The air we breathe

An inquiry into the causes and consequences of Bangkok's air pollution, its health effects and including thoughts on how to interpret and act on the various forms of data available.

What we breathe...

What is air pollution?

Primary: carbon monoxide, nitrogen oxides, particulate matter, sulfur oxides, and volatile organic compounds (VOCs)

Secondary: Ozone, Sulphuric and Nitric acids, Peroxyacetyl nitrates (PANs) Aldehydes

A mixture of primary and secondary pollutants. Primary pollutants we release into the directly air from industry, transport, domestic use etc.
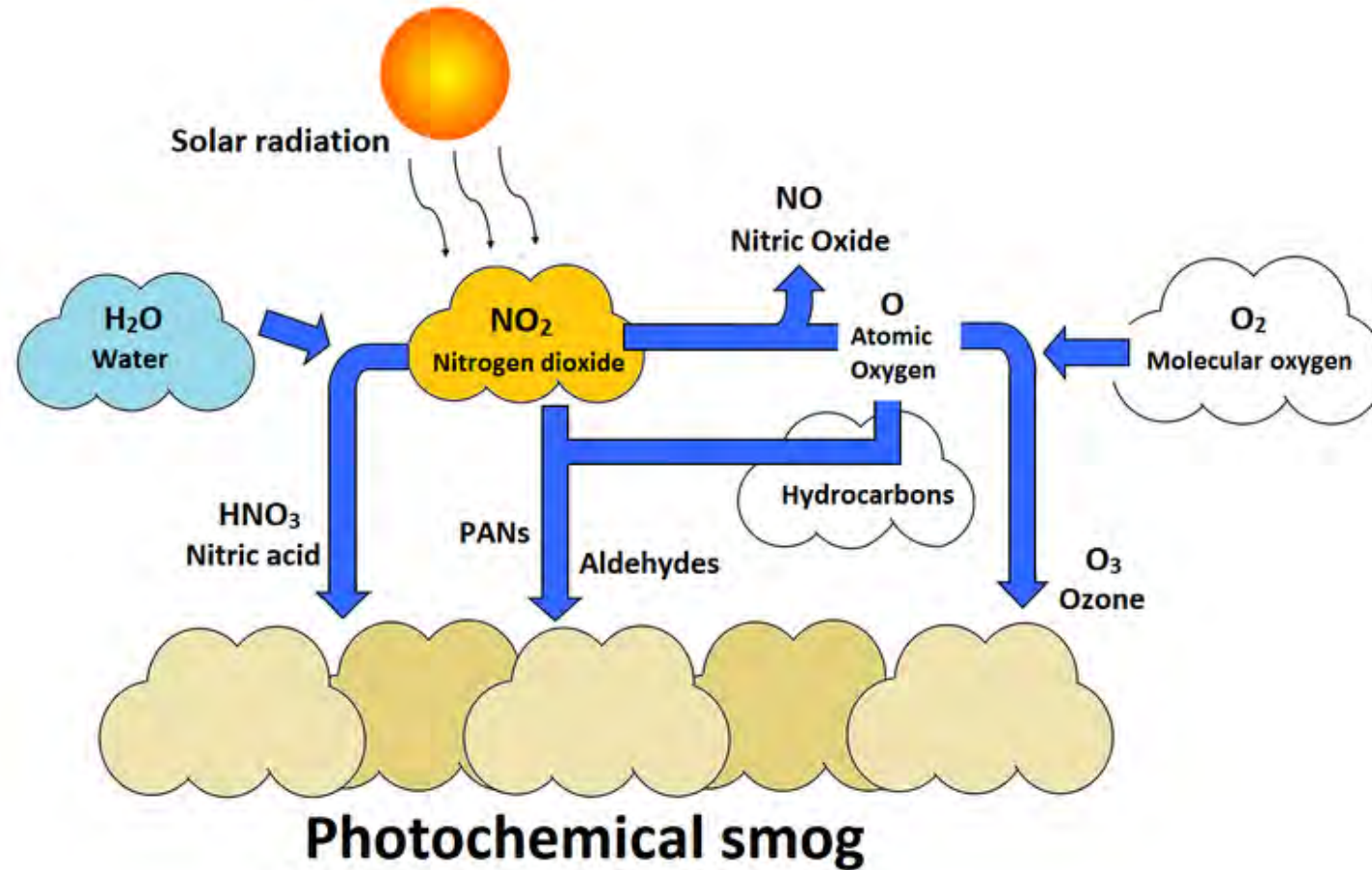
Secondary pollutants occur due to photochemical interactions in the atmosphere that combine to form a smog or haze.

Image source: http://www.nationmultimedia.com/detail/breakingnews/30360828

What is air pollution?

