Monitoring and Sources Identification of Air Pollution and Case Study

Research Project

Air Pollution survey, source apportionment of particulate matter :

A case study of area around the North Bangkok Power Plant

Project duration: 1st November 2019 – 30th April 2021

Supported by Electricity Generating Authority of Thailand

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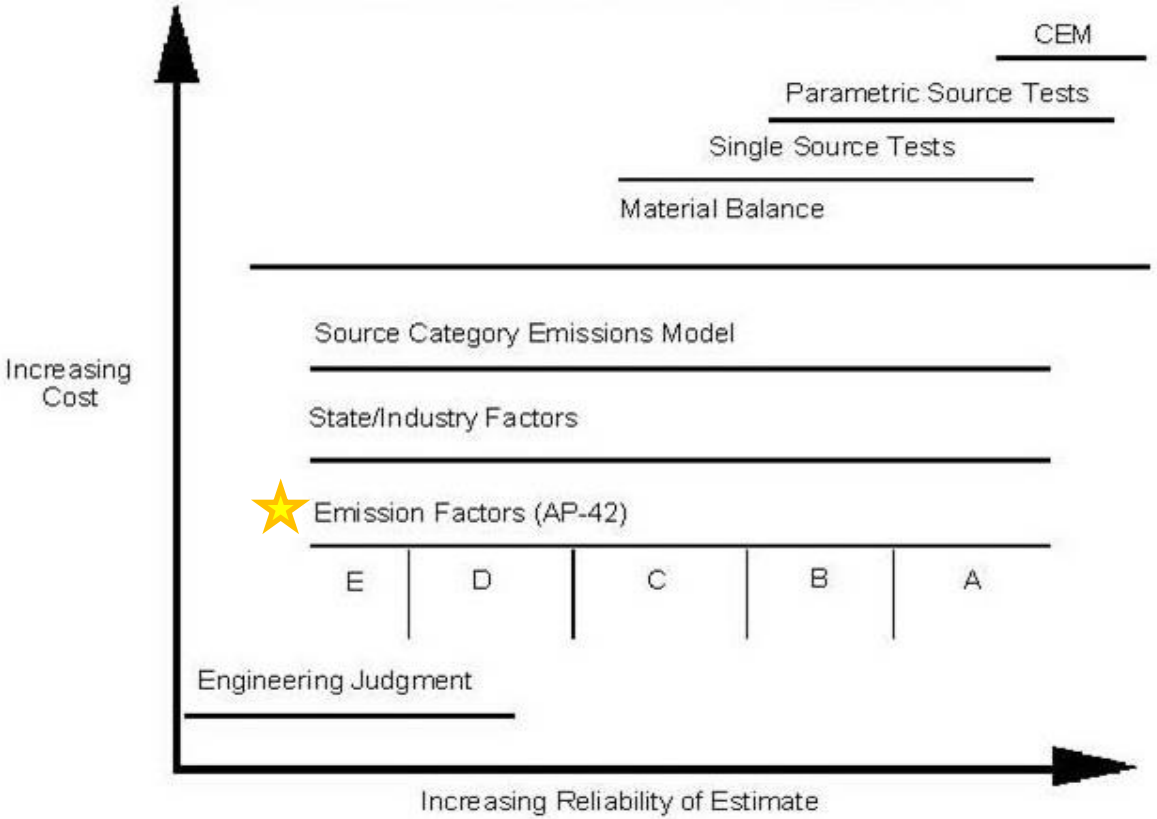
Emission Inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere during a year or other time period.



Source : U.S.EPA (2005)

Emissions estimates

- The most commonly used method is **Emission Factor (EF)**.
- Low cost, easy to use and reliability of estimate.

Emission factor (EF) database

- United States of America, Environmental Protection Agency (U.S.EPA)
- European Environmental Agency (EEA)
- World Health Organization (WHO)
- Intergovernmental Panel on Climate Change (IPCC)

Emissions estimates

Air Pollutant Receptor Modeling

Receptor models are mathematical or statistical procedures for identifying and quantifying the sources of air pollutants at a receptor location. These models are therefore a natural complement to other air quality models and are used as part of State Implementation Plans for identifying sources contributing to air quality problems.

- Positive Matrix Factorization (PMF)
- Chemical Mass Balance (CMB)
- Multiple Linear Regression (MLR)
- Edge Detection (RMAPS, UNMIX)

Introduction

In Bangkok and vicinity, the most serious pollutant is PM2.5, particles less than 2.5 micrometers in diameter. These fine particulates are very harmful to environment and health, if their concentrations in the atmosphere are high, they particularly can cause serious health problems.

Source: Manager online, 30th September 2019.

The primary sources of PM2.5 in general are from incomplete combustion, automobile emissions, dust and cooking and the secondary emission sources are from chemical reactions in the atmosphere.

