Introduction to Atmospheric Aerosols

Small liquid droplets or solid particles suspended in the atmosphere (0.01 – 10 μm)
(mist, fog, clouds, smog) (dust, smoke, pollen)

Associated with 'haze'
Cause incoherent scattering of visible light - interfere with optical transmission.

Scattering occurs when aerosols have size comparable to wavelength of light.
e.g., 400 nm (blue light) scattered by particles in the 0.04 μm to 4 μm range

Large particles (> 10 μm) settle out
Very small particles (< 0.01 μm) coagulate to form larger particles
Aerosols in the 0.01 – 1 μm range can remain suspended for months

Aerosols are classified by size, source and type (pre-formed vs condensation).

Natural Sources:

- Wind blown dust, silt, fine sand etc.
- Sea Spray
- Volcanoes: dust, ash, $\mathbf{H_2SO_4}$(aq)
- Forest Fires: smoke particles, soot
- Terpenes/isoprenes: naturally occurring VOC's and their breakdown products such as aldehydes
- Pollens

Anthropogenic Sources:

- Industrial dusts: eg cement, soot, fly ash (may be removed or reduced using scrubbers or precipitators)
- Agriculture: land clearing, tilling etc
- Transportation: roadway dust, diesel exhaust, PAH's, smog
- Oxidation of volatile gases; VOC's → aldehydes & acids
  $\mathbf{NO_x}$ → $\mathbf{NO_3^-}$ salts
  $\mathbf{SO_x}$ → $\mathbf{SO_4^{2-}}$ salts

Effects:

- Health:
  Large particles (> 10 μm) trapped in nose or upper respiratory tract.
  Small particles (< 2.5 μm) transported into lower lung cavity, where they become immobilized and cause serious ailments and disease.

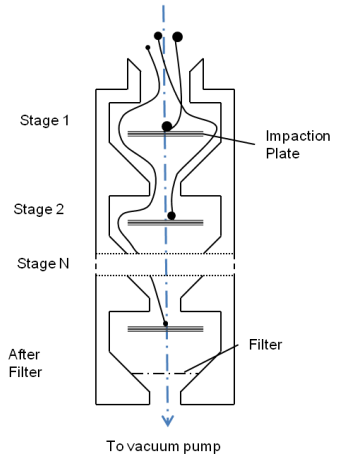
- Visibility, climate (affects radiation budget), soiling of materials.

- Major participants in heterogeneous atmospheric reactions (*e.g.*, ozone hole formation, acid rain production)

Quantitative Aerosol Measures

Total Suspended Particulate (TSP)
Known quantity of air is filtered and trapped particle mass is recorded ($\mu g/m^3$)
TSP ~ 10 – 30 $\mu g/m^3$ common
TSP > 60 $\mu g/m^3$ considered harmful
TSP > 250 $\mu g/m^3$ extreme

Particulate Matter (PM)
Particle mass reported in $\mu g/m^3$
Cascade impactors used to size fractionate
- PM_{10} – particles less than 10 μm
- $PM_{2.5}$ – particles less than 2.5 μm
- PM_1 – particles less than 1.0 μm



Optical Particle Counters/Sizers
Based on light scattering
Count number density of particles (i.e., N/m^3)
in different size bins
Can be converted to PM assuming shape and density

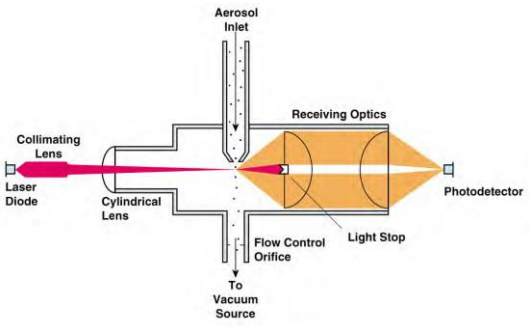


Figure 2
Flow Through an Optical Particle Counter

Total Dustfall (TDF)
Measured by recording mass of accumulated particles per m^2 per month
TDF > 7 g m^{-2} $month^{-1}$ considered excessive

Coefficient of Haze (COH)
300 linear meters of air drawn through porous filter (collecting mostly 5 – 10 μm)
Light transmission through filter is measured and compared to clean reference air
$COH = 100 \times \log (I_t/I_o)$
COH > 6 may cause adverse symptoms

Processes:

May be involved in many processes (diffusion, coagulation, condensation, chemical reactions, sedimentation).

$$\text{Sedimentation rate} \alpha \frac{(\text{size})(\text{density})}{(\text{air viscosity})}$$

e.g., 1 μm diameter droplet of $\mathbf{H_2O}$(l) settles about ~10^{-4} m s^{-1} whereas a 1 mm diameter droplet of $\mathbf{H_2O}$(l) settles at 6.5 m s^{-1}

Particulate Standards and Regulations in Canada and US

Particulate Standards

	(μg/m^3)	
	annual	24 h
B.C. PM_{10}	50	70
Canada PM_{10}	70	120
US EPA PM_{10}	50	150
US EPA $PM_{2.5}$	15	50

Proposed Canadian Ambient Air Quality Standards for PM2.5 (2015 - 2020)

	PM 2.5 (μg/m^3)	
	annual	24 h
Clean Air	0 - 4	0 - 10
Marginal	4 – 6.4	10 - 20
Poor	6.4 - 10	20 - 28
Excessive	> 10	> 28