SOURCES OF AIR POLLUTION IN KELANTAN

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ABSTRACT

Air pollution is one of the biggest issues around the world. This study focused on sources of air pollution and the trend of air pollution in Kelantan. Based on the data obtained from the Malaysian Department of Environment (DOE). Nine parameters about air pollution in two monitoring stations in Kelantan which is Kota Bharu and Tanah Merah for 4 years (2013–2017) were gathered. Principal component analysis (PCA) in the environ metric approach was used to identify the sources of pollution in the study locations. Mann Kendall Trend Test was used to identify the trend of the air pollution in Kelantan. The PCA was used to group eight parameters in Kota Bharu which are wind, temperature, humidity, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide and particulate matters 10 micrometres and for Tanah Merah only consists of six parameters which are wind, temperature, humidity, sulphur dioxide, nitrogen dioxide and particulate matters 10 micrometres into suitable components. In order to analyse the purpose of this study, the research used SPSS and XLSTAT software. The overall result shows that there are two main factors occur in this study which are environment and vehicle factors. Trend for this study shows increase pattern of air pollution index in Kota Bharu and decrease pattern of air pollution index in Tanah Merah.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Air pollution occurs in many big countries in the world. Many countries have shifted from an agrarian-based rural economy to an industrial-based urban economy over the past half-century. As a result, various human activities such as biomass burning, industries, transportation, economic growth and power production in Southeast Asia in these countries are now emitting harmful particulates (often defined as $PM_{10.0}$ *or* $PM_{2.5}$) and gases (e.g. ozone, nitrogen dioxide) and thus seriously contaminating the air that leading to problems of air pollution and air quality degradation in Southeast Asia (Shin, 2019; Lasko, 2018). Air pollution happens when natural and anthropogenic pollutants are contaminated with air. Anthropogenic pollutants are human-related contaminants that include polluting residues from consumption and industries activity (Ibrahim, 2013).

China and India have emerged as supreme economic powers, they are still struggling to manage their environmental air quality (Saud & Paudel, 2018). All the industries such as factory, vehicles that release dangerous smoke like carbon monoxide and black carbon should reduce its use. China and India are the world's two largest countries generating anthropogenic aerosols and they have been identified as the two hot spots observed from space in terms of high optical aerosol depth (AOD) over the past decade (Lu et al., 2011). Air pollution not only give an impact to the big cities but the whole state. The biomass contribution to air pollution levels in small country towns in Sweden can be extensive, leading to levels of particles comparable to busy street canyons in major cities (Oudin, 2018).

To make things worse, modern technologies act as a catalyst for the cause of air pollution as crops can be harvest faster, resulting faster and larger scale agricultural process can be done. The primary human source of atmospheric carbon dioxide (CO_2)

is fossil fuel burning for energy production and transport (Borhan, Musa, & Hitam, 2012). In other countries such as China and India, they have major active components of aerosols that causes of air pollution. Sulfate (the precursor being Sulphur dioxide, SO_2) and the primary carbonaceous aerosols black carbon (BC) and organic carbon (OC) are the major active components of aerosols in these two countries (Lu, Zhang, & Streets, 2011). Air pollution can affect all ages, affects to wildlife and plants. Therefore, air pollution has emerged as a major threat to the ecosystem as a whole (Saud & Paudel, 2018). Although there are many modern technologies to prevent the air pollution but it cannot success if people do not care about the environment.

Malaysia also not missed from air pollution. Therefore, air pollution monitoring duties are disseminated at different levels that consist of protocols and international agreements, and community legislation at the national and regional levels. Pollution in Malaysia is controlled through various environmental policies and laws, such as the 1974 Environmental Quality Act, with subsidiary legislation such as the 2013 Malaysian Ambient Air Quality Standard, the 2014 Environmental Quality (Clean Air) Regulations, and the like. These regulatory approaches act to mitigate and monitor pollutants emitted from different sectors (including particulates, ozone and nitrogen dioxide). Malaysia still suffers from air pollution despite this regulatory framework(Shin, Chin, Id, & Id, 2019).

The occurrence of haze is not an extraordinary phenomenon, every year Malaysia is often hit by haze problem due to the impact of open burning in neighboring Indonesia. The haze this time caused by fires detected in North Sumatra and West Kalimantan. Combating conditions when the Southwest Monsoon wind blows to the Peninsular causes the situation to last within this month, depending on wind direction and rainfall (Harian Metro, 2018). In 2019, a chemical pollution disaster that has never occurred in Malaysia until more than 4,000 people have been forced to seek treatment around the Pasir Gudang district (Berita Harian, 2019). This chemical pollution not only affect the river but surrounding air too. This is because the particle in the chemical can affect the air quality in that state.

1.2 PROBLEM STATEMENT

Air pollution is a serious problem in many parts of the world. According to World Health Organization (WHO), 4.2 million death every year as a result of exposure to ambient air pollution. Global warming, depletion of ozone layer and climate change are the main effects of air pollution. The increase in impermeable surfaces after urbanization without reasonable urban planning and increased energy consumption in response to urban population growth in metropolitan areas exacerbate air pollution (Gong et al., 2015). . According to the previous study by McConnell et al. noted that the incidence of freshly diagnosed childhood asthma is correlated with physical exercise in regions with elevated ozone and particulate matter levels (Losappio, Heffler, Contento, Cannito, & Rolla, 2011). Stroke (STK), lung cancer (LC), chronic obstructive pulmonary disease (COPD), acute lower respiratory infection (ALRI) and ischemic heart disease (IHD) is dangerous disease obtain from air pollution (Zou et al., 2019). According to the U.S. Department of Energy's Energy Information Agency, total CO_2 emissions in China in 2011 amounted to 8.38 billion metric tons, with 6.95 billion tons of coal burning, almost all of which are used to generate electricity (Zoback, 2012). So, there are many sources that contributes to air pollution such as smoke from vehicles, biomass burning and industries. According to Abdullah (2019) reported that State police chief Datuk Hasanuddin Hassan said that in combination with the festive celebration more than one million cars are anticipated to enter Kelantan (para. 3). Increasing number of vehicle and people is one of the sources of air pollution. The aim of the study is to determine sources of the air pollution. A recent study found that carbonaceous $PM_{2.5}$ is five times as toxic as inorganic particles (Lelieveld, 2015). This research is mainly focus in Kelantan. We need to reduce the sources of air pollution for not to make things worse that can impact to the new generation in this world. The more pollutions the more impacts to the world like heat wave, climate change and global warming.

1.3 RESEARCH OBJECTIVES

i. To identify the sources of the air pollution.
ii. To identify the trend of air pollution in Kelantan.

1.4 RESEARCH QUESTIONS

i. Which sources of air pollution that contributes the highest in Kelantan?
ii. What is the trend of the air pollution index (API)?

1.5 SIGNIFICANT OF THE STUDY

The findings of the study will find out the main sources of air pollution that will help government to monitor air pollution in urban area for better law enforcement. This research may help people to aware about dangerous of air pollution toward health if do not take serious about air pollution. Next, to educate the public on the importance of exposure to the quality of air. This analysis helpful for environmentalists to forecast the future air quality to take precautions in advance.

1.6 LIMITATIONS AND SCOPE OF THE STUDY

There are several potential limitations in this study. One of the limitations are the information about the sources of air pollution from the Department of Environmental. Next, this study just focuses on 8 parameters for Kota Bharu and 6 parameters for Tanah Merah. The time series data of air pollution index in Kelantan consists only 2013 until 2017. Target location covered only Kota Bharu and Tanah Merah, Kelantan. Thus, not present the whole country.

CHAPTER TWO
LITERATURE REVIEW

2.1 AIR POLLUTION

Air pollution is the one of the factors to the heat waves, climate change and global warming. Air pollution have become worst and worst since more all the country in this world want to become one of the high-tech nations. Increasing impermeable surfaces after urbanization without sensible urban planning and enhanced power usage in reaction to urban population development in metropolitan areas exacerbate air pollution (Gong et al., 2015). Primary energy sources such as gasoline, gas or diesel, kerosene, fuel oil, liquefied petroleum gas and natural gas and secondary energy such as electricity have been quickly growing (To, Lee, & Ng, 2017). Moreover, increasing population also can affect the air quality in this world. The top bad air quality in this world are China and India since their country have a big population. These two countries have emerged as supreme economic powers, they are still struggling to manage their environmental air quality (Saud & Paudel, 2018).

