Simulation of SO_2 and NO_2 gases dispersion from stack using ALOHA method.

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***Abstract*— This research is done based on this five types of pollutants which is SO_2, NO_2, PM_{10}, CO and O_3. These five type of pollutants have different sources of emission for instance SO_2 is produced due to the emission from industrial activities but mainly it is emitted due to the emission from the power plants which uses fossil fuel. For NO_2 the main source of its emission is from the combustion process that takes places in motor vehicles which utilizes the ambient air. The main source of emission for PM_{10} which are emitted directly into the air comes from roads which are unpaved, areas of constructions and also from smokestacks. Whereas for CO the main source of its emission comes from the incomplete combustion process where there is insufficient amount of oxygen. For O_3 the main source of its emission is from chemical reaction between NOx and several volatile organic compounds (VOC). This research will also be mainly carried out in Selangor namely in these five areas which are Shah Alam, Klang, Banting, Petaling Jaya and Kuala Selangor. To obtain the dispersion of these pollutants in each area, softwares such as ALOHA and Google Earth are used to show the dispersion and the source of the parameters in the conditions of the area. ALOHA operates by using the physical characteristics of the released chemical and the real-time circumstances of the release scenario to estimate and predict the dispersion of hazardous gas cloud. Upon obtaining the dispersion, it is moved to Google Earth where the dispersion can be displayed on a graphical image based on the area of study. The results obtained are the used in further discussion. Based on the results the highest mean concentration of SO_2 is in Kelang with a mean concentration of 8.419µg/m3. The highest concentration for SO_2 is also found in the month of May and June. Next, Petaling Jaya holds the highest concentration for NO2 which is 56.516 µg/m3. As for the O_3 gas the highest concentration is from Shah Alam with a concentration of 76.645 µg/m3 which are mostly the highest in the month of March. Whereas for CO and PM_{10} the highest concentration is recorded in Kelang with the highest concentration for CO and PM10 is 2.521 µg/m3 and 147.767 µg/m3 respectively.**

***Keywords*—Dispersion - Emission – Northeast monsoon – Southwest monsoon – Air quality.**

1. INTRODUCTION

Air pollution is becoming a serious issue in Malaysia especially in the state Selangor [1]. The public is not concerned about the environmental health of their surroundings and thus neglects their personal health issues. By conducting this research the public is able to know more about the pollutants such as SO_2, NO_2, PM_{10}, CO and O_3. The public is also able to understand the health effect due to these pollutants. When the reading of API is too high and the source is unknown residents who are living in the area have to face the consequences [2]. Most importantly, they are able to identify the trend of dispersion of all these substance in five main locations as shown in Table 1 below.

Table 1 : The studied Air Quality Monitoring Stations in Selangor.

Station Area	Air quality station location	Area category	Parameters	Coordinates
S1 Banting	Kolej MARA Banting	Urban	SO2, NO2, PM10, CO and O3.	N 2°48’59.89” E 101°37’23”
S2 Kelang	Klinik kesihatan Pandamaran	Urban	SO2, NO2, PM10, CO and O3.	N 3°00’53.52” E 101°24’48”
S3 Petaling Jaya	Sekolah Kebangsaan Bandar Utama	Urban	SO2, NO2, PM10, CO and O3.	N 3°07’59.40” E 101°36’29”
S4 Shah Alam	Sekolah Kebangsaan TTDI Jaya	Industrial	SO2, NO2, PM10, CO and O3.	N 3°06’17.07” E 101°33’22”
S5 Kuala Selangor	Sekolah Menengah Sains Kuala Selangor	Rural	PM10	N 3°19’16.56” E101°15’22.82”

2. METHODOLOGY

2.1 Data

The data obtained from the Department Of Environment (DOE) was from the year of 2013 for all of the five places. The data was analysed and studied to know the dispersion of the gases at the certain areas during the different monsoon season.

2.2 Aloha Software

In this research ALOHA software was used to predict the dispersion of the certain concentration of the toxic gas in the certain areas such as in Shah Alam, Banting, Klang, Kuala Selangor and Petaling Jaya. Thus, we are able to predict the area where a person might experience serious health impacts from contacts with the toxic gas at level of concern, LOC. ALOHA operates by using the physical characteristics of the released chemical and the real-time circumstances of the release scenario to estimate and predict the dispersion of hazardous gas cloud [3]. ALOHA also solves the release problem rapidly by using an extensive chemical library and release equations and also provides results in graphics which is very easy to be used.

