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“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)”

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**DEVELOPMENT OF EMISSION INVENTORY
OF MAJOR AIR POLLUTANTS FOR INDUSTRY
IN MALACCA HISTORY CITY COUNCIL**

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DECLARATION

“I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged.”

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DEDICATION

Praise to ALLAH the Almighty
To my beloved parents and siblings,
Thank you for your love, care and support.

ACKNOWLEDGEMENT

In the name of ALLAH, the Most Benevolent and the Most Merciful. Alhamdulillah, all praise to ALLAH for the strengths and His blessing unto me upon completing this thesis successfully.

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ABSTRACT

The purpose of this study is to develop an emission inventory for major air pollutants from industrial activities in Malacca History City Council (MBMB). Rapid growth of the demand in industrial sector had contributed to a vast amount of emissions of air pollutants to the environment which led to air pollution. An emission inventory is developed to account the amount of emissions being discharged to the atmosphere in a year by collecting all the data required and referring to related sources. The data will be based on the emission factor of pollutants taken from the CORINAIR 2013 with the activity rate produced from point sources. The type of gas emissions that are taken into consideration are CO₂, NO_x, NMVOC, CO, SO₂ and PM₁₀. The areas of study for this project are Bukit Rambai Industrial Park, Cheng Industrial Park, Krubong Industrial Park and Tangga Batu Industrial Park. The industrial activities in those areas are divided into 7 major sectors which are wood, paper, textile, concrete, chemical, food and drink, and steel and hard work. Overall, the industrial activities in MBMB gives out total emission rates of 1507 ton/year for NO_x, 80 ton/year for SO₂, 85 ton/year for NMCOV, 435 ton/year for CO, 70 ton/year for PM₁₀, and 6808 ton/year for CO₂ emissions. The sector that contribute most of the gas emissions is the food and drinks sector, followed respectively by the chemical sector, steel and hardwork sector, wood sector, paper sector, textile sector, and the least contributor is the concrete sector. The results also shows that the different rates of emission were affected by the activity rate from the industry. The higher the amount of fuel consumption from the activities in the factory, the higher the rate of emissions of pollutants.

ABSTRAK

Tujuan projek ini dijalankan adalah untuk merangka satu inventori mengenai pelepasan gas berbahaya daripada aktiviti perindustrian dalam kawasan Majlis Bandaraya Melaka Bersejarah (MBMB). Perkembangan sektor perindustrian telah menyumbang kepada pelepasan bahan pencemar dalam kuantiti yang banyak dan menyebabkan berlakunya pencemaran udara. Inventori ini dijalankan untuk memperoleh jumlah pelepasan bahan pencemar dalam masa setahun dengan menggunakan data dan sumber yang berkaitan. Data yang digunakan adalah berdasarkan faktor pelepasan bahan pencemar tertentu yang diperolehi daripada CORINNAIR 2013 dengan kadar aktiviti yang dijalankan berdasarkan lokasi yang telah dipilih. Bahan pencemar yang dikaji dalam kajian ini adalah CO₂, NO_x, NMVOC, CO, SO₂ dan PM₁₀. Kawasan kajian yang dipilih pula adalah Kawasan Perindustrian Bukit Rambai, Cheng, Krubong, dan Tangga Batu. Aktiviti perindustrian dalam kawasan yang dipilih kemudiannya dibahagikan kepada 7 sektor iaitu sektor kayu, kertas, tekstil, konkrit, kimia, makanan dan minuman, serta sektor pemprosesan besi. Secara keseluruhannya, aktiviti perindustrian dalam kawasan MBMB telah menyumbang sebanyak 1507 ton/tahun untuk NO_x, 80 ton/tahun untuk SO₂, 85 ton/tahun untuk NMCOV, 435 ton/tahun untuk CO, 70 ton/tahun untuk PM₁₀, dan 6808 ton/tahun untuk CO₂. Sektor yang menghasilkan pelepasan bahan pencemar paling banyak adalah sektor makanan diikuti oleh sektor kimia, sektor pembuatan besi, kayu, kertas, tekstil dan akhir sekali sektor konkrit. Hasil kajian menunjukkan bahawa jumlah pelepasan bahan pencemar dipengaruhi oleh jenis dan kadar aktiviti yang dijalankan. Semakin banyak jumlah bahan api yg digunakan, semakin tinggi jumlah pelepasan bahan pencemar.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE F CONTENT	viii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF ABBREVIATIONS	xiv
	LIST OF APPENDIXES	xv
CHAPTER 1	INTRODUCTION	
	1.1 Background	1
	1.2 Problem statement	2
	1.3 Objectives	3
	1.4 Scope	3
CHAPTER 2	LITERATURE REVIEW	
	2.1 Introduction	4
	2.2 Air Emissions	4
	2.3 Source of Air Emission	6
	2.3.1 Point Source	8
	2.3.2 Area Source	8
	2.3.3 Mobile Source	9
	2.3.4 Natural Source	9

