Particulate Matter (PM 2.5) At Construction Site: A Review

Putri Shazlia Rosman, Mohd Armi Abu Samah, KamaruzzamanYunus, Mohd Ramzi Mohd Hussain

ABSTRACT---In Malaysia, construction sector growing 8% to RM170 billion in 2017, 8.2 % or RM140 billion in 2015 and 7.4% t or RM166 billion in 2016.Construction activities at all phases ofconstruction from land clearing to building structure generate particulate matter emission (PM) that causes health impact to human and environment. Many researchers have done to identify and classified the particulate matter from its source of origins emissions at construction site. PM2.5 is a fine particle is potential to enter lung and bloodstream and lead to death. The objective of this paper to identify the potential of PM2.5 release at construction site, effect to receptor who exposed to it and determine the other factor that contribute to distribute the PM2.5 at construction site. The construction activity proved to cause PM2.5 emission effect to human health and environment. Though, meteorology such as wind direction, temperature, humidity, pressure, wind speed not only factor need to be considerate that influences the distribution dispersion of PM2.5 but other factor such as chemical formation, dispersion process and removal mechanism need to be measured. CDC 2013 studies, showed every PM2.5 decreases of 10 ug/m3 of air it will decrease 15% in the risk of heart disease deaths. Malaysia showed the annual mean concentration of fine particulate matter in urban areas was exceeding the WHO air quality guideline with 17.3 ug/m3. The construction site needs to control and monitored its emission of particulate matter by having a proper schedule construction time management and modeling the distribution of PM2.5 at site.

Keyword: PM2.5, construction activities, meteorology, health effect

I. INTRODUCTION

People breathe air freely every day without paying any cost that they inhale. It has because the air is available in atmosphere where we just breathe in. But what if the air that we breathe is polluted with toxic, bacteria and fungi for several days, months or maybe years? Do you concern the pollution from construction and how these pollutants occur to your nearby home? You can see, dusts were generating from the construction activities from your naked eyes, but do you know that these dusts can cause health impact to human and environment, partially or wholly. The emission of air pollutants from construction equipment is the main environmental concern because it may impact air quality as well as health of construction workers and climate change. In these paper reviews, we will discuss the type and source of construction activities that generate the particulate matterPM2.5from the construction activities that cause seriously health impact to human and environment. PM also causes adverse impacts to the environment such as climate impacts, visibility impairment, ecological effects and effects on materials (e.g building surfaces).

II. PM2.5 POLLUTED CITIES AND GLOBAL EPISODES.

According to the global air pollution database that released in Geneva by World Health Organization (WHO) dated on May 2, 2018 reveal that India has 14 out of the 15 in terms of PM2.5 concentration have most polluted cities in the world. In between year 2010 to 2014, the pollution level was improved but in year 2015 the pollution level in

Recently, deteriorations have been reported in Delhi. Specifically, a 2016 report by the World Health Organization reveals that the region has witnessed the rate of annual pollution, on average, stand at 143 $\mu g/m^3$. Indeed this figure is thrice the expected national standards. In 2019, Thailand's situation indicated that in Chang Mai, air pollution has been dominant in the last decade [1]. As such, many individuals have continually inhaled particulate matter, which originates from smog in the atmosphere. One of the lectures in the Faculty of Medicine (In Ching Mai University)< Dr. ChaichamPothirat, acknowledges that the exposure to particulate matter accounts for the rising cases of death, hence a high mortality rate in the region. Regarding PM2.5 dust particles, some of the health conditions that they cause, if inhaled for a significant period, include lung inflammation, heart disease, lung cancer, and stroke. Hence, the health conditions account for a significant reduction in life expectancy [1].

