REVIEW ARTICLE

INFLUENCE OF ATMOSPHERIC AEROSOLS ON HEALTH AND ENVIRONMENT-CLIMATE CHANGE

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ABSTRACT

Atmospheric Aerosols are consisting of very small, microscopic particles in the atmosphere which comes from different sources. Assessment of aerosol- climate interactions requires an understanding of the factors that determine the abundances and properties of aerosols in the atmosphere. From the standpoint of direct radiative forcing, critical aerosol properties are the surface size distribution, particle shape and complex refractive index. From the standpoint of indirect radiative forcing, critical aerosol properties are the number size distribution, hygroscopicity, phase and chemical composition. Present review paper deals withvarious examples of aerosols e.g. nucleation particles, soot particles, ammonium sulphate particles, sea salt particles, pollen and mineral dust particles and their properties are reviewed. Atmospheric particles – aerosols – are some of the key components of the atmosphere. They influence the energy balance of the Earth's surface, visibility, climate, human health and environment as a whole. According to World Health Organization (WHO), ozone, particulate, matter, heavy metals and some hydrocarbons present the priority pollutants in the troposphere. Direct and indirect effects of atmospheric aerosol on climate system and of epidemiologic studies and their causative interconnection between particles and health effects. Impact of aerosols on the clouds is also discussed..

Keywords : Aerosol; Health; Environmental effects.

INTRODUCTION

Atmospheric aerosols consist of very small particles, microscopic particles in the atmosphere which come from two different sources. One of which is of human origin from things like burning fossil fuels and other is natural aerosols which come from things like windblown dust or sea salt from breaking waves.

There are various types of suspended particulate matter in air (aerosols) such as soot (black carbon), organic matters, sea dust, sea salt, and sulfate from sulfur oxides and nitrate from nitrogen oxides. Aerosols have been called SPM (suspended particle matter) on the environmental administration, which can be classified as PM10 (defined as collection efficiency of 50% at 10μm aerodynamic diameter) or PM 2.5. As can be seen from that the main cause of Yokkaichi asthma was sulfate aerosol, they affect the respiratory system. PM2.5 can also have been incorporated into blood from the lungs, leading to cardiovascular diseases. Aerosols also cause less visibility as understood from hazy by air pollution.

Atmospheric particles are a complex mixture of organic and inorganic substances, suspended in the atmosphere as both liquids and solids, and they cover a very wide range from a few nm in diameter to 100 or more μm. They vary also in shape, chemical composition, and optical properties. Particle size is one of the key parameters that govern the transport and removal of particles from the air, their deposition within the respiratory system and is associated with the chemical composition and sources. Sizes of some typical atmospheric particles are presented in Table 1. (Tasić et al., 2006)

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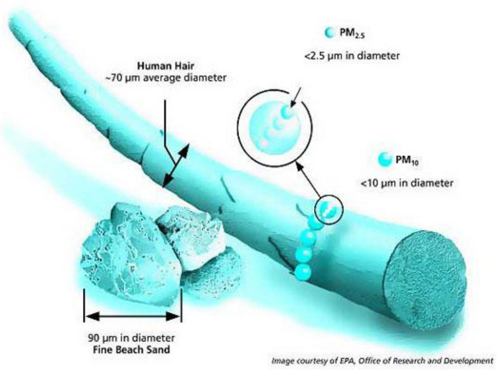


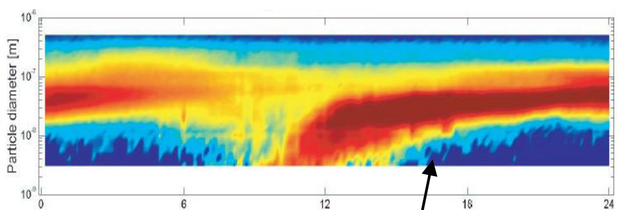
Figure. 1: size comparsons for aerosol pollution