2.3.5	Agricultural Source	10
2.4	Type of Gas Emissions	11
2.4.1	Particulate Matter (PM)	11
2.4.2	Carbon Monoxide (CO)	13
2.4.3	Nitrogen Oxide (NO _x)	15
2.4.4	Carbon Dioxide (CO ₂)	16
2.4.5	Hydrocarbon (HC)	17
2.5	Emission Inventory	18
2.6	Emission Factor	20
2.7	Area of Study	20
2.8	Summary of Previous Studies	22
CHAPTER 3	METHODOLOGY	
3.1	Introduction	25
3.2	Flowchart	25
3.3	Emission Sources of The Study Domain	27
3.4	Estimation of Emission Approach	27
3.5	CORINNAIR 2013	27
3.6	Tier 2 Approach	28
3.7	Data Collection Through Questionnaire	29
3.8	Site Survey	29
3.9	Summary	29
CHAPTER 4	DISCUSSION	
4.1	Point Source Emission	30
4.2	Emission Rate	33
4.2.1	Oxides of Nitrogen (NO _x)	34
4.2.2	Sulphur dioxide (SO ₂)	35
4.2.3	Non-methane volatile organic compound (NMVOC)	37
4.2.4	Carbon Monoxide (CO)	39
4.2.5	Particulate Matter (PM ₁₀)	41

4.2.6	Carbon Dioxide (CO ₂)	44
4.3	Overall Finding	46
4.4	Limitation	47
CHAPTER 5	CONCLUSION	
5.1	Conclusion	49
5.2	Recommendation	50
	REFERENCE	51
	APPENDIX A	56
	APPENDIX B	58
	APPENDIX C	59
	APPENDIX D	60
	APPENDIX E	61

LIST OF TABLES

NO	TITLE	PAGE
2.1	Types of pollutant and sources	6
2.2	Health concern cause by PM ₁₀ and PM _{2.5}	12
2.3	Human response on the effects of Carbon Monoxide	14
2.4	Summarization on previous studies	22
4.1	Number of factory according to each type	30
4.2	Total fuel consumption for the seven sectors	31
4.3	Emission factor for fuel combustion activity for diesel. Fuel oil, natural gas, and wood pellet in (g/GJ)	32
4.4	Emission factor for fuel consumption in non- combustion activity	32
4.5	Emission from industries in MBMB	33

LIST OF FIGURES

NO	TITLE	PAGE
2.1	Air emissions sources, transport and effect	5
2.2	Air emissions for agricultural source	10
2.3	Particulate matter	11
2.4	Nitrogen oxide structure	15
2.5	Changes in the global atmospheric contain of nitrogen oxide from 1978 to 2010	16
2.6	Carbon dioxide molecule	16
2.7	Changes in global atmospheric methane over the past three decades from 1985 to 2010	18
2.8	Asia national emissions on 2000	19
2.9	Map of the MBMB territory	21
3.1	Flowchart for the project	26
4.1	The rate of emission of NO _x according to the type of sectors	34
4.2	Thematic map fo NO _x emissions from MBMB region	35
4.3	The rate of emission of SO ₂ according to the type of sectors	36
4.4	The thematic map for SO ₂ emission from MBMB region	
4.5	The rate of emission of NMVOC according to the type of sectors.	38
4.6	The thematic map for NMVOC emission from MBMB region	39

