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CHARACTERISTICS OF FINE PARTICULATES OF TWO LARGEST CITIES IN INDONESIA USING ION BEAM ANALYSIS

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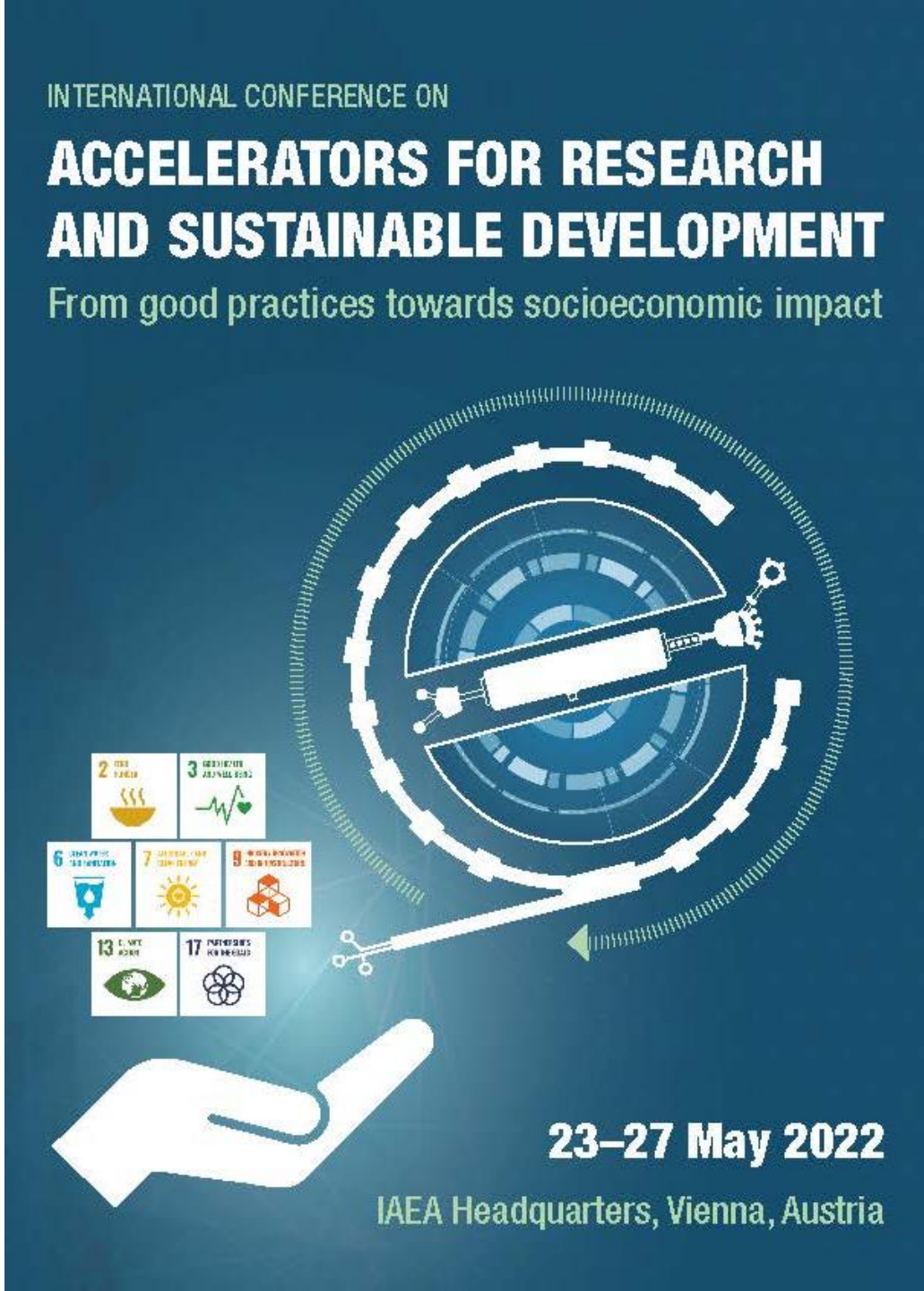

Presentation Outline

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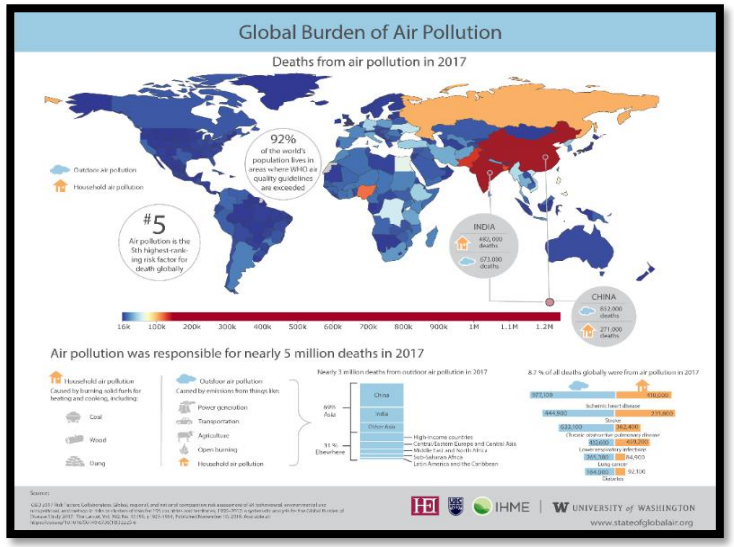
Air Pollution

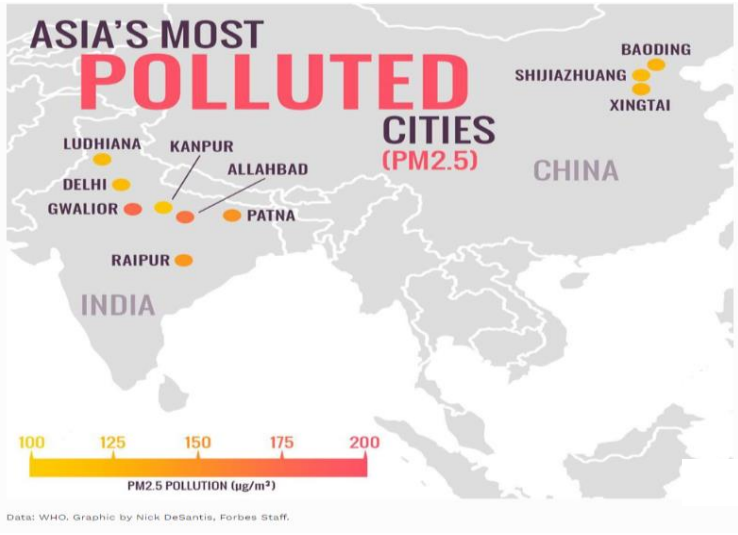
Air pollution is a global phenomenon and the 5th highest ranking risk factor for death globally.

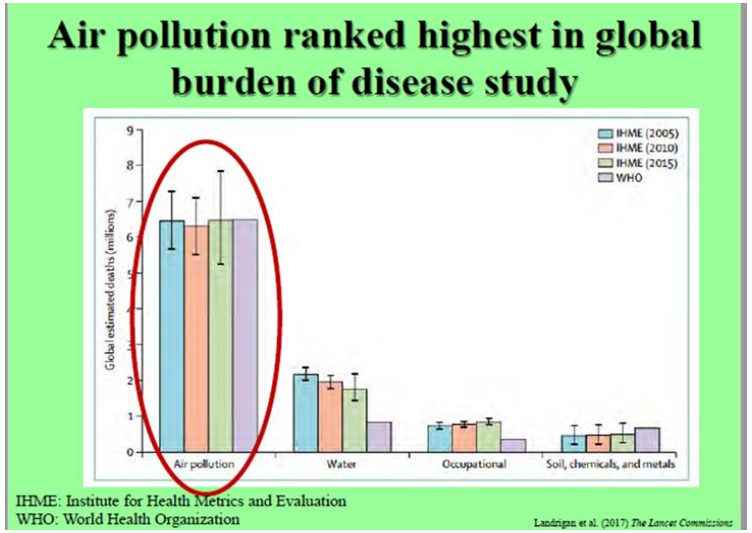
One of the greatest environmental challenges we faced today is air pollution.

More than 50% of the world's megacities were located in Asia.

