

## “Capacity Building and Strengthening Institutional Arrangement”

### Analysis and sampling of air and air pollution

# PM<sub>10</sub> AND PM<sub>2.5</sub> MONITORING EQUIPMENT

**Mr. Alessandro Di Menno Di Bucchianico**

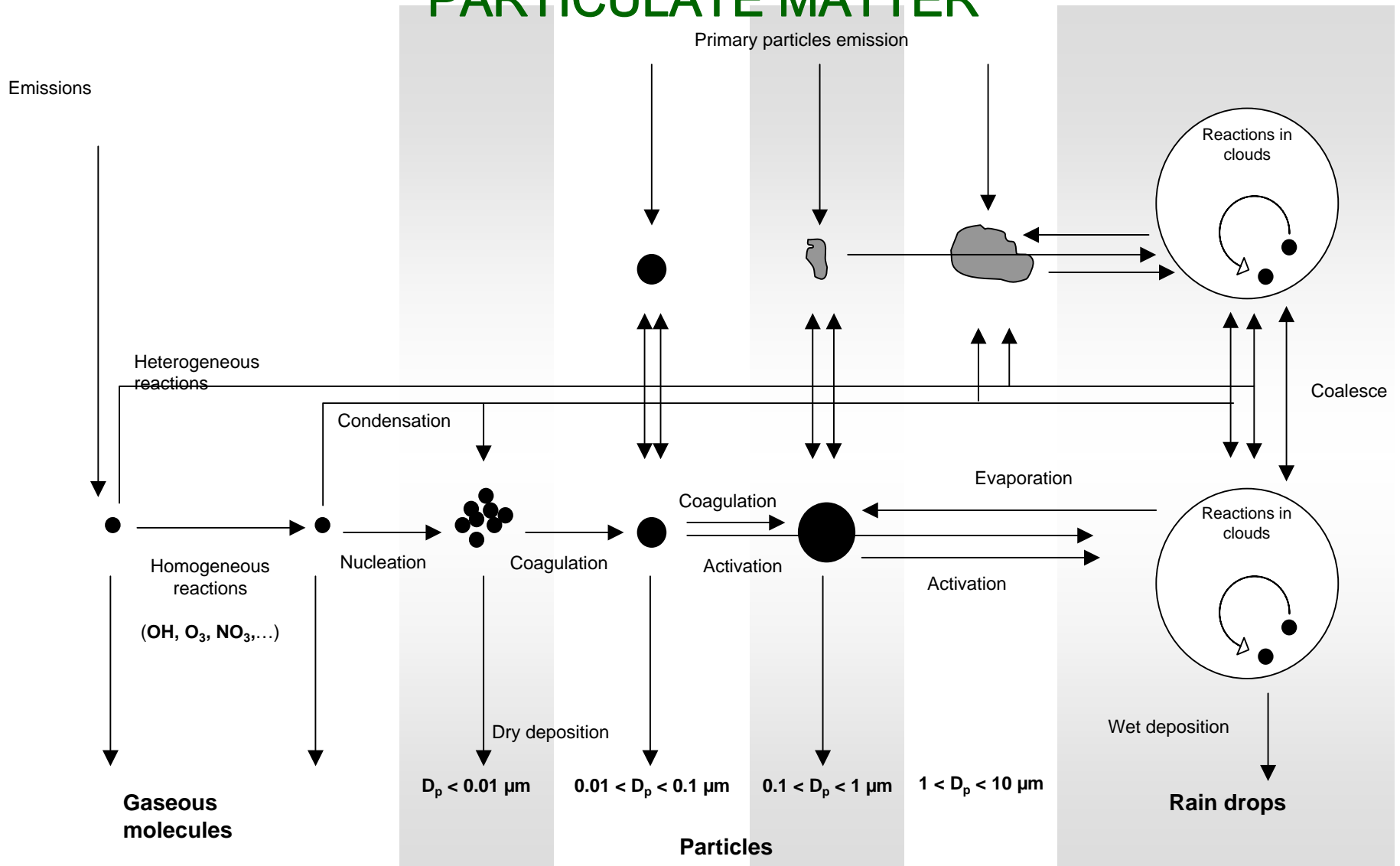
APAT

Agency for Environmental Protection and Technical Service

## GENERAL CONCEPTS

- Particulate matter consists in **liquid drops and/or solid particles**
- Particulate material can be **primary or secondary**:
  - **Primary particles** are composed of material emitted directly into the atmosphere;
  - **Secondary particles** form from condensable vapors formed by chemical reaction involving gas-phase precursors or by other processes.

