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Shifting of air pollutants distribution during car free day event

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Shifting of air pollutants distribution during car free day event

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Abstract. According to Decree of Semarang Mayor No. 22/2011, car free day activities is addressed to give clean air for facilitating citizens activities. This car free day event is held every Sunday in the morning in the city center of Semarang i.e. located at Simpang Lima square. This research is aimed at identifying the shifting of pollutant during car fee day event by comparing ambient air pollutant concentration represented by carbon monoxide during car free day event and non-car free day event. About 14 streets had been measured its ambient CO concentration during Saturday (non-car free day event) and Sunday (car free day event). We also modeled (using Caline4) the CO dispersion at the certain area on those streets to know the spatial distribution of concentration during those two events. The ambient CO concentration, in general, during car free day event were somewhat increase for certain roads. The emission load of vehicles emission during CFD event was 1.37 times of non-CFD event. Nevertheless, based on spatial distribution of ambient CO concentration at the area of roads of interest, its concentrations were below the ambient CO concentration standard (PP.41/99).

1. Introduction

As the city becoming bigger due to urbanization, transportation matter is important part of city growth. Uncontrolled growth of vehicles owned privately in one side and limited growth of road inner the city in other side make unbalanced growth and further it makes congestion and traffic jam. Based on this issue, it is indispensable for many cities to eagerly try to reduce the private vehicles use in city centers. Nowadays, cities from around the world seem to become more willing to try car free initiatives [1] particularly in developed countries. These initiatives supported by city government should be participated by the citizen to run it effectively. The measures on reduction of motorized traffic is deemed to give benefit to public health, both in the short and long-term [2].

Car sharing, carpooling and car free days are several measures for minimizing private cars. In Netherland, car sharers drive around 15%–20% fewer car kilometers than before they started car sharing and emit between 240 and 390 fewer kilograms of CO_2 per person, per year [3].

Based on the research in Italy, carpooling with certain strategy could reduce the emission by 22 – 28% [4]. Changing habitual commuting by bicycle in the area of Stockholm, theoretically, could reduce RR of NOx by 8% associated by 10 μgm^{-3} decrease [5]. Other study by Scheepers reviewed the effectiveness measure by shifting car use to cycling and its impact to mortality [6]. Car free day (CFD) is the foremost popular measure in developing world due to less costly and attract economical aspect. However, this CFD face big challenge as awareness and participation of the public are still in question.

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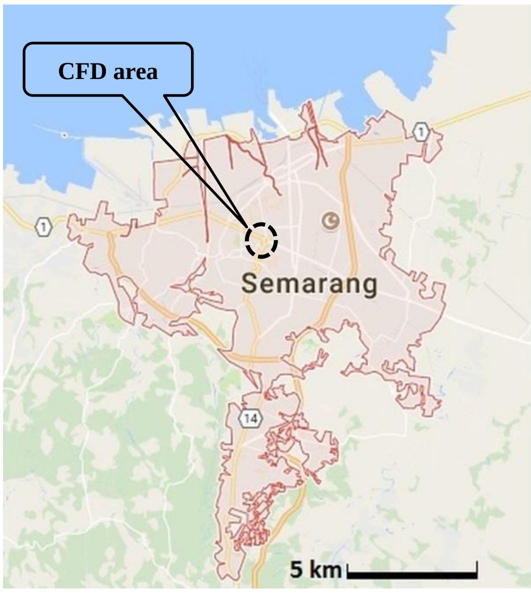
Clearly the awareness and event quality, in CFD event, were not the main driving factor for the people to participate at the CFD as regular event [7]. In Hanoi, Vietnam, car free city and city-of-short-distance concepts had difficulties in the management level of authority, awareness and public participation [8]. This CFD is claimed to clean the ambient air in the CFD area although it is temporary. The context of reducing pollutant by implementing CFD event is true only in the CFD area. Whilst in the surrounding area, it is predicted that level of air pollutant is higher than before CFD implementation. This study is aimed at knowing the impact of air pollutant distribution due to car free day event particularly at surrounding area. Emission load calculation and shifting distribution of air pollutant are the main topic of this study. The discrepancies of implementing CFD in the road segment could be handled by implementing CFD at wider area (comprising multiple roads, not operating CFD event at a road segment only).