People live in Asia are the most at risk of ambient air pollution







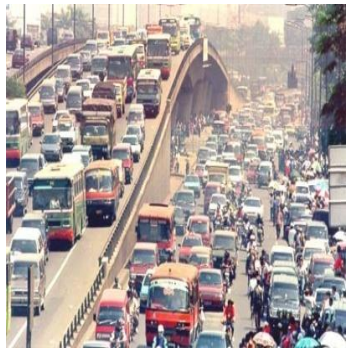
Air Pollution Problem in Indonesia

Indonesia

- Located on the equator, between Asia and Australia, and between the Pacific and Indian Ocean
- Consist of 17,508 islands & area: 1,904,569 sq km
- It has an estimated population of over 261 million people and is the world's 4th most populous country
- The capital and most populous city is Jakarta, which is also the most populous city in Southeast Asia
- Consist of 34 provinces and three time zones

- Increased economic development in the Indonesian region has often led to rapid and unplanned urbanization.
- Urban air pollution is a major problem in this region and growing recognition of the health effect problems resulting from airborne particles.
- Some cities have been identified for high air pollution level
- Forest fires and volcanic eruption are also problems that occur periodically in Indonesia. These can cause regional problem due to air transport taking place across countries in a few days and around the globe in a few weeks.

Jakarta



February 14, 2014
Indonesia's Mount Kelud Erupts

September-October 2015
Smoke and Fires in Sumatra and Borneo

Figure courtesy of NASA

Air Pollution & Human Health

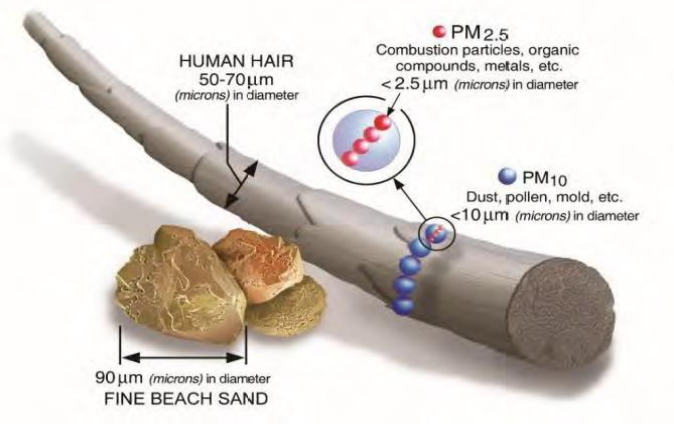
- Airborne particulates matter (APM) especially $PM_{2.5}$ is an important indicator because of its strong association with human health. The higher the concentration of $PM_{2.5}$ - the higher the mortality rate. Many global cities are challenged by air pollution and need to do more to reduce air pollution, including in Indonesia's big cities.

- High levels of heavy metals in $PM_{2.5}$ have been reported in several countries including China and Nigeria (industrial emissions contribute up to 20%, Pb levels reach 2.4-6.0 µg/m^3 (US standard 0.15 µg/m^3).

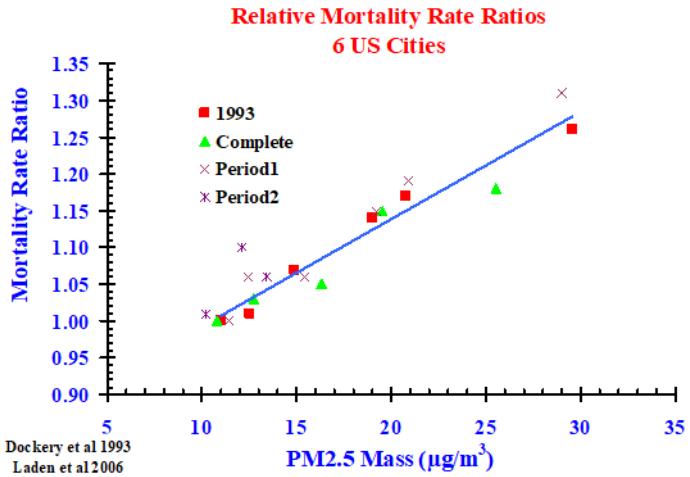
- Particulate matter combined with toxic metals are very dangerous. Information on the level of heavy metal in the atmosphere is very necessary in formulating appropriate policies for environmental management.

- It is necessary to characterize the APM that can provide comprehensive information regarding the high levels of heavy metals, as well as to understand its nature and to develop mechanisms that would help control this harmful pollutant.

- The level of air pollution in Indonesia's big cities is increasing along with the growth of fossil fuel energy use in the industrial and transportation sectors. Therefore, there has been a growing concern on monitoring of APM in mega cities and big cities in Indonesia.

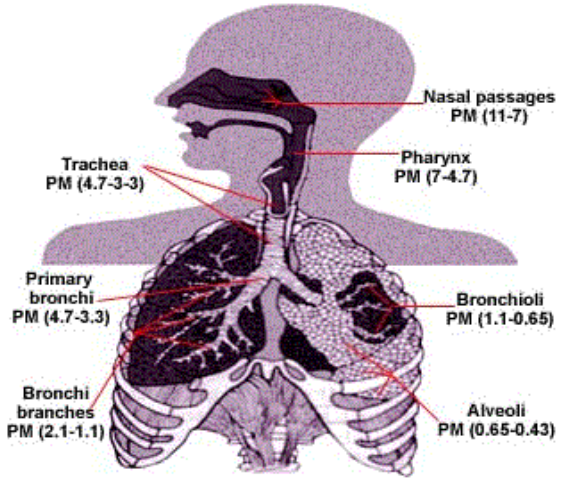


Sumber: Judy and Watson, 2019 Oct Workshop, Bandung



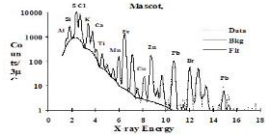
Why do we need fine particulate matter analysis?

- In Indonesia, data on $PM_{2.5}$ and its chemical composition are relatively scarce
- $PM_{2.5}$ data is needed to Identify pollutant sources which is an critical step towards developing strategies for its management
- The mass of $PM_{2.5}$ is very small (less than 1 mg), so the characterization method requires advanced analytical techniques that are sensitive, simultaneous, selective, and have a very low detection limit



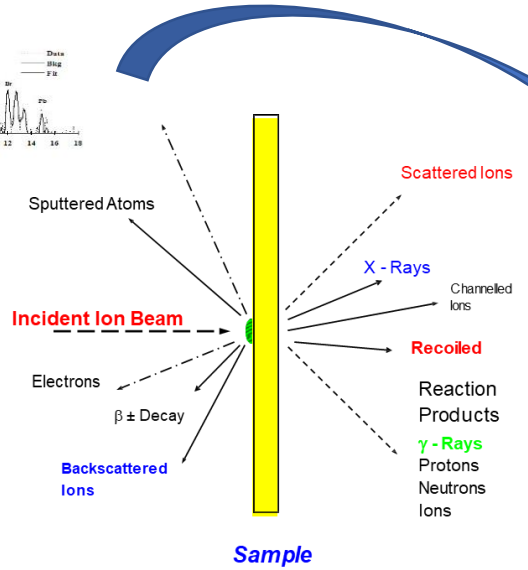
Disposition of Particulate Matter (PM) in the Respiratory system (Richard Wilson, Harvard Press,1996)

Accelerator Based Ion Beam Techniques



Advantages :

- Simultaneous multi elemental
- Non destructive, selective and sensitive
- Easier preparation
- Small weight samples
- Cost and time effective



Elemental analysis in APM is crucial to identify the pollution sources

Objectives

- To assess the characteristics of $PM_{2.5}$ in urban ambient air of two largest cities in Indonesia; Jakarta and Surabaya, including the level of mass and its chemical composition.
- To strengthen the application of nuclear analytical techniques with emphasize on ion beam analysis for supporting air quality management in Indonesia

Methodology

- Sampling of Airborne Particulate Matter
- PM and Black Carbon Measurement
- Elemental concentration measurement using IBA
- Data Analysis

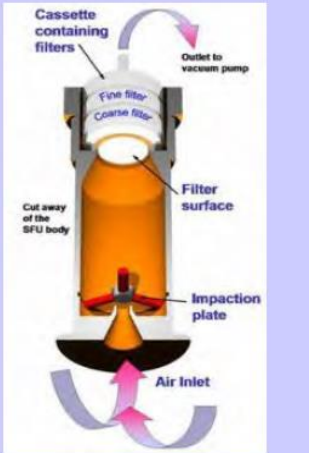
Sampling

- Sampling of ambient $PM_{2.5}$ were collected for 24-hours using GENT sampler from 2019 – 2020 carried in Jakarta and Surabaya: East Surabaya (1) and West Surabaya (2)

- Sampling were carried out using dichotomous sampler Gent stacked filter unit in each site, once a week
- The collected samples were sent back to BATAN laboratory for mass and BC analysis

Gent sampler

Dichotomous sampler



Sumber: Judy and Watson, 2019 Oct Workshop, Bandung

PM and BC Analysis

PM analysis

Determination of mass concentration $PM_{2.5}$ was done by gravimetric method using Mettler Toledo micro balance

Before weighing, the filter must be conditioned in a room with humidity between 45-55% and a temperature of 18-25°C.

