

Metal Contents in Epiphytic Bryophytes in Kitakyushu Area

Kozue NAKANISHI¹, Kyoko HIRAOKA² and Yuzo KITAZAWA³

¹*Plant Ecology Laboratory, Nagasaki University. Nagasaki 852, Japan*

²*Department of Materials Science and Engineering, Faculty of Engineering, Nagasaki University. Nagasaki 852, Japan*

³*Department of Biology, University of Occupational and Environmental Health, Japan. Kitakyushu 807, Japan*

Abstract : Metal contents in epiphytic bryophytes growing at Yahata Nishi-ku, Kitakyushu City and its vicinity were measured. Measurements were made both on the contents in the plant body of a single species *Clastobryella kusatsuensis* and on those of the whole bryophytic community. Contents of eight elements (Fe, Zn, Mn, Cr, Pb, Ni, Cu and Cd) decrease generally with increase in distance from the center of the industrialized area. No such marked regional difference was seen in the contents of Ca and Mg. The ratios of seven kinds of elements (Fe, Mn, Cr, Pb, Ni, Cu and Cd) in bryophytes almost coincide with those in airborne particulates. It was proved that *C. kusatsuensis* and communities of bryophytes can be an indicator of air pollution by metals.

Key words : bryophytes, metal contents, air pollution, Kitakyushu.

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Introduction

Many studies have been made on the influence of air pollution upon plants (cf. Taoda, 1974). However, studies on the relation between metals in airborne particulates and plants are few. It is reasonable that bryophytes are more easily influenced by air pollution than higher plants, because they do not have developed roots and absorb water and nutrients into their body directly through the body surface.

Le Blanc & Rao (1974) reviewed literature on bryophytes with respect to air pollution and stated that heavy metals found in the body of bryophytes are good indicators of the air pollution. Ishizawa *et al.* (1974) also pointed out that there are close interrelations between bryophytes and heavy metal contents. Nogawa (1978) and Nakanishi & Hiraoka (1981) reported that the bryophyte which grows on the surface of rocks and soil is a good indicator of environmental pollution caused by metals. The present work was carried out to obtain a basic material for the study of environmental conditions in the highly industrialized region of Kitakyushu.

Materials and Methods

1. Collection of bryophytes

Measurements of metal contents were made both on the plant body of a single species *Clastobryella kusatsuensis* (Besch.) Iwats. which is distributed through a wide range of environments, and on that of the whole bryophyte community. Nine stations with different environmental conditions were selected to collect bryophyte materials. The stations are arranged nearly in order of degree of urbanization.

St. 1. Takami Shrine at Yahata Nishi-ku, Kitakyushu City

This station is located in a densely built-up area. In the shrine and on a hill behind it, there is a small semi-natural forest of *Castanopsis cuspidata* var. *sieboldii* Nakai. Collection was made on the trunk of this tree which is about 15 m high and 30 cm in diameter at breast height (D. B. H.) on 29 Sept. 1980.

St. 2. A house at Einomaru in Yahata Nishi-ku, Kitakyushu City

Collection was made on the trunk of a single tree of *Podocarpus macrophyllus* Lamb. about 7 m high and 40 cm in D. B. H. growing in a garden of a house on 26 Sept. 1980. There is a road with much traffic in front of the house.

St. 3. Shiraiwa Shrine at Yahata Nishi-ku, Kitakyushu City

This station is located in the newly developed residential section in a rural area. Within the pale of this shrine, there is a forest of *Castanopsis cuspidata* var. *sieboldii*, and *Myrsine seguinii* Lev. *Machilus thunbergii* Kosterm., *Cinnamomum camphora* Sieb. and *Meliosma rigida* Sieb. et Zucc. are interspersed among them. Collection was made on the trunk of a *C. cuspidata* 15 m high and 55 cm in D. B. H. on 26 Sept. 1980.