Figure 1: Basic layout of ALOHA software.

2.3 *Google Earth Software*

After the threat zone displayed on ALOHA was studied and analysed it was exported to a format that is accepted by Google Earth. In the Google Earth software the threat zone obtained is imported based on the desired coordinates. The point of dispersion was also adjusted to a desired and suitable point. Upon completion of obtaining the desired dispersion the image was saved to be used in further discussion.

3 RESULTS AND DISCUSSIONS

3.1 *Highest concentration among places.*

3.1.1SO_2

Figure 2: Highest concentration for SO_2.

3.1.2NO_2

Figure 3: Highest concentration for NO_2.

3.1.3O_3

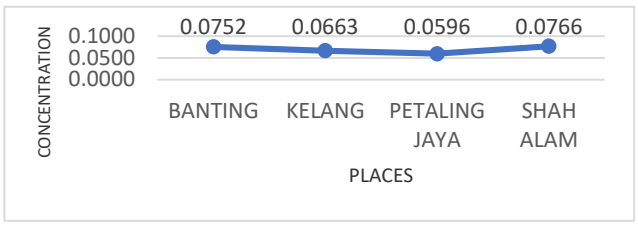

Figure 4: Highest concentration for O_3.

3.1.4CO

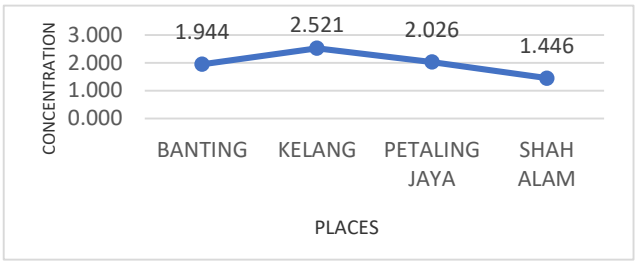

Figure 5: Highest concentration for CO.

3.1.5PM_{10}

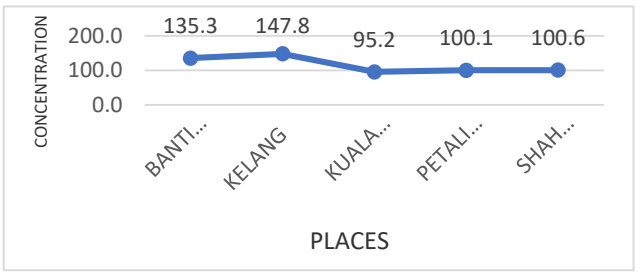

Figure 6: Highest concentration for PM_{10}.

From the obtained data in Figure 1 the highest mean concentration of SO2 is in Kelang with a mean concentration of 8.419µg/m3. The highest concentration for SO2 is also found in the month of May and June. In Klang valley almost 70-75% of the air pollution comes from mobile sources [4]. Next, Petaling Jaya holds the highest concentration for NO2 which is 56.516 µg/m3 as seen in Figure 2 however the months for the highest concentration are scattered. Another factor contributing to the pollution in Petaling Jaya is the mixed commercial-residential-industrial area which has the highest population in the Klang Valley. Moreover, the industrial area in Petaling Jaya is surrounded by the residential area[5]. These factors are believed to be one of the contributors for air pollution As for the O3 gas as shown in Figure 3 the highest concentration is from Shah Alam with a concentration of 76.645 µg/m3 which are mostly the highest in the month of March. Whereas for CO and PM10 the highest concentration is recorded in Kelang as shown in Figure 4 and 5 where the highest concentration for CO and PM10 is 2.521 µg/m3 and 147.767 µg/m3 respectively. The highest concentration for CO and PM10 were both recorded in the month of June. This is due to the haze season which occurred in Selangor during the period [6]. This may also be due to the location of the monitoring station which is located at the busiest area and also a short distance from the port where it is considered the busiest area. Every highest concentration recorded is still below the recommended Malaysian Ambient Air Quality Guidelines (MAAQG) for 1 hour [7].

3.2 *(Banting) Dispersion of gases during the Northeast and Southwest monsoon.*

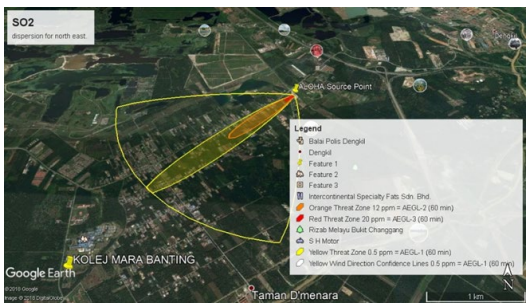

Figure 7: Dispersion of SO_2 and NO_2 in Banting for northeast monsoon.