2. Methodology

This section explains the methodology used in this research. The location of study, data collection method, and data analysis are elaborated in the following subsection.

2.1. Location of study and data collection

This study was conducted during car free day event (Sunday) and non-car free day event (Saturday) in 2016 and 2017. The location of the study and the sampling points are depicted in figure 1. We collected the data on number of vehicles passing through the measured road (hourly basis), CO concentration (Extech) and other micrometeorological aspects such as wind speed, wind direction and ambient temperature. Measurements were conducted during car free day event i.e. 06.00 – 09.00 AM. We also measured several ambient CO backgrounds during early morning (before 06.00 AM). We assume, during this time, the background CO was not affected by traffic emission. Totally 14 roads around the car free day area (Simpang Lima Square) were measured.



Sampling points	*Lat Long Coordinates*	Sampling points	*Lat Long Coordinates*
Kusumawardhani	6°59'46"S 110°25'16"E	Pandanaran_2	6°59'29"S 110°25'12"E
Undip Pleburan	6°59'40"S 110°25'26"E	Menteri Supeno	6°59'36"S 110°25'09"E
Erlangga	6°59'31"S 110°25'24"E	Gergaji	6°59'43"S 110°25'07"E
Ahmad Yani	6°59'31"S 110°25'36"E	Imam Bonjol	6°58'59"S 110°24'35"E
Ahmad Dahlan	6°59'22"S 110°25'30"E	Imam Bonjol – Pierre Tendean	6°58'43"S 110°24'44"E
Gajah Mada	6°59'18"S 110°25'23"E	Pierre Tendean	6°58'41"S 110°24'51"E
Pandanaran_1	6°59'20"S 110°25'12"E	MH Thamrin	6°58'42"S 110°25'01"E

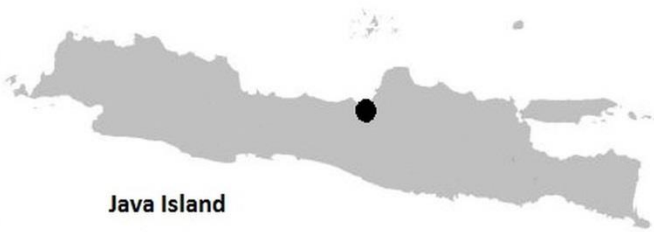


Figure 1. Location of the study.

2.2. Data analysis

After collecting the ambient CO concentration and number of vehicles (in category), we analyze the distribution of CO concentration in the concerned area using Caline4 in Calroad View. We compare it during car free day event and non-car free day event. Based on the modelled map, we are able to know the difference of CO distribution during CFD and non-CFD event. For knowing the impact of increasing number of vehicles in concerned roads we estimated the CO emission load (g/h). To do so, we used guideline for emission inventory for road transportation from Ministry of Environment.

3. Results and discussion

This section discusses the research results. Authors analyze the traffic activities and emission load during CFD and non-CFD event and estimate the distribution of ambient CO. The discussion of the result is elaborated in the following subsection.

3.1. Traffic activities and emission load

During CFD event, the number of vehicles in the road surrounding the CFD arena showed higher than during non-CFD event (see table 1). This is true to all mode vehicles i.e. gasoline car, diesel car and motorcycle. However, several few roads showed lower number of vehicles. The highest increase of vehicle number took place at small roads (i.e. alternative roads) such as Kusumawardhani road, Gergaji road. Ahmad Yani was the main road which had high increase of vehicles.

Quantitatively, as featured in figure 2, the increased of CO concentration at the roads were identified in Menteri Supeno street (208.7%), Gergaji street (145.5%), Kusumawardhani street (228.6%), Imam Bardjo street (85.7%), Erlangga street (63.6%), Pandanaran street section 2 (143.75%), Ahmad Dahlan street (79.4%), Pierre Tendean street (13,15%), Imam Bonjol (12,62%) and Pemuda street (18,94%). At contrast, at Gajah Mada street, it decreased by -13.3%, Pandanaran street (-34.3%). While at A. Yani street there was no increased or decreased. Due to this rise, commonly the ambient CO concentration at many roads surrounding CFD arena during CFD event were much higher than those at non-CFD event.