# ATMOSPHERIC PROCESSES THAT INFLUENCE PARTICULATE MATTER

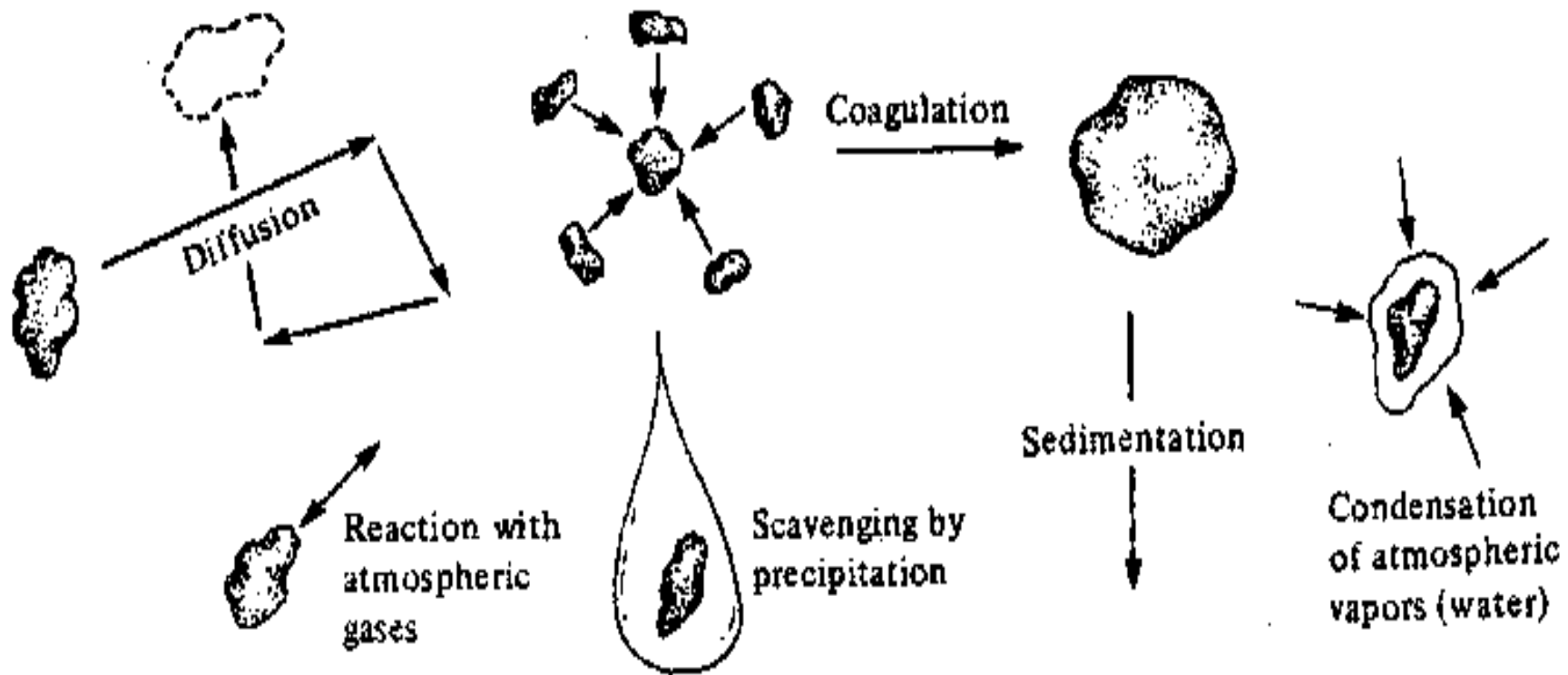


## SEA SPRAY

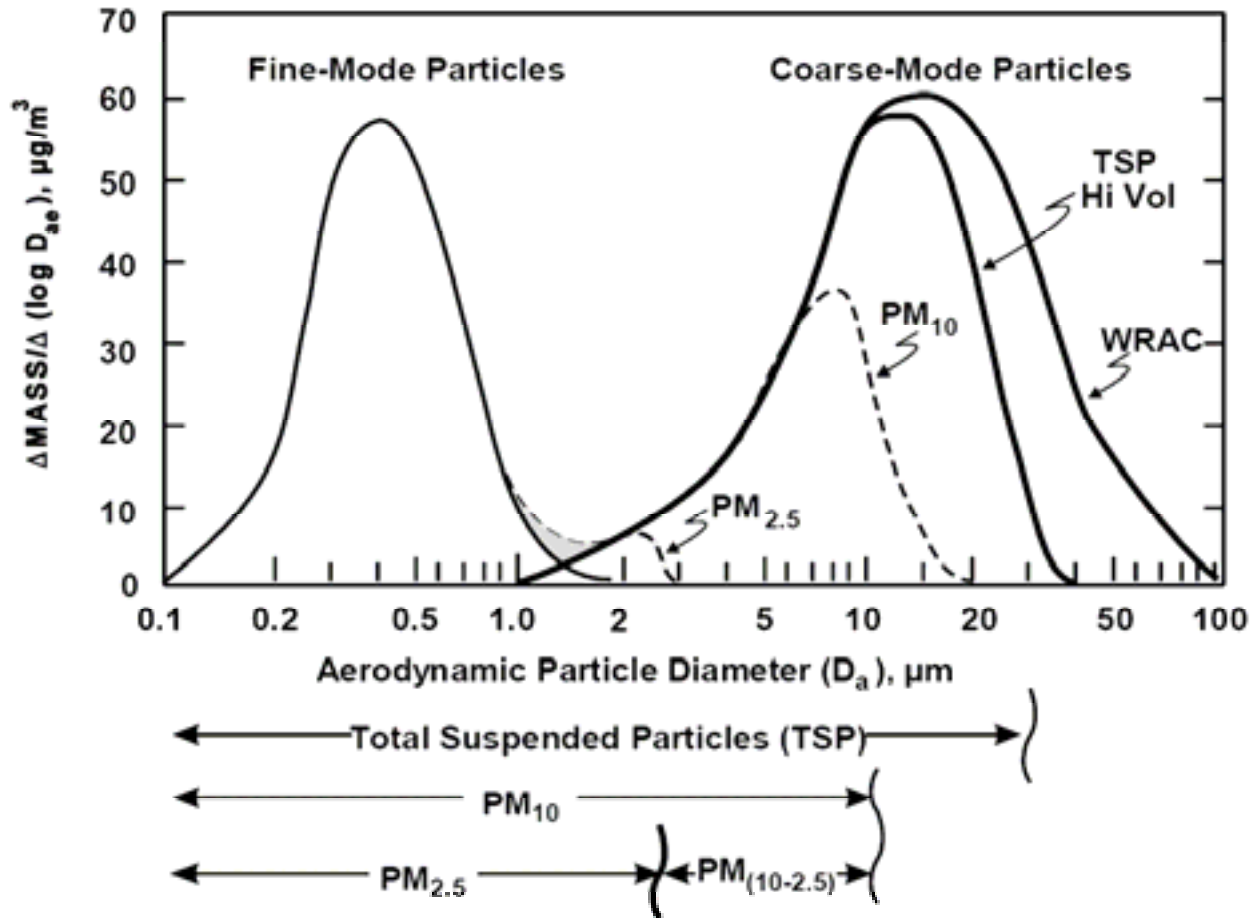


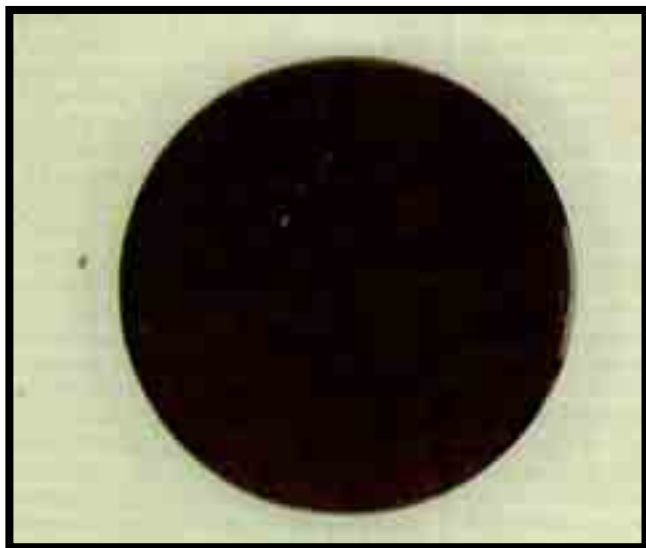
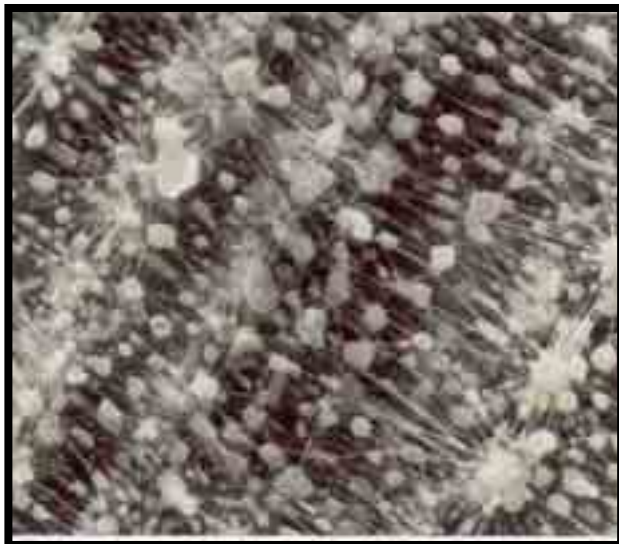
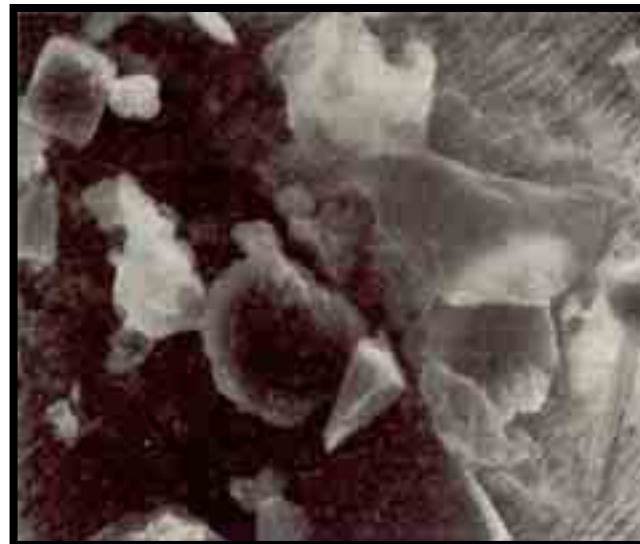
- The bursting of bubbles in seawater forms small liquid aerosol particles;
- Evaporation of water from the aerosol particles results in the formation on particles (sea salt nuclei).

