste, (e) noise, (f) terrestrial fauna/flora, (g) aquatic fauna/flora and (h) traffic [7]

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 [9]. Besides, Malaysia's population also has been defined. Malaysia's population includes in addition to 15.274 million people in Peninsular Malaysia, 1.583 and 1.744 million people from Sabah and Sarawak respectively. This puts Malaysia's population at 18.601 million as of 1992. The crude birth rate in 1992 is estimated at 27.7; the crude death rates at 4.6 giving a crude rate of natural increase per thousand in the population of 23.1 i.e. a 2.31% population growth rate. After year 2000, the population increases up to over 20 million people [10].

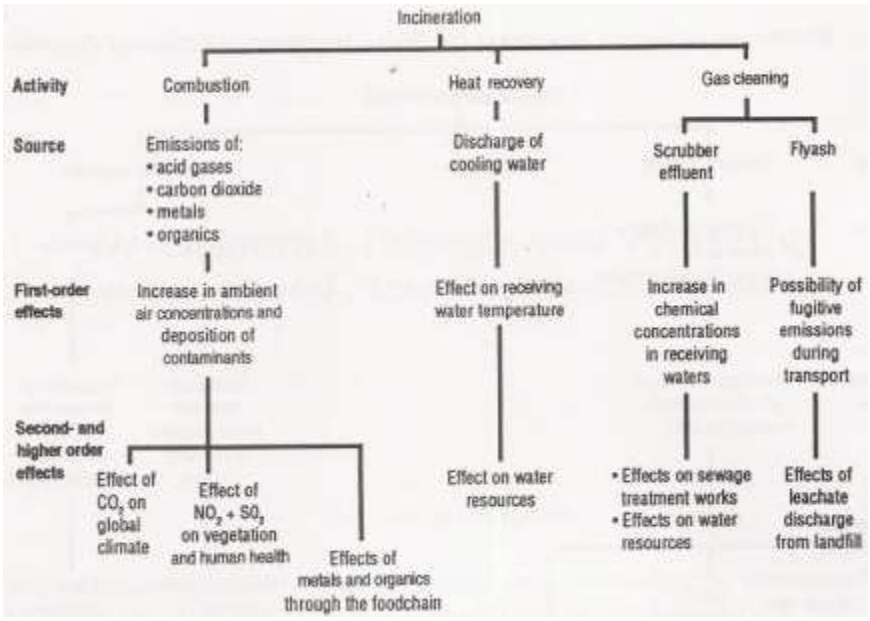

Fig. 4: Incineration-sources of impacts and effects on the environment [1]

Table 3: Basic details of the municipal solid waste incinerator [11]

Basic details	Value
Capacity (ton/day)	1350.00
Capacity of furnace, three sets (t/h/set)	18.75
Stack emission flow rate (Nm^3/min)	1600.00
Stack emission velocity (m/s)	160.00
Stack emission temperature (°C)	150.00
Stack height (m)	120.00
Stack diameter (m)	2.00

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 4 summarizes the key potential impacts of the releases on the environment by incineration process. It can be seen that an emission can have both a direct impact on the medium into which it is released (a first-order effect) and indirect impacts (or secondary and higher-order effects) resulting from contact between a receptor and the contaminated medium. In addition to the controlled releases to the environment, emissions and discharges could occur as a result of accidents or other abnormal events [1].

Pollutant control technology: The pollutants that give the highest impact from incinerator to the environment are air emission and residual incinerator ash. Research from a wide variety of facilities in the US and elsewhere has found that, when properly operated, the best air pollution control equipment can potentially remove up to 99% of dioxins and furans, more than 99% of heavy metals, more than 99% of particulate matter, more than 99% of hydrogen chloride, more than 90% of sulfur dioxide and up to 65% of nitrogen oxides. The pollutants modify the existing situation by releasing the emissions to air via the stack and the discharge of scrubber water or cooling water to a receiving water body or a sewer system. Since emissions to air are from a height, the area that can potentially be affected can extend several kilometers from the site. Some of these impacts will result from emissions of noise, etc., from process plant and equipment, while others (such as the risk of fire or the threat to groundwater from spillages of wastes during handling) will depend on the nature of the wastes accepted at the facility, i.e. the intrinsic hazards [1]. 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 listed 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 separated before the waste burning in the incinerator.

