Introduction to Acid Deposition Monitoring (2)
Dry Deposition Monitoring

ADORC

Concept of dry deposition monitoring for EANET

Dry Deposition Monitoring

Air Concentration Monitoring

Deposition Monitoring Site

Research on Dry Deposition Flux

Reference Site

Priority chemical species for dry deposition monitoring in EANET

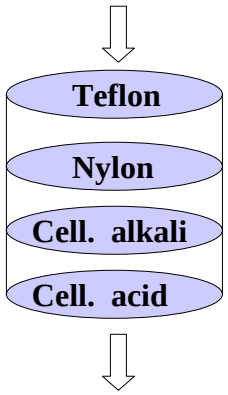
- 1st priority
  - SO_2, NO, NO_2 (urban), O_3, PM
- 2nd priority
  - NO_2 (rural, remote), HNO_3, NH_3
  - Particle component: SO_4^{2-} NO_3^-, NH_4^+, Ca^{2+}

Air concentration monitoring

- Automatic monitor - *expensive*
  - SO_2, NO, NO_2, O_3, PM
- Filter pack - *inexpensive, easy*
  - SO_2, HNO_3, HCl, NH_3, particle components
- Denuder - *expensive, requiring skillfulness*
  - SO_2, HNO_3, HCl, NH_3, particle components
- Passive sampler - *inexpensive, easy*
  - SO_2, NO, NO_2, HNO_3, HCl, NH_3, O_3, etc.

Filter pack method (1)

Flow rate: about 1 l/min (weekly sampling)



for particle

for HNO_3, SO_2, HCl, NH_3

for SO_2, HCl, ~~HNO_3~~

for NH_3

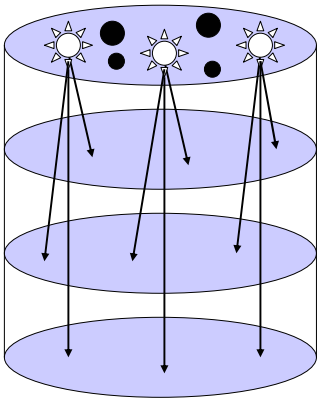
Filter pack method (2)

- Revised Format Dry C

Sample No.		Start Date	Start Time		End Date		End Time	Total flow (m^3)	Extraction (ml)
particle		SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}
Sample	F0								
	Quantity (µ g)								
Blank	F0								
	Quantity (µ g)								
Concentration (µ g/m^3)									
gas		SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}
Sample	F1								
	F2								
	F3								
	Quantity (µ g)								
Blank	F1								
	F2								
	F3								
	Quantity (µ g)								
Concentration (µ g/m^3)		SO_2	HNO_3	HCl	NH_3				

Filter pack method (3)

- Example of the artifacts on filter pack method



NH_4NO_3, NH_4Cl

⇩

HNO_3, HCl, NH_3

⇩

HCl

⇩

NH_3

Filter pack method (4)

- Recent studies indicate that the effect of artifact is not remarkable in case of weekly sampling with about 1 l/min flow rate.
  - Ex. Sickles et al., Atmos. Environ., 33, 2187-2202 (1999)
- For the time being, over-a-week sampling such as biweekly etc. might be acceptable, taking into account interval of precipitation sample collection.
- Technical document of filter pack method for EANET was developed at 2003.

Dry deposition flux (1)

- Present available methods for flux observation
  - Bowen ratio method (Japan, Thailand)
  - Gradient method (Korea)
- These methods consist of some specific conditions and require a large scale measurement system.

Dry deposition flux (2)

- Reference sites in Japan

Red pine forest in Oshiba, Nagano

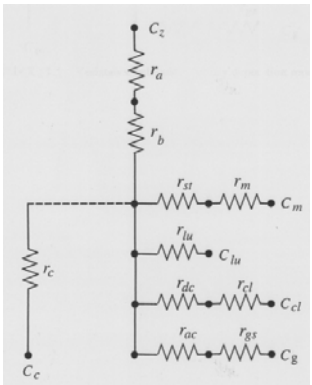
Agricultural land in Huchu, Tokyo

Inferential method (1)

- Dry deposition flux: F = C x Vd
  - Concentration: C
    - Automatic monitor, Filter pack, Denuder, Passive sampler, etc.
  - Deposition velocity: Vd
    - Inferred from some parameters (meteorological and biological elements etc.)