Air pollution also have the impact to the human health. There is proof that living close highways is connected with respiratory impairment, including asthma. Area with the largest $PM_{2.5}$ quartile from residential wood burning and which also had a wood-burning stove was more probable to create dementia than those without a wood-burning stove in the lesser three quartiles and Particular matter from exhaust traffic appeared to be associated with incidence of dementia (Oudin, Segersson, Adolfsson & Forsberg 2018). Reducing exposure from the use of solid fuel to indoor air pollution (IAP) is a possibly significant intervention for the prevention of childhood pneumonia. Severe pneumonia, which is best anticipated by hypoxemia, is more fatal than less serious (Dherani et al., 2008).

Air pollution also have the impact to the climate change. Recent studies progressively include impacts of aerosols on clouds and typically discover a decrease in precipitation during the monsoon-season by combining cloud impacts and changes in radiation (Africa, Knippertz, Evans, Field, & Fink, 2015). Fiore (2003) discover that the lifetime of CH_4 is longer when NO_x emissions are reduced and when VOC or CO emissions are reduced, in line with our understanding of the impact of these emissions on global OH. Due to its impact on air pollution, high ambient heat also impacts human health. There has been a positive association between temperatures > 32 ° C (> 90 ° F) and ozone manufacturing at ground level, and growing evidence suggests that ozone and elevated temperatures synergistically affect mortality. Urban forests, including riparian corridors along the rivers, are particularly at high risk of harm to air pollution(Serengil et al., 2011). In terms of emissions, CO_2 (85–96%) dominated them, followed by CO (3–13%) dominated them. CH_4, NO_x, N_2O, NH_3, SO_2, NMVOC, PM_{10}, $PM_{2.5}$, EC and OC contributed the remaining 1–3% of emissions. Among these pollutants, however, agents forcing favorable climate change such as EC, CO and CH_4 have been recognized as the main contributors to the GWP of open crop residue burning(Andini, Bonnet, Rousset, & Hasanudin, n.d., 2018).

2.2 WIND DIRECTION

Wind direction also ones of the factors that contribute the air pollution to spread around the places. Wind direction and intensity are very important factors when high-level emitters located near each other in an industrial-zoned part of the city are the main sources of pollutants. In areas where low-level emitters cause the greater proportion of the emissions, these factors are not important. Since the wind influences the movement of the pollutants, the predicted continuity of the wind direction as it relates to the topographical characteristics and the positions of the receptors must be considered both in the estimation of the potential for air pollution as well as in the selection of plant sites. Clearly, in choosing sites for large industries, these localities should be avoided where possible (Shenfeld, 1970).

Every country has their own season with different wind direction, same also with the weather in this world which have rain, hot, windy and so on. The weather classification results clearly show six Taiwanese synoptic weather patterns, each of which has distinct meteorological conditions and associated varying air pollutant behaviors (Hsu & Cheng, 2019). South wind was more common at spring in Beijing than north wind. Normally, however, north wind had greater velocity. The WS was low in summer, and mostly from the southwest. During fall, southern wind WS was low but strong was the northwest storm. South wind was much more frequent in winter than north wind but the intensity was much lower. In all seasons, wind in Shanghai has been from all directions. South winds were more frequent in spring and summer, while northern winds were more frequent in winter and fall. In Guangzhou, winds to the south and north dominated the direction of wind. North wind was slightly more frequent in spring, while in summer south wind was more frequent. North wind was prevalent in fall and winter, showing the transportation of contaminants from the north to Guangzhou may be significant (Zhang, Wang, Hu, Ying, & Hu, 2015).

Wind speed, wind direction, and mixing layer height (MLH) are important factors that affect ground level pollution exchange processes such as the concentration of gaseous pollutants. As the compounds are measured at different sites, in addition to local pollution sources, it can be inferred that wind speed and MLH affect primary pollutant concentrations (Schäfer et al., 2014). Days with predominantly southern winds recorded the highest concentrations of $PM_{2.5}$, and the second highest concentrations were days with calm / variable winds (Guerra et al., 2006).

2.3 TEMPERATURE

Temperature is one of the factors that can affect the air pollution around the surrounding. Since the increasing in temperature will produced the large heatwaves in surrounding. The combination of high air pollution rates and high temperatures has caused the growth of urban heat islands (UHIs) and air pollution in London, England (McMichael et al., 2003; Rooney, McMichael, Kovats, & Coleman, 1998). Heatwaves are especially intense in urban areas where surface conditions alter the difference in temperature between urban and rural areas. The differences are caused by low vegetation rates in cities and anthropogenic heat and air flow produced by urban infrastructure such as buildings and asphalt streets (Bibri & Krogstie, 2017).

Mirzaei (2015) indicated that extreme air temperatures in cities (UHIs) increase mortality due to heat and air pollution and increase energy demands for cooling buildings, which in turn leads to a further increase in air pollutants and greenhouse gas emissions. Air pollution, particularly fine particulate matter and weather fluctuations, such as temperature and humidity changes, are critical factors for the increased risks of respiratory and cardiovascular diseases in different populations (Brook et al., 2010; Koken et al., 2003; Schwartz et al., 2004). Few studies have examined the interaction between air pollution from particulate matter and temperature. The interaction between air pollution and high temperature was investigated by Katsouyanni et al. (1993) found possible correlation between high concentrations of particulate air pollution (measured by smoke) and high temperatures.

It is well known the association between temperature extremes and increased mortality (Basu and Samet, 2002; Curriero et al., 2002; Mercer, 2003). It is also recognized that marked changes in ambient temperature may cause physiological stress and alter the physiological response of an individual to toxic agents (Gordon, 2003). Over the years, studies have advanced understanding of the causes of air pollution with some accomplishments (Cuhadaroglu and Demirci, 1997; Hrdličková et al., 2008; Morbidelli et al., 2011). For example, meteorological factors such as temperature, pressure, humidity, precipitation, and wind are closely related to the air pollutant distribution and diffusion. Several research findings have shown exceptions where heavy air pollution may occur in warm air masses during the winter-half of the year, whereas light air pollution the correspond to relatively low temperatures (Azad and Kitada, 1998).

2.4 HUMIDITY

According to Academy, (2014), humidity is defined as some indicator of air or other gas water vapour content. The word "moisture" is a general term for quantifying the amount of water vapor in the gas. Water vapor plays a critical role in consistency and efficacy of goods that enhance our daily lives. In the current study, air pollutants and meteorological data include atmospheric PM with an aerodynamic diameter of less than PM_{10}, ozone, emission of nitrogen and sulfur dioxide, and relative humidity. Recent studies have shown that temperature and humidity during brief exposures greatly affect the understanding of air quality. For increased indoor air temperature or humidity, the air was considered to be less suitable and relations were decreased linearly for increased indoor air enthalpy (Wargocki & Clausen, 1999). Humidity is so important for living being and the surrounding. It can help our body to change it internal body temperature.

Humidity helps living being live their live comfortably. Based on Profile (2018), the human body transfers heat through processes of heat conduction to maintain thermal equilibrium. The temperature of the body is maintained between 36-37 ° C, so that the organs are not damaged and work properly. Body temperature varies depending on the measurement period, age, sex or any other personal factors. There are three levels of absolute humidity, relative humidity and individual humidity. There is an inverse relationship between temperature and relative humidity, when the relative humidity decreases. Factors influencing the relative humidity indoors are number of users, form of operation, room characteristics, personal factors and temperature, and so on. Low humidity levels cause dryness in people's respiratory tracts, hands, eyes and hair. Harmful substances enter the body more rapidly along with dryness and the amount of water vapor in the air decreases. Low humidity levels are also causing static electricity problems in an environment. High levels of humidity make it difficult for individuals to preserve their thermal equilibrium while it induces dampness on the body surface with clothes. In high humidity microorganism reproduction is accelerated.

