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EMSSION INVENTORY FOR AREA SOURCES
(CASE STUDY FOR PETROL STATION)

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This thesis is submitted as
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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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DATE   :   …………………………………...

Special for

**Ayah, umi, angah, emiey, adik
and for the special one
Thank You**

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ABSTRACT

Melaka Historic City Council (MBMB) has been choose to join this programme. There are many air pollutant that emit to the enviroment for example Ammonia (NH_3), Carbon monoxide (CO), Nitrogen oxides (NO_2), Non-methane volatile organic compounds (NMVOC) Sub-10 micron particulate matter (PM_{10}), sulfur dioxide (SO_2), and Lead (Pb). In this study, the emission programme will be held at petrol station for automotive refuelling activity that emit NMVOC from the petrol station. Sub-district such as Cheng, Klebang, Duyong, Tangga Batu, Tanjung Keling, Bukit Katil, Malim Jaya, Bukit Rambai, Peringgit, Melaka Tengah, Bandar Melaka, and Semabok has been covered in this study and twenty three petrol station at each sub-district data emission of NMVOC is succeed to be collected. The objectives of this study is, to obtain the data emission of NMVOC that released by petrol station at automotive refuelling activity. Next, the objective is to calculate the amount of pollutant that is NMVOC that emitted from refuelling activity at petrol station. Futrhermore, method use to approach the objectives of this study is by survey and calculation of emission of NMVOC by following CORINAIR manual and using method tier 2. To analyse the most polluted area that emitted by petrol station by using software Map Info 10.0. Mostly, all data needed is private and confidential to all oil and gas company .The result of this study, Cheng is the highest amount of emission NMVOC and the lowest amount of emission of NMVOC is Tanjung Keling.

ABSTRAK

Majlis Bandaraya Melaka Bersejarah (MBMB) telah dipilih untuk menyertai program inventori pelepasan gas pencemaran alam sekitar. Terdapat pelbagai jenis gas pencemaran udara yang telah dilepaskan oleh banyak sumber seperti Ammonia (NH_3), Karbon Monoksida (CO), Nitrogen dioksida (NO_2), *Non-methane volatile organic compound* (NMVOC), *Sub-10 micron particulate matter* (PM_{10}), sulfur dioksida (SO_2), dan Plumbum (Pb). Dalam kajian ini, program inventori pelepasan gas pencemaran telah diadakan di setiap stesen petrol untuk aktiviti pengisian bahan bakar automotif yang telah mangakibatkan penyebaran gas NMVOC kepada alam sekitar. Daerah seperti Cheng, Klebang, Duyong, Tangga Batu, Tanjung Keling, Bukit Katil, Malim Jaya, Bukit Rambai, Peringgit, Melaka Tengah, Bandar Melaka, dan Semabok telah menjalankan sesi kajian selidik. Objektif utama kajian ini ialah untuk mendapatkan data pengeluaran gas NMVOC daripada stesen petrol semasa aktiviti pengisiaan bahan bakar automotif dijalankan di setiap stesen petrol. Seterusnya, objektif program ini adalah untuk mengira pengeluaran NMVOC semasa process pengisian bahan bakar dilakukan di setiap stesen petrol. Tambahan lagi, metadologi yang digunakan untuk mencapai objektif kajian ini adalah dengan cara melakukan kaji selidik dan pengiraan pengeluaran NMVOC merujuk kepada manual corinair dan menggunakan metadologi tier 2. Selain itu, untuk menganalisa tempat yang paling banyak terdedah dengan pengeluaran gas NMVOC akan di analisis menggunakan perisian Map Info 10.0. kesemua data yang diperlukan untuk melakukan kajian ini merupakan data yang sulit dan rahsia bagi syarikat minyak dan gas. Kesimpulannya, Cheng merupakan daerah yang paling banyak mengeluarkan gas NMVOC berbanding Tanjung Keling yang hanya mengeluarkan sedikit pengeluaran gas NMVOC.

