Asia Center for Air Pollution Research
Japan Environmental Sanitation Center

The EANET Project for Promoting VOCs related Capacity Building in the EANET

General Introduction to VOCs Monitoring and Measurement Methods

Asia Center for Air Pollution Research
Network Center for the EANET
https://www.acap.asia
eanet@acap.asia

OUTLINE

- **Background**
- **Common VOC monitoring techniques**
- **VOC measurement methods**
- **Summary**

Background

- Volatile Organic Compounds (VOCs) are organic chemicals that easily evaporate at ambient temperature.
- Health impacts: Respiratory issues, irritation, and carcinogenic risks.
- Environmental impacts: Contributes to smog and air pollution.

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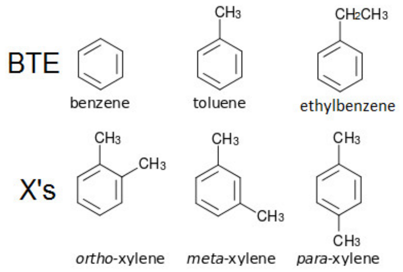


Sources: Industrial processes, vehicle emissions, household products.

Overview of key regulations

unit: µg/m^3

Compound	EPA[1]	WHO[2]	Japan Environmental Standard	Japan Guideline value
Benzene	1.3~4.5	1.7	3	-
Trichloroethylene	2	23	130	-
Tetrachloroethylene	40	250	200	-
Dichloromethane	-	3000	150	-
Acrylonitrile	0.1	0.5	-	2
Chloroethene	2.3	10	-	10
Chloromethane	-	-	-	94
Chloroform	0.4	-	-	18
1,2-Dichloroethane	0.4	700	-	1.6
1,3-Butadiene	0.3	-	-	2.5

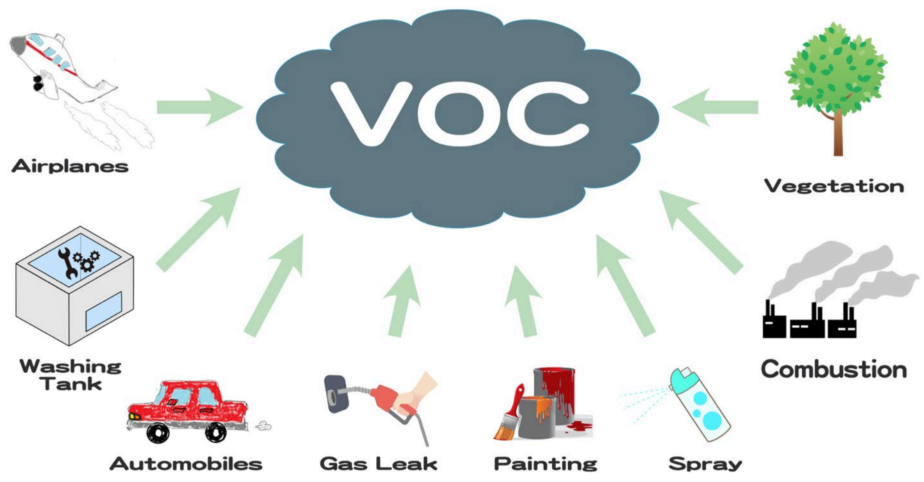
1) 10^{-5} risk level equivalents based on unit risk established by EPA
Ref : EPA Home Page Integrated Risk Information System (IRIS)

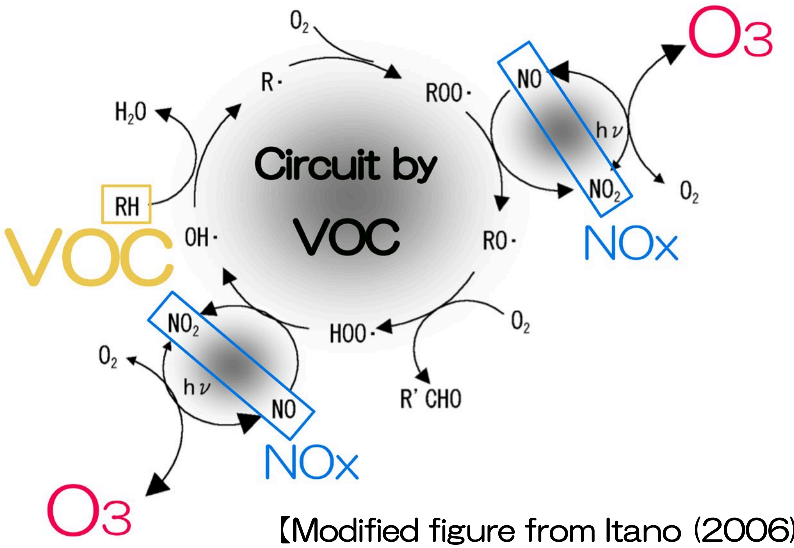
2) WHO Regional Office for Europe guideline values or 10^{-5} risk level equivalents
Dichloromethane and 1,2-dichloroethane are evaluated as daily averages
Ref : Air Quality Guidelines for Europe Second Edition(2000)