Table 1. Number of vehicles during CFD and non-CFD events.

Sampling points	Non-CFD Event (units)			CFD Event (Units)			CFD/Non-CFD		
	Gasoline		Motorcycle	Gasoline		Motorcycle	Gasoline		Motorcycle
	Gasoline	Diesel		Gasoline	Diesel		Gasoline	Diesel	
Kusumawardhani	235	42	1640	808	107	4801	3.4	2.5	2.9
Undip Pleburan	508	40	2032	720	44	3155	1.4	1.1	1.6
Erlangga	479	78	2040	145	29	2280	0.3	0.4	1.1
Ahmad Yani	442	62	1875	1981	170	7150	4.5	2.7	3.8
Ahmad Dahlan	1409	262	4266	1214	132	5125	0.9	0.5	1.2
Gajah Mada	2436	255	5919	1289	95	6204	0.5	0.4	1.0
Pandanaran_1	411	55	1684	449	53	2609	1.1	1.0	1.5
Pandanaran_2	935	127	3371	1037	163	5447	1.1	1.3	1.6
Menteri Supeno	806	86	4890	820	45	6972	1.0	0.5	1.4
Gergaji	65	8	655	195	28	798	3.0	3.5	1.2
Imam Bonjol	1657	253	6385	1947	508	7038	1.2	2.0	1.1
Imam Bonjol –Pierre Tendean	1571	361	6287	2676	403	7060	1.7	1.1	1.1
Pierre Tendean	1809	192	6449	2386	256	7087	1.3	1.3	1.1
MH Thamrin	1216	187	4516	1452	283	5172	1.2	1.5	1.1

There is a fluctuation of measured ambient CO concentrations (both during CFD event and non-CFD event) indicating that the number of vehicles vary with hour during CFD event or non-CFD event. There is no exact pattern of ambient CO concentration with time which may indicate dissipation of CO concentration in ambient air prevent accumulation of ambient CO concentration.

