# Effect of acid deposition on soil and vegetation

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## Effect on soil and vegetation

- Direct effect

  Acid/acidic gaseous pollutants ($SO_2$, $NO_2$, $O_3$, etc.), acid fog (mist) and particulate matters may cause direct effect on leaves of trees/grasses.

- Indirect effect

  Soil acidification by wet/dry deposition of acid substances: loss of nutrient ions, Increase of toxic Al ions, etc.

  Nitrogen saturation in ecosystem

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## Sensitivity of plant species

For evaluating direct effects, accumulation of the following basic information is important:

- Identification of (specific) response
  Visible symptoms, changes in chemical properties and/or growth rate, etc.
- Screening of Indicator plant
  Which species should be observed?
- Dose – Response relationship
  Concentrations (ppb) and exposure periods (hr.)

Enough information has not been accumulated in East Asia.

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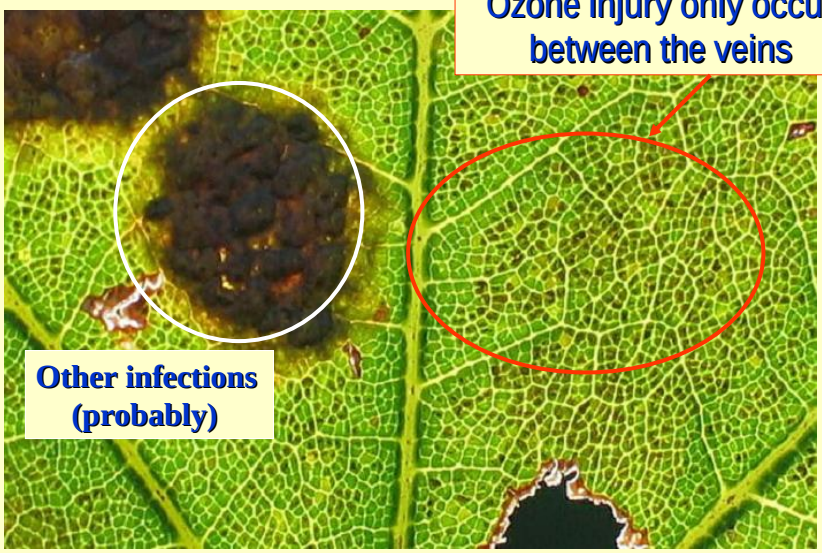


Example of visible injury by $O_3$
*Acer pseudoplatanus* (a kind of maple)
ICP Forests Ozone Training Course web page)

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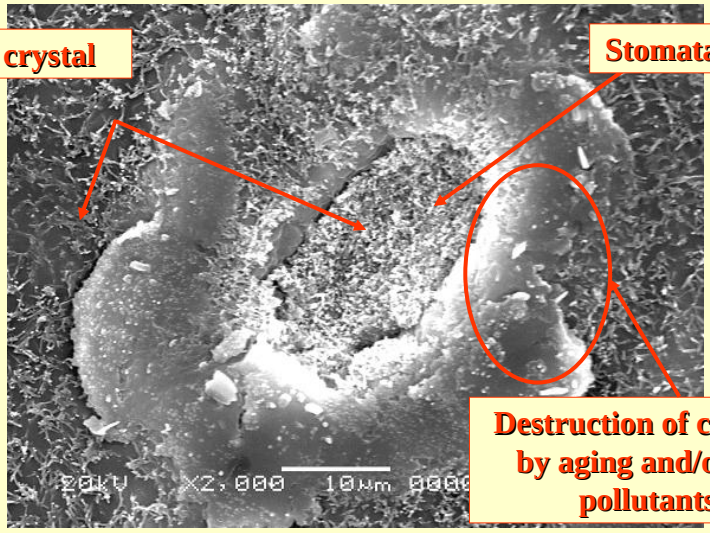


Changes in epicuticular wax structure of leaf surface

Erosion, destruction of crystals, changes of production rate, etc. by environmental factors such as air pollutions

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## Acidification of soil

- Van Breemen et al. (1983)

  Soil acidification can be defined as a decrease of Acid Neutralizing Capacity (ANC).