Secondary pollutants form a complex chemical cocktail

HEALTH EFFECTS OF AIR POLLUTION

HEART DISEASE

STROKES

REDUCES LUNG FUNCTION IN ADULTS

SUPPRESSES LUNG GROWTH IN CHILDREN
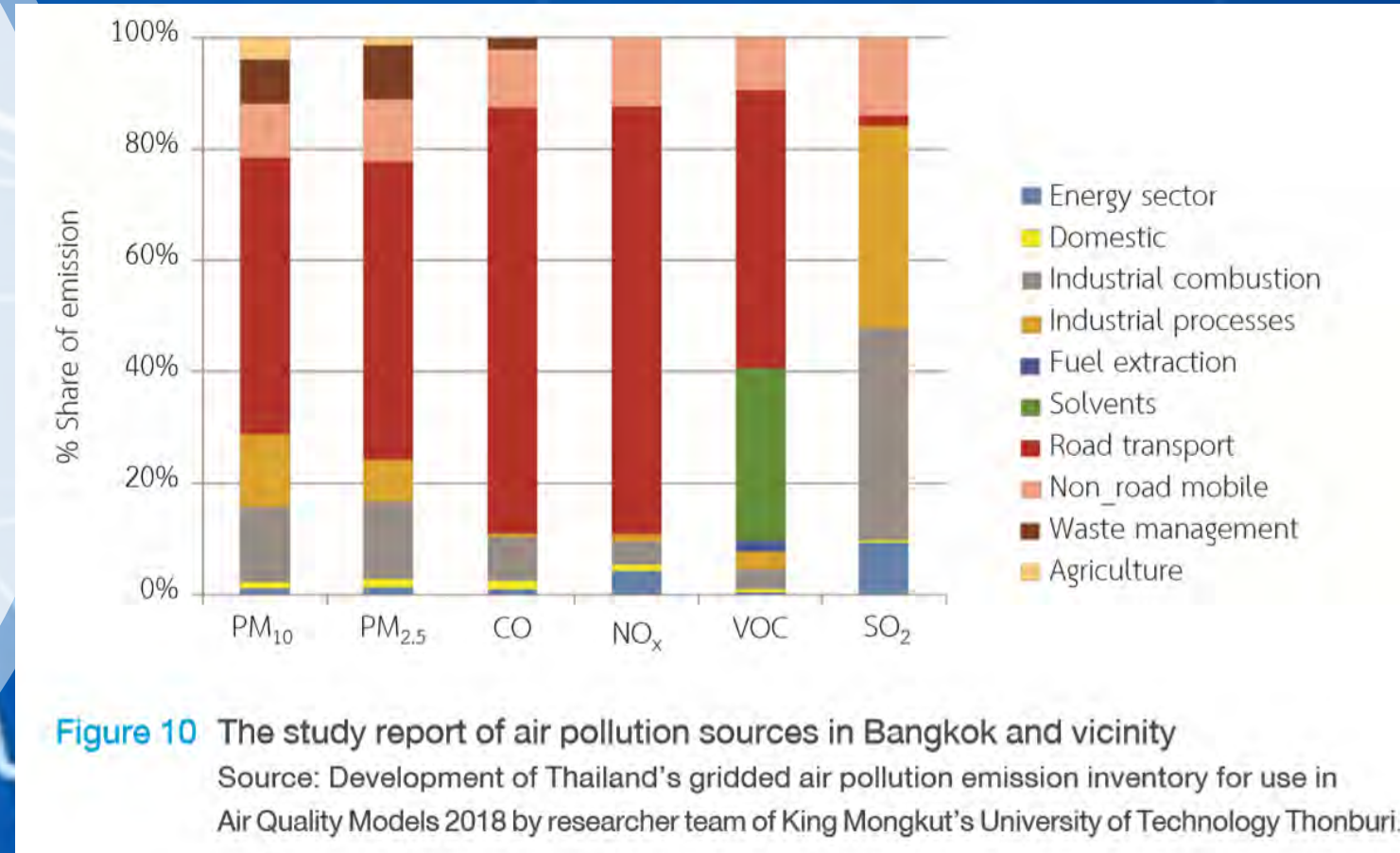
ASTHMA

CANCER
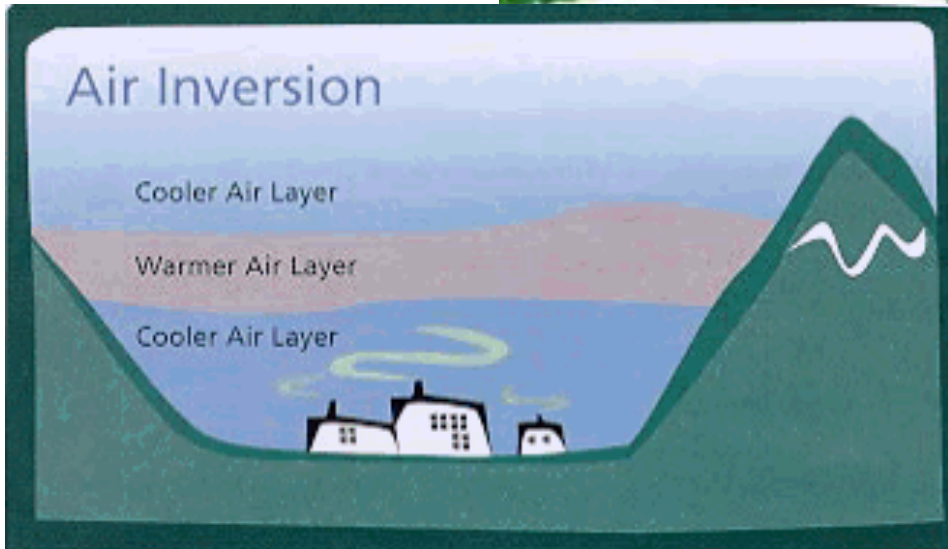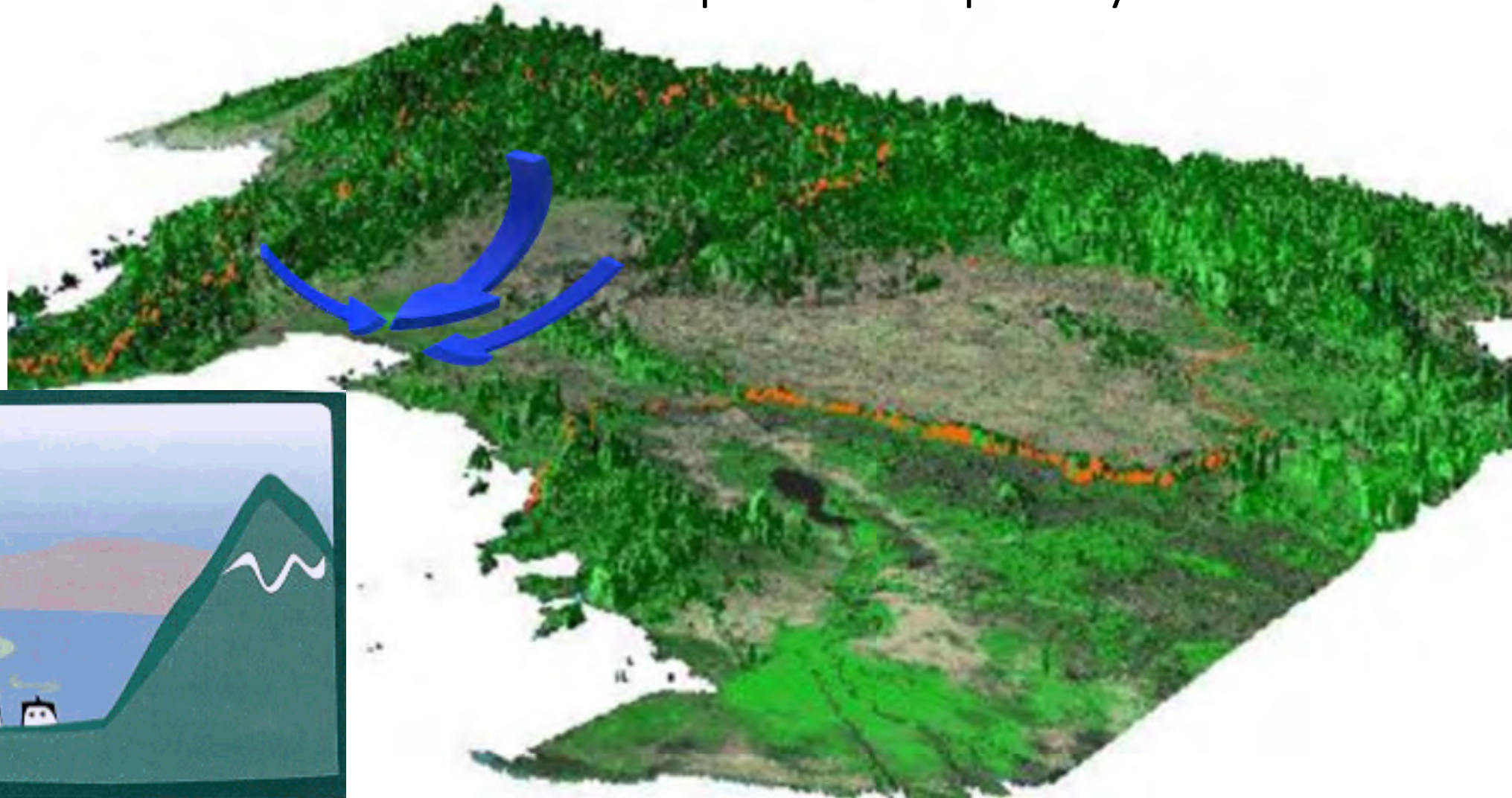
TYPE 2 DIABETES