Fine APM ($PM_{2.5}$) is obtained from the weighing of the sample weights on the fine filter.

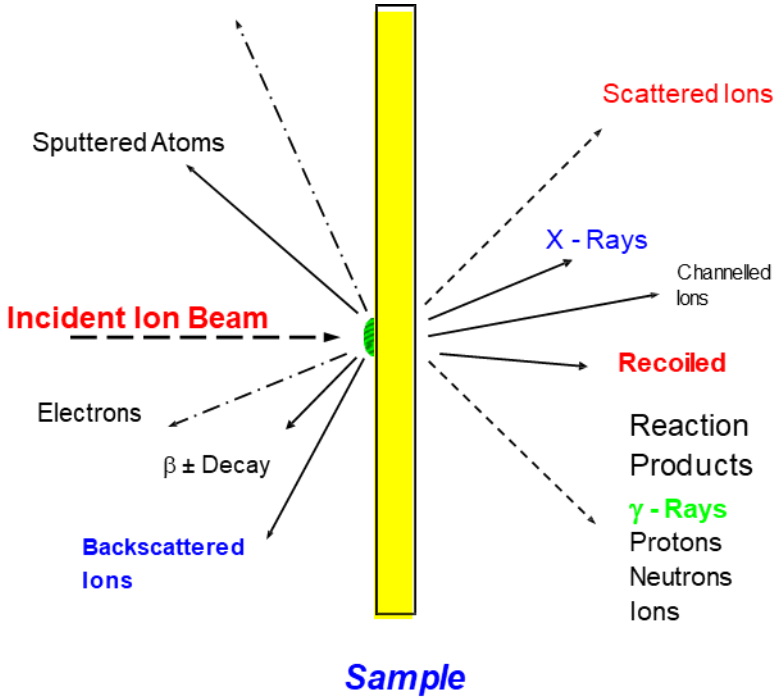
BC analysis

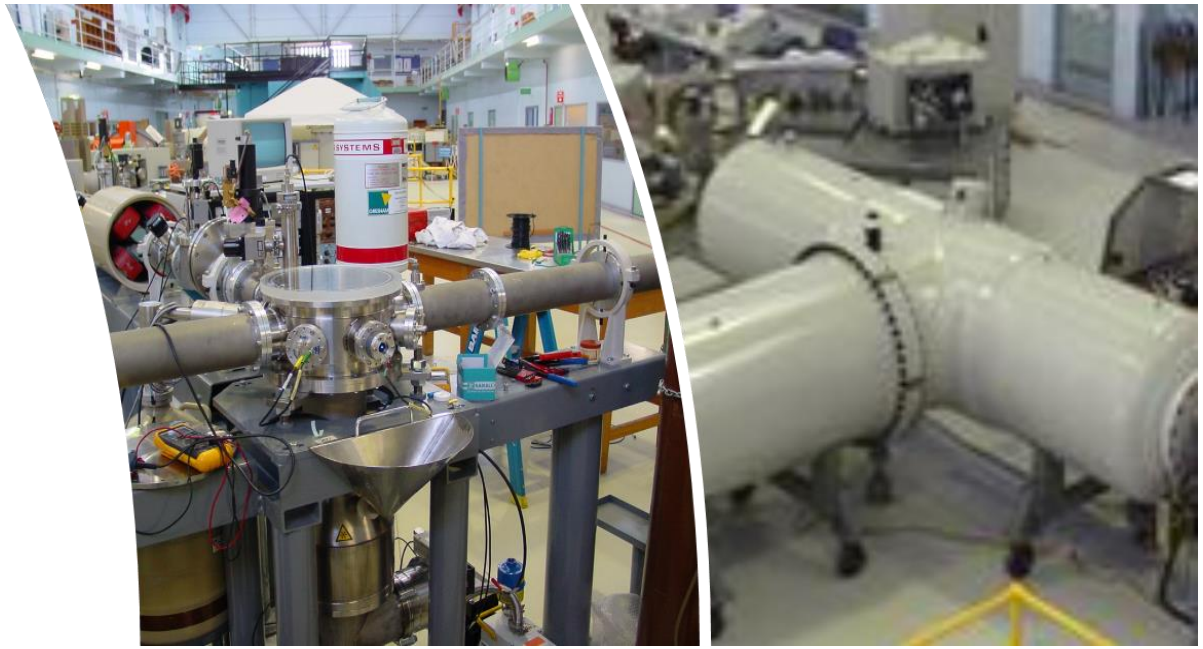
Determination of carbon in the filter is based on the process of light reflection. The absorption and reflection of visible light by airborne particulate matter in the filter depends on particle concentration, density, refractive index and size

BC was determined using a Digital Smoke Stain Reflectometer. Measurement of BC in the filter was done using the assumption that the average coefficient of particle mass absorption is 5.7 m^2/g

IBA for Elemental Analysis

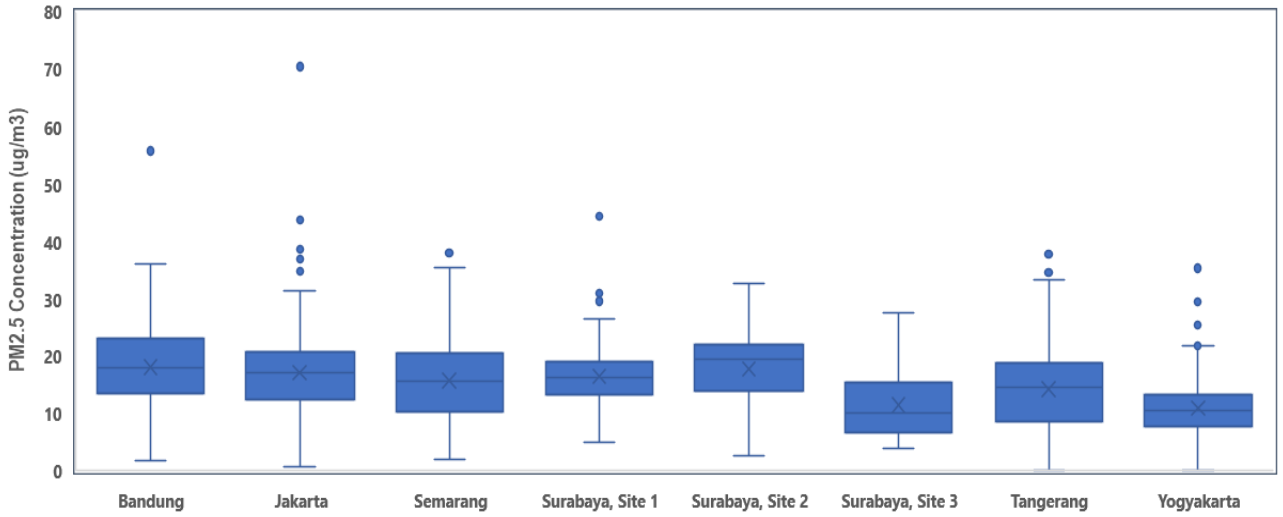
- Determination of the elements contained in airborne particulate matter is an important step in identifying sources of air pollutants
- The samples were analyzed using the IBA method at the ANSTO facility, which has the capability of multi-element analysis with detection limits in the order of ng/cm^2. A total of 18 elements have been detected, namely the elements Na, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Br, and Pb.