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CHAPTER 1

INTRODUCTION

1.0   BACKGROUND STUDY

Emission inventory (EI) is the program that trains for clean air in smaller cities. This program also known as a quality management program. This program is about a comprehensive of database that contain information about location of sources, type of sources, process that resulting emission of air pollutant, and the rates of emission that emitted into the air and into surrounding. Besides that, this EI program is used to conduct and use EI as part of the measurement of air quality level and to manage the air quality of the environment. This EI program will be covering the area of Melaka Historic City Council (MBMB) Melaka, Malaysia. The administration area for MBMB is around 30.86 km^2**. Figure 1. 1** shows the map of MBMB territory such as Tanjung Keling, Peringgit, Cheng, Melaka Tengah, Duyong, Bukit Katil, Bukit Rambai, Klebang, Semabok, Malim Jaya, Bandar Melaka and Tangga Batu.
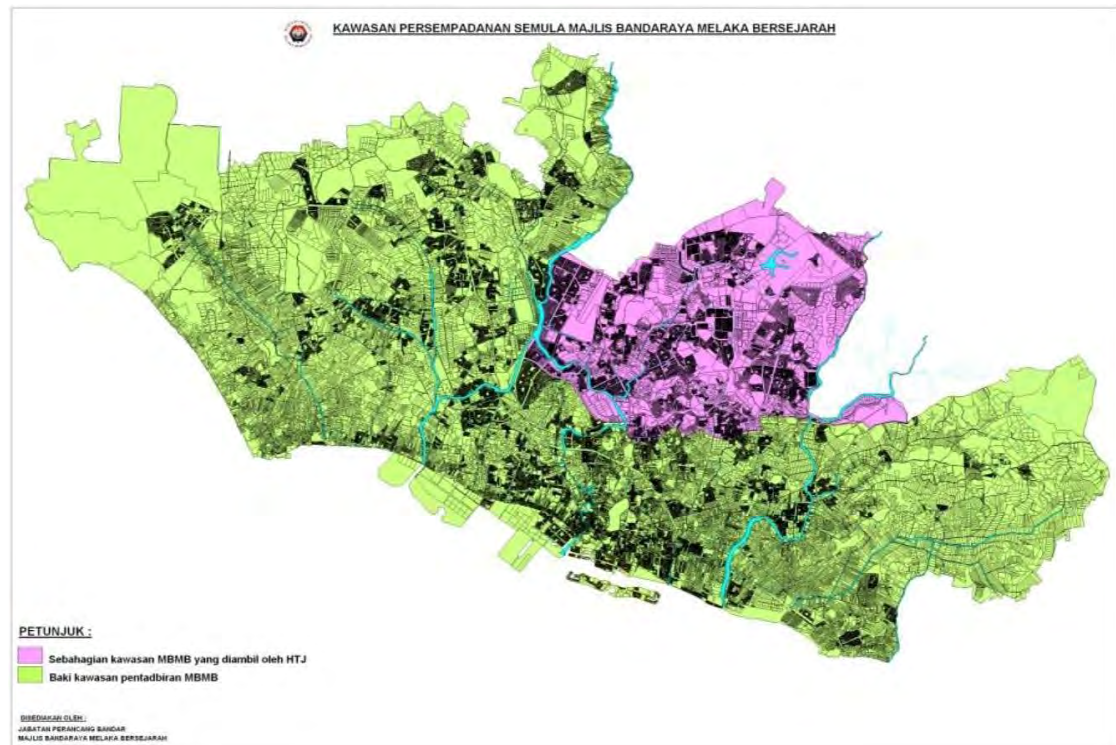
Figure 1. 1: The region of MBMB territory

(http://www.mbmb.gov.my/warga-mbmb)

In this program, there are four major emission sources that going to involved in this quality management program that are point sources, area sources, and mobile sources. Point sources are the emission sources that including manufacturer and production places, for example; hospital, boiler for hospital and hotel and industries. Other than that, area sources also known as non-point sources. This type emission source is included household or residential areas, petrol station, bus terminals and construction sites. For the mobile sources are defined as the equipment that can generate air pollution that can be moved from one place to another place. In the other hand, this type of emission is categorized into on-road and non-road. For on- road sources is the vehicles that use petrol, diesel and natural gas for example car and motorcycles. Meanwhile, for non-road sources are the equipment that is used for agriculture, construction and transportation that use petrol and diesel.

Next, all the data must be taken based on location of the emission sources, quantity of pollutant that emitted from the sources and type of sources can effect on the quality of air of each study area. The reasons to conduct this program is to get an idea and strategies to improve the quality of air of affected area. Besides that, this program also use to evaluate and make some review of emission of pollutants and impact to the pollution of some places. The reasons of this program is to make a legal decisions and action and revise the current air quality of the affected area.

