Air Quality Assessment in Perlis

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LIST OF ABBREVIATIONS

API	Air Pollution Index
CO	Carbon Monoxide
FA	Factor Analysis
HACA	Hierarchical Agglomerative Cluster Analysis
MLR	Multiple Linear Regression
VIF	Variance Inflation Factor
NO_2	Nitrogen Dioxide
O_3	Ground level ozone
PCA	Principal Component Analysis
PM_{10}	Particulate Matter 10 micrometres or less in diameter
SO_2	Sulphur Dioxide
WD	Wind Direction
WHO	World Health Organizations
WS	Wind Speed
BTS	Bartlett's tests
KMO	Kaiser-Meyer-Olkin
DOE	Department of Environment
SPSS	Statistical Package for Social Science
VIF	Variance Inflation Factor

LIST OF SYMBOLS

$\bar{x}$	Sample mean
S	sample standard deviation
N	total number of observation
$\sum$	Sum
R	correlation coefficient
SS	Sum Square
MS	Mean Square

Penilaian Kualiti Udara di Perlis

ABSTRAK

Tujuan kajian ini adalah untuk menentukan faktor-faktor yang mempengaruhi pencemaran udara di Perlis dan menentukan model regresi berganda untuk kepekatan ozon berdasarkan pembolehubah yang terlibat dalam pencemaran disamping untuk mengkaji ciri-ciri pemboleh ubah yang terlibat dalam pencemaran udara. Data diperoleh dari Jabatan Alam Sekitar untuk negeri Perlis dari tahun 2003 sehingga 2014. Data mengandungi pemboleh ubah kepekatan pencemar udara dan juga pemboleh ubah meterologi yang diambil setiap jam. Pemboleh ubah yang terlibat adalah O_3, CO, NO_2, SO_2, PM_{10}, suhu, kelembapan udara, serta arah dan kelajuan angin. Oleh sebab ianya melibatkan data yang besar, analisis faktor telah digunakan untuk menganalisis data tersebut. Kaedah tersebut telah mengkategorikan 9 pemboleh ubah kepada tiga faktor dan menamakan faktor tersebut sebagai: faktor aktiviti manusia, faktor angin dan faktor atmosfera. Melalui analisa yang dibuat, kepekatan ozon menunjukkan perbezaan ketara sewaktu siang dan malam. Jadi, data dikategorikan kepada dua tempoh masa iaitu siang dan malam dan seterusnya digunakan untuk kaedah regresi berganda bagi menentukan model O_3 berdasarkan pemboleh ubah pencemar (CO, NO_2, PM_{10}, SO_2) dan pemboleh ubah meterologi(suhu, kelembapan udara, serta arah dan kelajuan angin). Nilai R^2 telah menunjukkan sebanyak 45.6% O_3 diterangkan oleh 7 pembolehubah tidak bersandar untuk model waktu siang dan 34.5% O_3 diterangkan oleh 7 pembolehubah tidak bersandar untuk model waktu malam. Model regresi berganda telah diuji kesuaian model terhadap data yang ada menggunakan ralat mutlak min dan ralat mutlak normal. Ujian ini menunjukkan bahawa model regresi berganda untuk pembentukan O_3 pada waktu siang lebih baik penyuaiannya berbanding pada waktu malam.

Air Quality Assessment in Perlis

ABSTRACT

The aim of this research is to determine the factor involved in air pollution in Perlis and to define the Multiple Linear Regression model for ozone concentration based on the variables involved in air pollution and also determine the characteristics of the variables. The observable data refer to the recorded hourly air quality data for 2003 until 2014 for Perlis that have been received from Air Quality Division of the Department of Environment, Ministry of Natural Resources and Environment of Malaysia. Data refer to hourly recorded data that involved five major pollutants and four meteorological variables. The variables are O_3, CO, NO_2, SO_2, PM_{10}, temperature, relative humidity, wind speed and wind direction. Since it involve with large data set, factor analysis is applied. Factor analysis classify the 9 variables into three factors and name the factor as human activities factor, wind factor and atmospheric factor. Based on the analysis, concentration of O_3 show significant differences during daytime and night time. So that the data are separated into daytime and night time and then be applied with the multiple linear regression in order to model O_3 concentration based on the air pollutants (CO, NO_2, PM_{10}, SO_2) and meteorological variables(temperature, humidity, wind speed and wind direction). R^2 values showed that 45.6% variation of O_3 formation is explained by 7 independent variables during day time and 34.5% variation of O_3 formation is explained by 7 independent variables during night time. The Multiple Linear Regression model was tested for goodness of fit using Mean Absolute Error Value and Normalized Absolute Error. The test showed that MLR model is best fit model for O_3 formation during daytime compared to night time.