RESULTS AND DISCUSSIONS

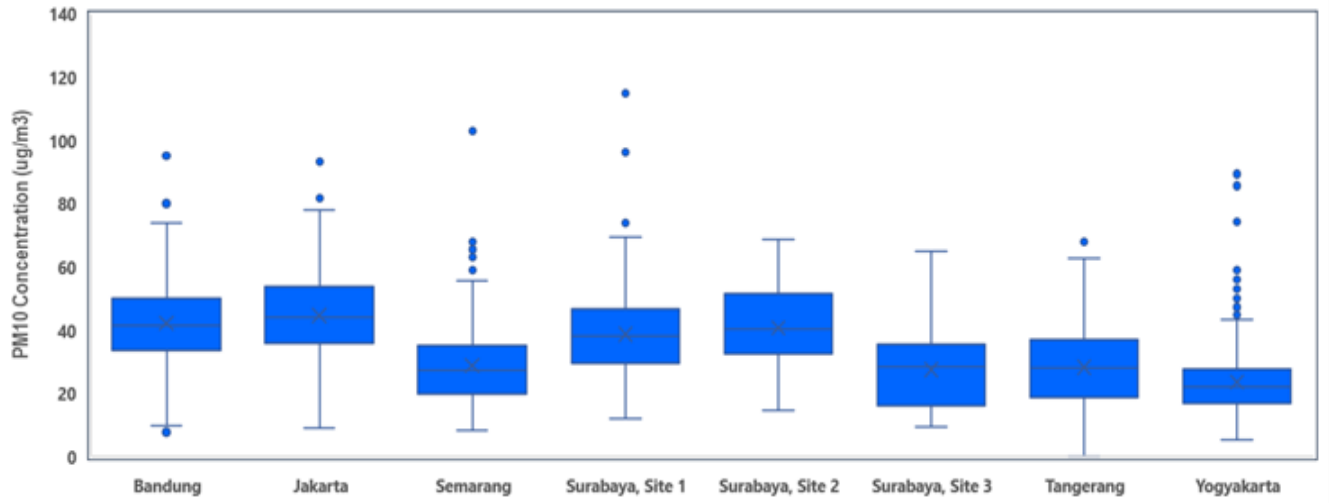
$PM_{2.5}$ and PM_{10}



Comparison is carried out between these sites in Java, since the sampling sites are located in the same island, Java and each city is the capital city of each province.

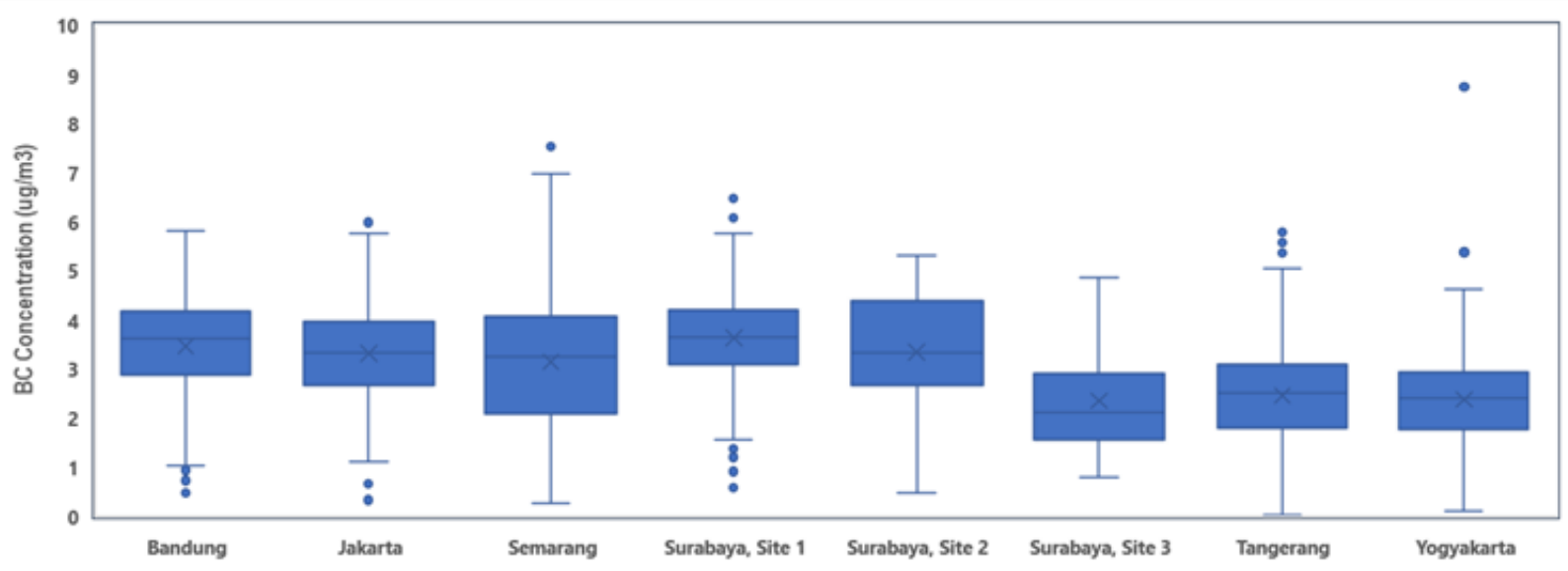
The level of $PM_{2.5}$ concentration in site 1 and site 2 are slightly higher than site 3, Tangerang and Yogyakarta. For the $PM_{2.5}$ and PM_{10} concentration in site 1 and site 2 are in the similar level with Bandung and Jakarta

$PM_{2.5}$ and PM_{10} comparison between Surabaya, Jakarta and other cities in Java



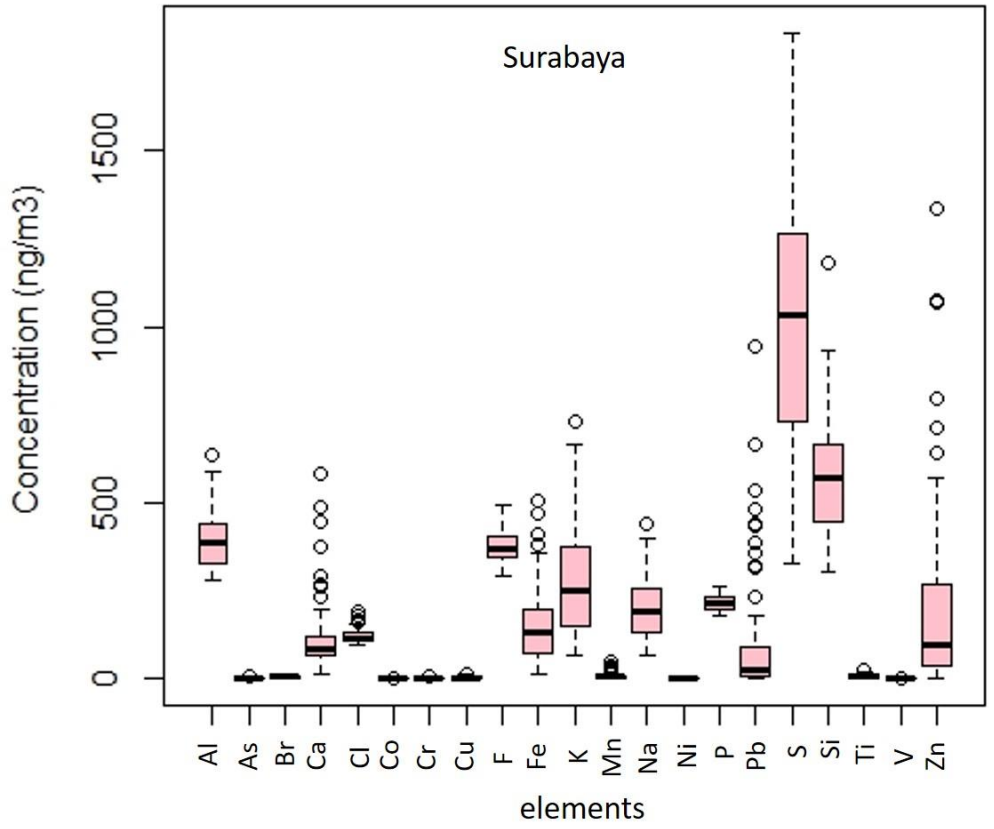
Black Carbon

Black carbon comparison in Surabaya , Jakarta and other cities in the Java



BC in industrial site 1 of Surabaya with average of 3.8 µg/m^3 and site 2 of Surabaya with average of 3.3 µg/m^3 were higher than other cities in Java. It can be assumed that the industrial activities have contributed to the BC level in that site due to the use of coal as their fuel.
In addition, around site 1, there is also an agricultural area where open burning still occurs