4.7	The rate of emission of CO according to the type of sectors.	40
4.8	The thematic map for CO emission from MBMB region	41
4.9	The rate of emission of PM ₁₀ according to the type of sectors.	42
4.10	The thematic map for PM ₁₀ emission from MBMB region	43
4.11	The rate of emission of CO ₂ according to the type of sectors.	44
4.12	The thematic map for CO ₂ from MBMB region	45

LIST OF ABBREVIATIONS

C	=	Carbon
CO	=	Carbon Monoxide
CO ₂	=	Carbon Dioxide
DEM	=	Department of Environmental Management
DOE	=	Department of Environment
DSM	=	Department of Statistic Malaysia
EMMP	=	Environmental Mitigation and Monitoring Plan
EPA	=	Environmental Protection Agency
H	=	Hydrogen
MBMB	=	Malacca History City Council
NMVOG	=	Non Methane Volatile Organic Compound
NO _x	=	Oxides of Nitrogen
O ₂	=	Oxygen
O ₃	=	Ozone
PM	=	Particulate Matter
PM ₁₀	=	Particulate Matter smaller than 10 μm
PM _{2.5}	=	Particulate Matter smaller than 2.5 μm
Pb	=	Lead
SO ₂	=	Sulphur Dioxide
USEPA	=	United State Environmental Protection Agency
VOC	=	Volatile Organic Compound

LIST OF APPENDIXES

NO	TITLE	PAGE
A	Sample questionnaire	53
B	Sample calculation	55
C	Gantt chart for PSM 1	56
D	Gantt chart for PSM 2	57
E	Poster	58

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Generally, emission is defined as the act of producing or sending out something such as energy or gas from a source (Webster. M, 2014). In terms of air pollution, it is used to describe particles or gases that are emitted to the environment by different sources. These air emissions are either beneficial or can bring harm to the surroundings especially to living things. For example, the oxygen (O_2) emitted by plants is needed by living creatures to breath and in return, they emitted carbon dioxide (CO_2) which is used by plants to make food through photosynthesis. However, other emissions such as carbon monoxide (CO), sulphur dioxide (SO_2) and also particulate matter (PM) may bring harm to people as these gases may affect the breathing mechanisms of humans. Therefore, emissions inventory was introduced by Environmental Protection Agency (EPA) to have better understanding about the sources that contribute to air pollutions and the health and environmental effects of the pollutions.

According to EPA, there are 187 of hazardous air pollutants. However, there are only six types of gases that are considered harmful in emission inventory which are particulate matter (PM), sulphur dioxide (SO_2), carbon monoxide (CO), lead

(Pb), Oxides of Nitrogen (NO_x) and ozone (O₃). These gases are determined as hazardous gases because they are majorly emitted to the environment by industrial activities, development of technologies and many other factors.

This inventory is also done to see the rate of emissions to air in each area of sources. However, the rate of emissions will change each year based on the changes in activities and resources used such as fuel and machinery in different places. The inventory are more concerned in controlling the air pollutant of certain places and to get clean air. This may help to control and improve the quality of air by analyzing different sources like area, point, mobile and agriculture. Therefore, Malacca History City Council (MBMB) can analyze the emissions inventory to lead the state to have cleaner and more productive air quality.

1.2 PROBLEM STATEMENT

Air is the most essential resource for humans as it is the prime cause of life on our planet Earth. Air consist of 79% nitrogen, 20% oxygen, and 1% other gases, mostly carbon dioxide and traces of other gases (Spellman, 2013). Air is naturally clean and suitable for human and animal survival but due to industrialization and other air pollution causes, the air is not safe to breathe and becomes very harmful to human's health. Air pollution is one of the major problems faced by major cities and countries all around the world because of the exponential growth of industrial activities for the past decade. The pollutants are being released to the environment without proper control and management especially in the emission of harmful gases. Gas emission is the discharge of pollutants into the atmosphere from stationary sources such as smokestacks, and other vents, and from surface areas of commercial or industrial facilities and mobile sources (EPA, 2011).