St. 4. Sugimori Shrine at Yahata Nishi-ku, Kitakyushu City

This station is near St. 3, and there is a forest dominated by *Castanopsis cuspidata* var. *sieboldii*. Other main tree species are *Camellia japonica* Linn., *Pasania glabra* Oerst and *Ilex rotunda* Thunb. Collection was made on the trunk of a *Podocarpus macrophyllus* which is 10 m high and 40 cm in D. B. H. on 26 Sept. 1980.

St. 5. North slope of Mt. Sarakura

Mt. Sarakura (622 m) is situated 3 km to the south of Kitakyushu City's industrial area. Collection was made on the trunk of a planted *Cryptomeria japonica* D. Don 15 m high and 60 cm in D. B. H. on the roadside halfway up the northern slope of this mountain on 26 Aug. 1980. This slope is directly facing the industrial area of Kitakyushu City. Near here there are a *Miscanthus-Pleioblastus* grassland, a *Quercus acuta* forest and plantations of *Cryptomeria japonica* and *Chamaecyparis obtusa* Sieb. et Zucc.

St. 6. A garden of a house at Kanda in Nogata City

Collection was made on the trunk of a *Celtis sinensis* Peris. var. *japonica* Nakai growing in a garden of a house in the rural area on 25 Sept. 1980. The tree is 10 m high and 80 cm in D. B. H.

St. 7. South slope of Mt. Sarakura

The south slope of this mountain is on the opposite side to the urban area of Kitakyushu City. Collection was made on the trunk of a *Cryptomeria japonica* 10 m high and 30 cm in D. B. H. growing in the plantation of this species distributed from the top of the mountain about halfway down the southern slope on 26 Aug. 1980.

St. 8. Aganokyo in Mt. Fukuchi

Aganokyo is on the south slope of Mt. Fukuchi (910 m) which is situated about 16 km south of the urban area of Kitakyushu City. Along a valley there is an evergreen broad leaved forest consisting of *Castanopsis cuspidata* var. *sieboldii*, *Quercus salicina* Bl., *Symplocos theophrastaefolia* Sied, et Zucc., *Elaeocarpus japonicus* Sieb. et Zucc., *Ilex latifolia* Thunb., and others. There is a *Pinus densiflora* forest on the ridge, where *Quercus glauca* Thunb., *Pasania glabra* Oerst., and other species grow. There seems to be very little air pollution here. Collection was made on the trunk of a *Cryptomeria japonica* which is 10 m high and 20 cm in D. B. H. on 30 July. 1981.

St. 9. Todorokikyo in Takaki Town in Nagasaki Prefecture

This station is about 120 km south-west of Kitakyushu City. There is a forest dominated by *Castanopsis cuspidata* var. *sieboldii* mixed with *Quercus salicina*, and *Machilus thunbergii*. Collection was made on the trunk of a *M. thunbergii* 15 m high and 60 cm in D. B. H. on 26 July. 1981. This station is in an entirely unpolluted area and was selected for comparison.

The locations of the above stations (1-8) are shown in Fig. 1.

2. Measurement of metal content

Measurements of contents of ten kinds of metals were made, i.e., Fe, Zn, Mn, Ca, Cr, Pb, Ni, Cu, Cd and Mg. The procedure of this experiment is as follows. Bryophytes collected were washed thoroughly with water, washed further with neutral detergent and once more with water and finally washed with distilled water. Materials were dried naturally in a room and weighed. They (0.5-2.0 g in weight) were then combusted in a crucible, and the ash was dissolved in HCl and filtrated. Distilled water was added to the filtrates. Total volume of sample solution for the determination of Fe, Zn, Mn, Ca and Mg was 50 ml, and that for Cr, Pb, Ni, Cu and Cd was 10 ml. The metal contents were measured by using an atomic absorption spectrophotometer (Shimazu AA-620). The content of Mg was measured by using a flame spectrophotometer (Shimazu AA-620). Analytical conditions are shown in Table 1. The detective lower limit of the analyzer was 0.001 ppm. Since the background absorption of alkali halides which

exists in the range of the atomic absorption of Cd and Ni was not corrected, it is possible that the determined values of Cd and Ni may be somewhat larger than the true values. However, we consider that this small over-estimation does not greatly affect the conclusion regarding the relation between the inorganic contents of a bryophyte and its environment mentioned in this paper.