III. MALAYSIA PLAN IN CONSTRUCTION

Eleventh Malaysia Plan 2016-2020, the development of infrastructure highly progressive occurred now in numerous mega infrastructure projects such as Refinery and Petrochemical Integrated Development project in Johor, Mass Rapid Transit Two in Klang Valley, and the Pan Borneo Highway connecting Sabah and Sarawak. The Central Spine Road, which connects Kuala Krai to SimpangPelangai Pahang, and Kota Bharu-Kuala Krai Highway that construct for better connectivity people in west to east coast

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PutriShazliaRosman, Kulliyyah of Sciences, International Islamic University Malaysia, InderaMahkota, Faculty of Engineering Technology, Universiti Malaysia Pahang, 26300 Gambang, Kuantan, Pahang.Malaysia (marmi@ iium.edu.my)

MohdArmi Abu Samah, Kulliyyah of Sciences, International Islamic University Malaysia, InderaMahkota, Kuantan, Pahang.Malaysia

KamaruzzamanYunus, Kulliyyah of Sciences, International Islamic University Malaysia, InderaMahkota, Kuantan, Pahang.Malaysia

MohdRamziMohdHussain, ulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Gombak, Selangor.

region. On the track now, the West Coast Expressway that expected to be complete in 2019 will benefit for people living in west coast of Perak and Selangor. The Kuala Lumpur-Singapore high speed rail (HSR) connecting the two cities to 99 minutes has place the project as high impact project, out of the 131 entry –point projects in the Malaysia governments Economic Transformation Programme Roadmap [2].

According to the Star Online date 11 April 2017 in the title news 'CIDB sees construction sector growing 8% to RM170 billion in 2017', 8.2 % or RM140 billion in 2015 and 7.4% t or RM166 billion in 2016. The construction volume increases from 140 billion involving 7455 projects in 2015 to 6305 project projects worth RM166.4 billion in 2016. However, the growth of the construction industry in 2016 was much driven by infrastructure projects with 49.7 percent from RM82.7 billion [3].

In the same light, other infrastructure development for the nation such as electricity power plant, water treatment system, construction of new school and hospital. implementation of high-speed broadband has, construct new and upgrade an airport were several plans that have been mention in Eleventh Malaysia Plan for the benefits of Malaysian people [3]. However, from the construction activities, the emissions of particulate matter contribute to cause health effect to human that are exposed to the PM either wholly or partial.ly. Particulate dust (more than 10μm) can cause irritant to throat, eye and nose and also able to deposits on the property such as cars, on leaves, windows and other material [4].

IV. PARTICULATE MATTER FROM CONSTRUCTION SITE

From the insights gained from the perspective o the Local Government Air Quality Toolkit, contruction sites have different sources responsible for the emission of particulate matter [5]. Some of these sources include the clearing of land for the establishment of structures, the excavation and compaction of the construction site, and the movement of construction equipment and heavy machinery (such as excavators, bulldozers and cranes). Also, the process of erecting the structures contributes to particulate matter in the air, including the use of metals, furnishing, hammering, grinding, drilling, grit blasting, and demolition of property or structure. Otehr processes inlcude wleding, brazing, soldering, and joining. Indeed, these procedures account for the generation of the debris and solid wastes at the construction sites, espec ially due to the pile-up of materials as they are transferred and also loaded onto trucks for transportation to waste disposal sites. It is also worth noting that the particulate matter piles up due to the transportation of construction materials and otehr supplies to the selected or designated sites; besides additional activities such as vehicle movement to and from the site(s), as well as movement within the construction site. Also, the process of establishing and maintaining roads or pavements contributes to particulate matter in the air, especially due to the furnishing processes that include adhesives and paints (and applying coatings onto the road and pavement surfaces).

To illustrate the contribution of industrial processes to the emission of particulate matter, especially in the Chinese context, Figure 1 is provided and summarizes these outcomes. From the figure, it is evidnet that in China, economic activities are a majorr contributor to air pollution and are seen to account for about 30 to 34 percent of all particulate matter emissions in the country (annually). The figure depicts the statitical outcomes documented between 1997 and 2010. From the perspective of industrialization, most sectors belong to manufacturing, agricultural, and processing industries. Production-related emissions, baed on 2010 statistical outcomes, dmeonstarte that the metal and machinery (as well as construction) operations accounted for 18 percent and 37 percent of the emissions, proving to be areas that contribute the majority of particulate matter in the country; with high consumption in the country compounding the situation.

