"건강한 환경 행복한 미래"

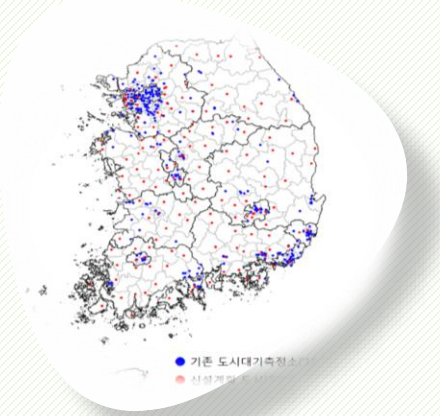
Latest National and Local/City Air Monitoring System in Republic of Korea

National Institute of Environmental Research (NIER)

Climate and Air Quality Research Department

Air Quality Research Division

Dr. Jin-Soo Choi



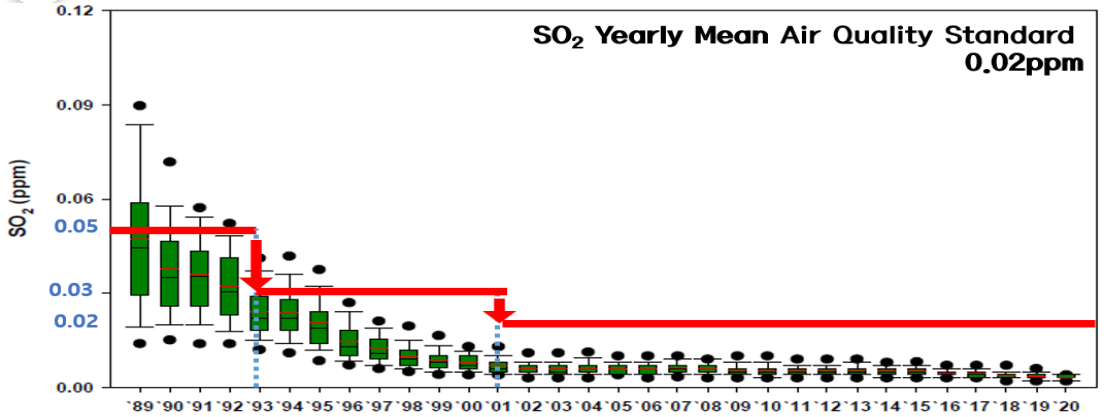
Contents

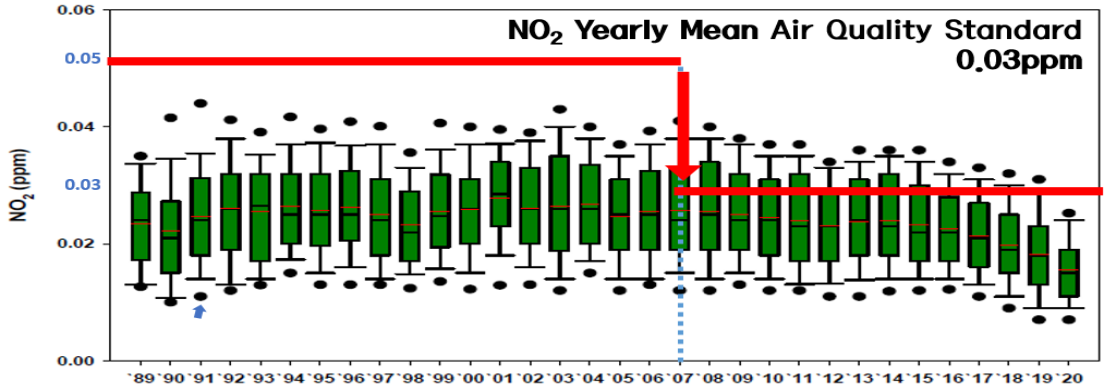
01 Air Quality Monitoring Network

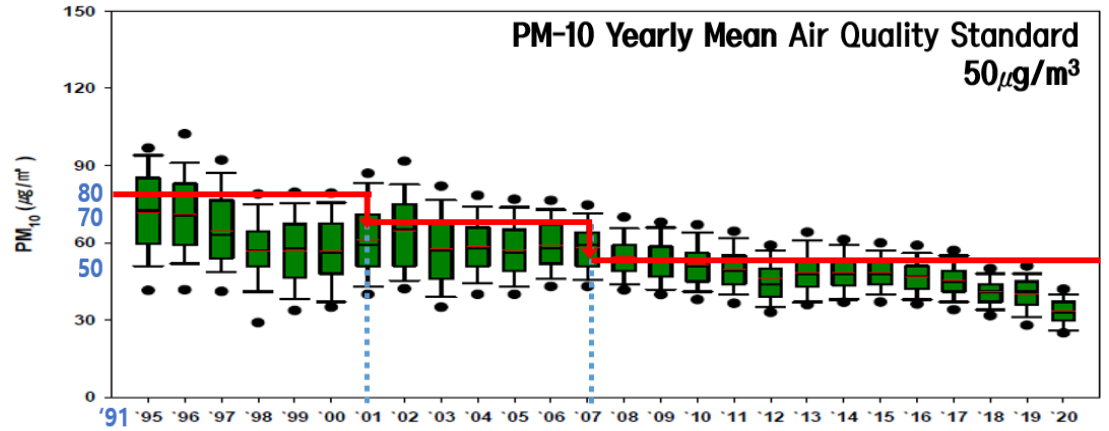
01 History of Air Quality Standard in Korea

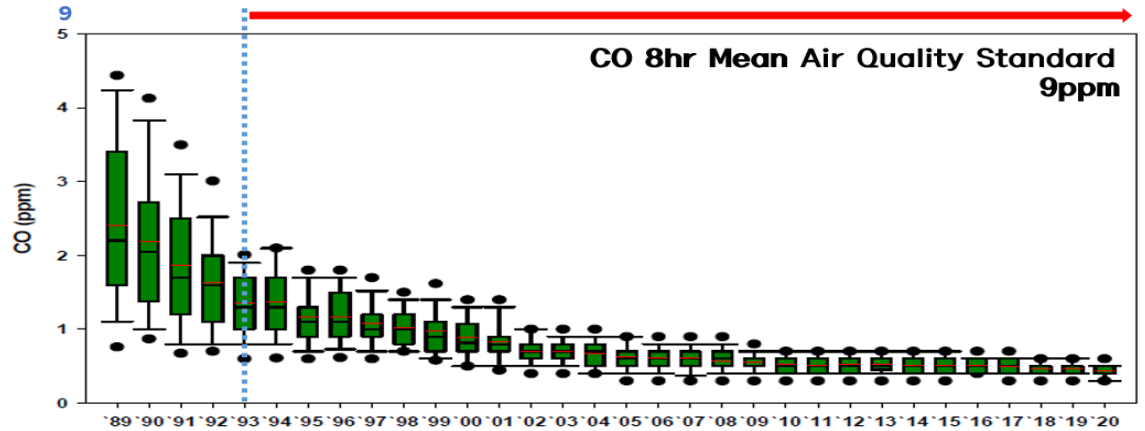
Item		'78	'83	'91	'93	'01	'07	'15	'18
SO_2(ppm)		0.05/year 0.15/24hr	0.05/year 0.15/24hr	0.05/year 0.15/24hr	★0.03/year 0.14/24hr 0.25/hr	0.02/year 0.05/24hr 0.15/hr	0.02/year 0.05/24hr 0.15/hr	0.02/year 0.05/24hr 0.15/hr	0.02/year 0.05/24hr 0.15/hr
CO(ppm)		-	8/month 20/8hr	★9/8hr 25/hr	9/8hr 25/hr	9/8hr 25/hr	9/8hr 25/hr	9/8hr 25/hr	9/8hr 25/hr
NO_2(ppm)		-	0.05/year 0.15/hr	0.05/year 0.08/24hr 0.15/hr	0.05/year 0.08/24hr 0.15/hr	0.05/year 0.08/24hr 0.15/hr	★0.03/year 0.06/24hr 0.1/hr	0.03/year 0.06/24hr 0.1/hr	0.03/year 0.06/24hr 0.1/hr
Particle (㎍/㎥)	TSP	-	150/year 300/24hr	150/year 300/24hr	150/year 300/24hr	-	-	-	-
	PM-10	-	-	-	80/year 150/24hr	70/year 150/24hr	★50/year 100/24hr	50/year 100/24hr	50/year 100/24hr
	PM-2.5	-	-	-	-	-	-	★25/year 50/24hr	★15/year 35/24hr
O_3(ppm)		-	0.02/year 0.1/hr	0.02/year 0.1/hr	★0.06/8hr 0.1/hr	0.06/8hr 0.1/hr	0.06/8hr 0.1/hr	0.06/8hr 0.1/hr	0.06/8hr 0.1/hr
Pb(㎍/㎥)		-	-	1.5/3month	1.5/3month	★0.5/year	0.5/year	0.5/year	0.5/year
THC(ppm)		-	3/year 10/hr	3/year 10/hr	-	-	-	-	-
Benzene(㎍/㎥)		-	-	-	-	-	★5/year	5/year	5/year

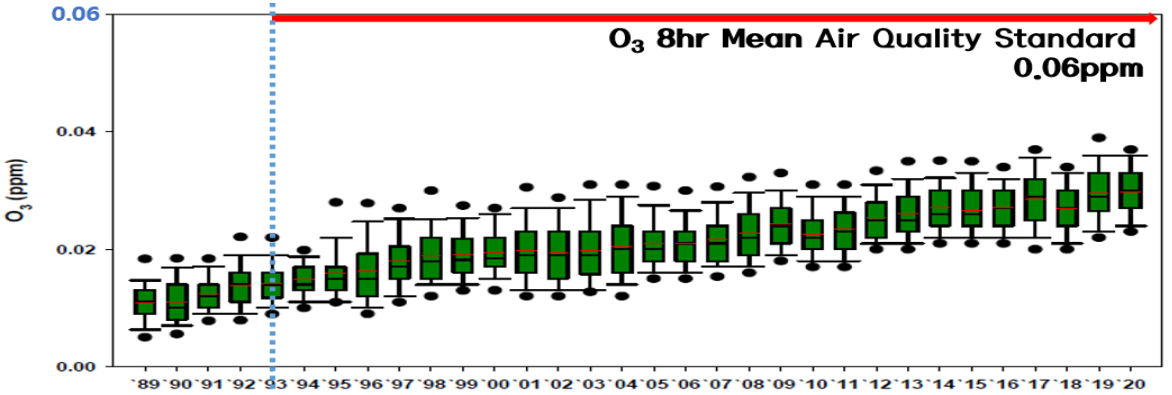
01 Attainment rate of Air Quality Standard in Korea