Elemental Composition ($PM_{2.5}$) Surabaya

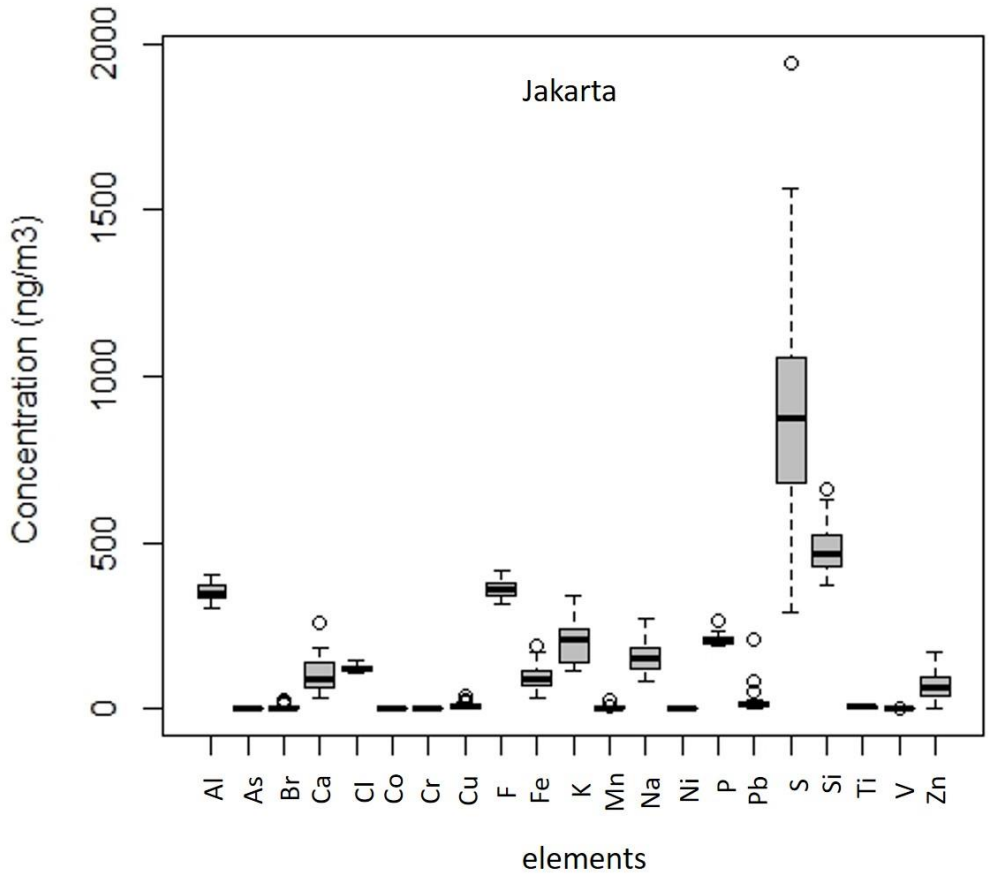


The major contribution of $PM_{2.5}$ of Surabaya is sulfur.
The use of fuels containing high concentration of S is one of the main sources of S emissions.

There are several types of diesel fuel or biodiesel that have a sulfur content ranging from 300 to 2500 parts per million (ppm).
This is one of the reasons of the high level of S in $PM_{2.5}$ in urban areas of Indonesia.

There are also high concentration of several heavy metals such as Fe, Zn and Pb

Elemental Composition ($PM_{2.5}$) Jakarta

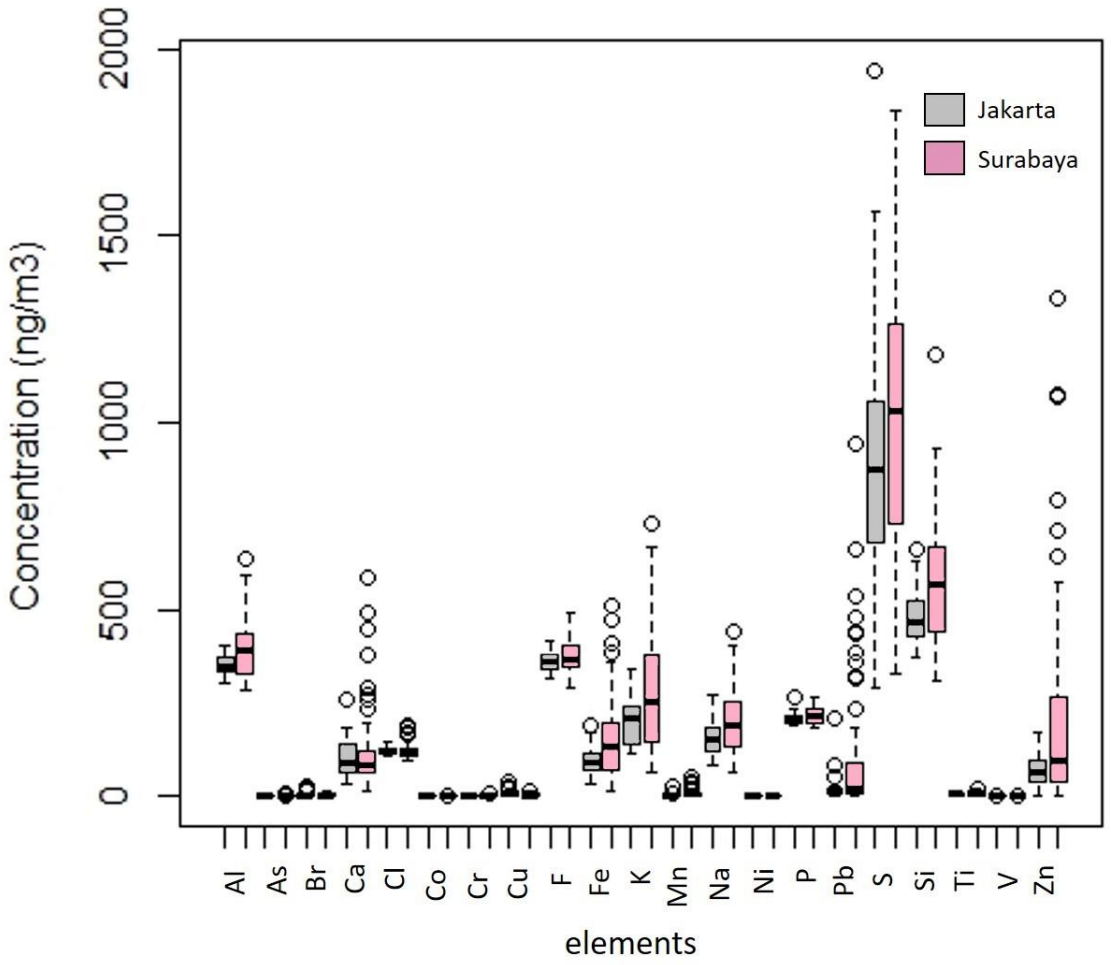


The major contribution of $PM_{2.5}$ of Jakarta is sulfur, followed by Aluminum and Silicon as crustal elements which may come from road dust.

The use of fuels containing high concentration of S is one of the main sources of S emissions.

There are also several high concentrations of Pb

Elemental Composition ($PM_{2.5}$) Comparison



Parts of elemental concentrations in $PM_{2.5}$ Surabaya are higher than in Jakarta → S, Al, Si, Zn, Fe, Pb

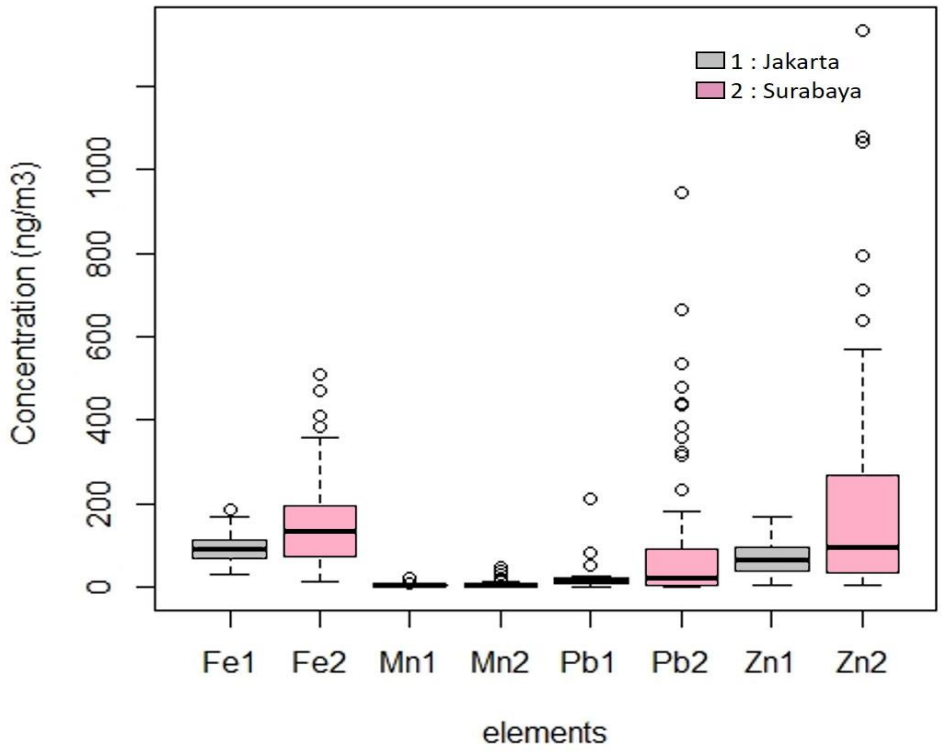
There are several industrial activities in the vicinity of Surabaya, much more closer to the sampling site. While in Jakarta, the industrial activities are mainly located >15 km away from the central Jakarta.