# PROCESSES AFFECTING ATMOSPHERIC PARTICLES



## Idealized distribution of ambient particulate matter

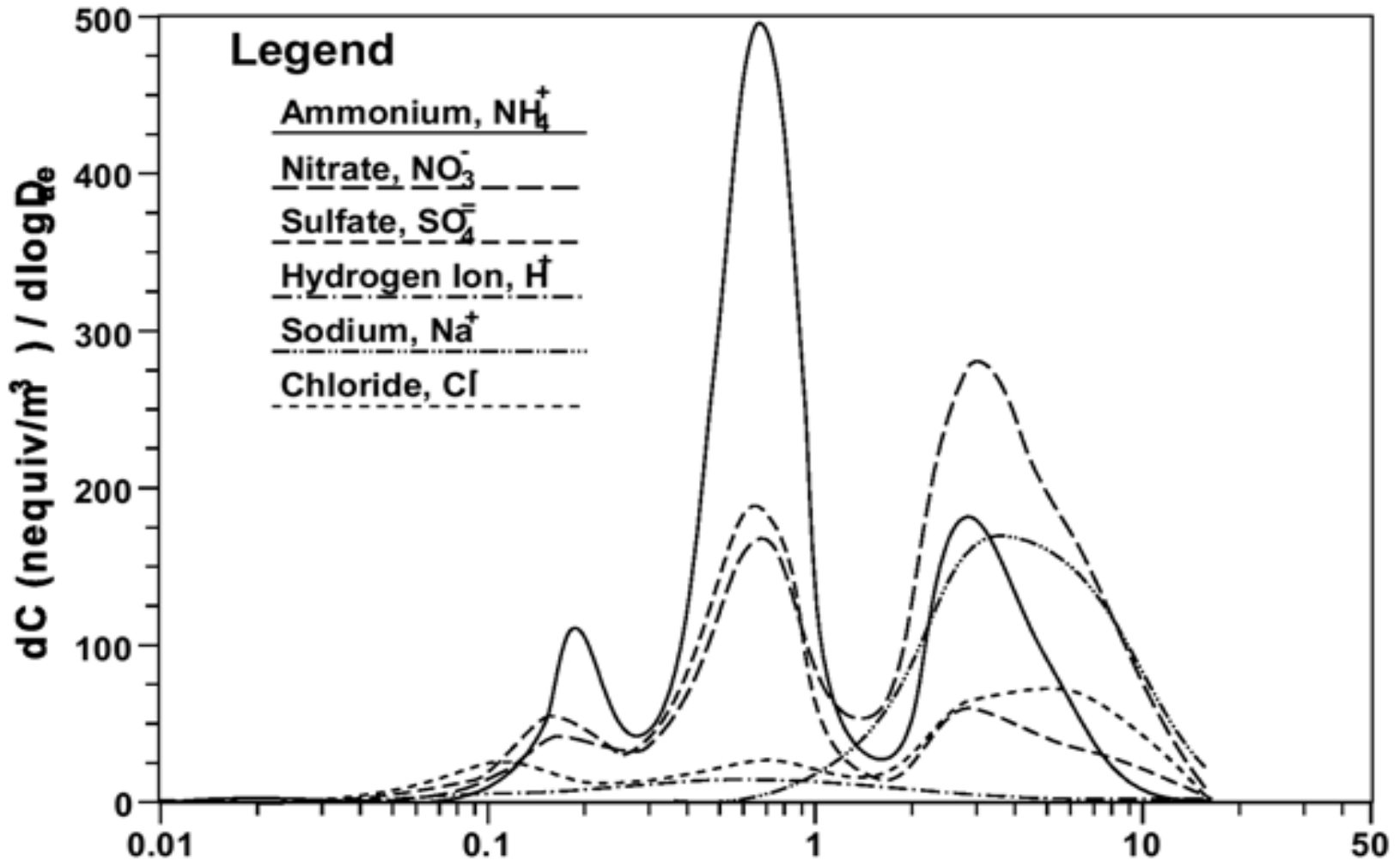


**FINE FRACTION****COARSE FRACTION**

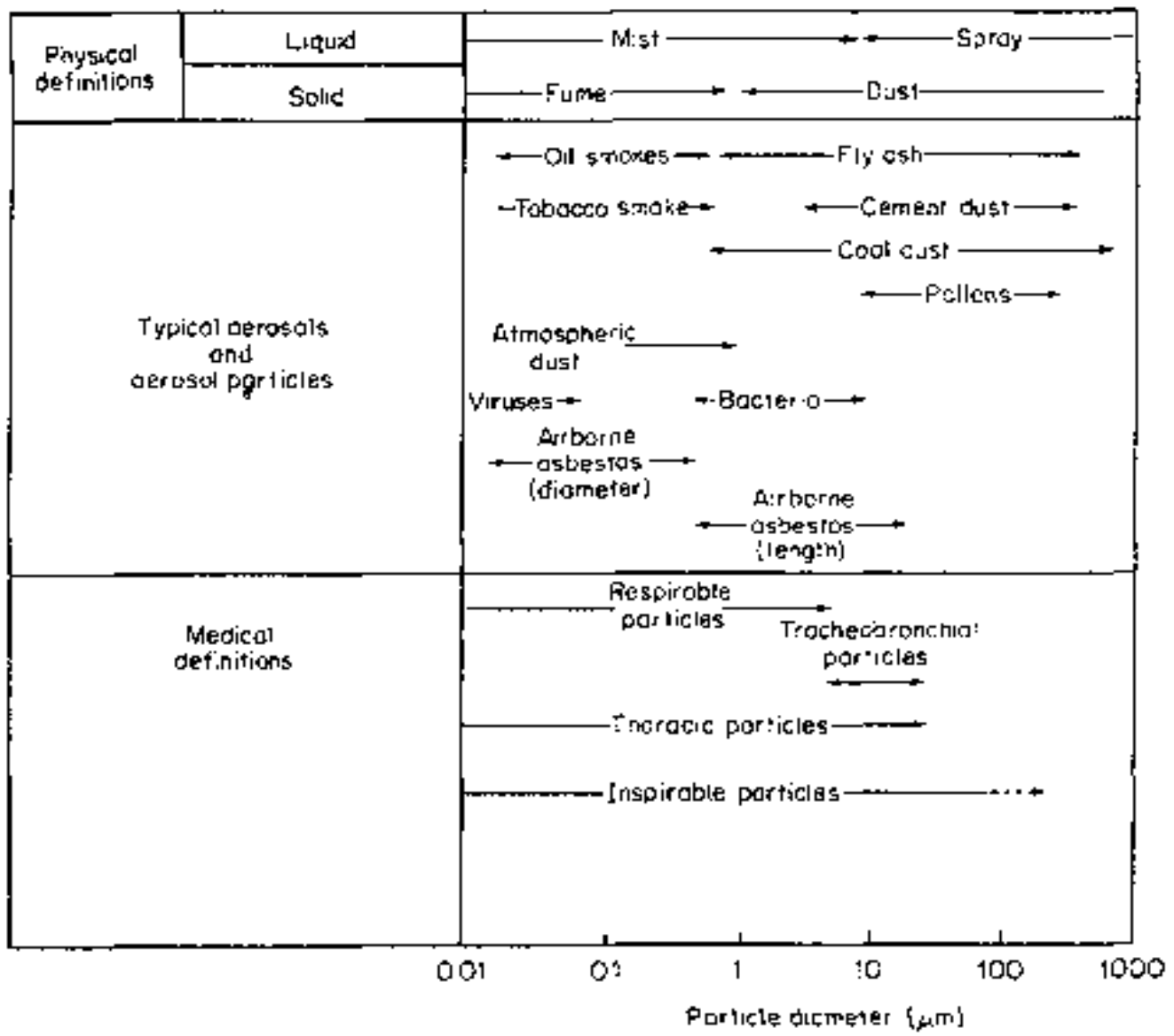
CONSTITUENTS OF ATMOSPHERIC FINE PARTICLES (<2.5 µm)				
PRIMARY SOURCES			SECONDARY SOURCES	
Species	Natural	Anthropogenic	Natural	Anthropogenic
<b>SO<sub>4</sub><sup>2-</sup></b>	Sea spray	Fossil fuel combustion	Oxidation of SO <sub>2</sub> and H <sub>2</sub> S emitted by volcanism and forest fire	Oxidation of SO <sub>2</sub> and H <sub>2</sub> S emitted from fossil fuel combustion
<b>NO<sub>3</sub><sup>-</sup></b>	---	Motor vehicle exhaust	Oxidation of NO <sub>x</sub> produced by soils, forest fire and lighting	Oxidation of NO <sub>x</sub> emitted from fossil fuel combustion
<b>Minerali</b>	Erosion re-entrainment	Fugitive dust; paved, unpaved roads; agriculture and forestry	---	---
<b>NH<sub>4</sub><sup>+</sup></b>	---	Motor vehicle exhaust	Emission of NH <sub>3</sub> from wild animals, undisturbed soil	Emission of NH <sub>3</sub> from animal husbandry, sewage, fertilized land
<b>Organic carbon (OC)</b>	Wild fires	Open burning, wood burning, cooking, motor vehicle exhaust, tire wear	Oxidation of hydrocarbons emitted by vegetation (terpenes, waxes), wild fires	Oxidation of hydrocarbons emitted by motor vehicles, open burning, wood burning
<b>Elemental carbon</b>	Wild fires	Motor vehicle exhaust, wood burning, cooking	---	---
<b>Metals</b>		Fossil fuel combustion, smelting, brake wear	---	---
<b>Bioaerosols</b>	Viruses, bacteria	---	---	---