There are many types of factor that can make pollutant emitted from emission sources to the environment. Major factor of the air pollution is caused by human activity for example the activity like open burning, forest fire, construction site, and many more. All this kind of human activity can give harm to human health, animal life, plant growth, and changes of climate and weather. Types of pollutant that emitted from the emission sources that is Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Lead (Pb), Volatile Organic Compound (VOC), Ozone (O_3) and Carbon Dioxide (CO_2). The type of emission that will be studied is area sources and the case study is for a petrol station. Petrol stations are one of the places that contributes pollution to the environment, the most pollutants that emitted from the petrol station is Non-methane Volatile Organic Compound (NMVOC).

1.2   PROBLEM STATEMENT

Emission inventory for area sources case study at petrol stations is need to study the emission of pollutant emitted by the petrol station is (NMVOC). In each petrol station, the amount of the NMVOC emitted is different and this depends on time and seasonal such as weekdays and weekend. Other than that, emission level could be increased by fuel evaporation.

In addition, there are various type of process that need to be covered at petrol station but in this study, only the process of automotive refuelling activity that need to give more attention. However, the major problem in this study is to get the data from the petrol station due to the fact that most of this data are private and confidential.

1.3   OBJECTIVES

The objectives of this study are to obtain data of emission of NMVOC released by petrol station. Other than that, this study is to calculate the amount of pollutant NMVOC that will be released by petrol station in MBMB territory. Next, the objective is to analyse the emission of NMVOC that emit from the petrol station to the environment by using map analysis.

1.4   SCOPE

The scope for this study is field visit. This field visit will be done at petrol station and data mining. Next, the method use is data processing data based on the survey form. This survey form will be distributed to each petrol station in MBMB territory. In survey form, the question will be asked is about the type of the petrol use such as Ron 95, Ron 97 and diesel, and the amount of fuel sold in litre per day. Lastly, the data from the survey form will be calculated and documented. The NMVOC will be calculated based on the amount of the fuel sold for each petrol station at MBMB area.

CHAPTER 2

LITERATURE REVIEW

2.0   INTRODUCTION

Emission inventory is the programme that train for a clean air. This programme **is** concern about the amount of pollutant that emit to the environment. In this programme, there are various types of method that can be apply to get the quantitative and qualitative data from various types of pollutant sources. The main objectives for this emission inventory programme is to know the type of pollutant that emitted to the environment. Next, the objective of this programme is to analyse the effect of the air pollution that can affect human health, animal growth and ecosystem. Emission inventory data can be calculate the product of emission factor and the activity rate because to make it easy to compare the result of emission before and after control the emission of air pollutant to introduce the prevention steps or strategies to reduce the air pollution of environment.

2.1 TYPES OF MANUAL USE FOR EMISSION INVENTORY PROGRAMME

The emission inventory programme has so much concern about the amount of pollutant sources in studied area. In this programme, there are various types of method that can be apply to get the quantitative and qualitative data from various types of pollution sources. In this study, most of pollutants that emit from the petrol station is a volatile organic compound (VOC) and non-methane volatile organic compound (NMVOC). This pollutant will emit when oil distributing process of petrol occurs at petrol station. Emission of oil distribution process can be occurred in various process that is from bulk storage tank, from the petrol station to storage tanks, transportation of refuelling activity from tank to the vehicle and other sources of NMVOC and VOC emission.

There are various type of manual can be used to obtain the data needed and how calculation of emission for each petrol station need to be calculated. Therefore, type of manual that can be used in this study are United Kingdom National Atmospheric Emission Inventory (NAEI), a programme to improve the air quality in Mexicali, Baja California, USA (PROAIR), United States Environmental Protection Agency (USEPA), and Core Inventory air emission, (CORINAIR). Each method is different in the step to get the data, time period to do the research that depends on the geography of the area of the country, and type of pollutant that emit to the environment in various sources.

2.1.1 UNITED KINGDOM NATIONAL ATMOSPHERIC EMISSION INVENTORY (NAEI)

Many country has manual for emission inventory programme Many countries have developed emission inventory database as part of their own air quality management programme and total pollutant emission for Glasgow and Edinburgh, Scotland (Harrop, 2002). The emission inventories for the constituent countries of the UK for the period 1990 to 2010, for the following priority Air Quality pollutants such

as Ammonia (NH_3), Carbon monoxide (CO), Nitrogen oxides (NO_X as NO_2), Non-methane volatile organic compounds (NMVOCs) Sub-10 micron particulate matter (PM10), Sulphur dioxide (SO_2), and Lead (Pb) (J.MacCarthy, G. Thistlethwaite et al., 2012).

