AIR POLLUTION ASSESSMENT ON PARTICULATE MATTER DISPERSION AT MEGA CONSTRUCTION SITE

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The research would not be succeeded without the full commitment given by all of them.

ABSTRACT

Deterioration of air quality is becoming an issue in the global environment, especially in Malaysia. The increase of the particulate matter's generative industry such as construction, biomass energy plant and foods producers in Malaysia due to the growth of population, and rapid urbanization are the main factors of contribution to the highest industrial air pollution sources by the state from the year 2010 to 2015. One of the pollutants involved in the cause of air pollution especially in Malaysia is from particulate matter emission. The emission of particulate matter in Malaysia comes from three primary sources which are mobile, stationary, and open burning sources. In the year 2000 - 2015, the estimation percentage of annual particulate matter emission accumulated in Malaysia is 7% for every year of air pollution sources. Consequently, this distribution of particulate matter in the atmosphere produced by human activities can cause serious problem such as radiation balance of the Earth, change in the cloud formation, contribution to global warming, reduced visibility and to be worst affected to the human health especially to the workers and publics. Based on the result of the calculated data from the selected site, the average concentration of particulate emitted to the air in 24-hour mean is 0.6944 mg/m^3 for both sizes. The average concentration of particulate matter is then compared with the guidelines provided by the World Health Organization (WHO). From the values, the concentration of both $PM_{2.5}$ and PM_{10} are exceeding the level of 24 hour mean of emission and can be concluded as critical.

Keywords: particulate matter; air pollution; AERMOD

ABSTRAK

Kemerosotan kualiti udara menjadi isu dalam persekitaran global, terutama di Malaysia. Peningkatan industri seperti pembinaan, loji tenaga biojisim dan pengeluar makanan di Malaysia berikutan pertumbuhan penduduk dan pembandaran pesat adalah faktor penyumbang utama kepada sumber pencemaran udara dari tahun 2010 hingga 2015. Salah satu pencemar yang terlibat dalam punca pencemaran udara di Malaysia adalah dari pelepasan bahan berzarah. Pembebasan bahan berzarah di Malaysia berpunca dari tiga sumber utama yang merupakan sumber pembakaran mudah alih, pegun, dan terbuka. Pada tahun 2000 - 2015, peratusan anggaran pelepasan bahan berzarah terkumpul di Malaysia adalah 7% untuk setiap tahun bagi sumber pencemaran udara. Oleh itu, penyebaran bahan berzarah di atmosfera yang dihasilkan oleh aktiviti manusia boleh menyebabkan masalah yang serius seperti keseimbangan radiasi bumi, perubahan dalam pembentukan awan, sumbangan kepada pemanasan global, gangguan penglihatan dan paling teruk adalah kepada kesihatan manusia terutamanya pekerja dan orang awam. Berdasarkan keputusan data yang diukur di tapak kajian yang dipilih, kepekatan purata zarah yang disebarkan ke udara dalam masa 24 jam adalah 0.6944 mg / m^3 untuk kedua-dua saiz. Purata kepekatan bahan berzarah kemudiannya dibandingkan dengan garis panduan yang disediakan oleh Pertubuhan Kesihatan Sedunia (WHO). Dari nilai-nilai tersebut, kepekatan $PM_{2.5}$ dan PM_{10} didapati melebihi tahap purata 24 jam pelepasan dan dapat disimpulkan sebagai amat kritikal.

Kata kunci: bahan bersaiz kecil; pencemaran udara; AERMOD

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1. INTRODUCTION

1.1. Background of the study

Air pollution is the one of the major environmental problem specifically in developing countries with a rapid development. In general, the emission of particulate matter (PM) is the one of the main contribution in air pollution in dry arid land areas especially for urbanization, industrialization and construction projects (Hassan, Kumar, & Kakosimos, 2016). The dispersion of particulate matter into the atmosphere produced by human activities can cause serious problem such as radiation balance of the Earth, change in the cloud formation, contribution to global warming, and reduced visibility (Amaral, de Carvalho, Costa, & Pinheiro, 2015).

Building construction and operation projects have large direct and indirect effects on the environment which is considered as an important source of atmospheric pollution due to particulate matter emission causing negative impacts on human health and the environment (Araujo et al., 2014). Although there are many factors which affecting to the air quality, the particulate pollution at the construction industry should be given the equal attention. Theoretically, construction industries contribute a big part in world's economy, in creating new public facilities and renovations for the sake of improving public living standards.

According to Construction Industry Development Board (CIDB), the latest statistics on construction industry in Malaysia from 2014 to 2015 recorded of 7,939 projects to 7,013 projects. Although it shows the decrease value, construction industry is still one of the factors which cause to air pollution. According to Sacramento Metropolitan Air Quality Management District in year 2016, construction activities have the potential to generate a substantial amount of air pollution such as exhaust emissions of particulate matter (PM) and oxides of nitrogen (NO_x), fugitive particulate matter dust, evaporative emissions of reactive organic gases, and exhaust emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Consequentially, the poor management at construction site such as adopting materials, techniques performing task and safety and health practices can cause high exposure of particulate matter particularly to the construction workers, which can cause the adverse impact to the workers' health (Ofori, 2000). According to the report by Environment Canada (EC), construction activities represent approximately 20% of total PMT emissions and 15% of total PM_{10} emissions in Canada which indicate significant health and environmental effects associated with emission of PM and other criteria air contaminants (Environment Canada, 2005). The immoderate inhalation of particulate matter can be a source of respiratory disease such as lung cancer, asthma, and cardiovascular disease (Azarmi & Kumar, 2016). Severity of these disease determined mainly by size, with possible health effects resulting from the presence of toxic substance. Besides, most dust particles are too big to be inhaled can cause eye, nose and throat irritation (Araujo et al, 2014; Schwartz et al, 2003).

1.2. Problem Statement

Particulate matter emission at construction site especially in Malaysia is the main problem of air quality issue. Dust and particulate matter can come from several sources based on the construction activities. One of the issues is to identify which of the activities are the main contributors to the air pollution. In addition, the radius of dispersion of particulate matter emission from construction sites should be taken as consideration. This is necessary to describing the sources which gives negative impacts on workers' health and also to the environment. Besides, the growth of construction and environmental impact are important of the need for sustainable construction processes and proper way to manage sustainability measures.

1.3. Research Objectives

This research will cover two main areas which will be decided as per discussions. First, the identification of the specific activities at construction sites have to be determined, so then we can measure the concentration of particulate matter emission. Besides, the process in capture of concentration of particulate matter is influenced by meteorological conditions including temperature, humidity, rainfall and wind speed. So, we are also aim to measure meteorological measurement. Finally, the data of concentration particulate matter and meteorological measurement will use for statistical modeling of air dispersion (AERMOD model).

1.3.1. Specific objectives

1. To measure the concentration of particulate matter by referring to Malaysian Ambient Air Quality Standard (MAAQS).
2. To apply statistical modeling of air dispersion at the targeted industrial site.

1.4. Research Questions

1. How to measure the concentration of particulate matter by referring to Malaysian Ambient Air Quality Standard (MAAQS)?
2. How to apply statistical modeling of particulate matter emission at industrial site?

