A STUDY ON THE CONCENTRATION AND DISPERSION OF PM_{10} IN UTHM BY USING SIMPLE MODELLING AND METEOROLOGICAL FACTORS

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This project report is specially dedicated to:

my loving and supporting parents
En ABD RAHMAN B MOHD ISA and Pn ZAHARAH BT IBRAHIM

and my sister
ZANARIAH BT ABD RAHMAN

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“**In The Name of Allah, Most Gracious and Most Merciful**”

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ABSTRACT

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere. Air pollution can also be known as degradation of air quality resulting from unwanted chemicals or other materials occurring in the air. The simple way to know how polluted the air is to calculate the amounts of foreign and/or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation and/or materials. The objective of this study is to create a simulation of air quality dispersion in UTHM campus by using computer aided design mechanism such as software and calculating tools. Another objective is to compare the concentration obtained from the end result of calculation with past studies. The air pollutant in the scope of study is Particulate Matter (PM_{10}). The highest reading recorded for E-Sampler was 305µg/m^3. It was recorded in Structure Lab sampling point while the highest expected concentration by the Gaussian Dispersion Model was 184µg/m^3 for UTHM Stadium. The recommended value for permissible exposure to particulate matter in 24 hours time is 150µg/m^3 according to the Recommended Malaysian Air Quality Guidelines.

ABSTRAK

Pencemaran udara adalah pengenalan bahan kimia, bahan zarahan atau bahan biologi yang boleh menyebabkan mudarat atau ketidakselesaan kepada manusia atau organisma hidup lain, atau menyebabkan kerosakan kepada persekitaran semulajadi atau alam bina, ke atmosfera.Pencemaran udara juga boleh dikenali sebagai degradasi kualiti udara yang terhasil dari bahan kimia yang tidak diingini atau bahan-bahan lain yang berlaku di udara. Cara mudah untuk mengetahui bagaimana tercemar udara untuk mengira jumlah bahan-bahan asing dan / atau semula jadi yang berlaku dalam suasana yang mungkin menyebabkan kesan buruk kepada manusia, haiwan, tumbuh-tumbuhan dan / atau bahan-bahan. Objektif kajian ini adalah untuk mewujudkan simulasi penyebaran kualiti udara di kampus UTHM dengan menggunakan bantuan model komputer seperti perisian dan alat pengiraan. Objektif lain adalah untuk membandingkan kepekatan yang diperolehi daripada hasil akhir pengiraan dengan kajian lepas. Pencemar udara di dalam skop kajian ini adalah Zarah Halus 10 micron (PM_{10}). Nilai bacaan tertinggi yang dicatatkan untuk E-Sampler adalah 305µg/m3. Ia telah direkodkan di dalam kawasan Makmal Struktur manakala nilai kepekatan tertinggi yang dijana oleh Model Serakan Gaussian adalah 184µg/m3 untuk UTHM Stadium. Nilai yang disyorkan untuk pendedahan yang dibenarkan untuk zarah halus dalam tempoh masa 24 jam adalah 150µg/m3 mengikut kepada Garis Panduan Saranan Kualiti Udara Malaysia.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Indoor air pollution and urban air quality are listed as two of the world's worst pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. (Blacksmith Institute, 2011)

The air we breathe contains particles and composition of particles, including mineral dust, metals, metalloids, sea salt, nitrate and ammonium sulphate, organic compounds, elemental carbon and organic and inorganic pollutants that live almost entirely in the gas phase. Some of them are directly emitted into the atmosphere either by natural sources and anthropogenic (primary particles), while others are the result of homogeneous or heterogeneous nucleation and condensation of gases (secondary particles) (Dongarrà, Manno et al. 2010).

Air quality is defined as a measure of the condition of air relative to the requirements of one or more biotic species or to any human need or purpose. (Johnson et al, 1997) while air quality indices (AQI) are numbers used by government agencies to characterize the quality of the air at a given location. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. To compute the AQI, it requires an air pollutant concentration from a monitor or model. The function used to convert from air pollutant concentration to AQI varies by pollutant, and is different in different countries.

