$PM_{2.5}$ Monitoring in Mass and Compositions: Comparison Using Different Equipment

Bandung, West Java- Indonesia

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Map of Indonesia

Photo by PI: finding my own legend 2012

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Background

- The impact of PM2.5 to health and Environment. Particulate with size less than 2.5 μm could penetrate deep into the lung and cause lung damage
- Lack of monitoring data on $PM_{2.5}$ Spatially and Temporally for epidemiology study in Indonesia specially in Bandung and Jakarta and other cities
- PM2.5 is regulated under Government Regulation No. 41/1999, however, there is very limited monitoring of $PM_{2.5}$
- Conventional filter based sampler for $PM_{2.5}$ is high cost and high maintenance.
- The used of Nephelometer may could overcome the monitoring data required.

City Characteristics

- Population > 2.5 millions
- Latitude 6.55 S, L 107.36 E
- Geographically, Bandung is surrounded by hills and volcanic mountains which some of them are still active.
- The city is congested with a large number of motor vehicles, including both public and private transportations

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Main Objectives

- To Conduct Sampling Performance Evaluation for $PM_{2.5}$ monitoring in Bandung (apply different equipment). Combination of Filter-based and Continuous measurement
- Measurements ► Hourly $PM_{2.5}$ Concentration
- To characterize the $PM_{2.5}$ particles in Urban area Bandung
- To collect long-term systematic data for $PM_{2.5}$ in Bandung

Sampling Location at Institute of Technology Bandung, S 06°53'18", E 107°36'36"

Co-located Mini Volume Portable Air Sampler (Minivol), Havard Impactor, AirPhoton-Nephelometer & Filter sampler , Sun photometer

Samplers were Placed on the roof of 8 story building on ITB Campus with elevation 826 m or 2709.974 ft asl

: Sampling Equipment

FILTER SAMPLER

- Gravimetric mass (µg/m3)
- 4 LPM
- 8-slots cartridges; each a pair of 2µm PTFE Teflon and 8-µm Nuclepore

NEPHELOMETER

- Particle light scattering (Mm^{-1})
- 450 nm (blue)
- 532 nm (green)
- 632 nm (red)

HARVARD IMPACTOR

- Also used as the reference instrument in development study of Personal Respirable Particulate Sampler and Compact Multistage Cascade Impactor.
- Gravimetric mass (µg/m3)
- 10 LPM
- 1 µm Teflon filter

MiniVol sampler

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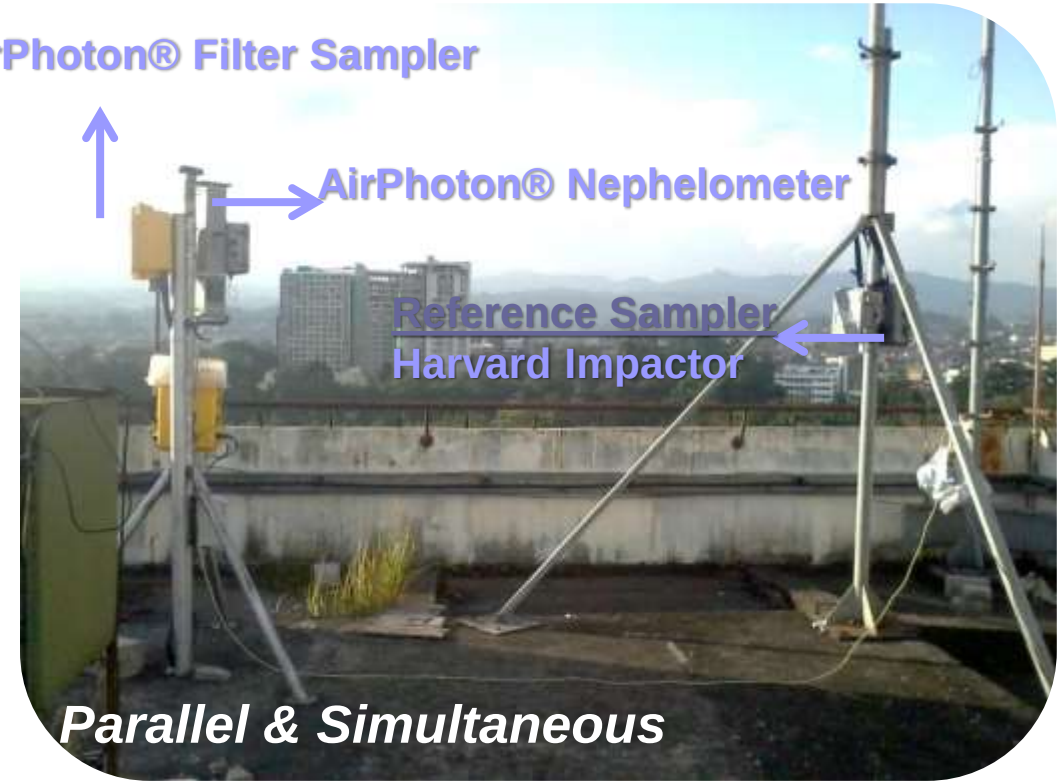
Co- Location of Sampling



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Sampling Program

- Co-Located sampling for Intercomparison evaluation (July-August 2014)
- 2014-2016, using AirPhoton (Nephelometer +Filter sampler) about 120 samples were collected
- Measurement were conducted during 2001 – 2007, with 24 hour period of sampling in Urban Mix sites & rural
- More than 350 samples were collected using Dichotomous and Mini volume Samplers
- Chemical Speciation (BC, an ions and cations and elements)

Sampling **Periods**

NORMAL PERIOD
Jan 2014- December 2016

To obtain $PM_{2.5}$ concentration data

COLLOCATION PERIOD
Jul 18 – Aug 20, 2014

Intercomparison for testing accuracy

63 days | 63 days | 63 days | 7 days | 7 days | 7 days


160 mins/day for 9 days
= 24 hours/filter

continuous



24 hours/day

continuous

24 hours/day

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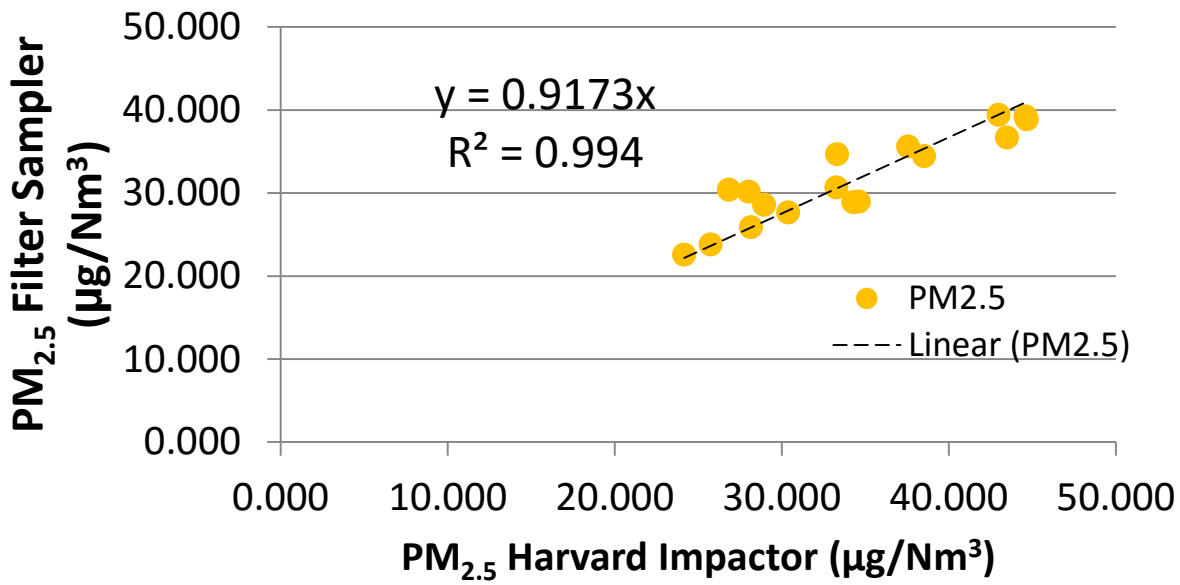
Filter Sampler
Sampling Performance Evaluation