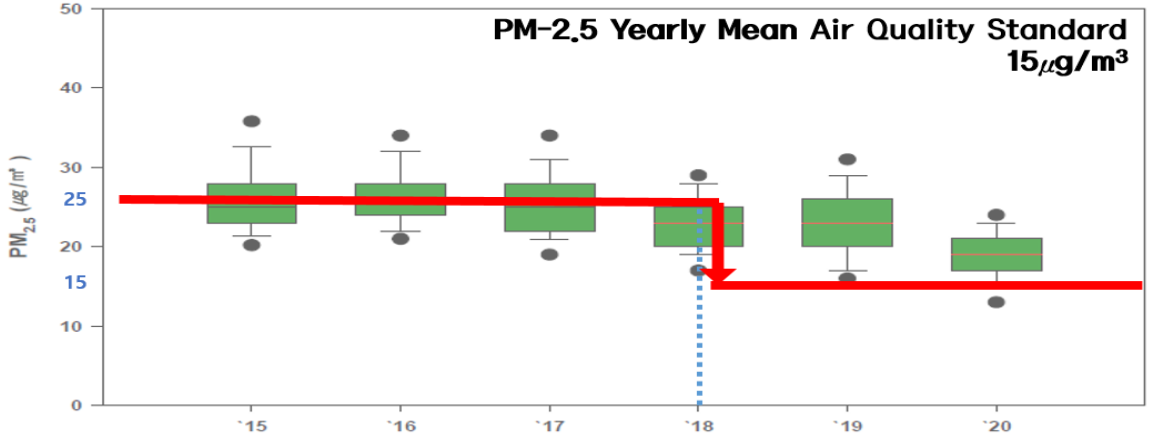




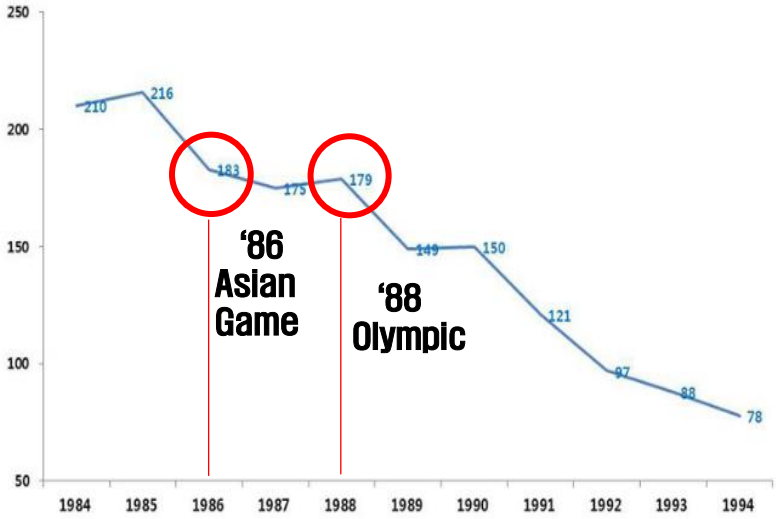




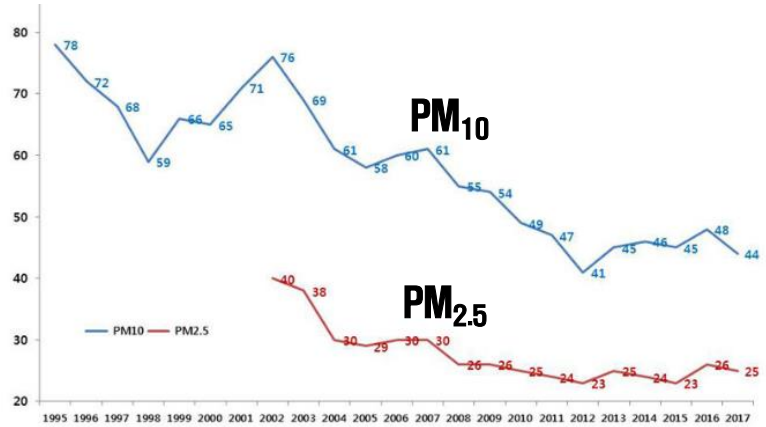




01 Air Quality Monitoring Network in Korea



〈Annual TSP Conc. in Seoul, Korea〉



〈Annual Particulate Matter(PM_{10}, $PM_{2.5}$) Conc. in Seoul, Korea〉

1 Background

- Implementation of Air Pollution Monitoring Network to understand the air quality in Korea(1973)

2 Operational Scheme

- Periodical re-establishment of an operational plan since the basic scheme of air quality in Korea, 1989

* History :
1989.Apr(1991~1996), 1999.Apr(2000~2005), 2005.Apr(2006~2010), 2010.Dec(2011~2015), 2016.Jan(2016~2020), 2020.Dec(2021~2025)

3 Operating Guidance

- Arrangement of operating guideline for Air Pollution Monitoring Network in 1991
- Revising guidance depending on change of monitoring network

01 Air Quality Monitoring Network Operating System

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1st confirmation of measurement results

- maintenance and operation
- local government network

local government

guideline

data

National Institute of Environmental Research

National Institute of Environmental Research (NIER)

comprehensive analysis

strategy

Final confirmation of measurement results

- maintenance and operation - Comprehensive analysis and evaluation of air pollution measurement results
- Create annual and monthly reports

Ministry of Environment

- General management of air pollution monitoring network
- Secure budget and support

mandate

data

푸른하늘 21

Metropolitan Air Environment Agency (MAMO)

1st confirmation of measurement results

- maintenance and operat
- local government network

data

Consignment

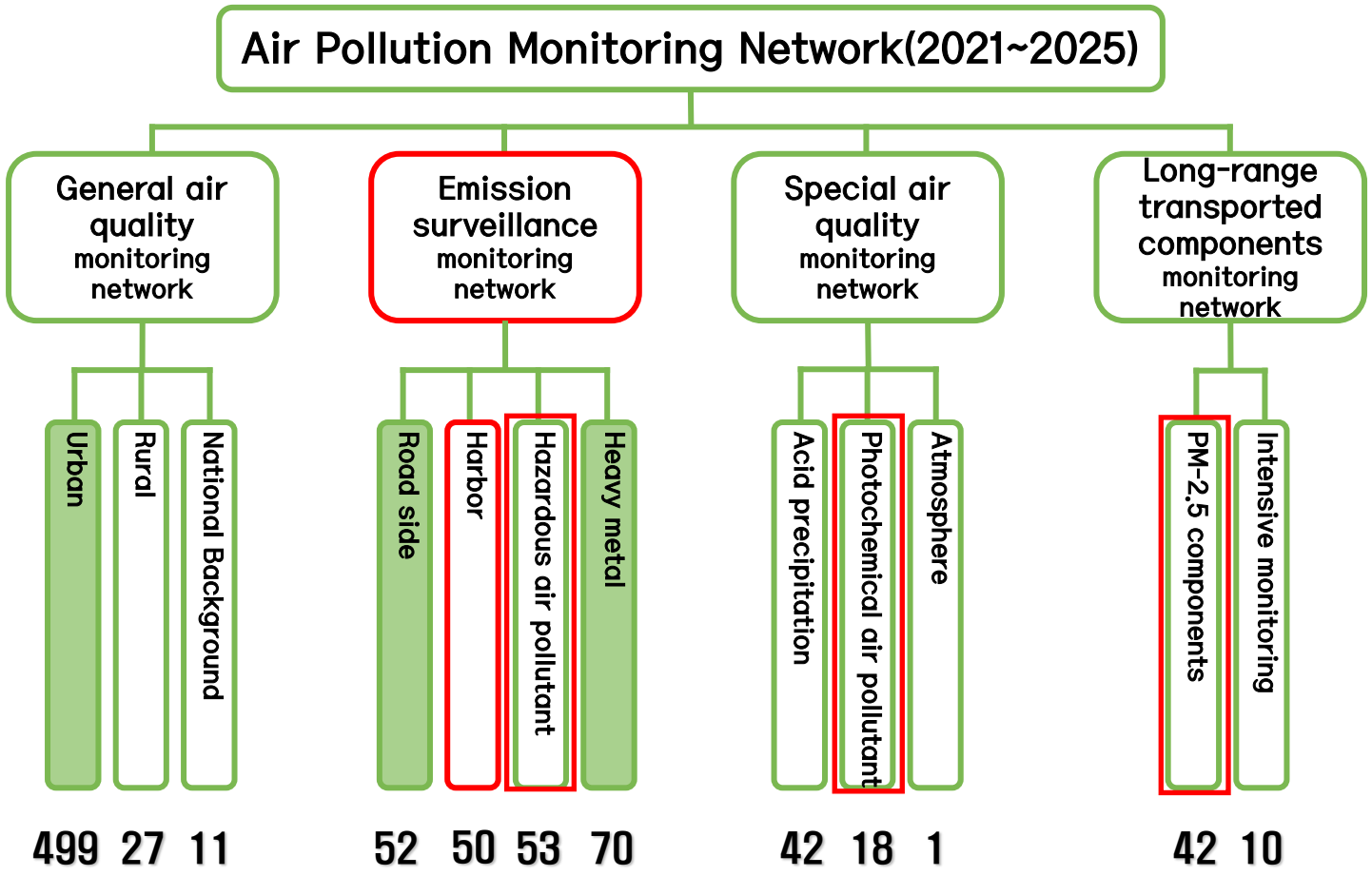
data

Korea Environment Corporation (KEKO)