Background

- **Precursors of $PM_{2.5}$ and Ozone**
  Understand the relative contribution from VOCs to secondary formation of $PM_{2.5}$ and Ozone to make the co-control policy.
- **Harmful effect on human health**
  Understand the concentration and identify the main sources of harmful VOCs to formulate the new air quality index including harmful VOCs.
- **Difficulty of VOCs measurement**
  Because of the complicated VOCs characteristics and high cost of measuring technology, it is important to enhance the capacity of VOCs measurement in EANET.

Formation Mechanism of Photochemical Ozone





【Modified figure from Itano (2006) 】

Common VOC Monitoring Techniques

1. Active Sampling (e.g., Sorbent Tubes, Canisters)

Air is actively pumped through a sorbent material to capture VOCs.

2. Passive Sampling (e.g., Diffusion Tubes)

VOCs diffuse onto the sorbent material without active airflow.

3. Real-Time Monitoring (e.g., PID Sensors, FTIR Spectroscopy)

Continuous monitoring with immediate data feedback.

Active vs. Passive Sampling

- Active Sampling:

  - Requires a pump, more accurate but more expensive.

- Passive Sampling:

  - No pump needed, simpler and cost-effective.

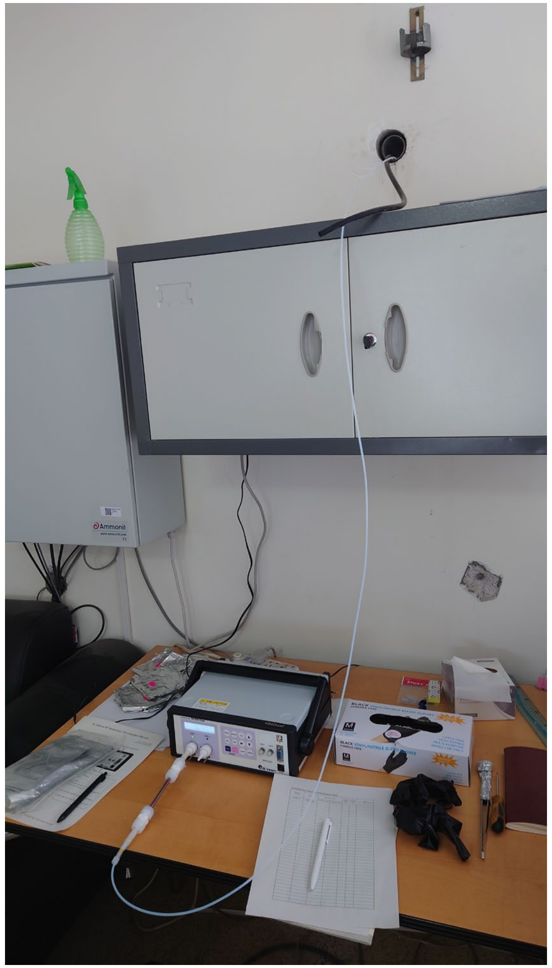
  - Used for long-term, low concentration monitoring.