CONSTITUENTS OF ATMOSPHERIC COARSE PARTICLES (>2.5 µm)				
PRIMARY SOURCES			SECONDARY SOURCES	
Species	Natural	Anthropogenic	Natural	Anthropogenic
<b>Minerals</b>	Erosion re-entrainment	Fugitive dust, paved, unpaved road dust, agriculture and forestry	---	---
<b>Metals</b>	Erosion re-entrainment, organic debris	---	---	---
<b>Ions</b>	Sea spray	Road salting	---	---
<b>Organic carbon</b>	---	tire and asphalt wear	---	---
<b>Organic debris</b>	Plant, insect fragments	---	---	---
<b>Bioaerosols</b>	Pollen, fungal, spores, bacteria agglomerates	---	---	---

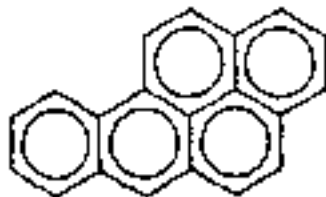


Ion concentration as a function of particle size

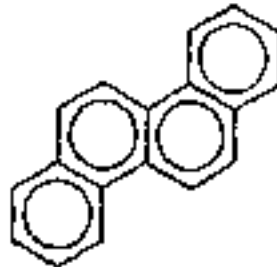


# ORGANIC CARBON

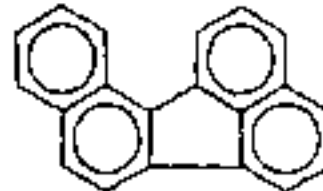
## POLYCYCLIC ORGANIC HYDROCARBONS (PAH)



benzo(a)pyrene



chrysene



benzo(j)fluoranthene

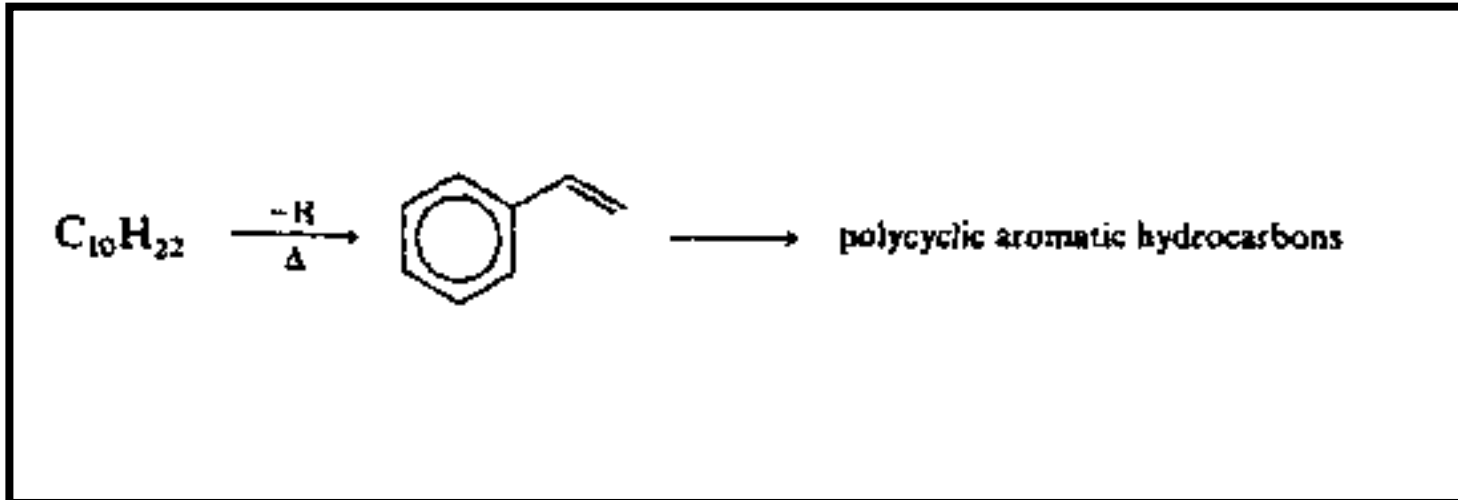
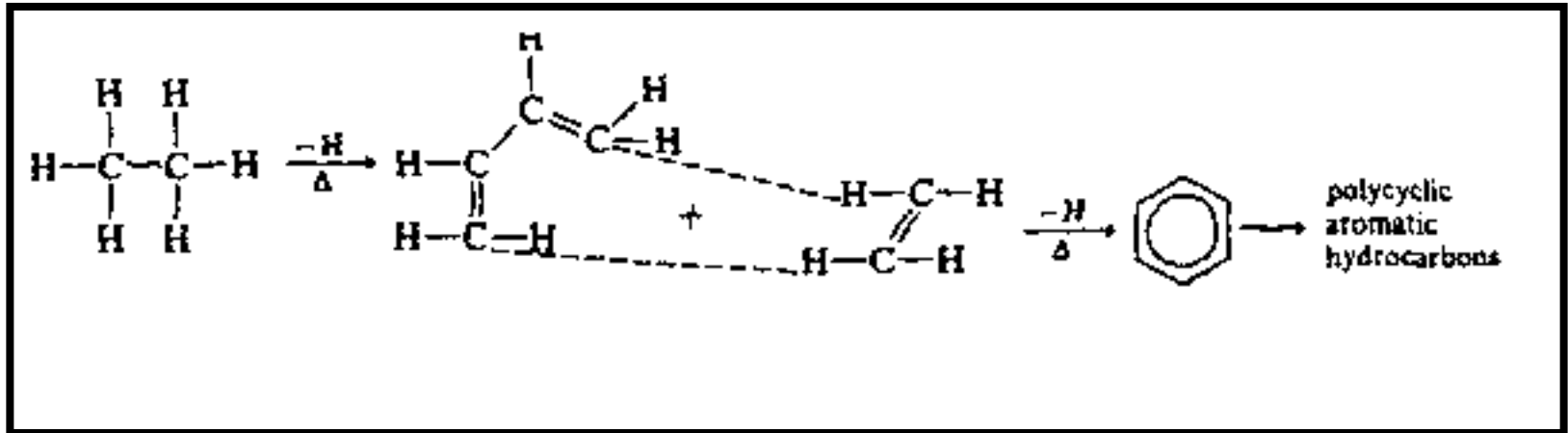
in 1975 the isolation of the first known cycloalkenyl derivate:



cyclopenta(cd)pyrene

## ORGANIC CARBON

The process that proceed to the formation of stable PAH structures: **pyrosynthesis**

