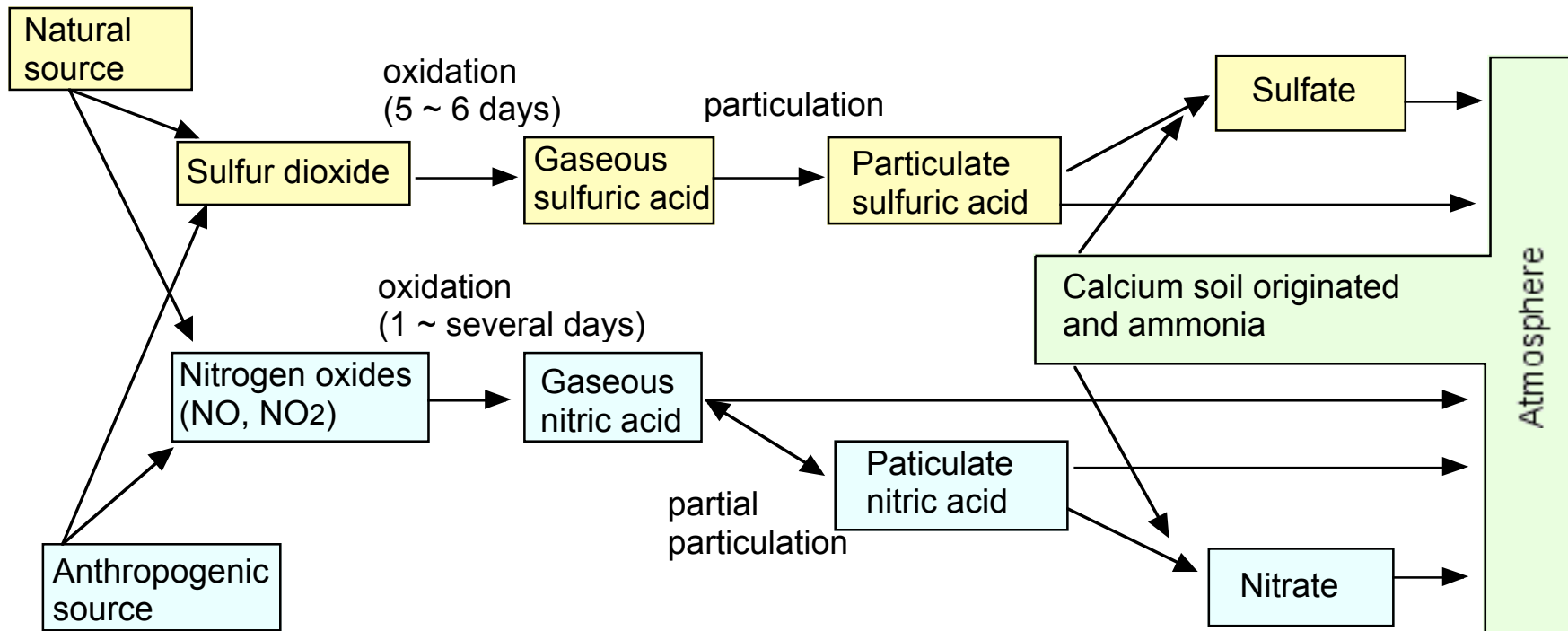


1. Morphology of the Air Pollution

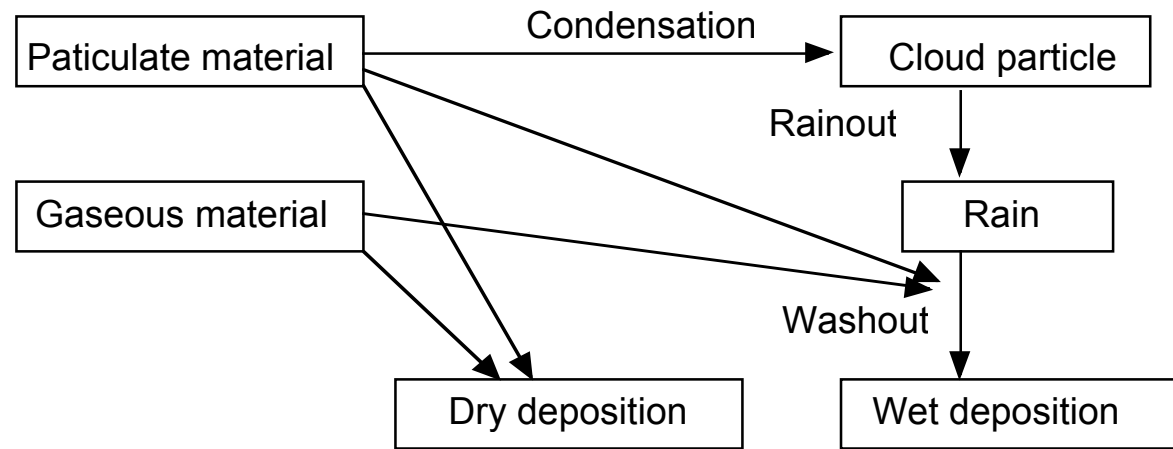
a. transition of the sulfur and nitrogen in the atmosphere

