Coal Airborne Particulates and its Relationship with Human Health

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Abstract

Airborne particles emitted from coal-fired power plant affects human behaviour. Two times 8 hours airborne particulate personal outdoor sampling through 7-hole and cyclone samplers has been conducted nearby a coal-fired power plant and a gas power plant. Two samplers used were 7-hole and cyclone. This research found that 58.25 per cent (%) from total inhalable dust exceeded the outdoor PM10 DOE 24 hours Malaysia Standard. The study also has found that the percentage ratio of respirable towards inhalable dust is at 51.7%. Finally, effects of coal particles to human health were identified.

Keywords: Airborne Particulates, Coal, Power Stations, Human Health.

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1.0 Introduction

The explosion of global warming and climate change occurs parallel to the rise of earth development. This is due to the deterioration of atmospheric environment that came from man-made sources. Ranges of air pollutants had been discovered. However, this research focuses on particulate matter (PM) from coal. The correlation between coal particulate matter with health also being established in this paper in the latter part as done by previous researcher likewise Lockwood A.H. et. Al. (2009) and PSR (2009).

It is to be highlighted here that this research aims at assessing the airborne particles of coal that disseminated by the coal-fired power plant and its effect towards workers and public health. Its objectives are to determine the particulate matter concentration contributed by the coal-fired power plant, assessing the effects of airborne particles towards human health while highlighting the result of airborne particles emitted from coal-fired power plant with the combined cycle gas turbine type of power plant that uses natural gas as the fuel source.

Figure 1: The Concept of Climate Change and Electrical Supply Sources

2.0 Coal-fired Power Plant

Manjung Power Station is also known as Sultan Azlan Shah Coal-fired Power Plant is a coal firing type of electrical energy supplied that contains 2,295 MW capacity. It is believed that there is a plan of increasing its capacity in the future. This power plant is managed by the TNB Janamanjung Sdn Bhd. The Sultan Azlan Shah coal-fired power plant is located in Manjung, Perak, at the man-made island off the coast. It is positioned at 4.5 m above mean sea level (Power, 2009). It is also close to the Lumut and Pangkor Island. Moreover, surrounding the power plant, there are residential areas. The Manjung coal-fired power plant is sited on a man-made island off the coast of Perak, Malaysia, 4.5 m above mean sea level. It is located 1okm of the south of the nearest town Lumut, approximately 288 km North of Kuala Lumpur and close to the tourist island of Pangkor (Power, 2009).

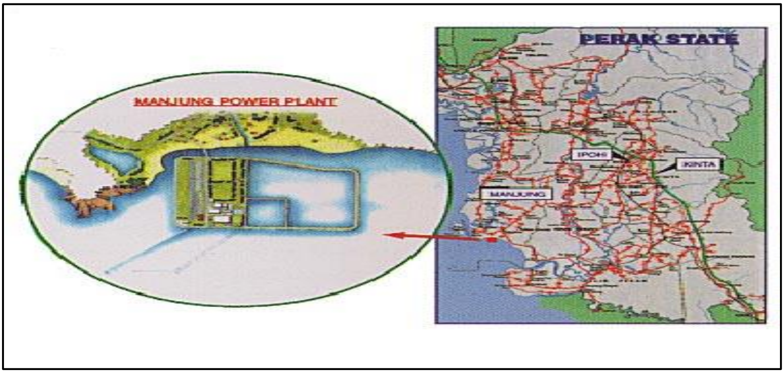

Figure 2: The Manjung coal-fired power plant is sited on a man-made island off the coast of Perak, Malaysia
(Source: Power-technology.com,2016)

2.1 Airborne Particles from Coal

Burning coal in a power plant produces a number of pollutants. It comes from the fuel type; combustion process; and design and configuration of the plant. The pollutants that contaminated the ambient from coal power plant are carbon dioxide (CO_2), sulfur dioxide (SO_2), fly ash, airborne particles and nitrogen oxides (NO_x) are being recognised as the air pollutants that emitted from the coal-fired power plant

Although the power plant management includes the arrangements to collect the ash, but the particulate matter is still emitted to the air through the stack. It is understood that the very tall stacks in power plant emit this ash throughout the area, reducing the concentration levels to human acceptable levels on the ground plane (Norsyamimi, 2011).

In order to reduce atmospheric pollution, Manjung power plant uses low sulfur and low bitumen, coal that is beneficial for the cement industry. Therefore, the plant uses low NO_x burners and a flue gas desulphurization facility. Dust control, the conveyor belt is covered and sprinkler systems remove up to 99.9% and electrostatic precipitators are important features for this factor.