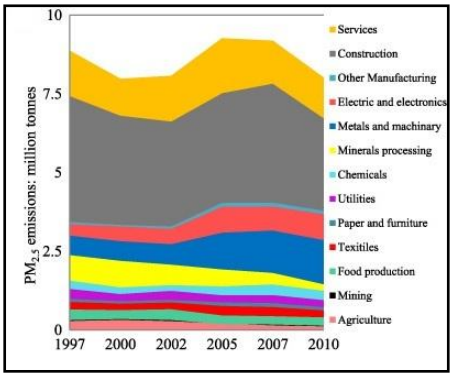

Figure1. PM2.5 Emission from industrial sector between 1997-2010

(Source: The socioeconomic drivers of China's primary PM2.5 emissions [6]

The emission of particulate matter at construction site causes negative impact to human health also the environment. Studies have been done that about 0.8 million premature deaths and about 6.4 million years of life lost was due to air pollution caused by PM2.5 [7]. Many studies indicate that particulate matter can cause mortality as low as 80μg per m3. The chemical and noxious gas that suspend in the air may enter body thru inhaled cause's injuries to delicate tissues the respiratory tract [8].In United States, limited research on PM2.5 has been done to identified the important sources of particulate matter emission from road and building construction activity [9]. Generation of dust, gaseous pollutants, particulate matter, noise, and other atmospheric contaminants were resulting either indirectly or directly from building construction activities. However, number of sources that generate the pollutants comes associated with mobile machinery (not restricted to roads) as well as construction works and onsite machinery (off road emission). The emission of PM is depending on different activities and it has no clearly defined that used by the builder on management control method and technology being used [10].

Whereas building and road construction operations have been affirmed to be crucial to the emission of particulate matter (PM), especially in the

U.S. context, it was until recent that there was growing research interest in this subject or debate. Between 1998 and 2001, particulate 2.5m and 10m in aerodynamic diameter was examined, especially in relation to the emission factor at specific construction sites. The majority of tests that were conducted targeted earthmovers with scrapers, especially due to the previous documentation that the machinery contributed significantly to PM emission – in the construction industry. Additional sources that were or have been tested include the dumping and loading of mud and crushed rocks (by trucks), as well as the transportation of the rest of the litter from the construction to the dumping sites (while moving along roads or pavements – or adjacent public paved roads). Tests have also been implemented in relation to the impact of watering on the management of PM emission, especially on routes that are used by scrapers. Similarly, the impact of using graveled and paved aprons at the construction site has been investigated [9].

V. METEOROLOGICAL INFLUENCE THE PARTICULATE MATTER

The role of meteorology in affecting the dissemination of information about PM emissions has been documented. Particularly, it is affirmed that the process of dispersing information such as chemical formations of PM and the mechanisms for removing the PM have been affirmed to be shaped by parameters such as the amount of rainfall, atmospheric pressure, the level of humidity, solar radiation, the speed of wind, and temperature [11]. Also, several studies have examined the attribute of PM in various urban contexts – with the aim of predicting how the PM levels and meteorological information or variables correlate [12]. In the context of Dublin, findings regarding the attribute of PM 10 suggest that as the speed of wind increases, there amount of mass concentration reduces significantly. Other factors documented to contribute to a reduction in mass concentration are seen to include increased temperature arising from high traffic density, as well as an increase in the level of precipitation. Also, the increase in temperature, which predicts a reduction in mass concentration, is seen to accrue from domestic heating; especially during the winter season. In these scenarios, it becomes inferable that the parameters of temperature and PM10 exhibit a negative or inverse correlation. The relationship among five meteorological parameters has been investigated in relation to the impact they pose on the total suspended particles (TSPs); especially in Turkey's Elaziğ City. Indeed, findings suggest that as winter sets in, the selected variables do not have a significant correlation [13]. However, other studies suggest a significant relationship between factors of temperature and wind and PM level variability [14-16].

A study conducted on air quality in Ohio, showed the wind blowing from south and southeast with wind speeds were below 8 mph and temperature 70^{o}F showed that the wind direction, temperature and wind speed have significantly influenced on PM 2.5 concentration [17]. The emission concentration particulate matter in construction site at Bangalore influence by the weather condition variables including velocity and wind direction and other local condition [10].