1.5. Research Framework

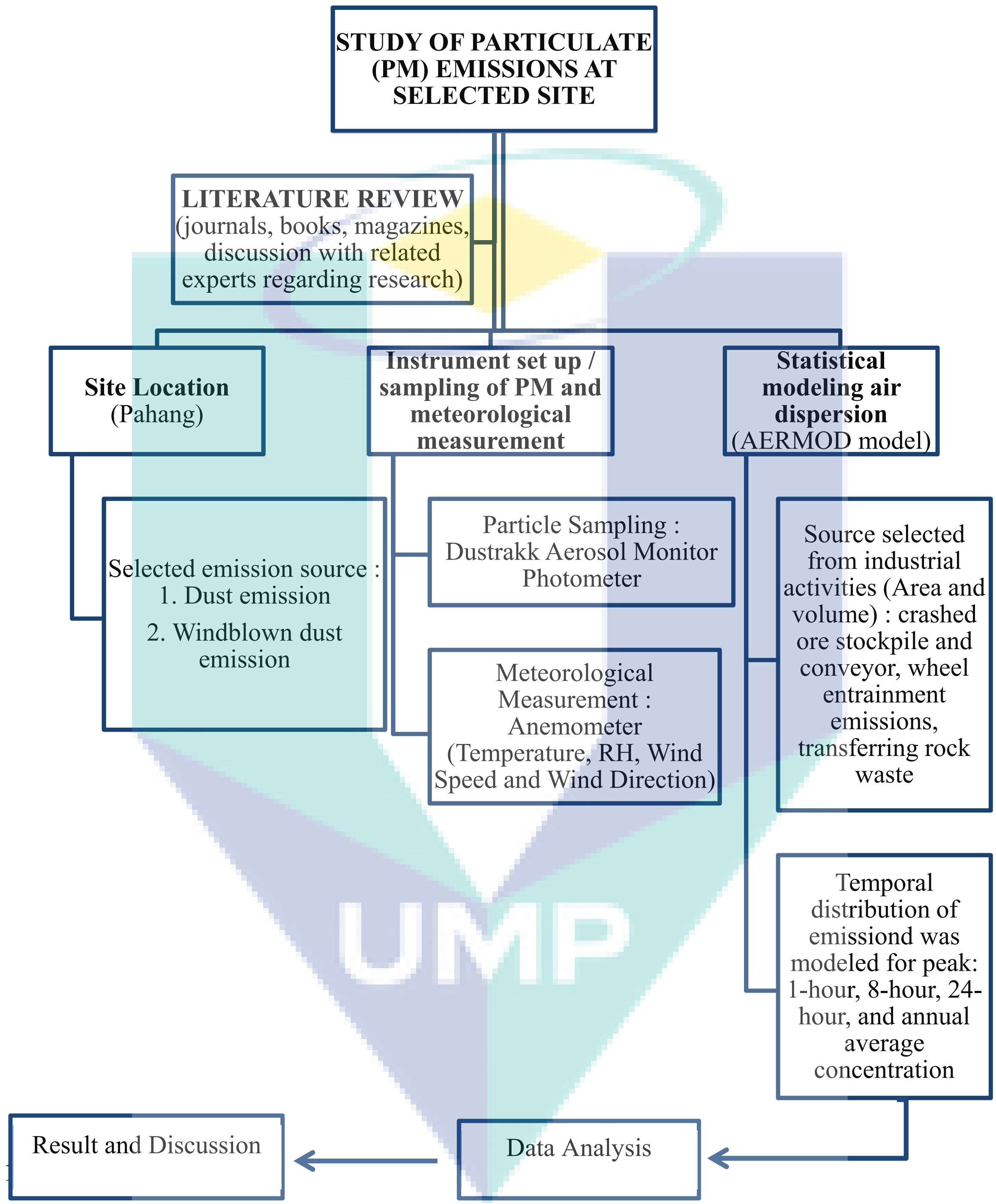


Figure 1: Research framework

2. LITERATURE REVIEW

2.1. Atmospheric Pollution and Particulate Matter

Air pollution can be defined as the anthropogenic emission of harmful chemicals that alter the chemical composition of the natural atmosphere. According to National Quality Standards (NAAQS), air pollutants are categorized into six types which are nitrogen oxides (NO_2), ozone, sulfur dioxide, particulate matter (PM), carbon monoxide, and lead. However, Malaysia Ambient Air Quality Standard (MAAQS) stated that particulate matter with the size of less 2.5 micron ($PM_{2.5}$) and the size of less than 10 micron (PM_{10}) are classified as two difference pollutants. Still, previous research proved that the factors of suspended particulate and dust fall are the main contributor for ambient air quality deterioration (Yuwono, Amaliah, Rochimawati, Kurniawan, & Mulyanto, 2014). This statement also support by other researcher who claimed that particulate matter is the pollutant which is mostly directly emitted from a sources which cause air pollution (Daly & Zannetti, 2007). Hence, air pollution exposure will give adverse effect on the health of living things at the same time reduce air's visibility for short and long term period (Araújo, Costa, & de Moraes, 2014).

Airborne particulate matter (PM) has a wide variety of sources especially from natural (sea spray and fire) and man's activities (construction, road transport and industry). Particulate matter in the air is made up of a complex mixture of solid and liquid particles that come from local regional sources which include elemental and organic carbon such as sulphate, nitrates, ammonium, solid chloride, mineral dust, water and a series of metal (Environment Agency, 2013). By referred to Malaysian Ambient Air Quality Standard (MAAQS), the limit concentration for particulate matter (PM_{10}) within 24 hours is not exceeding than 150 $\mu g/m^3$ and for particulate matter ($PM_{2.5}$) is not exceed to 75 $\mu g/m^3$.

2.2. Particulate Matter at Construction Industry

Generally, the four main sectors of construction industry in Malaysia, including residential buildings (houses and condominiums), none-residential buildings (warehouse and industrial buildings), civil engineering (bridges and highways) and special trade sectors (electrical and plumbing) are actively working towards achieving a high income status by 2020 (Olanrewaju & Abdul-Aziz, 2015). Basically buildings and structures essentially required to meet people social needs for shelter and economical lives (Nazirah Zainul Abidin, 2010). However, the rapid of construction development especially in urban area will be impacted to the quality of ambient air. This is proven that construction activities have been recognized as dynamic sources for the input of particulate particles and hazardous trace gases into the atmosphere (Faber, Drewnick, & Borrmann, 2015).

Furthermore, the pollutant of particulate matter is produced from the source of construction operations and building demolition (Enger & Smith, 2000). Previous research recognized that activities related to building construction involving earthmoving operation, truck loading and dumping are the main contributor of particulate emission (Muleski, Cowherd, & Kinsey, 2005). Similarly, research claimed that, the construction procedure such as grinding produced the high level of particulates (Wu, Zhang, & Wu, 2016). Therefore, by considering the negative impact of particulate matter to the atmosphere, the evaluation for particulate matters emission from construction activities should be conducted especially when standards for particulate matter are exceeded and control plans are needed (Sinesi, Petracchini, & Allegrini, 2008).

2.3. Impact of Particulate Matter to the Construction Workers

The large quantities of particulate matter emission generated from activities at construction site could be inhaled by on-site workers and people living in the neighborhood will impacted to the human health (Azarmi & Kumar, 2016). These particulates will penetrates into sensitive regions of the respiratory system and can lead to the increases in mortality and hospital admissions (Qureshi et al., 2015). Previous research shows that the construction workers are face to the respiratory problem including bronchitis, emphysema and asthma (Mabahwi, Leh, & Omar, 2014). Besides that, particulate matter is a very small particle that can be carried deep into the lungs and cause inflammation, worsening heart and lung disease (Defra, 2013; Botkin & Keller, 2007).

U.S Bureau of Labor Statistics (BLS) reported that, 41% of construction workers had an abnormal pulmonary function and 1.4% of them suffered beryllium sensitivity (BeS) (Societies, 2013). In Malaysia, statistic shows that only one case related to Malaysian construction safety and health issues in 1961-2011 which is caused by gaseous fumes and vapor was recorded (Chong & Low, 2014). Although, the health issues related to construction workers is low, it still has to give equal attention as another accidents due to the chronic term effect proven by previous research.

2.4. Statistical Modeling Approach for Particulate Matter (AERMOD Model)

Air quality assessment by integrating measurement techniques and modeling tools is a crucial element in pollution mitigation which is improves the accuracy of prediction which translates directly into a better understanding of the risk at involved receptor (Turtos et al., 2010). AMS/EPA Regulatory Model (AERMOD) is applicable to multiple sources including point, area and volume sources which is assumes the concentration distribution to be Gaussian in both vertical and horizontan direction (Mohan et al., 2011;Kakosimos et al., 2011). Furthermore, this model is an advance plume model that combines updated treatments of turbulence and dispersion in the planetary boundary layer for flow over the flat and complex terrain (Turtos et al., 2010).

Airborne Particulate Matter (PM) around us is generated from two important sources; natural (e.g. sea sprays, entrained dust and fires) and man's activities (e.g. construction, road transport, combustion, industry and minerals extraction) which is known to have significant impacts on the environment and human health *(Environment Agency 2013)*. Basically, Particulate Matter (PM) also known as particle pollution is a complex mixture of extremely small particles and liquid droplets *(Mohd Zin et al. 2008)*. Meanwhile, suspended particulate is a complex mixture of particles that may be solid, liquid or both, suspended in the air and consisting of organic and inorganic substances *(Yuwono et al. 2014)*.

Particulate matter can be divided into three categories; inhalable coarse particles, fine particles, and ultra-fine particles. Coarse particles are defined as those having an aerodynamic diameter larger than 2.5 µm ($PM_{2.5}$) and smaller than 10 µm aerodynamic diameter (PM_{10}). Fine particles are those having an aerodynamic diameter less than 2.5 µm, and ultra-fine particles are those less than 100 nm in diameter *(Lee 2010)*. From these categories, coarse particles are less harmful to public health than fine particles ($PM_{2.5}$) *(Bari and Kindzierski 2016)*. The common parameters used to determine the concentration of particulate matter is based on the particulate mass concentration *(Dominick et al. 2015)*. Besides, meteorological factors also contribute to the amount of particulate matter in the region. Higher concentrations of particulate matter have been recorded during the dry season, predominantly during the El Nino/Southern Oscillation (ENSO) events *(Shaadan et al. 2015)*.

Inter-comparison studies of major Asian cities in most cases shown the excessive of USEPA 24-hrs and annual standards with high levels of PM_{10} and $PM_{2.5}$ in those cities especially during the dry season *(Mohd Tahir et al. 2013).* China is one of the countries experiencing rapid urban population growth, and industrialization produces large quantities of particulate matter and contributes to the particulate-bound pollutant contents of road dust *(Zhao et al. 2016).*

Similarly, Malaysia has also undergone developing rapid urban growth which affected by local and regional air pollution from three main sources of air pollutants which are mobile especially motor vehicles, stationary such as construction works and industrial waste incinerators, and transboundary sources *(Dominick et al. 2012).* Klang Valley is one of the most economic zones and developed areas in the growth of urbanization, population, and industrial activities are constantly exposed to the problem of air quality *(Azmi et al. 2010).* Besides, PM_{10} has been recognized as an important atmospheric pollutant in in Klang Valley, Malaysia *(Juneng et al. 2011).* The emission of PM_{10} in Klang Valley is due to the rapid transformation into the wide urban region during last decade of the twentieth century, and it contributed to the environmental issues particularly air pollution *(Abdullah et al. 2012).*

As a consequence, particulate matter can cause serious problems in the environment such as the change in the radiation balance of the Earth, change in cloud formation, contribution to global warming, and reduced visibility. The levels of PM_{10} concentration in Malaysia complies to the Malaysia Ambient Air Quality Guidelines (Table 1) *(DOE, Environment Quality Report 2015).*

Table 1: Malaysia Ambient Air Quality Guidelines.

Pollutant	**Averaging Time**	**ppm**	**(µg/m³)**
Ozone	1 hour	0.10	200
	8 hours	0.06	120
Carbon	1 hour	30.00	35**
Monoxide	8 hours	9.00	10**
	1 hour	0.17	320

Nitrogen Dioxide	24 hours	0.04	
Sulphur Dioxide	1 hour	0.13	350
	24 hours	0.04	105
Particulate Matter (PM_{10})	24 hours		150
	12 months		50
Total Suspended Particulate (TSP)	24 hours		260
	12 months		90

Note: ** mg/m^3

The trends of annual average concentration of PM10 in Malaysia from the year 2010-2015 (Figure 2) shows slightly fluctuated for every year and in the year 2010 until 2014 is not exceed the guidelines. However, in the year 2015, the annual average value of PM_{10} in the ambient air was 53 µg/m^3 which exceeded the Malaysia Ambient Air Quality Guidelines, and it is recorded as the highest concentration of PM_{10} for five years.