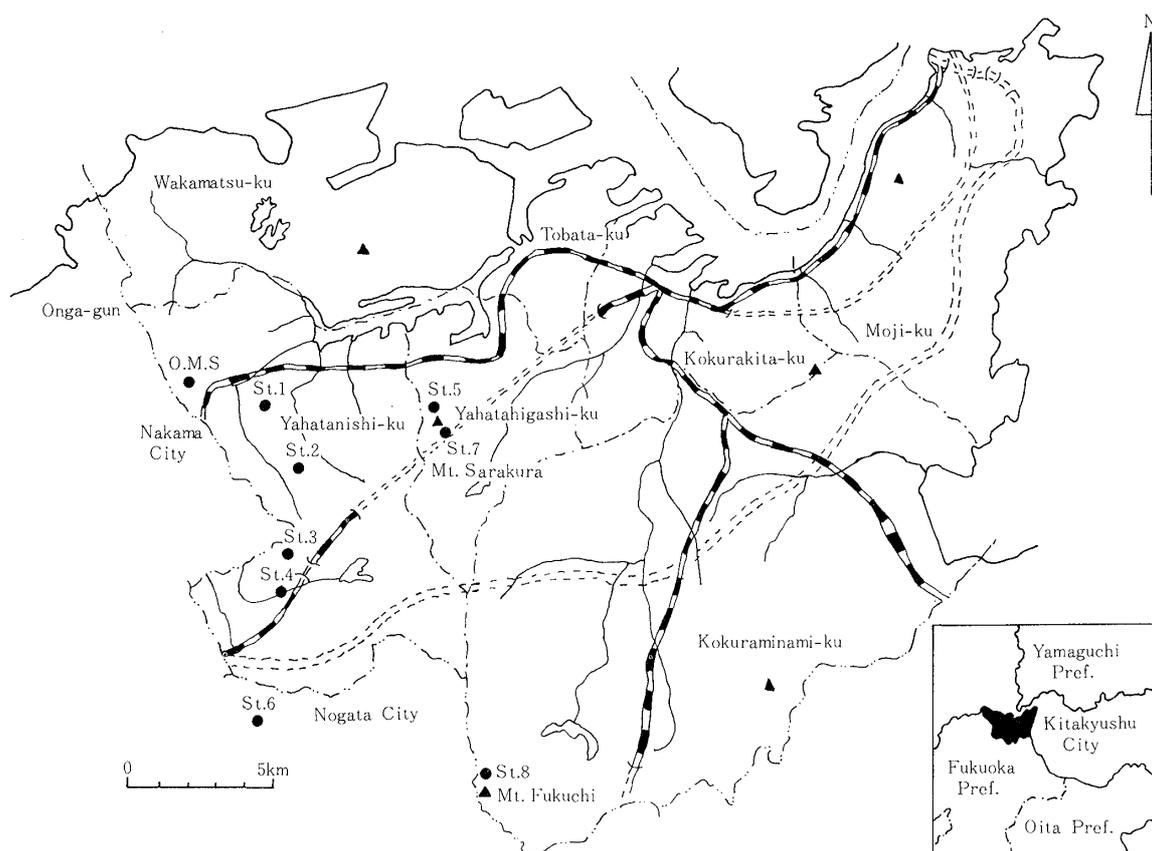


Fig. 1. Map showing the locations of study stations in the Kitakyushu area. (O. M. S. : Orio Monitoring Station)

Table 1. Analytical conditions

Elements	Wave length (Å)	Lump current (mA)	Flow rates of gas		Response
			Carrier (Air)	Sheath (C ₂ H ₂)	
Fe	2483	10	10	2.5	2
Zn	2139	10	10	2.4	2
Mn	2795	10	10	2.6	2
Ca	4227	10	10	2.6	2
Cr	3579	10	10	2.5	2
Pb	2833	6	10	2.6	2
Ni	2320	10	10	2.3	2
Cu	3247	10	10	2.3	2
Cd	2288	6	10	2.5	2
Mg	2582	10	10	2.4	2