LINEARITY TEST

☑ Statistically significant relationship between $PM_{2.5}$ Filter Sampler (n = 17, $\bar{x}$=31,55 µg/Nm^3) with $PM_{2,5}$ Harvard Impactor (n = 17, $\bar{x}$=34,10 µg/Nm^3) with *p-value* of 0.000.

☑ These two samplers show identical measurement.

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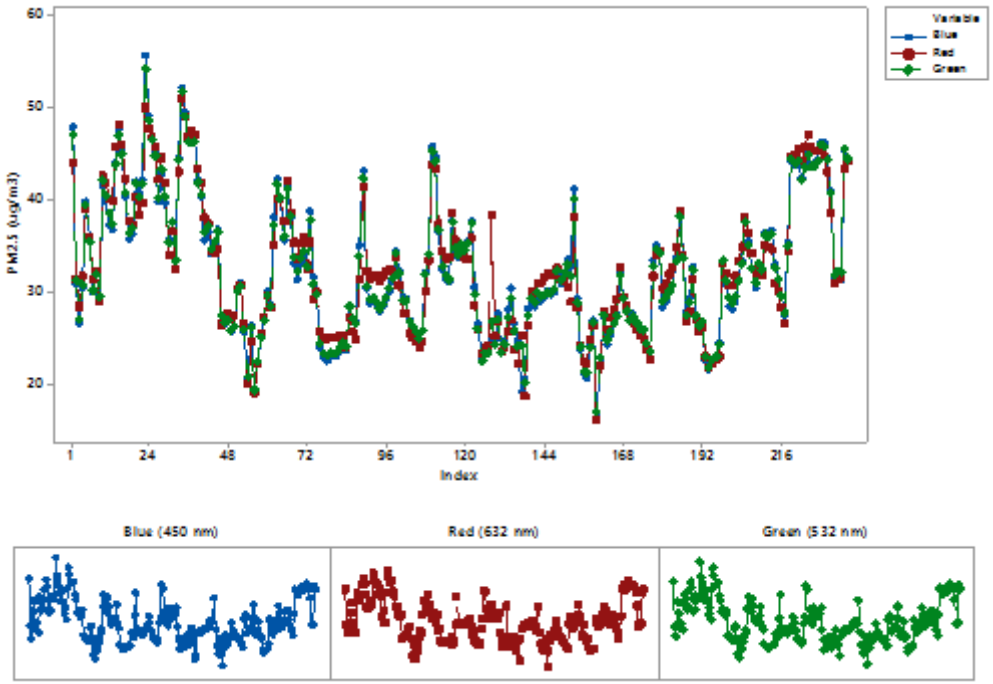
Nephelometer ampling Performance Evaluation



HOURLY ESTIMATES

Harvard Impactor

34.10 µg/m3

Variable	N	N*	Mean	SE Mean	Min	Max
$PM_{2,5}$ (Red)	236	0	**32,765**	0,472	16,272	51,13
$PM_{2,5}$ (Green)	236	0	**32,574**	0,469	17,15	54,204
$PM_{2,5}$ (Blue)	236	0	**32,561**	0,48	17,136	55,671

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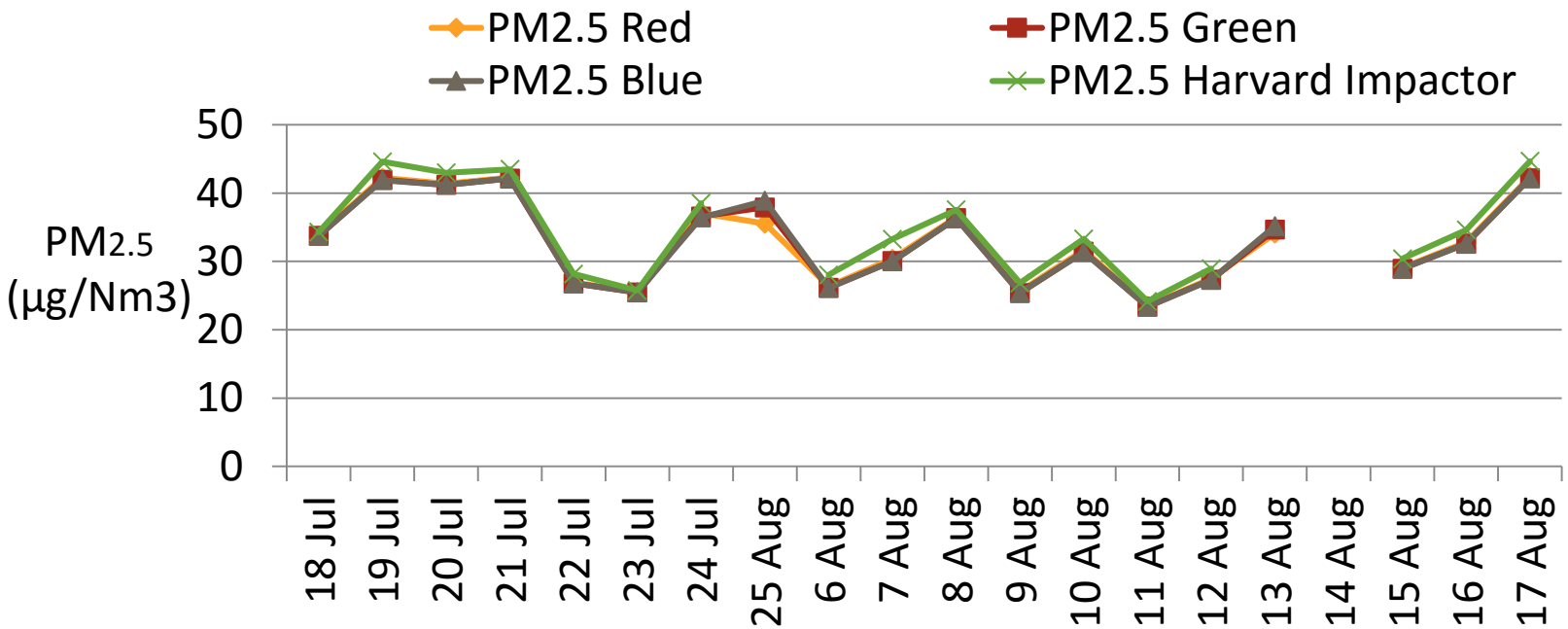
Nephelometer Sampling Performance Evaluation