Sulfur dioxide and/or nitrogen oxides released from the anthropogenic or natural sources are transformed in the atmosphere.



Transition of the sulfur and nitrogen in the atmosphere

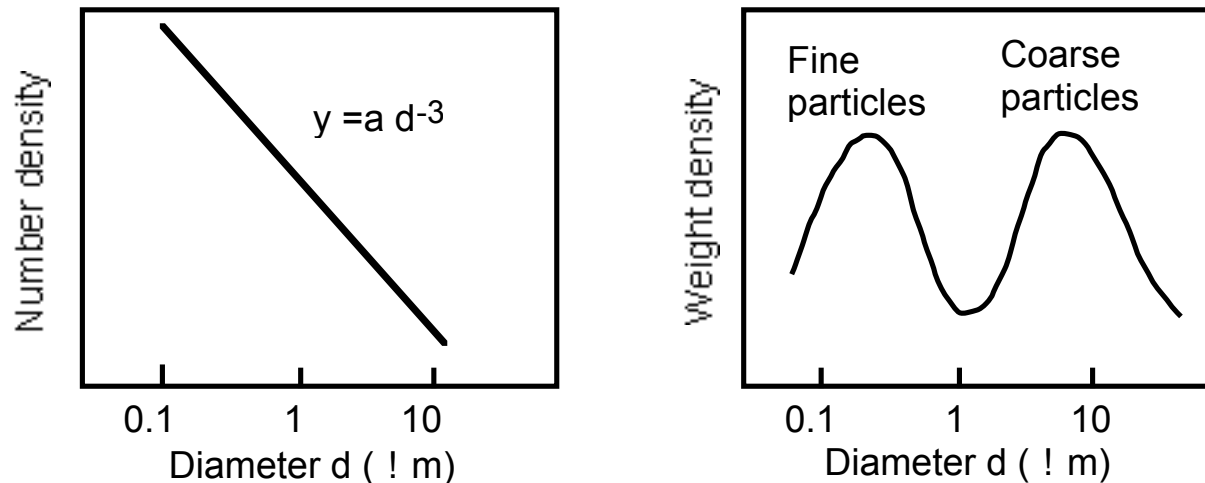
b. removing process of the pollutants from the atmosphere



Removing process of the atmospheric pollutants

c. aerosols

A gaseous suspension of fine solid or liquid particles is called aerosol, and we called these particles as **aerosol particle** or **aerosol**. In terms of the atmospheric pollution, aerosol is sometimes called as **suspended particulate matter**. The aerosols include the **primary** aerosol which is released into the atmosphere as the particle, and the **secondary** aerosol which is converted from the gaseous materials. The atmospheric aerosol size is distributed in the wide range, 10^{-3} to 10 micro meters. The aerosol **size distribution** has general characteristics in the atmosphere. The distribution with the number density (left figure), the distribution function is in proportion of d^{-3} (d is the aerosol diameter), and is called **Junge distribution**. When we make the distribution function with the weight of aerosols, the function shows 2 peaks of the **fine particles** and the **coarse particles**. The fine particles are composed of the particles produced by the **combustion** and **secondary particles** produced by the chemical reaction. The coarse particles are mostly composed of **sea salt particles** and **soil** originated particles.



Aerosol size distributions

NOTES: very fine particles occurs aggregation and become larger particles

2. Air Pollution and Environmental Impacts

a. classification

Air pollution affect the environment directly or indirectly. We classify the air pollution affections as:

- Affection on the human health
- Affection on the plants
- Affection on the buildings/ structures

b. parameters of pollution effect

The effect of the air pollution to the living body (human or plant/animal) is determined with the exposure dose and the human body condition, where **exposure dose** is represented as the product of **density of the pollutant** and **exposure time**.