DEMENTIA

BRAIN DEVELOPMENT IN CHILDREN

BRAIN FUNCTION IN ADULTS

source: CCN - How Toxic Is City Cycling? https://www.youtube.com/watch?v=ySzmo_sScQk&feature=youtu.be

Where does it all the pollution come from?

- Local
  - Transport
  - Industry
  - Domestic
- Rural
- Regional

Figure 10 The study report of air pollution sources in Bangkok and vicinity
Source: Development of Thailand's gridded air pollution emission inventory for use in Air Quality Models 2018 by researcher team of King Mongkut's University of Technology Thonburi.

Image source: CCN - How Toxic Is City Cycling? https://www.youtube.com/watch?v=ySzmo_sScQk&feature=youtu.be

Why does the cold season often have poor air quality?

Air Inversion

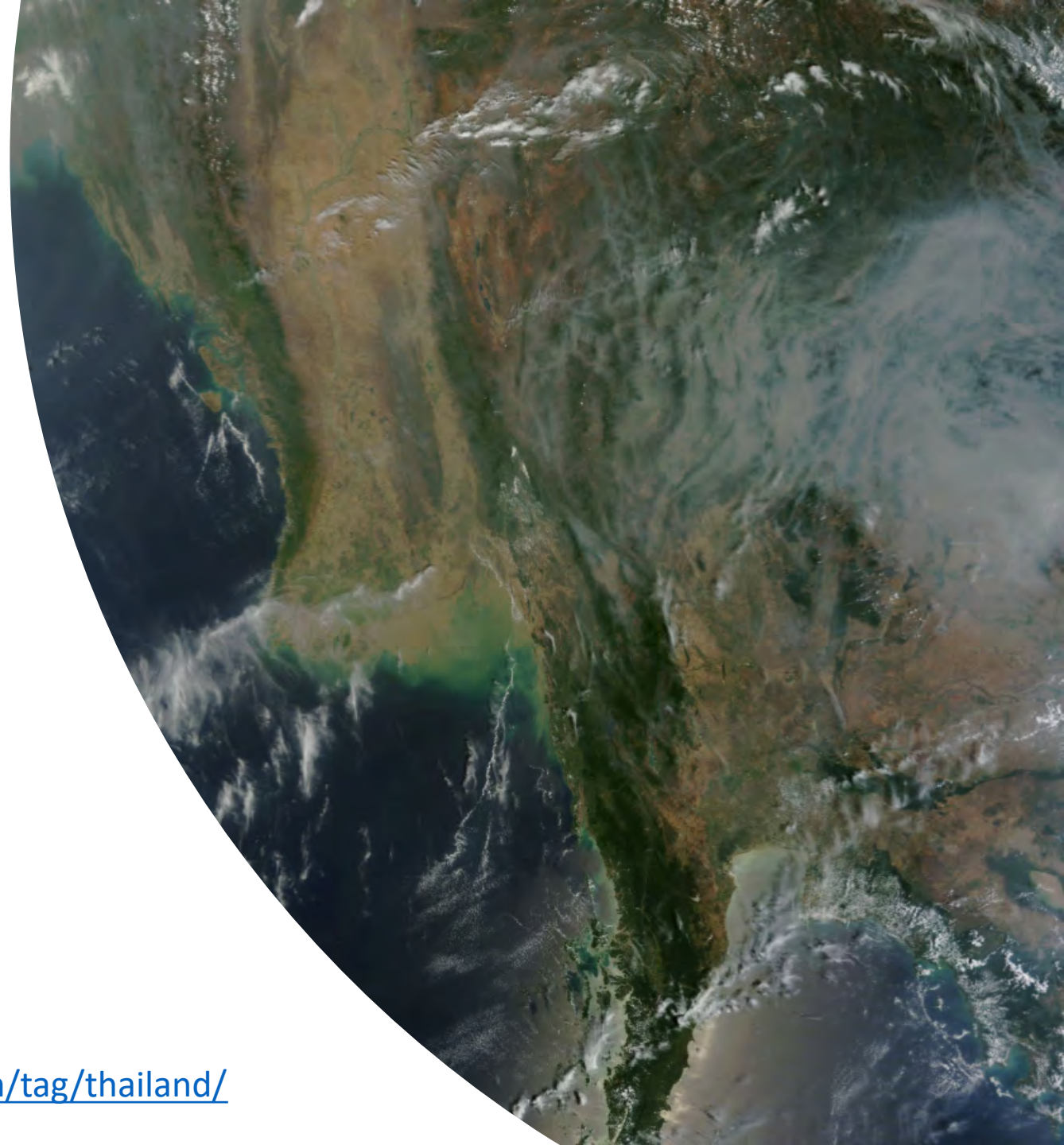Cooler Air Layer

Warmer Air Layer

Cooler Air Layer

Climatic features of the cold season that increase pollution levels.