The study area of North Bangkok Power Plant (NBPP) is located in the middle of the city surrounded by the communities. Therefore, the research has been initiated aiming to investigate air quality within an area of 5 kms. around the NBPP.

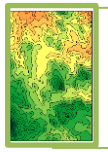

North Bangkok Power Plant

Objective

1) Study the ambient air quality and analyze the PM2.5 within the area of 5 kms around the North Bangkok Power Plant (NBPP).
2) Analyze the particulate matters from stacks of the North Bangkok Power Plant.

Output

1) Emission Inventory of area around the North Bangkok Power Plant.



2) Isopleth maps to describe air pollutions.

3) Information on air pollutions and their emission sources.

4) Information on particulate matters released from stacks of the North Bangkok Power Plant.

Air Pollution survey, source apportionment of particulate matter :
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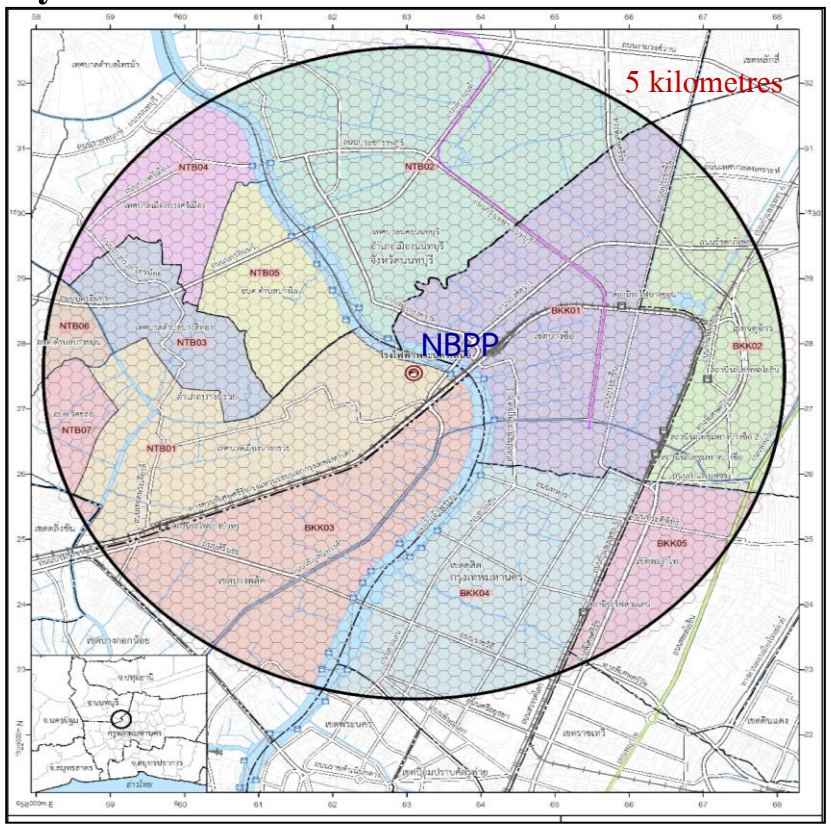
1) Emission Inventory of the area around the NBPP