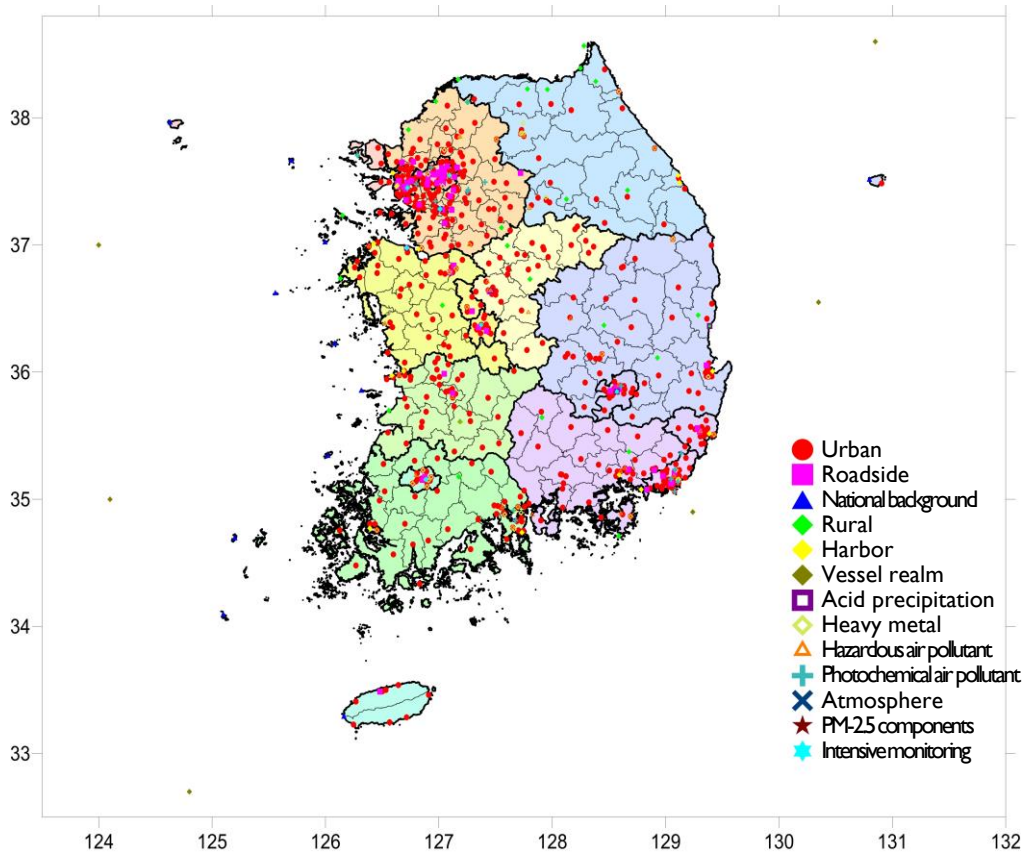
1st confirmation of measurement results

- maintenance and operation
- Airkorea&NAMIS system operation

01 Air Pollution Monitoring Network – Current Status



<National Monitoring Network>



Total 875 Stations

01 $PM_{2.5}$ Quality Control and Equivalence Evaluation

1) Type Approval

The country sets the performance standards for measuring equipment and approves the type (first time, accreditation period 10 years)

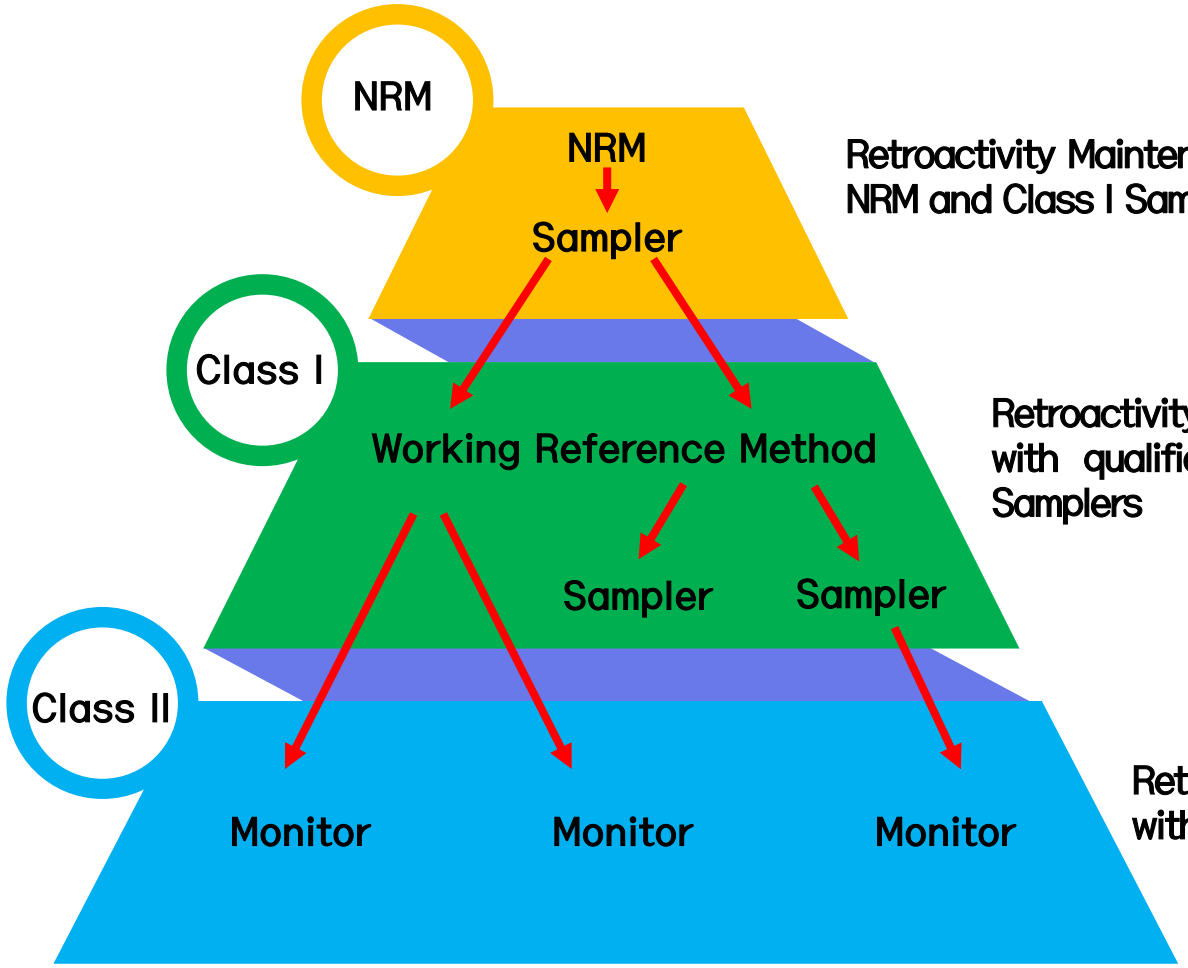
2) Inspection

Periodically inspect whether the structure and performance of the measuring device are maintained (1 year)

3) Equivalent Test

Compare Continuous Particulate Monitor($PM_{2.5}$, PM_{10}) to National Reference Method(NRM)

01 National Reference Method(NRM) Operating Procedure



Retroactivity Maintenance by comparing with NRM and Class I Sampler

1 time/ year

Retroactivity Maintenance by comparing with qualified Class I and other Class I Samplers

≥ 10 days/year

Retroactivity Maintenance by comparing with qualified Class I and Class II Sampler

$PM_{2.5}$: ≥ 23 days/2years

PM_{10} : ≥ 14 days/2years

〈 Particulate Matter Equivalence Evaluation Criteria〉

Item	Criteria	Range
PM2.5	Slope	0.9~1.1
	Intercept	-2.25~2.25
PM10	Slope	0.9~1.1
	Intercept	-5.00~5.00

01 Equivalence Test Procedure

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■ Test procedure of $PM_{2.5}$ continuous monitor

Pre-check
- Instrument check
- Leak test
- Flow Check
- Zero calibration
- Temp & Pressure Check : 3day

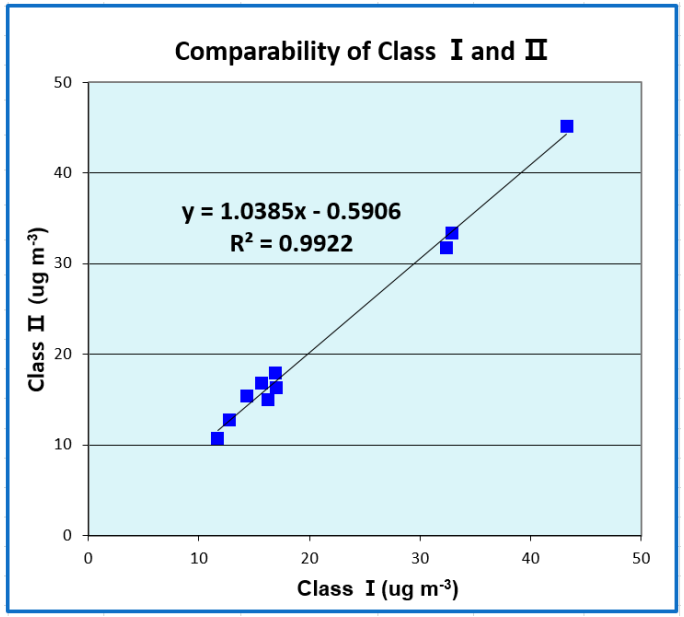
Pre-Measurement
- 7 days measurement
- inform NRM Conc.

