

# Introduction of VOCs

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# Definition of Volatile Organic Compounds (VOCs)

## General description:

- organic compounds;
- vaporize at room temperature
- Low boiling point at standard pressure/high vapor pressures at room temperature;
- Low molecular weights and low-to-medium water solubility;
- Air pollution and indoor pollution

## EU:

Low b.p., <250°C, at a standard atmospheric pressure

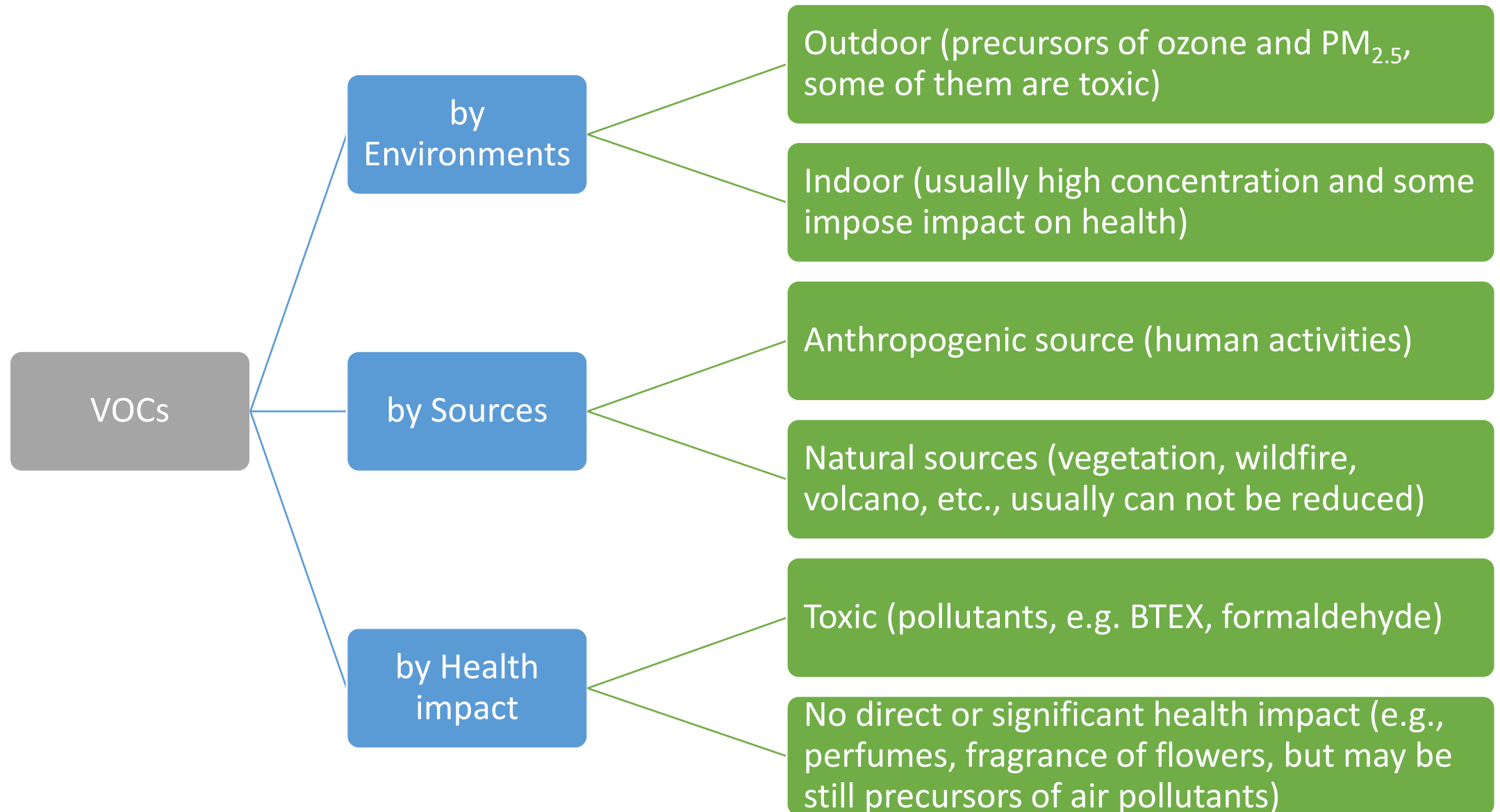
## WHO:

- **Very Volatile or VVOC** (b.p. <0 to 50-100 °C): Propane, butane, methyl chloride;
- **VOC** (b.p. 50-100 to 240-260 °C): Formaldehyde, d-Limonene, toluene, acetone, ethanol (ethyl alcohol), hexanal;
- **Semi-Volatile or SVOC** (b.p. 240-260 to 380-400°C): Pesticides (DDT, chlordane, plasticizers (phthalates), fire retardants (PCBs, PBB)

## EPA regulatory definition:

- Impact photochemical oxidation in outdoor air (Reactive Organic Gases or ROG).
- Not necessarily the same species of concern as indoor pollution or ozone depletion in stratosphere.