One of the main sources of air pollutants is industrial activities such as factory with combustion. Since the activities are conducted in large scale, the harmful substances or pollutants from industrial activities are ten times more than any other emission from other source. Air pollution will affect human's health and also the environment. It will contribute to the incidence of respiratory diseases,

contaminate drinking water and vegetation, disorientation, decreased muscular coordination and visual acuity. As for the environment, it can cause acid rain, damage aquatic life, the thinning of the ozone layer, greenhouse problems and also lead to erosion of buildings (Sharma, 2009).

Therefore, Malacca Historic City Council (MBMB) have taken serious concern regarding this issue since the region under MBMB supervision is half of the Malacca state. Besides, it consists of areas that may lead to the contribution of air pollutants emissions. It consist of 503, 127 of population of people (MBMB, 2013). The initiative is done due to the development of Malacca as a historical and vacation city. Hence, a research on air quality will be done on the air emissions to take control of this issue. By doing this research, the results on the emission of air in a certain pin point area can be shown. It may help to visualize the air index in Malacca city accordingly especially in MBMB region.

1.3 OBJECTIVES

1. To develop emission inventory of major air pollutant caused by the industrial activities in the territory of Malacca History City Council or MBMB.
2. To determine the emissions rate of each type of air pollutants.

1.4 SCOPES

1. This emission inventory covers the specific industrial area of territory of MBMB which are Bukit Rambai Industrial Park, Cheng industrial Park, Tangga Batu Industrial Park and Krubong Industrial Park.
2. The pollutants source that will be analysed is the point source.
3. There are only 6 major pollutants included in this inventory which are PM₁₀, NO_x, SO₂, CO, NMVOC and CO₂.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Air emission is generally the gases that are released to the atmosphere through the natural causes or human causes. These gases are useful in daily life but a few types of gases can be hazardous too. Some of the examples of hazardous gases are particulate matter (PM), carbon monoxide (CO), sulphur dioxide (SO₂) and nitrogen dioxide (NO₂). The excess of these gases may cause air pollution which will affect the air quality and may harm the human breathing. In order for Malacca to achieve a green technology state, the rate of air quality must be analyzed to determine whether the air quality is below the dangerous rate appointed. In this chapter, a definition on gas emissions, types of sources, types of gases, the area of study and the summary of previous studies will be reviewed and discussed.

2.2 AIR EMISSIONS

Air pollution has been one of the most serious environmental concerns because of its negative impact on the air quality, public health, and the economic development, and as a result need to be paid much attention to the effective control (Kara et al., 2013). This type of pollution is caused by the pollutants which are emitted to the air from

various sources and mainly occur in development area. Air emissions is better known as particles or gases that were released into the atmosphere through natural or industrial activities that lead to exposure of hazardous gases and harmful to human being and potential environmental problems (Zhang. X, 2013).

There are many types of sources of air emissions and many examples for each type, such as power plants, factories, domestic households, buildings, cars and other vehicles. The types of gases that are considered as harmful gases by the United States Environmental Protection Agency (EPA) are particulate matter (PM), sulphur dioxide (SO_2), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2) and ozone (O_3). These gases are classified as hazardous gases and toxics to the air (Air Emission Sources, 2011).

All of these gases are discovered to be hazardous gases which can be harmful to human especially in breathing systems. Figure 2.1 is an example of pollutant emissions sources, how the pollutants are transported in the atmosphere and the general effect caused by them.