Image source: Earth Science – Temperature Inversion http://www.rpdp.net/sciencetips_v3/E8A5.htm
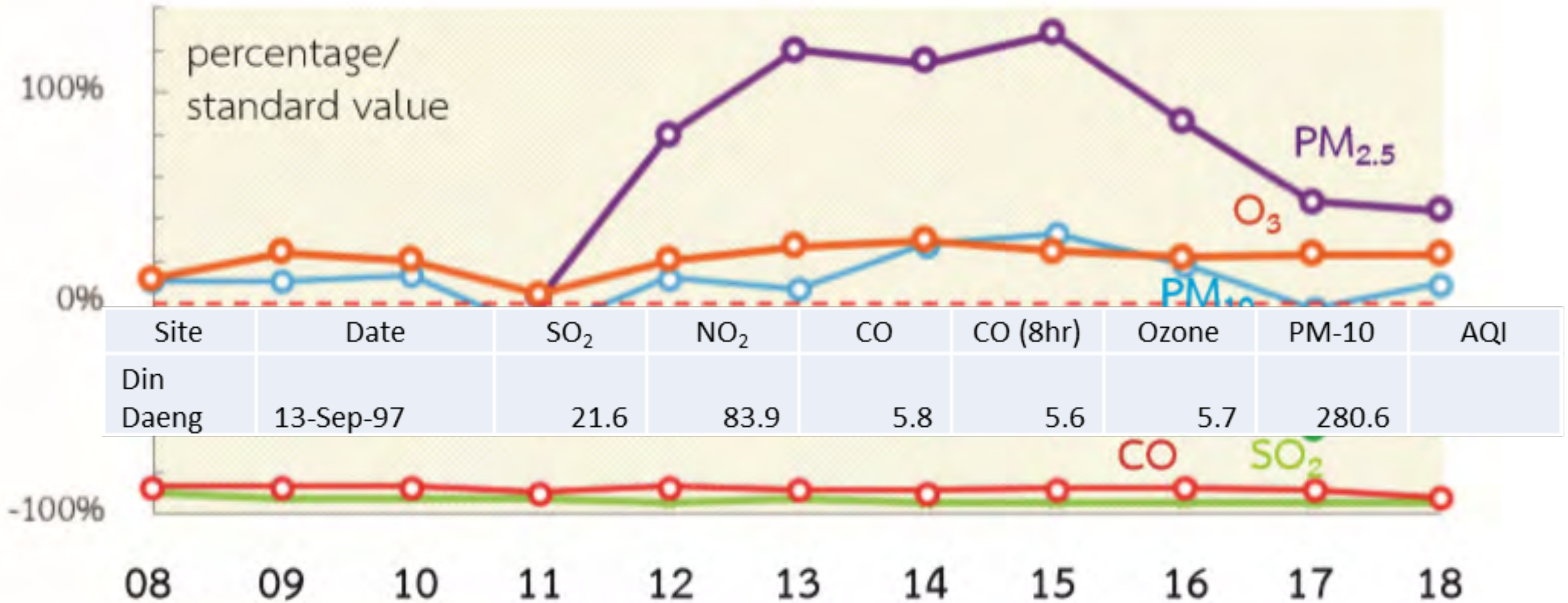
Rural and Regional sources

- Forest and agricultural fires are a major source of particulate matter. Burning begins as the cold season ends and hot season begins.

- Forest fires are widespread in the North and Western areas, some trans-boundary pollution as well.

- Stubble burning from the agricultural regions such as Isan.

Image source: Earth Snapshot http://www.eosnap.com/tag/thailand/

Which pollutants are of the most concern?

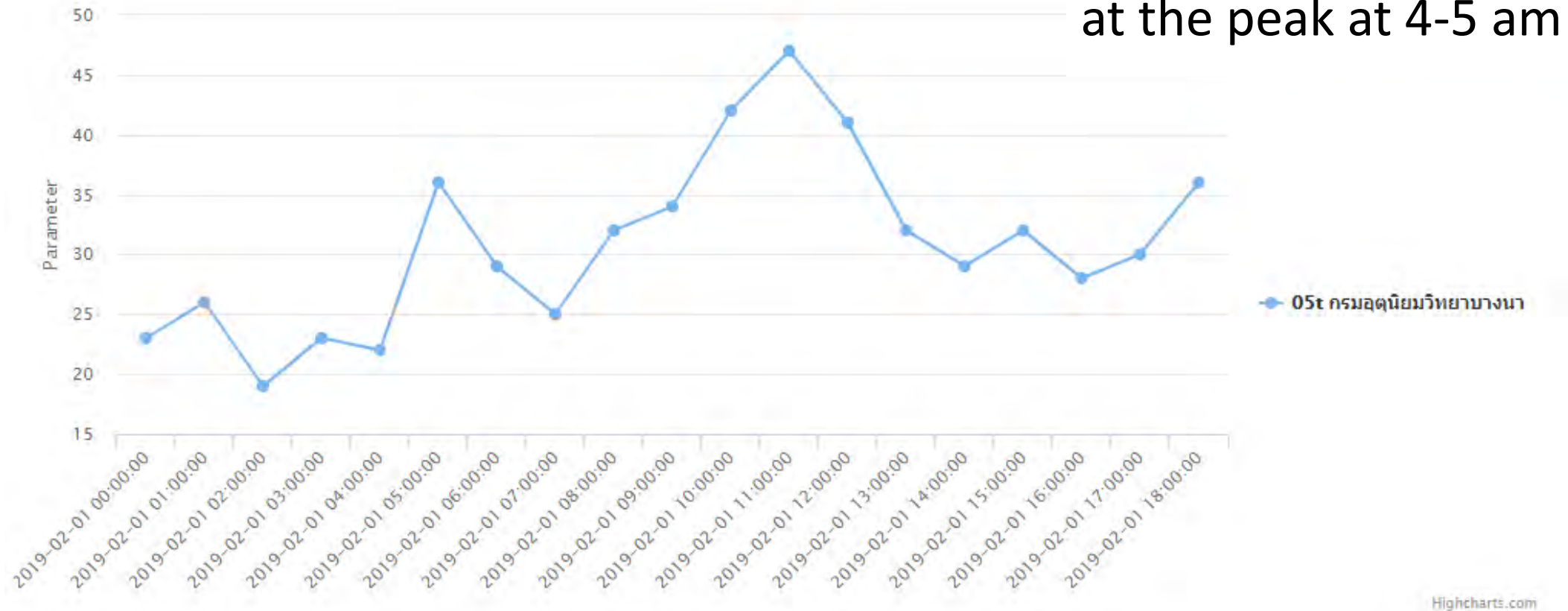| Site	Date	SO₂	NO₂	CO	CO (8hr)	Ozone	PM-10	AQI
Din Daeng	13-Sep-97	21.6	83.9	5.8	5.6	5.7	280.6	

The main concerns are with particulate matter (10 and 2.5 microns) and the secondary pollutant ozone. Look at the long term data set, are they getting worse?