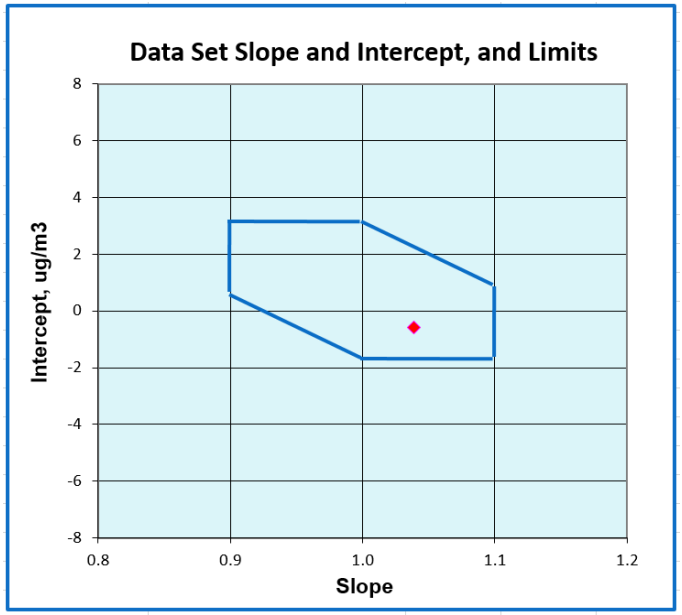
Calibration
- slope factor
- Heating condition
- Film response
- Beta count : 1 day

Audit
- 23 day Audit
- 23hr/day measure

Pre-check → Pre-measure → Calibration → Main Audit

Linear Regression Result		Slope	Intercept
Sampler		1.04	-0.59
Criteria	Upper	1.10	2.25
	Lower	0.90	-2.25
QA/QC (PASS/FAIL)		PASS	PASS



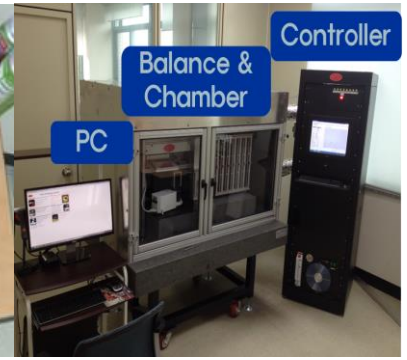


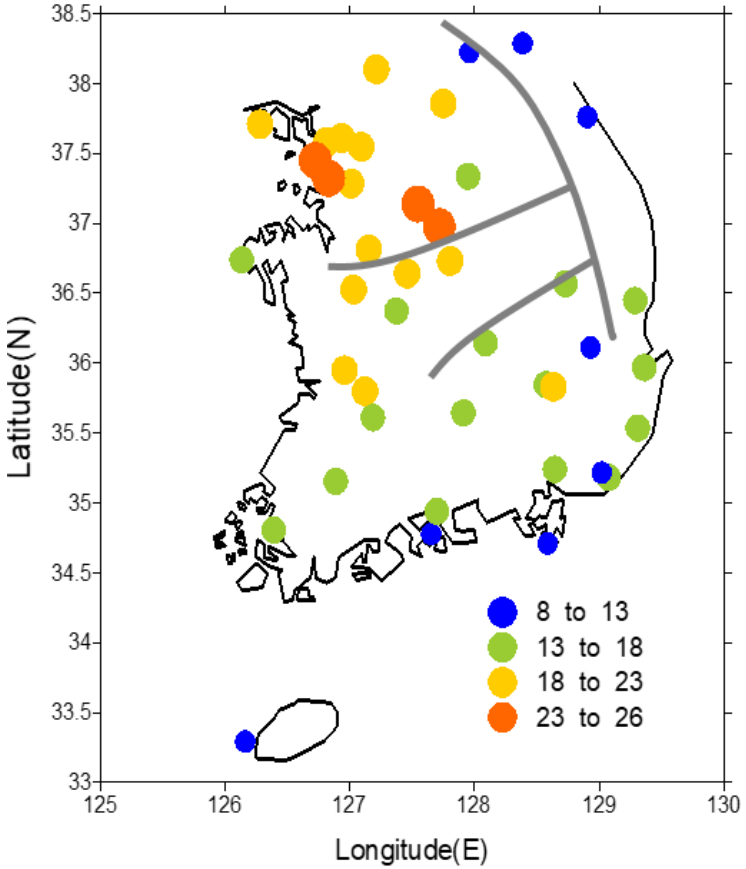
01 Result of PM-2.5 Network

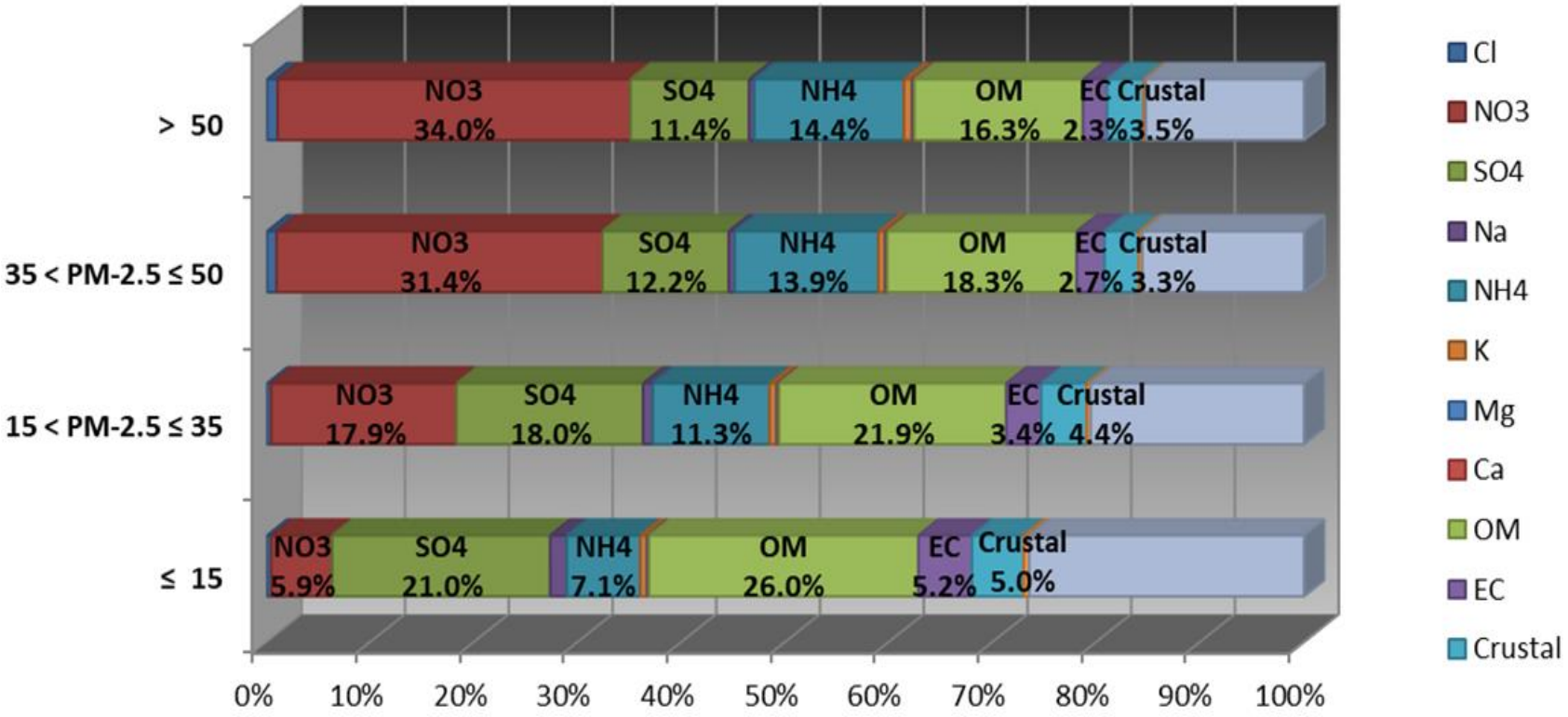
Total 42 sites of PM-2.5 Supersites are currently running

- PM-2.5 Mass and Components(Ion, OC/EC, Trace Metal) Conc.
- Sampling : 1time/Week(Mass), 1time/6days(Components)

- Ion : Ion chromatography / OC/EC : Thermal optical Transmittance / Trace Metal : X-ray Fluorescence







〈Nationwide PM-2.5 Mass Distribution in 2020〉

02 Hazardous Air Pollutant Monitoring Network (PAHs&VOCs)

02 Hazardous Air Pollutants Monitoring Network

■ Operational purpose

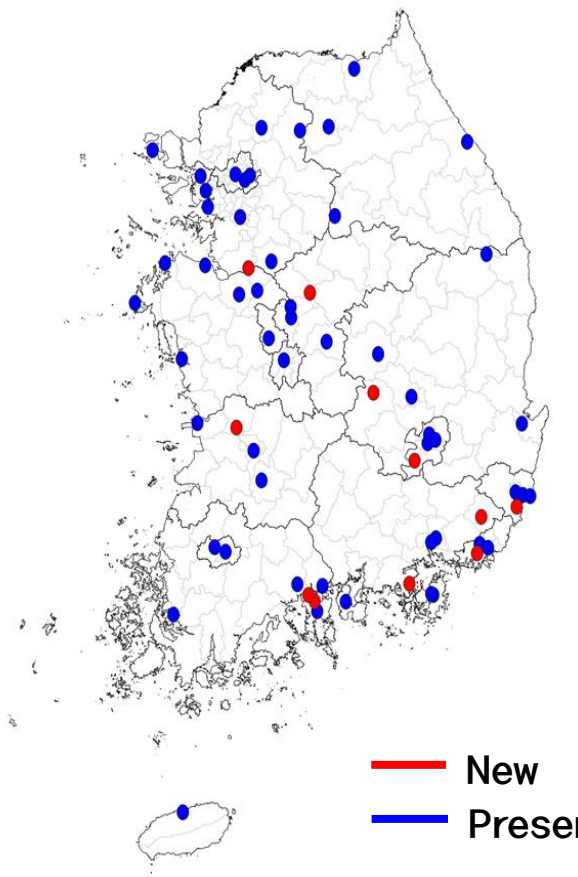
○ Use of basic data to establish reduction measures for specific air pollutants by identifying the pollution levels of volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) that are harmful to the human body, such as benzene and toluene, in the air in urban areas or near industrial complexes

○ Produces basic air pollution data necessary to evaluate whether or not the Atmospheric environment standards have been achieved by measuring the concentration of benzene air quality