1.2 Research Objective

The objective of this research is to predict the dispersion of PM_{10} by means of meteorological factor mainly wind using a simple modelling and also to compare the difference between concentrations of PM_{10} gained by using E-Sampler to the Recommended Malaysian Air Quality Guidelines. A simple modelling system was chosen which is name as Gaussian Dispersion Model is and it will be used to provide a more detail on the results of concentration and dispersion. The model is use to provide some basis for discussion whether meteorological factor remains as the source for concentration dispersion throughout UTHM campus.

1.3 Research Scopes

The scope in this research is to use the collective data from past research and current research on particulate matter size 10 µm (PM_{10}) and then use it to predict the possible future dispersion patterns. Apart from that, the data collected will also be used to compare with any Malaysian regulations regarding air quality.

The sampling locations are limited to 3 places and those are Structure Laboratory, Tun Syed Nasir Residential College and UTHM Stadium. These places are selected because of the distance factor and also the impact it may cause for a highly concentrated area.

1.4 Problem Statements.

In Malaysia, there are no ambient air quality standards but the Malaysian government however established ambient air quality guidelines in 1988 (Department of Environment, 2012). Pollutants addressed in the guidelines include ozone, carbon monoxide, nitrogen dioxide, sulphur dioxide, total suspended particles, particulate matter under 10 microns, lead and dust fall. The averaging time which varies from 1 to 24 hours for different air pollutants in the Recommended Malaysian Air Quality Guidelines represents the period of time over which measurements is monitored and reported for the assessments of human health impacts of specific air pollutants.

Universiti Tun Hussein Onn Malaysia (UTHM) is located in a unique area because it is surrounded by industrial area which emits pollutants directly into the air. There have been cases; but it is not reported as formal reports, more on visual reports; where particulate matters released from the industrials area goes up in the air and then for some reason fall down back to earth like snow and it accumulate on the ground surface. For this reason, people in the UTHM compound are always in questions with their health when they encounter any sickness whether it is caused by the long exposure to pollutants emitted by the factories or because of some other factors.

1.5 Research Significant

This thesis will provide knowledge about the dispersion of pollutant mainly particulate matters fewer than 10 microns by looking further into the meteorological factors. Furthermore, this research is hopefully to help others in their search for the best system to use in the future.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Air pollution can also be known as degradation of air quality resulting from unwanted chemicals or other materials occurring in the air. The simple way to know how polluted the air is to calculate the amounts of foreign and/or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation and/or materials. Urban air pollution with its long and short term impacts on human health, well – being and the environment has been a widely recognized problem over the last 50 years (Gurjar et al. 2008; Ozden et al. 2008). In addition to population growth, the rapid growth of urbanization and industrialization; where the progressive expansion of suburbs into closer proximity with industrial facilities in certain areas has led to the problem of air pollution becoming an increasingly important issue (Ferger 1999; Molina and Molina 2004). Besides deleterious effects on human health, air pollution can negatively impact ecosystems, materials, buildings and works of art, vegetations and visibility (Ilyas et al. 2009; Mage et al. 1996; Riga-Karandinos and Saitanis, 2005).

2.2 Meteorological Aspect for Air Pollution

The transport and dispersion of air pollutants in the ambient air are influenced by many complex factors. Global and regional weather patterns and local topographical conditions affect the way that pollutants are transported and dispersed. The amount and kind of pollutants that are released into the air play a major role in determining the degree of air pollution in a specific area. However, other factors are involved, mainly:

1. Atmospheric pressure;
2. Topography or earth surfaces;
3. Temperature inversion;
4. Wind speed and wind direction

2.2.1 Effects of Atmospheric Pressure in Air Pollution

Atmospheric pressure is the force per unit area exerted into a surface by the weight of air above that surface in the atmosphere of Earth. In most circumstances atmospheric pressure is closely approximated by the hydrostatic pressure caused by the mass of air above the measurement point. Low-pressure areas have less atmospheric mass above their location, whereas high-pressure areas have more atmospheric mass above their location. Likewise, as elevation increases, there is less overlying atmospheric mass, so that pressure decreases with increasing elevation. On average, a column of air one square centimetre in cross-section, measured from sea level to the top of the atmosphere, has a mass of about 1.03 kg and weight of about 10.1 N. The difference in atmospheric pressure and density varies widely on Earth as can be clearly seen in Figure 2.1 while Figure 2.2 will show the atmospheric composition from the ground surface.

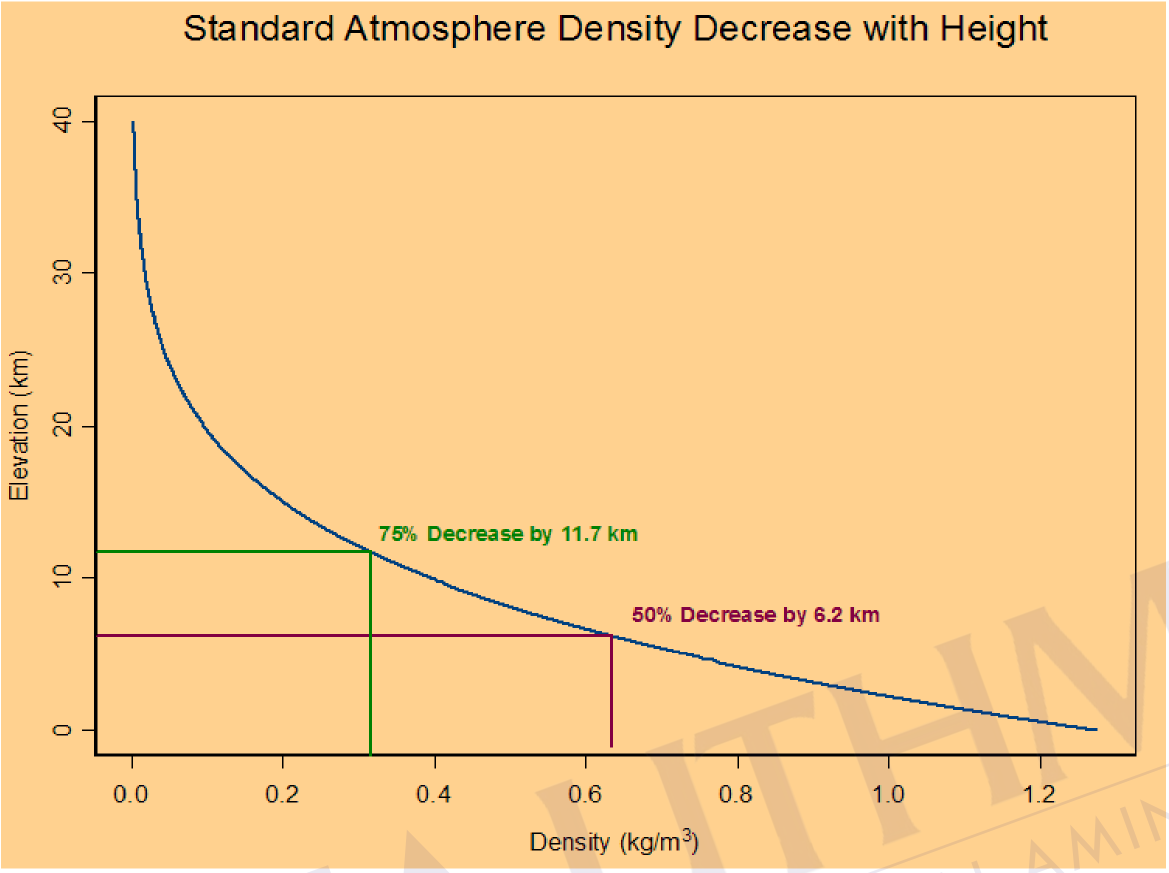

Figure 2.1: Standard Atmospheric Density Based on Elevation. (Source: University of California Santa Barbara.)