  ANC

  = 6[$Al_2O_3$] + 2 [CaO] + 2 [MgO] + 2 [$K_2O$] + 2 [$Na_2O$] + 4 [$MnO_2$] + 6 [$Fe_2O_3$] + 2 [FeO] – 2 [$SO_3$] – 2 [$P_2O_5$] – [HCl]

  = Basic solid components – Acidic components

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## Buffer systems and pH ranges in soil

| pH range | Buffer system |
|---|---|
| (8.6 – 6.2) | Carbonate ($CaCO_3$) |
| (6.2 – 5.0) | Exchangeable cations, carbonic acid, silicate<br>(Loss of exchangeable cations) |
| (5.0 – 4.2) | Silicates, clay mineral<br>(Silicate and clay mineral destruction, decrease of CEC, Increase of Al saturation) |
| (4.2 – 2.8) | Aluminum (Al) hydroxy compounds<br>(Increase of $Al^{3+}$ in solution) |
| (3 > ) | Iron (Fe) oxides/hydroxides |

Kaupenjohann et al. (1989); Ulrich (1986)

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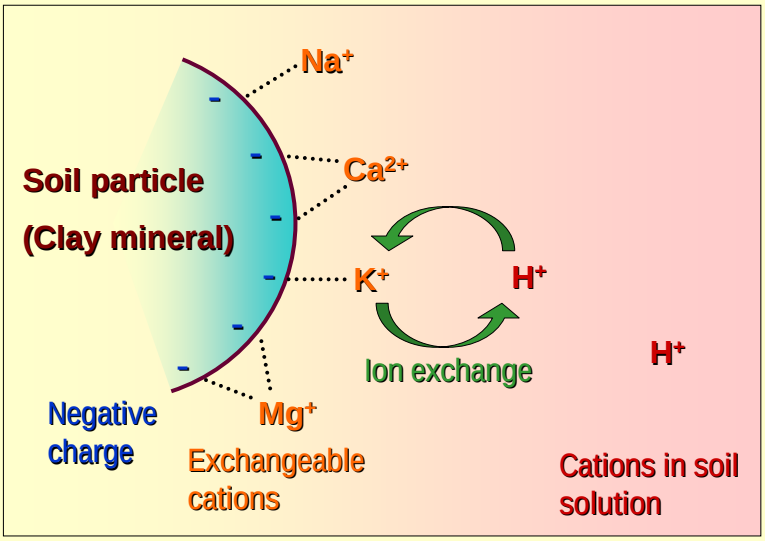
## Exchangeable cations

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## Effective Cation Exchange Capacity (ECEC)

ECEC
= Exchangeable base cations + Exchangeable acidity

(Ex-Ca, Mg, K, and Na) (Ex-Al and H)

**ECEC is nearly equal to total amount of exchangeable cations, and could be used for estimation of cation exchange capacity of soil.**

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## Acidification process

- **pH:** ↘
- **Acidity (acid cations: H and Al):** ↗
- **Base cations (Ca, Mg, K, and Na):** ↘

- **Ca/Al, Mg/Al, and/or (Ca+Mg+K)/Al:** ↘
- **Base saturation (BS):** ↘
  **BS (%) = (Ex-(Ca+Mg+K+Na)/ECEC)*100**

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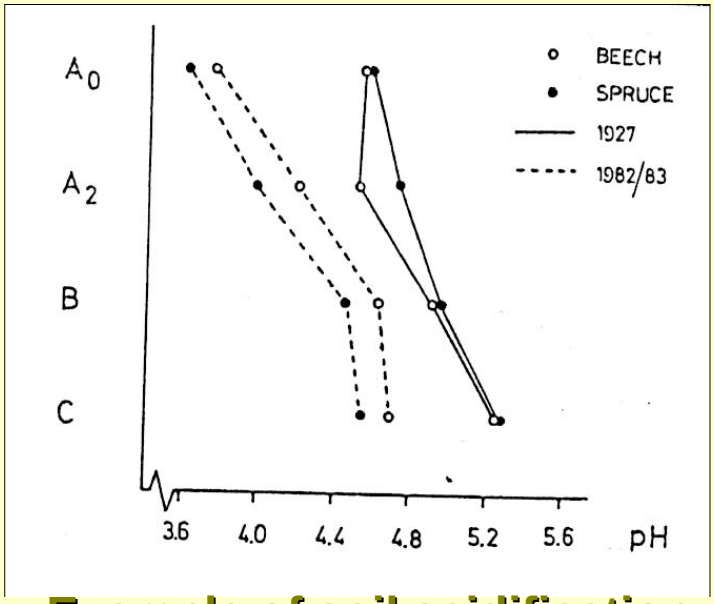


**Example of soil acidification**
(Hallbacken and Tamm, 1986)

## Critical load approach

- The maximum deposition of acidifying compounds that will not cause chemical changes leading to long term harmful effects on ecosystem structure and function
- Steady States Mass Balance Model:
  - Only final results of certain deposition level is considered;
  - The time to reach this final state is not considered;
  - It is assumed that ion exchange is at steady state, and that there is no net change in base saturation.
  - Weathering of the mineral matrix is the major long term source of alkalinity to neutralize acidity in soil.