DAILY AVERAGES



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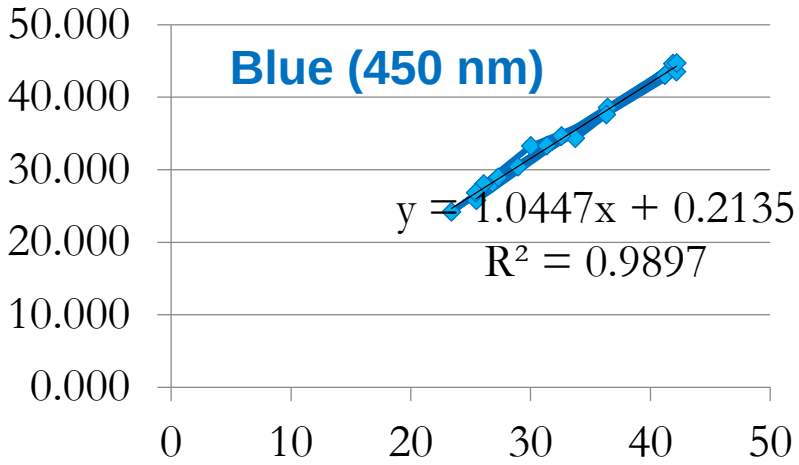
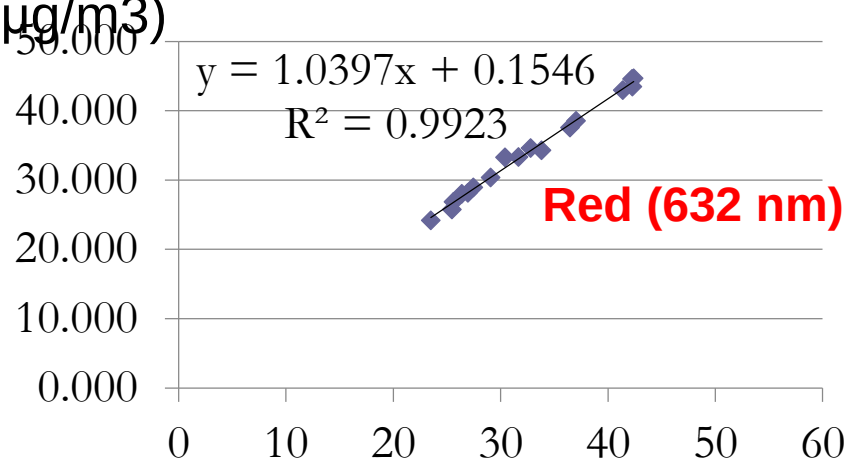
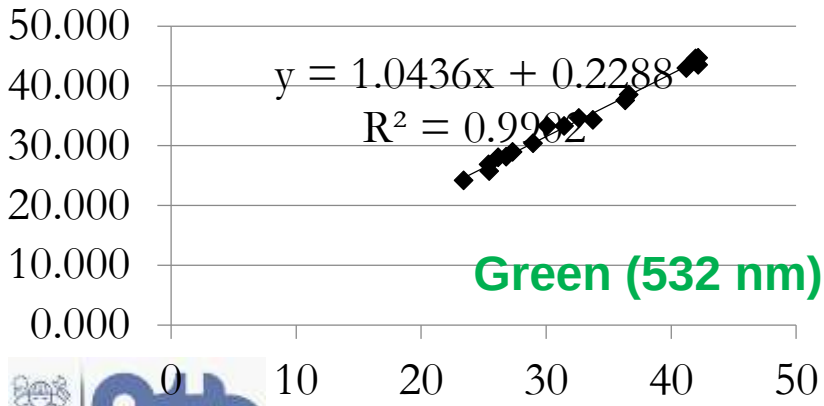
Nephelometer ampling Performance Evaluation

Legend : **Y** = Neph PM2.5 (µg/m3), **X** = Harvard Impactor PM2.5 (µg/m3)







LINEARITY TEST

Good correlations for all wavelengths

☑ These two samplers show identical measurement

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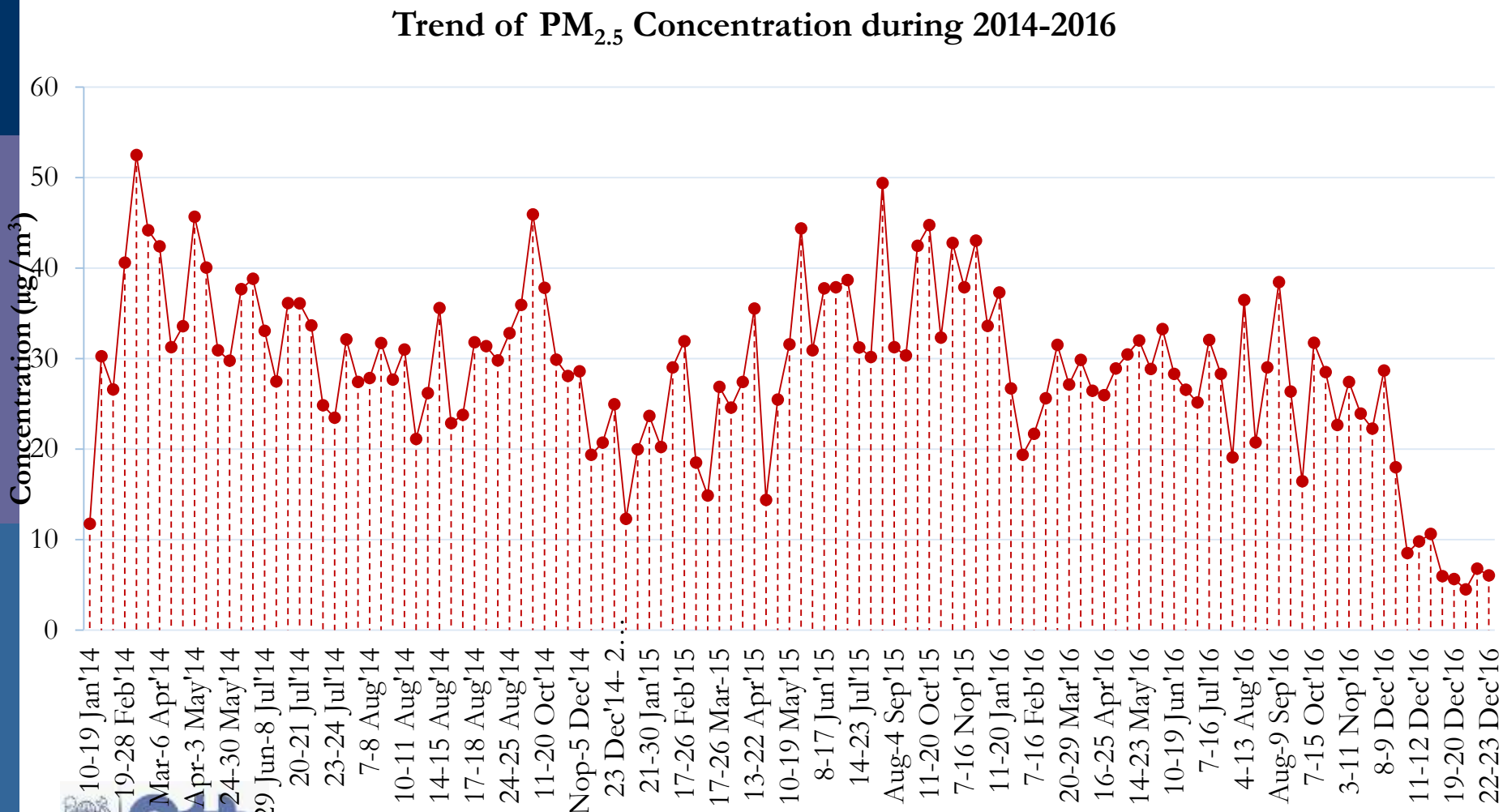
Concentration of PM2.5 (2014-2016)