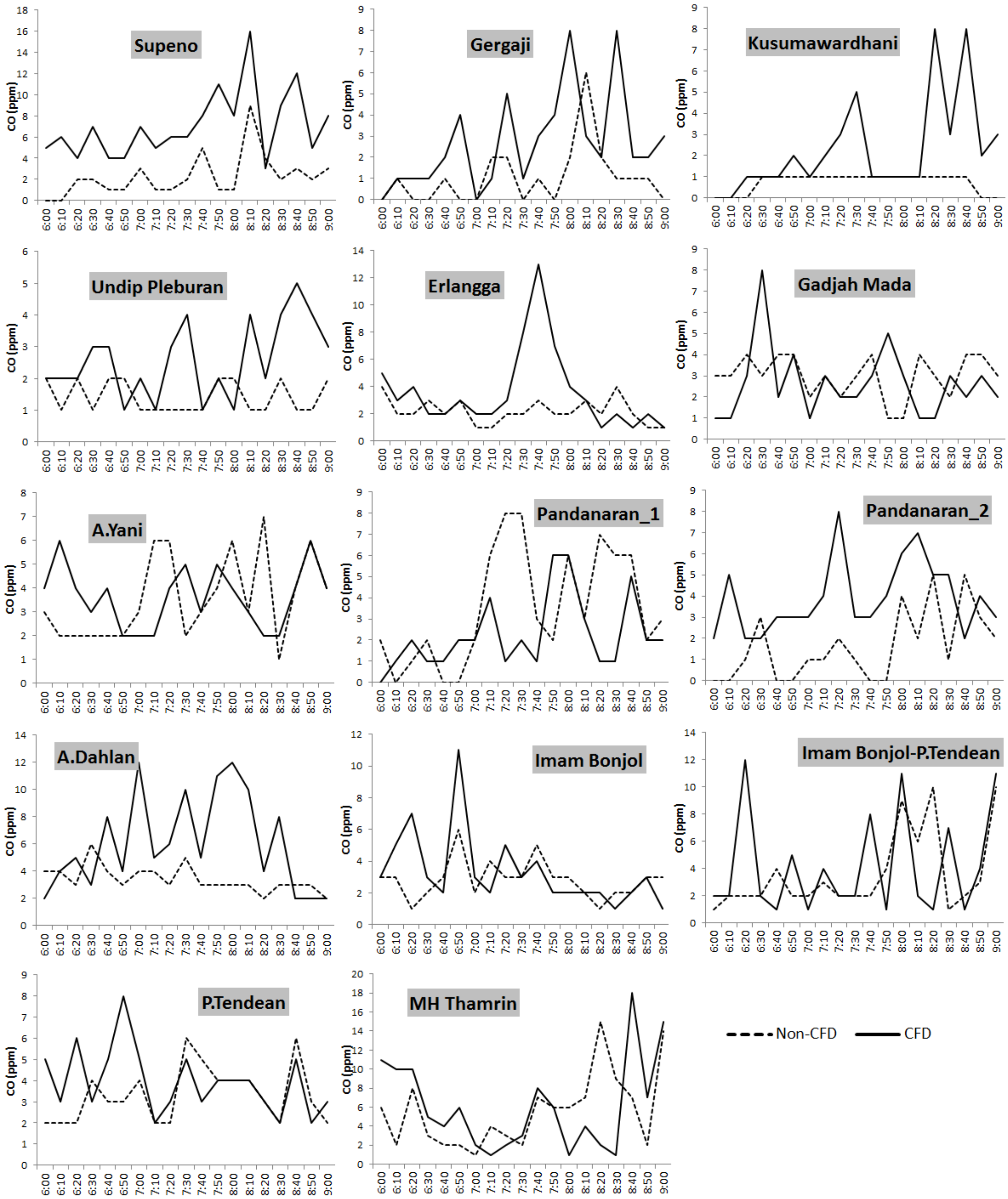


Figure 2. Varying concentration of ambient CO during CFD and non-CFD event.

As derived from figure 3, the emission load of vehicles during CFD event in total roads about 16.5 ton CO_2/year (if we assume the CFD take place every two weeks). This value is 1.37 times of non-CFD event. Thus this CFD objective to reduce the emission from its activity will be irrelevant. It is important to apply this CFD as an area CFD (not just for CFD implication for certain roads). No more attracted activities should be delivered in the CFD arena to prevent people to buy things at CFD arena which may be interested for CFD users.

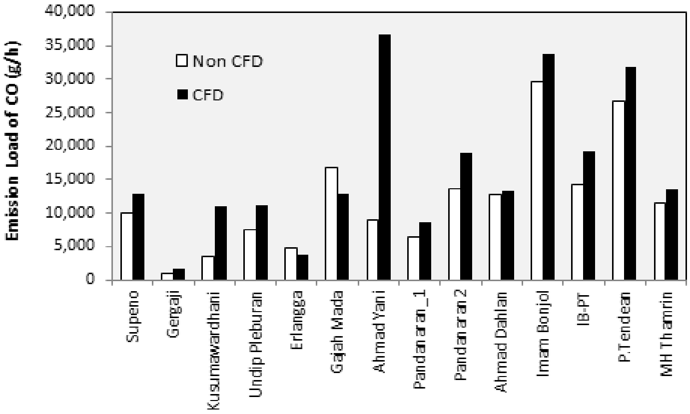


Figure 3. Ratio of emission load during CFD and non-CFD.

3.2 Estimated distribution of ambient CO

In modeling air pollutant distribution, we used Caline4 in Callroad View in concerned roads with several assumption parameters as follows: wind direction deviation 20°, atmospheric stability class 7, mixing height 450 m and mixing zone with 10 m. While the CO emission factor for gasoline car vehicle, diesel vehicle car and motorcycle are 64.37 g/mil, 4.5 g/mil, 22.53 g/mil respectively. We accommodate field measurement of temperature, wind (speed and direction) and traffic volume to be inputted in the model. Receptor sites then could be plotted to know the CO distribution, in this study we select 7 receptor sites (around Pemuda road) and 20 receptor sites (around Simpang Lima square). After defining link activities for each related road, then we could get the results of Caline4 model as depicted in figure 4 where (A) and (C) for non-CFD event and (B) and (D) for CFD event.