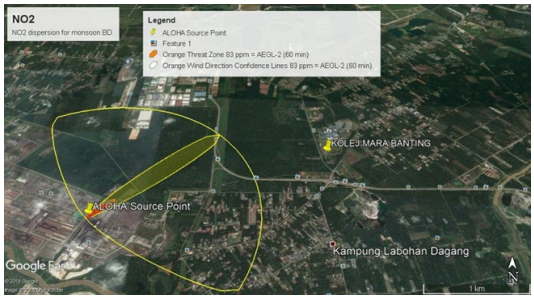

Figure 8: Dispersion of SO_2 and NO_2 in Banting for southwest monsoon.

The dispersion of SO_2 and NO_2 is generally the result from industrial activities and motor vehicles, however at these stations, the main source of SO_2 and NO_2 is expected to come from motor vehicles, and more predominantly diesel-engine trucks and buses [8]. Figure 7 shows that the source of SO_2 and NO_2 is from residential areas in Kampung Kubang Beras and Kampung Bukit Changgang during the northeast monsoon period. On the other hand Figure 8, the situation is different during the southwest monsoon where the source is from the nearby industrial area in Olak Lempit. This is a result from the production of the SO_2 and NO_2 from the industry area. Annual data also shows that the worst Air Pollution Index (API) reading recorded in Banting is often related to the haze [9]

3.3 (Kelang) Dispersion of gases during the Northeast and Southwest monsoon.

Figure 9: Dispersion of SO_2 and NO_2 in Kelang for northeast monsoon.

Figure 10: Dispersion of SO_2 and NO_2 in Kelang for southwest monsoon.

This station is located near the busiest area in Kelang which is near to the Port Klang [10]. The area is always busy with lorries and trucks carrying trailers to and from the Port and also many vehicles passing by. Based on the threat zone displayed by Figure 9 during the northeast monsoon the source of the SO_2 and NO_2 comes from the nearby residential area Taman Sri Pelabuhan, Kampung Sungai Udang, Kampung Teluk Kecil, and Teluk Gadong. Whereas during the southwest monsoon as shown in Figure 10 the source of the gases are mainly from heavy industrial area located in Kawasan Perindustrian Selat Klang Utara, Pelabuhan Klang (Port Klang), and Kawasan 13. As for the CO source is from passing by vehicles from the nearby road from the monitoring station.

3.4 (Petaling Jaya) Dispersion of gases during the Northeast and Southwest monsoon.

Figure 11: Dispersion of SO_2 and NO_2 in Petaling Jaya for northeast monsoon.

Figure 12: Dispersion of SO_2 and NO_2 in Petaling Jaya for southwest monsoon.

CO concentration is the highest during the school drop off and pickup time since vehicles of transportation (parents, school busses) pass by this area to send or pickup the children from the school [11]. For the dispersion during the northeast monsoon the source of the gases SO_2 and NO_2 came from the area of Mont Kiara, Desa Sri Hartamas and Sri Hartamas as shown in Figure 11. As for the southwest monsoon season the source of the gases SO_2 and NO_2 comes from a mixture of residential and industry area as shown in Figure 12 which are Ara Damansara, Pusat Perdagangan Dana 1, Kelana Idaman and Taman Putra Damai.

3.5 (Shah Alam) Dispersion of gases during the Northeast and Southwest monsoon.

Figure 13: Dispersion of SO_2 and NO_2 in Shah Alam for northeast monsoon.

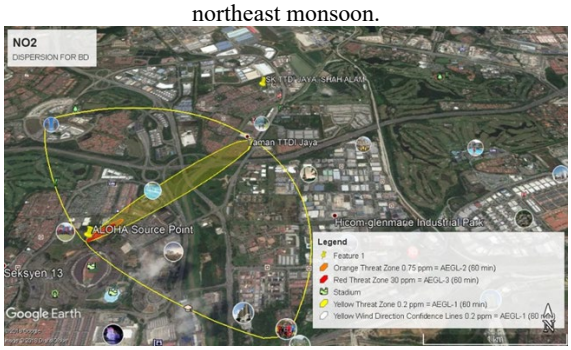

Figure 14: Dispersion of SO_2 and NO_2 in Shah Alam for southwest monsoon.