2.5 SULPHUR DIOXIDE (SO_2)

According to Branis (2009), Sulphur dioxide is one of colourless gas that produced by combustion of Sulphur containing fossil fuels such as heavy oil and coal. Sulphur dioxide is major of air pollutant in the world. Sulphur dioxide also known as SO_2 is the solid fuel combustion specific indicator. In Prague, the gases such as NOx and TSP were gradually decrement comparing to the concentration of SO_2 gas. The decrement is closely followed the trend of emission characteristics and fuels (solid and liquid) consumption in Prague. SO_2 gas are no longer be an important air pollutant compound compare in year 1970s and 1980s.

Volcanic and anthropogenic emissions are the principal sources of SO_2 that are gains from refinement of sulphide ores and the burning of sulphur contaminated fossil fuels. The anthropogenic SO_2 emissions are pre dominantly in or slightly above the PBL and the volcanic SO_2 can causes injected at high altitudes above the planetary boundary layer in the atmosphere (Krotkov et al, 2016). In Eastern China, it found that SO_2 are highest used over industrialized and populated regions as known that the world's second largest economy relies of SO_2 approximately 70% of its energy consumption. India is the world's second largest SO_2 emitting country in 2014 but it surpassed to the US to be the world's second largest SO_2 emitting country. Now, it reached more than 40% of the SO_2 emission of SO_2 emitter, which is China.

According to Krotkov et al., (2016), SO_2 level concentrations is decrement over the Ohio River Valley and Western Pennsyl between year 2005 until year 2015. National Emission Inventory (NEI) reported that the SO_2 concentrations over the Ohio River Valley and Western Pennsyl decreases by 80% consistently and for US, SO_2 concentration decline fby 66%. SO_2 in Middle East cities is mostly uses of mobile and stationary sources. SO_2 also uses as another important oil burning boilers in cities or population centers and it implies the high sulphate in the country. SO_2 emissions are related with coal which is approximately 90% uses for industrial facilities and power plants in country. Beijing is the one of the states in China that are negligible SO_2 flux and more despite for the NO_2 signal. It shows the limit of coal burning in Beijing and more extensively apply to the technologies (Rohde & Muller, 2015).

2.6 NITROGEN DIOXIDE (NO_2)

Many countries in this world have been try hard to be one of the countries that good in term of economy, technology and others. This may have contributed the air pollution to that country despite to the world. All combustion processes emit nitrogen oxides and play a key role in the photochemical induced catalytic ozone production, resulting in summer smog and increased atmospheric ozone levels globally (Richter, Burrows, Nüß, Granier, & Niemeier, 2005). This sources always found in the large country such as China, India and Indonesia. There are effects if the NO_2 too many in the air. It can effect to health and economy which may brought the country to the unhealthy air. Among the chemical species designated by the term NOx, is nitrogen dioxide (NO_2), which is associated with adverse health effects: high concentrations cause inflammation of the airways and function reduced lung (Cannistraro, Cannistraro, Cannistraro, & Galvagno, 2017).

Previous studies have concluded that NO_2 have a significant to the air pollution. We found an evident decrease in the level of NO_2 over China after 2011 by 6 percent year and the grid-based trend analysis implies that the rapid decline occurred on a provincial or larger spatial scale and was likely due to a nationwide action such as the widespread use of DE nitrification units (Irie, Muto, Itahashi, Kurokawa, & Uno, 2016). The air pollution always come from the industrial area which is in urban area since all the industrial things happen there. NO_2 is a pollutant produced by almost all combustion processes and is well correlated with other primary pollutants, making it a good indicator of urban pollution.

Community-based ambient NO_2 concentrations result from meteorological transportation of pollutants to the community, local point and area source emissions, and local mobile source emissions (Gauderman et al., 2005). CO, NO_2, and SO_2 were extremely correlated with reduced complete granulocytes and NO_2 exposures, and plasma cell proportions were also linked with SO_2 (Gao et al., 2019). This phenomenon is attributed to the huge quantity of NO_2 generated by burning biomass, which in the afternoon would encourage photolysis responses by consuming NO_2 and thus produce more ozone(Zhu, Zhang, Chen, & Quan, 2019).

2.7 OZONE (O_3)

As stated by Crutzen et al., (2013), Ozone is a molecule that consists of three oxygen (O) atoms and is located mostly in the stratosphere, where it protects us from harmful ultraviolet (UV) radiation from the Sun. Though it comprises only a small fraction of the atmosphere, O_3 is vital to Earth's existence. Also, O_3 in the stratosphere, an atmospheric layer between 15 and 50 kilometers above us, aids as a shield to guard the surface of the Earth from the damaging ultraviolet radiation of the Sun. Within the stratosphere, O_3 is healthy as it grips both the most energetic ultraviolet radiation, most UV-B radiation and some of the least energetic UV radiation. Within the troposphere, O_3 is "bad" because it is hazardous to breathe and is the primary component of smog during the summer. Based on Thangavel, (2018), the O_3 layer is not really a layer, but has become known as such because the majority of O_3 particles are spread between 19 and 30 kilometers up in the atmosphere of the Earth, in the region called stratosphere. O_3 concentration in the ozone layer is normally less than 10 parts of O_3 per million.

Furthermore, there are three types of oxygen involved in the ozone-oxygen cycle: oxygen atoms, oxygen gas and O_3 gas. A number of free radical catalysts can kill O_3, the most important of which are radical hydroxyl, radical nitric oxide, atomic chlorine, and bromine (Wikipedia, n.d.). There are a few ways that we can protect our O_3 layer from thinning, those are to minimize the usage of cars. Few alternatives to travel in a short distance is to use an urban transportation such as bicycle or walking. If considered to use a car try to carpool with others to lessening the use of cars in order to pollute less and save environment. Besides, we can also avoid the consumption of gases that are harmful to the O_3 layer because of their manufacturing process, some of these gases are nitrous oxide. We can also buy local product to save the Earth's O_3 layer as the more distance traveled, the more nitrous dioxide is produced due to the medium used to transport of product. Without O_3 life on Earth cannot be as great as it is now today.

According to Thangavel, (2018), Oxygen build-up in the atmosphere has led to the formation of the O_3 layer in the upper atmosphere. This layer filters out incoming radiation in the ultraviolet part of the spectrum that destroys cells. The emergence of more advanced life forms thus came with the growth of the O_3 layer. Without taking care of the environment, the Earth will be affected by our work. O_3 will eventually have holes. The term O_3 hole is created to describe any O_3 depletion. Without the O_3 layer, much ultraviolet radiation from the Sun would not stop reaching the surface of the Earth, causing untold harm to the majority of living species. That is why we should avoid making the Earth O_3 layer thin. O_3 depletion happens when the normal balance between stratospheric O_3 production and degradation is tipped toward destruction. While natural phenomena can cause temporary loss of ozone, chlorine and bromine emitted from man-made compounds such as chlorofluorocarbons are now recognized as the major cause of this depletion. These high abundances of chlorine and bromine would have caused very great losses of O_3. All other things being constant, over the middle of the next century, the O_3 layer would be expected to return to normal state. It was proposed initially by Drs. M. and Molina S. Rowland in 1974, that the main source of O_3 depletion was possibly a man-made group of compounds known as chlorofluorocarbons.

The ozone (O_3), particulate matter (PM) and nitrogen dioxide (NO_2) are air pollutants whose concentrations and impacts are known to be caused by heatwaves. Such toxins, released from a range of natural and anthropogenic sources into the atmosphere, pose a significant threat to human health (World Health Organization, 2010). Recent research suggests that O_3 will become the new major contaminants in the summer after well-controlled particulate matter (J. Xu et al., 2011a, b; Lin et al., 2011; Lei et al., 2015). O_3 as an oxidant in the troposphere can cause considerable damage to human health and ecosystems (Lee et al., 1996; Leiva et al., 2011; Tang et al., 2013). O_3, especially in summer, is increasingly becoming one of the primary pollutants (Zhang et al., 2016).