Results and Discussion

1. Metal contents in the body of a single species *Clastobryella kusatsuensis* (Besch.) Iwats.

Values of measured contents of metals are shown in Table 2. Contents of eight elements, i.e. Fe, Zn, Mn, Cr, Pb, Ni, Cu and Cd are generally large in and near the industrial area of Kitakyushu City, and they decrease with distance from this area. There are large iron mills and many related factories in Kitakyushu City, and the large contents of Fe in *C. kusatsuensis* are remarkable. It is especially noticeable that a marked difference was seen in the contents of Fe and others on the both sides of Mt. Sarakura (St. 5 and St. 7).

Contrary to the above eight elements, no marked changes were seen in the contents of Ca and Mg due to change in stations. The contents of these elements at the stations in Kitakyushu area are hardly different from those at St. 9. Contents of Fe and Ca which represent the above two types are shown in Fig. 2. to indicate the characteristic feature of the distribution.

The relationship between metal contents in *C. kusatsuensis* and those in fine particulates in the air were examined. For this purpose, data on metal contents in *C. kusatsuensis* obtained at St. 1 and those in airborne particulates measured by the Orio Monitoring Station of the Department of Environmental Pollution Control of Kitakyushu City (1980) were used. Metal contents in the air in $\mu\text{g}/\text{m}^3$ are as follows: Fe 2.94, Mn 0.07, Cr 0.01, Pb 0.07, Ni 0.01, Cu 0.13 and Cd 0.02. The ratio of content of each element to that of Fe is shown in Table 3. A parallel relation is seen in Table 3 between the ratio in the plant body and that in the air. It was proved that *C. kusatsuensis* can be a good indicator plant for the air pollution caused by metal elements.

Table 2. Metal contents in ppm in the body of *Clastobryella kusatsuensis* (Besch.) Iwats. collected at nine stations arranged in order of urbanization

Elements	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9
Fe	3075	2589	2388	1909	1723	1482	907	726	392
Zn	692	370	381	337	203	295	224	182	157
Mn	43.1	23.0	41.9	32.4	42.3	12.9	32.4	10.9	10.2
Cr	4.90	4.95	4.48	2.28	—	2.31	—	—	—
Pb	73.0	73.2	17.2	21.0	52.2	33.9	33.7	27.1	4.5
Ni	4.54	4.87	3.37	3.64	2.23	3.31	0.97	1.51	0.78
Cu	50.0	45.9	27.8	27.5	25.2	24.1	27.8	21.5	18.28
Cd	1.38	0.93	0.98	1.04	0.65	0.63	0.32	—	—
Ca	69.2	33.1	31.3	50.2	32.8	34.1	64.8	60.5	65.3
Mg	1706	1947	2447	2847	1166	2214	1684	1573	1620

— : Not detected.

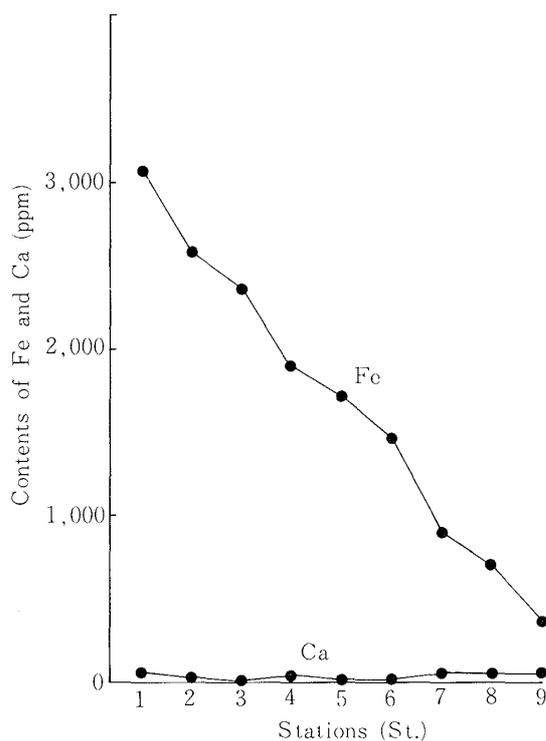


Fig. 2. Contents of Fe and Ca in the plant body of *Clastobryella kusatsuensis* (Besch.) Iwats.