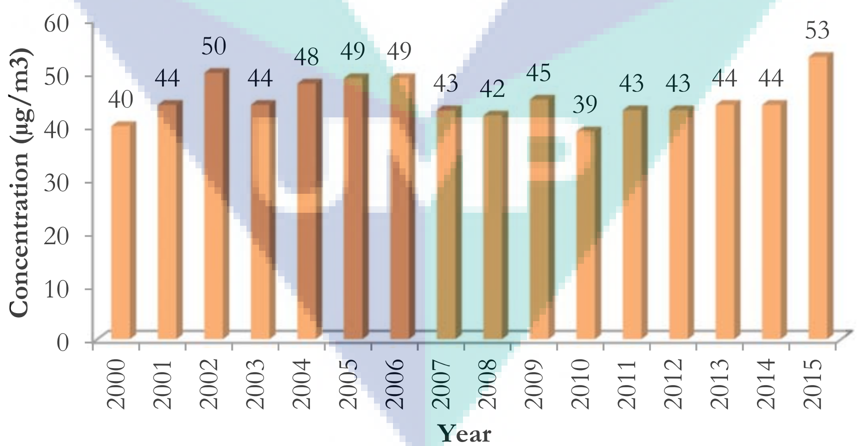
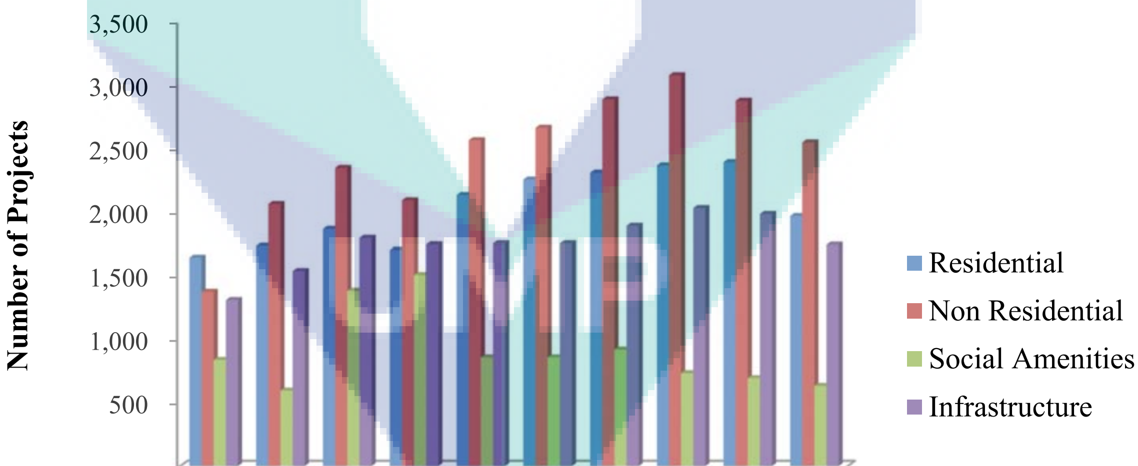


Figure 2: Annual Average Concentration of PM_{10} in Malaysia from 2010-2015.

Generally, a construction site is the place for construction work including design, manufacturing, technology, material and workmanship and services for the purpose of construction (*CIDB, Act A1407 2011)*. In Malaysia, four main sectors of the construction industry are identified as residential buildings (houses and condominiums), none-residential buildings (warehouse and industrial buildings), civil engineering (bridges and highways) and special trade sectors (electrical and plumbing) which are actively working towards achieving a high-income status by 2020 *(Olanrewaju and AbduL Aziz 2015)*. The rapid of construction development, especially in urban area, will give an impact to the ambient air quality by the generation of fugitive Particulate Matter (fPM) from construction dust in the dry arid land at the site which is a frequent product of soil erosion from winds *(Hassan et al. 2016)*. For many activities that result in fugitive dust emissions, the dust emission is strongly dependent on the material or soil moisture content because moisture tends to promote particles to clog together, preventing particles becoming airborne *(EEA 2016)*.

Moreover, construction dust is a major source of particles and contributes greatly to the PM_{10} and $PM_{2.5}$ in the atmospheric environment *(Yongjie et al. 2016)*. Construction activities have the potential to generate a substantial amount of air pollution such as exhaust emissions of particulate matter (PM) and oxides of nitrogen (NO_x), fugitive particulate matter dust, evaporative emissions of reactive organic gases, and exhaust emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) *(SMAQM 2009)*. In sequencing of performing of construction dust from construction and demolition activities, it also becomes the largest contributors of the street dust which suspends into the air under influence of human activities and wind action *(Abdel Hameed at al. 2016)*.

Building and road construction such as land clearing, drilling, and blasting, ground excavation, cut and fill operations (i.e., earth moving), and construction of a particular facility itself are the two examples of construction activities with high dust emissions potential with vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions *(USEPA 2016)*. Also, the construction activities involving excavation, loading, and transport of soil by an excavator and several dump trucks have been recognized as dynamic sources for the input of particulate particles and hazardous trace gasses into the atmosphere *(Faber et al. 2015)*. Other activities related to building construction act as the main contributor of particulate emission are involved the earthmoving operation, truck loading and dumping *(Muleski et al. 2005)*. Previously, prior research on environmental impacts of construction works was more focused on raw materials, its manufacturing and operational phase of the facility which is related to the global warming potential of pavement based on eight components such as materials extraction and production, transportation, onsite equipment, traffic delays, carbonation, lighting, albedo, and rolling resistance *(Ma et al. 2016)*. Thus, the latest research now highlights particulate emissions during the construction and mainly due to the operation of onsite heavy construction equipment *(Waris et al. 2014)*. The exposure of human population to PM originating from construction related activities is expected to increase because of the recurring infrastructure developments that accompany the exploding urbanization occurring around the world *(Li et al. 2015)*. Recently, the latest statistics on the construction industry in Malaysia from the year 2014 to 2015 is recorded from 7,939 projects to 7,013 projects *(CIDB, Annual Report 2015)*. Besides, the sector of non-residential is recorded as the highest ranking of the construction project in Malaysia from the year 2006-2015 (Figure 3) with 24,471 projects, followed by residential sector with 20,352 projects, and the third ranking of the highest project in Malaysia is infrastructure sector with 17,523 projects. The lowest number of projects is under sector of social amenities with 9,009 projects from the year 2006 to 2015.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Residential	1,642	1,732	1,865	1,701	2,131	2,253	2,307	2,365	2,390	1,966
Non Residential	1,373	2,060	2,345	2,090	2,563	2,661	2,884	3,075	2,874	2,546
Social Amenities	837	596	1,381	1,505	857	857	918	733	693	632
Infrastructure	1,308	1,536	1,794	1,743	1,751	1,751	1,889	2,028	1,982	1,741

Year

Figure 3: Number of projects in Malaysia 2006-2016.

Construction industry generates a variety of different wastes which affected to the serious environmental impacts especially air pollution is regarding lacking implementing environmental management in the stage of construction, type of construction work and construction practices on site *(Muhwezi et al. 2012).* The high impacts of environmental also caused by the sources of construction processes (i.e., waste generation, energy consumption, resource depletion, etc.), emissions from onsite construction equipment account for more than 50% of the total impacts, emissions from equipment (power-driven by diesel engine such as non-road construction equipment, machinery, and vehicles (*Waris et al. 2014).* The pollutant of particulate matter is produced from the source of construction operations and building demolition (*Araújo et al. 2014*). Besides, similar research claimed that the construction procedure such as grinding activities proved to produce a high level of particulates *(Wu et al. 2016).*

Therefore, by considering the negative impact of particulate matter on the atmosphere, the evaluation for particulate matters emission from construction activities should be conducted especially when standards for particulate matter are exceeded, and control plans are required *(Sinesi et al. 2008).* The rise in the number of construction of new buildings give an impact to the air quality and the matter related to the construction has become an important issue. The statement is proved based on the total number of construction projects for every state in Malaysia in the year 2015 (Table 2) affected to the .percentage of industrial air pollution sources by states in Malaysia year 2015 (Figure 4). The states of Selangor is the highest undergoing construction project, and the result is parallel to the most polluted of air quality in Malaysia with 21%. The state of Perlis is undergoing the least number of Malaysia construction projects in 2015, and it is significant to the lowest percentage of industrial air pollution sources with 1%.

Table 2: Number of construction projects year 2015.

States	**No. of Projects**
Johor	1,110
Selangor	1,472
Wilayah Persekutuan	637
Sabah	381
Sarawak	509

Negeri Sembilan	442
Perak	451
Pulau Pinang	507
Pahang	481
Terengganu	273
Melaka	275
Kedah	295
Kelantan	139
Perlis	41

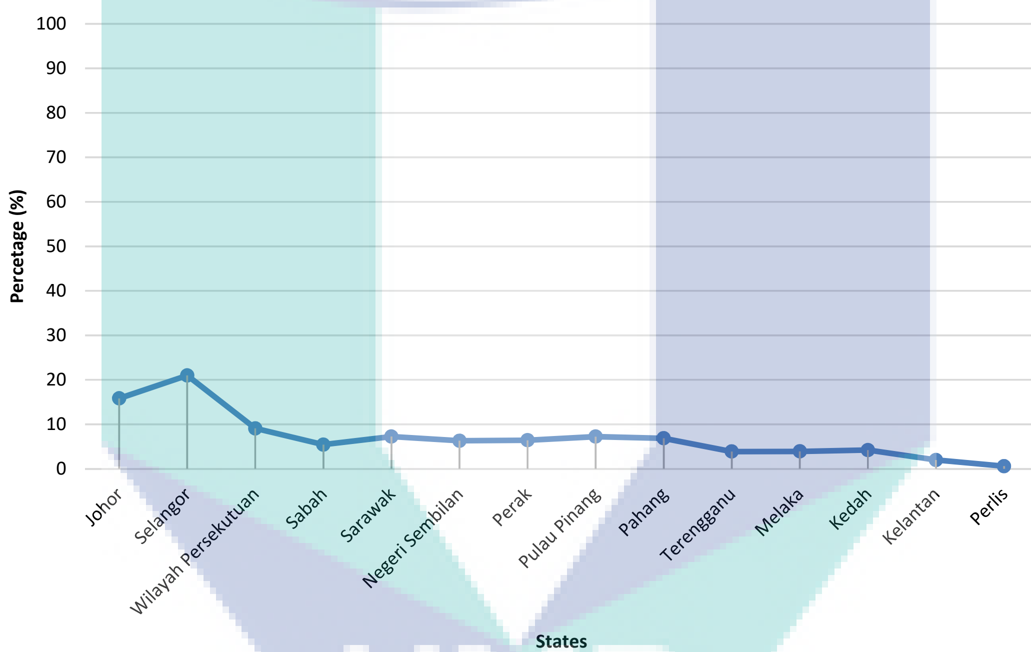


Figure 4: Percentage of Industrial Air Pollution Sources by States in Malaysia Year 2015.