■ Measurement list

<table>
<tr><th>type</th><th>PID ECD</th><th colspan="3">Sampling Cycle</th></tr>
<tr><td rowspan="2">VOCs
(16 types)</td><td rowspan="2">1. Benzene, 2. Toluene, 3. Ethylbenzene, 4. m,p-xylene, 5. Styrene, 6. o-xylene,
7. Chloroform, 8. Methylchloroform, 9. Trichloroethylene,
10. Tetrachloroethylene, 11. 1,1-dichloroethane, 12. Carbontetrachloride,
13. 1,3-butadiene, 14. Dichloromethane, 15. Vinyl chloride, 16. 1,2-Dichloroethane</td><td>Passive</td><td>‘22
twice a month
(24hr/day)</td><td>‘23
every six days
(24hr/day)</td></tr>
<tr><td>automatic</td><td>continuity (2hr)</td><td>continuity (2hr)</td></tr>
<tr><td>PAHs
(16 types)</td><td>1. Benzo[a]anthracene, 2. Chrysene, 3. Benzo[b]fluoranthene,
4. Benzo[k]fluoranthene, 5. Dibenzo[a,h]anthracene, 6. Indeno[1,2,3-cd]pyrene,
7. Benzo[a]pyrene, 8. Naphthalene, 9. Acenaphthylene, 10. Acenaphthene,
11. Fluorene, 12. Phenanthrene, 13. Athracene, 14. Fluoranthene, 15. Pyrene,
16. Benzo(g,h,i)perylene, 17. Acrylonitrile('23 new)</td><td colspan="3">twice a month
(24hours/times)
every six days
(24hours/times)</td></tr>
</table>

02 Hazardous Air Pollutants Monitoring Network



VOCs

2006~2015	2015~2018	2018~2022	2026~
13 Types	14 Types	16 Types	17 Types
Benzene	Benzene	Benzene	Benzene
Toluene	Toluene	Toluene	Toluene
Ethylbenzene	Ethylbenzene	Ethylbenzene	Ethylbenzene
m,p-Xylene	m,p-Xylene	m,p-Xylene	m,p-Xylene
Styrene	Styrene	Styrene	Styrene
o-Xylene	o-Xylene	o-Xylene	o-Xylene
Chloroform	Chloroform	Chloroform	Chloroform
Methylchloroform	Methylchloroform	Methylchloroform	Methylchloroform
Trichloroethylene	Trichloroethylene	Trichloroethylene	Trichloroethylene
Tetrachloroethylene	Tetrachloroethylene	Tetrachloroethylene	Tetrachloroethylene
1,1-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethane
Carbontetrachloride	Carbontetrachloride	Carbontetrachloride	Carbontetrachloride
1,3-Butadiene	1,3-Butadiene	1,3-Butadiene	1,3-Butadiene
	Dichloromethane	Dichloromethane	Dichloromethane
		Vinyl Chloride	Vinyl Chloride
		1,2-Dichloroethane	1,2-Dichloroethane
			Acrylonitrile

PAHs

2006~2018	2018~Present
7 Types	16 Types
Benzo(a)anthracene	Benzo(a)anthracene
Chrysene	Chrysene
Benzo(b)fluoranthene	Benzo(b)fluoranthene
Benzo(k)fluoranthene	Benzo(k)fluoranthene
Dibenzo(a,h)anthracene	Dibenzo(a,h)anthracene
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(a)pyrene	Benzo(a)pyrene
	Naphthalene
	Acenaphthylene
	Acenaphthene
	Fluorene
	Phenanthrene
	Anthracene
	Fluoranthene
	Pyrene
	Benzo(ghi)perylene

■ 53 sites : urban(24), Industrial Complex(22), Background(7)

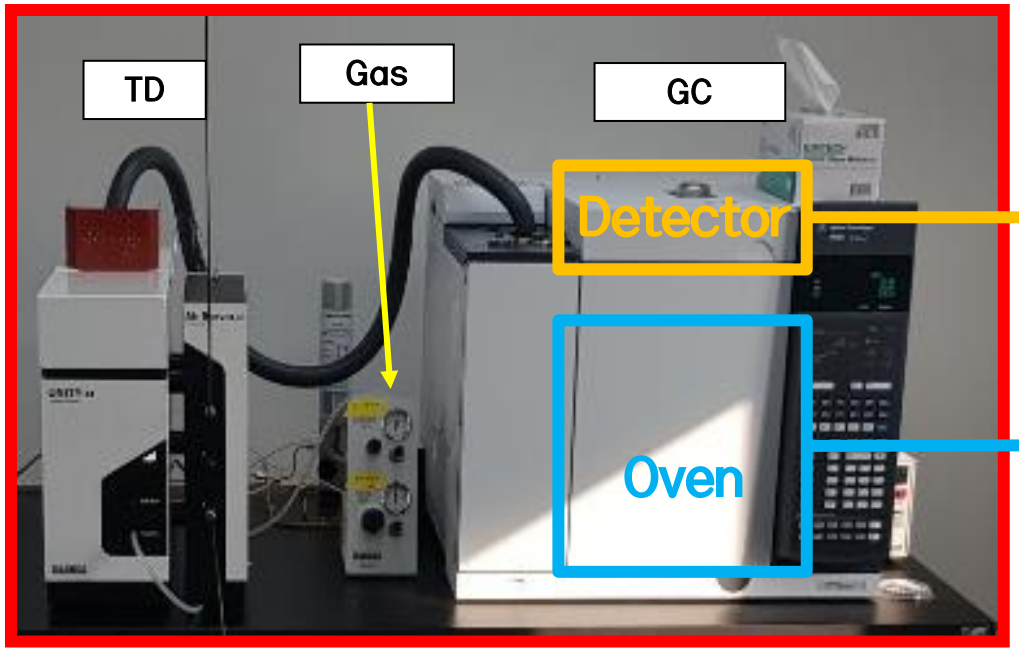
- Planning to expand from 53 sites(2022) to 64 sites(2025)

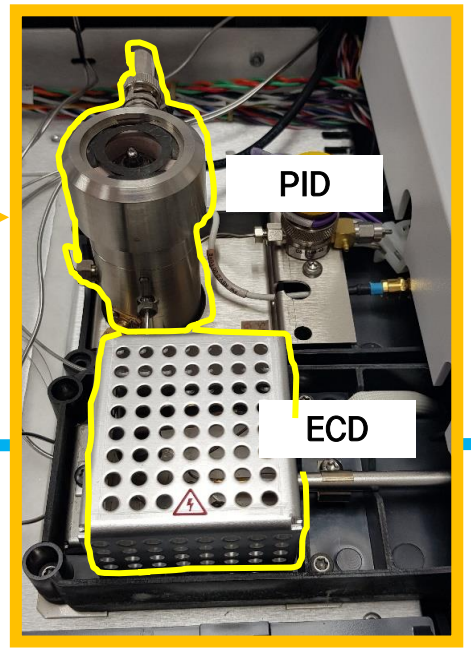
GC/ECD-PID

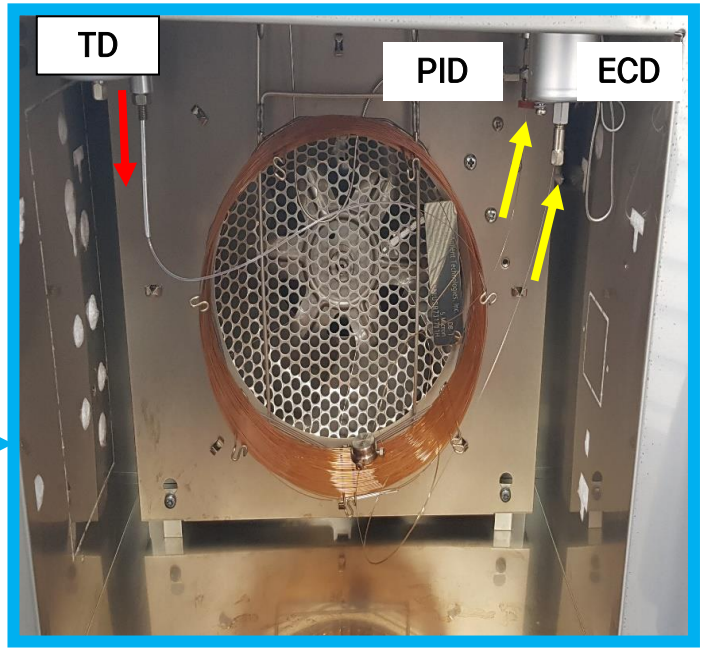
Installation (Unity/ Air-server -xr with Agilent GC / ECD-PID)

GAS

- Carrier Gas (N_2) -> about 30 psi
- Purge Gas (Air) -> about 45~60 psi
- Naflon dryer (N_2) -> about 100~200 psi