As the elevation decreases, the density is increasing. It clearly shows that the higher we go up into the atmosphere, the air around us will get thinner and the density of the atmosphere will also decrease. The height and temperature of a column of air determines the atmospheric weight. Because cool air weighs more than warm air, a high pressure mass of air is made up of cool and heavy air. Conversely, a low pressure mass of air is made up of warmer and lighter air. Differences in pressure cause air to move from high pressure areas to low pressure areas.

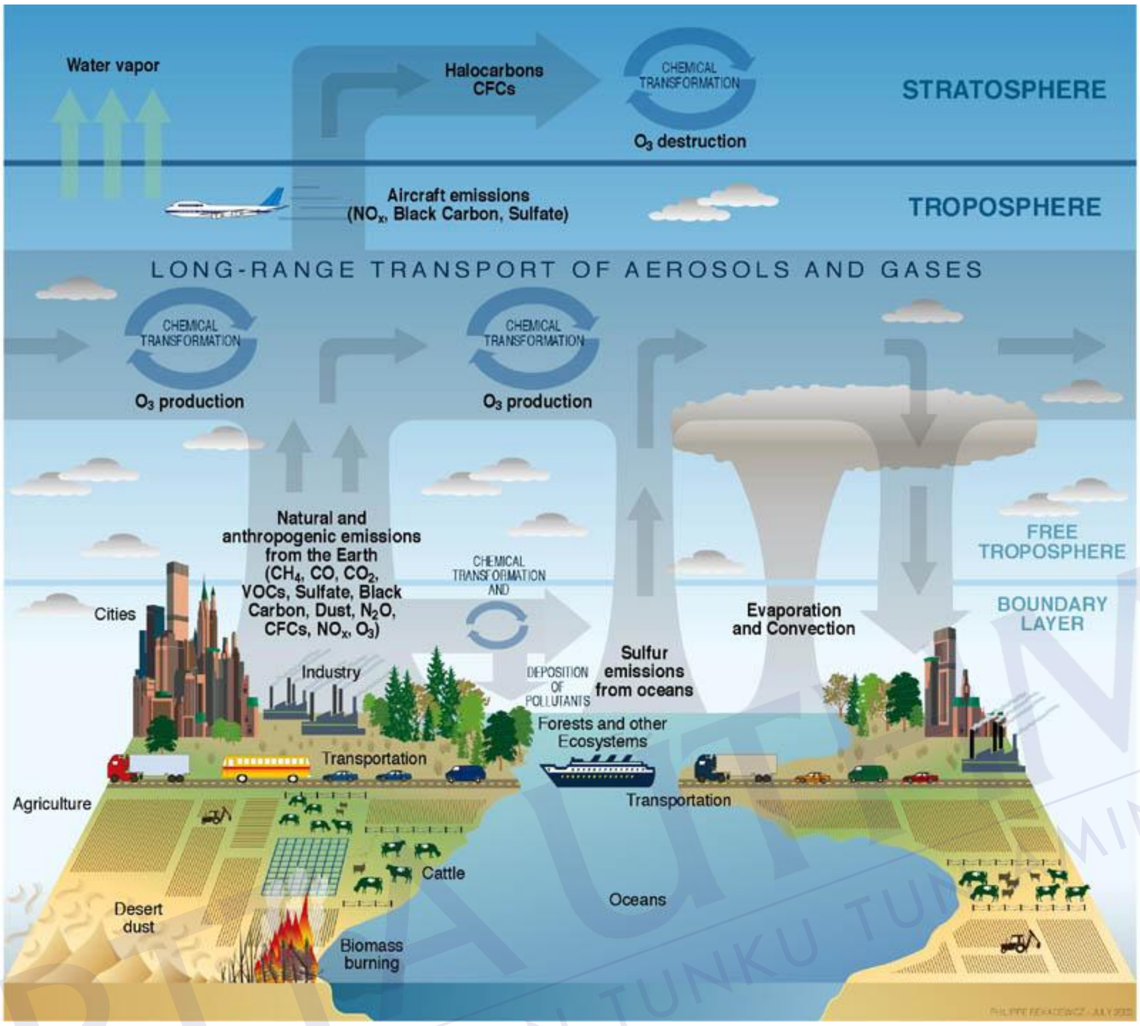

Figure 2.2: Air Pollution Sources and Means of Dispersion. (Source: US Strategic Plan for the Climate Change Science Program, Final Report July 2003)

Another point to remember is that the warm air is heavier than the cool air so the air cycle in the atmosphere will always be in an order of the warm air that have lost its heat goes up to replace the cool air that has gain heat from atmospheric interaction.

2.2.2 Effects of Topography in Air Pollution

Topography is a field of planetary science comprising the study of surface shape and features of the Earth. It is also the description of such surface shapes and features (especially their depiction in maps). The topography of an area can also mean the surface shape and features. Topography also means the arrangement of the natural and artificial physical features of an area. Topography specifically involves the recording of relief or terrain, the three-dimensional quality of the surface, and the identification of specific landforms.

Terrain, or land relief, is the vertical and horizontal dimension of land surface. Terrain is used as a general term in physical geography, referring to the lay of the land. This is usually expressed in terms of the elevation, slope, and orientation of terrain features. Terrain affects surface water flow and distribution. Over a large area, it can affect weather and climate patterns.

In terms of terrain, mountain areas are generally colder than surrounding land due to higher altitudes. Mountainous regions block the flow of air masses, which rise to pass over the higher terrain. The rising air is cooled, which causes condensation of water vapour, and precipitation. These being the case, one side of a mountain, the windward side, will often have more precipitation and vegetation; the leeward side is often drier.