2.8 CARBON MONOXIDE (CO)

Carbon monoxide is one of the most important gas in the earth atmosphere and human health, but too much of CO can cause a breathing problem for human beings which means that it will make people suffocate and lose consciousness. Based on Minnesota (Health Officer), most common sources of CO in our house come from the gas stoves, ovens, clothes dryers, water heaters, fireplaces, power tools and motor vehicle. Sources from Miller et al., (2008), if a construction site is placed in a rural area, the volume for CO will increase showing that the distinct peak event period detached by distinct non-peak period. Most industries do not install a pollution control gear. This will make the air more polluted, especially in the industrial area where there are houses live near or close to the site. Open burning are one of the sources that CO come from including the burning of forest fires and solid waste (Afroz et al., 2003).

Another factor include for the causes of CO to exceed the air is vehicle. Chamberlain (2016), have stated that CO is a poisonous gas that released from the exhaust of a combustible engine of vehicle that uses diesel or petrol as a fuel neutral, tasteless, non-irritating and colourless. According to the Department of the Environment and Heritage, 2005 the amount of CO that are not harmful for human is around 0.2 parts per million (ppm). The additional sources for CO are industrial activities, such as making steel and tobacco smoke in one of the core indoor sources of CO. CO can be reduced by promoting alternative fuels, supporting the implementation of tighter vehicle emission standards and applying national fuel quality standards.

The importance for making the air clean from poisonous CO are to make the world less dangerous. According to Chamberlain (2016),a noxious sound effect from CO will cause a reversible displacement of oxygen from hemoglobin in the human lungs to form a carboxyl-hemoglobin. Moreover, water-pipe smoking is also the main causes for CO to produce. In the Middle east, India and China, water-pipe smoking or as referred by different names like shisha, hookah and sheesha have become more popular including in the United Kingdom. By slurping the gas from water-pipe smoking, is can causes an overdose of CO to the human that will cause headache, dizziness, nausea and lethargy if the level of CO exceeds 0.12 pulse CO-oximeter. Based on Folinsbee (1992), CO has a high attraction for hemoglobin which it infiltrates the oxygen transportation tissues and it also known to be the cause of poisoning at high concentrations. Thus, such high levels are little interest to those concerned with the health effect of the community of air pollution.

2.9 PARTICULAR MATTER (PM)

Airborne Particular Matter which known as harmful particles to human health that have been approximated that cause around 3 to 7 million deaths every year that worsening the cardiorespiratory diseases in human health. According to Rohde & Muller (2015), it has been measured that 1.6 million deaths per year that is based on prefecture level population and pollution data. Based on WHO model, it shows 95% confidence that 0.7 to 2.2 million deaths per year that equivalent to 17% deaths in China. Previous studies represent that $PM_{2.5}$ can cause premature deaths such as acute lower respiratory infection (ALRI), lung cancer (LC), ischemic heart disease (IHD), stroke (STK) and chronic obstructive pulmonary disease (COPD) (Zou et al., 2019).

According to Zou et al., (2019), the premature death and would overestimate or underestimated with high or low $PM_{2.5}$ concentrations in urban and populated areas. $PM_{2.5}$ concentrations can be measured by other potential variables such as land use, digital elevation model (DEM), road network, aerosol optical depth (AOD) and meteorological factors. Hence, the collected data have been processed at annual scale, analogous to the time scale of the averaged $PM_{2.5}$. North America and Europe have been states that have low averaged $PM_{2.5}$ concentrations based on associate studies by ERCs. The reading of $PM_{2.5}$ concentrations in North America and Europe are improper to China because China have high pollution of $PM_{2.5}$. The integrated exposure response (IER) functions were gradually transmit to access the GBD projects with respects to the global comparison of premature deaths of various countries.

Timely structure adaptive modelling (TSAM) is one of modelling method that used to validate $PM_{2.5}$ concentrations. The validation process namely 10-fold-cross-validation was enforced to test the reliability of the final hybrid remote sensing-geostatistical models establish. The predicted $PM_{2.5}$ concentrations between overall fit R2 values and RMSEs and extra-observed ones was engaged as validation statistics (Zou et al., 2019). 12.3% of total death (1.20 million) reported because of exposure of $PM_{2.5}$ of which are 52.6% from STK, 25.6% from HD, 13.0% from COPD, 8.4% from LC and 0.5% from ALRI respectively. The total number of premature deaths was decreases from 1.20 million in year 2013 to 1.05 million in year 2017. It shows there is decrement of 12.6% of number of total deaths between years 2013 to year 2017. Same situations always occurred for all the provinces with significant spatial differences in similar period. People that lived in the high reading of $PM_{2.5}$ concentration from residential wood burning and had a wood stove in their homes this means the group of wood stove have highest exposure to the $PM_{2.5}$ concentration from residential wood burning. The group wood stove had higher dementia incidence than other participants (Oudin et al, 2018).

2.10 SOURCES OF AIR POLLUTION

There are sources that contributes to the air pollution. Based on study conducted by Chavent (2012) using factor analysis found that sources of air pollution can be divided into five category which is soil dust, vehicles, industry, combustion and sea. Human-made pollutants are caused by combustion of fossil fuel, industrial production, waste burning, road dust, smoke, and exhaust from cars, ships, and aircraft. In the form of smoke and black carbon, fires and brush clearing are also a major source of pollution. Solid fuel burning for household cooking, heating and lighting is a significant cause of air pollution in the household or indoor. Particulate pollution, also known as particulate matter (PM), comes from various sources such as factory and utility smokestacks, wood burning, construction activity or agriculture, vehicle exhaust, mining (Chavent et al., 2012).

NMHC and THC are both volatile organic compounds, while low toxicity to humans, contribute to air pollution in the district, primary aerosols are emitted directly from human emission sources (factories and vehicle emissions) as well as from non-human emission sources (street and soil dust and near as close-sea salt), secondary organic aerosols and photochemical reactions. In specific, the fuel needed during combustion is a fixed source of pollution such as creosote, coal, coking coal used in factories for fuel and vehicle diesel engines producing the significant pollutant, SO_2 (Wu & Kuo, 2013). According to Sivaramanan (2014) mention that are various type of sources of air pollution which is transportation, sources of energy generation, industry, agriculture, households, land mining, construction, natural sources and combustion.

Transportation is the most advanced and leading CO source. Gas, gasoline, diesel, and kerosene are primarily used for combustion in automobiles. Long-range sub-sonic aircraft jet engines are a significant cause of NO_x. Most sectors, as they generate CO and CO_2, sulfur hexafluoride and particulate matter, are directly or indirectly dependent on fossil fuel. Carbon and soot emissions during cooking can be regarded here through the use of fossil fuels. Volatile toxicants such as insecticidal permethrin compounds may contaminate in the atmosphere or even food, leading to intoxication.

Activities in agriculture such as natural fertilizer use release greenhouse gases. Pesticides release persistent organic contaminants (POPs). Enteric fermentation generates greenhouse gasses primarily methane in cattle ranching. Drilling, loading, unloading, blasting, and transport often leads to the production of dust. Compounds emitted from volcanic activities like black smoke, ash, metals, SOx, COx and methane release form the thawing of northern hemisphere permafrost areas, wetlands, sanitary landfills. Forest fires and bush fires, dust storm, sea spray and land-use conversion and forest release of isoprene and terpenes (low-level ozone precursors).

CHAPTER THREE
METHODOLOGY

3.1 STUDY AREA

Peninsular Malaysia is part of Malaysia, where economic growth is faster, with the same issues with air pollution as other advanced and developing nations in the world (Azid et al., 2015). Kelantan is a rural state in the northeast of Peninsular Malaysia. In recent years, tourism, especially to offshore islands, has increased in importance. A few reputable hotels have been established and more modern shopping malls have been opened to cater for urban folks. Kelantan is the state on the rapid growth especially Kota Bahru serves as the state capital of Kelantan which acts as a center of business activities, industrial areas, and public agencies. Kota Bahru has the population of approximately 425 294 people, making it the largest town on the east coast of Peninsular Malaysia (Azid et al., 2015). Since many various human activities happen in Kelantan, there are many sources that contributes to the air pollution.