Table . Sizes of some typical Atmospheric particles

Description	Examples
Very small 0.01 to 5 (µm)	Paint pigments, Tobacco Smoke, Dust, Sea-Salt particles.
Larger 5 to 100 µm	Cement dust, wind-blown soil dust, Foundry dust, Pulverized coal, Milled Flower.
Liquid (Mist) 5 to 10,000 µm	Fog, Smog, Mist, Raindrops.
Of Biological Origin 0.001 to 0.01 µm	Viruses, Bacteria, Pollen, Spores.
Of Chemical Formation 0.001 to 100 µm	Atmospheric sulphur dioxide oxidizes producing sulfuric acid; the acid attracts Atmospheric water forming small droplets (haze). Metal oxides form when Fuels that contain Metals are burned.

EXAMPLES OF AEROSOLS PARTICLES:

Nucleation Particles:



1 to 20 nm

Fig. 2. Nucleation in the atmosphere

Size of the nucleation particles are 1 to 20 nm. Sources are various gas-phase precursor compounds, both natural (plants) and anthropogenic. Frequently found near busy roads, but also in pine forests. Formed via photo-oxidation of gas-phase traffic or industrial emissions or organic emissions from pine trees. Appearances are presumably spherical and liquid. Life time is few hours. Mainly limited by coagulation with larger particles. Other properties are if nucleation particles are observed, then in high number concentrations.

Soot Particles:

Soot, a product of incomplete combustion, is major size of soot particles is very variable length in the order of 1000 nm, equivalent diameters in the order of 100 nm. Sources are anthropogenic incomplete combustion of fossil fuel (e.g., diesel engines) also biomass burning. Appearance is fractal-like, complex shaped, black. Lifetime is about one week. The lifetime depends on the aging processes of the soot particles. These processes modify the ability of soot particles to take up water (hygroscopicity) and thereby the efficiency of wet removal. Other properties are cancerogenous, penetrate deep into the lungs, absorb solar radiation (positive direct climate effect), Fresh soot particle are hydrophobic, i.e., they are not water soluble and do not take up water, while aged soot is usually more hygroscopic and can take up water → important for cloud formation.

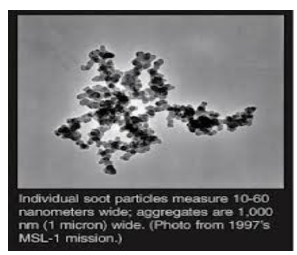


Fig.3. Soot particles

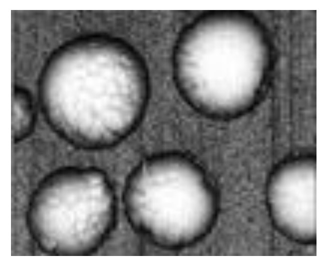


Fig.4. Ammonium sulfate ($(NH_4)_2SO_4$) particles

Ammonium sulfate ($(NH_4)_2SO_4$):

Size are about 100 - 400 nm. Sources are various: formed via chemical processes in the atmosphere (H_2SO_4+ NH_3) → secondary aerosol precursor gases: SO_2 from fossil fuel combustion, NH3from industry and agriculture. Appearances are compact, white. Lifetime is about one week. Other properties are highly water soluble, effective for cloud formation, usually in internal mixture with other secondary compounds (NH_4NO_3, organics).

Sea Salt:

The principal mechanism for emission of sea salt particles is the bursting of air bubbles at the sea surface. Size particles range from 200 nm up to about 10 µm. Sources are evaporation of sea spray produced by bursting bubbles or wind-induced wave breaking. Appearance is compact, white. Lifetime hours to a few days Other properties are composed mainly of NaCl (sodium chloride), also NO^{3-}, K^{+}, SO_4^{2-}, Mg^{2+}, Ca^{2+}; highly water soluble, effective in cloud formation and no adverse health effect .

