PRELIMINARY STUDY ON SOURCE APPORTIONMENT OF AMBIENT AIR IN SEMARANG CITY USING CMB MODEL (CASE STUDY IN PEDURUNGAN SITE)

Haryono S Huboyo, Arief Budihardjo, Eko Primabudi
Environmental Engineering Department, Diponegoro University Semarang
(haryono@lingkungan.ft.undip.ac.id)

Abstract

High concentrations of fine particulate matter currently represent the main air quality problem in Semarang, and in order to develop effective control strategies its necessary to estimate the contributions of different sources to the ambient air quality. The application of receptor models for source apportionment can provide useful insight into this problem. CMB models (US-EPA 2001) was applied to a set of PM10 data collected in Pedurungan monitoring station for Semarang Regional Environmental Impact Control Agency (Bapedalda) urban air quality monitoring. Elements were analyzed using AAS, whereas UV spectrophotometer and turbidimeter were used for cations and anions anaylizing. Refer to the monitoring station data, the average of PM10 concentrations was only 60,42  g/m3 during the field sampling. Based on model calculations, transportations sector dominated this source apportionment contributing for 42% followed by geological material counts for 19%. Secondary aerosols only contributed 24 %, the rest was predicted come from industry and sea aerosols. Unindentified fraction was only 6%.

Keywords : Air Pollution, PM10, Source Apportionment, Semarang

1. Introduction

Numerous evidents trough epidemiologic studies showed that fine particles have adverse effect on human respiration. Some tend to be mutagenic and carcinogenic particularly those for elements (heavy metals), polyaromatic hydrocarbons and elemental carbon (REC, 1998). Fine particles with less than 10 m aerodinamic diameter would be deeply inhaled to the lungs structured and cause damage to human health (Balaceanu et al, 2004). This ambient concentration are ever increasing notably for public area (Panyacosit, 2000; Syahril et al., 2002; Zhang et al., 2004).

Semarang city as a capital city of Central Java Province has more than 2 million people and numerous potential air pollutant emitters. Almost 180 heavy industries lie in and more than 10,000 vehicles passing the crowded roads everyday. There is no study have been conducted yet to know the magnitude of source contribution. CMB models are widely used to quantify the contributions of each group air pollutant emitter to the atmosphere. Research in Delhi, 2004 conducted by World Bank showed that biomass burning, road dust and diesel combustion were dominate contributors. Slightly different, Zhang et.al (2004) also identified that road and geological dust as main source emitter (24%) followed by coal burning (15%) and secondary aerosol (16%) in China using CMB models. The toxic parameter in the air, PAH, was mainly originated from fossil fuel combustion (gasoline) is the research result from Buttini (Milan) and Mattiot (Paris) in 1999.

In Indonesia, as comparison, there were three studies which also using CMB for quantifying source contributors. In Bandung city, Lestari and Haryono (2003) indicated that secondary aerosol plays important role that contributes almost 33-44% for fine particles. While in coarse particles, metal industry as well as lime stone dust contribute 14% and 19% of total coarse particles respectively. In Jakarta, during 1995 – 1996, a study conducted by Bapedal and JICA using CMB concluded that the main contributor for particles airborne (SPM) was diesel vehicles (50%). For fine particles contributors, using CMB 7.0, PCI and Bapedal study showed that biomass burning and exhaust from motorcycles were the main sources reaching up to 22% and 21% respectively.

This study is aimed at quantifying PM10 particle contributors in Semarang city which by now there are not related data available, though its just initial research.

2. Methodology

Field sampling site was chosen in Pedurungan because this area are completely mixed. There are congested roads, numerous industries, densely (regularly or irregularly) housing settlements and this place is relatively in the center of Semarang. The location chosen are depicted in figure 1. In this site, there is fixed station monitoring station operated by Semarang Regional Environmental Impact Control Agency.

Samples were collected from Fixed Station Monitoring Station (in Pedurungan site). This continuous monitoring devices was run to report daily concentration of PM10 (ESM Eberline particulate monitoring instrument FH-62-I). Each filter paper (Schleicher & Schuell Glass Fibre Papers GF 10) was periodically taken out from the station each 7 days cycle during almost 1 month (May 27 - June 2005). About five samples were extracted for chemical analysis in Chemical Analytic Laboratory, Universitas Gadjah Mada Yogyakarta. The metal elements i.e Si, Al, Fe, Ca, Cu, Mg, Na, K, Mn, Pb, Zn are analyzed using AAS (Perkin-Elmer 3110). Ti elements was exclusively analyzed using UV-Vis Spectrophotometry. SO4 ions was analyzed was using Turbididimetry. The other ions (NO3-, Cl-, NH4+) were analyzed using UV Vis Spectrophotometery.