Pump and sorbent-tube sampler

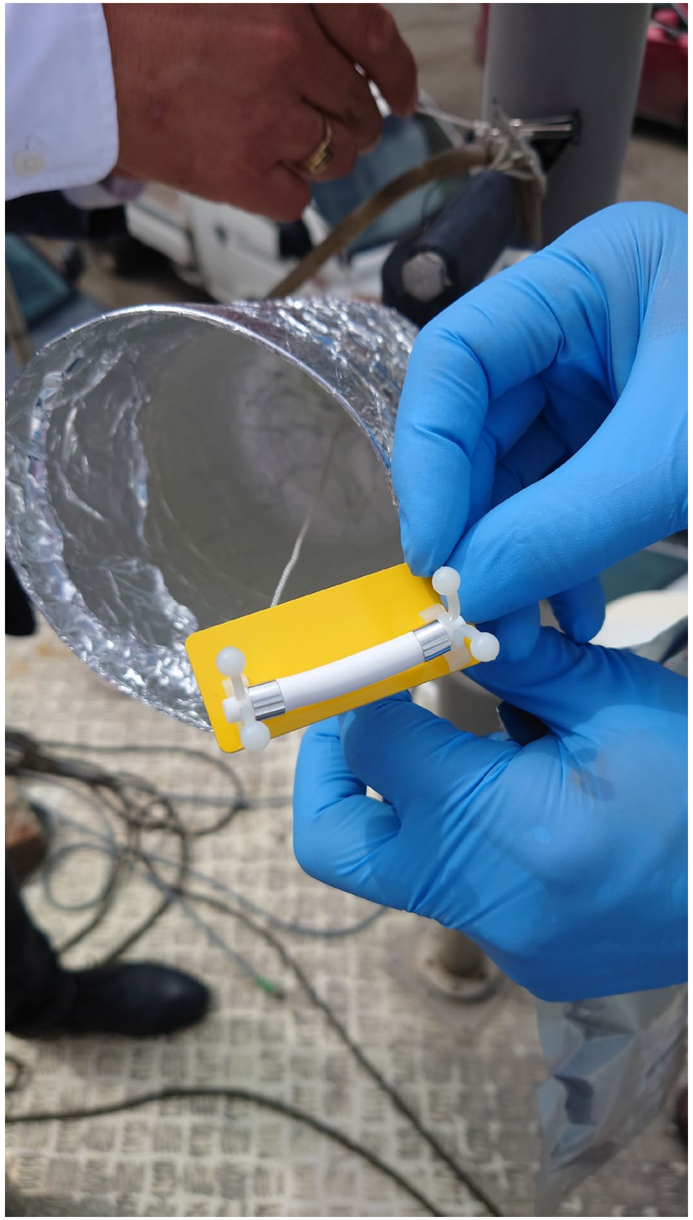
Passive sampler and shelter

Sorbent tubes for VOC monitoring

(Sorbent tube and GC/MS US EPA TO-17)



Passive Sampling Methods



Factors Affecting VOC Monitoring

- Sampling location

  Urban, rural, remote, industrial areas, residential areas, and other specific environments.

- Sampling time

  Daily, hourly, instant, and continuous online sampling.

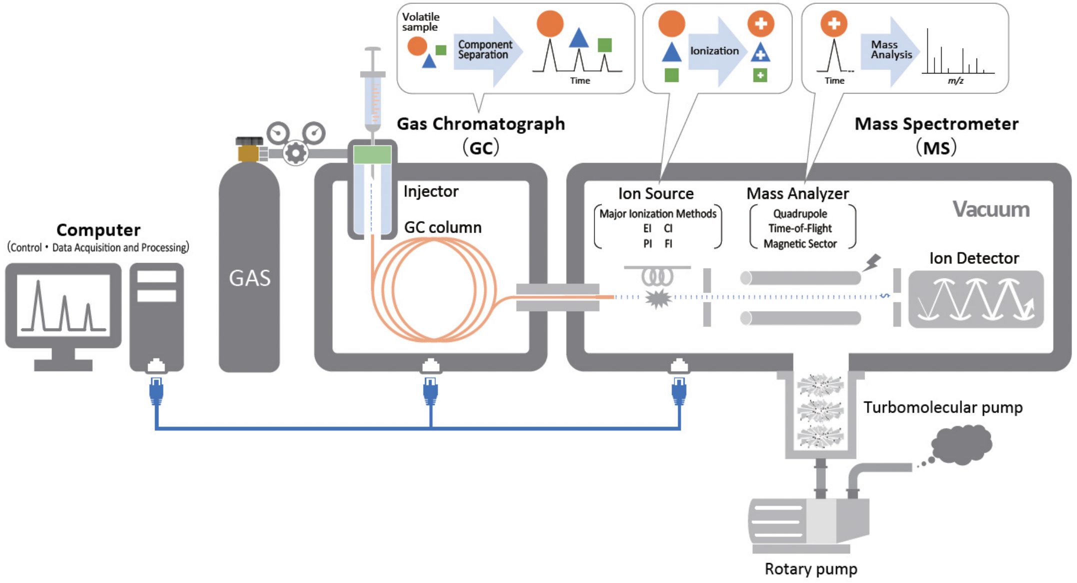
- Meteorological conditions

  Wind direction, wind speed, ambient temperature, humidity, and other atmospheric factors.