In terms of proximity to the ocean, land and water retain different amounts of heat. Land heats more quickly than water, but water holds heat longer. Proximity to water moderates the climate, while inland climates are harsher. Those living near the water will experience breezy, moist weather, when the warm air from the land meets the cooler air from the water and rises, making for a windy climate with precipitation. The further inland one goes, the drier the climate in most regions.

Concentrations of pollutants can be greater in valleys than for areas of higher ground. This is because, under certain weather conditions, pollutants can become trapped in low lying areas such as valleys. This happens for example, on still sunny days when pollution levels can build up due to a lack of wind to disperse the pollution. This can also happen on cold calm and foggy days during winter. If towns and cities are surrounded by hills, wintertime smog's may also occur. Pollution from vehicles, homes and other sources may become trapped in the valley, often following a clear cloudless night. Cold air then becomes trapped by a layer of warmer air above the valley (USEPA, 2011).

2.2.3 Effects of Temperature Inversion

The situation of having warm air on top of cooler air is referred to as a temperature inversion, because the temperature profile of the atmosphere is "inverted" from its usual state. Inversions layers can occur anywhere from close to ground level up to thousands of feet into the atmosphere and because of that, there are two types of temperature inversions:

1. Surface inversions that occur near the Earth's surface;
2. Aloft inversions that occur higher above the ground.

2.2.3.1 Causes of Temperature Inversions

The most common manner in which surface inversions form is through the cooling of the air near the ground at night. Once the sun goes down, the ground loses heat very quickly, and this cools the air that is in contact with the ground. However, since air is a very poor conductor of heat, the air just above the surface remains warm.

Conditions that favour the development of a strong surface inversion are calm winds, clear skies, and long nights. Calm winds prevent warmer air above the surface from mixing down to the ground, and clear skies increase the rate of cooling at the Earth's surface. Long nights allow for the cooling of the ground to continue over a

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