Trends of air pollution are not only depend on the emission of certain pollutants but also of the meteorological condition in the area of interest such as at construction site *(Barmpadimos et al. 2011)*. The defining of pollutant levels is based on the factors of meteorological in the transport and diffusion stage of the air pollution cycle such as wind speed, precipitation and mixing height is well recognized for a given rate of pollutant emission *(Bhaskar and Mehta 2010)*. It is also estimated the volume and variability of pollution are largely affected by meteorological conditions, which can have an effect on both dilution and concentration of pollutants *(Olszowski 2016).* Additionally, photochemical reactions depend upon favorable temperature, relative humidity, and solar radiation. Also, the accumulation and transport of particles are closely related to the synoptic system and atmospheric circulation *(Li et al. 2015).*

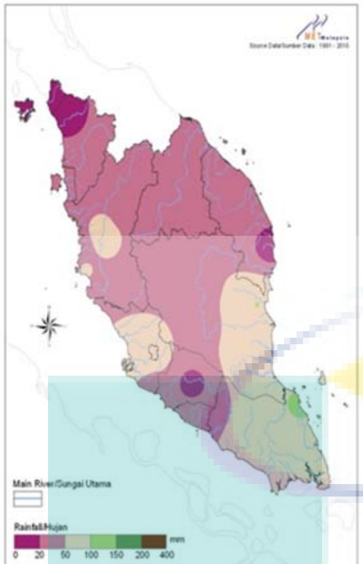
Rainfall acts as a remover for atmospheric particulates and moisture restricts the possibility of resuspended soil particulate by making the soil humid *(Owoade et al. 2012).* Thus, the effect of precipitation scavenging effect on the reduction of gaseous and particulate pollutants specifically with a diameter below 10 µm, such as PM_{10} during the wet season is greatly reduced *(Kim et al. 2014).* In Peninsular Malaysia (Table 3), the month of November is recorded as a maximum average of rainfall while February is the minimum average of rainfall in the year 2015. The highest average on November is due to the northeast monsoon or rainy season which has started in Malaysia at the end of last October. The most of the areas in Peninsular Malaysia have received more rainfall are Penang, Perak, Pahang north, south Kelantan and Selangor by adding the percentage of anomalies from 20% to 60% *(MMD 2017).* However, the month of February is in the final phase of the Northeast Monsoon which recorded less rainfall. Most areas in the north and west of Peninsular Malaysia such as Perlis, Kedah, Penang, Perak, and Selangor have recorded a reduction of rainfall 40% to 60% below the average, and the amount of rainfall are below 100 mm *(MMD 2017).*

Table 3: Average of rainfall in Peninsular Malaysia in the year 2015 *(DIDM 2015).*

Month	Average of Rainfall (mm)
January	136.5
February	52.6
March	93.0
April	210.4
May	189.2
June	138.3
July	160.4
August	194

September	212
October	216
November	318
December	198

The previous study proved the rainfall removal efficiency for Total Suspended Particles (TSP) *(Guo et al. 2016)*, and it is shown from the agrometeorology data and mean of (PM_{10}) based on the region in Peninsular Malaysia in the year 2010 (Figure 5). Agrometeorology data (Figure 5) represent 10 days rainfall average in Peninsular Malaysia for the third decade for every month from the year 1981-2010. Generally, all of the region in Peninsular Malaysia involve north, east, central, and south Malaysia have experienced the optimum quantity of rainfall with 50-100 mm from March to September. Also, the states of Perlis, several places in Negeri Sembilan and Terengganu is recorded as the driest place with the least average of rainfall (0-20 mm). Heavy rain occurred mostly in the North and East region of the Peninsular region in the month of October until December. The concentration of particulate matter was collected at selected station. In the central region, the location is chosen at Sek. Men. Perempuan Raja Zarina, Klang, the station for East region is Sek. Keb. Chabang Tiga, Kuala Selangor, while the north region is located at Sek. Men. Pegoh 4, Ipoh, and the location station in the south region is at Sek. Men. Teknik Tuanku Jaafar, Seremban. According to Figure 5, the highest concentration of PM10 was recorded from January to May.



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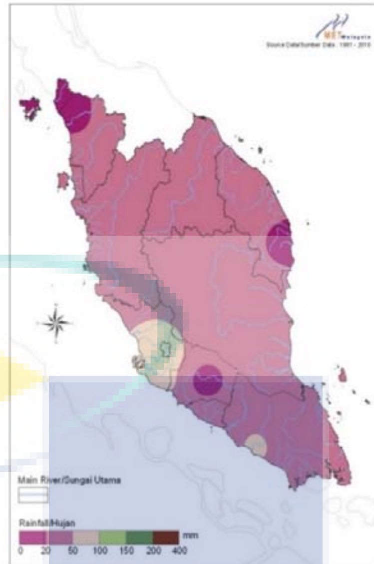

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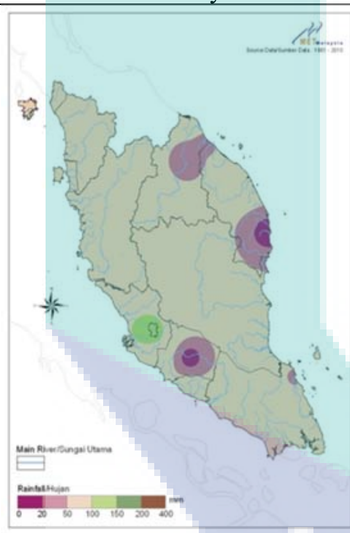

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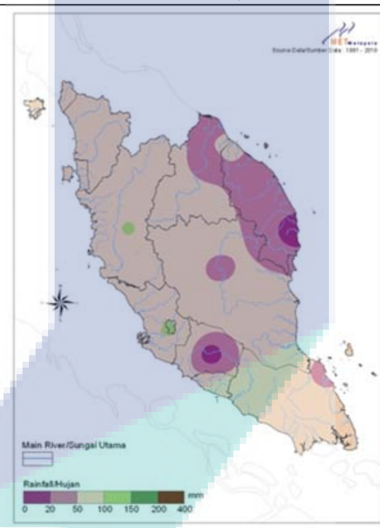

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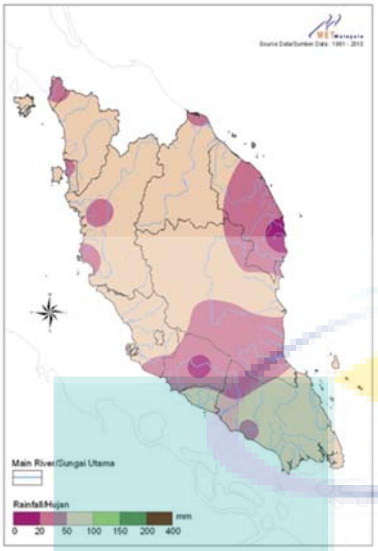

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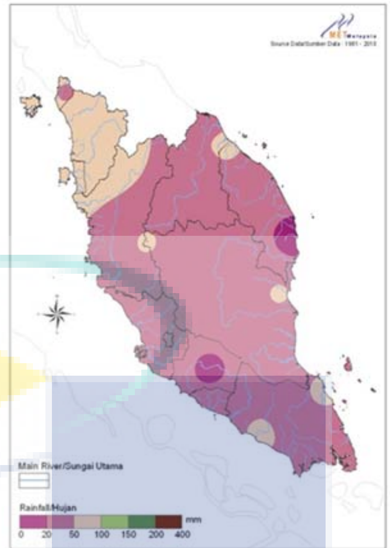

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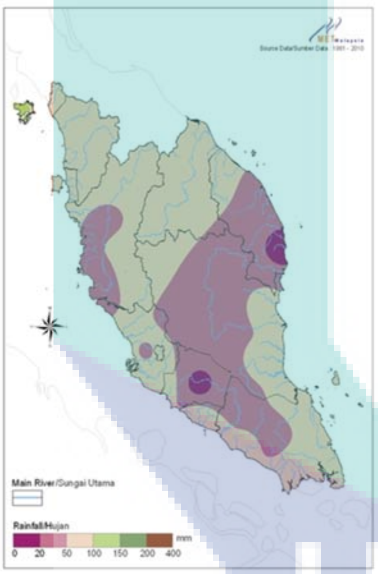

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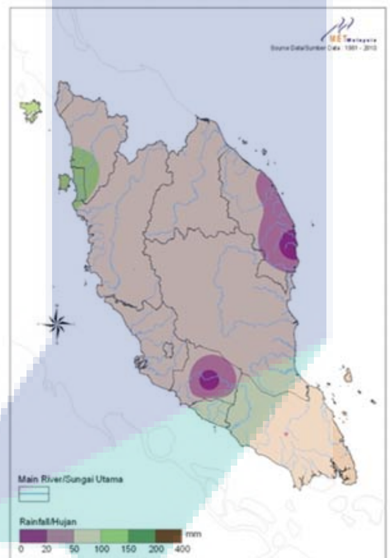