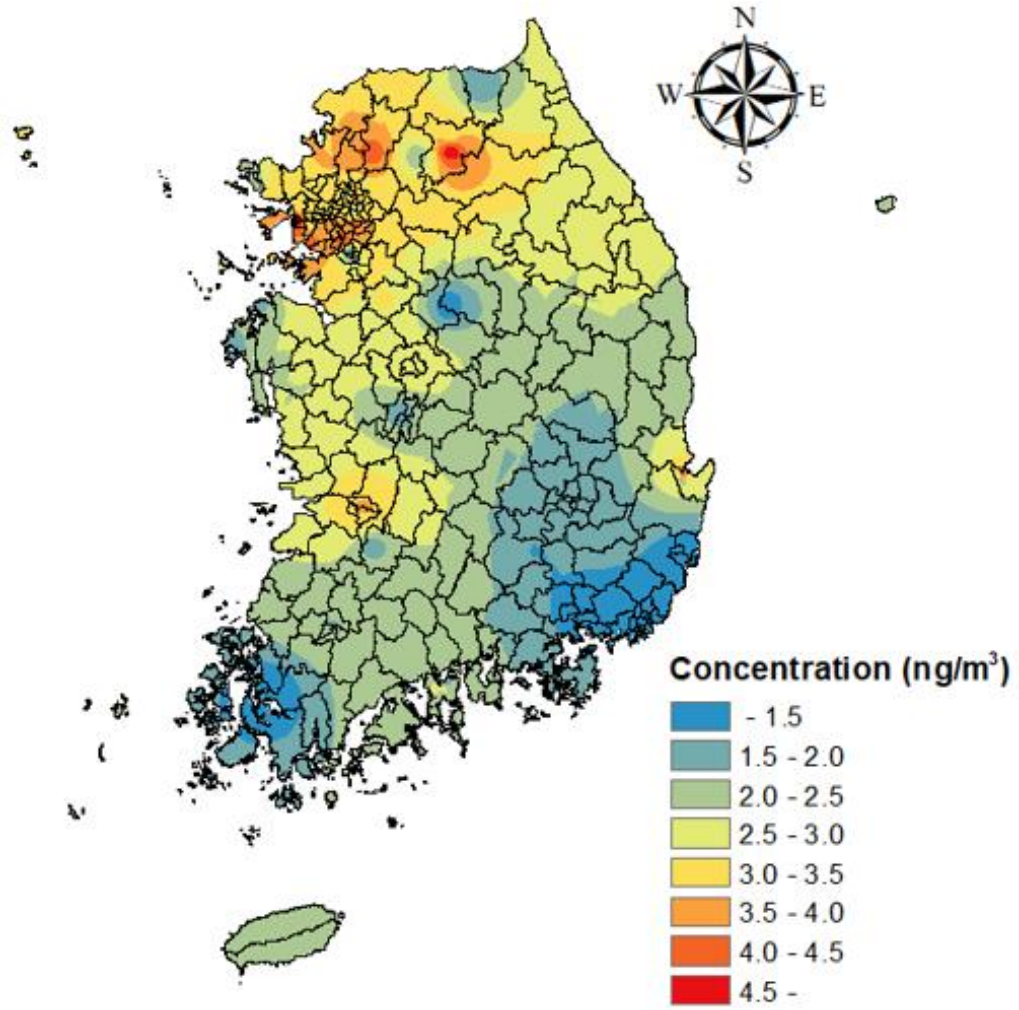


▪ VOCs and PAH internal quality control

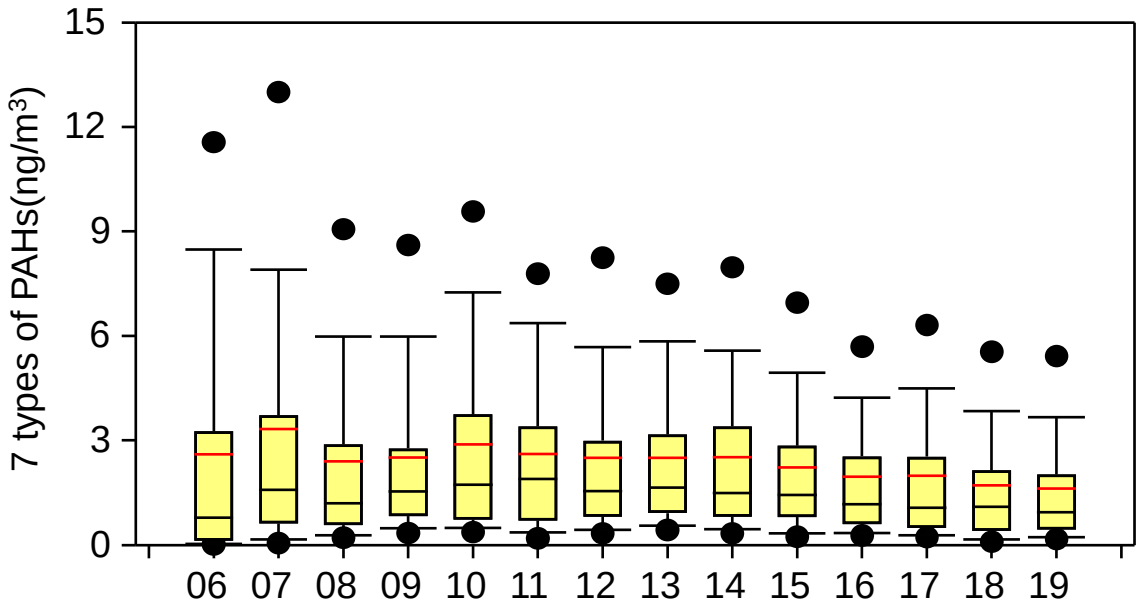
Item	quality control procedure	Criteria for judgment	Inspection cycle	Action in case of nonconformity
Background test	analysis of system blank using zero air or high quality N_2 gas	the detection concentration of each substance is 0.05 ppb or less	quarterly inspection or replacement of major parts	1) Repeat analysis 2) System leak check 3) System cleaning 4) Column and Sample Trap conditioning
Linear	Create a calibration curve of at least 3 to 5 (the expected concentration of each substance must be within the range of the calibration curve)	the correlation coefficient must be 0.98 or more	weekly or replacement of major parts	1) Repeat analysis 2) Revaluation of Linearity 3) Revaluation with New Standard
Reproducibility	working standard analysis with the intermediate concentration level used to create the weekly calibration curve	variation of individual substance residence time ± 0.1 minutes, Relative Percent Difference(RPD) ± 20 %	weekly or replacement of major parts	1) Repeat analysis 2) Revaluation with New Standard
Method Detection Limit(MDL)	conducted in accordance with the US EPA estimation method (40 CFR136 Part B)	MDL=t(n-1, 0.99) × S approximately the detection limit analysis at least 7 times (Use concentrations below 1)	quarterly inspection or replacement of major parts	1) Repeat analysis 2) Revaluation with New Standard

02 VOCs & PAHs – Current Status

◆ **Spatial Distribution of 7 types of PAHs Concentration (2006-2019)**



PAHs:
Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene, Benzo(a)pyrene`

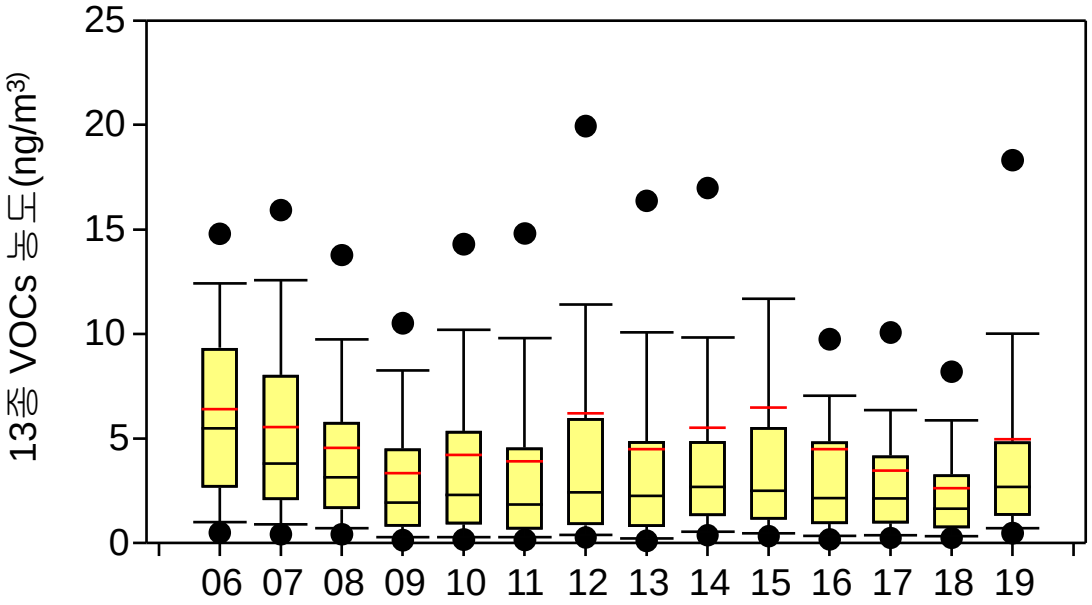


■ **Conc. : Roadside > Residential, Industrial > Background**

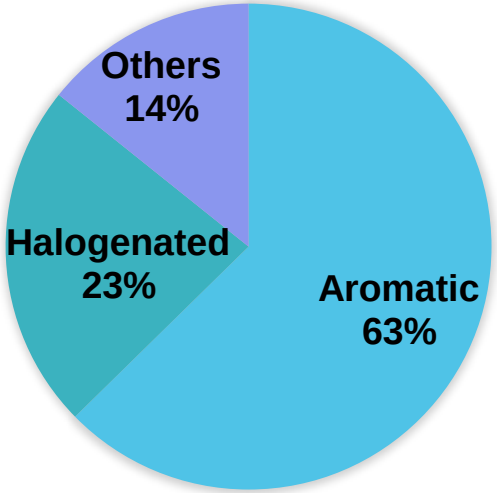
- Decreasing trend overall
- Ratio of 7 Types of PAHs is similar depending on regional characteristics

02 VOCs & PAHs – Current Status

■ 13 Types of VOCs Concentration Trend (by year)



■ VOCs average ratio by its Group(2006-2019)



Aromatic VOCs:
Benzene, Ethylbenzene, Toluene, Xylene, Styrene

Halogenated VOCs:
Chloroform, Methylchloroform, Trichloroethylene, Tetrachloroethylene, 1,1-Dichloroethane, 1,1-Dichloroethane

Aromatic VOCs

■ **Conc. : Industrial > Roadside > Residential > Background**

- Toluene has highest spatial distribution
- Background area has increased trend of Benzene ratio, same trend as Industrial area(Xylene)
- Aromatic VOCs' ratio among VOCs is above 63%

Halogenated VOCs

■ **Conc. : Roadside, Industrial, residential > Background**

- In industrial part, Halogenated VOCs has increased trend
- Halogenated VOCs' ratio among VOCs is less than 23%
- 13 types of VOCs has no significant trend