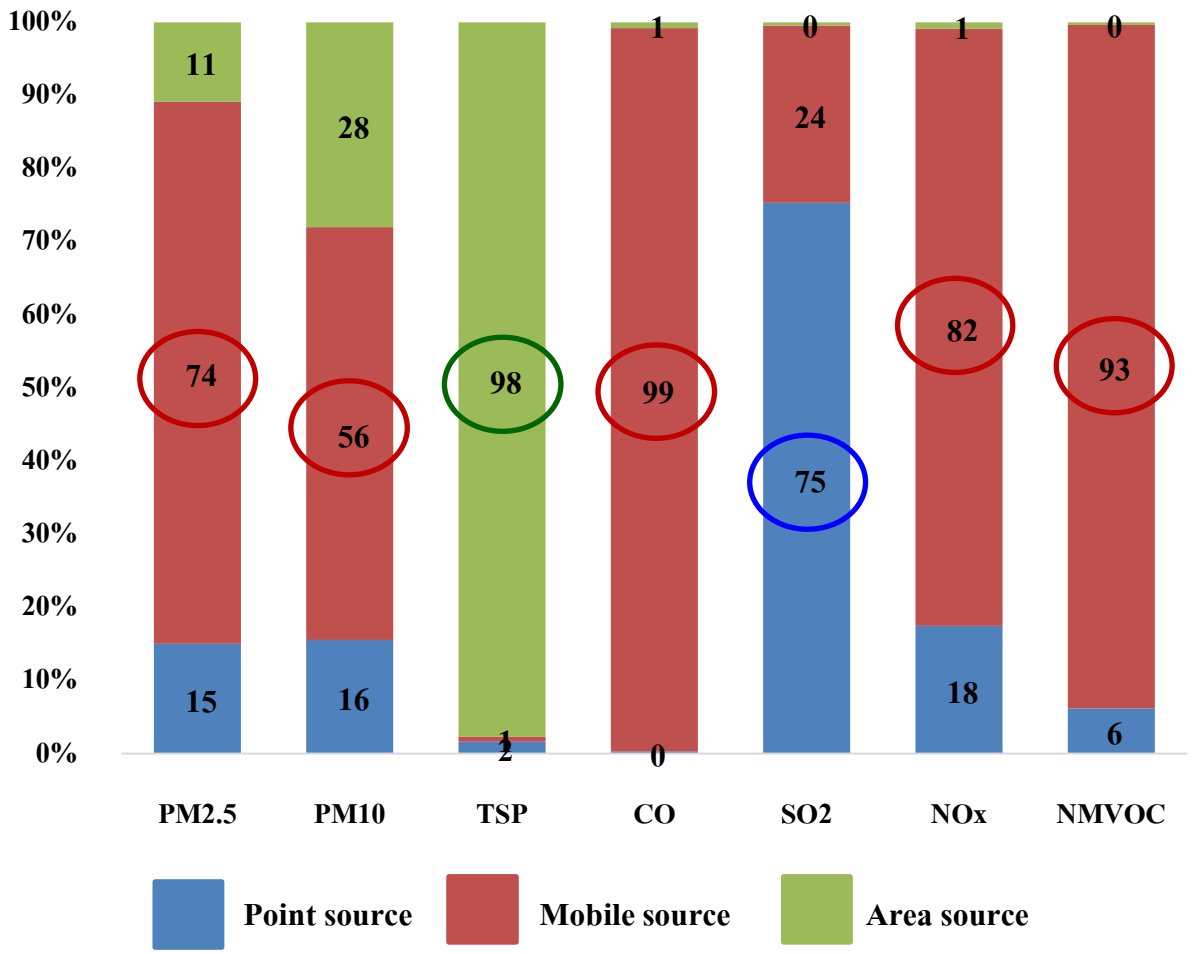
Study Area : 5 kilometers around the NBPP



- **Point source** and **Area source** data collection with questionnaires.
- **Mobile source** data collection with video recording.

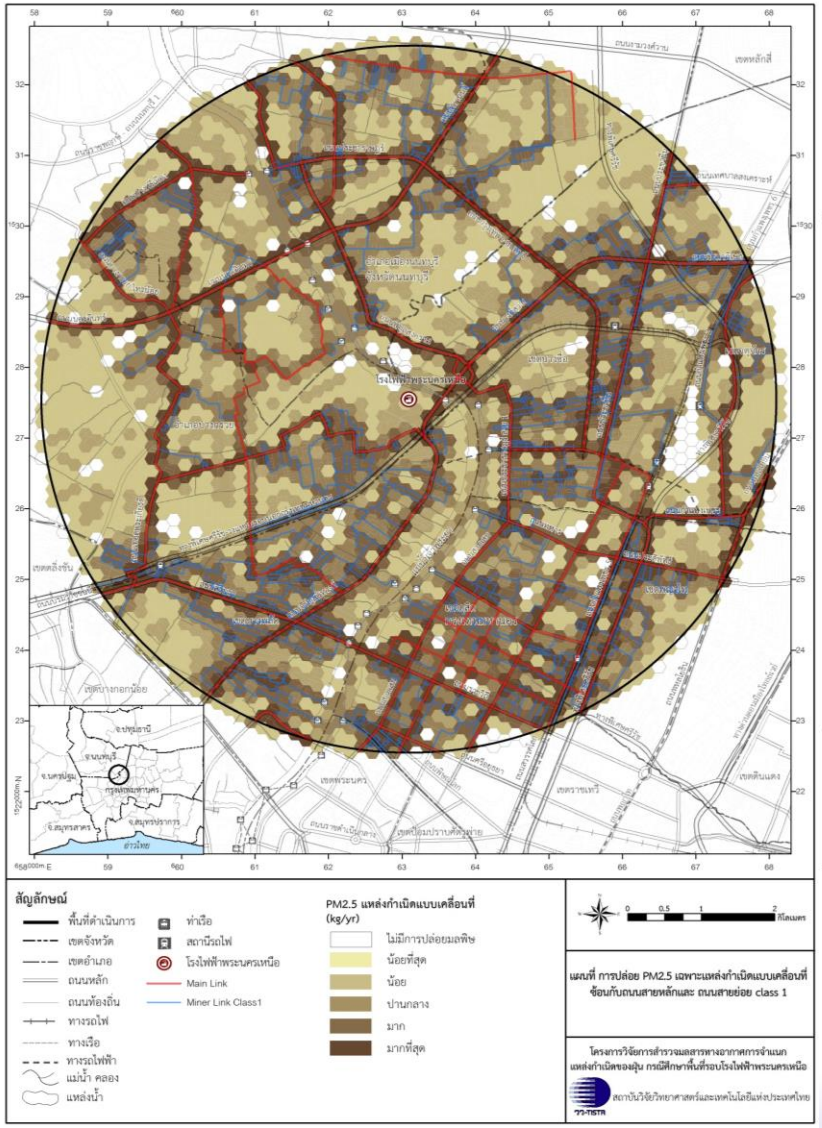
Activities	Number of samples
1) Point Source	
1.1) Industry	199
1.2) Gas station	30
1.3) Temple (Crematory)	56
1.4) Hotel /Hospital /Department store/ Restaurant/ Market	30/ 23/ 30/ 60/30
2) Mobile Source	
2.1) Vehicle	17
2.2) Transport vessels	5
2.3) Train	1
3) Area Source	
3.1) Residence	240
3.2) Construction	12 Zones
3.3) Biomass open burning	30