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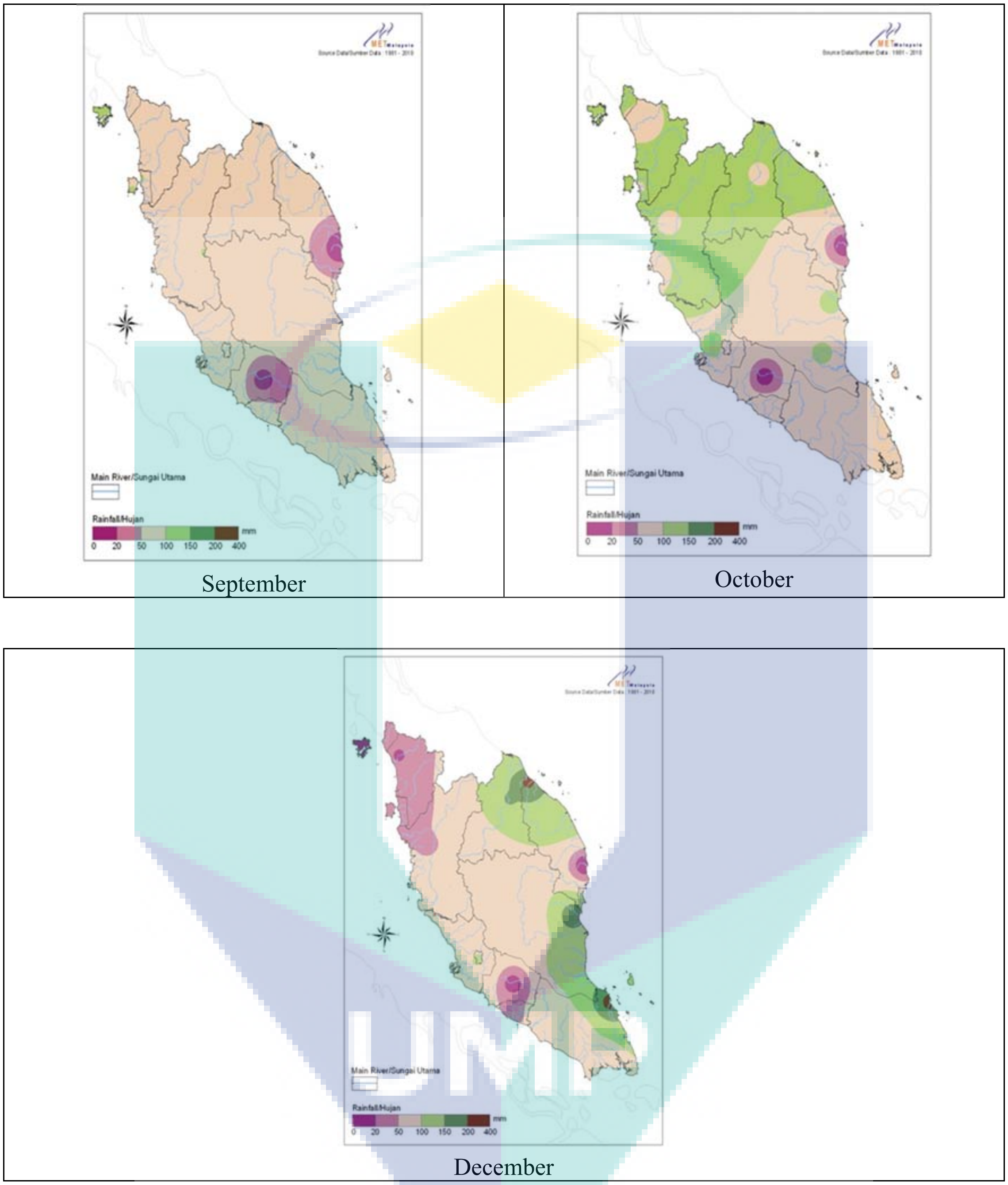


Figure 5: 10 days rainfall average for the third decade (21^{st} – 30^{th}) from 1981-2010.

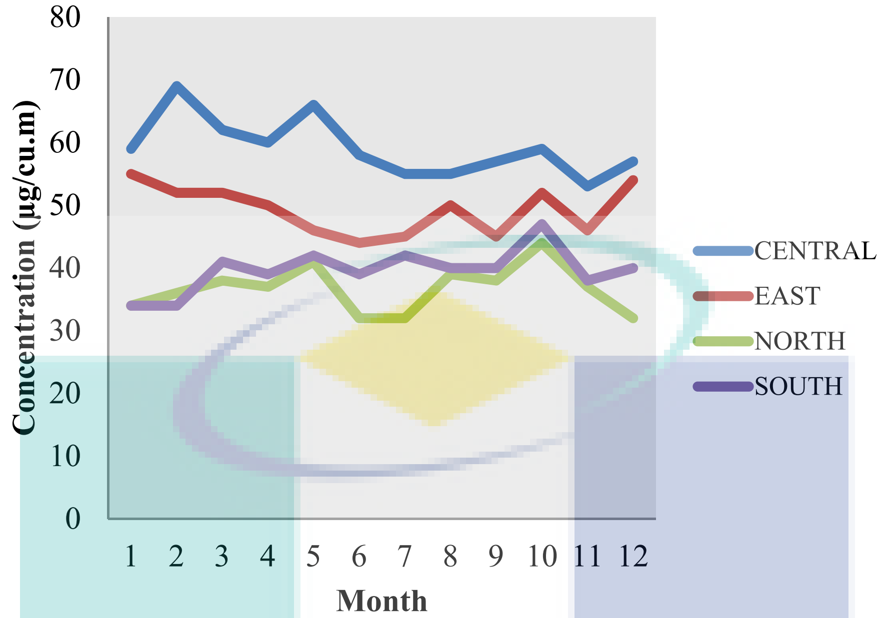


Figure 6: Mean of (PM10) based on the region in Peninsular Malaysia in the year 2010.

Effects particulate matter to the construction workers

Workers in cement plants are exposed to airborne particulate matter (dust) generated from cement and raw materials during the production of cement exposed to cement-containing dust, although in lower concentrations *(Nordby et al. 2016)*. Regarding the article by Scroll.in published on November 2016, construction workers in India highly exposed to the cement (contain chromium and metal) and construction dust enter the lungs and damage the alveolar macrophage and form the first line of defense in lungs and cause fibrosis *(Yadav 2016)*. Likewise, hazardous respirable dust like steel dust, cement dust, black carbon, and rubber are occupationally exposed were associated with acute and chronic health effects especially on the respiratory system and lung function performance *(Masngut et al. 2015)*. Research also claimed that the continued exposure to dust particles at such sites accelerates the decline in lung functions *(Sumana et al. 2016)*. The construction workers also were exposed to particulate matter with tiny particles in the air with the shape of dust, soot, fly, ash, wood smoke, sulfate aerosols and diesel exhaust particles which are the trigger to the respiratory problem including bronchitis, emphysema, and asthma *(Mabahwi et al. 2014)*. The inhalation of small particles induces an inflammatory reaction in the airways and subsequent induction of systemic inflammation and coagulation disturbances, and associates between ambient particulate air pollution and disturbances of the cardiac autonomic nervous system where there are changes in heart rate variability associated with ambient particulate air pollution *(Torén et al. 2007)*.

Besides, U.S Bureau of Labor Statistics (BLS) reported that 41% of construction workers had an abnormal pulmonary function and 1.4% of them suffered beryllium sensitivity (BeS) *(Beryllium Network 2016)*. Consequentially, the adverse impact to the construction workers' health is caused by high exposure to particulate matter due to the poor management at construction site such as adopting materials, techniques of performing task and safety and health practices *(Ofori 2000)*.

Relationship between particulate matter and public effects

Recently, the exposure to tiny particles present in indoor and outdoor air pollution causes about 2 million death per year *(Gozzi et al. 2016)*. The large quantities of particulate matter emission generated from activities at construction site could be inhaled by on-site workers, and people living in the nearby neighborhood will give an impact to the human health *(Azarmi and Kumar 2016)*. These particulates will penetrate into sensitive regions of the respiratory system and can lead to the increases in mortality and hospital admissions *(Qureshi et al. 2015)*. Besides that, particulate matter is a very small particle that can be carried deep into the lungs and can cause inflammation, worsen the heart and lung disease risks. Aerosols like particulate matter also render harmful effects on human health, mostly lung and eye diseases, as a major component of the air pollution (PM_{10} and $PM_{2.5}$) and degradation of visibility *(Kanniah et al. 2016)*. This is also proved by other research where ultrafine particles penetrate the pulmonary alveolus causing breathing problems *(Amaral et al. 2015)*. Numerous scientific studies have linked particulates pollution exposure to a variety of problems, including increased respiratory symptoms (such as irritation of the airways, coughing, or difficulty in breathing), decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease, and the people with heart or lung diseases, children, and older adults are the most likely to be affected by particle pollution exposure, However, healthy people may experience temporary symptoms from exposure to elevated levels of particulates pollution *(Mohddin and Aminuddin 2014)*.

In Malaysia, statistic shows that only one case related to Malaysian construction safety and health issues in 1961-2011 which is caused by gaseous fumes and vapor was recorded *(Chong and Low 2015)*. Although the health issues related to construction workers is low, it still has to be given an equal attention as another incident due to the chronic term effect is proven by previous research. Therefore, it is necessary to cancel mass actions for people who are sensitive to air pollution which makes the construction site as a certain type of objects unprofitable in the area *(Sanzhapov et al. 2016).*

3. MATERIALS AND METHODOLOGY

3.1. Sampling Area

Essentially, Malaysia is situated in central South-East Asia, tropical climate weather with high temperature and high humidity throughout the year. In daytime, the temperature can rise above 30 °C (86°F) year-round and temperatures rarely drop below 20 °C (68 °F) during in night time. Selangor is one of the states along the west coast of Peninsular Malaysia at the northern outlet of the Straits of Malacca. Recently, Selangor is undergoing to the rapid urbanization which led to extreme changes in the state land use pattern (Mabahwi, Leh, & Omar, 2015). The increase of needs in building and structures are to meet their social needs for shelter and economic needs (Nazirah Zainul Abidin, 2010). Therefore, Selangor is an interesting place in conducting the air quality study hence the increase of the urbanization projects.