NOTE: Global indirect air pollution is discussed in other lectures.

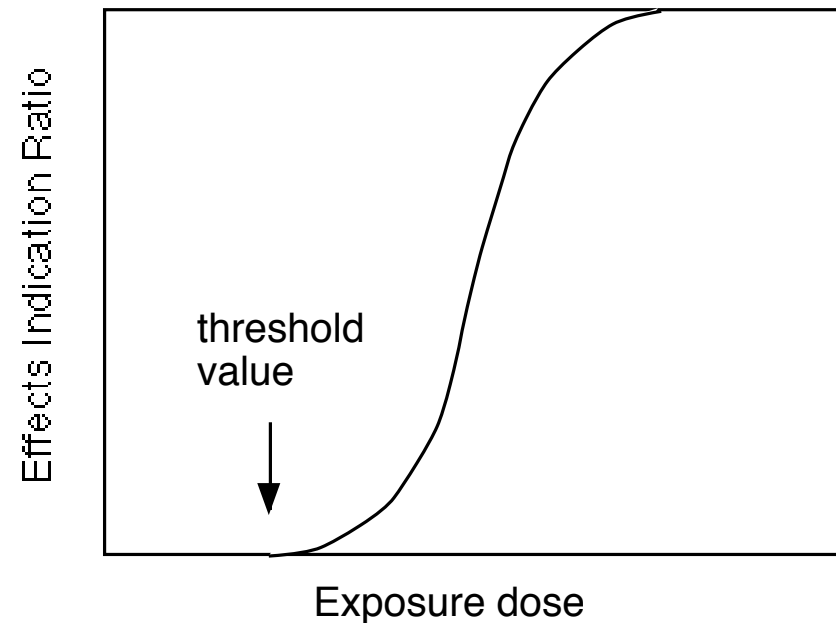
3. Effect of the Human body - Classification of the Pollution Effect

a. effect levels

The effect of the environmental pollution to the human body is classified by the WHO with 4 levels:

- Level I: no direct or indirect effect is observed
- Level II: indication of stimulus for sense organs, such as a nasty smell
- Level III: indication of damage or change for the physiological function
- Level IV: acute disease or death is observed

The indication or appearance are relative because the effect of pollutants is relating to each human body condition, as shown in the following. From the threshold value, we can obtain the idea of **permissible amount**.



b. acute and chronic effects

The major atmospheric pollutants are SO₂, NO₂, CO, Photo-chemical oxidant (O₃ or PAN), and SPM. The effect of the pollutants to the human body appears on the respiratory organs as an acute or chronic disease.

acute effects (short time exposure)	chronic effects (long time exposure or delayed appearance of symptoms)
<ul style="list-style-type: none"> • increase of asthma fits • increase of death rate (observed at the London Smog disaster) • increase of acute respiratory disease (observed at the Donora incident) • stimulus for the eye or pharynx (observed relating photo-chemical smog) • acute effects or death caused release of toxic gases (observed Bhopal disaster) 	<ul style="list-style-type: none"> • chronic bronchitis • increase of lead density in the human body (observed in the residents nearby the crossing) • increase of leukemia or thyroid cancer by the radioactive materials (observed at Chernobyl accident)

NOTE-1: PAN (peroxyacetyl nitrate)

NOTE-2: asthma [azma] fits : A chronic respiratory disease and the sudden appearance of a symptom

NOTE-3: Chronic bronchitis is also appeared by the smoking, and the effect of atmospheric pollution is evaluated as 1/3~1/7 of the smoking effect.

NOTE-4: leukemia : disease of unrestrained proliferation of white blood cells.

NOTE-5: Iodine included tablet is used for the preventing the thyroid cancer at the radioactive incidents.

NOTE-6: Chernobyl means wormwood in Russian.