VI. PARTICULATE MATTER AND ITS HEALTH IMPACT

People who work and live at nearby surrounding construction area may get health effect from emission of PM. The fine particles (PM≤ 2.5μm in diameter) are potential to enter lung and also get into the bloodstream. The fine particles are also can cause several effects to our body. Numerous scientific studies had been done that the exposure of these fine particles into our body can cause several problems. Some of these problems include breathing difficulties, coughing, airway irritation, decreased lung function, aggravated asthma, and heart disease; which account for growing cases of premature death. The exposure to PM2.5 may reduce eyes visibility (haze) [18]. When airborne concentration of PM2.5 increases, it effects number of people health in the cities [19]-[20]-[21]. The respiratory illness is such as changes in hearth rhythms, respiratory problems, severe respiratory and heart attacks and heart malfunctions leading to death. Due to upsurges of airborne concentration in the atmosphere, more absences happened in the school and workplace studies shown that every PM2.5decline of 10 ug/m^3 of air, decrease 15% in the risk of heart disease deaths[22]. Figure 2 shows the route of exposure PM2.5 into the heart and lung. The smaller PM2.5 is easily get into deep of the lung and enter circulatory system and remain embedded for long periods [23].

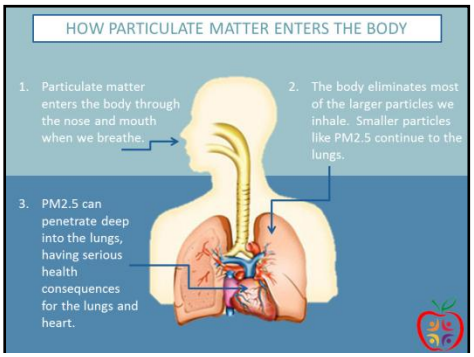

Figure 2. How particulate matter enters the body

(Sources: Air Pollution and Public Health in Utah, Bureau of Epidemiology [23].)

According to global health observatory (GHO) data in 2016 [24], population living that exposed to particulate matter in the cities about 90% exceeding the WHO air quality guidelines. The Air quality guideline is an annual mean concentration for particulate matter that set by WHO. The guideline stipulates for PM2.5 not exceed 10 ug/m^3 annual mean or 25 ug/m^3 for 24 hours mean, and PM10 not exceed 20 ug/m^3 annual mean or 50 ug/m^3 for 24 hours mean. Figure 3.shows the annual mean concentration of fine particulate matter (PM2.5) in urban areas (ug/m^3) by WHO region 2016. Starting from India (68 ug/m^3), Bangladesh (58.6 ug/m^3),Bhutan (35.4 ug/m^3), Myanmar(34.6 ug/m^3), Democratic People's Republic of Korea(31.0 ug/m^3),Thailand(26.6ug/m^3),Timor-Leste(18.2 ug/m^3),Indonesia(16.4 ug/m^3)and Sri Lanka (15.1 ug/m^3) except Maldives (7.7 ug/m^3) showed the annual mean concentration of fine particulate matter in urban

areas were exceed the air quality guideline set by the WHO.

Malaysia also showed that our annual mean concentration of fine particulate matter in urban areas was exceeding the WHO air quality guideline with 17.3 ug/m^3[24]. Group of vulnerable people such as heart disease or pre-existing lung including children and elderly people are extremely threat to highly exposed PM. The effect to children in a long expose to PM could cause reversible deficits in lung function and also diminish lung growth rate and its lung functions for a long term. In this matter, there is no evidence of a safe level exposed or a line of threshold would cause no adverse effect occurred [24]. A six cities study conducted in Harvard, showed that the increased of death rate in heart problems, respiratory and as well as from lung cancer were due to increase in PM2.5 mass and PM2.5 SO2− 4 [25]. Other report exhibited in Holland, the incomplete combustion produces black smoke or dark particles in which if high concentration of black smoke contains in atmosphere may lead to increase of death rate. The black smoke may emit from motor vehicles and diesel generator sources [26].Other than that, the incomplete combustion produces black carbon which part of PM2.5 contribute not only harmful to health but as well as on climate [27] Report by the International Agency for Research state that the particles from diesel engines consists of PAHs that are carcinogenic to human [28].