Result : Emission Inventory of the area around the NBPP

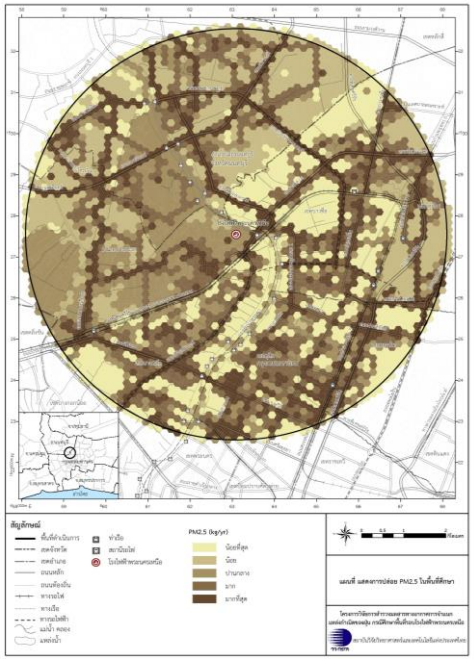


Ratio of Emissions

- **Point source** of SO2 emissions ratio about 75%, mainly from industrial facilities.
- The result of PM2.5, PM10, CO, NOx and NMVOC emissions ratio about 74%, 56% 99%, 82% and 93% respectively, mainly from **mobile source** such as vehicle on road.
- **Area source** of TSP emissions ratio about 98%, mainly from demolition and construction.



PM2.5 from mobile source overlaid with main roads (red line) and minor roads (blue line).



PM2.5 in the study area

Grid map of PM2.5

- The study area was divided into sub-areas or "grids", hexagonal shape with a length of 100 meters on each side, with a grid area of 25,980.75 square meters, totaling 3,139 grids.
- The concentration of PM2.5 (kg/year) is highest along the main roads (red line). Followed by a group of minor roads (blue line).
- On road, the dust is produced both from contact between the tires and the road surface when the vehicle is moving and include fuel combustion.

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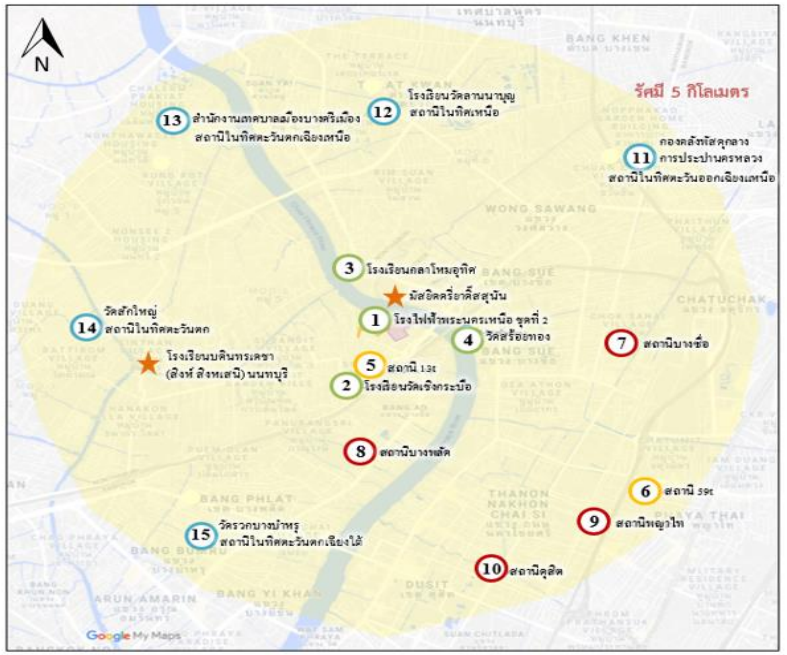
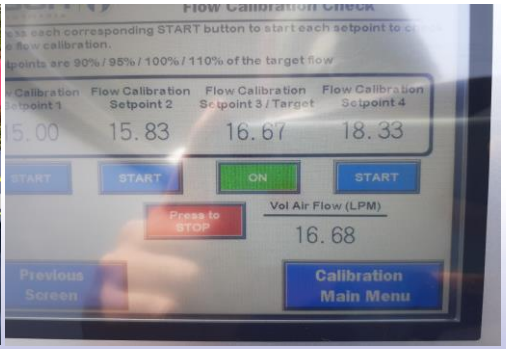
2) Study for isopleth map to describe air pollutions