The NAEI is made up of the Greenhouse Gas Inventory (GHGI) and the Air Quality Pollutant Inventory (AQPI) and deliver these estimates, the GHG inventory team at Ricardo-AEA collect and analyse information from a wide range of sources – from national energy statistics through to data collected from individual industrial plants ("National Atmospheric Emission Inventory", 2013). Method that will use is based on the number of resources that will used to analyse UK emission for NAEI point data base, emission mapping by grid data, regional data based on the activity data trends to develop Greenhouse Gas (GHG) inventories, and generic parameter and proxy data (J.MacCarthy, G. Thistlethwaite et.al., 2012).

For NAEI point data base on production data. This data request from the manufacturer industry. The emission of pollutant is based on production data for example data from power station, refineries and cement and lime manufacturer and others. Besides that, the location of site will extract all emission with geographical area. The point source database covers nearly 100% of emissions, and is regarded to be the best available dataset for such sources, which is based on energy use and emissions data derived from regulatory agency sources that are subject to quality checking and independent verification (J. MacCarthy, G. Thistlethwaite et.al., 2012)

2.1.2   PROAIR

This programme to improve the air quality (PROAIR) at Mexicali, Baja California, USA. The purpose of this programme is to improve the air quality of Mexicali. This programme has been started from 2010-2015 and this project is the result of cooperation from combination of local economic sector, the society and the government (Margarito Quintero, Lourdes Meza, Miguel Canales, 2010). The factor that may cause higher emit of pollutant is due to the highest of urbanisation of industry and entrepreneurial. The purpose of this programme is to protect health of population,

reducing the concentration pollution in atmosphere and to control emission by industry. There are five strategies on each group with different specific action that applied according to;

- Industry, commerce, and services
- Motor and vehicles
- Urban and transport management
- Ecological recovery
- Research and international agreement

Mexico has set standards for six categories of pollutants: ozone, carbon monoxide, total suspended particulate maters, sulfur dioxide, lead, and nitrogen oxide (Margarito Quintero, Lourdes Meza et.al., 2010). Type of emission is based on three types that is point sources, area and natural sources, and motor vehicles sources. Emission of point source, area source, and motor vehicle emissions that all result from human activities, natural source emissions represent emissions occurring regardless of human presence.

Natural emissions should be estimated in order to provide an accurate assessment of background conditions for a particular area, to understand the relative significance of each source category contributing to the total emissions, and to develop appropriate air quality control strategies ("Mexico Emissions Inventory Program Inventory Methodology Development for the Country of Mexico: Lessons Learned from the Application of the Mexico Emissions Inventory Methodology in the City of Mexicali, Baja California," 2000). VOC sources is emitted from major contributor from the vehicle emission that powered by gasoline and diesel (Vega et al., 2011). In addition, emission from gasoline distribution emission factors are based on typical gasoline volatility is much higher than diesel volatility ("Mexico Emissions Inventory Program Inventory Methodology Development for the Country of Mexico: Lessons Learned from the Application of the Mexico Emissions Inventory Methodology in the City of Mexicali, Baja California," 2000).

2.1.3   UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)

United State environmental protection agency (USEPA) is one of the manual that can be used to obtain data from the emission process. USEPA has been identified air pollutants of concern because of their impacts on health and the environment (Williams and Kilaru, 2014). The type of pollutant involve are ozone (O_3), penetrate matter (PM), Carbon monoxide (CO), Nitrogen Oxide (NO_2), Sulphur dioxide, (SO_2) and Lead (Pb).

Besides that, many air pollutants can remain in the environment for long periods of time and are carried by the wind hundreds of miles from their origin and effects resulting air pollutants that may be seen associated after short-term for example, hours to weeks or long term exposures like a months to years. In addition, air pollution can also effect environmental that including climate change, acid rain, smog and haze. Air quality is a complex and may take a years to gain understanding of air pollution.

The steps to get the data by using the air quality concept is by choosing the location, factoring in pollutant type, consider atmospheric condition, factoring pollutant with time and sensor or response time (Williams and Kilaru, 2014). Choosing a location is an important factor to get right amount of pollutant that emitted. The concentration of pollutant is highest near the source of emission and will dropped within a few hundred feet from the emission sources. Other than that, pollutant type also contribute the effect to the amount of emission. There are two types of pollutant that is; "primary pollutant" and "secondary pollutant" that is the pollutant is direct by sources and there is some chemical reaction between pollutants respectively. Next, consideration of environment condition for example; wind, atmospheric condition, temperature, sunlight and humidity will decrease the concentration of pollutants. Time, day of the week, and season also affects the concentration level of pollutants.