CHAPTER 1

INTRODUCTION

1.1 Air Quality

1.1.1 Introduction

Air defined as a mixture of gas surrounded in the atmosphere. The gas include ground level ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2). Quality is a term that is used to show the level to which something is good or bad. In environmental field, the good air quality refers to clean and clear air which is important in balancing the ecosystem. The biologist state that human and other things like animal, plants, water and soil need air to survive. While the bad air quality is known as air pollution in which the bad gaseous has been release to atmosphere and can affect human health. Air pollution occur when the concentration of air pollutants are high. The word pollution is derived from Latin word ***pollutionem*** to make something not clean (Sharma, 2001).

Nowadays, air pollution becomes a world-wide issue. Malaysia which situated in Southeast of Asia also faces the air pollution problem due to industrial development and rapid urban growth especially the region in peninsular of Malaysia (Dominick, Juahir, Latif, M.Zain, & Aris, 2012). There are a lot of phenomena happen to show that our earth is polluted , for example haze problem that often appear , climate change and greenhouse effect which also related to air pollution problem.

Air pollution had cause many health problem such as respiratory and cardiovascular problem. Based on recent report from World Health Organization, air pollution in Malaysia has caused about seven thousand deaths in 2012 (Khor, 2016). Thus, it can be seen that air pollution is serious problem should be encounter compare to other pollution.

1.1.2 Sources of Air Pollution

Based on DOE (2016), the source of air pollution in Malaysia are from the industries, development activities, motor vehicles, power generation, land cleaning, open burning and forest fires. The sources are sorted into three main source: mobile sources, stationary sources and open burning sources (Afroz, Hassan & Ibrahim, 2003; Ul-Saufie, Yahya & Ramli, 2011; Dominick et al., 2012).

Mobile source which refer to the emission from personal or private vehicles and motorcycles gives the most contribution towards air pollution (Afroz et al., 2003). The stationary source refer to the emission from the industries, power generation and fuels burning. The open burning source include open burning and forest fires. The forest fires from neighbouring countries could transport the air pollution. Refer to the DOE report, the haze episode due to forest fire from Sumatera, Indonesia in 2012 had caused the air quality in Malaysia to the level of unhealthy and hazardous. Most of the regions in Malaysia experienced the haze episode where the southern region first received the effect of forest fires and then shit to the central and northern region of Malaysia.

1.1.3 Impact of Air Pollution

Air pollution can affect human health. A study conduct by Afroz et al. (2003) reviewed that health problem like asthma, acute respiratory infection and conjunctivitis increased during haze period and decline during normal period.

Besides can affect health, air pollution also can cause environmental problem such as climate change, haze and greenhouse effect (Rana, 2013). Air pollution also gives impacts to the crops, animals and forests. Air pollution can affect crop. Cutting down the trees may pollute the air as the ecosystem could not balance. For example, a haze issue in Malaysia last year is due to fire forest from Indonesia. A "slash-and-burn" method is applied by small-scale farmer for the vegetation. The fires react toward environment thus cause air pollution. This show that crop can also cause air pollution.

1.1.4 Air Pollution Indicator

There a lot of report showing that although human practise a healthy life, healthy food and those entire thing, but if the air that human breath is pollute, human still also get sick. Generally, human cannot ensure that the air that the human breathe is clean or not? Thus an indicator from Malaysia Department of Environment which known as air pollution index (API) will give information about air quality level. The air pollutants that include in the Malaysia's API are O_3, NO_2, SO_2, CO and PM_{10}. The API scale and terms used in describing air quality levels are categorised as in Table 1.1 (DOE, 2016).