4. Air Pollution and the Plants

a. Classification of damages

The damages on the plants by the air pollution are classified as follows:

- visible damages
 1. acute effects
Relatively high density pollutants (**> ppm level**) affect the plant organ and introduce: the **chlorosis** (yellowing or whitening of normally green plant tissue) or the necrosis (death of cells or tissues through injury or disease)
 2. chronic effects
Relatively low density pollutants (**ppm ~ pphm level**) affect the plant organ and introduce a light chlorosis
- Invisible damages
The very low level pollutants (**ppb level**) sometimes affect the plant organ and introduce the insufficient growth.

b. Sulfur dioxides damages

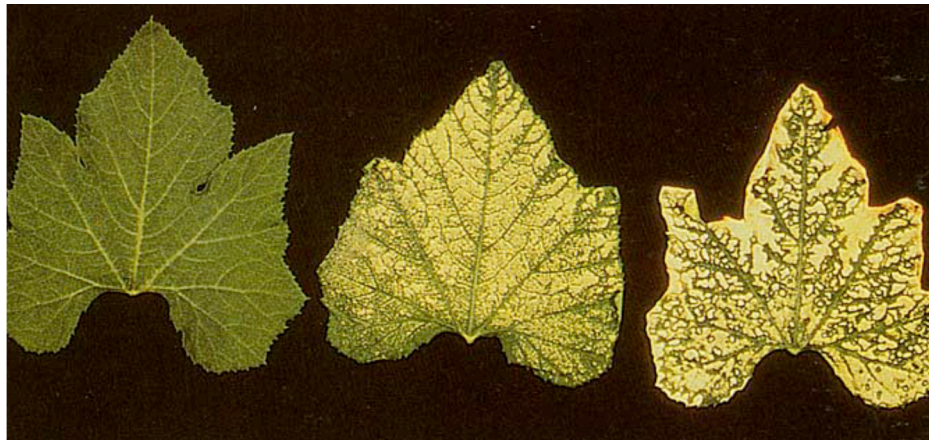
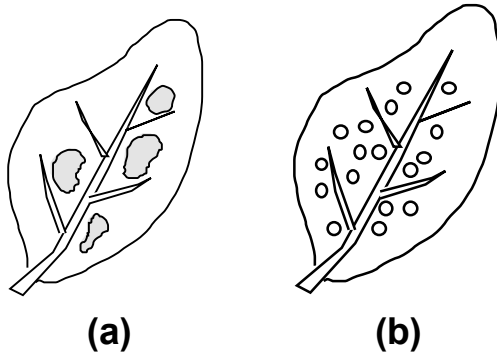
Sulfur dioxides effect is presented as the spots (chlorosis or necrosis) between the vein of leaf (**a**), as the suppression growth, and/or as the early casting leaves.

c. Nitrogen dioxides damages

Nitrogen dioxides effect is similar to the effects of sulfur dioxides or ozone, and the toxicity is weaker than these gases.

d. Photochemical oxidants

90 % component of the photochemical oxidants is ozone, however, PAN (peroxyacetyl nitrate) sometimes affect for the plants. The weak effect of the ozone is presented as the small whitish spots on the face of leaf (fig. **b**). The stronger effect is presented as the yellow-white or brown blots (fig. **c**), as the suppression growth, and/or as the early casting leaves. The plants exposed with PAN shows the back side of leaves became glossy or having metallic color (silver-gray or bronze).



(c)

Ozone injury appears first on older leaves. Affected leaves appear silvery to whitish. Bleaching will eventually kill the leaves in most severe cases. Watermelon appears to be fairly sensitive to ozone. (<http://aggie-horticulture.tamu.edu/cucurbit/leaf/35.2.html>)

5. Air Pollution and the Effects on Structure

It is reported that the air pollution began in this century damaged the historic structures in the world:

- Taj Mahal in India: affected by the air pollutants from automobiles and the industry stack gases.
- Acropolises of Athens: affected by the acid rain.

6. Regional Air Pollution Transport and the Evaluation of Deposition

a. RAINS-Asia model

Considering rapid economic growth of Asian countries and accompanying increasing of the emissions, following sulfur deposition should be evaluated. The World Bank and by the Asian Development Bank, funded the development of The RAINS (Regional Air Pollution INFORMATION and Simulation)-Asia model.

The RAINS-Asia model has been developed as an analytical tool to help decision-makers analyze **future trends in emissions**, estimate regional impacts of resulting **acid deposition** levels, and to evaluate costs and effectiveness of alternative mitigation options.

b. Model Structure

The RAINS model provides data on energy scenarios, emission control technologies and abatement costs, atmospheric transport and critical loads. The various sub-models of RAINS are organized into three modules:

Regional Energy Scenario GENERator: creates regional energy pathways and estimates future energy trends.

ENERgy-EMissions Module: estimates the pollutant (SO₂) emissions.

DEPosition and Critical loads Assessment Module: estimates the deposition.

http://www.iiasa.ac.at/Research/TAP/rains_asia/docs/rains.asia.html#menu