- Challenges in VOC Monitoring

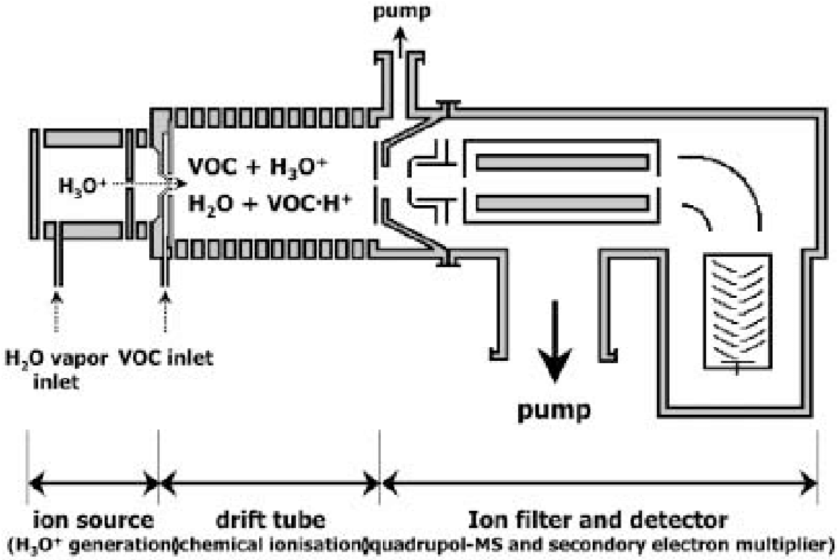
  Low detection limits, complexity of VOC mixtures, high costs, time-consuming processes, sensor calibration, and environmental interference.

VOC measurement methods

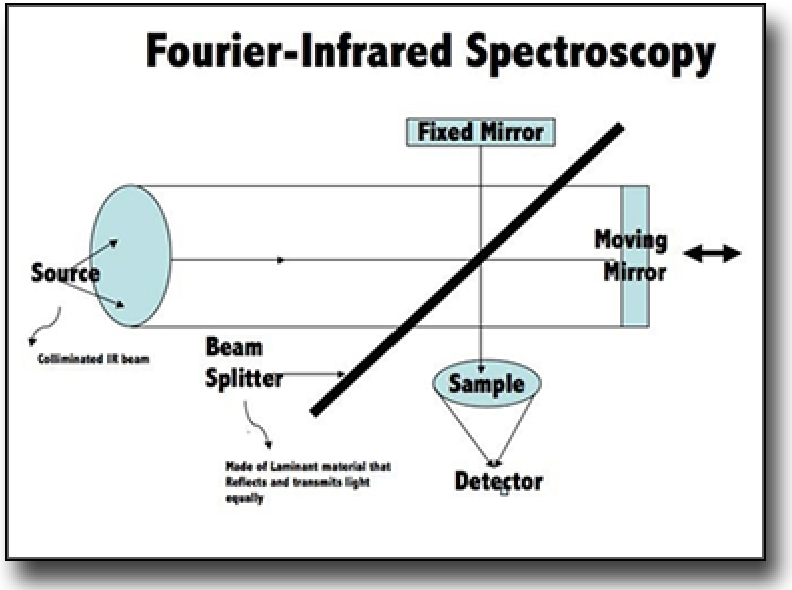


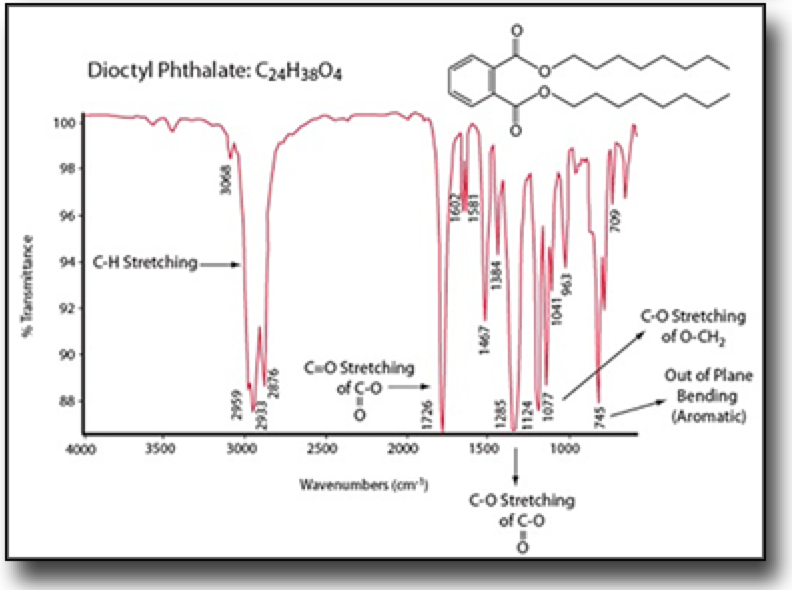
Gas chromatography-mass spectrometry (GC-MS)