Image source: State of Thailand's Pollution 2018 PCD
http://www.pcd.go.th/file/Booklet%20on%20Thailand%20State%20of%20Pollution%202018.pdf

So why does the PM 2.5 data show twin peaks?
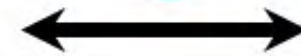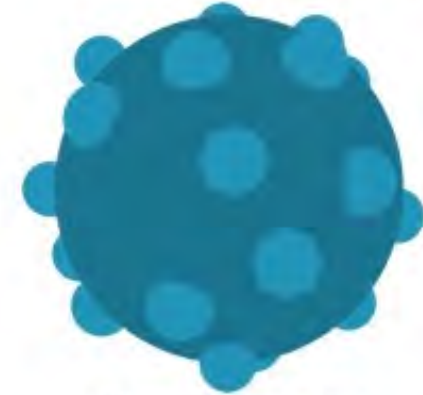
It isn't just the traffic. Look at the peak at 4-5 am

Source: Air4Thai http://air4thai.pcd.go.th/webV2/index.php
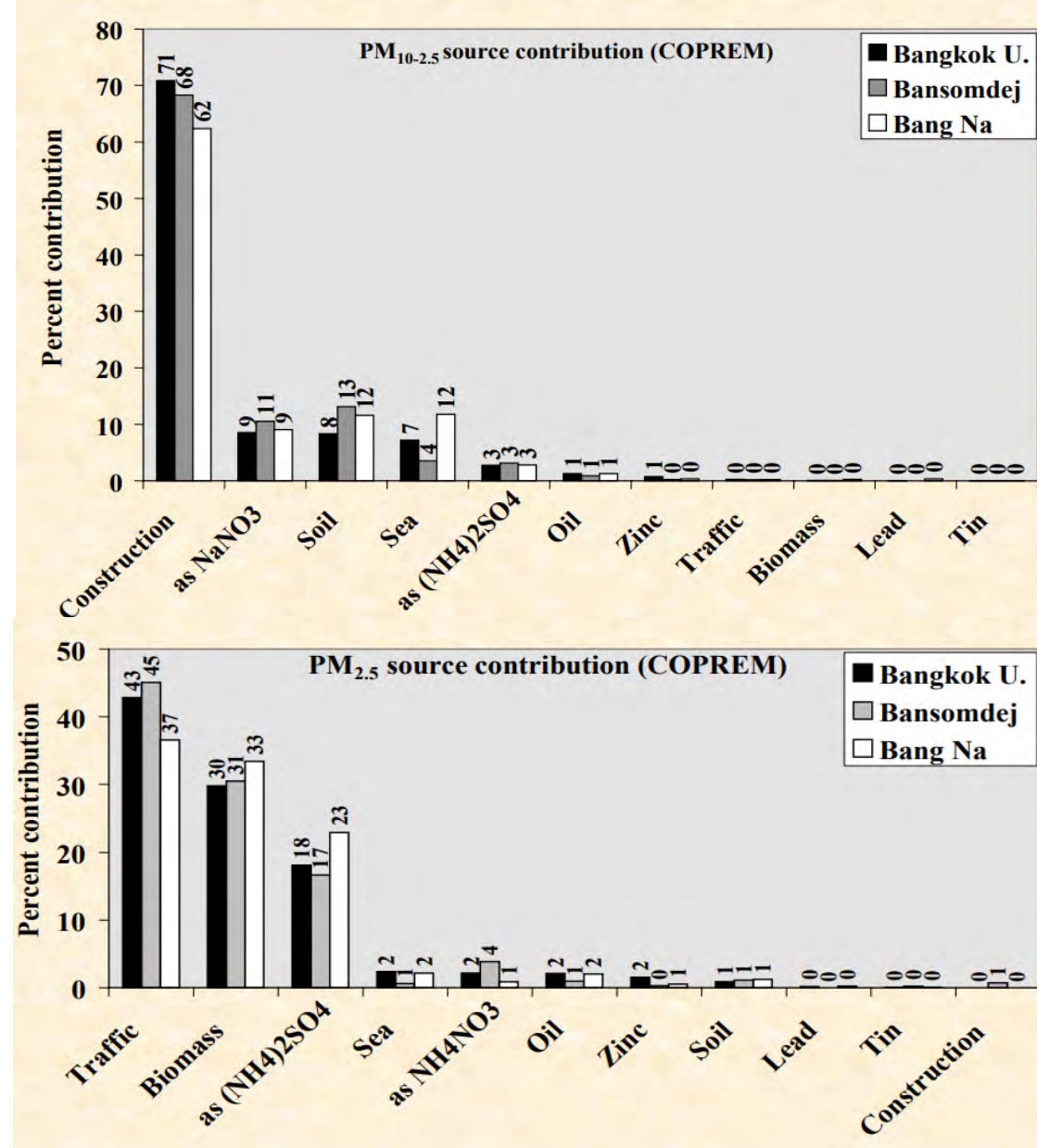
How big are the particles?

100 nanometers

Human Hair

100 microns

Air pollution nanoparticles linked to brain cancer for first time
https://www.theguardian.com/environment/2019/nov/13/air-pollution-particles-linked-to-brain-cancer-in-new-research

basics

What is the particulate matter?

