Comparing contributors and PM$_{10}$ dispersion around Tugu Juang and in governor office area of Jambi City, Indonesia

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Abstract. Sources origin of particulates matter (PM) especially which is under 10 µm (PM$_{10}$) become important because of its characteristic as a transboundary pollutant, besides human health effect in the respiratory system. While method to recognise the susceptible areas that have PM$_{10}$ risk need to be developed. NOAA’s HYSPLIT has been applied as a tool to the PM trajectory and dispersion analysis which was used to predict PM from the fire forest and volcanic ash in the first time. This research aimed to understand the PM$_{10}$ trajectories and dispersions around Tugu Juang and Jambi’s in the Provincial Government Office in Jambi city on weekday and weekend to recognise PM$_{10}$ source origin and dispersion. The results showed that the source origin both in Tugu Juang area and also in the Provincial Government Office location did not just come from the local area, but also came from the near Provinces which were Sumatera Selatan and Lampung, and also even until from the sea near from Bangka Belitung Island. Moreover, PM$_{10}$ disperse direction in Tugu Juang zone on a weekday was to the west in daylight subsequently to the north at evening and on weekend was still in that area in daytime, afterwards moved to the west and went to the north in the evening. Whereas, in the Provincial Government Office location, PM$_{10}$ dispersion moved on a weekday from the northwest in the daytime, later went to the west in the evening and on weekend ranged to the west in daylight moved to the north.

1. Introduction

Air pollution is the first polluter that has affected human health which its important sources were changed dynamically since BC. Chimney and wood that used as a result from industries combustion were the first important sources after steam engines changed it in the middle of the 19th century due to massively used for industries. Again, after large-scale expansion of private vehicles in the 20th century, automobile sources altered industrial to be an important source of air pollution. This phenomenon is enabled to another change in the future which is indicated by unpredictable atmospheric and climate condition recently.

This unpredictable trend can make air pollutant that comes from many contributors continued to be more harmful to human health and the environment. Particulate matter (PM) is one of the examples which come from local sources and also by transporting the regional atmospheric pollutant from the surrounding area (Li et al, 2017). Consequently, one region or a country can be impacted by PM pollutant although its local sources are lower than the air quality standard like when Indonesia’s forest fire incident happened.
and become a scourge in almost every year for several Southeast Asia’s countries near Indonesia such as Malaysia, Singapore, Brunei Darussalam and Thailand.

Although the haze disaster has not happened since 2016, efforts for understanding how haze debacle from Indonesia’s forest fire activities is still needed. The monitoring activity could be directed to know the trajectories and the dispersions of PM, besides develop other measurement techniques or methods to have comprehensive view of PM concentration values were also important. Moreover, as many monitoring campaigns have performed in several Southeast Asia countries such as Thailand with East Asia Nanoparticle Monitoring Networks, Prince of Songkla University–Kanazawa University and Malaysia which was performed by University Kebangsaan Malaysia, monitoring and assessing the condition in the location near Indonesia’s forest fire hotspot also important.

Jambi one of Indonesia’s city which is near from the forest region located in Sumatera Island with latitude 1°36’00” S and longitude 103°37’44” E. Besides as a near city from the forest, Jambi has been a big city with 583,487 populations (BPS, 2018) which induce transportation sector also become an important source of air pollution. Therefore, air pollution monitoring activities are needed for Jambi city especially to PM due to the sources can come also from a forest fire. In addition, the concentration of PM also might be higher in one specific area than others due to the dispersing mechanism which then increases human health risk in that location.

Jambi City’s Government has exhibited a commitment to control urban air pollution. They have had an Air Quality Monitoring System which was installed to have daily data for main air pollutant such as PM$_{10}$. It became an important air pollutant because of the character as a trans-boundary pollutant, besides human health effect in the respiratory system. This research was intended to understand how dispersions and trajectories mechanism of PM$_{10}$ in a busy transportation zone and institutional location happen by using HYSPLIT. Moreover, HYSPLIT was challenged to get appropriate information about PM$_{10}$ situation and the characteristic to support policymaker in planning their urban air pollution management.

2. Method

2.1 Location and Time Period of PM$_{10}$ Measurement

In this research, two locations as a study area were identified. They are Tugu Juang region which represents a transportation zone and Governor Office area reflected as an institutional zone. The first location exhibit was as a busy transportation condition due to crowded transportation around this area every day, while the second area became a comparing location with a condition which did not have any air pollutant’s contributor sources to have knowledge about PM$_{10}$ dispersion and the trajectories. Description of the situation in each sampling location is shown in figure 1 and 2.