# Classifications of Volatile Organic Compounds (VOCs)



# Chemistry of VOCs in Atmosphere

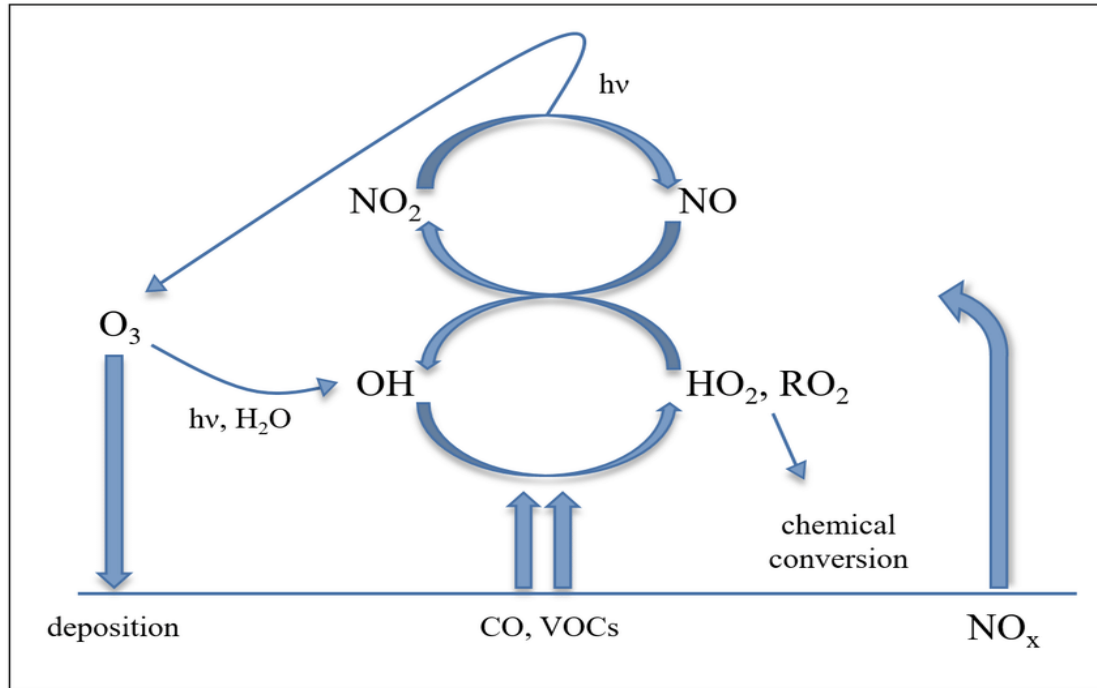
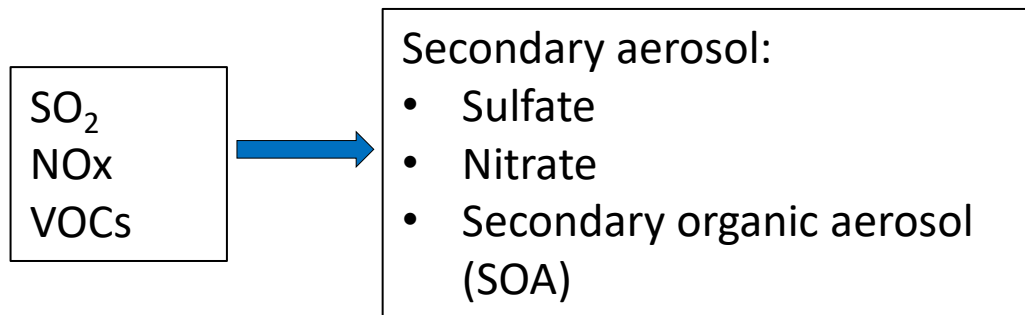


