

9.13 Field survey of effects on vegetation

As a method of evaluating the effects on plants, evaluation of the visible damage to the leaf surfaces, phytometer, the open top chamber method, and survey method for evaluating state of plants grown in the field are used.

9.13.1 Methods of indexing the appearance of visible damage (plant indicator)

Higher plants can not generally change their domain like animals do, so their growth is induced, due to environmental impact upon their habitat, or they change their lifestyle in response to the environment. Further, compared with animals, plant sensitivity to air pollutants is extremely high.

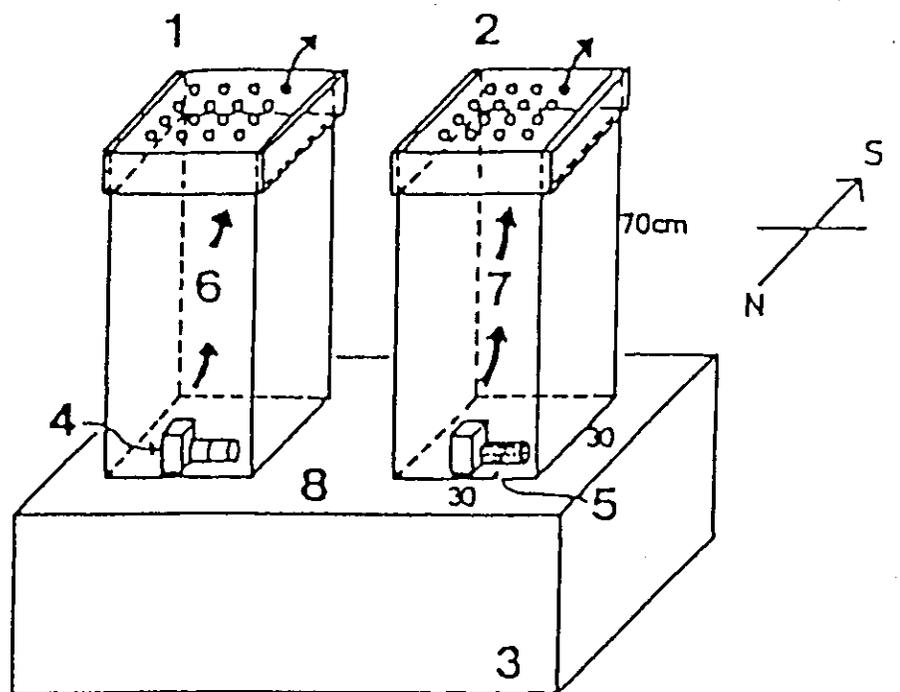
Plants that are highly sensitive to air pollutants, even a comparatively low concentration of air pollution results in the manifestation of visible damage to the leaf surface. For example, with the morning glory (strain "Scarlett O'Hara") visible damage is manifested with an ozone concentration of 4 ppb or above, and when the concentration increases above that level, the damage becomes proportionally great. When visible damage manifests on the leaf surfaces, plant growth thereafter is affected. In alfalfa, when 5% or more of the leaf surfaces are visibly damaged, not only does the rate of damage accelerate, but the growth in plant dry weight is linearly reduced ¹⁾.

9.13.2 Open top chamber method

With the Open Top Chamber (OTC) method, two transparent chambers with open ceilings are installed in the field. On one chamber, the surrounding air is introduced directly into the chamber, which is designated as the unfiltered plot. On the other one, clean air from which all of the airborne pollutants have been removed by means of an activated charcoal filter is introduced into the filtered plot. The growth of indicator plants grown within both chambers is compared, and the effect on plants of air pollution at a given site is evaluated. When the air at a site in which the OTC has been installed is polluted, visible damage occurs to the leaf surfaces of plants raised in the unfiltered plot, and dry weight growth of the plant and its total leaf area is retarded when compared with plants raised in the filtered plot. By comparing the growth reactions of plants in both plots, the effects of air pollution on plants in the field can be evaluated.

