

A Lichen (*Parmelia conspersa*) Surviving with Elevated Concentrations of Lead and Copper in the Center of Sendai City

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Lichens have been reported to be one of the most suitable plants to assess the severity of air pollution because of their unique sensitivity to polluted air (BADDLEY & HAWKSWORTH 1973, SKYE & HALLBERG 1969). Mapping studies of lichens have been reported for several cities in Japan, and the relevance of air pollution to the distribution of lichens has been discussed (TAODA 1972, 1973, SUGIYAMA 1973). This is, however, the first report which depicts the significance of heavy metals for the survival of lichens in Japan.

The city of Sendai and its surroundings were the study area in this report. The location, densely populated areas, roads of main traffic, railways, rivers, and sites of sampling of lichens are shown in Fig. 1. The size of the population in the city of Sendai was about 580,000 and the population density was about 2,400/km² in 1973. The surroundings consist of four cities and two towns, where the size of the population was about 255,000 and the population density was about 380/km² in 1973.

The surveillance of lichens flora was started in 1973 and has been repeated annually. Sites chosen for surveillance were mainly the graveyard of temples which scatter fairly uniformly in the study area, and lichens grow on the tombstones there. Generally speaking, lichens were found infrequently in the center of cities compared with the periphery of study area. The lichens belonging to the genus *Parmelia*, i.e. four species (*P. tinctorum*, *P. caparata*, *P. reticulata* & *P. clavulifera*), were completely absent, and only one species (*P. conspersa*) was occasionally found in the center of Sendai city (Fig. 1).

On June 1974, *P. conspersa* was sampled from 21 graveyards, and analysed for lead and copper. The lichen sampled was cleansed by using 0.1% sodium lauryl sulfate solution after removing dust and soil

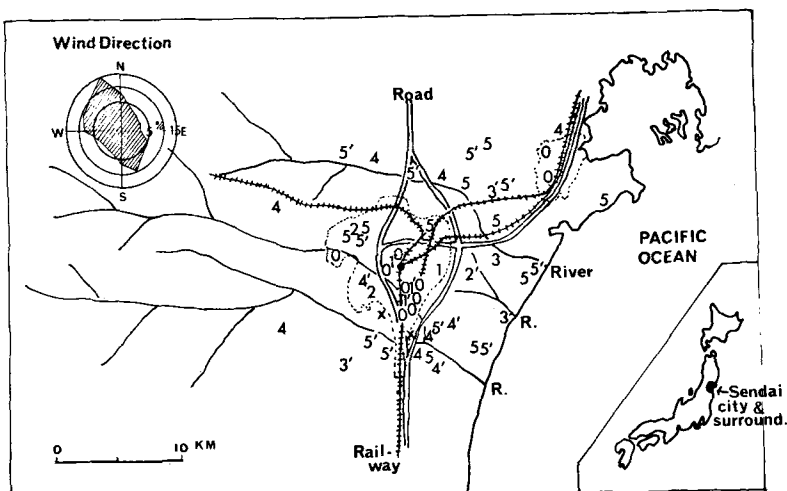


Fig. 1. Map of study area. Areas encircled with dotted line show the densely populated area where the population density is over 4,000/km². Figures in the map show the sampling site of lichens; 0: Absence of 5 species of the genus *Parmelia*, 1: Only *P. conspersa*, 2: *P. conspersa* & *P. caperata*, 3: *P. conspersa*, *P. tinctorum* & *P. clavulifera*, 4: 2 + *P. tinctorum*, 5: Existence of all 5 species. Black dot on the railway shows the central station. Figures with dash like 5' show the sampling site of lichens which was analysed for metals contents. R: River. Two metal refineries (x) are on the southern margin of densely populated area of Sendai city. Wind directions are shown as relative percentages in the period from April 1973 to March 1974.

which encrusted the base of lichens. The cleansed specimens were washed three times with distilled water. After washing, the specimens were dried at 60°C for 2 hours in a desiccator. One to 2 g of dried specimens were oxidized with conc. HNO₃ and H₂O₂

solutions. After oxidation, specimens were measured for the contents of lead and copper by atomic absorption spectrometry. Results are shown in Fig. 2, where the contents are related to the distance of sampling sites from the central station of railway. As the location of the central station shows, it is the center of the city in terms of population density, crowded traffic, and aggregation of various shops.

By the way, just outside of the densely populated area and about 5 km south of the central station, there exist two metal refineries where alloys including Ni, Fe, Cu, Mn and/or other metals are manufactured. The concentrations of lead and copper in lichens have not shown orderly relationships to the distances of sampling sites from either refinery.

The concentrations of lead and copper in *P. conspersa* sampled from the densely populated area

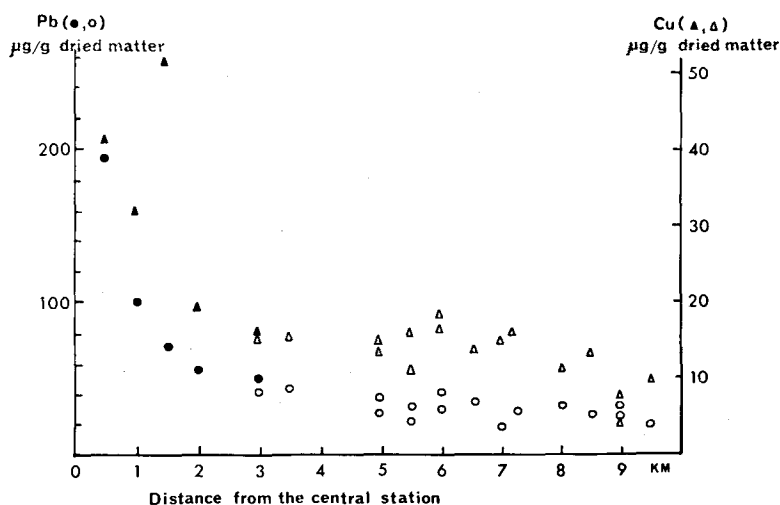


Fig. 2. Concentrations of lead and copper in *P. conspersa* with reference to the distance of sampling sites from the central station. Samples from the densely populated area smeared like ● or ▲.

were higher than those from the not densely populated area, and they decreased reciprocally with the distance from the central station.

Elevated concentrations of lead and copper in the survived lichen (*P. conspersa*) in the center of city may be the result of air pollution originating from aggregated human population, especially by automobile driving. Whether this interpretation is correct will be judged later, because the use of gasoline containing alkyl lead was recommended to stop since February 1, 1975 by the national government of Japan. The conversion to unleaded gasoline is now proceeding. After the completion of this conversion, which is expected as March 1977 at the latest, the measurement of lead in *P. conspersa*, if it will survive, will reveal the true cause.

Many factors such as aridity, elevation of temperature, increase of evaporation, and air pollutants like SO_x or NO_x are likely contributing to the decay of lichens in the urban environment. In addition to these factors, the influence of metals in atmospheric air is not negligible. Nevertheless, the reason why *P. conspersa* has survived in the center of city is not known.

In a case where a localized center of air pollution with metals, viz. a Ni-refinery, existed, contents of metals (Cu, Ni, Zn, Fe, Pb, & Mn) in lichens were reported to be reciprocal to the distance from the center (NIEBOER et al. 1972). In this study, lichens tolerated simultaneously high concentrations of several metals. Species studied were completely different from ours. Therefore, it is impossible to compare the tolerance to metals between two studies, but levels of copper found were about 10 times higher and those of lead were about one fourth comparing with our results. The sensitivity of lichens to metals may differ according to genus or species.

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