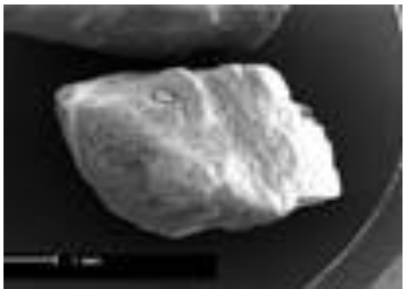


Fig.5. Sea salts particles

Pollen:

Size: around 3 to 100 µm Sources are plants and vegetal material Appearance is many different shapes. Lifetime are hours to days. Pollens are effectively removed by precipitation. Other properties are little water soluble, health problem for persons suffering from allergies (hay fever) and Ice nuclei.

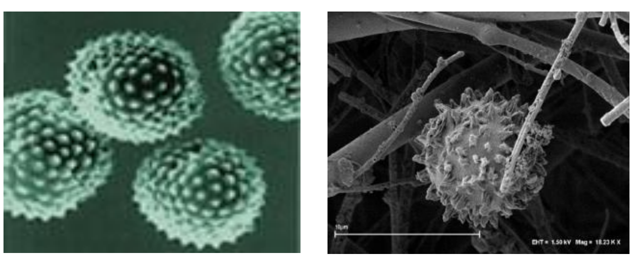


Fig.6. Pollen

Mineral Dust:

Mineral dust makes a major contribution to the aerosol optical depth. Primary sources are the arid and semi arid regions of the world, which account for about 15% of the global land.
Mineral dust particles are generally between 1 and 20 µm (several up to 100 µm. Appearance are non-spherical, irregular. Lifetime of mineral dust is hours to days. Sahara dust can be transported to Europe and even to South America. Other properties are not water soluble and good ice nuclei.

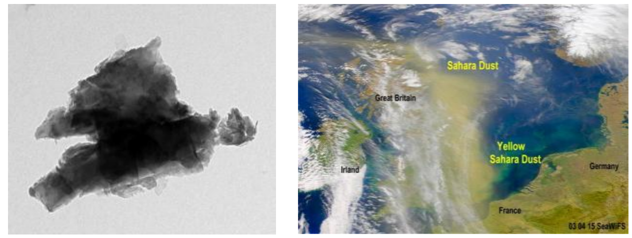


Fig.7. Mineral dust particles

AEROSOLS EFFECT ON CLIMATE SYSTEM:

Aerosol effects on climate system can be roughly classified into three. The first is the "***direct effect***" in which aerosols scatter and absorb the thermal radiation that is emitted from the Earth's surface and atmosphere and the solar radiation, leading to a change in radiation balance. (McCormick and Ludwig, 1967; Charlson and Pilat, 1969; Atwater, 1970; Mitchell Jr., 1971; Coakley et al., 1983).The direct effect is much dependent on the physical and chemical properties of aerosols, such as particle size, hygroscopicity, and complex refractive index. For example, sulfate aerosol cools the atmosphere because it mainly scatters the solar radiation back to space. On the other hand, black carbon heats the atmosphere because of efficient absorption of the solar and thermal radiation. The second is the "***indirect effect***". Aerosols have roles of cloud condensation nuclei and ice nuclei. An increase in the aerosol number concentration without changing the mass of the cloud water results in smaller cloud droplets and ice crystals, leading to stronger scattering and absorption of the solar and thermal radiation (referred to as "cloud albedo effect" or "first indirect effect"). (Gunn and Phillips, 1957; Twomey, 1977; Liou and Ou 1989; Albrecht, 1989). Consequently it causes a change in time to grow to precipitation and snowfall and then in cloud fraction (referred to as "cloud lifetime effect" or "second indirect effect"). In addition, an increase in aerosols which can be ice nuclei, such as black carbon and soil dust, promotes freezing of super cooled cloud droplets. Ice crystals grow to precipitation and snowfall faster than cloud droplets, so that a change in the number concentration of ice nuclei can results in a change in the cloud fraction. The third is the "***semi direct effect***" by aerosols which absorb the solar and thermal radiation, such as black carbon and soil dust. They heat the ambient air and then affect generation of clouds due to changes in atmospheric stability and in saturated water vapor pressure.