Table 3. Relative contents of metals in the body of *Clastobryella kusatsuensis* and in airborne particulates when quantity of Fe (=3075 ppm in the former and $2.94 \mu\text{g}/\text{m}^3$ in the latter) is put at 1000

	Fe	Mn	Cr	Pb	Ni	Cu	Cd
In the body of <i>C. kusatsuensis</i>	1000	14.02	1.593	23.74	1.476	16.26	0.449
In the air	1000	23.81	3.401	23.81	3.401	44.22	0.680

2. Metal contents in the body of a whole bryophyte community

A phytosociological study on the epiphytic Bryophyta was carried out in the same area of the present study and twelve bryophyte communities were identified (Nakanishi & Kitazawa, MS). Metal content in the body of a whole bryophyte community was measured in some of these communities. The measured values in the *Acrolejeunea pusilla* community and *Leucobryum neilgherense* community are shown in Tables 4 and 5. In the two communities, except for Ca and Fe, many elements decreased in proportion to the distance from the industrialized area, as seen in the case of a single species of *C. kusatsuensis*. In the *L. neilgherense* community, the content of Fe was very high at every station, though the tendency of the change in content of it was about the same as that of

Table 4. Contents in ppm of metal elements in the plant body of *Acrolejeunea pusilla* community

Elements	St. 2	St. 5	St. 6
Fe	1448	1244	1116
Zn	239	262	168
Mn	31.7	65.5	13.9
Cr	2.28	—	—
Pb	29.6	8.0	24.5
Ni	1.43	—	—
Cu	43.9	39.0	28.8
Cd	0.37	0.36	—
Ca	37.4	52.4	39.6
Mg	1935	1833	1512

— : Not detected.

Table 5. Contents in ppm of metal elements in the plant body of *Leucobryum neilgherense* community

Elements	St. 5	St. 7
Fe	4839	3351
Zn	296	294
Mn	50.9	13.6
Cr	9.57	—
Pb	59.0	23.8
Ni	2.00	2.56
Cu	27.1	23.3
Cd	0.89	—
Ca	19.1	15.6
Mg	1861	1432

— : Not detected.

others. The *L. neilgherens* community is always restricted to the base of the trunk. This would be the reason for the high content of Fe as stated in Nogawa (1978). The same tendency was seen also in the *Hypnum plumaeforme* community.

It was reported that the lichen accumulates metals from the air into its body and the metal concentrations in the body are related to those in the air (Saeki *et al.*, 1977). By our study it was proved that the bryophyte can be a plant indicator of metal pollution of air like the lichen.

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北九州地域における着生蘚苔類の金属含有量

中西 こずえ¹・平岡 教子²・北沢 右三³

¹長崎大学教養部植物生態学研究室 ²長崎大学工学部材料工学教室 ³産業医科大学生物学教室

要 旨： 高度開発地域での金属による環境汚染を探る基礎資料を得る目的のため、北九州市八幡西区とその周辺地域の着生蘚苔類の体内金属量を、コモチイトゴケ1種および群落全体について測定した。Fe, Zn, Mn, Cr, Pb, Ni, Cu, Cdの量は工業の中心地域から遠ざかる程減少する傾向を示したが、Ca, Mgは地域的な差が見られなかった。Fe, Mn, Cr, Pb, Ni, Cu, Cdの蘚苔類体内の含有量の比率は、大気中の比率とほぼ一致した。コモチイトゴケ1種、蘚苔類群落全体について、大気金属汚染の生物指標となることが示唆された。

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