Uncertainties for ions and elements analysis were estimated by repeated samples measurements. Due to lack of local data measurement on source profile, secondary data provide by EPA model library, Speciate 3.1 (USEPA, 2002) and other (Park, 2001) were compiled to get sites-specific Semarang source profile.

3. Result and Discussion

3.1 Particles Concentration

During research observation i.e May 27 – June 23 2005 (as shown in figure 2), the daily particulate matter concentration reached it peak on May 28 2005 (89,07 µg/m3). On average, it concentration from January – June 2005 was 60.42 µg/m3. It violated yearly NAAQS-USEPA standard though it did’nt exceed for Indonesian standard (24 hours). It expected to somewhat lower in third quarter of the year when most location in Indonesia come into rainy season.

3.2 Chemical Composition

Secondary aerosol compounds i.e SO42- and NO3- coped the big fraction in articulate composition showing 8.4% and 8.06% of total mass. These pieces were precursory by SOx, NOx gases (mean concentration NOx from anuary – June 2005 was 15.79 ug/m3). The soil originated species such as Ca, Si, Al only taken up 5% fraction, the rest analyzed species only had lower fraction i.e less than 1%. Unindentified fraction

was very high, occupied around 55%. This discrepancy could be associated with un-analyzed carbon element and organic fraction.

3.3 Speciation.

Based correlation coefficient matrix, it could be inferred that strong relation (R square>0.75) were showed by among elements originated from geological elements: Al-Si-Fe, secondary aerosol i.e NH+4 - NO-3 – SO2-4 and seaspray aerosol: Na-Cl. Other moderate correlation (Cu-Mn-Zn-Ti-K) could not be explained clearly what their sources are. The speciation
could be summarized as follows :

Table 1. Speciation of PM10 composition

Elements	Source prediction
Si-Al-Fe	Geological material, power plant, industry
K-Mg	Geological material, vegetation burning
Mn-Al	Soil dust, vehicles exhaust
NH+4 - NO-3 – SO2-4	Secondary aerosol
Ca-SO42	Vehicles exhaust, industry
Na-Cl	Seaspray aerosol
SO42- - Cl	Oil combustion, soil
Cu-SO42	Burning process

Overall, it indicates that major anthropogenic-based elements occupied insignificant proportion to suspended particulate in Semarang airshed.

3.4 Source Apportionment

Source contributions was estimated using CMB 8.2 for each sample. Source profile used in CMB calculation were soil dust, industry, transportation, seaspray and secondary aerosol (ammonium sulfate and ammonium nitrate). The best calculation for

each sample was then averaged to get mean contributions. Its performance arrived at standard CMB calculation as stated in user manual.

The CMB calculation indices were satisfied i.e 2 < 4, R2 >80%, % mass explained around 94% and the result were depicted as under:

The emitter in Semarang are mainly associated with transportation sector followed with secondary aerosol that might be transportation sector originated too. Industry only shared 7% of contribution although there are hundreds industry reside in the western and eastern Semarang. Soil dust was comparatively lower than those studies in other area. Negligible amounts of seaspray aerosol also be identified since Semarang lies in the seasore of Java sea. Unindetified source fraction also be observed in this model though only accounted up to 6%. Based on windrose data (figure 4), it was concluded that wind dominantly blowed from southeast which brings air pollutant from growing populated area i.e Tembalang, Pedurungan and Genuk.

Considering that transportation are responsible as main contributor of air pollution, it advisable that transportation management would be high priority issue on urban air quality management

4. Conclusion

Generally, daily SPM concentration did’nt not exceed daily Indonesian standard though it violated yearly NAAQS USEPA standard. The result showed that chemical composition of were predominated by geological material and secondary aerosol, however since carbon fraction wasn’t analyzed, the unindentified fraction were high. From this preliminary CMB calculation view, potential contributor to SPM was pointed to transportation sector and its derivative (secondary aerosol).

5. Aknowledgments

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