3.2. Sampling Station

This study will be conducted in construction site in Selangor. The early phase of construction site is selected because in this phase, construction activities such as; site preparation, foundation work, installation of major structure and demolition, are categorize as earthmoving operations that potentially as a contributor for particulate matter emission (Muleski, Cowherd, & Kinsey, 2005).

3.3. Study Design

This study will be a cross sectional study.

3.4. Study Period

This study is about monitoring the ambient air at construction site which is influenced by the weather of surrounding targeted area. Therefore, this study is conducted in one month during Southwest Monsoon. The early of June 2017 is selected because in this month is the driest months in most districts. Thus, the selected month is very suitable to conduct this study.

3.5. Sample Size

According to Guideline for Ambient Air Quality Monitoring (2003), the number of distribution of sampling station that should be conducted is one station.

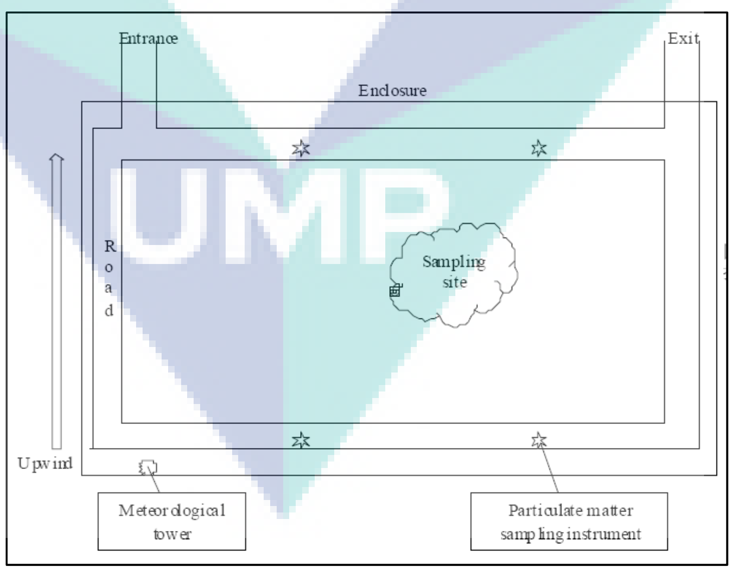
Table 4: Distribution of Sampling Stations

Total number of stations	**Number of stations**	
	In city center or industrial areas	**In residential area**
1	1	0
2	1	1
3	2	1
4	2	2
5	3	2
10	6	4

(Source: Pollution, Board, & Environment, 2003)

3.6. Sampling Method

3.6.1. Particulate Sampling



- Monitoring stations will be set up at construction site for one month to evaluate the concentration of particulate matter:

- The construction site divided into four sections based on the type of construction activities. The selected construction activities including crashed ore stockpile and conveyor, wheel entrainment emissions, and transferring rock waste.
- Total Suspended Particulate (TSP) and Particulate Matter (PM) can be determined by using Dustrakk Aerosol Monitor Photometer Model 8530.
- It will be attached approximately 3m (±0.3m) height above ground, at all the monitoring stations.

- Construction emissions:
- Maximum 24-hour Emissions: Maximum daily (24-hour) emissions from construction were calculated by first calculating daily emissions from individual construction activities and elements.
- Maximum 1-hour and 8-hour Emissions: The construction schedule is assumed to be 10 hours per day, 6 days per week, and 52 weeks per year for SCIG site construction, and 10 hours per day, 5 days per week and 52 weeks per year for relocated tenant site construction. Daily construction activities were assumed to be constant throughout the workday. Therefore, the maximum 1-hour emissions were estimated by dividing the maximum daily emission rates by 10 hours. The same emission rates, on a per-hour basis, were used for the 8-hour averaging period.

3.6.2. Preparation Meteorological Measurement

3.6.2.1. Selecting the Site of Operation

In general, anemometers are designed to record wind conditions over a large area. In order to obtain comparable values for the determination of surface wind, measurements should be made at a height of 10 meters over open level terrain. Open level terrain is defined as an area where the distance between the anemometer and an obstruction amounts to at least 10 times the height of the obstruction. If, this condition cannot be met, then the anemometer should be set up at such a height where the measured values are, to the greatest extent possible, not influenced by local obstructions (approximately 6-10 meters above the obstruction). Besides that, the anemometer should be installed in the middle of flat roofs - not at the edge - in order to avoid a possible bias to one direction or the other.

3.6.3. Statistical Modeling of Air Dispersion (AERMOD)

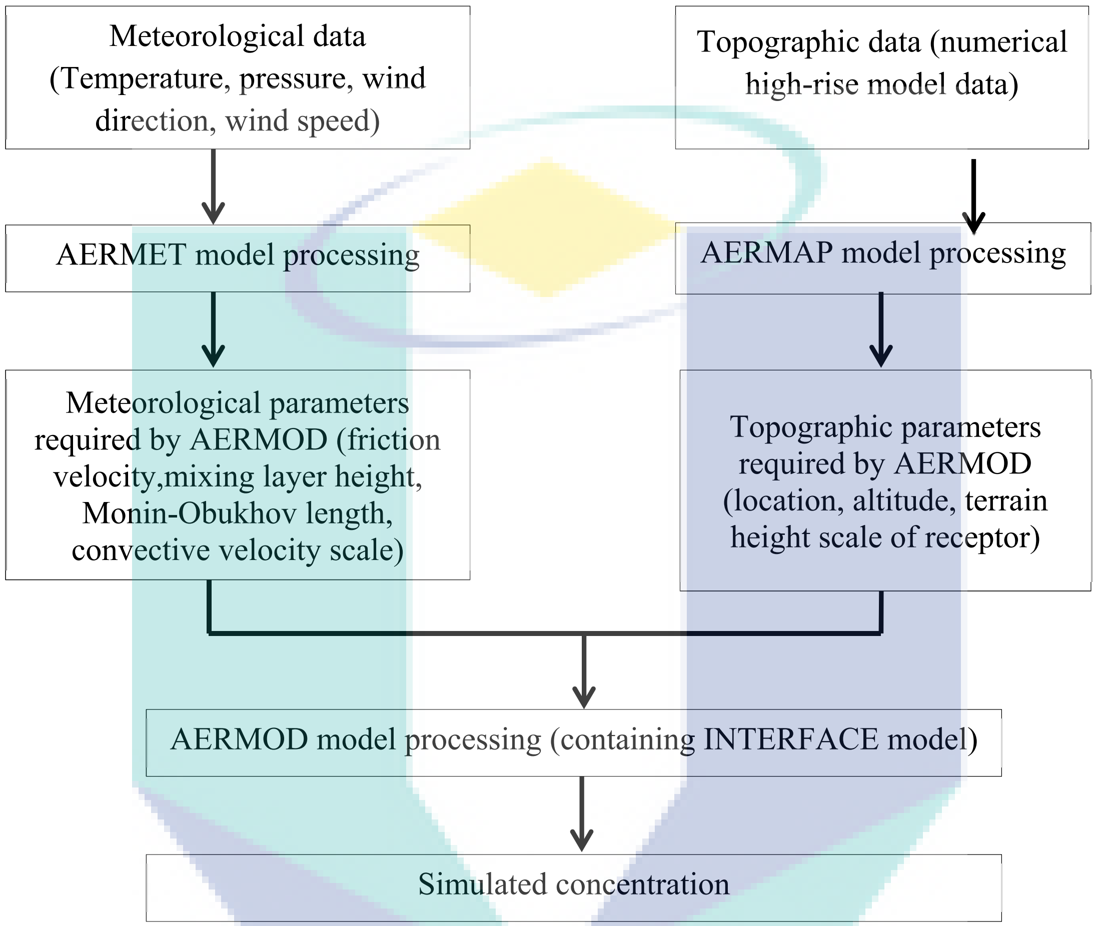


Figure 7: Theoretical framework of AERMOD model
Source: (Yongjie, Hong, Weiguang, Beibei, & Xianrui, 2016)

4. RESULT AND DISCUSSION

Due to an unexpected administrative issue with the construction developer (partner), the study location has been changed to dust of biomass from energy plant Research concept and objectives are still the same. The results of the case study as presented belows:-

4.1 Particulate Matter Measurement

Before the data were collected, the location of the critical point was identified and APS were placed at critical points. Table 5 and 6 shows the concentration of $PM_{2.5}$ and PM_{10} from the measurement of the particulate matter. The data were measured and collected after 24 hours of emission and particulate matter emission was calculated.

Table 5: Concentration of $PM_{2.5}$

Activity	**BIOMASS BURNING**					
Date	Wind Speed (m/s)	Wind Direction	Temperature (°C)	Weather	Relative Humidity (%)	Particulate Matter Emission (mg/m^3)
10/7/18	1.17	South West	25.5	Cloudy	73	1.3899
12/7/18	1	South	26	Cloudy	75	0.6944
26/7/18	2	South West	32	Cloudy sunny	60	0.6944
9/8/18	0	South	29	Humid & Overcast	71	1.3899
10/8/18	0	SSW	32	Overcast	53	0.6944
11/8/18	2	SSW	34	Overcast	44	2.0833
13/8/18	1	South	26	Mostly cloudy	69	0.6944
14/8/18	3	South	31	Mostly cloudy	61	0.6944
15/8/18	3	South	34	Mostly cloudy	47	0.6944
17/8/18	1	South East	24	Overcast	90	0.6944

Table 6: Concentration of PM_{10}

Activity	**BIOMASS BURNING**					
Date	Wind Speed (m/s)	Wind Direction	Temperature (°C)	Weather	Relative Humidity (%)	Particulate Matter Emission (mg/m^3)
10/7/18	0	South West	25.5	Cloudy	73	1.3899
12/7/18	0	South	26	Cloudy	75	1.3899
26/7/18	0	South West	32	Cloudy sunny	60	0.6944
9/8/18	0	South	29	Humid & Overcast	71	0.6944

10/8/18	0	SSW	32	Overcast	53	0.6944
11/8/18	2	SSW	34	Overcast	44	0.6944
13/8/18	0	South	26	Mostly cloudy	69	0.6944
14/8/18	0	South	31	Mostly cloudy	61	1.3889
15/8/18	0	South	34	Mostly cloudy	47	0.6944
17/8/18	0	South East	24	Overcast	90	0.6944

Based on Table 5 and 6, the average concentration of particulate emitted to the air in 24-hour mean is 0.6944 mg/m^3 for both sizes. The data shows a consistent value on the particulate matter emissions as the emission was only dispersed in that area. If we compared the values between the data and guideline provided by the WHO, the particulate matter emitted to the surrounding already exceed the limit.