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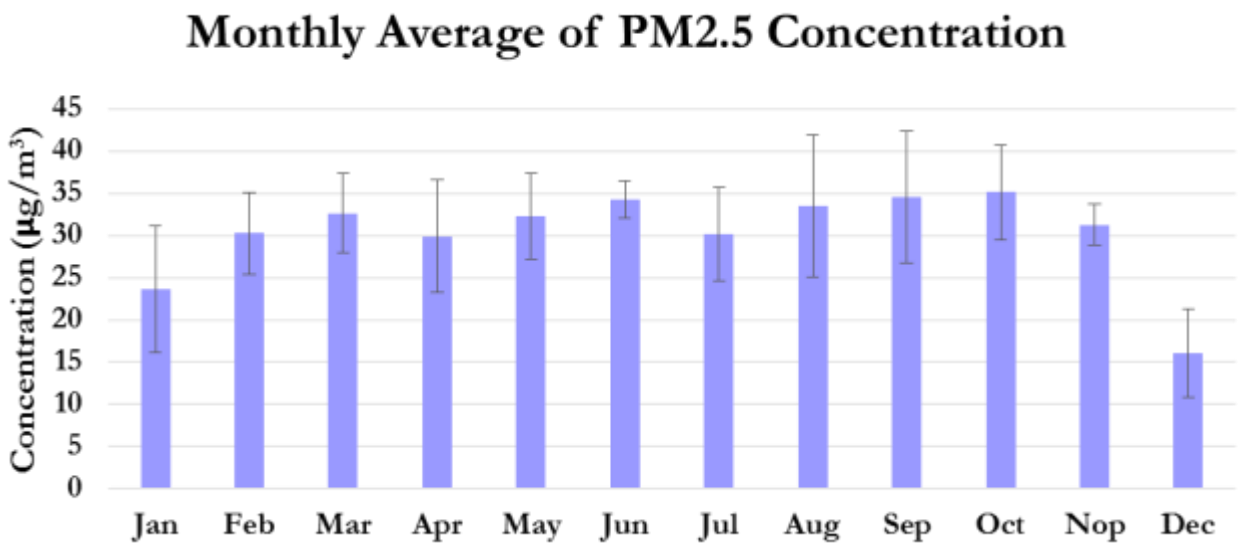
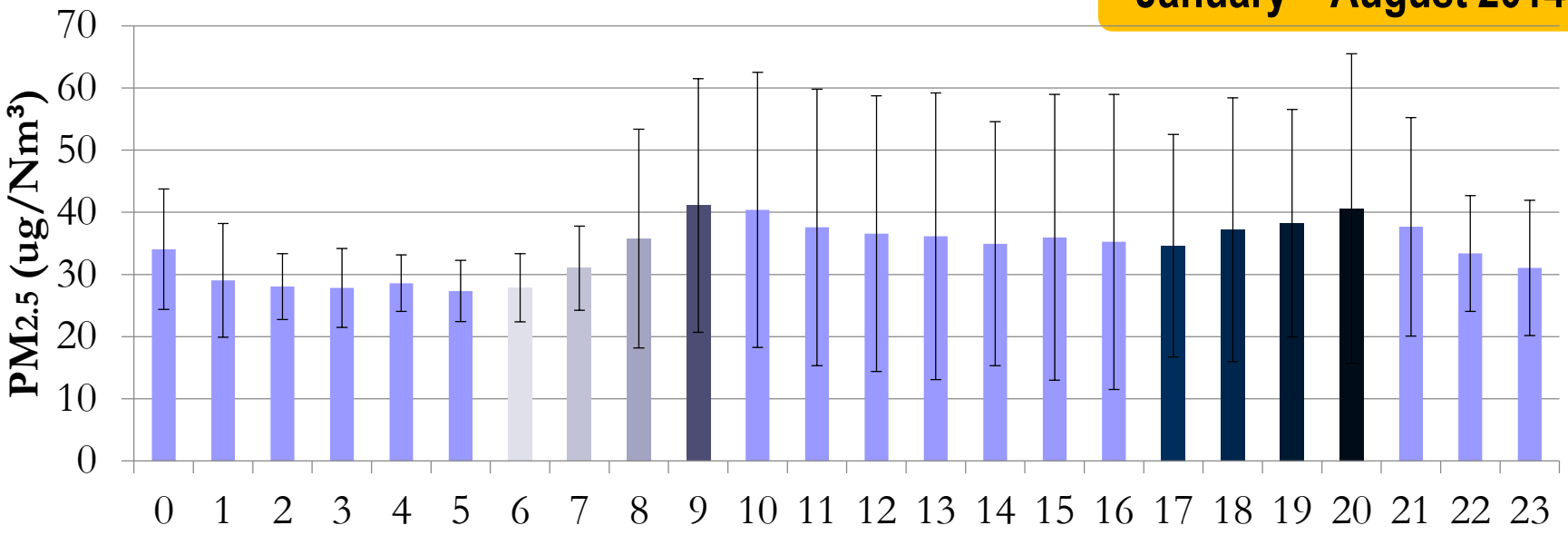

Monthly Average of PM2.5 Concentration
Concentration (µg/m³)
45
40
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nop
Dec