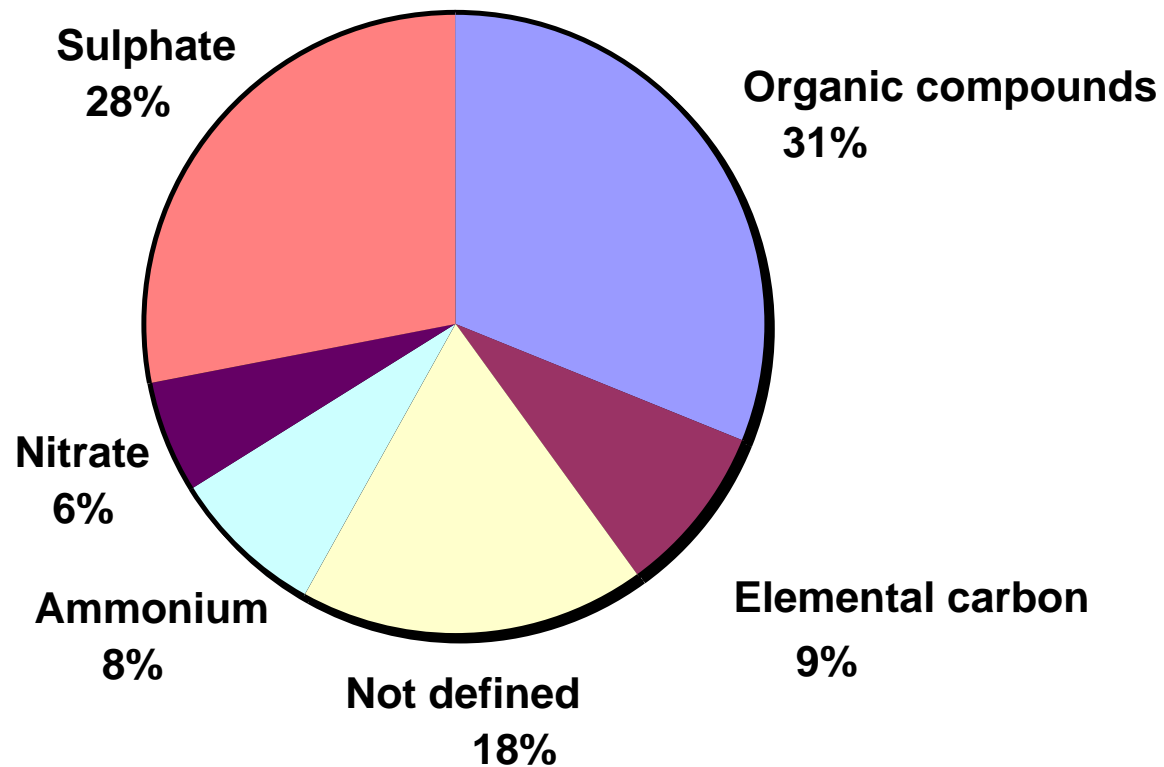


## SOME SECONDARY ORGANIC COMPOUNDS IDENTIFIED IN AMBIENT PARTICLES IN URBAN AIR

<b>COMPOUND</b>	<b><i>n</i></b>
HOOC(CH <sub>2</sub> ) <sub>n</sub> COOH	1-8
HOOC(CH <sub>2</sub> ) <sub>n</sub> CHO	3-5
HOOC(CH <sub>2</sub> ) <sub>n</sub> CH <sub>2</sub> OH	3-5
HOOC(CH <sub>2</sub> ) <sub>n</sub> CH <sub>2</sub> ONO	3-5
CHO(CH <sub>2</sub> ) <sub>n</sub> CH <sub>2</sub> OH	3-5
CHO(CH <sub>2</sub> ) <sub>n</sub> CHO	3-5
HOOC(CH <sub>2</sub> ) <sub>n</sub> COONO	3-5
CHO(CH <sub>2</sub> ) <sub>n</sub> COONO	3-4
HOOC(CH <sub>2</sub> ) <sub>n</sub> COONO	3-4
HOOC(CH <sub>2</sub> ) <sub>n</sub> COONO <sub>2</sub>	4-5
HOOC(CH <sub>2</sub> ) <sub>n</sub> CH <sub>2</sub> ONO <sub>2</sub>	3-4
(C <sub>6</sub> H <sub>6</sub> )-(CH <sub>2</sub> ) <sub>n</sub> COOH	1-3
HOOC-(C <sub>6</sub> H <sub>4</sub> )-(CH <sub>2</sub> ) <sub>n</sub> CH <sub>3</sub>	1-2

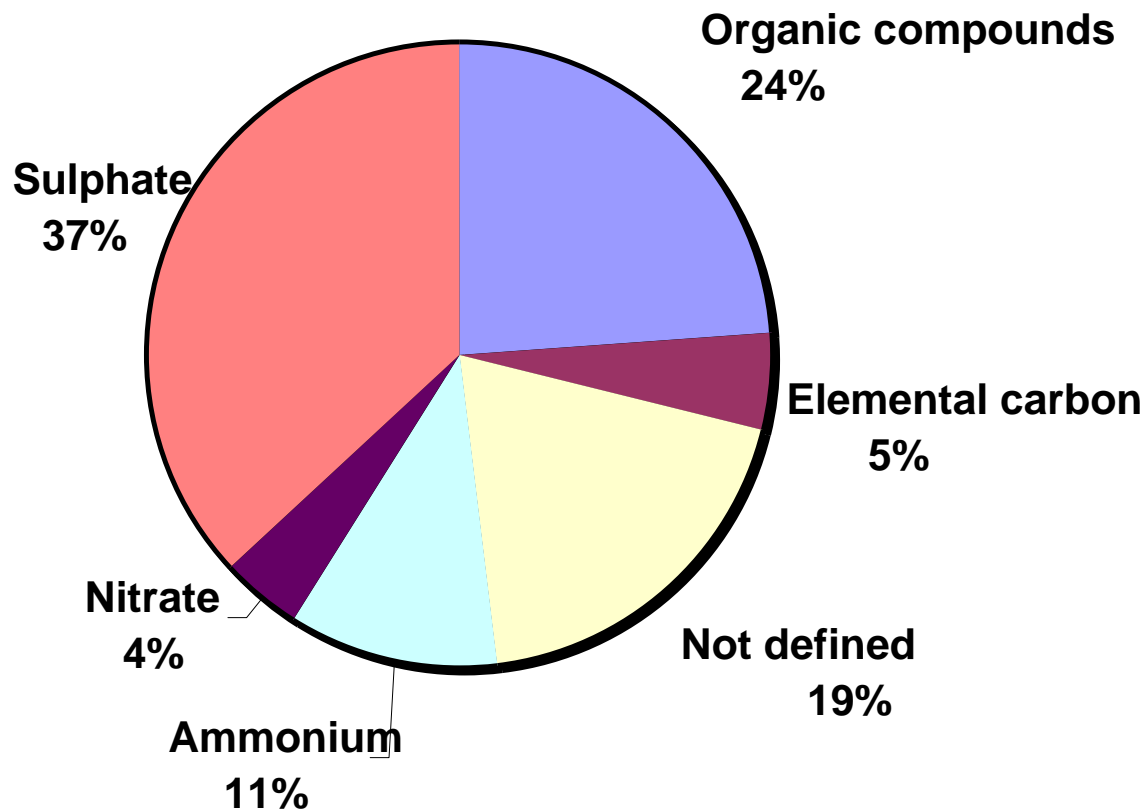
# MEAN COMPOSITION OF PARTICULATE MATTER