22 elements, primary and secondary pollutants. Coarse is typically more dominated by silicates, fine includes both solid and liquid particles.
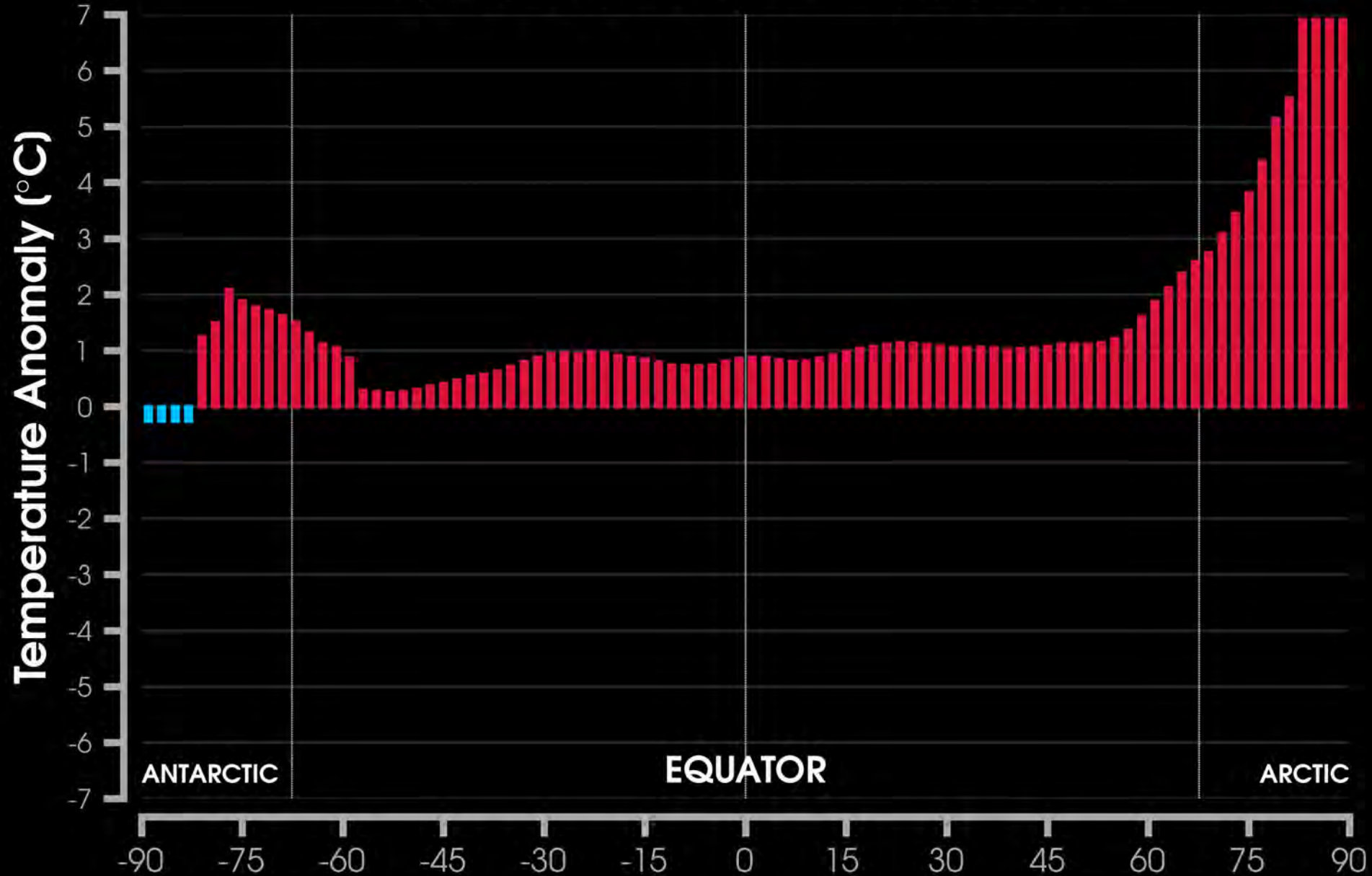
The five common sources of PM2.5 were traffic, biomass burning, secondary sulfate, soil and aged sea salt.

(Wimolwattanapun et al. – Atmospheric Pollution Research 2 (2011) 172-181)

Graph source: AIRPET - Regional Air Pollution Research Program 2003

http://www.rrcap.ait.asia/male/Meeting%20Document/Att4_AIRPET_AIT_Male_%20DrKIM.pdf

OCTOBER – 2019

SOURCE: https://data.giss.nasa.gov/gistemp/
DATA: NASA/GISS GISTEMPv4 Baseline: 1951-1980

GRAPHIC: Zachary Labe (@ZLabe)

Understanding the numbers...

Why doesn't the data match?

There are two reasons:

1. The same EPA formula is used, but the standards vary. This gives different categories for the same data. The formula uses the standards to calculate the AQI

2. The data is collected differently (mass or absorbance), different volumes of air are taken in to different designs of monitor.

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}.$$

Air Quality Indexes and Standards

Raw data or index?

Easy to get mixed up with the figures for the AQI contribution from PM2.5 and the actual concentrations. That is for example reported from the commonly use aqicn.org site is the contribution to the AQI from the PM10 not the mass concentration it is based on from the Bangna monitoring station. This is against US EPA standards.
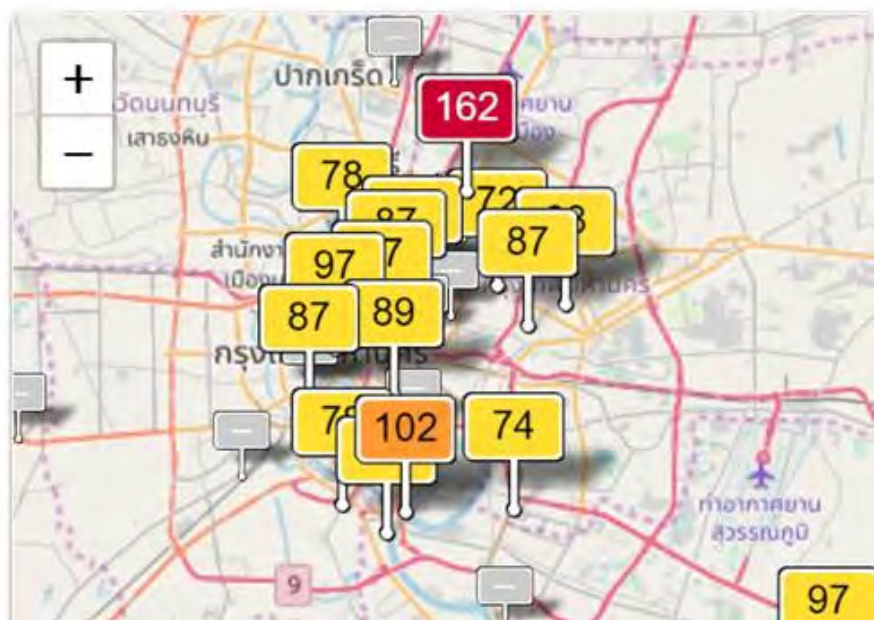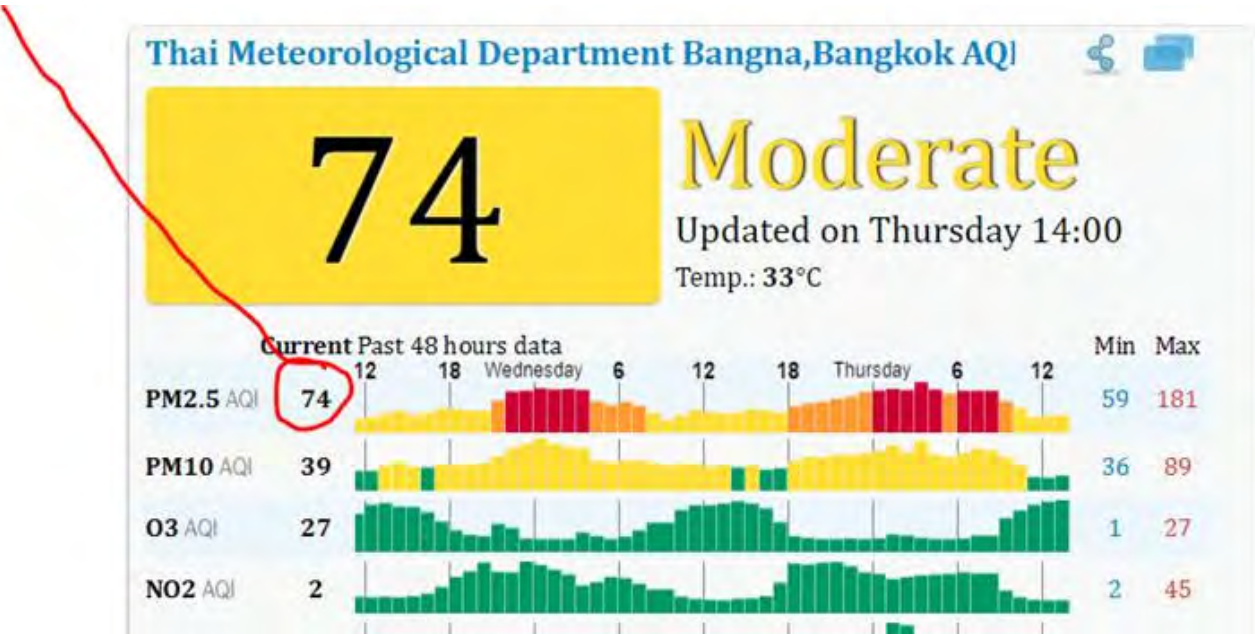
Breakpoints and Categories