The API reading throughout Malaysia showed the air quality is good. From the API reading, the air quality in Perlis was healthy most of the time. The latest reading of API for Perlis is 33 (DOE, 2016) showing that the air quality in Perlis is good.

Table 1.1: API categories

API	Descriptor
0-50	Good
51-100	Moderate
101-200	Unhealthy
201-300	Very unhealthy
More than 300	Hazardous

1.1.5 Air Pollutants and Meteorological Variables

There are five main pollutants involved in the studies and the definition for each of the pollutants can be refer in Table 1.2 (Department of Environment and Energy of Australian Government, n.d). The instruments used is differ for each variables. The instrument for measurement of concentration of the air pollutants need to be checked in term of sensitivity, maintainability, durability and specificity regularly, thus the data can be recorded. If the system facing a problem, thus a missing value occurs as the data cannot be recorded.

Table 1.2 Five air pollutants

Air pollutant	Description
CO	A colourless gas that has no taste and smell.
NO_2	An unclean and smelly gas.
O_3	A gas that formed from the reaction of the pollutants in the air with the presence of the sunlight.
PM_{10}	Particle may be in form of dust, dirt, smoke and liquid.
SO_2	A colourless gas that has nasty smell.

Meteorological variables such as wind direction, wind speed, temperature and humidity helps a lot in the prediction of the dispersion of the pollutant. Wind and temperature are important in distribution of pollutants into the atmosphere. The wind speed will rise with height as the surface friction in upper atmosphere are decrease (Khopkar, 2004) while the direction of wind are affected by obstacle like building, mountain valley and the ocean. Anemometers and wind meter are used in the measurement of wind speed and direction, however the instrument would give wrong reading if the bad winds exist (Khopkar, 2004). Temperature and humidity are also related to each other. The low reading of wind speeds together with consistent wind direction can cause the air pollutants dilute. Winds is more calm during night as the atmosphere is more stable compared to day time. Wind direction is not critically explained.

1.2 Problem Statement

In Malaysia, the northern region refer to Perak, Perlis, Kedah and Penang. Perlis is just a small state with a moderate population density but not excepting from facing the air pollution problem. Most of the studies showed that industrial and urban area has been selected as their case study but not the suburban area. Perlis can be categorized as suburban area. This research will also help us to understand the behaviour of the variables involved in air pollution for the suburban area. The result from suburban area can be compared with the other sites. So it is important to assess the air pollution in Perlis.

1.3 Objectives

The objectives of this study are:

i. To compare the behaviour of the air pollutants and meteorological variables for day time and night time.

ii. To determine the main factor that affect air pollution in Perlis.

iii. To develop the multiple linear regression model on the O_3 concentration based on the air pollutant and meteorological variables for day time and night time.

1.4 Scope of The Research

The study was carried out on air pollution for Perlis only. A set of data involved which have been acquired from Air Quality Division of the Department of Environment (DOE), Ministry of Natural Resources and Environment of Malaysia. The data is collected hourly from 2003 until 2014. Data involved five air pollutants and four meteorological variables which are: ground level ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter 10 micrometres or less in diameter (PM_{10}), temperature, humidity, wind direction and wind speed.

1.5 Significance of Study

Statistical analysis play important role in environmental investigations and it proved that many published thesis comes out. Many researchers nowadays have used multivariate analysis to study air quality assessment. This study can give baseline information for air quality in Perlis, so that, the environment sector can take alternative action in handling air pollution problem.

1.6 Outlines

The dissertation contain 5 chapter which is: Introduction, Literature Review, Methodology, Results and Discussion and Conclusion and Future Work.

Chapter 1 give us a little bit basic on air pollution and therefore create a problem to be solved by this assessment. Chapter 1 will cover on definition air pollution, review problem to be encounter and objective.

Chapter 2 will review the research that have been done in previous study and should relate to the topic of this proposal. A few gaps have been recognized to be discovered to proceed with this project.