Figure 1. Simplified scheme describing the ozone chemical cycle. (Clara Betancourt1, 2021)



- Complicated reactions that leads to the formation of ground level ozone, SOA and involved in transformation of other air pollutants.
- Chemical species and structures:
  - Alkanes: saturated hydrocarbons like methane, ethane, etc.
  - Alkenes: with one or more double bonds, such as ethene and propene.
  - Aromatics: with benzene rings such as benzene and toluene etc.
  - Aldehydes: formaldehyde and acetaldehyde.
  - Ketones, such as acetone.
  - Alcohols, acids, .....
- Activities affect the chemical and physical processes
- Difficult to measure.
  - Low concentration;
  - different methods for different VOCs species or TVOC
  - Frequency of measurements and continuity.
  - Cost and data quality

# Anthropogenic VOCs Emission Sources

**Transportation or vehicles:** including cars, trucks, airplanes and off-road.



**Industrial Processes:** manufacturing, chemical production, and petroleum refining.



**Biomass Burning:** burning of wood, agricultural waste.



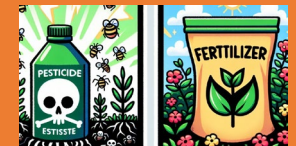
**Solvents and Paints:** the use of solvents in cleaning, painting processes and glues.



**Consumer Products:** products like perfumes, cleaning agents, and personal care products.



**Agriculture:** fertilizers, pesticides, and livestock.



- VOCs: a wide range of anthropogenic sources.
- Pattern: continuously or intermittently. From industrial processes might be released continuously, while those from household products might be emitted sporadically during use.
- Pathways: can be through various pathways, not just through stacks or pipes. They can evaporate from surfaces, during the use of products, or leak from equipment and storage containers.
- Chemical diversity: comprise a large and diverse group of organic chemicals, including alkanes, alkenes, aromatics, and oxygenated compounds. Chemical profiles of emission important.
- Volatility: related to the temperature.

# Natural VOCs Emission

## Natural VOCs Emission Sources

### Plants(Biogenic):

- Many plants emit VOCs, such as terpenes and isoprene, which contribute to the characteristic scents of forests and can play a role in plant communication and defense.

- Low concentration and spread widely.

### Forest fires and vegetation burning:

a significant amount of VOCs into the atmosphere.

### Volcanic eruptions:

Volcanoes emit various gases, including VOCs, during eruptions.

### Decomposition and microbial activity:

The breakdown of organic matter, such as dead plants and animals. certain bacteria and fungi produce VOCs as part of their metabolic processes.

It was estimated that the annual emission of BVOCs in the world was about 106 Gg C/year, accounting for more than 90 % of the total non-methane volatile organic compounds (NMVOCs) (Guenther et al. 1995,2012).



# Control of Anthropogenic VOCs Emissions

## 1. Source Control

- Material substitution: Use low-VOC or VOC-free materials in manufacturing and processing, e.g. using water-based solvents instead of organic solvents.

## 2. Process Control and modification

- Processes to reduce VOC generation,
- Leak Detection and Repair (LDAR): Regularly inspect and repair leaks in equipment and pipelines to prevent fugitive emissions.
- Enclosed systems: Use closed systems for storage and transfer to minimize VOC release.

## 3. Operational Procedures

- VOC management Plans: Develop and implement comprehensive plans that include monitoring, reporting, and mitigation strategies.
- Training: ensure staff are trained in best practices for handling VOC-emitting materials and equipment.

# Control of Anthropogenic VOCs Emission

## 4. End-of-Pipe Treatments

- **Thermal Oxidation:** Burn VOCs at high temperatures to convert them into less harmful substances like CO<sub>2</sub> and water.
- **Catalytic Oxidation:** Similar to thermal oxidation but uses a catalyst to lower the required temperature, making the process more energy-efficient.
- **Adsorption:** Use materials like activated carbon to capture VOCs from gas streams.
- **Absorption:** Use liquids to absorb VOCs from gas streams, which can then be treated or recycled.
- **Cryogenic Condensation:** Cool VOC-laden gases to very low temperatures to condense and remove VOCs.
- **Membrane Separation:** Use selective membranes to separate VOCs from gas streams.
- **Biotreatment:** Employ biological processes to degrade VOCs, often using biofilters or bioreactors.



The Acid Deposition  
Monitoring Network  
in East Asia (EANET)

Thank you very much!

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