## URBAN AEROSOL



# MEAN COMPOSITION OF PARTICULATE MATTER

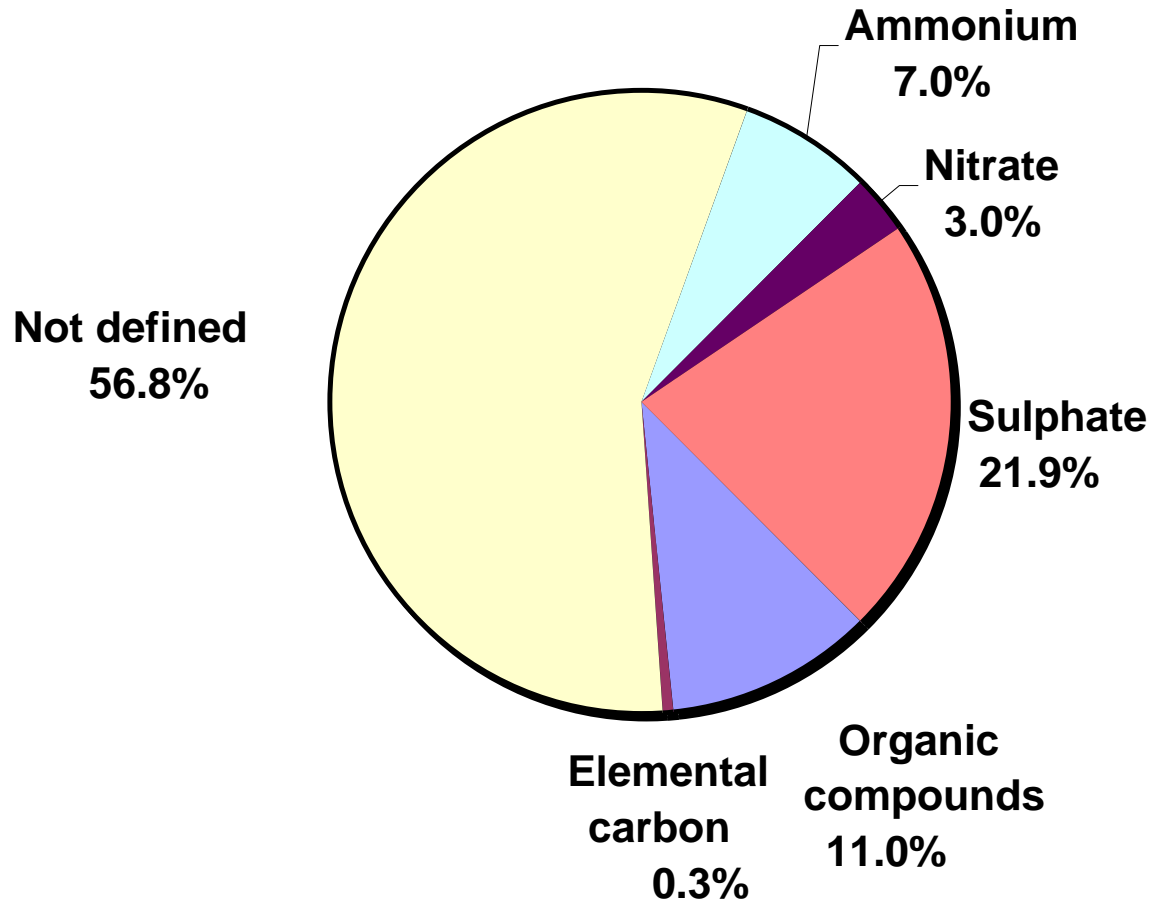
## RURAL AEROSOL



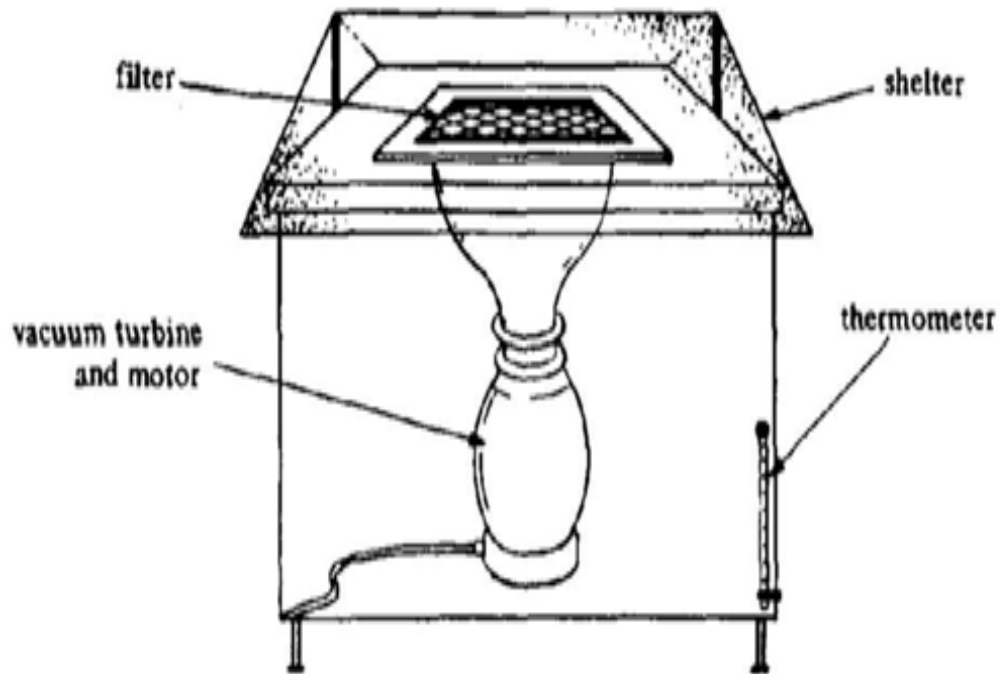


# MEAN COMPOSITION OF PARTICULATE MATTER

## NATURAL AEROSOL

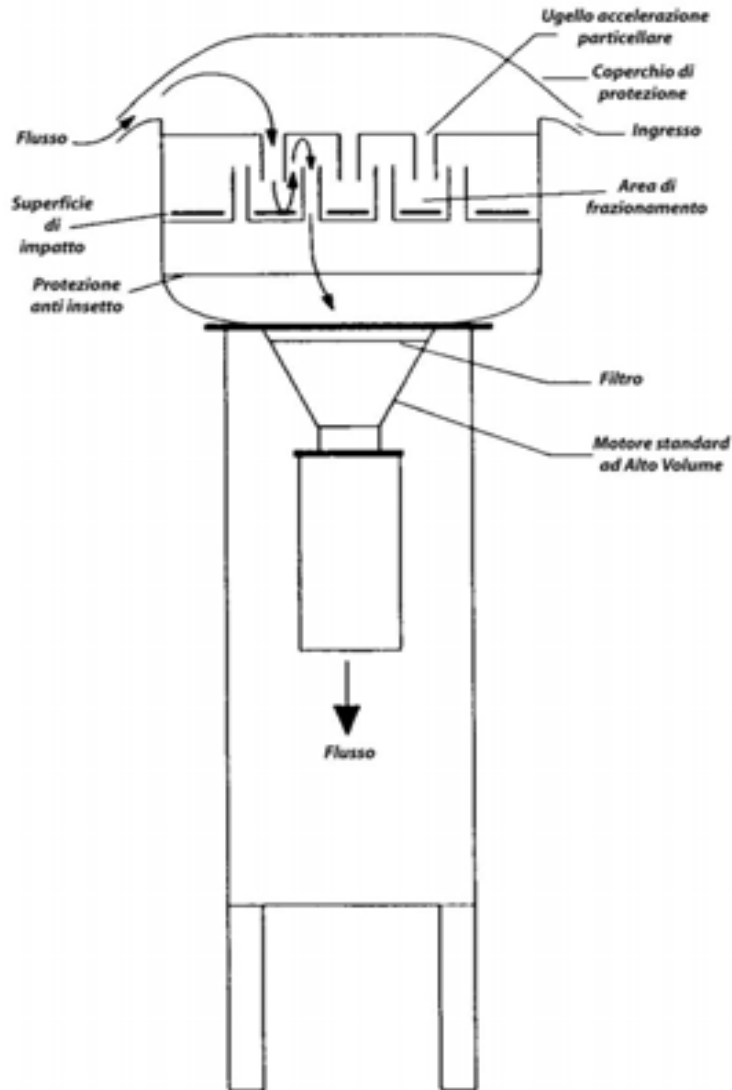


## Sampling and analysis



**HV sampler for Total Suspended Particulates (TSP)**

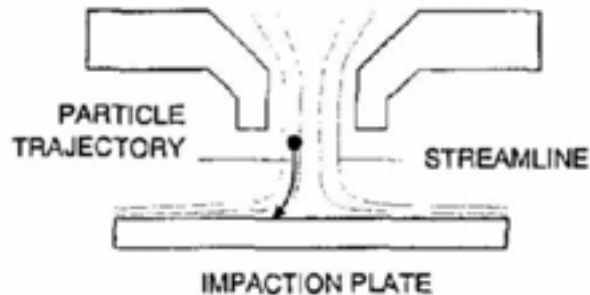
## Sampling and analysis



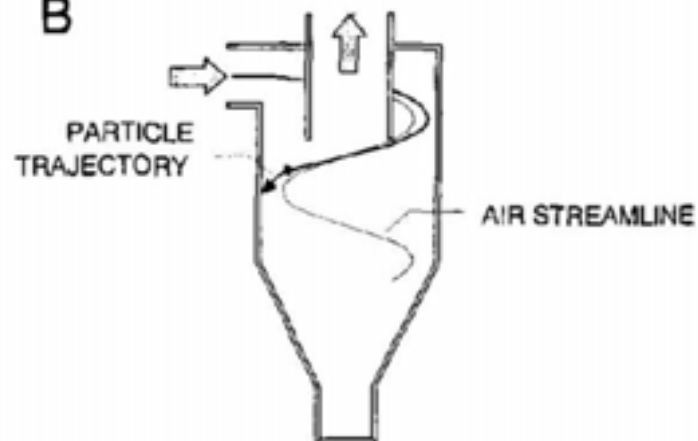
**HV sampler for PM<sub>10</sub>**

## Sampling and analysis

A

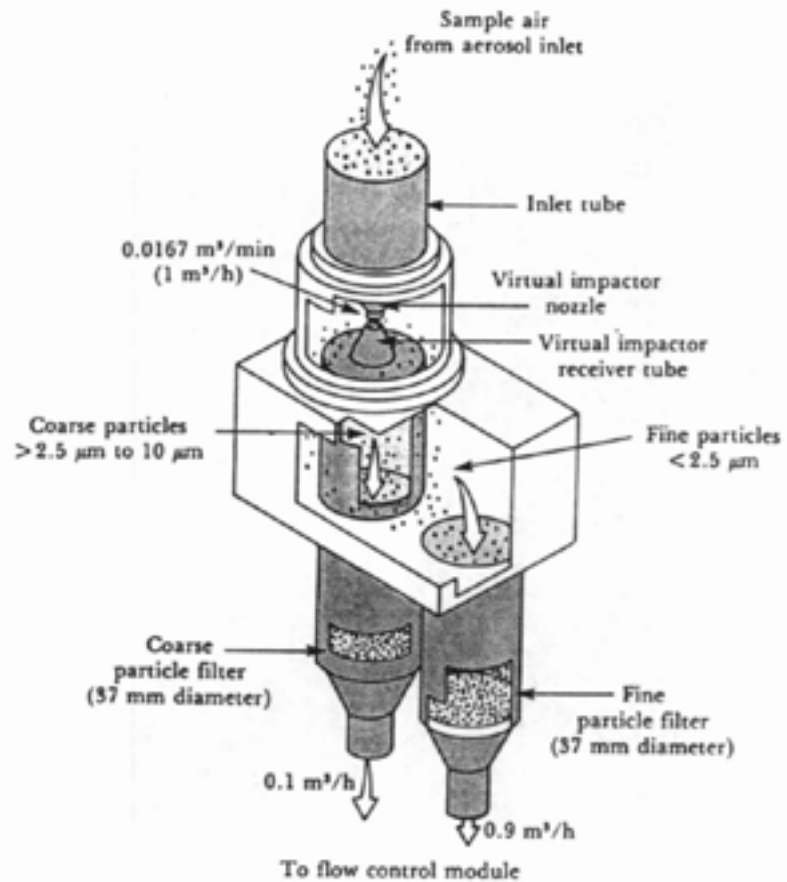


B



Inertial impactors: **(A) impactor, (B) cyclone**