3.2 SOURCE OF DATA

We obtain the data from Department of Environmental (DOE) since we use a secondary data for our study. The procedure of getting data not too complicated since we just need to send the permission letter to the DOE and they will response it whether we can get the data or not. We have eight parameter for Kota Bharu which is wind direction, temperature, humidity, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and PM_{10} while for Tanah Merah we have six parameters which is wind direction, temperature, humidity, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and PM_{10} . Data is available in daily from year 2013 until 2017, this data consists of 3128 for Kota Bharu and Tanah Merah. Each city has 1564 observations. The sources that we choose are the most main sources that previous study have done. All the sources are include in urban and rural area in Kelantan.

3.3 DATA ANALYSIS

3.3.1 Factor Analysis

Factor analysis is a technique used to decrease a large number of variables into fewer factors. This method extracts from all variables the highest common variance and places them in a common score. Factor analysis is component of the general linear model (GLM), and this technique also assumes several hypotheses which are: -

i. There is a linear connection.
ii. There is no multicollinearity.
iii. Involves appropriate variables in the assessment.
iv. There is a real correlation between variables and factors.

3.3.1.1 Orthogonal Factor Model

In this study let p observable random variables, $x_1, x_2, \ldots, x_p$ with means $\mu_1, \mu_2, \ldots, \mu_p$ where p=1,2,3, …,8 parameters.

Let $\mathbf{X} = (\mathbf{X_1}, \mathbf{X_2}, \ldots, \mathbf{X_p})$ be the variables in population with

mean $\mathbf{E(X)} = \mu = \begin{pmatrix} \mu 1 \\ . \\ . \\ . \\ \mu p \end{pmatrix}$ and variance $\mathbf{var(X)} = \Sigma = \begin{pmatrix} \sigma_{11} & \cdots & \sigma_{1p} \\ \vdots & \vdots & \vdots \\ \sigma_{p1} & \cdots & \sigma_{pp} \end{pmatrix}$

The orthogonal factor model is

$$X_{p\times 1} - \mu_{p\times 1} = L_{p\times m}F_{m\times 1} + \varepsilon_{p\times 1}, \quad (3.1)$$

where $m \leq p$, $\mu = E(X)$,

$$\mathbf{L} = \begin{pmatrix} l_{11} & \cdots & l_{1m} \\ \vdots & \vdots & \vdots \\ l_{p1} & \cdots & l_{pm} \end{pmatrix}$$ is called the factor loading matrix (which is non-random),

$$\mathbf{F} = \begin{pmatrix} F_1 \\ \vdots \\ F_m \end{pmatrix}$$ are called the factors or common factors,

and $\varepsilon = \begin{pmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_p \end{pmatrix}$ are called errors or specific errors.

The model can be re-expressed as

$$X_i - \mu_i = \sum_{j=1}^{m} l_{ij} F_j + \varepsilon_i, \qquad i = 1, \ldots, p. \qquad (3.2)$$

And lij is called the loading of X_i on the factor F_j .

The assumptions of the orthogonal model are:

a) $\mathbf{E(F)} = \mathbf{0}_{m\times 1}$ and $\mathbf{var(F)} = I_m$.
b) $\mathbf{E}\ (\varepsilon) = \mathbf{0}_{p\times 1}$ and $\mathbf{var}\ (\varepsilon) = \psi$, a diagonal matrix with diagonal elements: $\psi_1, \ldots, \psi_p$.
c) $\mathbf{cov}\ (\mathbf{F}, \epsilon) = \mathbf{0}_{m\times p}$.

The above model assumption implies that

$$\text{cov}\ (F_i, F_j) = \begin{cases} 1 & if\ i = j \\ 0 & if\ i \neq j \end{cases} \qquad \text{cov}(F_i, \varepsilon_j) = 0 \ \text{ and } \text{cov}(\varepsilon_i, \varepsilon_j) = \begin{cases} \psi_i & if\ i = j \\ 0 & if\ i \neq j. \end{cases}$$

Moreover,

$$\text{cov}\ (X, F) = \text{cov}(LF, F) = L \qquad \text{cov}(X_i, F_j) = l_{ij}, \qquad i = 1, \ldots, p;\ j = 1, \ldots, m.$$

Under the orthogonal factor model, the variance matrix of X, $\sum$, can be written as

$$\sum = var(X) = (LF + \epsilon) = var(LF) + var(\epsilon) = L\,var(F)L' + \psi = LL' + \psi. \tag{3.3}$$

In particular,

$$\sigma_{ii} = var(X_i) = \sum_{j=1}^{m} l_{ij}^2 + \psi_i = h_i^2 + \psi_i$$

$$\sigma_{ij} = cov(X_i, X_j) = \sum_{k=1}^{m} l_{ik} l_{jk}, \quad i \neq j.$$

3.3.1.2 VARIMAX ROTATION

Varimax, which was developed by Kaiser (1958), is indubitably the most popular rotation method by far. For varimax a simple solution means that each factor has a small number of large loadings and a large number of zero (or small) loadings. This simplifies the interpretation because, after a varimax rotation, each original variable tends to be associated with one (or a small number) of factors, and each factor represents only a small number of variables. In addition, the factors can often be interpreted from the opposition of few variables with positive loadings to few variables with negative loadings. Formally varimax searches for a rotation (i.e., a linear combination) of the original factors such that the variance of the loadings is maximized, which amounts to maximizing. Varimax minimizes the number of variables with high loads on each element, and it works to make even smaller loadings (Nkamnebe et al., 2017).

3.3.1.3 KMO and Bartlett's Test

Kaiser-Meyer-Olkin sampling adequacy tests and Bartlett's Sphericity Test (testing the null hypothesis that the original correlation matrix is an identity matrix) have been determined to test the validity of the data set. For the rotation of the factor matrix the varimax criterion of the orthogonal rotation approach was used (Yakubu, Salako, & Abdullah, 2011). Kaiser-Mayer Olkin (KMO) is a collection of variables, a common diagnostic measure, which tests whether there are small partial correlations among variables. It is the indicator of variable homogeneity. KMO's interest extensively tests the adequacy of sampling, and calculates the adequacy of sampling for each variable. For factor analysis to be considered feasible, the KMO value should be equal to or greater than 0.5. Bartlett's sphericity test shows that the element association is not an identity matrix, if the p-value $< \alpha = 0.05$ and research can proceed with the factor analysis (Ayuni & Sari, 2018).

3.3.2 Mann Kendall Tau

The study used XLSTAT software for the trend test of Mann Kendall. This experiment was used to determine if the information sets contained trends. This test is often used due to its property that it requires no assumptions about the data to be tested. The null Ho hypothesis in the trend test is that there is no trend in the population from which the dataset is taken and the information sample {xj, j equivalent to 1, 2... n} is autonomous and distributed in the same way. The alternative H_1 hypothesis is that in the dataset there is a trend. Two key assumptions were also made in processing the data:

i. The average value of all these samples was presumed to be the representative sample when numerous samples were gathered on a single day. This was a needed move since the Mann-Kendall assessment at a specified moment of moment needed only one data point.

ii. The variation in the sampling depths was presumed not to be sufficiently big to produce a bias in the trend statistics.

The Mann Kendall Trend Test, S is calculated by using a formula equation 3.4 below

$$S = \sum_{k=1}^{N-1} \sum_{t=k+1}^{N} sign(x_t - x_k) \quad (3.4)$$

where x_j and x_k are the sequential data value and j greater than k, n is the length of the data set

$$Sgn(x_j - x_i) = \begin{cases} +1, > (x_j - x_i) \\ 0, = (x_j - x_i) \\ -1, < (x_j - x_i) \end{cases}$$

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend.

Variance of S is determined by:

$$VAR(S) = \frac{1}{18}[(n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5)] \quad (3.5)$$

where t is the extent of any given time and the summation over all ties. For n greater than 10, the standard normal variate z is calculated by using calculation below:

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & if \quad S < 0 \end{cases}$$

The positive z value indicates an increasing trend while a negative z value indicates a decreasing trend. When testing two sided trends at a selected level of significance a, the null hypothesis of no trend is rejected if the absolute value of z is greater than $z_{a/2}$.