- PM2.5 stays under 12.5 microg/m^3 for "good" in the EPA scale, but the Thai scale "high quality" is up to 25 microg/m^3.

- Compared with Thailand, the EPA is more stringent for 2.5, but the opposite is true for PM10.

- WHO and EU standards are more stringent.

Thailand

range	color	level
0 .. 50		คุณภาพดี (high quality)
50 .. 100		คุณภาพปานกลาง (medium quality)
100 .. 200		มีผลกระทบต่อสุขภาพ (there are health effects)
200 .. 300		มีผลกระทบต่อสุขภาพมาก (affects health)
300 .. 500		อันตราย (danger)

ตารางที่ 2 ค่าความเข้มข้นของสารมลพิษทางอากาศที่เทียบเท่ากับค่าดัชนีคุณภาพอากาศ

AQI	PM2.5 (ug/m^3)	PM10 (ug/m^3)	CO (ppm)	O$_3$ (ppb)	NO$_2$ (ppb)	SO$_2$ (ppb)
	เฉลี่ย 24 ชั่วโมงต่อเนื่อง		เฉลี่ย 8 ชั่วโมงต่อเนื่อง		เฉลี่ย 1 ชั่วโมง	
0 - 25	0 - 25	0 - 50	0 - 4.4	0 - 35	0 - 60	0 - 100
26 - 50	26 - 37	51 - 80	4.5 - 6.4	36 - 50	61 - 106	101 - 200
51 - 100	38 - 50	81 - 120	6.5 - 9.0	51 - 70	107 - 170	201 - 300
101 - 200	51 - 90	121 - 180	9.1 - 30	71 - 120	171 - 340	301 - 400
มากกว่า 200	91 ขึ้นไป	181 ขึ้นไป	31 ขึ้นไป	121 ขึ้นไป	341 ขึ้นไป	401 ขึ้นไป

ช่วงเวลาเฉลี่ย และหน่วยสารมลพิษทางอากาศที่ใช้ในการคำนวน

- PM2.5 เฉลี่ย 24 ชั่วโมงต่อเนื่อง : ไมโครกรัมต่อลูกบาศก์เมตร หรือ มคก./ลบ.ม. หรือ µg./m^3
- PM10 เฉลี่ย 24 ชั่วโมงต่อเนื่อง : ไมโครกรัมต่อลูกบาศก์เมตร หรือ มคก./ลบ.ม. หรือ µg./m^3
- CO เฉลี่ย 8 ชั่วโมงต่อเนื่อง : ส่วนในล้านส่วน หรือ ppm หรือ 1/1,000,000
- O$_3$ เฉลี่ย 8 ชั่วโมงต่อเนื่อง : ส่วนในพันล้านส่วน หรือ ppb หรือ 1/1,000,000,000
- NO$_2$ เฉลี่ย 1 ชั่วโมง : ส่วนในพันล้านส่วน หรือ ppb หรือ 1/1,000,000,000
- SO$_2$ เฉลี่ย 1 ชั่วโมง : ส่วนในพันล้านส่วน หรือ ppb หรือ 1/1,000,000,000

These Breakpoints...

O$_3$ (ppm) 8-hour	O$_3$ (ppm) 1-hour[1]	PM2.5 (µg/m^3) 24-hour	PM10 (µg/m^3) 24-hour	CO (ppm) 8-hour	SO$_2$ (ppb) 1-hour	NO$_2$ (ppb) 1-hour	...equal this AQI	...and this category
0.000 - 0.054	-	0.0 – 12.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	12.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 150.4)[3]	255 - 354	12.5 - 15.4	(186 - 304)[4]	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(150.5 - 250.4)[3]	355 - 424	15.5 - 30.4	(305 - 604)[4]	650 - 1249	201 - 300	Very unhealthy
([2])	0.405 - 0.504	(250.5 - 350.4)[3]	425 - 504	30.5 - 40.4	(605 - 804)[4]	1250 - 1649	301 - 400	Hazardous
([2])	0.505 - 0.604	(350.5 - 500.4)[3]	505 - 604	40.5 - 50.4	(805 - 1004)[4]	1650 - 2049	401 - 500	Hazardous

Data source: EPA : https://www3.epa.gov/airnow/aqi-technical-assistance-document-sept2018.pdf
PCD: http://aqmthai.com/aqi_info.php

Bangkok Patana School

- BPS follows the more stringent EPA standards in its air quality policy.