Temporal $PM_{2.5}$ Variations in Bandung

January – August 2014



Diurnal Variations

Increase starts at 6 am → peak at 9 am

and at 5 pm → peak at 8 pm

- **Closely related to human activities**
- **Anthropogenic emission**

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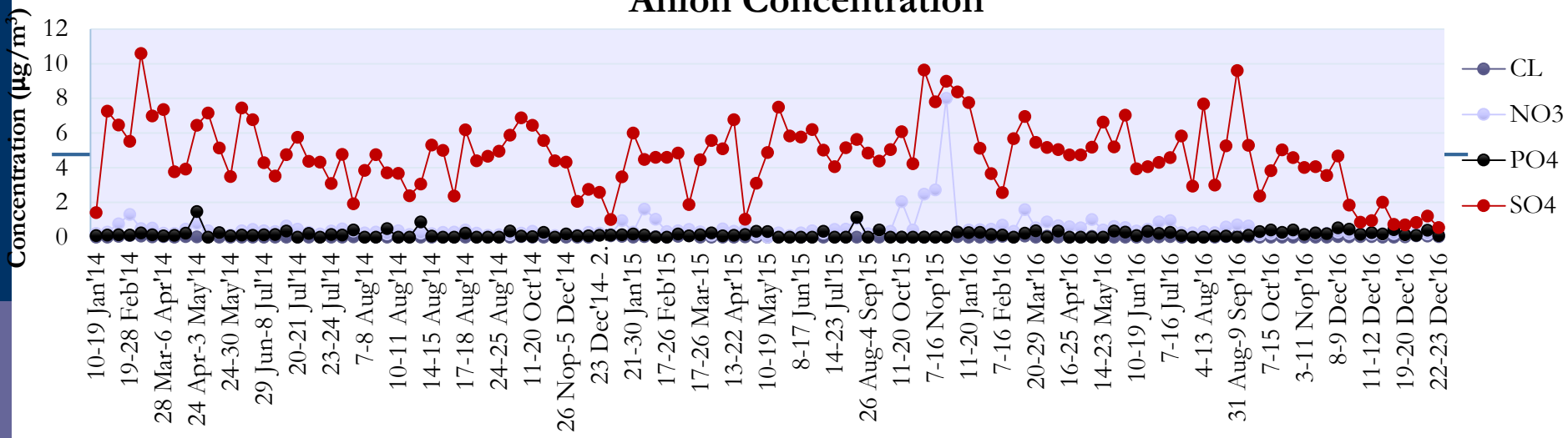
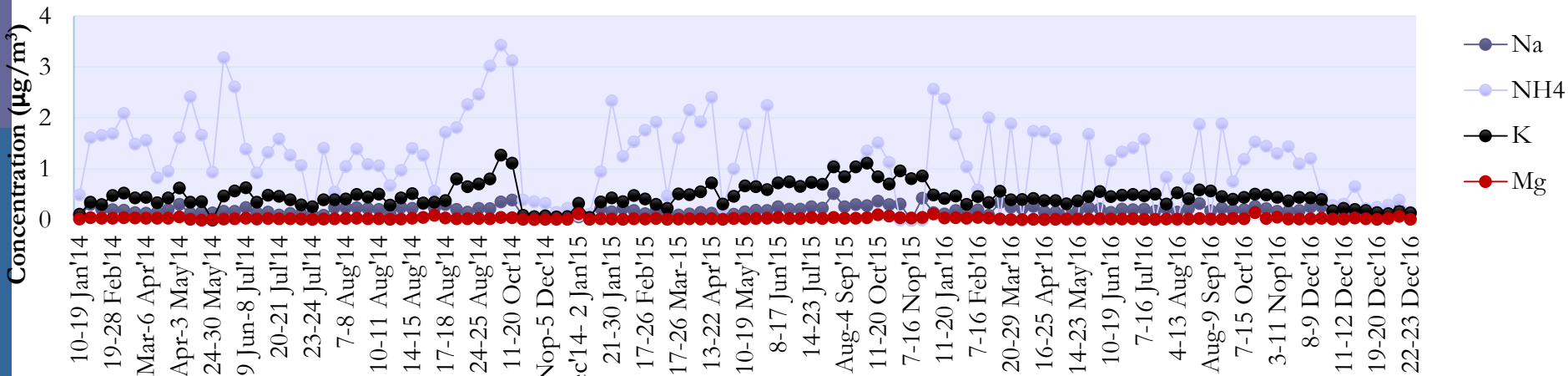
Anion Concentration



Cation Concentration



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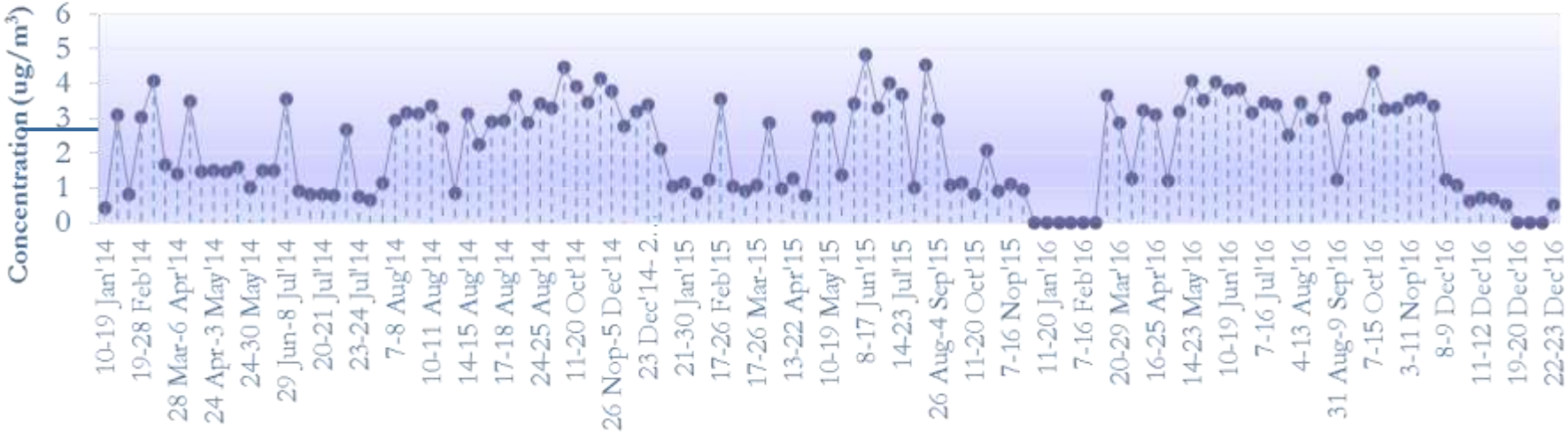
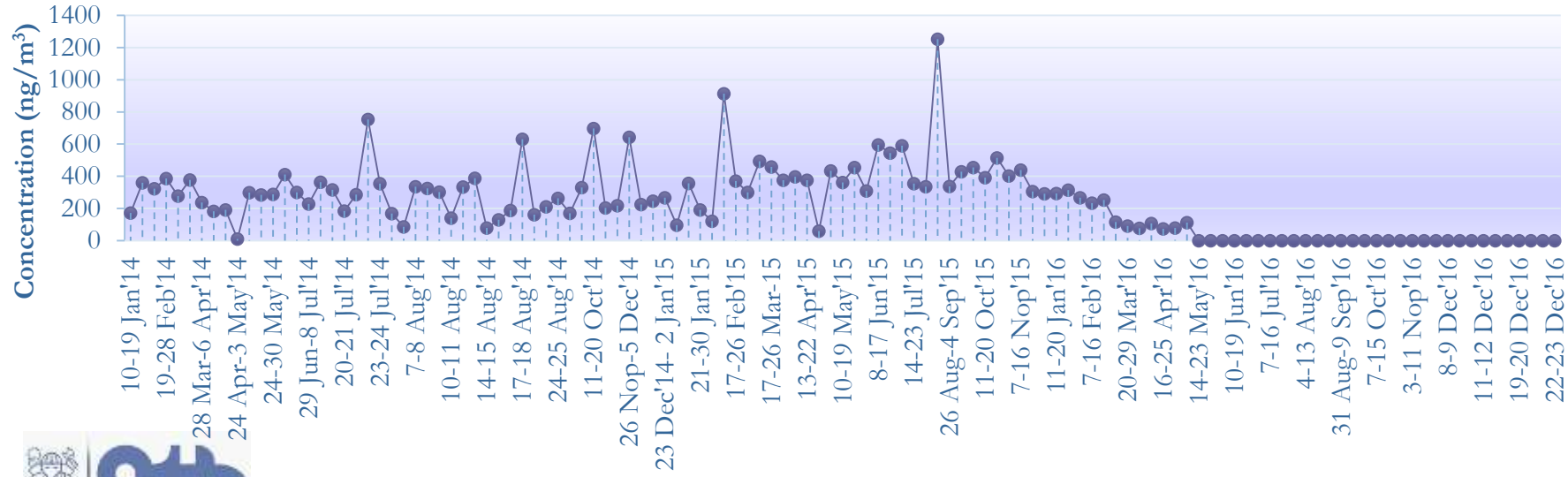
Trend of BC Concentration