Before the wastes are being deposited into the sea, it is being treated by waste water treatment facility (Norsyamimi, 2011 and Manjung Malaysia Conventional Thermal, 2011). In addition, Manjung power plant is designed to meet far higher emission standards than would be typical for an ASEAN country. It operates to particulate levels of 50mg/Nm^3 that is lower than the expected ASEAN level of 400mg/Nm^3. (Power, 2009 and Manjung Malaysia Conventional Thermal, 2011).

2.2 Airborne Particles from Coal and its Health Impact

The adverse health impact of particulate matter is defined by Norsyamimi and Shamzani (2012) as the impact of air pollution on human health is the direct effect of the airborne particles towards the well-being of human health. As referred to the following Figure 4, the British Lung Foundation (2011) had stressed out that the coal burning in the cities begins previous forty (40) years. In a tragedy of London smog in the year 1952, there are about four thousand (4,000) premature death occurs.

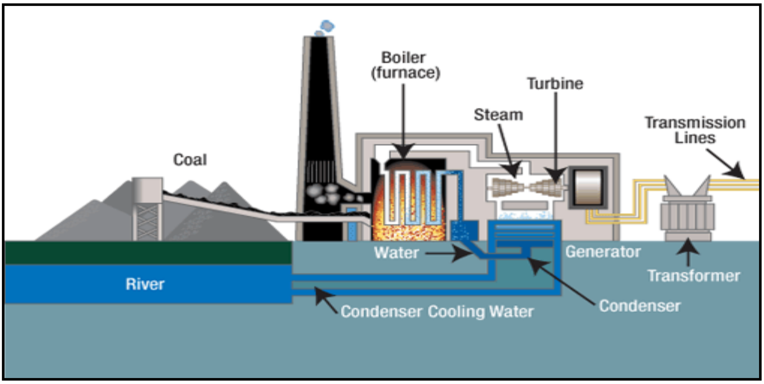

Figure 3: Coal Fired Thermal Power Plant: The Basic Steps and Facts
(Source: Johnzactruba,2011)

In Manjung residents' scenario, the residents experienced many years of living in areas with high particle levels emitted from the coal-fired power plant are exposed to the risk of facing decreased development of chronic bronchitis, premature death, decreased lung function and cardiovascular mortality (US EPA, 2003 and PSR, 2011). However, in the visitors' condition, they are exposed to short-term coal particulate matter pollution either in hours or days. They are facing risk towards heartbeat irregularities, the heart attacks, hospital admissions, increased respiratory symptoms, decreased lung function, increased emergency room visits for heart or lung disease and premature death. These detrimental health impacts shall affect at greater risk towards elderly, children and people with heart or lung disease.

According to the US EPA (2003), the particulate matter causes adverse health impact towards human beings. The sizes play a vital role as the largest airborne particles only provides less health impact. While the coarse and fine particles lead to a health problem for it can be deposited into the lung and bloodstream. It is to be highlighted that the coal particulate matter is at average sizes of less than 2.5 μm called PM2.5. Therefore, it is also believed that it can be deposited into the lung system and causes respiratory illness (Norsyamimi, 2011).

Moreover, the PSR, (2011emphasizes that the coal particulate matter also affects all major body organ systems. Those are respiratory, cardiovascular and nervous system. As listed in the diagram, the contaminant from the coal combustion process can lead to decrease lung development in children, asthma, and lung disease and lung cancer. Furthermore, coal particulate affects cardiovascular by causing artery blockages that leading to heart attacks, cardiac arrhythmias, congestive heart failure and tissue death due to oxygen deprivation that root towards permanent heart damage. Furthermore, the nervous system also can occur due to the exposure from coal airborne particles. It is believed that coal contaminant leads to stroke.

Besides, the emissions of coal particulate matter are disseminated to the surrounding area also. Hence, it leads to global warming and climate change. The global warming scenario affects human health too. It causes scarcity in water supplies, declining food production, malaria, heat stroke, social conflict and starvation.