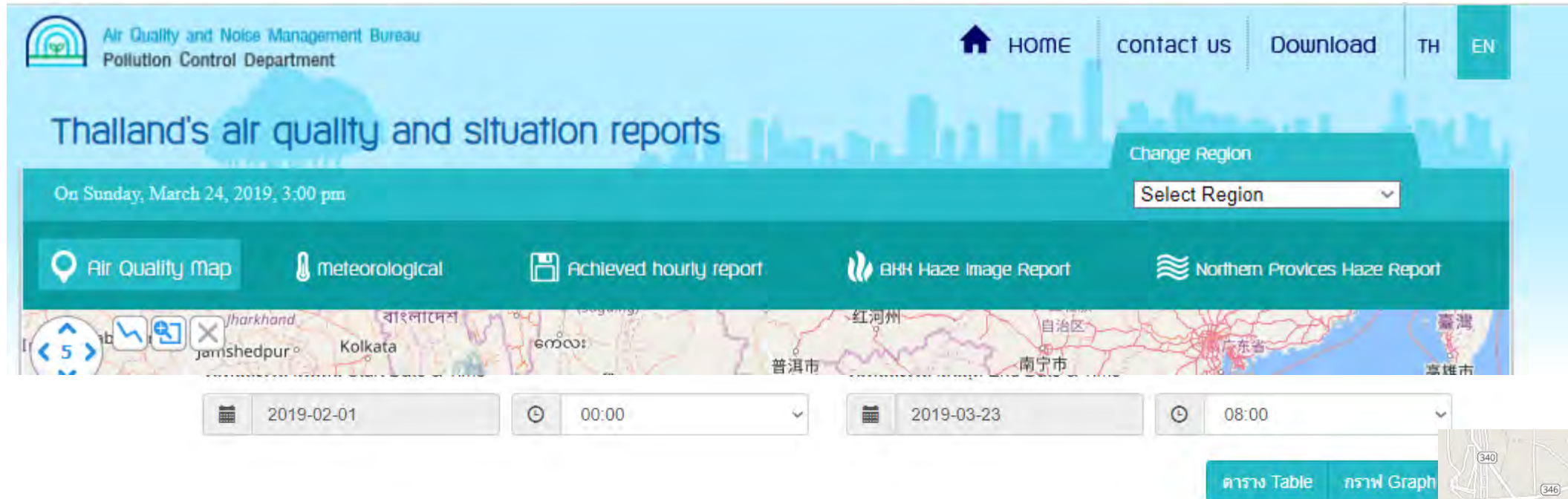![Bangkok Patana School logo] Bangkok Patana School

Bangkok Patana School Air Quality Policy

PM 2.5	General Air Quality Index	Health Effects	Precautionary Actions defined by US EPA*	Bangkok Patana Response	Communication
0 to 12.0	Good 0 to 50	Air quality is considered as satisfactory Little to no risk.	None	All Students: All outdoor activities unaffected. Staff: Duties are unaffected	None
12.1 to 35.4	Moderate 51 to 100	Air quality is acceptable. However, for some pollutants, a very small number of unusually sensitive individuals may experience moderate health concerns.	People who are unusually sensitive to pollutants should consider reducing prolonged or heavy exertion.	All Students: All outdoor activities unaffected. Staff: Teachers monitor students with unusual sensitivity to pollutants as identified through medical records.	None
35.5 to 55.4	Caution for Sensitive Groups	Members of sensitive groups may experience health effects. The general	People with respiratory or heart disease, the elderly and children should	All Students: Outdoor activities continue as planned. There may be some modifications to avoid prolonged exertion for those with unusual sensitivity to pollutants as identified	None

Source: Bangkok Patana
School Air Quality Policy
https://docs.google.com/document/d/17IyxPfmatYkkDciAdKlFPkH4LffjphC_7KhZ6C0lFW8/edit
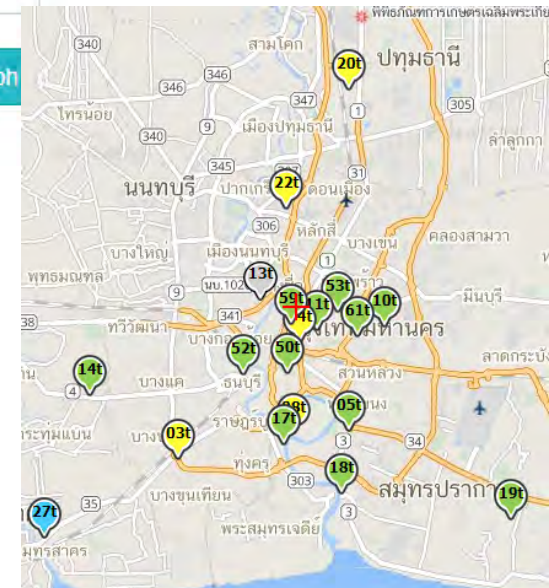
Raw data can be accessed at this site:

Though it is in Thai, easy enough to navigate for a non- Thai speaker –

if you know the site you are interested in.

Click "achieved hourly reports" from the home page.

Source: Air4Thai http://air4thai.pcd.go.th/webV2/index.php

Breathe Easy at Patana

Masks and Exercise

- Even in heavily polluted areas "the benefits of physical activity will outweigh the risks of air pollution.... in places like Delhi or Beijing it is safe to cycle for an hour or an hour and half" Dr. Audrey De Nazelle, Imperial College London.

Image source: CCN - How Toxic Is City Cycling? https://www.youtube.com/watch?v=ySzmo_sScQk&feature=youtu.be

Indoor Air Pollution

- PM2.5 levels in a house can rise to 200 micrograms per cubic metre for one hour of cooking a roast.

- Air conditioning if not maintained can breed bacteria and chill particles exacerbating allergic responses.

- VOCs such as formaldehyde, benzene, naphthalene, chloroform, acetone, ammonia etc. come from a variety of sources, including paint, printers, copiers, cleaning products, hairspray, nail varnish remover, insecticides, fabrics, building materials.

Source: The Guardian 17th February 2019 – Cooking a Sunday roast causes indoor pollution worse than Delhi

Plants as air cleaners

Dracaena, bromeliads, snake plants, peace lily, spider plants, bamboos, ferns..

All plants can help – but specifics have been researched.

e.g. *Dracaena*, Bromeliad are particularly good at VOCs

Snake Plants absorb nitrogen oxides and formaldehyde

See research by Vadoud Niri at State University of New York (2016)
https://www.sciencenewsforstudents.org/article/houseplants-suck-air-pollutants-can-sicken-people

Source of plant images: Wikimedia commons. *Dracaena* By Louise Wolff May 2005

Bangkok Patana School
The British International School in Thailand
Established 1957

PATANA

- Monitoring - GAMS sampler installed in school and 20 internal monitors

- Air Filters (2.5 micron) – pre-cooled and filtered air

- Solar capacity expanded to 1.9MW

- Green Campus

System Power 1.9 MWp

Image source: Energreen for Bangkok Patana Sch
https://www.youtube.com/watch?v=xCCi4nkpAS

Have all your questions answered

Let's talk about and understand air quality.
Our panel of presenters will help inform and advise.