Figure 1. Around Tugu Juang Monument (Busy Transportation Location)  
Figure 2. Governor Office Location (Institutional Region)
Day and condition of PM$_{10}$ measurement were differed by the date and type of the day. At Governor Office location, sampling was performed in Friday, August 30$^{th}$, 2018 for weekday and in Saturday, September 1$^{st}$, 2018 for the weekend. Whilst, at Tugu Juang was performed in Sunday, September 2$^{nd}$, 2018 for the weekend and on Monday, September 3$^{rd}$, 2018 for a weekday. Values of PM$_{10}$ concentration were needed for further dispersion and trajectory analysis in HYSPLIT, which were measured by using high volume air sampler (HVAS) in sampling location. After 24 hours of sampling, each filter was weighted by using analytical balance in the room with a temperature between 15 to 27°C and relative moisture in the range 0 – 50%. The concentration of PM$_{10}$ was counted by this formula:

$$C = \frac{(W_2 - W_1) \times 10^6}{V}$$

Where:
- $C$: Concentration of PM$_{10}$ ($\mu g/ Nm^2$)
- $W_1$: Initial filter weight (g)
- $W_2$: Final filter weight (g)
- $V$: Volume of air test samples (m$^3$)
- $10^6$: g conversion to $\mu g$

2.2 Hysplit
The National Oceanic and Atmospheric Administration’s (NOAA) Air Resources Laboratory’s (ARL) Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) is a computation system for simple air parcel trajectories as well as complex transport, dispersion, chemical transformation, and deposition simulations, which continues to be one of the most extensively used atmospheric transport and dispersion models in the atmospheric sciences community, recently (Stein et al, 2015). The method of model calculation is a hybrid between the Lagrangian approach, using a moving frame of reference for the advection and diffusion calculations as the trajectories or air parcels move from their initial location, and the Eulerian methodology, which uses a fixed three-dimensional grid as a frame of reference to compute pollutant air concentrations (the model name, no longer meant as an acronym, originally reflected this hybrid computational approach).

In this research, dispersion way and also back-trajectory analysis of PM$_{10}$ were performed to have an understanding about the way of PM10 dispersion and source-receptor from each sampling location. On the dispersion, analyses were executed by doing 6 hours period to compare between Tugu Juang location and Governor Office place in the weekend and also in weekday. Whereas, on the source of PM$_{10}$ contributor, analyses were operated every 1 hour to do backward trajectory at these two locations in weekend and weekday.

3. Findings and discussion
3.1 PM$_{10}$ Concentration Analysis
Measuring concentration of PM$_{10}$ has been done both on Tugu Juang Location and Governor Office spot. The PM$_{10}$ concentrations were measured two times in each sample place. The values of PM$_{10}$ concentration are shown in this picture.
In general, PM10 concentrations in transportation location were bigger than in institutional zone, which there was a little different when weekend (84.8 µg/m$^3$) and weekday (83.2 µg/m$^3$) at Tugu Juang as a transportation zone. The lowest PM$_{10}$ concentration occurred at Governor Office location when weekend (33.1 µg/m$^3$), while PM$_{10}$ concentration was 69.1 µg/m$^3$ in weekday. In the period of sampling, rain occurred in 3 until 5 hours during the duration of PM$_{10}$ sampling (24 hours) which was projected as a reason why the PM$_{10}$ concentrations were low, especially for a transportation location.

3.2 Dispersion Analysis of PM$_{10}$

The analysis of dispersion has been made by operating every 6 hours period. The difference of dispersion happened between weekdays PM$_{10}$ at Governor Office and weekdays PM$_{10}$ at Tugu Juang in each period of analysis. The dispersion of PM$_{10}$ in 6 hours period at the two locations was analyzed and the results are showed in figure 4 (a,b,c,d).

Figure 3. PM$_{10}$ Concentration in Sampling Locations

Figure 4a. Weekday PM$_{10}$ Dispersion in 6 Hours Period at Governor Office
Figure 4b. Weekday PM$_{10}$ Dispersion in 6 Hours Period at Tugu Juang

Figure 4c. Weekend PM$_{10}$ Dispersion in 6 Hours Period at Governor Office
Figure 4d. Weekend PM\textsubscript{10} Dispersion in 6 Hours Period at Tugu Juang

From these pictures, there are some differences in the disperse direction of PM10. These differences do not just happen cause of time (weekend and weekday) and place (at Governor office and at Tugu Juang), but also in the extent of PM10 dispersion for each of results from HYSPLIT analysis. Therefore, the PM10 distinction can be observed in the same location which has different time (figure 4a. and 4c.; figure 4b. and 4d.), besides in the different location and in the different time (figure 4a. and 4d.; figure 4b and 4c).