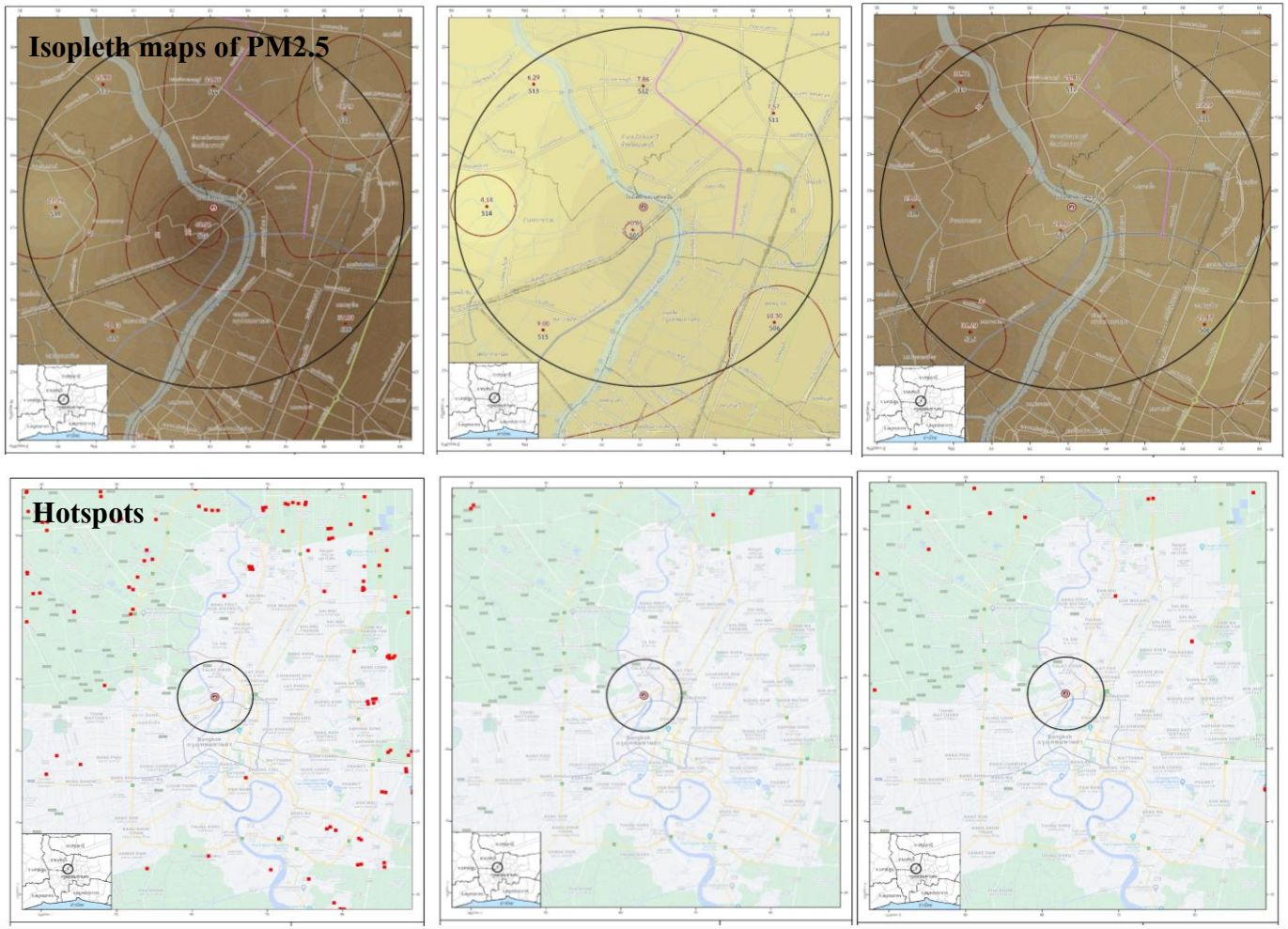
Parameters for this study

Parameter	Methodology
Total Suspended Particulate (TSP)	High Volume Air Sampler/Gravimetric Method
Particulate Matter less than 10 micrometers (PM_{10})	Size Selective, High Volume Air Sampler/Gravimetric Method
Particulate Matter less than 2.5 micrometers ($PM_{2.5}$)	$PM_{2.5}$ Separator, Quartz Filter, Gravimetric Method
Nitrogen dioxide (NO_2)	NO_2 Analyzer/Chemiluminescence Method
Sulphur dioxide (SO_2)	SO_2 Analyzer/Ultraviolet Fluorescence Method
Carbon monoxide (CO)	CO Analyzer/Non-Dispersive Infrared Method
Wind speed and Wind direction (WS/WD)	Wind Vane and Cup Anemometer



Equipment for ambient air sampling

Result : isopleth map to describe PM2.5



- In February and November 2020, concentration of PM2.5 more than June because Bangkok has been struggling with PM2.5 pollution often in Winter (October - March).
- This problem comes from many reasons, such as the wind direction, a lot of humidity in the air, increase of vehicles and factories in the area and including open burning of agriculture in nearby province.
- The results of the hotspots are consistent with the results of isopleth map of PM2.5.

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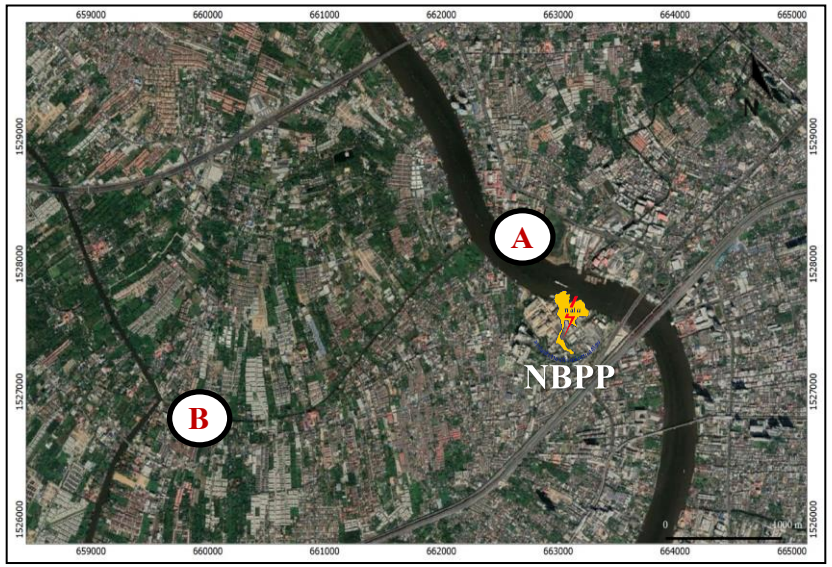
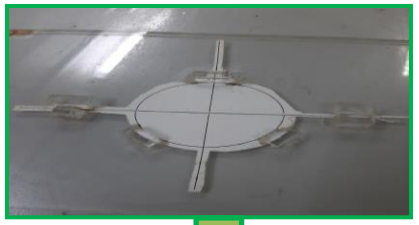
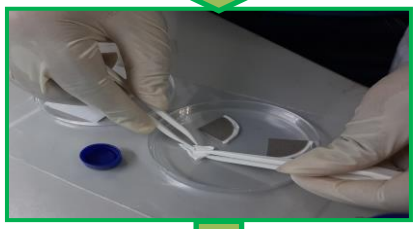
3) Analyze of PM2.5 emission sources