Trend of Metal Concentration



Note: Al, Fe, Ti and Fe

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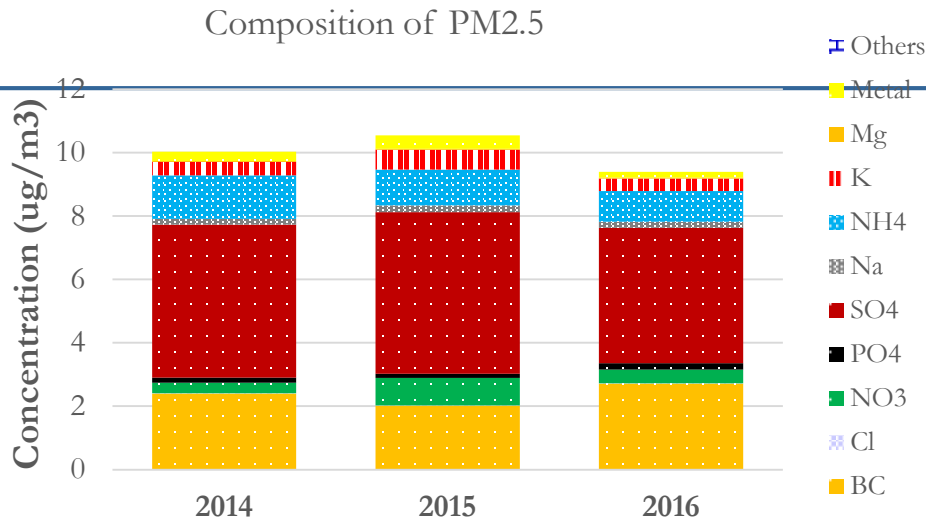

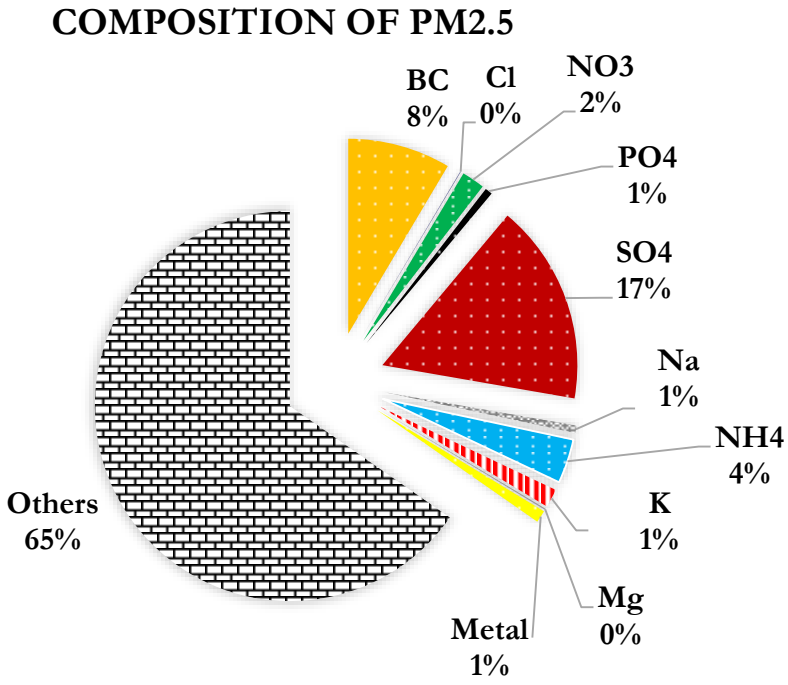

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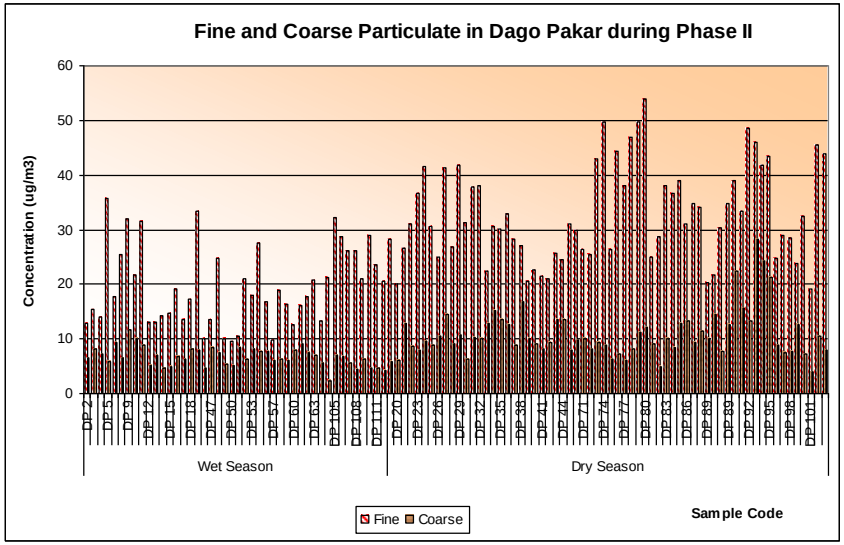
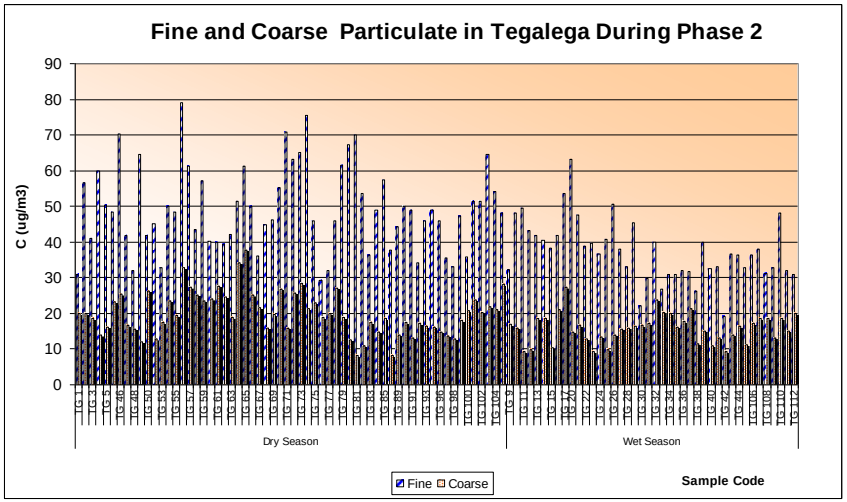
PM2.5 and PM10-2.5 Concentrations in Bandung (2001-2007)