(Canister and GC-MS US EPA TO 15)



Proton transfer reaction mass spectrometry (PTR-MS)





Fourier transform infrared spectroscopy (FTIR)

(US EPA TO-16)

Real-Time VOC Measurement Technologies

•On-line GC/FID/PID, On-line GC-MS/FID, PTR/MS, DOAS

- **Photoionization Detectors (PIDs):**

  Uses UV light to ionize VOCs and detect concentrations in real-time.

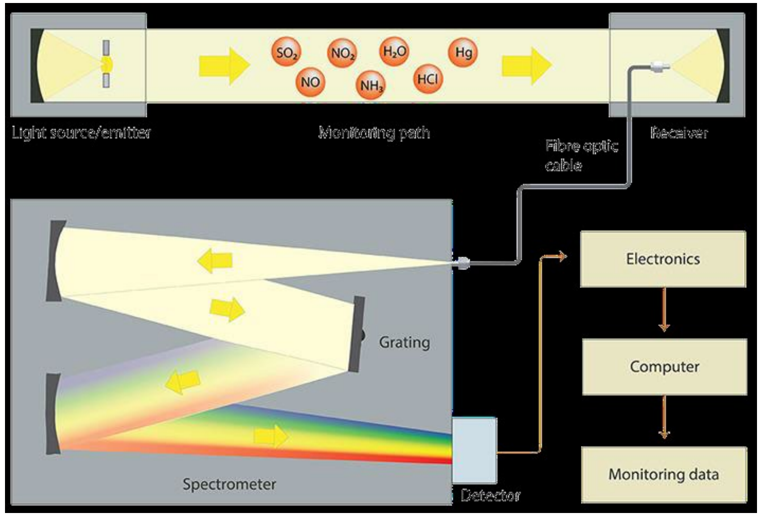
- **Flame Ionization Detectors (FIDs):**

  Burns sample gas to ionize VOCs for measurement.

- **DOAS (Differential Optical Absorption Spectroscopy)**

  DOAS is based on Beer Lambert's absorption law. It is the principle used on the detection of concentration of a selected gas in a mixture based on the ability of gases to absorb unique light wavelengths. One system can monitor NO2, SO2, O3, Benzene, Toluene and P Xylene.

On-line BC monitor (left) and VOC monitor GC-PID (right) from Ewha Womans University, Korea



Principle of DOAS system

Summary

Method	Advantages	Disadvantages
Sorbent-tube	Small size, lightweight, and easy to carry; a wide range of adsorbent options are available to match different target substances.	Easily susceptible to human contamination; during sampling, reactions with the target compounds may cause collection losses.
Canister	Capable of collecting whole air samples; convenient for sampling and analysis; allows for repeated analysis from a single sample; samples are easy to preserve.	Highly polar compounds may degrade during storage.
On-line GC	Good selectivity; high sensitivity; fast analysis speed; capable of measuring a wide range of species.	Standard compounds are required for qualitative analysis.
On-line GC-MS/FID	Low detection limit; high time resolution; comprehensive measurement of species.	The measurement of highly polar compounds is easily affected by wall effects; unable to measure formaldehyde; high operational and maintenance costs.
OP-FTIR	Open-path spectroscopy preserves sample integrity and results in minimal chemical contamination.	High detection limit; limited spectral dataset for compounds.
PTR/MS	No separation required, extremely high time resolution; samples can be injected directly; high sensitivity and low detection limit.	Unable to differentiate between isomers; limited range of measurable species.

Summary and Conclusions

- VOC monitoring is essential for health, environmental, and industrial safety.
- A variety of methods exist, ranging from passive to real-time monitoring.
- Proper method selection depends on application, cost, and accuracy needs.
- Future Trends in VOC Monitoring

  Advanced analytical techniques, Continuous monitoring systems

  Remote sensing methods, Data analysis and modeling


Thank you very much for your attention