03 Photochemical Assessment Monitoring Stations (O_3)

03 Photochemical Assessment Monitoring Stations – O_3

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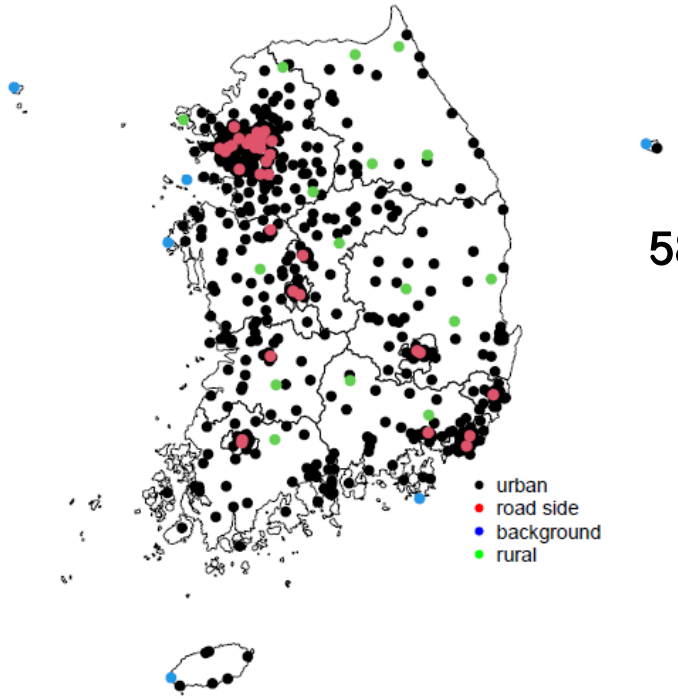
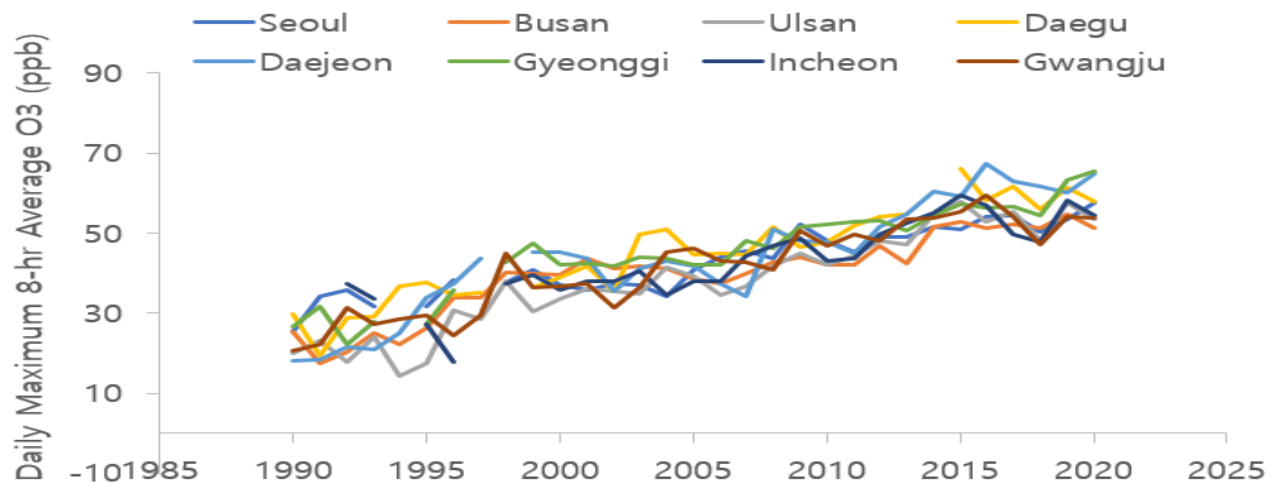
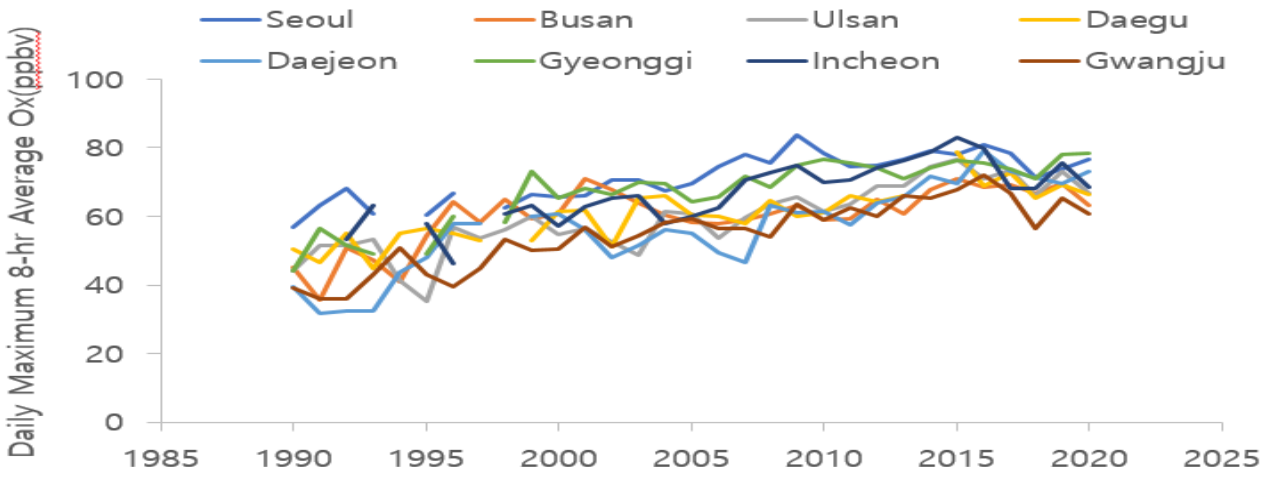
■ Comparison of Ozone Standard

	8-hr Avg.	1-hr Avg.
Korea	0.06 ppm	0.1 ppm
USA(EPA)	0.08 ppm	-
EU	120 ug/m³	-
WHO	100 ug/m³	-



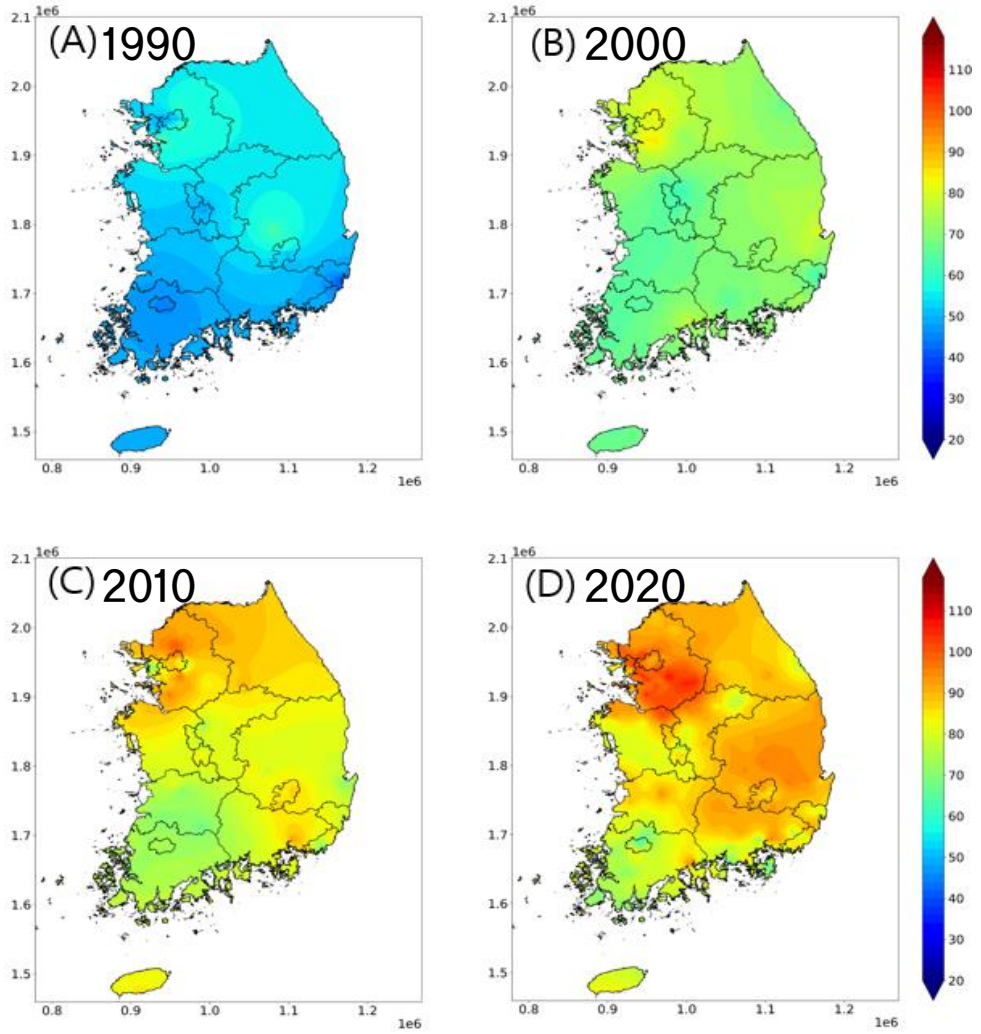
589 stations
(2022)





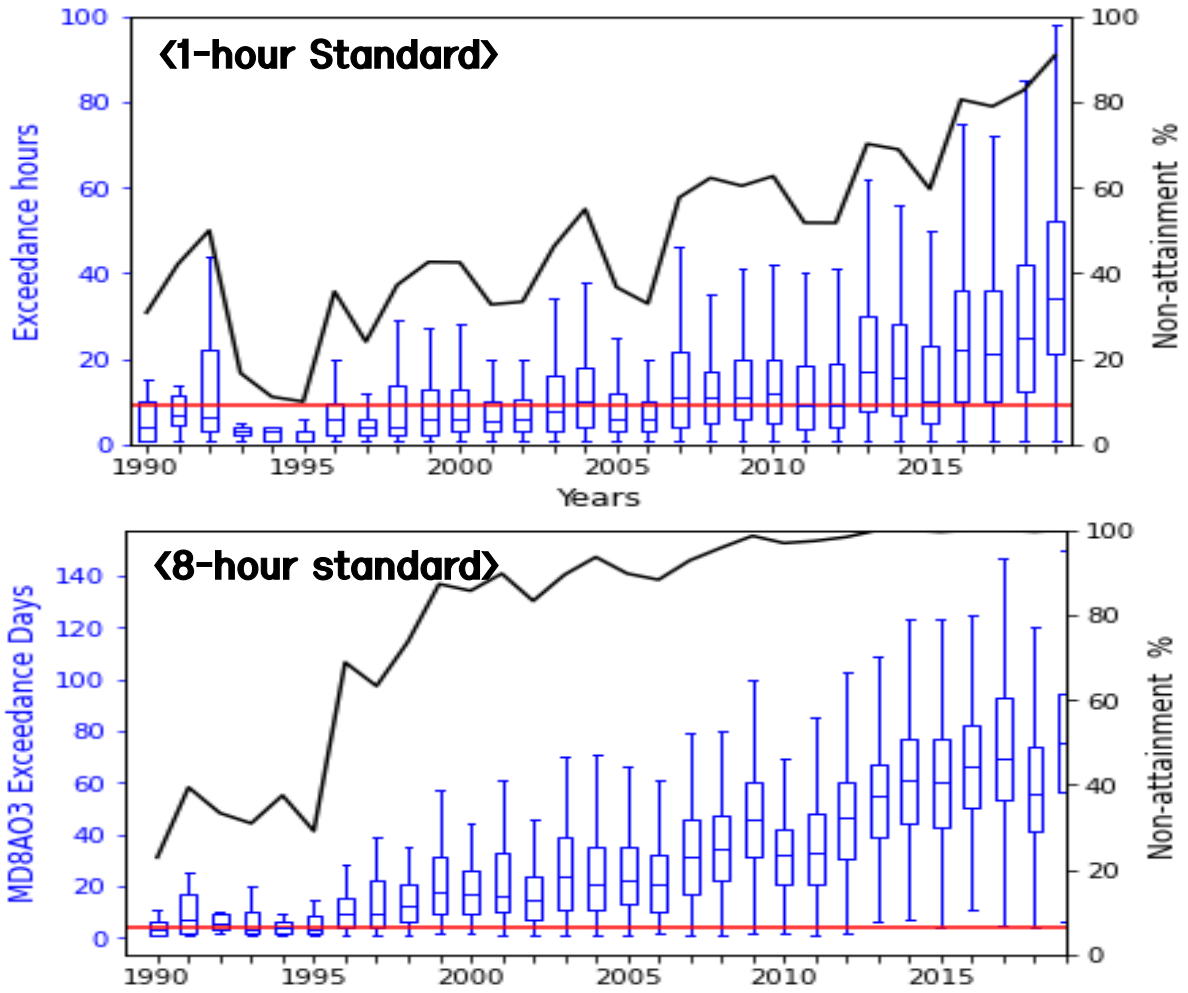
Increasing Rate of O_3 in Korea is ~1 ppbv/yr, O_x has recently decreased trend
→ Effect of NOx Reduction Policy