DAGO PAKAR

Non Urban site

No activities

TEGALEGA

Urban Mixed site

Commercial road

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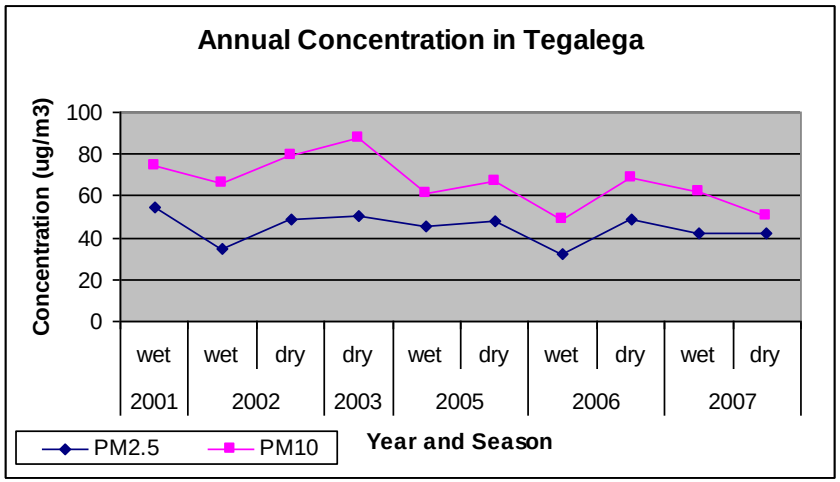
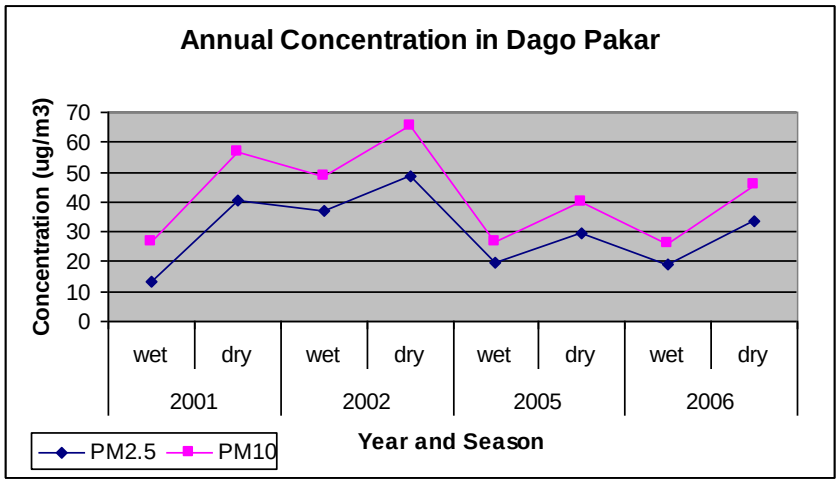
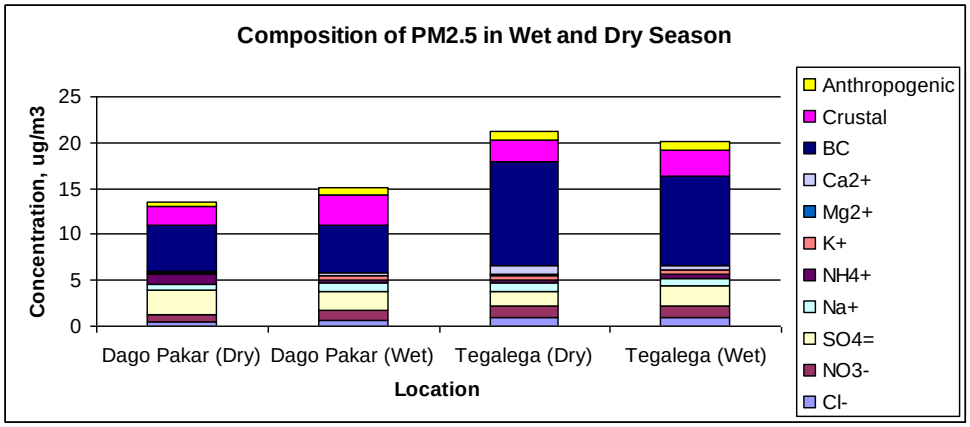
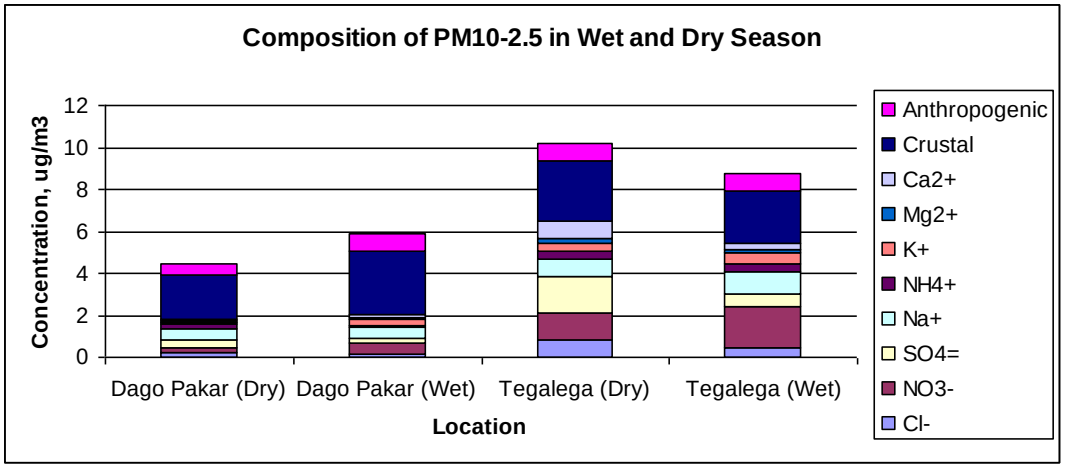
Annual Concentrations of PM