Potassium in Surabaya were also slightly higher than in Jakarta that may related to biomass burning.

High concentrations of Zn and Pb were also found in Surabaya, reaching 4.5 and 7.8 times, respectively, compare to Jakarta.

Cu concentration in Jakarta was 2-3 times higher than Surabaya.

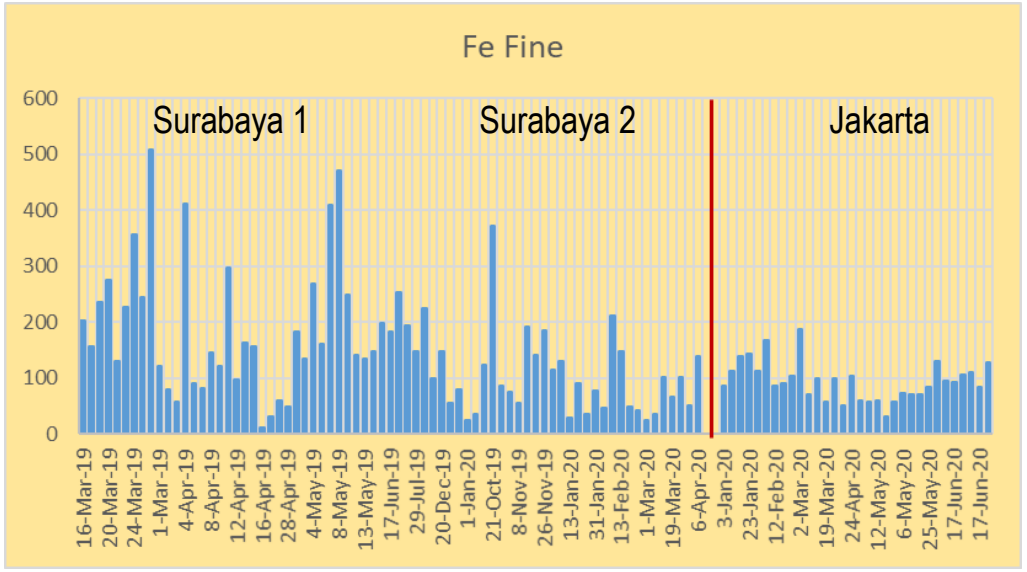
Heavy Metals Comparisons

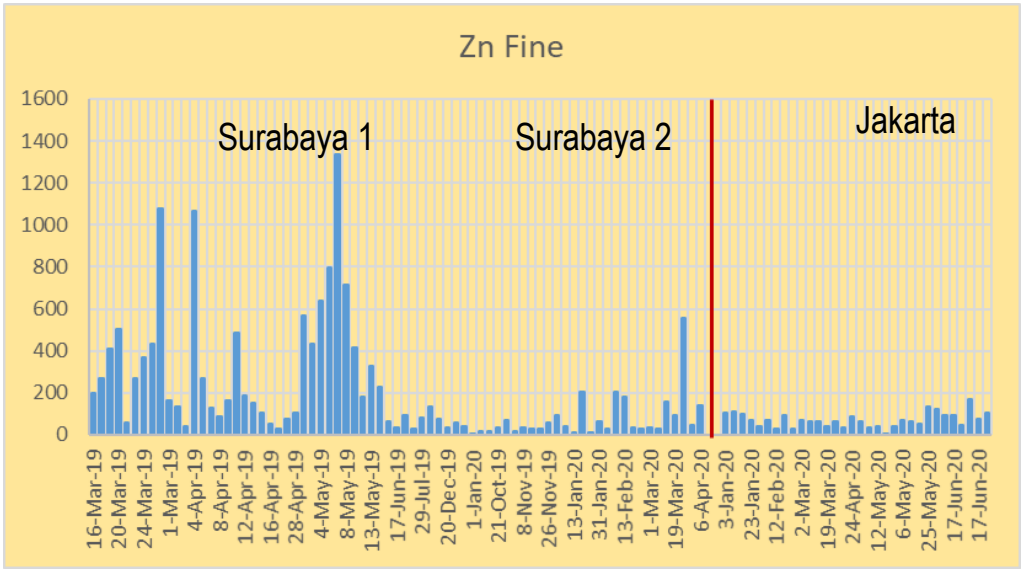


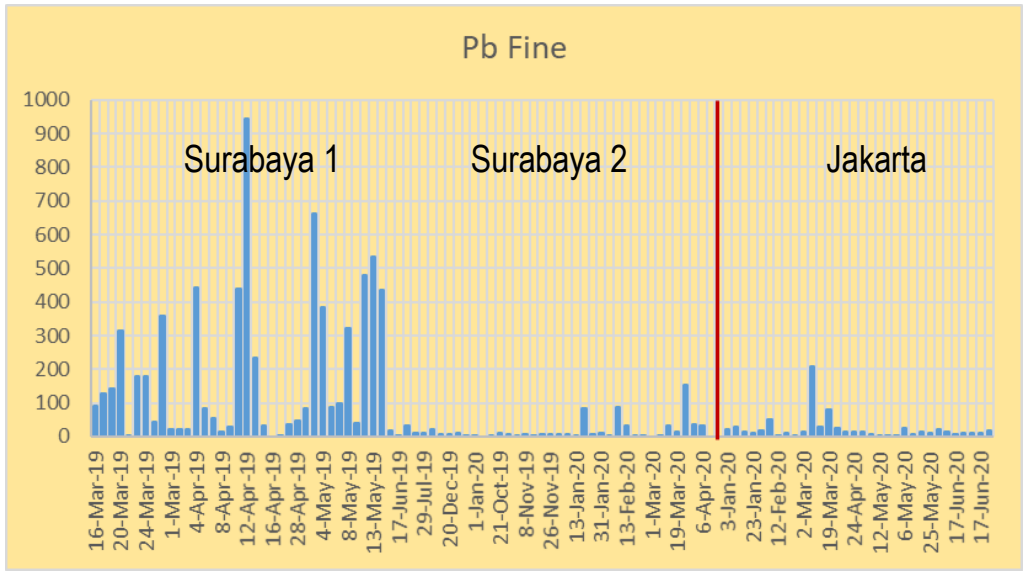
- Characteristics of elements as tracers of industrial emissions: Zn, Fe, Mn, and Pb for the steel industry, Cu and Pb for the metal industry, and Pb for acid batteries.

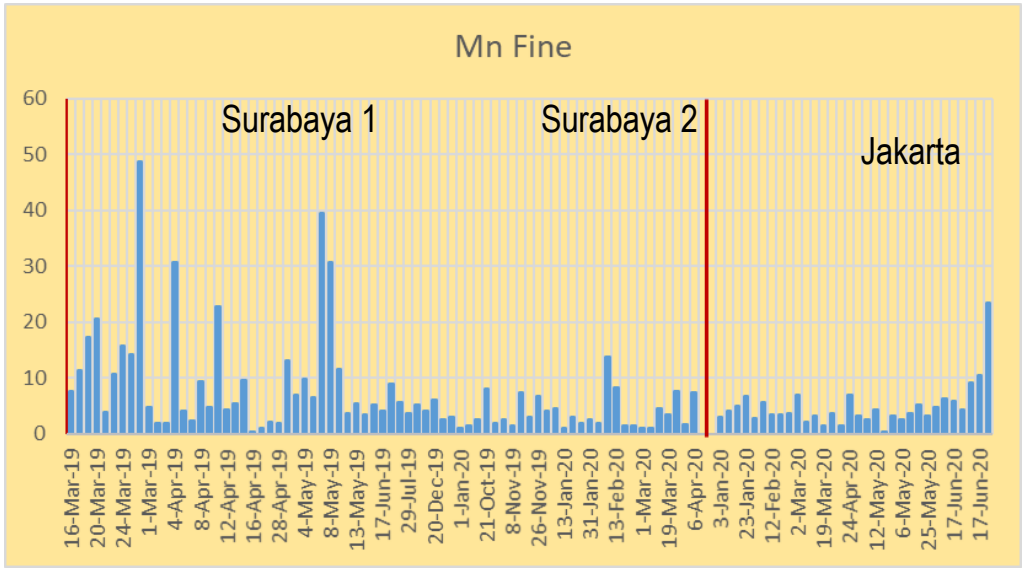
- The concentrations of Fe, Mn, Zn, Pb at Surabaya were higher than at Jakarta
- Compared to the steel industry area in the Yangtze River Delta region China, the concentrations at Surabaya are still lower, except for Pb where the concentration is 2 times higher.
- The high concentrations of Pb in Surabaya were likely come from Lead Battery smelter in Surabaya's vicinity
- Similar results with high level of Mn, Ni, As, Cd, Pb were also found for a scrap iron and steel smelting industry in Nigeria and the results also showed that the source contribution from metallurgical production reached 6% of the total mass of $PM_{2.5}$.