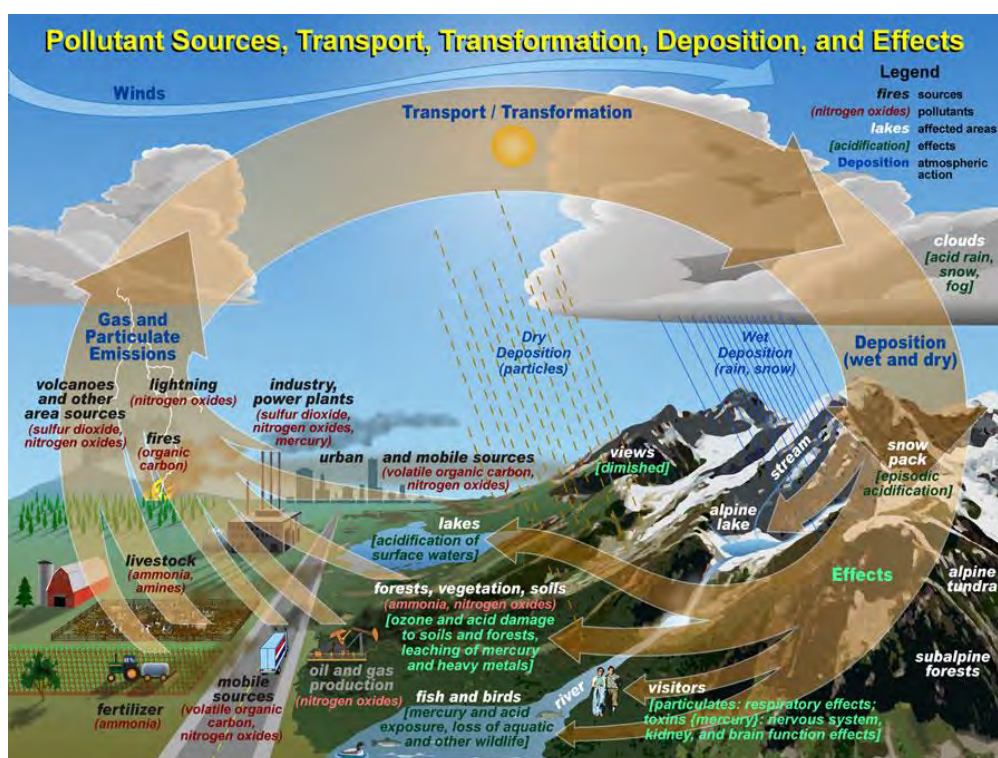


Figure 2.1: Air emissions sources, transport and effect

(Source: Natural Park Service, USA, 2013)

2.3 SOURCES OF AIR EMISSIONS

Air emissions sources can be natural or caused by humans. Natural sources of pollutants include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity. Human sources include emissions the exhaust of factories for manufacturing, from fossil fuel burning whether it is oil, gas or coal, and also the waste product from burning fuels for vehicles and transportation (C. Jerry, 2010).

When the pollutants are emitted to the atmosphere, they will be interacting with each other and the environment through various ways chemically and physically depending on the environment conditions. The pollutants can be divided into two group, primary and secondary pollutants. The primary pollutants are from human activities while secondary pollutants are the interaction of primary pollutants with the atmosphere.

As stated earlier, the type of gases that were a concern are particulate matter (PM), carbon monoxide (CO), sulphur dioxide (SO₂) and nitrogen dioxide (NO₂). From Table 2.1, it is stated that most of these harmful gases were released from burning and combustion activities. Not to mention, burning and combustion are majorly occur in all industries and activities such as industrials process and refinery, burning fuel in vehicles and also agricultural process.