However, the best value of basic details for typical municipal solid waste incinerator can also be used for reference which is as in Table 3 [11].

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:

- 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).
- 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).
- 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 listed 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. As for other complete combustion processes, nearly all of the carbon content in the waste is emitted as CO_2 to the atmosphere. MSW contain approximately the same mass fraction of carbon as CO_2 itself (27%), so incineration of lmetric ton (1.1 short tons) of MSW produce approximately 1 metric ton (1.1 short tons) of CO_2. In the event that the waste was landfilled, 1 metric ton (1.1 short tons) of MSW would produce approximately 62 cubic metres (2,200 cu ft) methane via the anaerobic decomposition of the biodegradable part of the waste. This amount of methane has more than twice the global warming potential than the 1 metric ton (1.1 short tons) of CO_2, which would have been produced by incineration. In some countries, large amounts of landfill gas are collected, but still the global warming potential of the landfill gas emitted to atmosphere in the US in 1999 was approximately 32 % higher than the amount of CO_2 that would have been emitted by incineration [12].
- 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.
- Integrate incinerator as part 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:

- 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.
- The ranking of the potential environmental impacts based on the effects that they give to the incinerator, from lowest to highest are:

land impact ⟶ water impact ⟶ air impact

- 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.
- One of the suggestion area to build incinerator in Malaysia is at existing landfill such as Pulau Burung Sanitary Landfill.

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REFERENCES

1. Judith Petts and Gev Eduljee, 1994. Environmental Impact Assessment for Waste Treatment and Disposal Facilities. John Wiley and Sons Publisher.
2. Donald R. van der Vaart, James J. Spivey, William M. Vatavuk and Albert H. Wehe, 1995. Thermal and Catalytic Incinerators.
3. United Nations Environment Programme, 1991. Newsletter and Technical Publications <Municipal Solid Waste Management>.
4. John Manuel, 1998.
5. Ting Ming Chung and Abdul Yamin Saad, 2008. Recuperative energy potential from a typical landfill in Malaysia. International Conference on Environment 2008 (ICENV 2008).
6. Yomart Environmental Systems (M) Sdn. Bhd., 2001. Environmental Management Plan for Proposed Sanitary Landfill Development at Pulau Burong, Mukim 11, Seberang Perai Selatan, Pulau Pinang for Idaman Bersih Sdn. Bhd.
7. Pai, T.Y., R.J. Chiou and H.H. Wen, 2007. Evaluating impact level of different factors in environmental impact assessment for incinerator plants using GM (1, *N*) model. International Journal of Applied Science and Engineering 2007. 5, 1: 7-16.
8. Loh Yin San and Broga Documentary Team, 2006. ALICE LIVES HERE. Documentation and Popularization of a Community Struggle against the Broga Municipal Waste Incinerator.
9. Consumers' Association of Penang, 2005. Malaysia Country Situation Report.
10. Agricultural Research and Advisory Bureau ARAB], 1995. Environmental Constraints to Pacific Rim Agriculture, Country Report: Malaysia.
11. Jenshi B. Wang, Mao-Sung Wang, Edward Ming-Yang Wu, Guo-Ping Chang-Chien and Yi-Chieh Lai, 2007. Approaches adopted to assess environmental impacts of PCDD/F emissions from a municipal solid waste incinerator. Journal of Hazardous Materials , 152 (2008) 968-975.
12. Nickolas J. Themelis in Waste Management World (www.iswa.org), 2003-2004. An overview of the global waste-to-energy industry. Review Issue, July-August 2003, pp: 40-47.