## Sampling and analysis



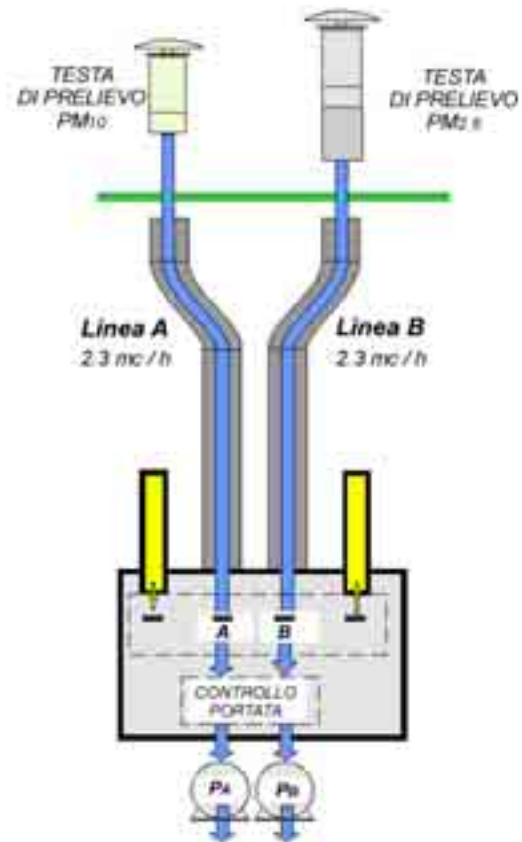
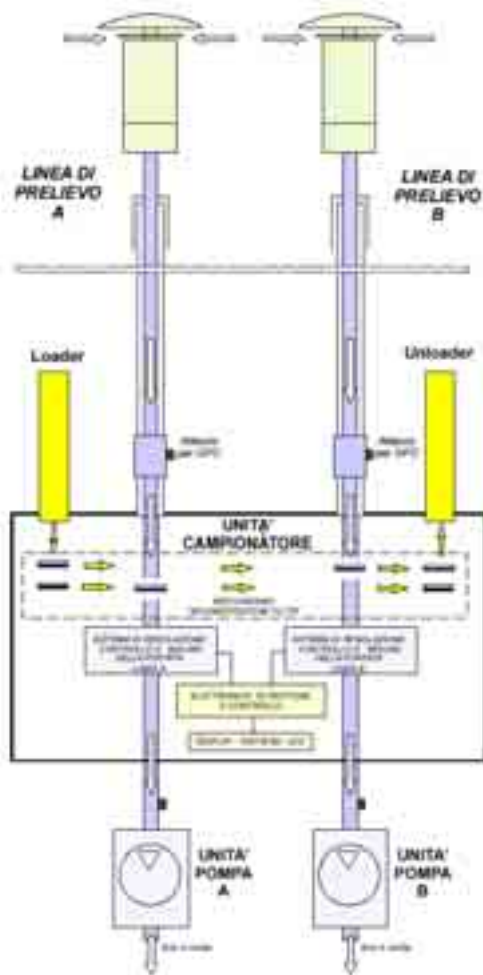
dichotomous

## PM<sub>10</sub>, PM<sub>2.5</sub> dual sampler



FAI Hydra automatic sampler that can work with any sampling inlet (PM<sub>10</sub>, PM<sub>2.5</sub>, PM<sub>1</sub>) within the operating flow rate range 0.8 ÷ 2.5 m<sup>3</sup>/h, on two distinct independent channels

## PM<sub>10</sub>, PM<sub>2.5</sub> dual sampler



## Sampling and analysis



diffusion denuder



diffusion denuder

## Sampling and analysis

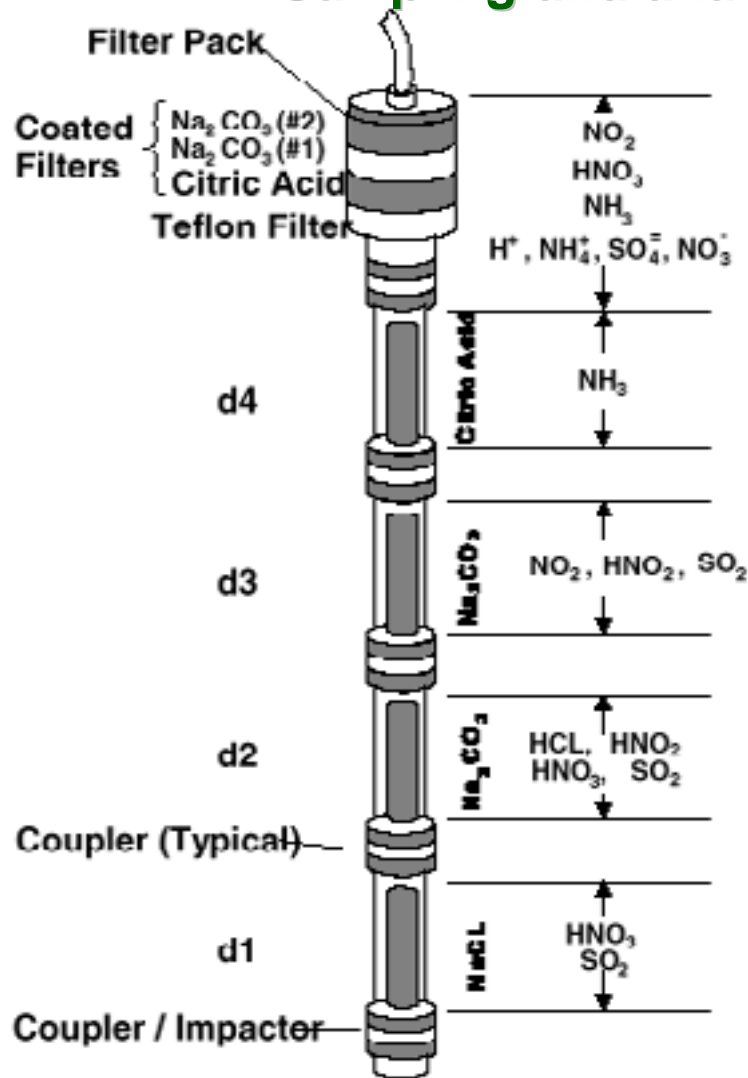
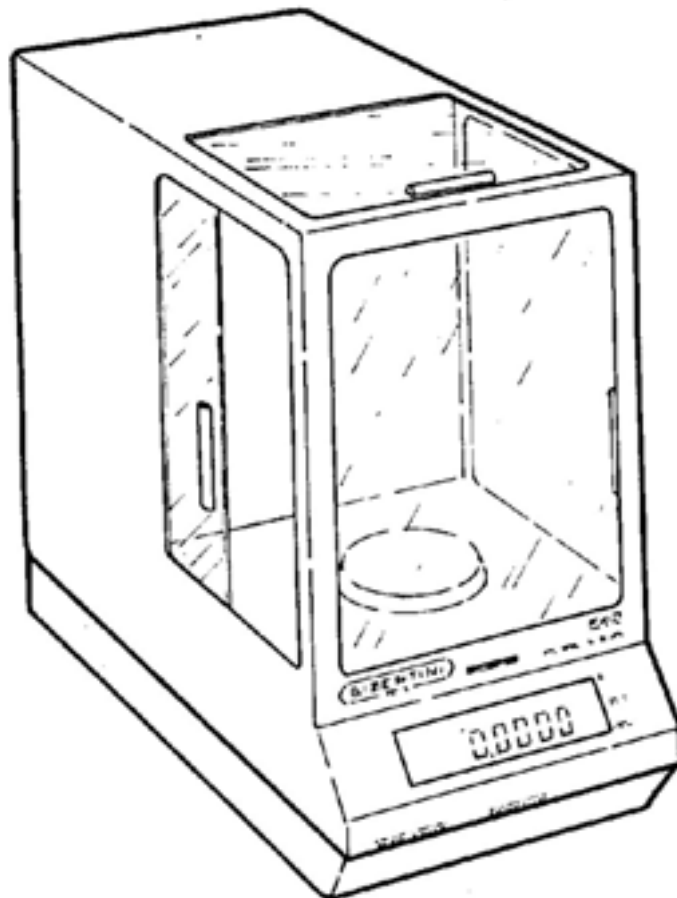