4.2. AERMOD Dispersion Modelling Results

Figure 8 shows the map of Bioenergy Plant from the satellite view which has been used as a base map. The map was needed to simulate the region of emission. Unfortunately, the cloudy view from above makes the view of plant invisible and not clear.

Figure 8: Base Map of Biomass Energy Plant.

From the view of the base map, the building parameter and gridded parameter were identified. From there, the simulation generated the 3-dimensional view of the building block. Figure 9 shows the view of the object from the 3-dimensional view of plant layout of biomass energy plant meanwhile Figure 9 show the 3-dimensional side view of emission after the model objects which included building parameters, gridded receptors and boundary receptors were identified. The emission was only dispersed at the space (volume) and not harm the citizen but would cause harm to the worker's area there. The dispersion of particulate matter depended on the wind direction and speed. The particle would disperse in the air through the wind and caused long-term effects towards the workers around the location.

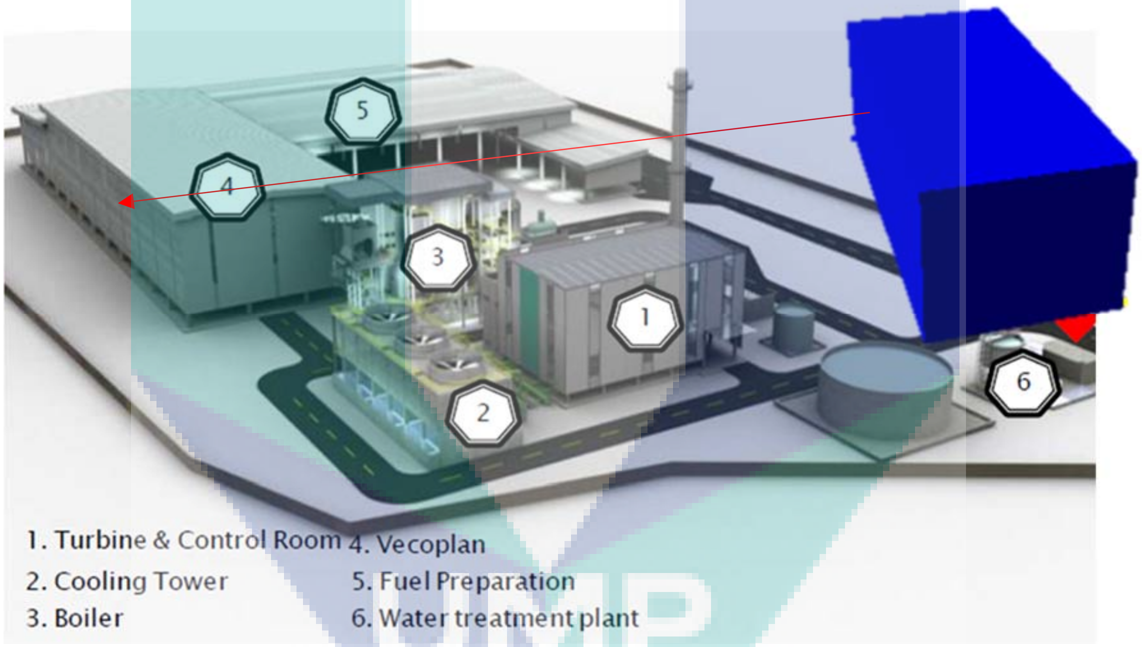
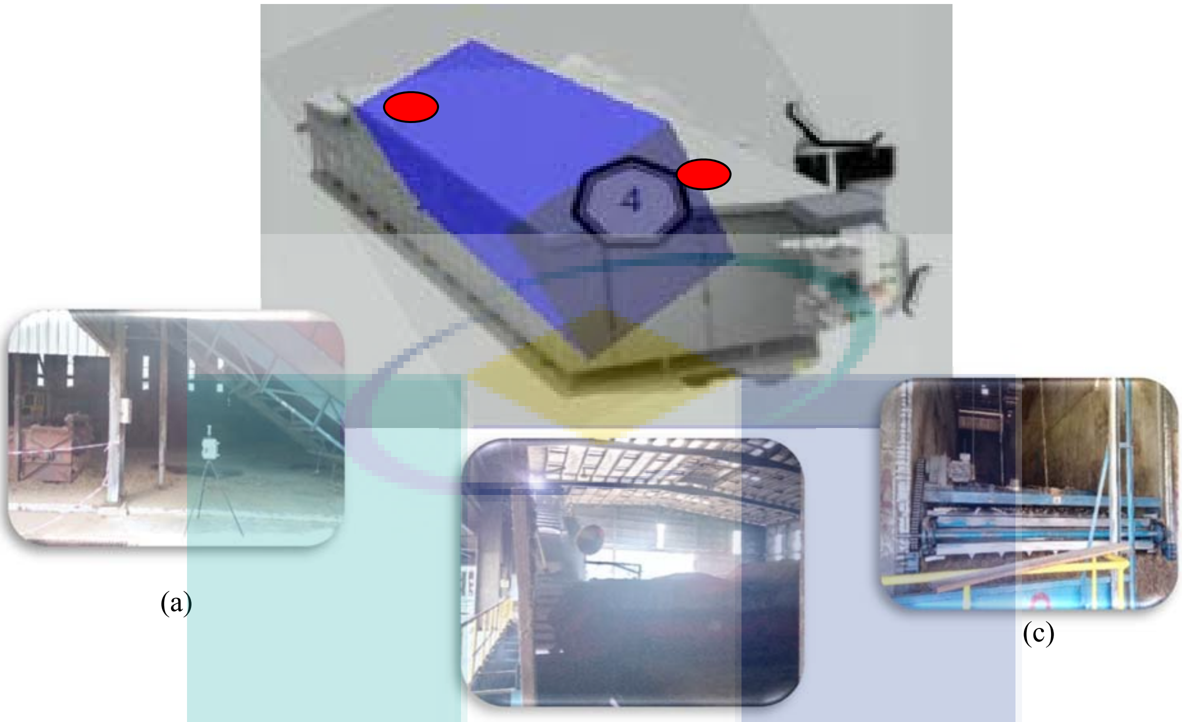


Figure 9: 3-Dimensional View of Emission Sources.



(a) (b) (c)

Figure 10: Parts (a), (b) and (c) show the location of the red dot on the superimpose view of the emission from the sources.

From Figure 10, the 3-D block was generated from the vecoplan. The data inserted in the modelling simulation were indicated the size of vecoplan (63.5 m × 126.11 m). The red circle indicate the critical location of the source of pollution in which included the location of parts (a), (b) and (c). Therefore, the generated 3-D block model has indicated the critically polluted area at the biomass energy plant.

5. CONCLUSION

This study has shown that AERMOD Model can be used to provide an insight into the surface impact of $PM_{2.5}$ and PM_{10} from the point and major line at annual and hourly averaging periods in model domains within Bioenergy Plant at Jengka, Pahang. This study has highlighted the concentration of particulate matter disperse from the plant. Based on the calculated raw data, the average concentration of particulate emitted to the air in 24-hour mean is 0.6944 mg/m^3 for both sizes. The average concentration of particulate matter is compared with the guidelines provided by the WHO. From the values, the concentration of both $PM_{2.5}$ and PM_{10} are exceeding the level of 24 hour mean of emission and can be concluded as critical. However, AERMOD Modelling result of simulation does not include certain parameters like weather, relative humidity and temperature. It causes limitations to the results and provides inaccurate data. The analysis of dispersion is done based on the collected data and identify the critical location. The critical location of both particulate matter emission has been identified as both locations located at Vecoplan (Fuel Storage) but at a different work station.

6. REFERENCES

Amaral, S., de Carvalho, J., Costa, M., & Pinheiro, C. (2015). An Overview of Particulate Matter Measurement Instruments. *Atmosphere*, *6*(9), 1327–1345. https://doi.org/10.3390/atmos6091327

Araújo, I. P. S., Costa, D. B., & de Moraes, R. J. B. (2014). Identification and characterization of particulate matter concentrations at construction jobsites. *Sustainability (Switzerland)*, *6*(11), 7666–7688. https://doi.org/10.3390/su6117666

Azarmi, F., & Kumar, P. (2016). Ambient exposure to coarse and fine particle emissions from building demolition. *Atmospheric Environment*, *137*, 62–79. https://doi.org/10.1016/j.atmosenv.2016.04.029

Botkin, D. B., & Keller, E. A. (2007). Environmental science: Earth as a living planet. Hoboken, NJ: Wiley.

Chong, H. Y., & Low, T. S. (2014). Accidents in Malaysian construction industry: Statistical data and court cases. *International Journal of Occupational Safety and Ergonomics*, *20*(3), 503–513. https://doi.org/10.1080/10803548.2014.11077064

Daly, A., & Zannetti, P. (2007). An Introduction to Air Pollution – Definitions , Classifications , and History. *Science And Technology*, 1–14.

Dispersion Modeling of Criteria Pollutants for the Southern California Intermodal Gateway Project Development of Emission Scenarios Used in the Air Dispersion Modeling Construction Emission Sources,” 2011)

Faber, P., Drewnick, F., & Borrmann, S. (2015). Aerosol particle and trace gas emissions from earthworks, road construction, and asphalt paving in Germany: Emission factors and influence on local air quality. *Atmospheric Environment*, *122*, 662–671. https://doi.org/10.1016/j.atmosenv.2015.10.036

Guerrero, Lilliana Abarca, Ger Maas, and William Hogland. "Solid Waste Management Challenges For Cities In Developing Countries". *Waste Management* 33.1 (2013): 220-232.