3.3.2.1 Sen's Estimator Method

Sen's non-parametric estimator method was used to predict the magnitude (true slope) of hydro-metrological time series results. Sen's slope estimator method uses a linear model for trend analysis. All data pairs ' slope (Ti) is determined using equation 3.6 (Hussain et al., 2015).

$$T_i = \frac{x_j - x_k}{j - k} \; for \; i = 1, 2, 3, \ldots, n \tag{3.6}$$

Where, and are data values at time j and k (j > k) separately. The median of these n values of Ti is represented by Sen's slope of estimation (true slope) which is calculated using equation 3.7

$$Q_i = \begin{cases} T_{\frac{n+1}{2}} & for \; n \; is \; odd \\ \frac{1}{2}\left(T_{\frac{n}{2}} + T_{\frac{n+2}{2}}\right) & for \; n \; is \; even \end{cases} \tag{3.7}$$

The estimator of Sen is determined using the above equation depending on the value of n being either odd or even and is then calculated using 100 (1–α) percent confidence interval using non-parametric testing depending on normal distribution. A positive Qi value shows a rising (upward) trend while a negative Qi value reflects a downward or decreasing trend in data from time series (Hussain et al., 2015)

CHAPTER FOUR
ANALYSIS AND FINDING

4.1 DATA ANALYSIS

Descriptive statistics of the pollutants studied in the Kelantan have been carried out. A statistical summary of these data is shown in Table 4.1, including measures of central tendency, variability, and form.

From the descriptive statistics, we can conclude that the more polluted area is in Kota Bharu since this place was labelled as the town with full of industry activities. Since Kota Bharu is a big town, there are many people driving their car rather than taking public transport. This might happen the traffic jam since many cars on the road. The car's exhaust are the main factors that affect the air quality.

Even though there are not many differences in Kota Bharu and Tanah Merah but Kota Bharu dominate the other places as the town with the highest pollution. As stated from the above table, the mean for wind direction at Kota Bharu is 292.582 while Tanah Merah is 240.542. The average temperature for Kota Bharu is 29.578 °c which is far hotter than Tanah Merah because of the number of populations. The API reading for both places are slightly similar with Kota Bharu reading is at 49.811 and Tanah Merah is at 45.055. The mean for SO2 for both places is the same with the value of 0.001 but the value for NO2 is different. Kota Bharu have a lower value of NO2 which is 0.011 compare to Tanah Merah which is 0.162. NO2 is produced by human activities such as combustion of fossil fuels and fuel used in car. The average ozone in Kota Bharu is stated at 0.031 while Tanah Merah is at 0.000. The quality of CO in Kota Bharu higher than Tanah Merah with the value of 0.739. This indicate that there are many cars in Kota Bharu. The sources of CO are mostly produced by running a car in encircled space.

Table 4.1: *Descriptive statistics*

	sitecode	Wd	Temperature	UVB	Humidity	API	SO2	NO2	O3	CO	PM10
Count	KB	1564	1564	1564	1564	1564	1564	1564	1564	1564	1564
	TM	1564	1564	1564	1564	1564	1564	1564	1564	1564	1564
Mean	KB	292.581	29.578	0.000	80.388	49.811	0.001	0.011	0.031	0.739	53.967
	TM	240.542	26.772	0.000	78.164	45.055	0.001	0.162	0.000	0.000	49.073
Standard Deviation	KB	82.788	7.450	0.000	28.661	13.983	0.001	0.005	0.014	0.301	22.687
	TM	141.073	13.019	0.000	37.395	16.000	0.001	0.005	0.000	0.000	22.576
Coeff. of variation	KB	0.283	0.252	0.000	0.357	0.281	1.382	0.440	0.452	0.407	0.420
	TM	0.586	0.486	0.000	0.478	0.355	0.860	0.032	0.000	0.000	0.460
Minimum	KB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	TM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	KB	359.000	35.300	0.000	100.000	124.000	0.013	0.027	0.066	2.880	198.000
	TM	360.000	40.000	0.000	100.000	123.000	0.006	0.041	0.000	0.000	196.000
Range	KB	359.000	35.300	0.000	100.000	124.000	0.013	0.027	0.066	2.880	198.000
	TM	360.000	40.000	0.000	100.000	123.000	0.006	0.041	0.000	0.000	196.000
Stnd. skewness	KB	-1.908	-3.442	0.000	-2.406	0.376	3.813	-0.681	-0.423	0.360	1.350
	TM	-0.985	-1.486	0.000	-1.602	0.159	0.861	-0.183	0.000	0.000	1.212
Stnd. kurtosis	KB	3.626	10.910	0.000	3.934	2.355	26.618	0.314	0.092	2.805	4.291
	TM	-0.824	0.408	0.000	0.598	0.719	0.914	1.395	0.000	0.000	3.908

4.2 FACTOR ANALYSIS

Factor analysis were conducted on two different location namely Kota Bharu and Tanah Merah. The data was from 2013 to 2017. We have eight parameter for Kota Bharu which is wind direction, temperature, humidity, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and PM_{10} while for Tanah Merah we have six parameters which is wind direction, temperature, humidity, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and PM_{10} .

4.2.1 Kota Bharu

Table 4.2: *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.682
Bartlett's Test of Sphericity	Approx. Chi-Square	2679.769
	df	28
	Sig.	0.000

The KMO measures the sampling adequacy (which determines if the responses given with the sample are adequate or not) which should be close than 0.5 for a satisfactory factor analysis to proceed. Since the results shows that KOM is 0.682 which is the data accepted because the recommend value is 0.5 as minimum for KMO. Factor analysis is appropriate to be done for this study.

Bartlett's test is another indication of the strength of the relationship among variables. Since the value of the p-values = $0.000 < \alpha = 0.05$, which we reject the H_0. This means that correlation matrix is not an identity matrix. So, factor analysis can be done to group the variable into suitable component.

Table 4.3: *Factor Analysis and Variance for Kota Bharu*

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.472	30.894	30.894	2.472	30.894	30.894
2	1.752	21.902	52.796	1.752	21.902	52.796
3	0.918	11.478	64.275			
4	0.856	10.705	74.98			
5	0.734	9.18	84.16			
6	0.527	6.59	90.75			
7	0.4	4.995	95.745			
8	0.34	4.255	100			
Extraction Method: Principal Component Analysis.						

Table 4.3 shows that there are only 2 component that are extracted which is component 1 and 2. This is because the two factors have an eigenvalue greater than 1. Also, the total cumulative of total sample variance for this component is 52.796 %. Hence, two factors to be extract in this study.

Table 4.4: *Component Matrix of Air Quality Factor Loadings for Kota Bharu*

Rotated Component Matrix		
	Component	
	1	2
Wd	**0.408**	0.193
Temperature	**0.845**	-0.112
Humidity	**0.813**	-0.241
Sulfur dioxide	-0.133	**0.507**
Nitrogen dioxide	**0.698**	0.285
Ozone	0.03	**0.691**
Carbon monoxide	0.445	**0.649**
Particulate matters 10 micrometers	0.124	**0.785**
Extraction Method: Principal Component Analysis.		
Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

From the output using Factor Analysis, there are two groups that have classified for location Kota Bharu which is nature or environment factor and vehicles factor. For the environment factors which is temperature, humidity, nitrogen dioxide and wind direction. Nitrogen dioxide is naturally formed by lightning in the atmosphere and some are produced by plants, soil and water as the environment factors (Nitrogen Dioxide (NO2), 2005). The temperature, humidity and wind direction are the pure sources for the environment factors since all these sources are not control by the humans but the nature.

Carbon monoxide (CO) is a colorless and odorless gas produced during incomplete and inefficient fossil fuel combustion. Ozone is a gas created in the atmosphere when three oxygen atoms are mixed. In metal smelting, oil refining, and other industrial processes, SO_2 may also be produced. PM_{10} is released from combustion sources such as coal-fired sources directly into the air (Easterly, 2015) Therefore, we can conclude that the components are classified as vehicles factor.

4.2.2 Tanah Merah

Table 4.5: *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.501
Bartlett's Test of Sphericity	Approx. Chi-Square	4838.182
	df	15
	Sig.	0.000

The KMO measures the sampling adequacy (which determines if the responses given with the sample are adequate or not) which should be close than 0.5 for a satisfactory factor analysis to proceed. According to Taherdoost et al. (2014), 0.50 considered suitable for FA. Since the results shows that KMO is 0.501 which is barely accepted because the recommend value is 0.5 as minimum for KMO.