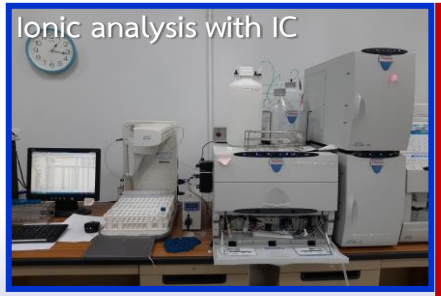
Measuring station of PM2.5

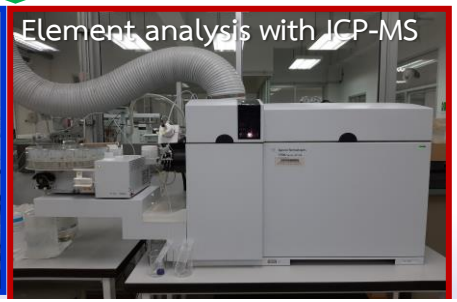


sample of $PM_{2.5}$



sample extraction





analyze ionic and element of PM2.5 in Laboratory

Characterization of particulate matter emission

Natural source	Source fingerprint
- Soil	Al, Si, Ti, Fe, Sr, Ca, OC
- Sea spray	Na, Cl
- Secondary aerosol	NH_4^+, Na, NO_3^-, SO_4^{2-}, OC
Human source	**Source fingerprint**
- Road dust	Al, Si, Ti, Fe, Sr, Ca, K, OC, EC
- Diesel vehicles	EC, OC, NO_3^-, SO_4^{2-}, Cu, Fe, Zn
- Gasoline vehicles	OC, EC, Ca
- Refuse incineration	K, Zn, Pb, EC, OC
- Cement industry	Ca, Si, Al, Fe
- Biomass burning	OC, EC, K, Cl^-, NH_4^+
- Ferrous industry	Fe, Cr, Zn
- Non ferrous industry	Zn, Cu, Pb, Al

Source : Kim Oanh, N.T. (2013)

Using Positive Matrix Factorization (PMF) version 5.0 for analysis PM2.5 emission source.

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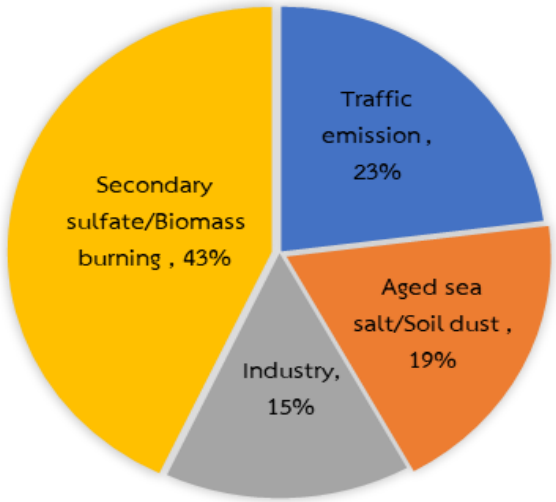
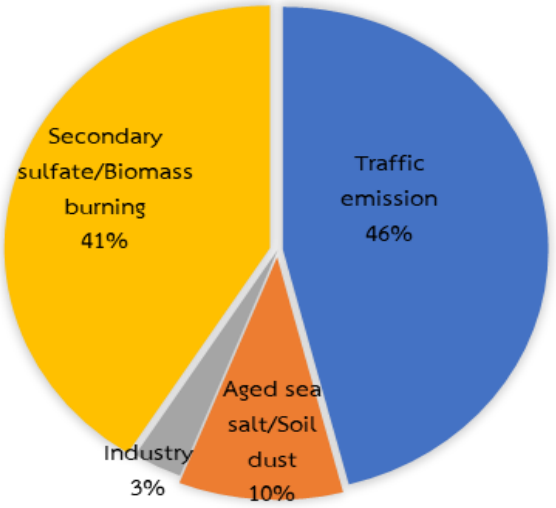
Result : Analyze of PM2.5 emission sources

PM2.5 emission sources of (A) and (B)





(A) **Secondary sulfate/Biomass burning** accounted for 43%, with the largest proportion coming from open burning. Moreover, PM2.5 also comes from cooking because around the A it is a relatively dense community. There are a lot of grilled food shops. There is also an oxidation reaction of SO2 in the atmosphere, mostly from engine exhaust and some from the factory in the study area.

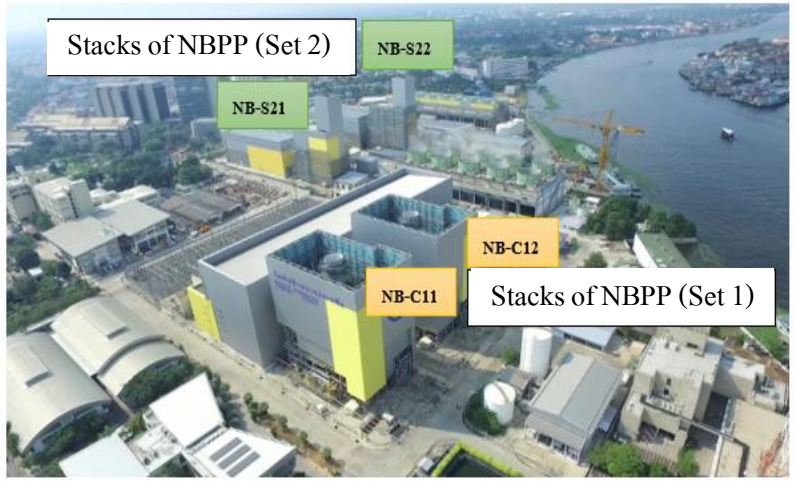
(B) **Traffic emission** accounted for 46%, the largest proportion of sources. Because B is located in urban area with heavy traffic. There are government centers, shopping centers, markets, temples and tourist attractions.