Base on case study for petrol station, USEPA also use this method to determine the emission that occur in petrol station. USEPA is study about the emission from oil and gas process that involved from the extraction and production of oil and natural gas. Besides that, the emission of pollutant such as VOC will emitted by processing, transmission, and distribution of oil and gas (Beusse et al., 2013). VOC is made up by carbon compound and participate in atmospheric photochemical reactions. VOC sources is emitted from "fuel combustion" that is from coal, gas and oil. Other than that, VOC also emitted from "industrial process" by process of production and fuel combustion. VOC also can be emitted from "on-road vehicle" and "non- road vehicle". The example for on-road vehicle is car, motorcycle, and truck for the non-road vehicle like aircraft, boat, ship and others. All of them use petrol or diesel to move from one place to another place (Thesis on environment, 2008).

The method used to determine quantifying emission is by direct measurement of emission and collecting data from the process. Next, a pollutant that released to the environment will represent as emission factor. In EPA the emission factor is used to predict the emission produce for specific process. Lastly, the emission will be used as engineering parameter and will referred to calculate the emission level.

Emission of oil and gas has some complexity because of different geological and the location, condition will produce different types of fluid and gas therefore, the pollutant emit also will be different. Other than that, emission also will be different if the flow rate of the well can vary at different time and the emission also not remain the same and varies with the season and temperature. Well pressure also affects the effectiveness to push emission out of the ground, technically the emission of pollutant is unobtainable (Beusse et al., 2013).

2.1.4 CORE INVENTORY AIR EMISSION (CORINAIR)

Another method use in emission inventory programme is Core Inventory air emission (CORINAIR). This method is used based on human activity that can emit air emission for instance is combustion process, production of industrial and agricultural and forestry sector. Besides that, in CORINAIR natural process also one of the factor of emission of pollutant (Adams, 2013). The type of pollutant that emit to the air is Sulphur dioxide (SO_2), Nitrogen oxide (NO_X), Volatile Organic Compound (VOC), and Particulate matter (PM). Generally, the basic policy in estimating emission inventory of air pollutant is by emission estimation method. The basic formula for mobile, area, and point sources of emission is;

$$\text{Emission} = \text{Emission Factor} \times \text{Active data} \qquad \textbf{(2.1)}$$

Where; Emission factor is the average of emission of pollutant per unit for activity data for category, Active data indicate the activity that cause the emission that collected from statistic survey and the emission is the amount of pollutant that emit from the source.

According to Eq. (2.1) this equation will use to calculate the emission for various type of emission sources. There are two method that use to determine emission estimation, which is simple and detailed method. For simple method use top-down approach and estimate emission by multiplying emission factor with activity data based on amount of fuel used over a period of time, using data which indicates the active data over a period of time of the emission source to be estimated. Besides that, for detailed method use bottom-up approach estimate by accumulating the information of each emission sources ("Guidelines for Developing Emission Inventory in East Asia," 2012) .

There are two type of emission inventory method that can be applied that is top-down approach and bottom-up approach. The method is;
- Top-down approach
  This type of emission inventory is characterize by lacked of information about location and emission from individual sources. The data is getting from fuel

consumption, production, vehicles and other activity and will covered larger region (Sylke Davison, Sef van den Elshout, 2011).

- Bottom- down approach

  The emission inventory that construct from more about the emission sources, location and consumption data. Easy to diagnose the situation and local police because each location and activity area are determined (Sylke Davison, Sef van den Elshout, 2011).

- Combined approach

  Emission inventory by using combined approach is the combination from the top-down approach and the bottom-down approach. This is because there are some weakness of using bottom-down approach because lack of available input data and for top-down approach data is based on individual sources. So the combination of two other method can help to approach the construction to make sense because has double counting or forgetting emission (Sylke Davison, Sef van den Elshout, 2011).

CORINAIR is developed by the European Environmental Agency (EAA) that serve general database for emission information and calculation of different levels. In addition, CORINAIR is based on point and area sources. Other than that, CORINAIR is divided into three type of method that can be apply for emission inventory programme. **Table 2.1** shows that, the description about the type of tier use in CORINAIR for point, area and mobile sources.

Table 2.1: The type of tier use in CORINAIR (Goodwin, 2014)

Type of tier use	Description
Tier 1	Technique use is simple and high level of uncertainty and not use to estimate emission
Tier 2	Has specific knowledge, process condition and more complex that can reduce error
Tier 3	More complex and dynamics model that lead emission in great detail