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## Calculation of critical load

- Based on the Steady State Mass Balance Model, critical load was calculated:

  $CL = BC_w + Al_{limit} + H_{limit}$

  CL: Critical load of acidity

  $BC_w$: Weathering rate of base cations (Ca, Mg, and K)

  $Al_{limit}$: Maximum permitted leaching of Al

  $H_{limit}$: Maximum permitted leaching of H

- For calculating limit of Al ($Al_{limit}$), an idea of threshold, BC/Al was applied:

  BC/Al: (Ca + Mg + K)/Al molar ratio

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## BC/Al = 1.0 (?)

- According to experiments for European plant species, such as spruce, pine, and beech, growth of stems would significantly decrease if BC/Al molar ratio of soil water would be below 1.0 (Sverdrup & Warfvinge, 1993).
- The value, 1.0, was used as threshold value for BC/Al molar ratio for calculation of the critical load.
- However, in Japanese cedar (*Cryptomeria japonica*), the value was estimated at about 10.0 (Izuta & Totsuka, 1996).

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## Questions for critical load approach

- The threshold values would vary with plant species.
- In the field condition, other factors, such as temperature, water condition, other nutrient condition, may affect the threshold value.
- Quality of basic data

  Weathering rate is the most important parameter in the calculation process, and some estimation methods for the rate were proposed. However, estimated rates would be varied with used methods. Its quality should be discussed.

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## Application of critical load

- In Europe, by using the integrated assessment model (simulated from transport to impact), RAINS, regional assessments were carried out, and the results were used for negotiation on reduction of emissions in the respective countries; e.g. Oslo protocol for $SO_2$ in 1994.
- In East Asia, possibility of applying critical load to assessments should be discussed carefully considering characteristics of the ecosystem.

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## Terrestrial ecosystem analysis

- Ecosystem is not at steady state but dynamic.
- Continuous monitoring of ecosystem including deposition, soil, vegetation, and surface water, can give us information on elemental dynamics.
- In the Strategy Paper for Future Direction of Soil and Vegetation Monitoring of EANET, catchment analysis and simulation modeling on soil and surface water acidification were proposed for achieving the ultimate objective of the monitoring.

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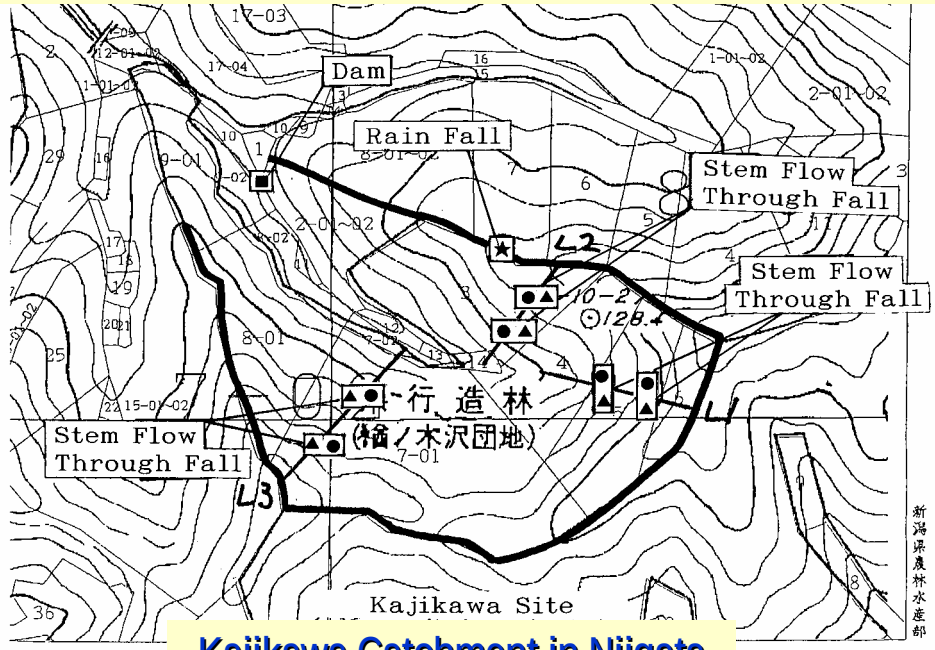


Kajikawa Catchment in Niigata


森林影響調査地
水質調査のため
沢の中を歩かないで下さい。
設置してある機材には
お手を触れないで下さい。

## References


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