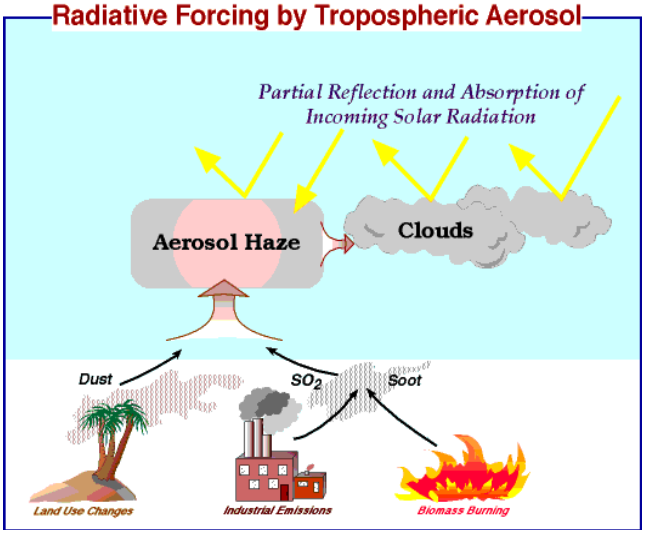


Fig. 8. Direct and indirect aerosol effects

HEALTH EFFECTS OF PARTICLES:

Effects of airborne particles health effects (epidemiology as the main trigger); effects on atmospheric properties; visibility reduction; fog formation and precipitation; solar radiation reduction; temperature and wind distribution alteration (e.g. climate change); effects on materials; effects on vegetation. Health effects of particles – seldom with direct proofs about the mechanism. In general, inhalation of airborne particles contributes to excess mortality and morbidity (not all adverse effects result in death). Specific health “end points” include: Declines in lung function; increased respiratory symptoms such as cough, shortness of breath, wheezing and asthma attacks; chronic obstructive pulmonary disease; cardiovascular diseases (diffusion across the epithelium of alveoli, changes coagulation of blood); Lung cancer.

a) Syndromes, illnesses and sensitivities exhibited or acquired as a result of indoor environment exposures - The indoor exposures causing these responses are believed to be a function of the synergistic effects of two or more pollutants (or even among particles): Sick Building Syndrome (goes away once building is avoided); Building Related Illness (acquisition due to exposure to that building); Multiple Chemical Sensitivity (synergistic effects to a number of chemicals).

b) Factors influencing particle deposition in the respiratory tract: The physio-chemistry of aerosol (particle size/size distribution; density; shape; hygroscopic/hydrophobic character; chemical reactions); The anatomy of the respiratory tract (diameter; length; breathing angles of airway segments); The physiology of the respiratory tract (airflow pattern; breathing pattern).

c) Particle deposition in respiratory tract; can be either total or fractional deposition (extra thoracic in nose or mouth; bronchial; bronchiolar; or alveolar).

d) Determination of particle deposition in respiratory tract can only be determined via experimental studies involving human or animal experiments; lung cast experiments in post mortem. Alternatively, computational modelling: NB: Experimental studies show significantly higher deposition rates than predicted by modelling.