Fig.9.13.1 shows an outline of OTC ²⁾. The chamber (30 cm long × 30 cm wide × 70 cm high) is made of transparent acrylic sheet. A hole is made in the bottom of the wooden pot to allow water to drain from the base (90 cm long × 45 cm wide × 30 cm high) for growing plants, and a suitable culture medium is used for growing plants in the pot.

As a plant indicator used in the OTC, when using plants that are highly sensitive to air pollution, even the extremely low concentrations of air pollution on-site can be detected from the plant reaction, and it is thus also possible to evaluate the air quality. For example, the radish plant, *Raphanus sativus*, highly sensitive to photochemical oxidants like O₃, grows rapidly, and is comparatively easy to cultivate ³⁾.



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|------------------------|------------------------|-------------------------------------|
| 1. OTC unfiltered plot | 2. OTC unfiltered plot | 3. Plant pot for cultivating plants |
| 4. Sirocco fan | 5. Activated charcoal | 6. Unfiltered air |
| 7. Filtered air | 8. Plant culture soil | |

Fig.9.13.1 Outline of open top chamber (OTC) (Aihara et. al., 1988)

9.13.3 Phytometer

Among the survey methods of the air pollution effect on vegetation, phytometer can compare the growth rates of plants in the vegetative growth period in different regions. This requires potted young plants to be placed in each region under a fixed condition regarding inorganic nutrient status and water content of the soil. The dry weight of each plant is measured at regular intervals. From the obtained data the extent of the impact of air pollution on plants at the relevant site can be evaluated. As a plant for this purpose, the following characteristics may be cited:

- 1) Easy cultivation and synchronized growth in an initial growing stage;
- 2) A high sensitivity to air pollution, and resistant to disease and insect damage;
- 3) Possibility of evaluation in a relatively short period of time, such as from one week to one month, regardless of the season.

The plants hitherto used often are as follows: buckwheat (*Fagopyrum esculentum*), sunflower (*Helianthus annuus*), oats (*Avena sativa*), perennial rye grass (*Lolium perenne* L. cv. S23), and radish (*Raphanus sativus* L. cv. comet). In addition, trees such as Zelkova and Japanese cedar are used for long-term evaluation.

At the sites in which the potted plants are installed, the state of air pollution and meteorological conditions are also ideally measured, using equipment for simple measurements of air pollution, an accumulated solarimeter, maximum and minimum thermometers, and so forth.

Fig.9.13.2 shows an example of phytometer for field survey ⁴⁾. Ten potted plants showing homogeneous growth are installed in a given site and then collected back in one to two weeks later. After measuring the leaf area, the plant is divided into foliage, stem, and roots, and the dry weight of each organ is measured. The initial sampling of plants is also necessary. As an indicator for evaluating the impact of air pollution on plants, the Relative Growth Rate (RGR) is determined.

RGR (g/g/day) can be determined by Eq. (1).

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \times 100 \quad \dots \dots \dots (1)$$

Here, W_1 and W_2 denote plant dry weight at initial sampling t_1 and that at final sampling t_2 , respectively. (t_2-t_1) is the number of days between two sampling dates, which is normally one or two weeks.

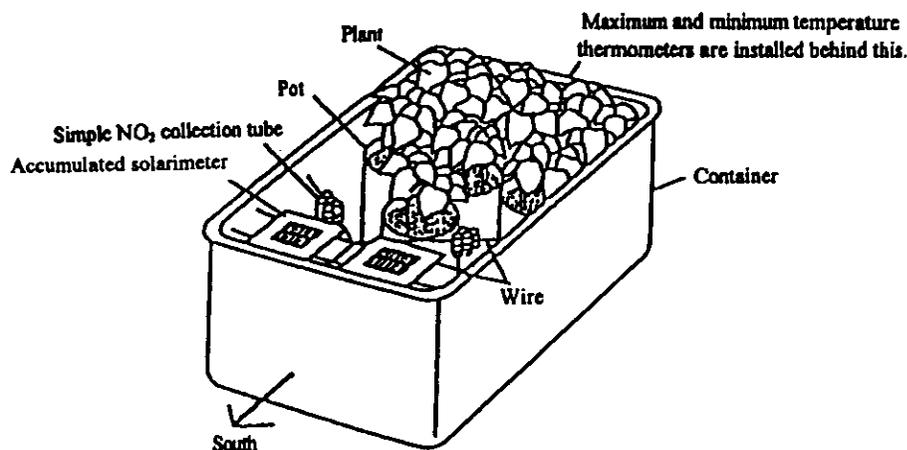


Fig.9.13.2 Example of a phytometer (Ushijima, 1981)