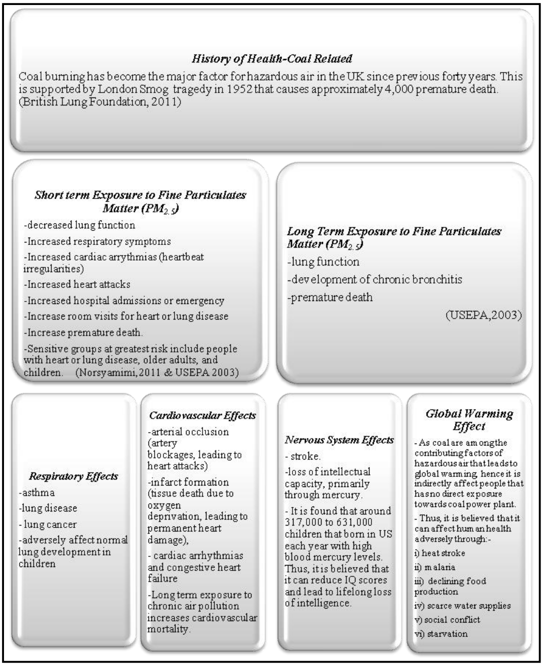

Figure 4: The Adverse Health Impact of Coal Airborne Particles

3.0 Methodology

This research uses both qualitative and quantitative research methodologies. Literatures of primary and secondary sources are being reviewed. The research technique applied is the 8hours inhalable and respirable air sampling using Casella 7-hole sampler at 2.0L/min air flow and cyclone sampler at 2.2 L/min air flow. The sampling is done two times that are in the month of March and July, 2011. The sampling had been located nearby area of a coal-fired power plant and a combined cycle gas turbine type of power stations. The mass concentrations are then obtained by adopting the following formula. Later, statistical approach being used to analyse the attained data.

$$\text{Mass concentration} = \frac{\text{Filter Paper Weight after - Weight before (mg)}}{\frac{1\,m^3}{1000L} \times \frac{\text{Flow Rate}}{\text{min}} \times \text{Duration of sampling (min)}}$$

4.0 Results and Discussion

This research found that for Manjung Power Plant, total inhalable dust exceed 58.25 per cent (%); while -19.42% exceeding the PM10 standard of 0.15mg/m3. As indicated in the chart in Figure 5 below, it is clearly viewed that none of the result exceeds the US EPA PM2.5 standard of 0.35mg/m3. However, it is to be highlighted here that the March and July,2011 airborne particulate sampling are done at eight (8) hours while the standard and guideline are both at 24 hours standard. In comparison with the gas type power plant emissions, it is believed the weather factor plays a role in indicating the particulate level and vice-versa.

Besides, it is also found that the 7-hole sampler obtain a higher result in Manjung rather than Lumut. Thus, it can be concluded that the mass concentration level of coal fired power plant in Manjung is high and may cause adverse health impact towards human beings. This is as supported by the London Smog tragedy occurs in 1952 (British Lung Foundation, 2011) and Lockwood et al. (2009) highlighted that the coal particulate causes health impact toward respiratory, cardiovascular and nervous system.

Another outcome of this sampling is that the gas type of power plant produces lower risk to the atmosphere than the coal-fired power plant type. This is due to the fact that the smaller particle deposited into deeper lung and causes higher risk towards human health. This is clearly demonstrated in the Figure 5.

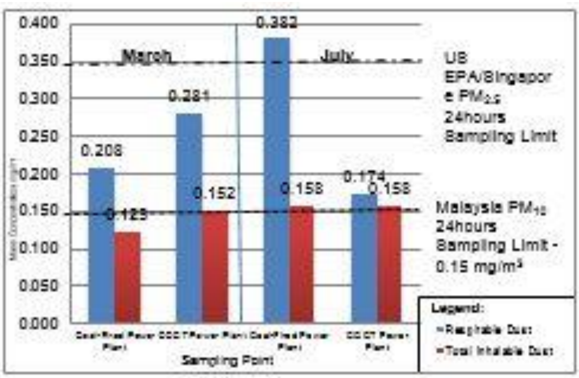

Figure 5: The Mass Comparison between Manjung and Lumut Power Plant Sampling on March and July, 2011.

Study in Manjung found that the percentage ratio of respirable towards inhalable dust is 51.79%; while 58.90% had been found in the area of Lumut gas power plant. This is highlighted in Figure 6 below. As the gas is in ultrafine particle size, thus it offers a higher percentage of respirable towards inhalable dust ratio. However, it can be seen that the percentage of respirable dust of Manjung coal-fired power plant exceed half than the inhalable dust. Thus, explaining that it is still at a critical level.

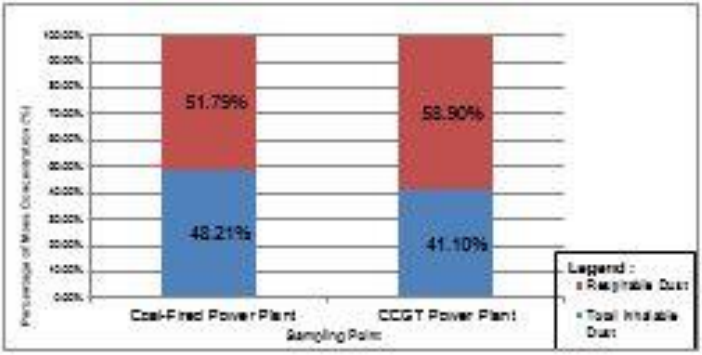

Figure 6: The Ratio Between Respirable towards Inhalable Dust of Manjung and Lumut Power Plants Sampling on March and July, 2011.