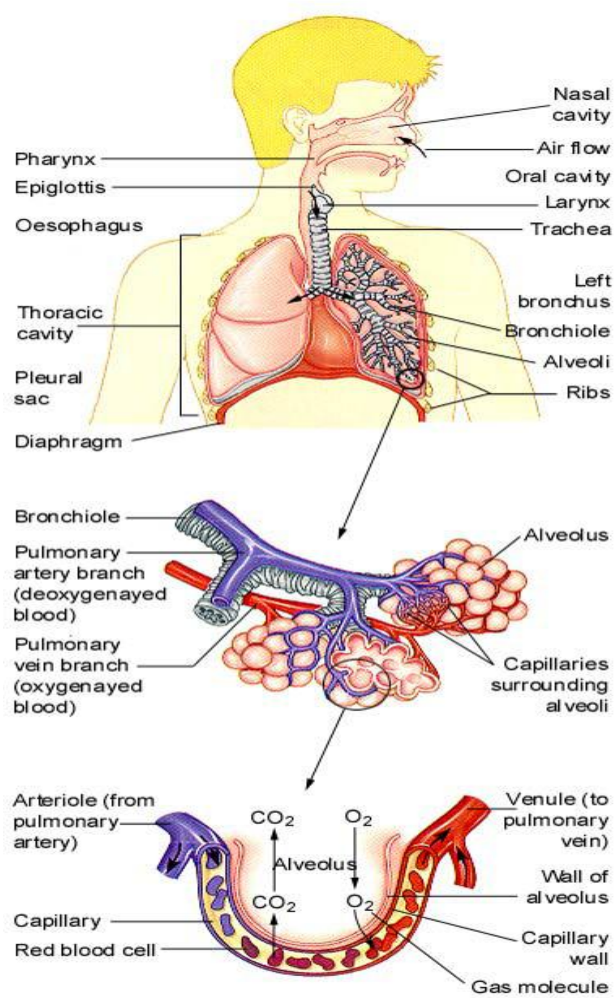


Fig. 9. Respiratory Tract; schematic diagram of the human respiratory tract and its compartments

IMPORTANCE OF AEROSOLS FOR HUMAN HEALTH:

A series of epidemiologic studies has clearly shown the causative interconnection between particles and health effects; frequency rates of chronic obstructive respiratory diseases seem to be increasing. The World Health Organization (WHO) as well as different authorities in Europe and the US, recognized the potential risks of atmospheric particulate matter, PM to public health, and atmospheric pollution by particles has become an important policy theme. Many studies have generally accepted that the ability for particles to cause health effects is dependent on their size [6]. In spite of the fact that particles up to 100 μm enter the body through breathing, only very small particles, below 5 μm aerodynamic diameter can reach deep into the lung and these very small particles have the main potential for causing health effects. The current focus of health-related sampling of particulate matter is on particles with aerodynamic diameter less than 10 μm (PM10) but recent research pointed out the great health effect of fine particles PM2.5, and even PM0.1. The importance of chemical composition of fine particles is also outstanding. Four main fractions are defined: inhalable fraction (E) defined as the mass fraction of total airborne particles which is inhaled through the nose or mouth and for ambient atmosphere is given by:

$$E = 0.5\ (1 + \exp\ [-0.06D]) + 10-5U\ 2.75\ \exp\ (0.05D)$$

Where D is the aerodynamic diameter of the particle and U is the wind speed (up to 10 m s-1).

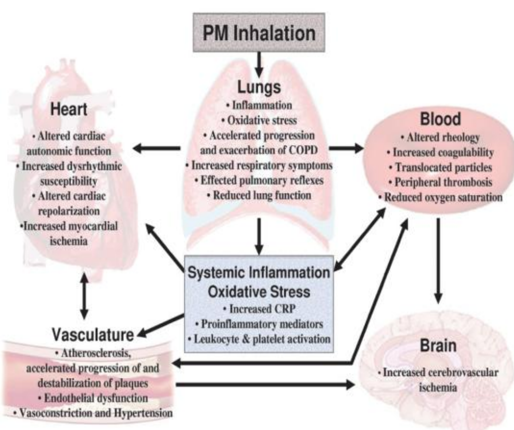


Fig.10. Potential general pathophysiological pathways linking PM exposure with cardiopulmonary morbidity and mortality

Thoratic fraction, defined as the mass fraction of inhaled particles penetrating the respiratory system beyond the larynx (median aerodynamic diameter of 10 μm); *respirable fraction,* defined as the mass fraction of inhaled particles which penetrate to the unciliated airways of the lung with a median aerodynamic diameter of 4 μm, and high risk" respirable fraction for the sick, and infirm or children with a median aerodynamic diameter of 2.5 μm

CONCLUSION:

Air quality investigation in Belgrade urban area has shown that the annual PM mass concentrations, in comparison to majority of European cities are significantly higher. The main sources of suspended particle are traffic, power stations, local heating and dust re-suspension. To predict future trends in the atmospheric loading of aerosols as a result of global change, we must first be able to quantify the sensitivity of the aerosol atmospheric loading.

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