Elemental Composition (daily $PM_{2.5}$) Comparison





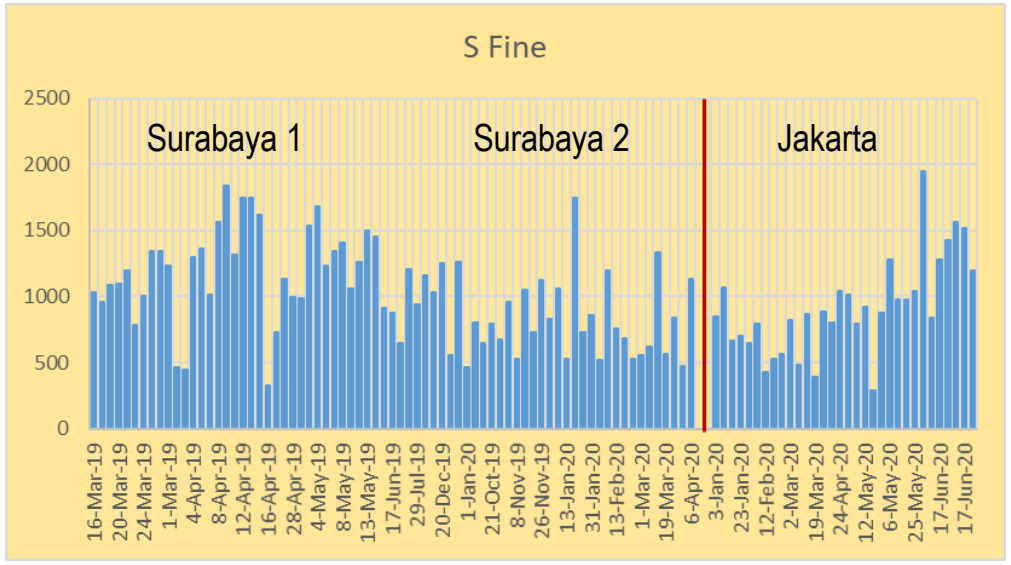


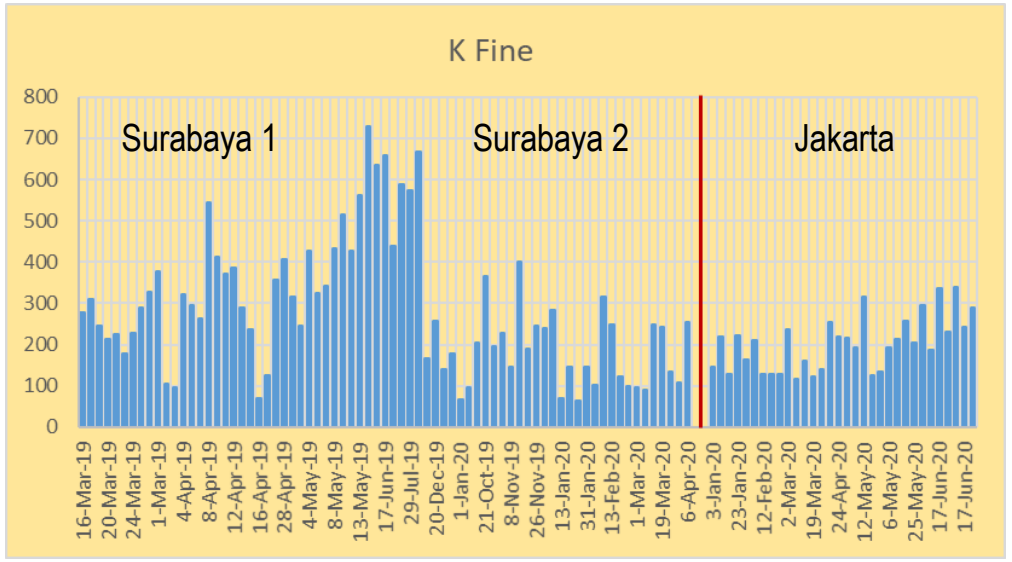


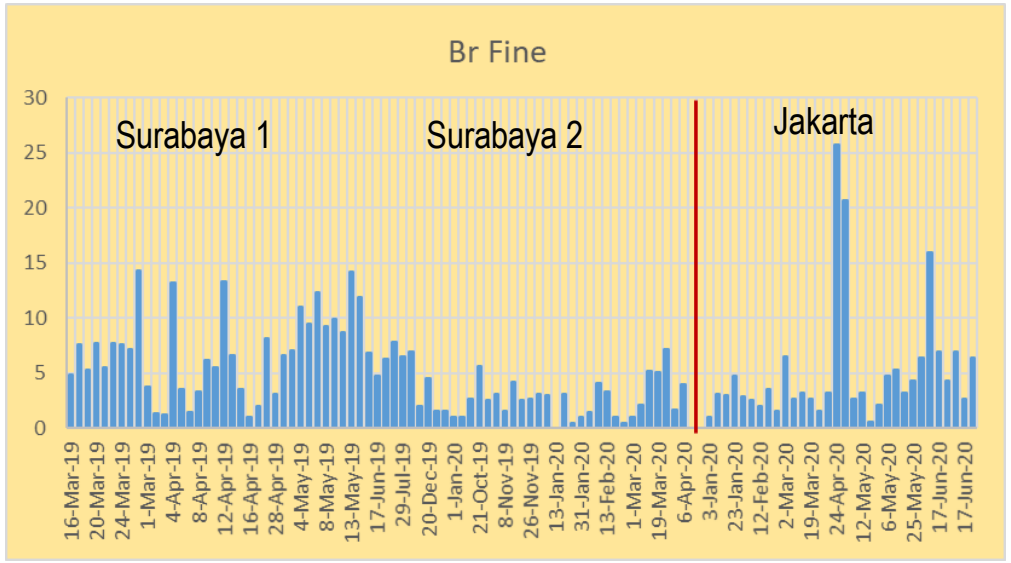
Fe, Zn, Pb and Mn concentrations in Surabaya 1 were higher than it's found in Surabaya 2 and Jakarta due to the closeness to the smelter industrial area.

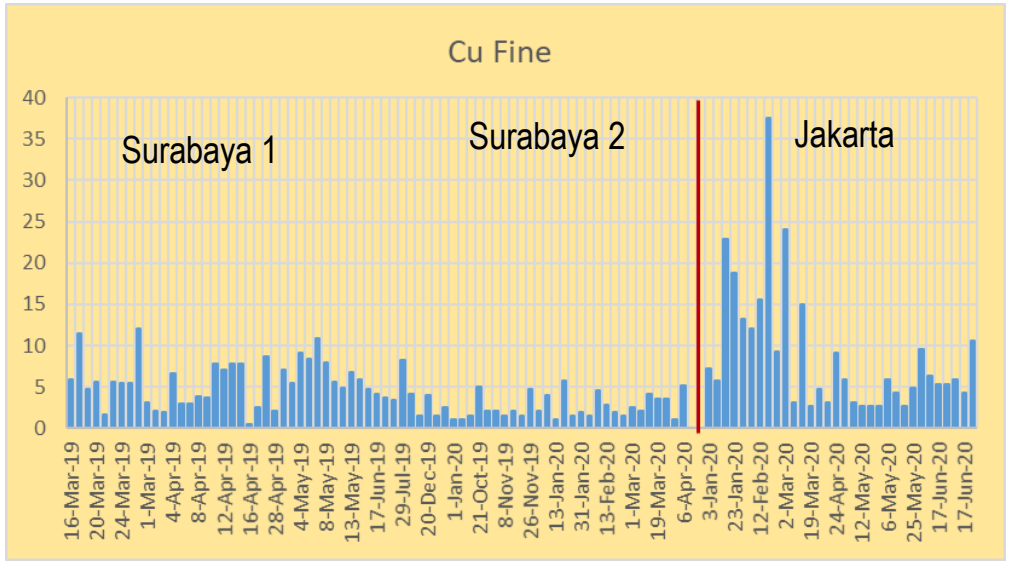
Surabaya 2 and Jakarta seems have similar range of Zn, Pb and Mn concentration except for Fe