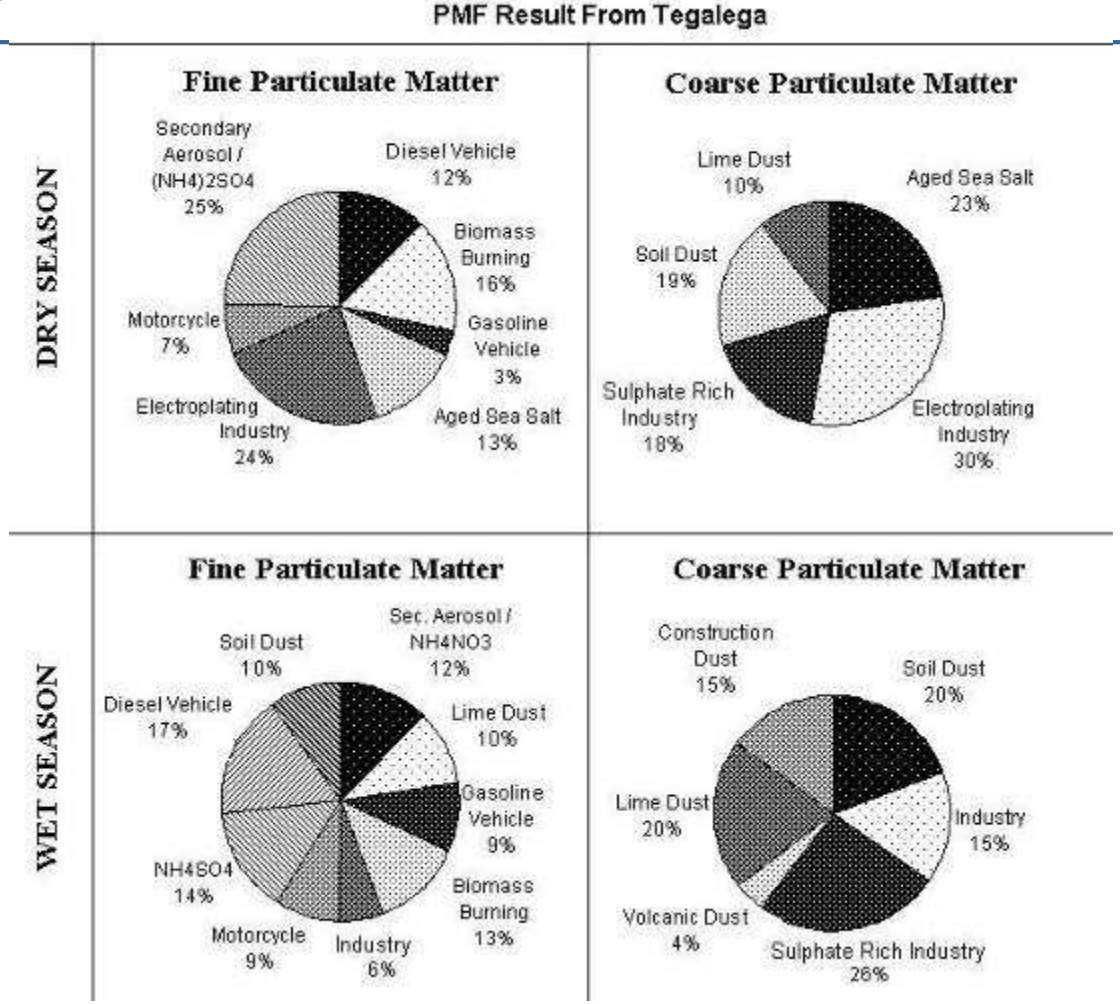


Composition of PM2.5 and PM10-2.5





Source Apportionment results from Urban Mixed site (Published in AE 2009)



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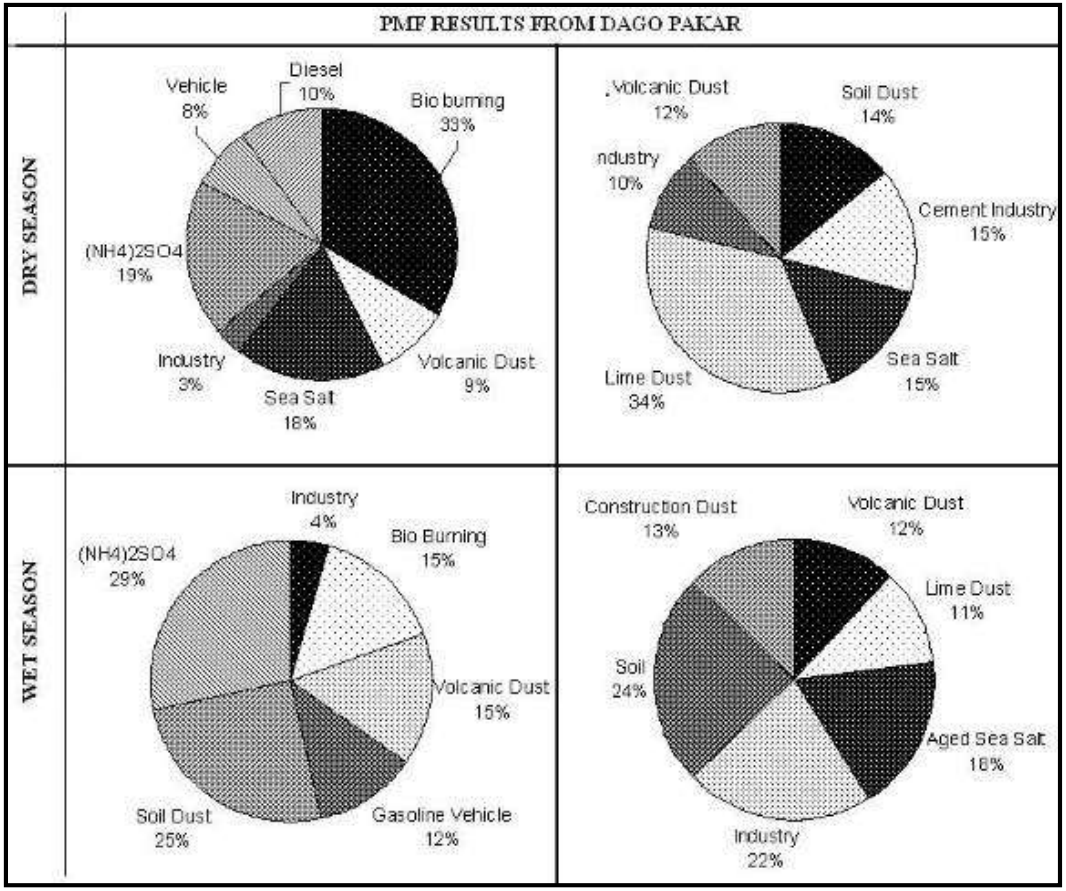
Source Apportionment Results: Dago Pakar



Conclusions

- Intercomparison study with reference instrument Harvard Impactor showed that AirPhoton® Filter Sampler and AirPhoton® Nephelometer is a reliable combination of $PM_{2.5}$ measurement that is applicable for long term monitoring.
- Black Carbon, Sulfate and Ammonium are the primary compounds in the fine particles in Bandung
- In general. the main Sources of fine particles in Bandung, were secondary aerosol (ammonium sulfate and nitrate), Biomass burning and vehicles, while the main Sources for coarse particles were soil dust, lime dust and construction dust.

Thank you

Nephelometer

ling Performance Evaluation

- (Snider et al., 2014).

$$b_{sp,dry,1h} = \frac{b_{sp,1h}\{RH < 80\%\}}{f_m(RH)} \quad \text{(Eq. 1)}$$

$$PM_{2,5,dry,1h} = PM_{2,5,dry,9d} \frac{b_{sp,dry,1h}}{b_{sp,dry,9d}} \quad \text{(Eq. 2)}$$

- $b_{sp,1h}$ = Backscatter averages for 1 hour;
- $b_{sp,9d}$ = Backscatter average for 9 days;
- $f_m(RH)$ = Higroscopic mass correction factor
  = $1 + 0{,}2\,RH/(100 - RH)$;
- $PM_{2,5,dry,1h}$ = Hourly $PM_{2.5}$ mass concentration estimates;
- $PM_{2,5,dry,9d}$ = 9-day filter result for $PM_{2.5}$ mass concentration.

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