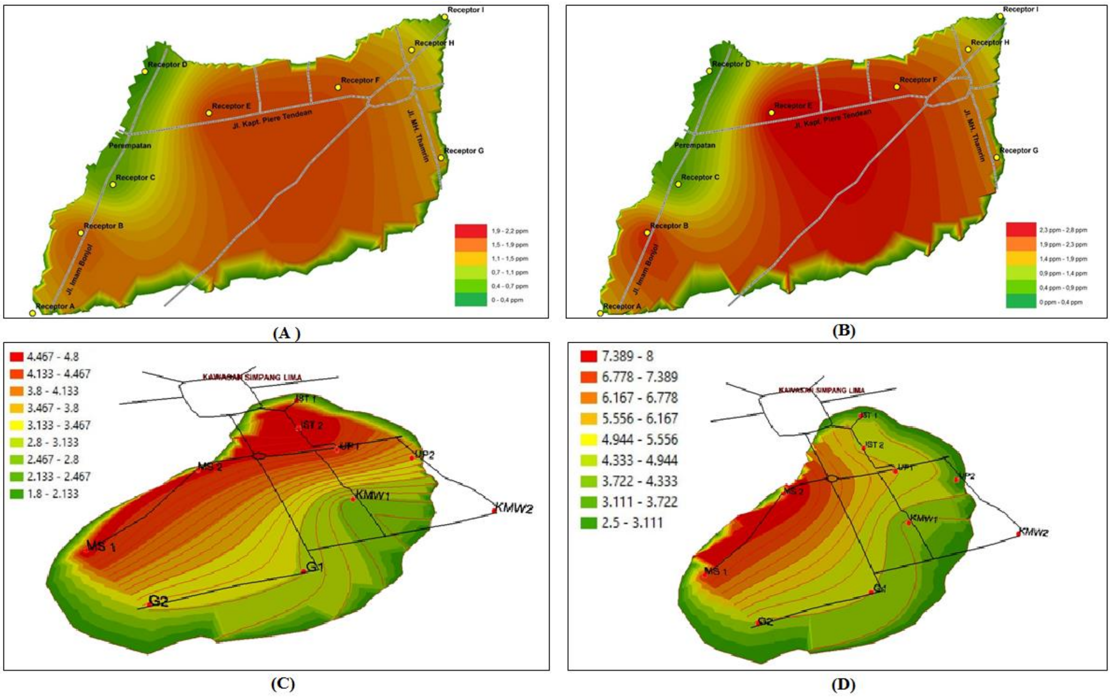


Figure 4. Increasing ambient CO concentration surrounding CFD area.

Based on the model results, the majority of the roads surrounding CFD area had higher ambient CO concentration than those during non CFD event. The reason for this incidence CFD event attracted more vehicles to come the area, avoiding vehicles driving through Simpang Lima square to surrounding available roads. Nevertheless, this shifting of CO distribution from CFD area to surrounding CFD area were still less than CO ambient standard (Government Regulation 41/1999).

4. Conclusion

About 14 streets had been measured its ambient CO concentration during Saturday (non-car free day event) and Sunday (car free day event). We also modeled (using Caline4) the CO dispersion at the certain area on those streets to know the spatial distribution of concentration during those two events. The ambient CO concentration, in general, during car free day event were somewhat increase for certain roads. Based on the model results, the majority of the roads surrounding CFD area had higher ambient CO concentration than those during non CFD event. The reason for this incidence CFD event attracted more vehicles to come the area, avoiding vehicles driving through Simpang Lima square to surrounding available roads. Nevertheless, based on spatial distribution of ambient CO concentration at the area of roads of interest, its concentrations were below the ambient CO concentration standard (PP.41/99).

Acknowledgement

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