03 Photochemical Assessment Monitoring Stations

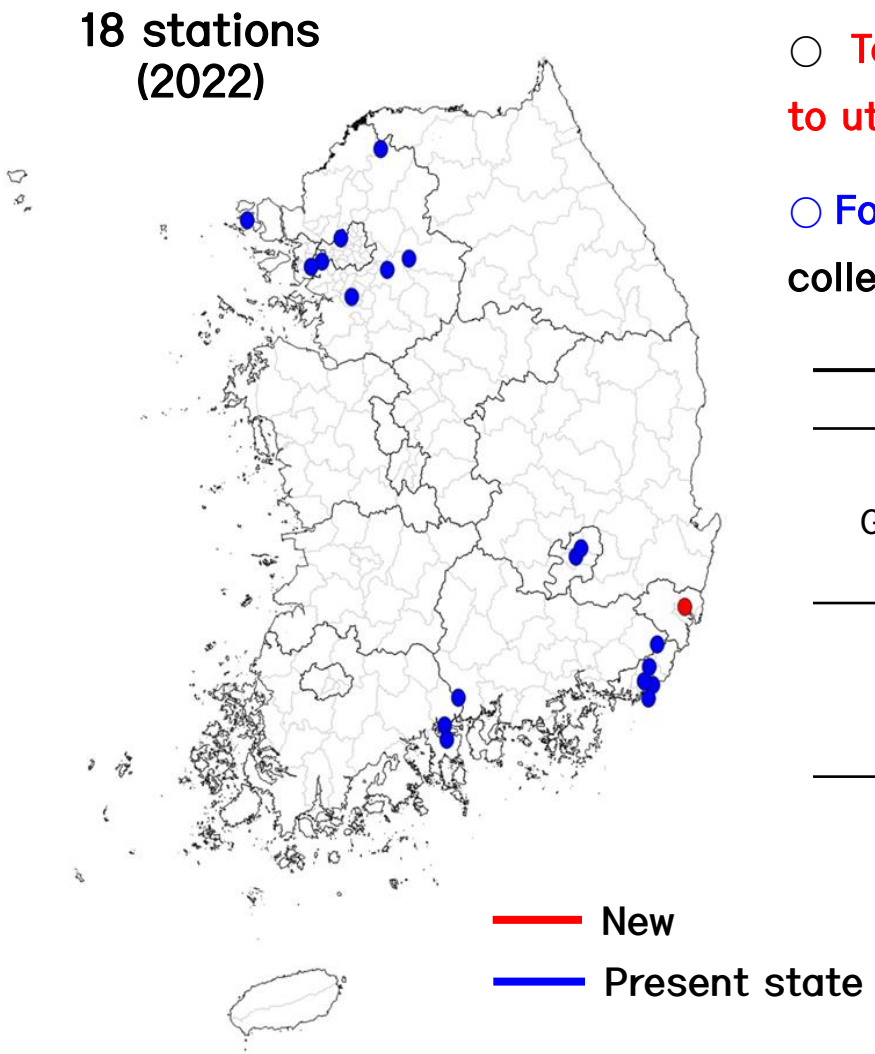


■ Spatial Distribution of 99 percentile of Daily Maximum 8 hours Average O_3 Conc. (MDA803) by year

■ Distribution of overtime and non-achievement rate nationwide of ozone standards



03 Photochemical Assessment Monitoring Stations



□ Aim of Operation

○ To monitor and collect the data of VOCs, which are ozone precursor substances, and to utilize as fundamental data searching for phenomenon caused by ozone

○ Focusing on Seoul Metropolitan Area(SMA), Daegu, Busan and Yeosu to monitor and collect the data of VOCs

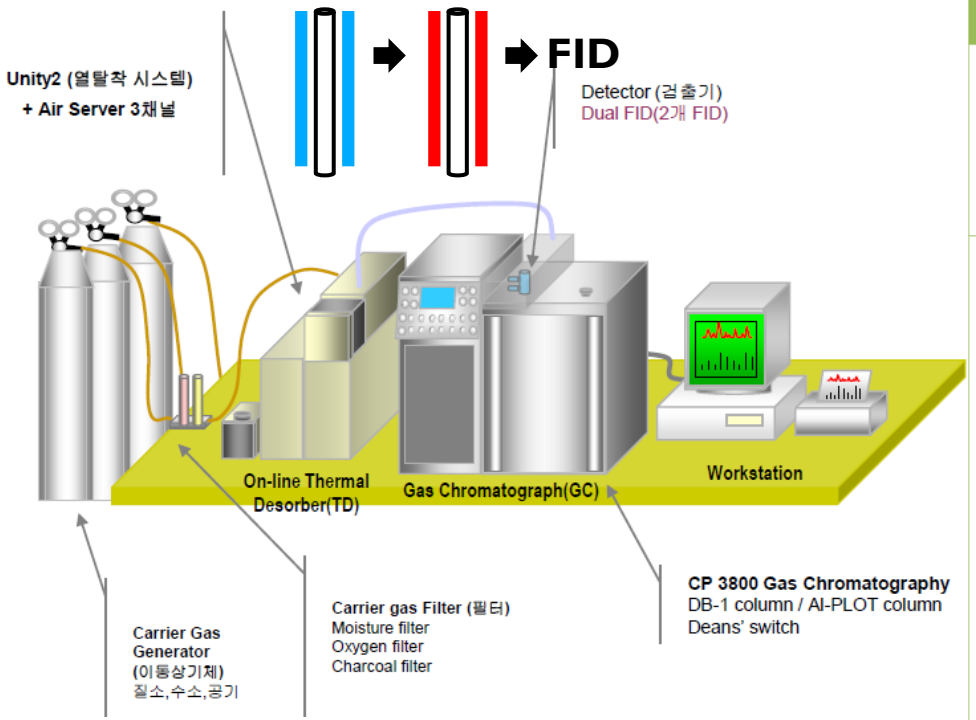
List	Items	Sampling Cycle
General	1. NOx, 2. NOy, 3. PM-10, 4. PM-2.5, 5. O_3, 6. Low Conc. CO, 7. Weather(Wind Direction, Wind Speed, Temperature, Humidity, Insolation, Ultraviolet Radiation, Rainfall, Atmospheric Pressure)	1 Hour term (throughout the year)
VOCs	Benzene, Propane, etc (Ozone precursor 56 species)	1 Hour term (throughout the year)

□ Location selection

- High Conc. O_3 generated region among metropolitan areas in Korea
- High Conc. O_3 generated region among less than a half million populations area or industrial area emitted lots of VOCs

■ Photochemical Assessment Monitoring Stations(PAMs)

- PAMs has been operated to monitor and collect the data of VOCs, which are ozone precursor substances as well as harmful to the human body
- PAMs is helpful to not only monitor those substances also reserve the data which come up with the effective countermeasures



Index	QA/QC	Procedure	Criteria	Period	Action in case of nonconformity
Environment	Temperature	Temp. measurement at the station	10-25℃	Once a week	Control the Temp.
	Condition of measurement instruments	Depending on the instrument manual	Depending on the instrument manual	Once a week	Depending on the instrument manual
	Condition of sample line	Depending on the instrument manual	Depending on the instrument manual	Once a week	Depending on the instrument manual
Measurement	Background Test	Using High purity nitrogen, BKG test	1)PLOT+BP-1 ≤ 2ppbV or 20ppbC 2)Each Components Peak ≤ 2ppbC	Twice a year (Additional Check-up when the main part is replaced)	1) Repeat 2) Leak Check 3) Cleaning Check 4) Sample Trap Conditioning
	Linearity	Preparation of standard mix gas **(1,5,10ppb)** **3 point Calibration**	Correlation coefficient **≥ 0.995**	Twice a year (Additional Check-up when the main part is replaced)	1) Repeat 2) Redrawing the calibration curve using new standard gas
	Accuracy, Precision, Resolution (Qualitative/Quantitative Assessment)	Check the Each components' RT and the Accuracy/ Precision of Propane& Benzene	RT: ± 0.5 min % Recovery: 80-120% RPD%: ± 20% (Daytime interval, twice continual analysis)	Once a week	1) Repeat 2) Redrawing the calibration curve using new standard gas
	Detection Limit	Following the USA EPA MDL Method (40 CFR136 Part B)	**MDL=t(n-1, 0.99) × S**	Twice a year (Additional Check-up when the main part is replaced)	Repeat

Thank you for your attention.

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