Bartlett's test is another indication of the strength of the relationship among variables. Since the value of the p-values = $0.000 < \alpha = 0.05$, which the null hypothesis is rejected. This means that correlation matrix is not an identity matrix. Factor analysis can be used to group the variable.

Table 4.6: *Factor Analysis and Variance for Tanah Merah*

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.035	33.916	33.916	2.035	33.916	33.916
2	1.199	19.989	53.904	1.199	19.989	53.904
3	1.01	16.827	70.731	1.01	16.827	70.731
4	0.906	15.095	85.826			
5	0.826	13.767	99.593			
6	0.024	0.407	100			
Extraction Method: Principal Component Analysis.						

Based on Table 4.6 shows that there are only three factor that have an eigenvalue greater than 1. The proportion of total sample variance explained due to 3rd factor is 70.731. Hence, three factors were extracted for this study which is component 1, 2 and 3.

Table 4.7: *Component Matrix of Air Quality Factor Loading for Tanah Merah*

Rotated Component Matrix			
	Component		
	1	2	3
Wd	-0.028	-0.041	**0.958**
Temperature	**0.986**	0.028	0.019
Humidity	**0.989**	0.014	-0.009
Sulfur dioxide	-0.025	**0.639**	-0.094
Particulate matters 10 micrometers	-0.035	**0.729**	-0.018
Nitrogen dioxide	0.239	**0.518**	0.307
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 4 iterations.			

The wind direction has been identified as one group, humidity and temperature as second group and PM_{10}, nitrogen dioxide and sulfur dioxide as third group. Wind direction have been classified as wind factors since the wind direction can bring air pollution all over the place.

For humidity and temperature have been summarized as environment factor because these two sources are likely affecting the environment with the natural events that occurs at Tanah Merah, Kelantan. With the low humidity and high temperature, the air quality will be worst because hot weather can give bad impact to the air quality. The weather was hot and dry, and the atmosphere was calm, allowing suspended dust to remain trapped in the airspace and creating haze across the border from fire zones (Yard, 2014).

PM_{10}, NO_2 and SO_2 have been summarized as vehicle factor because all of these components from the gas emission that comes from the vehicles.

4.3 MANN KENDALL TAU

This section emphasizes on the overall trend of the data series on each station. Time series plot, Mann Kendall Trend Test and descriptive statistical analysis were used in determining the trend associate for each station. Results obtained show a significant trend at 95% confidence level for certain stations. Trend line also drawn to show the trend clearly. The p-values smaller than 0.05 must be fulfilled before the trend test was concluded to be significant. Figure 4.1 and 4.2 shows the graph of Air Pollution Index at Kota Bharu trends and Air Pollution Index at Tanah Merah respectively.

4.3.1 Trend of API for Kota Bharu

Table 4.8: *Summary Statistics*

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
API	1564	0	1564	0.000	124.000	49.811	13.983

Table 4.9: *Mann Kendall Tau Trend Test*

Kendall's tau	0.146
S	176561.000
Var(S)	425214258.333
p-value (Two-tailed)	< 0.0001
Alpha	0.05
An approximation has been used to compute the p-value.	

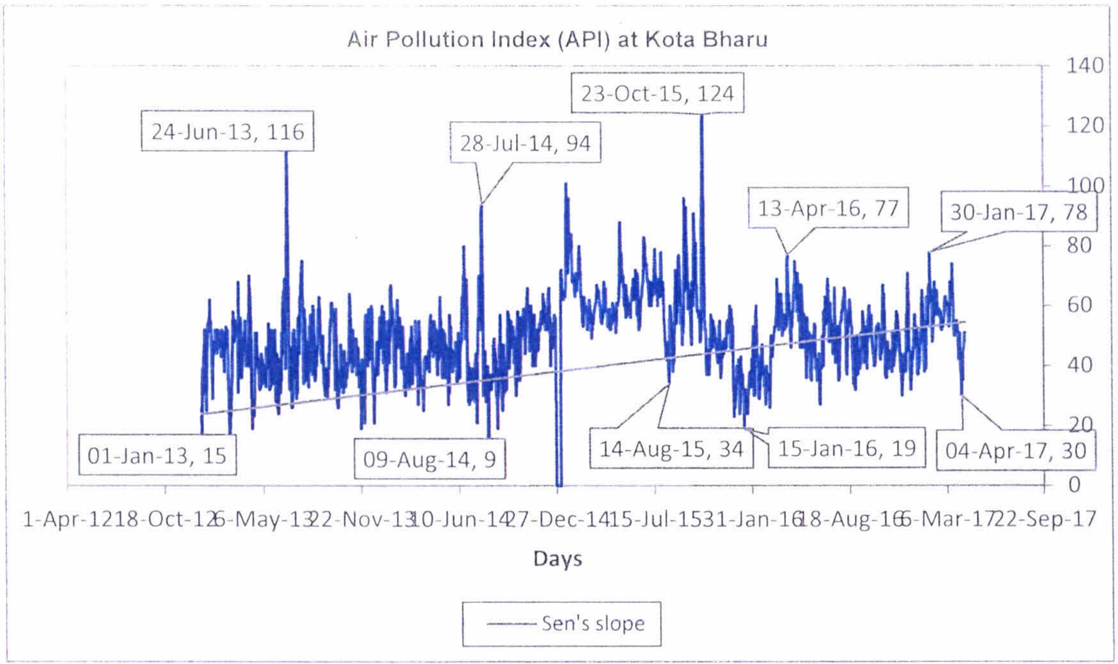

Figure 4.1: Air Pollution Index (API) at Kota Bharu

In Figure 4.1, the analysis from Mann-Kendall Trend Test have resulted the trend of Air Pollution Index (API) from 1st January 2013 to 13th April 2017 on Sek. Men. Keb. Tanjung Chat, Kota Bahru station. It shows that the data are seasonal. The Kendall's tau values were 0.146. For this station, the p-value that computed are lower than significant level alpha equal to 0.05, which was 0.0001. It indicates that there is a significant trend of API. We can conclude that there is enough evidence to conclude that the trend exists on this station which at Kota Bharu. It also shows that there is significant positive API trend.

Table 4.10: *Sen's Slope*

	Value
Slope	0.006
Intercept	-202.686

$$y = 0.006API - 202.686$$

Sen's slope estimator for the API is presented in Table 4.10. This analysis revealed positive (increasing) trend from Kota Bharu station whose Z values were 0.146. The magnitude of seasonal API by Sen's estimator from Kota Bharu station was 0.006.

4.3.2 Trend of API for Tanah Merah

Table 4.11: *Summary Statistics*

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
API	1564	0	1564	0.000	123.000	45.055	16.000

Table 4.12: *Mann Kendall Tau Trend Test*

Kendall's tau	-0.222
S	-268502.000
Var(S)	425265710.000
p-value (Two-tailed)	< 0.0001
Alpha	0.05
An approximation has been used to compute the p-value.	