9.13.4 Survey method for plants growing in the field

In order to evaluate the impact of air pollution on plants, as a method of monitoring plants growing under natural conditions there is a method which evaluates changes in the form of trees, and in the width of their annual rings evaluated.

Fig.9.13.3 shows an example of changes in form of tree by air pollution impact, where evaluation in fifth stages is shown in Japanese cedar and Zelkova ⁵⁾. Further, Table 9.13.1 indicates an example of evaluation items for a tree vitality index ⁵⁾.

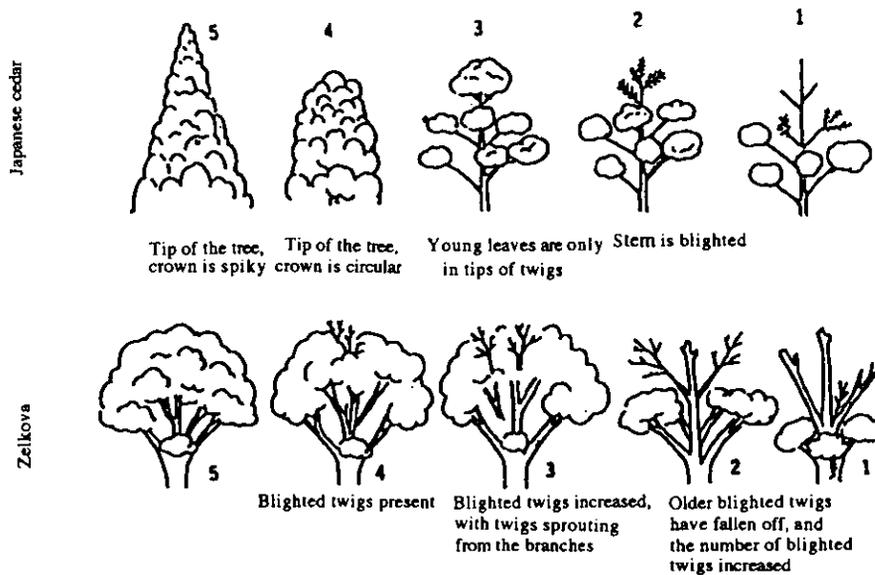


Fig.9.13.3 Decline scale of trees in Japanese cedar and Zelkova (Matsunaka, 1975)

Table 9.13.1 Evaluation standards for tree vitality index (Matsunaka, 1975)

Measurement items	Evaluation standards			
	1. Good, normal	2. Affected, but nearly normal	3. Deterioration is considerably advanced	4. Striking deterioration
Tree vitality	No damage	Slightly damaged	Evidently damaged	Severely damaged
Form of tree	Normal	Some branches lacking	Evidently wanting	Severely wanting
Branch growth	Normal	Somewhat reduced	Short and slender	Extremely short and slender
Dieback of stem	None	Slightly diebacked	Evidently diebacked	Completely dead
Density of foliage	Healthy foliage	Unbalanced foliage	Sparse foliage	Very sparse with dead leaves
Leaf shape	Normal	Slightly deformed	Evidently deformed	Completely deformed
Leaf size	Normal	Somewhat small	Evidently small	Strikingly small
Leaf color	Normal	Somewhat abnormal	Abnormal	Strikingly abnormal
Injury of leaves	None	Slight	Considerable	Striking
Red (yellow) leaves	Leaves shed normally in spring or autumn Annually	Slightly early compared with normal Annually	Leaves shed at odd times Biannually	Leaves shed at odd times Three or more times a year
Leaf shedding	Normal	Color slightly off	Leaves partially red and yellow, but color is bad	No red or yellow colors; leaves shed in dirty state