4) Analyze of Particulate matter released from stacks of the North Bangkok Power Plant

Parameters for this study

Parameter	Methodology	Method[/1]
Carbon monoxide (CO)	NDIR Analyzer	U.S. EPA, Method 10
Sulphur dioxide (SO_2)	UV Fluorescence Analyzer	U.S. EPA, Method 6C
Oxide of Nitrogen (NO_x)	Chemiluminescence Analyzer	U.S. EPA, Method 7E
Oxygen (O_2)	Paramagnetic O_2 Sensor	US EPA Method 3A
Total Suspended Particulate (TSP)	Isokinetic Stack Sampling Technique	U.S. EPA, Method 5I
particulate matter between size 2.5-10 micron (PM 2.5-10)	Isokinetic Stack Sampling Technique	U.S. EPA, Method 201A
particulate matter more than size 10 micron (PM> 10)	Isokinetic Stack Sampling Technique	U.S. EPA, Method 201A
Particulate Matter 2.5 ($PM_{2.5}$)	Isokinetic Stack Sampling Technique	U.S. EPA, Method 201A

Remark: [/1] US. EPA. Code of Federal Title 40 (Protection of Environment) Part 60 (STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES) Appendix A (Test Methods)

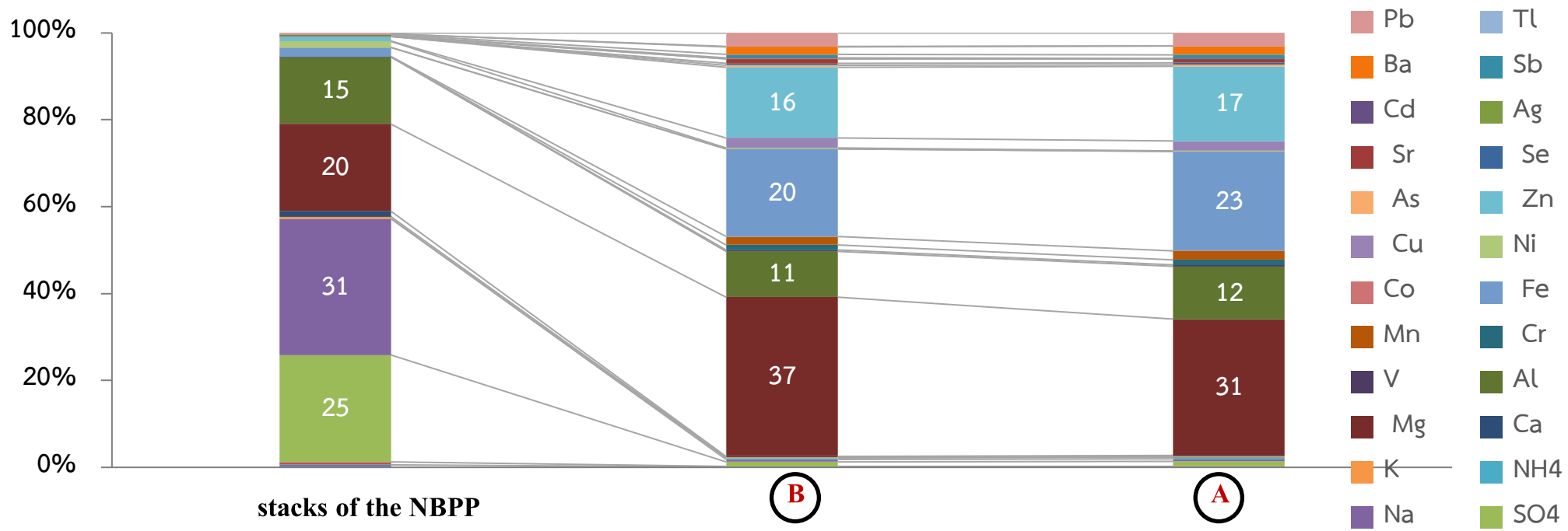


Measure of air pollution form stacks of the NBPP

Analyze of particle ratio form stacks of the NBPP




Comparison of chemical components of PM2.5 between stacks of NBPP, B and A



- Chemical components of PM2.5 of B and A are similar, but difference with stacks of NBPP.
- PM2.5 from Stacks of the NBPP has a high proportion of Na^+ , SO_4^{2-}, Mg, Al, while B and A has a high proportion of Mg, Fe, Zn, Al .
- This suggests that PM2.5 in area around the NBPP is generally from other sources. This is consistent with the PM2.5 source classification results using the PMF model of this study.

THANK YOU

Thailand Institute of Scientific and Technological Research