This area is categorised as an industrial area where there is active industries being carried in the area. There are also many factories nearby which are one of the source of the gases being released to the atmosphere. As for the dispersion of the gases, the source for SO2 and NO2 gases during the northeast monsoon are from Taman Perindustrian Jaya, Ara Damansara Mutiara, U3 Shah Alam and Subang Airport as shown in Figure 13. For the southwest monsoon the sources of the SO2 and NO2 gases are from Tadisma Business Park, Seksyen 13 industrial area and Hicom Glenmarie Industrial Park as shown in Figure 14.

3.6 (Kuala Selangor) Dispersion of gases during the Northeast and Southwest monsoon.

The monitoring station for Kuala Selangor is located in Sekolah Menengah Sains Kuala Selangor and this area is categorised as a rural area as there isn't much industry carried out in this area. The area is far away from the busy city and there is several residential and shop areas. Thus, the only concerning gas in this area is PM10 which is released by the vehicles of the residents in that area. The highest mean concentration of the PM10 is recorded on June which is due to the effects of haze. However the level did not exceed the MAAQG standards for PM10.

4 Conclusion

As a conclusion the research has been carried out successfully. The sources of the dispersion of gases was successfully obtained based on the respective places. Many factors that influences the dispersion of the gases in the atmosphere was known. One of the major factor were the conditions of the atmosphere where the factors to be considered would be the air temperature, wind direction, wind speed, humidity and the cloud cover for an area. It was recorded that during the northeast monsoon season from the month of November to March and southwest monsoon which is expected from end of May to September. During the northeast monsoon the wind direction is from the northeast and heavy rain is expected, humidity and the cloud cover increases. The wind speed is also made average on the north east monsoon and taken as 1.62 m/s. During this season the rainfall is expected to be heavy and the humidity is taken to be as 80% as well as the cloud cover was taken somewhere between completely cloudy to partially cloudy. Whereas for the southwest monsoon it is expected to be a slightly dry season and the wind is from the southwest and the average speed is taken to be 1.92 m/s. Since the rainfall during this season is expected to be low the humidity is taken as 25% only and the cloud cover is taken as between partially cloudy to clear sky. Hence, the dispersion of the gas can be obtained accurately when the conditions of the atmosphere is obtained.

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References

[1] Clean Malaysia, "Air Pollution is "Worse than You Think' - Clean Malaysia," 2014. [Online]. Available: http://cleanmalaysia.com/2017/08/24/air-pollution-worse-think/. [Accessed: 14-Nov-2017].

[2] K. S. Loshana, "Haze: Port Klang air quality getting more and more hazardous Tuesday - Nation | The Star Online," *STAR*, 2013. [Online]. Available: https://www.thestar.com.my/news/nation/2013/06/25/haze-port-klang-air-quality-getting-more-and-more-hazardous-tuesday/. [Accessed: 04-Jun-2018].

[3] O. US EPA, OSWER, "ALOHA Software," 2017.

[4] A. M. Abdullah, M. Armi, A. Samah, and T. Y. Jun, "An Overview of the Air Pollution Trend in Klang Valley , Malaysia," pp. 13–19, 2012.

[5] A. Amir, "Air Pollution Trends in Petaling Jaya, Selangor, Malaysia," no. January 2007, p. 25, 2007.

[6] N. Sutopo purwo, "Haze from Indonesian fires causes pollution spike in Malaysia," 2015.

[7] DoE, "New Malaysia Ambient Air Quality Standard," *Dep. Environ. , Malaysia*, p. 1989, 2013.

[8] A. Y. Watson, R. R. Bates, and D. Kennedy, "Atmospheric Transport and Dispersion of Air Pollutants Associated with Vehicular Emissions," 1988.

[9] G. HARRY BEATTY, "Air quality in Banting remains unhealthy as of 2pm | New Straits Times | Malaysia General Business Sports and Lifestyle News," 2015. [Online]. Available: https://www.nst.com.my/news/2015/10/air-quality-banting-remains-unhealthy-2pm. [Accessed: 24-May-2018].

[10] F. M. Binyehmed, A. M. Abdullah, and Z. Zainal, "Trend and Status of SO 2 Pollution as a Corrosive Agent at Four Different Monitoring Stations in the Klang Valley ," *Int. J. Adv. Sci. Tech. Res.*, vol. 3, no. 6, pp. 302–317, 2016.

[11] M. D. Adams and W. J. Requia, "How private vehicle use increases ambient air pollution concentrations at schools during the morning drop-off of children," *Atmos. Environ.*, vol. 165, pp. 264–273, 2017.