Furthermore, it is found that as the temperature increases from 29.70 degree Celsius (°C) to 30.47 °C, the particulate matter concentration is also increasing from 0.768 to 0.474 mg/m3. As the temperature decrease 22.19%, the mass concentration of the particulate matter also decreases at 38.28%. This is demonstrated in the following Figure7. Thus, it is believed that weather and climate factor affect the amount of particulate disseminated to the atmosphere and ground. This is supported by Jacobson (2002) that the ground surface temperatures affect the mixing depths and pollution mixing ratios. Hence, the warm ground is found to produce high inversion base heights and low pollution mixing ratios which are in contrast to the cold ground surfaces that produce thin mixing depths and high pollution mixing ratios.

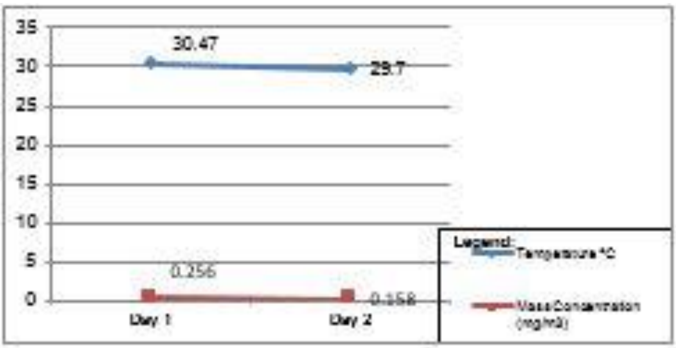

Figure 7: The Comparison between Temperature and Mass Concentration of Day 1 and Day 2 Respirable Dust Sampling at 500 m to Manjung Power Plant

5. Conclusion

Climate change that offers by coal as the source of electrical supply leads to high emissions of fine particulate matter to the atmosphere. Moreover, it is also found that high temperature with low relative humidity causes the dispersion of plumes from the stack at a higher level. These later provide adverse health impact towards human directly or indirectly, and with short term or long term exposure. It is recommended to revise the standard of particulate matter that is practiced in Malaysia suitable to the Malaysian weather condition. Another approach is to develop standard specifically for particulate matter and other air pollutant that emitted from electrical generation. We also shall review other alternative to produce electricity from clean, safe and renewable sources.

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References

Ahmad Johari Jaafar, (October, 2009). Energy Commission, Malaysia for APEC EGCF Incheon 2009. 12-14 October 2009.Incheon.

British Lung Foundation, Air Pollution And Your Lung, March 2011, Retrieved from Http://www.lunguk.org United States Environmental Protection Agency, (2003). US EPA Particle Report, EPA 454-R-04-002, United State of America.

Johnzactruba, (Sep 8, 2011). Coal Fired Thermal Power Plant: The Basic Steps and Facts. Retrieved from Http://www.brighthubengineering.com/power-plants/18082-coal-fired-thermal-power-plant-the-basic-steps-and-facts/

Lockwood A.H, Walker-hood,K., Rauch M., and Brouttleb B, (November, 2009). Coal's Assault on Human Health: A Report from Physicians for Social Responsibility, Washington, DC, November 18, 2009, Retrieved from http://www.psr.org/assets/pdfs/psr-coal-fullreport.pdf

Manjung Malaysia Conventional Thermal, (2011). Coal-Fired Power Plant. Retrieved on January 28 2011 from www.power-technology.com/projects.

Norsyamimi H., (2011). The Effects Of Airborne Particulate Towards Historical Heritage At Manjung, Perak And National Museum, Kuala Lumpur: A Dissertation, Malaysia. (Unpublished)

Norsyamimi H. and Shamzani Affendy M.D.,(2012). A Study on th Airborne Particulate Matter in Selected Museums of Peninsular Malaysia, Procedia- Social and Behavioral Sciences, Vol. 50, 2012 pp. 602-613.

PSR (2009).Coal's Assault on Human Health. November 18, 2009, Washington, D. Retrieved from Http://www.psr.org/assets/pdfs/psr-coal-fullreport.pdf

Power A., (2009). Manjung - Malaysia Coal-Fired Steam Power Plant. Retrieved on January 28 2011 from www.power.alstom.com

Power-technology.com (2016). Manjung Coal-Fired Power Plant, Perak, Malaysia. Retrieved from http://www.power-technology.com/projects/manjung/manjung1.html