

Lecture 9 Feb 16, 2012.

Environmental science FFY471, Env physics FYP350

Lecture on aerosol particles and their environmental effects.

Air pollution is due to Gaseous pollutants and Particulate pollutants.

We will entirely focus on particulate pollutants or aerosol particles (briefly particles).

General questions to be raised concerning environmental aspects of aerosol particles:

- Do we have a particulate pollution problem?
- What are the effects of aerosol particles
- What is the atmospheric particle situation today? Concentrations. Trends.
- What are the sources of particulate matter?

Physical questions concerning aerosol particles

- How is it appropriate to describe and characterize them?
- How can one measure aerosol particles?
- How is particulate matter produced or formed?

In this course and in this lecture we will discuss

- Important particulate concepts
- Aerosol particle formation
- Effects of aerosol particles on
 - (- ecosystems). Just mentioned.
 - climate
 - health

First a general introduction on aerosol particles

The starting point of forceful measures toward air pollution was probably the famous Great London Smog in 1952. The smog caused around 4000 extra deaths. Large emissions of pollutants and unfortunate weather conditions created very high concentrations of sulfur dioxide and particulate matter. The visibility during the worst period was just a few meter and it was impossible to drive. Even the ambulance service stopped and sick people had to transport themselves to hospital.

What are aerosol particles ?

Aggregates of atoms and molecules, with a considerable solid fraction, and with diameters in the range 3 nm to 100 μm . Atoms and molecules are also particles, but when we talk about particles, in the sense of aerosol particles, we mean heavier material aggregates in the air.

An aerosol is an suspension of gases and particles in the air, that means that the aerosol contains both the gases and the particles.

Do the aerosol particles have any serious environmental effect ?

There are probably quite more hazardous effects than was believed a few decades ago. The focus of air pollution has somewhat changed from gases to aerosol particles. The real, or true, effects of aerosol particles have found to be very hard to reveal.

The aerosol particles have effects

- on human health
- on ecosystems
- on climate

The climate effects are divided into

- direct effects (from solar and heat radiation)
- indirect effects (related to clouds)

It should be stated that aerosol particles are natural constituents of the air and they are even necessary. Without them we would not survive. The problems are that the human society cause unnatural concentrations of aerosol particles and produce particles with unnatural composition.

Description, characterization of aerosol particles

Individual particles are characterized, primarily, by size, composition and shape. The shape is almost always unimportant.

All the particles in a volume, i.e. 1 m³ of air, are characterized by total mass, size distribution and composition distribution.

Particle size.

The particles are divided into fine particles with diameters less than 2,5 μm
 coarse particles with diameters between 2,5 and 10 μm

Particle mass

PM₁₀; the mass of all particles in a volume of 1 m³ with a diameter less than 10 μm

PM_{2,5}; the mass of all particles in a volume of 1 m³ with a diameter less than 2,5 μm.

Even the quantities PM_{1,0} and PM_{0,1} are used.

The air quality, when it comes to particles, has conventionally been defined from PM₁₀.

The limits and the regulations are given in PM_{xx}, usually PM₁₀.

The annual average value of PM₁₀ may not exceed 40 μg/m³.

The diurnal average value of PM₁₀ may not exceed 50 μg/m³ except during 10% of the days of the year.

Sources and origin of particles.

Primary particles; emitted into the atmosphere as particles

Secondary particles: gases in the atmosphere condense and form particles

Natural sources; sea, open land areas (deserts), volcanoes, forest fires

Anthropogenic sources; industrial processes, fossil fuel burning, biomass burning.

The natural sources dominate the total mass of the particles in the earth atmosphere. The “natural particles” are usually larger than the “man made” particles.

In the lecture we then discussed *the formation of aerosol particles in combustion*.

See http://www.dieselnet.com/tech/diesel_emiform.php#pm
for a short introduction to the topic.

Climate effects of aerosol particles

Basically the particles are cooling objects. They reflect the solar light and prevent the light to reach the earth surface.

However particles can both cool and heat. Soot particles are quite effective in absorbing light and then contribute to the global warming.

The net effect of particles in the atmosphere is clearly cooling, but as the soot fraction of the particle pollution increases the cooling effects will be less.

The physical phenomenon behind the climate effect of particles is the interaction of light with matter. Light incident on a particle can be absorbed or scattered. The reduction of light in the straight forward direction is called the extinction of light. The extinction is due to both scattering and absorption. The scattering and absorption depend upon composition, shape and size of the particle.

Without going further into this topic an interesting case can illuminate the situation.

Pure sulphate particles are weakly absorbing.

Soot particles are strongly absorbing.

When soot is mixed with sulphate the extra absorption is 2 - 2,5 times as great as the absorption that would occur from soot alone.

Health effects of aerosol particles

This is the major subject of the Problem package 5.

The effects are extensively described in the link from the homepage.

Study the link thoroughly and make an effective summary of it.