In Chapter 3, the methods applied have been shown. There are a few sections in this chapter for better understanding. First section is on descriptive statistics. Next section will show why the factor analysis is used and how the method can generate the factor that affects the air pollution. The last part is on the multiple regression analysis which will be explained in specific scope.

In chapter 4, this study will try to come out with the comparison between day time and night time for each of the 9 variables involved, the "main" factor that affect the air pollution in Perlis, and the variation of O_3 formation that is explained by independent variables in Perlis. In chapter 5 will conclude the study and suggest the future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Malaysia, a few studies have been conducted on air quality. Recently, many statistical approach widely used on environment field. Numerous studies of air pollution that had been conducted are on factor contribution and air pollution modelling. Here is a few selected works that related to these study.

2.2 Air Pollution in Malaysia

Air quality in Malaysia based on the API readings has been considered good most of the time except for the serious haze problem. The calculation of API is based on the five air pollutants: PM_{10}, SO_2, NO_2, CO and O_3 (DOE, 2016). A study of air quality (Afroz et al., 2003; Sulaiman, Saidah & Latif, 2008) discuss on health effect from the transboundary pollution. Transboundary pollution refer to the air pollution that is transported from forest fires in neighbouring country (Ling, Ting, Shaharuddin, Kadaruddin, & Yaakob, 2010).

Azmi, Latif, Ismail, Juneng & Jemain (2010) focus on the air quality study in urban area and found out that the averaged concentration of PM_{10}, SO_2, NO_2, CO and O_3 at Petaling Jaya, Shah Alam and Gombak are still under controlled value by Malaysia Department of Environment. The level of air quality in urban area is higher compared to the background area (Jerantut). PM_{10} and O_3 related to the transboundary pollution because of photochemical reaction. The rest of air pollutants related to the emission of motor vehicles.

Ling et al. (2010) conduct study in Kuala Lumpur and found that air pollution occurs due to urbanisation process. Mobile source contribute most to the air pollution and the increase in number of vehicles showed that more harmful pollutants (PM_{10}, CO, NO_2 and O_3) has been released to the atmosphere. Based on the analysis, the trend of air quality level in Kuala Lumpur do not show a clear improvement even though the number of good days has increased.

Ghazali et al. (2010) conduct a study to describe the characteristics of O_3 and NO_2 over a year period on urban area. Using time series, the study found out that the formation of O_3 related with the emission of NO_2. However, Awang, Ramli, Mohammed, & Yahaya (2013) evaluated only the O_3 concentration in four stations which are Kajang, Bakar Arang, Seberang Perai and Jerantut. By using time series analysis, Jerantut was identified as the lowest O_3 concentration while Kajang as the highest concentration of O_3. The study showed that the urban area faced higher concentration of O_3 compared to suburban, industrial and background area.

Saini, Singh, Awasthi, Kumar & Taneja (2014) conduct the study of air quality in urban area (Agra). With high population density and worse air quality due to human activities, the results showed that the O_3 concentration is higher during day time. The study indicated that O_3 depend on the O_3 precursor and meteorological variables.

2.3 Factor Contribution

Dominick et al. (2012) applied Principal Component Analysis (PCA) to determine the major source of air pollution from the eight stations that had been clustered. Each cluster conclude that the main factor is from the emission from motor vehicles. For Olumeyede (2012), the factor analysis group the chemicals involved in Nigeria into the factor of the emission of vehicles and also the activities of anthropogenic.

Edward & Shu (2013) showed that the factor analysis has classify seven air pollutants in 8 stations in Taiwan into three factors: organic, photochemical and fuels. The accumulated total variance explained by the three factor is 66.12%. In order to review the air quality management effectiveness, the study has applied cluster analysis to present pollution's characteristics and degree of air quality.

Mapoma, Tenthani, Tsakama, & Kosamu (2014) evaluate air quality in urban by indicate carbon monoxide, nitrogen dioxide and sulphur dioxide levels by using cluster analysis and factor analysis. The study assessed on diurnal, monthly and seasonal variation of CO, SO_2, and NO_2, the result of factor analysis (rotated component plot in the space) explained that air temperature contribute to the variation.