Elemental Composition (daily $PM_{2.5}$) Comparison





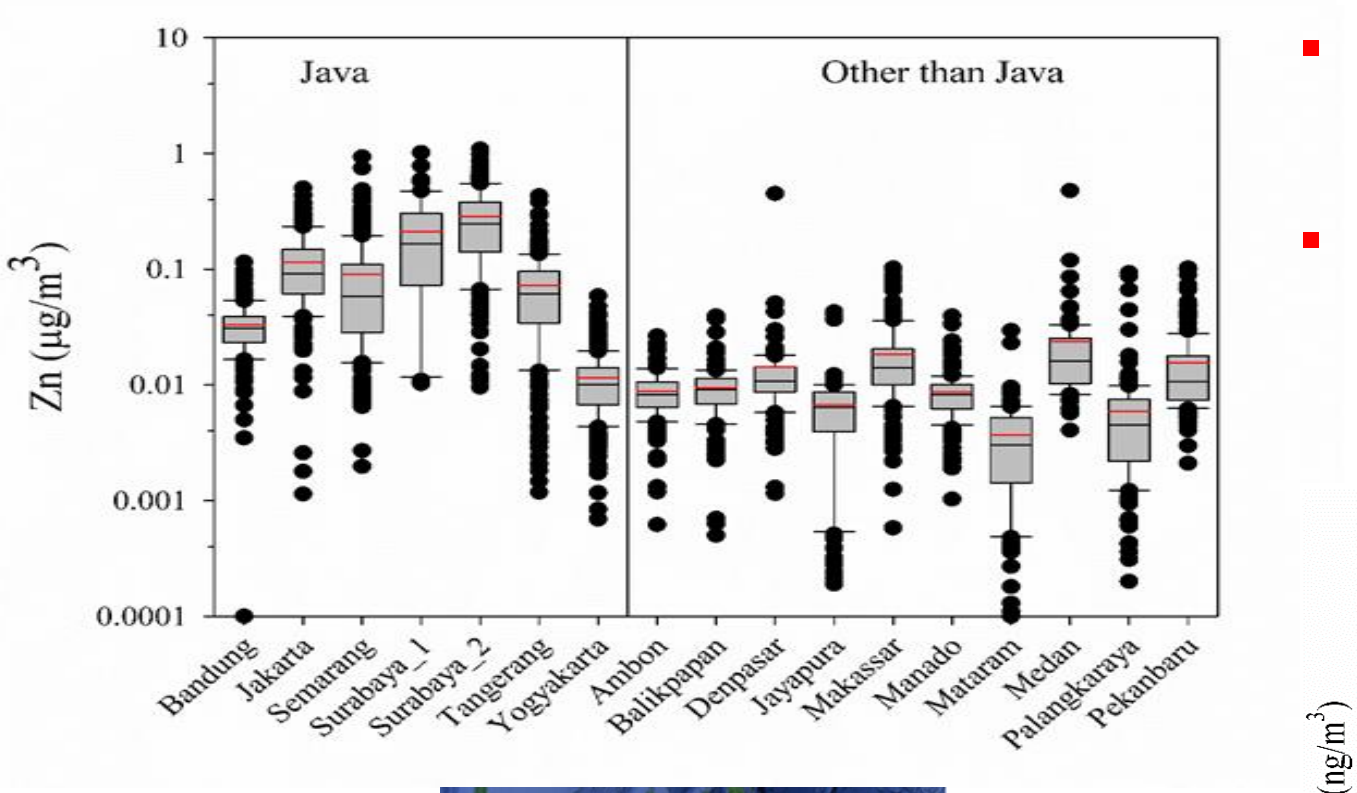


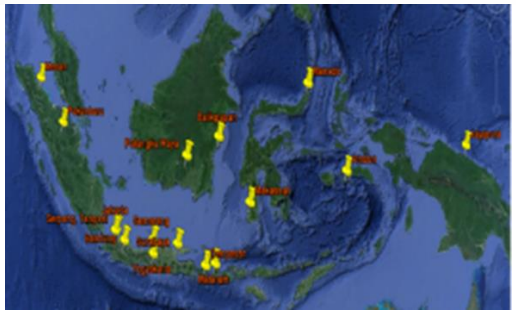


S concentrations of Jakarta and Surabaya seems doesn't have significant difference while K concentrations in Surabaya 1 were higher than it's found in Surabaya 2 and Jakarta

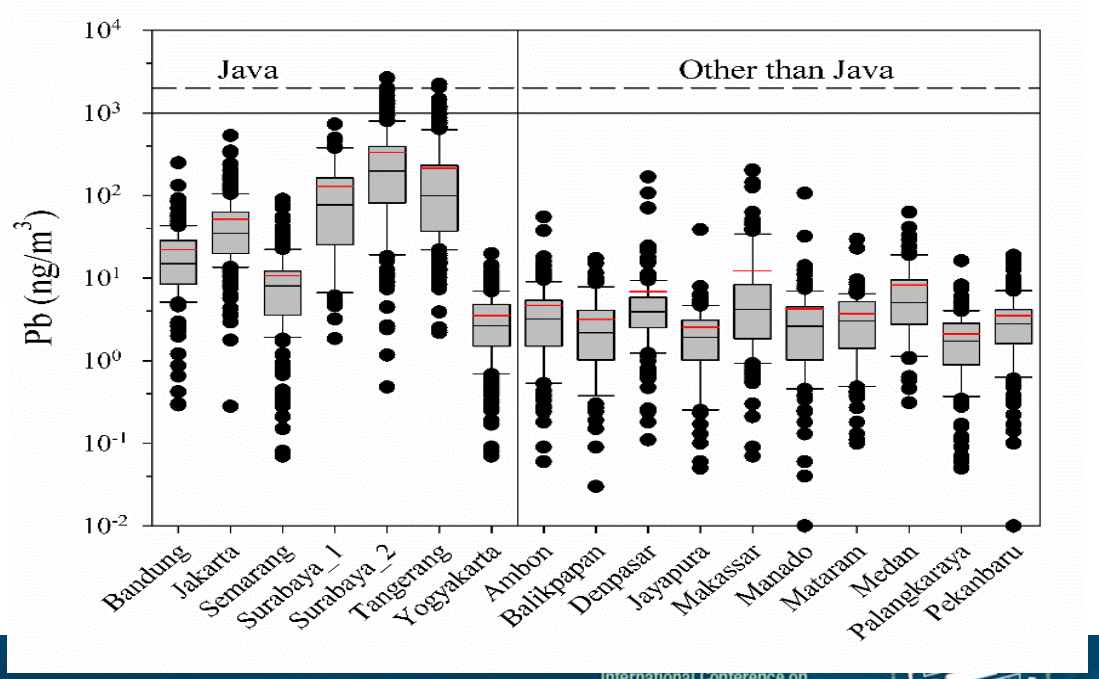
Cu concentrations in Jakarta were higher than it's found in Surabaya, describing the possibility of the sources from non-ferrous industries

Comparison of Heavy Metals





- Zn and Pb concentration in Surabaya is higher compared to Jakarta and other cities in Indonesia
- The results obtained can then be used to determine the source apportionment in Jakarta and Surabaya to formulate appropriate strategies and policies.



Conclusions

- The results of elemental composition in ambient air $PM_{2.5}$ using IBA technique analysis is able to provide good and comprehensive results in term of urban air characterization.
- Three sampling locations from Jakarta and Surabaya gave different results according to the characteristics of the area.
- The multi-element identification from the IBA analysis is also able to provide an overview of the contribution of emissions from industry to air quality in the surrounding environment.
- Heavy metal concentrations (Fe, Zn, Mn, Pb) in East Surabaya (1) were higher than those measured in West Surabaya (2) and Jakarta, while higher Cu was found in Jakarta compared to the 2 sites in Surabaya
- These results indicate that the concentration of heavy metal in East Surabaya is likely to be correlated with industrial activities in the vicinity. Although the concentration of heavy metals is still below the national standard, the problem of heavy metal pollution cannot be ignored because it is very harmful to human health even in low concentrations.
- These results can be used as an early warning to formulate appropriate strategies and policies so that greater losses can be avoided.

Thank you

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