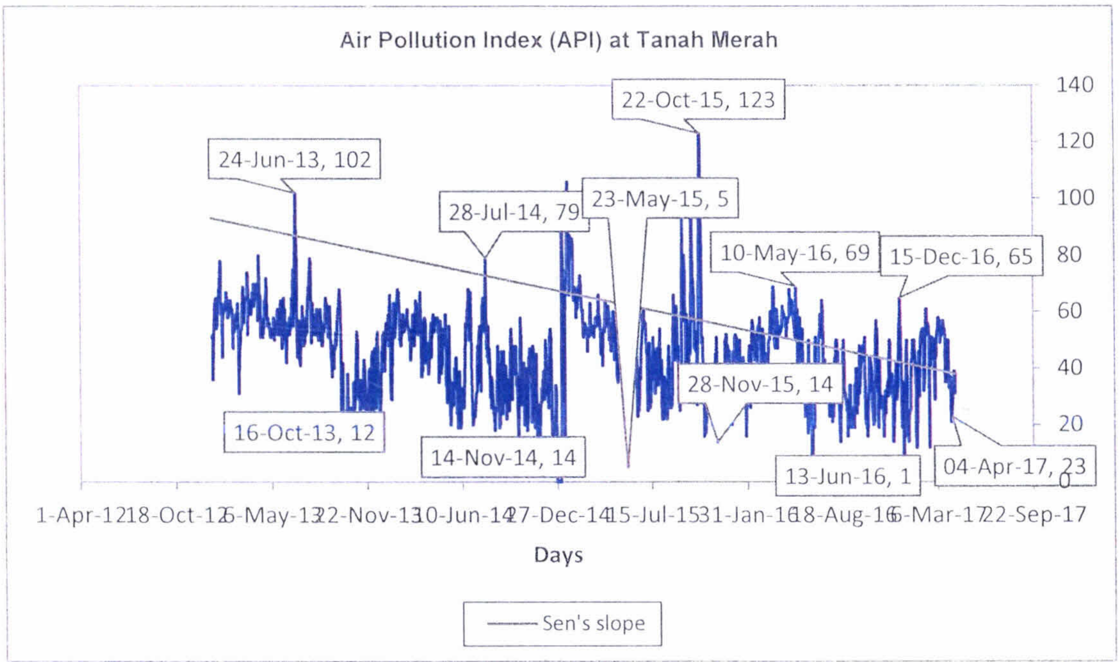

Figure 4.2: Air Pollution Index (API) at Tanah Merah

In Figure 4.2, the analysis from Mann-Kendall Trend Test have resulted the trend of Air Pollution Index (API) from 1st January 2013 to 13th April 2017 on Sek. Men. Tanah Merah station. It shows that the data are seasonal. The Kendall's Tau values were -

0.222. For this station, the p-value that computed are lower than significant level alpha equal to 0.05, which was 0.0001. It indicates that there is a significant trend of API. We can conclude that there is enough evidence to conclude that the trend exists on this station which at Tanah Merah. The trend line shows that it is negatively and decreasing pattern. It shows that there is significant negative API trend.

Table 4.13: *Sen's Slope*

	Value
Slope	-0.011
Intercept	500.565

$$y = -0.011API + 500.565$$

Sen's slope estimator for the API is presented in Table 4.13. This analysis revealed negative (decreasing) trend from Tanah Merah station whose Z values were -0.222. The magnitude of seasonal API by Sen's estimator from Kota Bharu station was -0.011.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

In this chapter, it will be covered the results and conclusion that the researchers found in this study. Furthermore, the recommendation for the future research also was discussed in this chapter.

5.1 CONCLUSION

The research was conducted to study on sources of air pollution at Kelantan states. There are several variables that have been investigated which are wind, temperature, humidity, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide and PM_{10}.

Firstly, descriptive statistics was conducted to describe the basic features of the data for Kota Bharu and Tanah Merah. Based on the result findings, it was found that Kota Bharu has the higher air pollution in Kelantan as compared to Tanah Merah. Mean for each variable in Kota Bharu are higher compared to Tanah Merah except for nitrogen dioxide which is 0.011 less than 0.162. Even though, there is no slightly difference between Kota Bharu and Tanah Merah but Kota Bharu act as rapidly growth city in Kelantan that contribute to the highest pollution.

Besides, the research investigated which sources contribute to the air pollution at Kelantan and group it into a specific group. For this analysis, factor analysis has been performed to classify the variable into a suitable component. KMO and Bartlett's tests shows that factor analysis is appropriate to be done and correlation matrix are no identity matrix for both cities. So, factor analysis can be done in this study. The result shows that there are two factor that has been extracted for Kota Bharu which is environment factor and vehicle factor. For Tanah Merah three factor where been extracted in this study which are wind factor, environment factor and vehicle factor. The weather was hot and dry, and the atmosphere was calm, allowing suspended dust to remain trapped in the airspace and creating haze across the border from fire zones (Yard, 2014).

Lastly, Mann Kendall Trend has been used in this study to identify the trend of air pollution in Kelantan. Variable that be use to perform Mann Kendall trend is air pollution index from both cities. Based on the analysis it shows that increasing trend occur at Kota Bharu while decreasing trend at Tanah Merah. The data in daily from 1st January 2013 until 13th April 2017. Based on graph it shows seasonal data for both cities since some of the plot are spike at a certain date.

For overall conclusion, the research had fulfilled all of the objectives in this study. From these results, this study proved that the main two factors of air pollution at Kelantan is environment factor and vehicle factor. Kota Bharu need to focus more about air pollution since the trend show increasing in pattern of air pollution. This research was meaningful since all the objective has been achieved.

5.2 RECOMMENDATION

Based on the findings and the results of this research, there are some of the recommendations can be made. For further study, it is recommended to include more variable in order to perform a better principal component analysis, since it required more variable in order to classify it into a group. Since this study was conducted in a limited period of time and limited access to data, the researcher that would want to carry out the same purpose of this research should consider a longer period of time and added more variable in order to find out the suitable component for each variable.

Moreover, this study only covered at Kota Bharu and Tanah Merah, so it does not present the whole country. Thus, the next research should cover a larger area such as rapidly growth city from each state. The result will be more accurate and precise to classify the component and identify the trend, if the variable and location increase the result may be differ from this research. Most of the air pollution comes from environment and vehicle factor. Therefore, people should know which factors that may affect air pollution and give attention to prevent it before it become worst.

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APPENDICES

Factor Analysis of Kota Bharu

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Wd	292.58120	82.787677	1564
Temperature	29.57788	7.449525	1564
Humidity	80.38811	28.661430	1564
Sulfur dioxide	.00089	.001233	1564
Nitrogen dioxide	.01070	.004837	1564
Ozone	.03083	.013709	1564
Carbon monoxide	.73905	.300934	1564
Particulate matters 10 micrometers	53.96739	22.687244	1564

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.682
Bartlett's Test of Sphericity	Approx. Chi-Square	2679.769
	Df	28
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.472	30.894	30.894	2.472	30.894	30.894	2.261	28.264	28.264
2	1.752	21.902	52.796	1.752	21.902	52.796	1.963	24.533	52.796
3	.918	11.478	64.275						
4	.856	10.705	74.980						
5	.734	9.180	84.160						
6	.527	6.590	90.750						
7	.400	4.995	95.745						
8	.340	4.255	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
Wd	.408	.193
Temperature	.845	-.112
Humidity	.813	-.241
Sulfur dioxide	-.133	.507
Nitrogen dioxide	.698	.285
Ozone	.030	.691
Carbon monoxide	.445	.649
Particulate matters 10 micrometers	.124	.785

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 3 iterations.

Factor Analysis of Tanah Merah

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Wd	240.54220	141.072948	1564
Temperature	26.77238	13.019389	1564
Humidity	78.16432	37.395166	1564
Sulfur dioxide	.00121	.001035	1564
Particulate matters 10 micrometers	49.07289	22.575581	1564
Nitrogen dioxide	.01621	.005151	1564

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.501
Bartlett's Test of Sphericity	Approx. Chi-Square	4838.182
	df	15
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.035	33.916	33.916	2.035	33.916	33.916	2.012	33.526	33.526
2	1.199	19.989	53.904	1.199	19.989	53.904	1.211	20.180	53.706
3	1.010	16.827	70.731	1.010	16.827	70.731	1.022	17.025	70.731
4	.906	15.095	85.826						
5	.826	13.767	99.593						
6	.024	.407	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component		
	1	2	3
Wd	-.028	-.041	.958
Temperature	.986	.028	.019
Humidity	.989	.014	-.009
Sulfur dioxide	-.025	.639	-.094
Particulate matters 10 micrometers	-.035	.729	-.018
Nitrogen dioxide	.239	.518	.307

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 4 iterations.

Mann Kendall Tau for Kota Bharu

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
API	1564	0	1564	0.000	124.000	49.811	13.983

Kendall's tau	0.146
S	176561.000
Var(S)	425214258.333
p-value (Two-tailed)	< 0.0001
alpha	0.05

	Value
Slope	0.006
Intercept	-202.686

Mann Kendall Tau for Tanah Merah

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
API	1564	0	1564	0.000	123.000	45.055	16.000

Kendall's tau	-0.222
S	-268502.000
Var(S)	425265710.000
p-value (Two-tailed)	< 0.0001
alpha	0.05

	Value
Slope	-0.011
Intercept	500.565