Figure 4-12. Schematic diagram of an annular denuder system.

## Sampling and analysis

### gravimetric method



## Automatic samplers and analysers

### Tapered Element Oscillating Microbalance (TEOM)

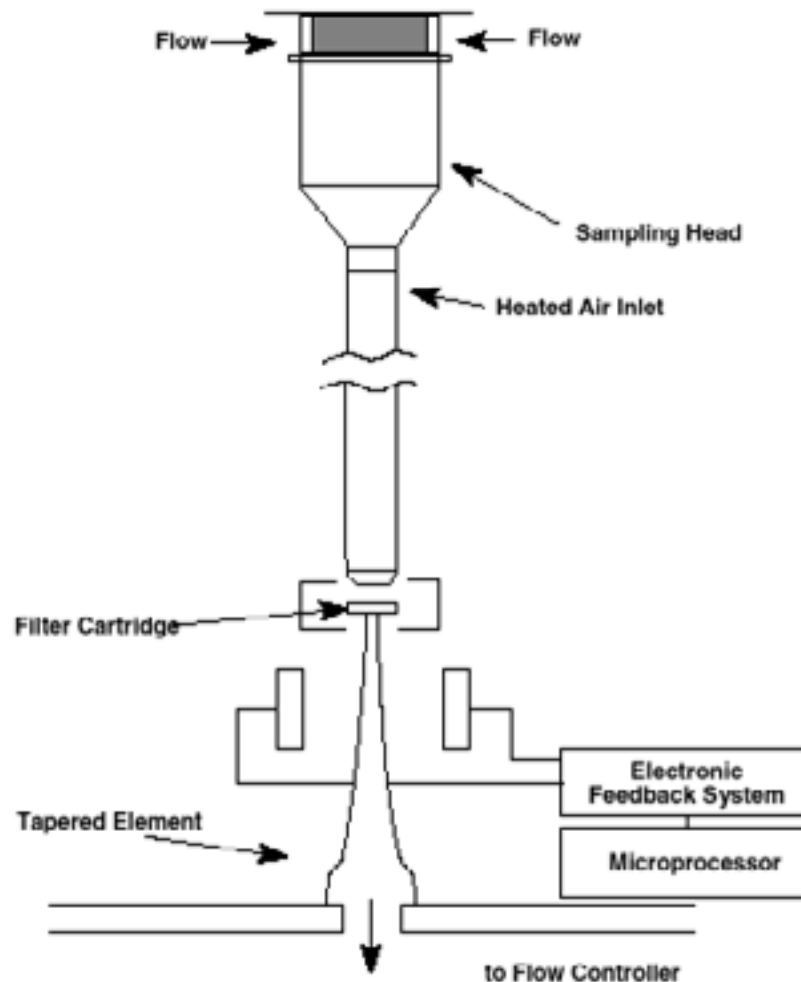


Figure 4-15. Rupprecht and Patashnick TEOM® sampler.  
 Source: Patashnick and Rupprecht (1991).

## Automatic samplers and analysers

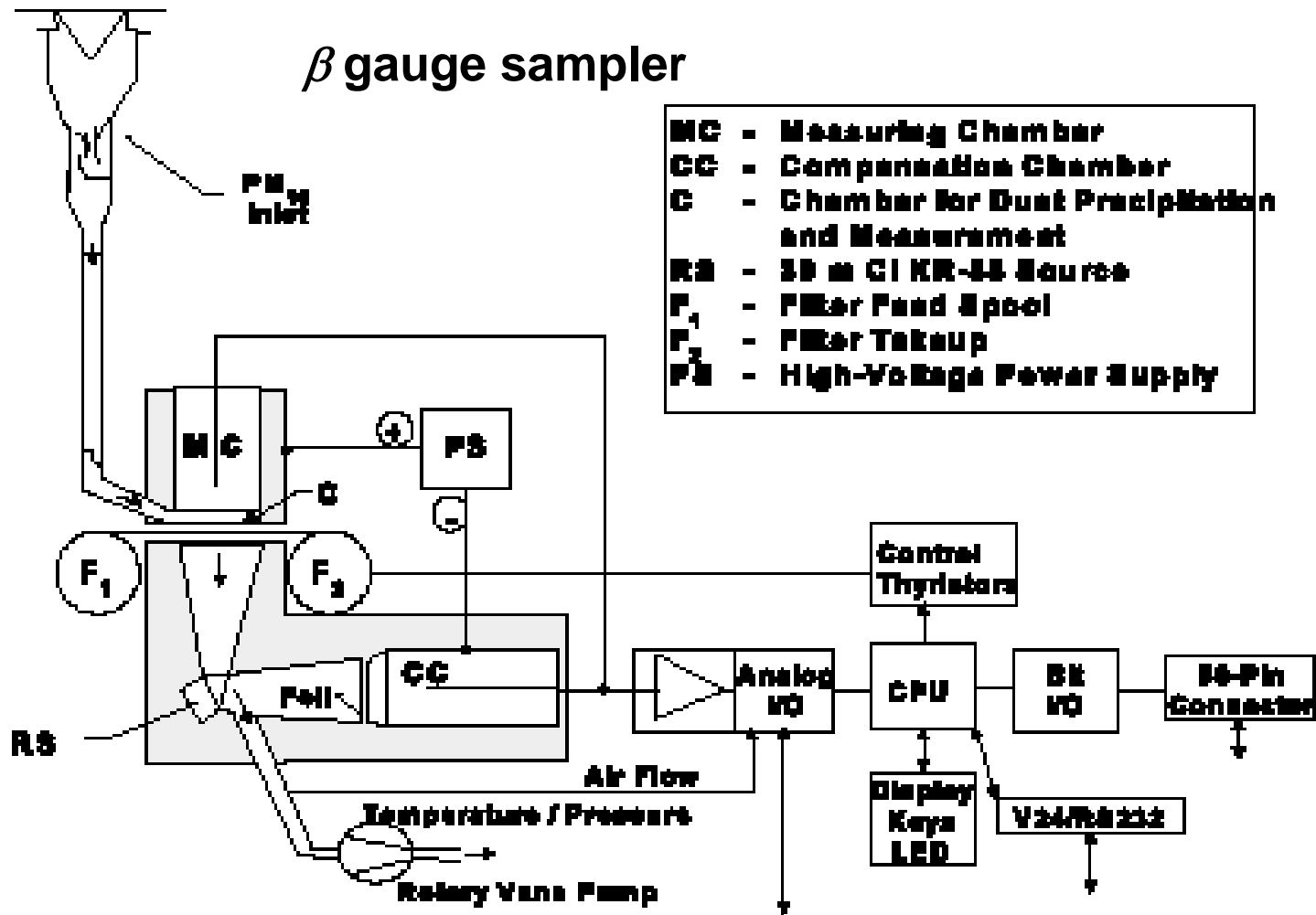


Figure 4-16. Andersen beta gauge sampler.

## Automatic samplers and analysers

### Atmospheric Dust Automatic Monitor (ADAM)