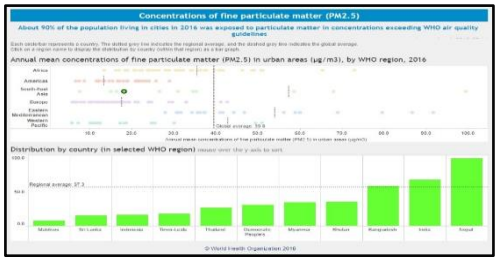

Figure 3. Concentration of fine particulate matter (PM2.5) in urban area (ug/m^3) by WHO in 2016.

(Source: World Health Organization 2018, Global Health Observatory [24])

VII. AIR QUALITY REGULATION FOR CONSTRUCTION ACTIVITY

In Malaysia, there is no regulation or guidance document to control, reduce or monitor the particulate matter for PM2.5 at construction site. Many countries have set and adopted their regulations for air quality standard, especially PM2.5, to counter the air quality. Other countries, especially, local authorities have a planning document on application for construction and development sites typically specified to in line with air quality standard and monitoring regulation set by their environmental agencies. For example, environmental agencies in New Zealand, United Kingdom and Australia has published their guidance on monitoring dust and emissions from constructions and demolition sites.

VIII. DISCUSSION

In this study, we analyses that the particulate matter from construction especially PM2.5 can cause health effect to human, environment and also can lead to serious climate change. The source of emission form construction activity including such as clearing of land and others related activities such as compaction and excavation, operation of heavy machinery and equipment that related to construction and earthmoving purposes are contributor of PM emission across the construction industry. Thailand and India have been experiencing a hazardous episode of PM for quite a long term and they have several plans in overcoming the pollution. Construction activities emit particulate matter from many sources of site operation. From equipment travel, on-site material handling operations, track out dirt onto adjacent paved road, equipment exhaust ant other sources produce particulate matter. The emission of PM not only we have to determine the source of activity but also the condition construction that influence the PM emission that include engine type, soil type and moisture content, wind condition travel speed, size and load.

Wind speed, wind direction, temperature, humidity and pressure have significant influences on PM2.5 concentration and distribution. It is difficult to control the factor that influences the PM2.5 as it stays in atmosphere. Without unidentified chemical compounds inside the PM, the time period of suspended to stay in the atmosphere can't be determine unless more study on the meteorology need to be carried out. The deceasing of particulate matter concentration may reduce adverse health effects as these to be strongly associated with composition, particle size and concentration. However, numerous external factor such as socioeconomic, lifestyle, working area and meteorology are an extremely challenging to measuring the relevant quantifying and parameters for the health effect. The standard and regulation set by the country should be compiled by all the countries that produce PM2.5. In this matter, the industry and the construction activities produce emission need to control and monitor the daily, weekly and monthly the emission of PM2.5 that release to atmosphere. Nevertheless, the difficult part is, the non-point sources of emission such as open burning, peat fire, un illegally burning, it is quite difficult to control and monitored within the time and size of area that burns. The enforcement by the government needs to be more stringent and stricter to punishment to those who disobedient against the regulations.

IX. CONCLUSION

The construction site needs to control and monitored its emission of particulate matter by having a proper schedule construction time management at site. The baseline data for PM2.5 need to be established also to measure and the mapping the distribution pattern of PM2.5 from source emission at construction site. From the baseline data, a modeling of PM2.5 can be used to understand the prediction of emission in construction activity.

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	PutriShazliaRosman is a lecturer in Universiti Malaysia Pahang (UMP) under Environmental Technologies (Energy and Environment) programme and former ex Environmental Officer at Department of Environment Malaysia. Her expertise in Environmental auditing and Management.
	I. Assistant Professor DrMohdArmi Abu Samah II.Kulliyyah of Sciences, Department of Biotechnology,International Islamic University Malaysia | (IIUM) ·
	Professor DrKamaruzamanYunus, Campus Director, International Islamic University Malaysia. Department of Marine Biotechnology
	Assoc. Prof. LAr. Dr. MohdRamziMohdHussainKullliyyah of Architecture and Environmental Design, International Islamic University Malaysia.