The first analysis was for the direction of PM10 dispersion. These two locations showed that PM10 had spread in the range of the west and the north sides. Weekend PM10 at Tugu Juang seen as the largest dispersion which was spread evenly in the range from the west to the north (figure 4d.). The dispersion spread in a weekend at Governor office was also deployed like in weekend at Tugu Juang (figure 4c.), while in weekday the PM10 dispersion at Tugu Juang and at Governor office appeared straight in its direction, respectively (figure 4a. and 4b.). Therefore, the PM10 in the weekend was more disperse than the PM10 in weekday.

While the PM10 in weekday was less spread than in weekend, the different phenomenon occurred in the distance span analysis for PM10 at these locations. Although weekday PM10 at Governor office (figure 4a.) did not spread enough, the longest distance span took place in it. The distance of its dispersion was more than 200 km to the northwest direction, then followed by weekend PM10 at Tugu Juang (figure 4d.) which span nearly to 200 km and spread to the west and reach to the north. Moreover, although dispersion pattern in weekday PM10 at Tugu Juang (figure 4b.) was similar to weekday PM10 at Governor office (figure 4a.) and weekend PM10 at Tugu Juang (figure 4d) was similar too with weekend PM10 at Governor office (figure 4c.) although all the span of dispersion was not reached in the same distance. Therefore, the longest distance span of PM10 happened at Tugu Juang in the weekend and in weekday at Governor office.
### 3.3 Sources of PM$_{10}$ Contributor

The sources of PM$_{10}$ contributor analysis were operated in every 1 hour and every 24 hours for backward trajectory. These analyses were done to have knowledge about the trajectories of the PM$_{10}$ sources from those locations.

Firstly, the results in every 1-hour analysis were pictured in figure 6 (a,b) for Tugu Juang location and 6 (c,d) for Governor office location.

All pictures describes that the sources of PM$_{10}$ came from between the southeast and the east side. However, there were differences between them. PM$_{10}$ trajectory in weekdays (figure 6b. and 6d.) tended to come from the southeast, while in weekday (figure 6a. and 6c.) also tended to come from the east way. Moreover, the PM$_{10}$ trajectories at Tugu Juang were more focused from the southeast area whereas the PM$_{10}$ trajectory at Governor Office was seen more escalated to the east side especially in weekend. The PM$_{10}$ trajectories at Governor Office indicated that majority of PM$_{10}$ at Governor Office did not come from local sources.

Moreover, the PM$_{10}$ origin in these locations did not just come from local but also from the near provinces such as Sumatera Selatan and Lampung and even until from the sea near Bangka Belitung.
Island. It was really seen on the PM10 trajectories at Governor Office which in weekend the sources had come from the sea near Bangka Belitung Island, while in weekday originated from Sumatera Selatan Province. However, the origins of PM10 at Tugu Juang were more set in the southeast which it was originated mostly from Sumatera Selatan Province and slightly from Lampung Province. Beside using every 1 hour, analysis for every 24 hours was also acted in this PM10 backward trajectory. The results can be seen in figure 7 (a,b,c,d).

From the results of 24 hours analysis, the trajectory sources were seen more sprawls and tended to come from both the southeast and the east. Comparing to 1-hour analysis before, there were difference trajectories from all the results.

Figure 6a. PM$_{10}$ Backward Trajectory every 24 Hours at Tugu Juang in Weekend

Figure 6b. PM$_{10}$ Backward Trajectory every 24 Hours at Tugu Juang in Weekday

Figure 6c. PM$_{10}$ Backward Trajectory every 24 Hours at Governor Office in Weekend

Figure 6d. PM$_{10}$ Backward Trajectory every 24 Hours at Governor Office in Weekday
4. Conclusion

It can sum that:

1) Disperse direction of PM$_{10}$ at Tugu Juang zone on a weekday was to the west in daylight subsequently to the north in the evening and on weekend was still in that area in the daytime afterwards moved to the west and went to the north in the evening. Whereas, in the in the Provincial Government Office location, PM10 dispersion moved on a weekday from the northwest in the daytime, later went to the west in the evening and on weekend ranged to the west.

2) The source origin both at Tugu Juang area and also at in the Provincial Government Office location did not just come from local, but also came from the near Provinces such as Sumatera Selatan, Lampung and even until from the sea near from Bangka Belitung Island.

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