Inferential method (2)

- Vd = 1/(Ra+Rb+Rc)
  - Ra: aerodynamics resistance
  - Rb: quasi-laminar resistance
  - Rc: surface resistance
- It should be noted that each of Ra, Rb and Rc is site-specific.
- Each of the resistances display a strong diurnal cycle.



Resistance schematic (Wesely)

Step-wise approach

- According to the present status, it seems difficult to quickly develop sufficiently complete conclusions on the methodologies to be applied for EANET routine monitoring activities.
- The combination of research activities and routine monitoring, and step-wise approach of dry deposition monitoring activities, may require continued attention in East Asia for several years to come.

Step 1

- Commencement of concentration monitoring using any available measurement technology at as many sites as feasible

Step 2

- Extensive review of the methodologies for inferring the dry deposition velocities (in other words, the resistances Ra, Rb and Rc) of the relevant chemical species
  - Focus on the various different surfaces typifying East Asia
  - Identify the variables to be measured at all dry deposition field sites

Step 3

- Setting up of reference sites, where more direct measurements of dry deposition are initiated
  - These site should be flat, and the surroundings should be uniform as far as a distance of 500 m in all upwind directions.
  - The depositing species in question must have measurable concentrations around the sites.
  - It is desirable to set up the sites on several different surfaces such as coniferous and deciduous forests, cropland, rice field, etc.

Step 4

- Intensive research on the methodology for dry deposition monitoring

Reference site

Direct flux measurement

$$\frac{F}{C} = Vd = \frac{1}{Ra + Rb + Rc}$$

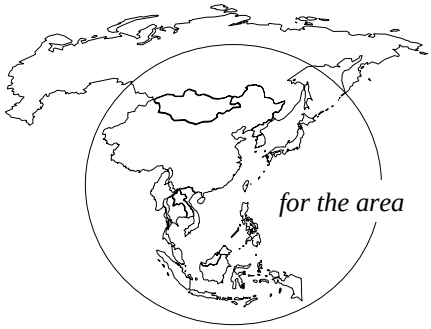
Concentration measurement

Inferential method

Step 5

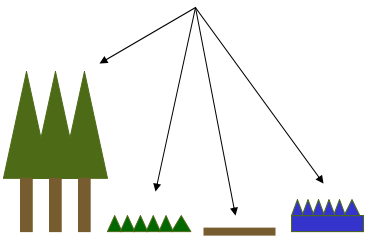
- Selection of monitoring sites suitable for dry deposition computation from among the concentration monitoring sites

Concentration monitoring



for the area

Deposition velocity research



for each specific surface

Data report on the Acid Deposition in the East Asian Region 2002:

Dry deposition monitoring (Air concentration)

ADORC

19

Applied monitoring methods in 2002 (Table 4.1)

- Automatic monitoring method
  - UVF (SO_2) , CLD (NO, NO_2) UV photometric (O_3), TEOM, β-ray (PM) etc.
  - *China, Japan, Malaysia, ROK, Russia, Thailand*
- Filter pack method
  - *Indonesia, Japan, Malaysia, Mongolia, Philippines, ROK, Russia, Thailand, Vietnam*
- Other methods
  - Passive sampler & Aerosol sampler
  - *Malaysia*

Automatic monitoring methods (Table 4.2)

Country	SO_2	NO	O	PM
China	UVF Doas	CLD Doas	UVP Doas	β-ray TEOM
Japan	UVF	CLD	UVP	β-ray TEOM
Malaysia	-	-	-	TEOM
ROK	UVF	CLD	UVP	β-ray
Russia	-	-	UVP	-
Thailand	UVF	CLD	UVP	β-ray

Manual sampling methods

- Four-stage filter pack (**Fig. 4.1**.)
  - Indonesia, Japan, Malaysia, Mongolia, Philippines, Russia, Thailand, Vietnam
- Aerosol sampler
  - Republic of Korea (three-stage filter pack)
  - Malaysia (aerosol sampler)
- Passive sampler
  - Malaysia