Table 2.1: Types of pollutant and sources

(Source: European Lung Foundation (2011))

POLLUTANT	SOURCE
PRIMARY POLLUTANTS	
Sulphur Oxide (SO)	From burning coal and oil
Nitrogen Oxide (NO) / Nitrogen Dioxide (NO ₂)	From burning fuel in vehicles and other industrial process

Carbon Monoxide (CO)	From combustion processes with low oxygen content, burning wood, coal, burning fuel in vehicles
Carbon Dioxide (CO ₂)	From volcanic activities and hot springs, combustion processes, vehicles and power plants
Volatile Organic Compound (VOC)	Evaporates from various sources such as cleaning agents, fabric softeners, and furniture polish
Particulate Matter (PM)	Fine particles from natural erosion, burning of fossil fuels
Ammonia (NH ₄)	From fertilisers and agricultural processes
Lead (Pb)	Naturally occurring, produced by smelters, contained in old painting and plumbing
Persistent Organic Pollutants (POP)	From industrial processes and waste incineration.
SECONDARY POLLUTANTS	
Particulate Matter (from sulphates and nitrates)	Fine particles either man made or natural.
Ozone (O ₃)	From chemical reaction with sunlight

There are five types of sources that contribute in the emissions of pollutants which are stationary sources, area sources, mobile sources, agricultural sources and natural sources. However, the major classification that is being considered by the USEPA are anthropogenic sources (point, area and mobile sources) and the natural sources.

2.3.1 Point source

Point source is majorly focused on the industrial facilities such as refineries, power plants, incinerators, hotels and hospitals (Sopajaree, 2012). Point sources are usually stationary sources that roughly contribute 10 tons per year of any type hazardous air pollutants or 25 tons of a more than one type of pollutants per year (GoodGuide, 2011).

Point source is also defined as a stationary location or fixed facility from which pollutants are released in a big amount. Moreover, pollutants mostly released to the atmosphere through chimneys at a certain height that is sufficient enough to provide ample dilution before the pollutants reach the ground level (Andrew & Harrison, 2005). Industrial factory is considered as a point source as it produces mass amount of gas emissions while being located in a fixed area.

2.3.2 Area source

Area source is almost the same as point source but it is considered as a small contributor as it emits less than 10 tons per year of one type air pollutant or less than 25 tons per year of a combination of pollutants (GoodGuide, 2011). The sources that may release hazardous air pollutants are painting or surface coating, fuel combustion, equipment leaks, and material discharged through vents or transferred location (Maine DEP, 2013).

Other than that, gas stations, shopping mall, residential area, and light industrial area also can be considered as the sources contributors. Although it is only considered as a small portion in air emissions, similar health and environmental risks as the point and mobile source also can be caused by this source. The emissions from the area source can be calculated by various methods and depend on the data available by the area source.

2.3.3 Mobile sources

The emission in these sources is defined as pollutants emitted from vehicles that can affect the air quality and cause problems to human and environment (EPA, 2013). It also includes sources that move from place to place. Mobile source can be divided into two categories which are on road mobile source and off road mobile source. On road mobile sources are the all the vehicles on the road or the emission area which are divided into two major classes, light duty and heavy duty. Light duty vehicles are passenger cars, light duty truck and even a motorcycle. Heavy duty vehicles are trucks that have more than 8500 *lbs* gross vehicles weight rate. (Rhode Island DEM, 2014).

Off road mobile source encompasses a variety of equipment that moves under its own power or are capable of being moved from site to site such as the recreational engines, construction equipment, farm equipment, aircraft, marine vessels and locomotives (Rhode Island DEM, 2014). Mobile source had been listed as major contribution of air emission for most of the country (Sopajaree, 2012). This is due to the rapid increment of the total usage of vehicles year by year.

2.3.4 Natural sources

Apart from the pollutants emitted through industrialization and vehicles, nature also contributes to air pollution. Natural sources are sources that contribute to air pollution without the involvement of human beings and any other artificial factor (Woodford, 2014). Some of the examples of natural sources are volcanic eruptions, geysers, radioactive decays, and forest fires. For example, volcanoes produce numerous amounts of particles and gases, thus volcanic eruptions caused the substances rose up into the atmosphere.

Apart from that, forest fires are also a natural phenomenon that produces potentially harmful gas and particulate matter in large amount (Friedl, 2014). In addition, biogenic sources such as pine trees release volatile organic compounds (VOC) and about 80% of the overall VOC emissions are from biogenic sources.