Guerreiro, C. B. B., Foltescu, V., & de Leeuw, F. (2014). Air quality status and trends in Europe. *Atmospheric Environment*, *98*, 376–384. https://doi.org/10.1016/j.atmosenv.2014.09.017

Hamer, Geoffrey. "Solid Waste Treatment And Disposal: Effects On Public Health And Environmental Safety". *Biotechnology Advances* 22.1-2 (2003): 71-79.

Hassan, H. A., Kumar, P., & Kakosimos, K. E. (2016). Flux estimation of fugitive particulate matter emissions from loose Calcisols at construction sites. *Atmospheric Environment*, *141*, 96–105. https://doi.org/10.1016/j.atmosenv.2016.06.054

Kakosimos, K. E., Assael, M. J., Lioumbas, J. S., & Spiridis, A. S. (2011). Atmospheric dispersion modelling of the fugitive particulate matter from overburden dumps with numerical and integral models. *Atmospheric Pollution Research, 2*(1), 24-33.

Mabahwi, N. A. B., Leh, O. L. H., & Omar, D. (2014). Human Health and Wellbeing: Human Health Effect of Air Pollution. *Procedia - Social and Behavioral Sciences*, *153*, 221–229. https://doi.org/10.1016/j.sbspro.2014.10.056

Mabahwi, N. A., Leh, O. L. H., & Omar, D. (2015). Urban Air Quality and Human Health Effects in Selangor, Malaysia. *Procedia - Social and Behavioral Sciences*, *170*, 282–291. https://doi.org/10.1016/j.sbspro.2015.01.038

Mamady, Keita. "Factors Influencing Attitude, Safety Behavior, And Knowledge Regarding Household Waste Management In Guinea: A Cross-Sectional Study". *Journal of Environmental and Public Health* 2016 (2016): 1-9

Mohan, M. (2011). Performance evaluation of AERMOD and ADMS-Urban for total suspended particulate matter concentrations in Megacity Delhi. *Aerosol and Air Quality Research*.

Monitoring of particulate matter in ambient air around waste facilities. (2004). Bristol: Environment Agency.

Muleski, G. E., Cowherd, C., & Kinsey, J. S. (2005). Particulate Emissions from Construction Activities. *Journal of the Air & Waste Management Association*, *55*(6), 772–783. https://doi.org/10.1080/10473289.2005.10464669

Nazirah Zainul Abidin. (2010). Sustainable Construction in Malaysia – Developers ’ Awareness. *Proceedings of World Academy of Science, Engineering and Technology*, *5*(2), 122–129.

Ofori, G. (2000). Challenges of Construction Industries in Developing Countries : Lessons from Various Countries. *Citeseerx.Ist.Psu.Edu*, 15–17. https://doi.org/10.1.1.198.2916

Olanrewaju, A. L., & Abdul-Aziz, A. R. (2015). Building maintenance processes and practices: The case of a fast developing country. *Building Maintenance Processes and Practices: The Case of a Fast Developing Country*, 1–331. https://doi.org/10.1007/978-981-287-263-0

Pollution, C., Board, C., & Environment, M. O. F. (2003). Guidelines for Ambient Air Quality Monitoring Guidelines for Ambient Air Quality Monitoring. *Science Communication*.

Qureshi, M. I., Rasli, A. M., Awan, U., Ma, J., Ali, G., Faridullah, … Zaman, K. (2015). Environment and air pollution: health services bequeath to grotesque menace. *Environmental Science and Pollution Research*, *22*(5), 3467–3476. https://doi.org/10.1007/s11356-014-3584-2

Sinesi, M., Petracchini, F., & Allegrini, I. (2008). Evaluation of fugitive dust from construction sites in the city of Shanghai. *Hrvatski Meteoroloski Casopis*, *43 PART 1*(November), 129–134.

Societies, F. f I. R. (2013). Respiratory diseases in the world, *53*(2012), 1–35. Retrieved from papers3://publication/uuid/605D7CD3-0FE0-4918-8941-96F2920D09DD

Wu, Z., Zhang, X., & Wu, M. (2016). Mitigating construction dust pollution: State of the art and the way forward. *Journal of Cleaner Production*, *112*, 1658–1666. https://doi.org/10.1016/j.jclepro.2015.01.015

Yongjie, D., Hong, R., Weiguang, C., Beibei, Q., & Xianrui, M. (2016). Effect of Construction Dust on Urban PM 2 . 5 Emission Characteristics : A Case Study of the Main Urban Area of Chongqing , China Key Words :, *15*(3).

Yuwono, A. S., Amaliah, L., Rochimawati, N. R., Kurniawan, A., & Mulyanto, B. (2014). Determination of emission factors for soil borne dustfall and suspended particulate in ambient air. *ARPN Journal of Engineering and Applied Sciences*, *9*(9), 1417–1422.

APPENDIXES

ESChE 2019 (Paper 1)- Pulau Pinang

Air particulate matter dispersion at biomass energy plant using AERMOD Modelling

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Abstract. Biomass is included as one of the conventional sources other than solar and hydro energy. There are different types of biomass such as empty fruit bunch (EFB), fronds, mesocarp fibre (MF), trunk and shell. Each type provides a different level of particulate matter and the particulate matter had already emerged as one of the most critical pollutants. The main purpose of this paper is to identify the critical location on-site and to measure and analyse the particulate matter dispersion by using AERMOD Modelling. This paper presents a simulation study of particulate matter dispersion at biomass energy plant. The dispersion of the particulate is studied at Bioenergy plant located at Jengka, Pahang which generates electricity from the EFB waste. The shredded EFB had produced abundant of dust and particulate matter which suspends in the air and deteriorating the air quality. Thus, the dispersion of particulate matter pollutant by the biomass power plant is a rising concern. The influence of other operating variables were studied (temperature, relative humidity, wind speed, wind direction and activity). This paper also compares the concentration of $PM_{2.5}$ and PM_{10} disperse from a location that had been marked as critical. From the result, the average concentration of particulate emitted to the air in 24-hour mean is 0.6944 mg/m^3 for both size. Based on the guidelines provided by the World Health Organization (WHO), the concentration of both $PM_{2.5}$ and PM_{10} are exceeding the level of 24 hour mean of emission and can be concluded as critical.

1. Introduction

Particulate matter has been commonly and frequently referred to as one of six chemicals of air pollutants along with carbon monoxide, lead, nitrogen oxide, ozone and sulphur dioxide. These chemicals are known as toxic pollutants which can cause cancer and other serious health problems or lead adverse environmental effects [1]. In addition, the particulate matter had already emerged as one of the most critical pollutants [2] aside from other elements which already contribute to the pollution. Based on the guidelines of air quality of particulate matter size stated by the World Health Organization (WHO), 24-hour mean of $PM_{2.5}$ and PM_{10} emission are 25 µg/m^3 and 50 µg/m^3.

EGTEIC- Caceras, Spain

proceedings

MDPI

Type of the Paper: Proceedings

Consequence modelling for estimating the toxic material dispersion using ALOHA: case studies at two different chemical plants †

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Abstract: Industrial disaster does not only result in enormous calamities and huge property damages but also deteriorate the environment especially when it involved hazardous materials. The occurrence of major accident at major hazard installation (MHI) is unpredictable. Therefore, both structural and non-structural measures should come in the forefront before it claims human life and tremendously destroy the assets and environment. Thus, the main objectives of this study is to simulate the consequence modelling due to toxic materials dispersion (sulfuric acid) and subsequently suggest the evacuation mapping. The Areal Location Hazardous Atmosphere (ALOHA Version 5.4.7) was used to determine the threat zone and estimates the radius of toxic material dispersion from the source point. Two petrochemical plants were selected in this study and both are located at different petrochemical industrial estates in East Coast Region of Peninsular Malaysia. Based on the findings, it can be concluded that the radius of toxic material affects the adjacent facilities and other chemical plants in proximity. The threat zones with the radius of 0.72 miles (red), 2.6 miles (orange) and 6.0 miles (yellow) respectively were determined for the first case study. As for the latter, the threat zones are greater than 6 miles for all zones. Based on both estimations, the evacuation mappings were proposed by sketching the map from Google satellite in the MARPLOT application.

Keywords: ALOHA; evacuation mapping; MARPLOT; threat zone

Major Accident Hazard In Bioprocess Facilities: A Challenge To Sustainable Industrial Development

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Abstract. Sustainable components of renewable biological resources in Malaysia provide the prospect for the growth of the bioeconomy via research, innovation and commercialisation. Malaysia is one of the few Asian countries that has most of its bio safety regulations and guidelines in place. In spite of the government is driving the sector in full force, there are still missing links and challenges. Some recent accidents involving the bioprocess raised concern on the safety of such technologies. The bioprocess of L-Methionine production which is one of the BTP Trigger Projects was taken as a case study.

1. Introduction

Bioprocess or biotechnological process is a process that uses living organisms or its component, in order to make or modify desired product [1]. Meanwhile, bioprocess or biochemical engineering combine biotechnology and chemical engineering to make or modify desired product. The range and application is quite enormous, from waste water treatment to agriculture, food, feed, pharmaceuticals, paper, polymer and energy production [2]. The implementation of these ground-breaking processes and technologies in the industry [3-5] can increase the potential of the facilities where bioprocesses are carried out [2]. Generally, bioprocesses are deeming to pose less risk compared to conventional chemical processes. However, several major accidents happened in this industry in recent years [2,7-8]. Moreover, in some of the accident scenarios not identified in the risk assessment which may be considered as exceptional [9]. Such trend may be considered as warning signs of the emerging risk issue, something that unusual as defined by International Risk Governance Council (IRGC) [10]. Furthermore, this phenomenon may suggest that some limitations may be present during the risk assessment process [2].

In a bioprocess facility, both biological hazards and conventional chemical hazards may be present. However, the holistic techniques for risk assessment in this industry are not available [7-8]. Only few studies attempted to apply conventional methods for risk assessment such as to bioprocesses [11-14]. At this time, there is no uniform risk assessment methodology to approach bioprocess facility.

CITREX 2019- UMP (Silver)