# DISTRIBUTION AND ABUNDANCE OF SOIL BACTERIA IN THE VICINITY OF SYOWA STATION IN ANTARCTICA, WITH SPECIAL REFERENCE TO HABITAT CONDITIONS

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***Abstract:*** The distribution of soil bacteria was investigated on twelve soil samples collected from ice-free areas near Syowa Station in Antarctica, with special reference to the environmental conditions. The total number of bacteria in samples from the various sites ranged widely from approximately $10^2$ to $10^7$ per gram soil. Although the environmental conditions of the twelve sampling points differed from each other, two interesting trends were observed between the bacteria flora and their habitats. (1) In general, the abundance of soil bacteria was higher in the surface soil which was covered with macroscopic plant community than that in the exposed soil. (2) The total number of bacteria, except for a few soil samples near Syowa Station, seems to be controlled by soil carbon (organic matter), which differed from the findings of other workers on the soils of the Dry Valleys area, Victoria Land, where the shortage of water limits life.

## 1. Introduction

During the past ten years, some bacteriological studies have been made on the soil, water, snow and ice taken from in and around Syowa Station, Antarctica, by the members of the Japanese Antarctic Research Expedition (JARE) and co-workers (MIWA, 1976, 1977; WATANABE *et al.*, 1977). These studies were made chiefly from the medical point of view and aimed at the isolation of some special genera such as *Clostridium*, *Bacillus* and *Escherichia*, but no detailed study was made on the relation between the distribution of soil bacteria and the environmental conditions near Syowa Station, though numerous studies have been published on the Dry Valleys in Victoria Land, Antarctica (BENOIT and HALL, 1970; CAMERON *et al.*, 1970a, b; HOROWITZ *et al.*, 1972; INGHAM *et al.*, 1974).

The first author, a member of the wintering party of JARE-15, stayed at Syowa Station from January 1974 to February 1975 and collected many soil samples from ice-free areas near Syowa Station. Among them, twelve samples which were collected

from various sites were studied bacteriologically for the purpose of finding the distribution pattern of soil bacteria in Antarctica.

The authors are indebted to the members of JARE-15 party for their helpful cooperation in the field survey.

## 2. Materials and Methods

Field work was carried out chiefly from the austral spring of 1974 to the summer of 1975 in Antarctica (Fig. 1). The soil samples were collected with a sanitary stainless-steel spoon from the ground surface to a depth of 2 cm, except Point 1 where the

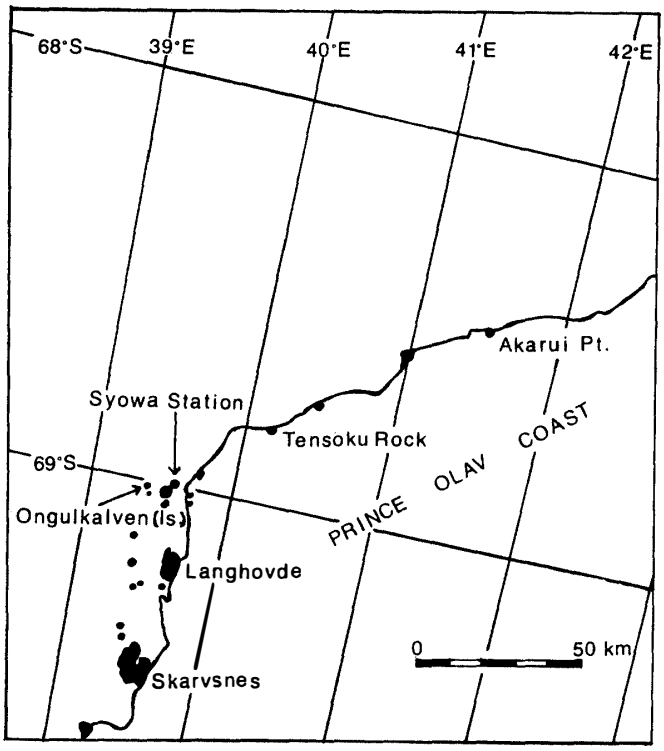


*Fig. 1. Map showing the area studied.*

sample was taken from about 30 cm below the surface. The collected soil samples were put into a sterile polyvinyl bag, and the bag was immediately sealed. All samples were brought back in a frozen state to Japan.

The bacterial number in the soil was determined by the plate count method. The soil samples preserved in a freezer were thawed in the laboratory and were diluted decimally in sterilized tap water. The first dilution was treated with supersonic wave for 90 seconds in order to disperse bacterial cells sufficiently. The reasonably diluted samples were poured into sterilized Petri dishes along with melted sodium-alubumenate agar culture medium devised by WAKSMAN and FRED. This nutrient poor culture medium is generally used to count soil bacteria. After the agar plates solidified, the dishes were incubated at 15°C for 2 weeks and the bacterial colonies which grew on the plates were counted. The bacteria which could be cultured in the medium containing 5 ppm

crystal violet were identified as Gram negative. The bacteria which survived after heating the last dilution at 80°C for 10 minutes were spore-forming bacteria. The total carbon of the soil was determined by Tyurin's method.

The laboratory work, mentioned above, was carried out in May 1975 at Biological Institute, Faculty of Science of Tohoku University, under the direction of Shiogama Branch Office of Yokohama Plant Protection Station, because the both authors were the staff of Tohoku University at that time.

## 3. Results and Discussion

The results of the present study are summarized in Table 1.

*Table 1. Numbers of soil bacteria in soil samples and habitat conditions of the sampling points near Syowa Station.*

| Point No. | Station | Vegetation | Soil* water (%) | Total carbon (%) | Number of total bacteria | | Gram negative bacteria | Spore-forming bacteria |
|---|---|---|---|---|---|---|---|---|
| | | | | | No./g dry soil | No./g total carbon | No./g dry soil | No./g dry soil |
| 1 | Langhovde (Yukidori Valley) | | 19.8 | 0.30 | $7.2\times10$ | $2.4\times10^4$ | $<10$ | $<10$ |
| 2 | Skarvsnes (Lake Hunazoko) | Algae | 97.6 | 3.54 | $<10^3$ | $<2.8\times10^4$ | $<10^3$ | $<10$ |
| 3 | Langhovde (Yatude Valley) | | 0.5 | 0.27 | $5.8\times10^3$ | $2.1\times10^6$ | $5.3\times10^2$ | $4.7\times10$ |
| 4 | Langhovde (Yatude Valley) | Mosses, lichen | 12.5 | 0.90 | $3.3\times10^4$ | $3.7\times10^6$ | $1.2\times10^4$ | $1.1\times10$ |
| 5 | Langhovde (Koke Strand) | | 0.2 | 0.08 | $5.6\times10^4$ | $7.0\times10^7$ | $1.8\times10^3$ | $<10$ |
| 6 | Langhovde (Koke Strand) | | 4.8 | 0.76 | $1.7\times10^5$ | $2.2\times10^7$ | $2.1\times10^4$ | $<10$ |
| 7 | Langhovde (Koke Strand) | Mosses | 22.5 | 1.94 | $8.9\times10^5$ | $4.6\times10^7$ | $1.9\times10^5$ | $9.1\times10^2$ |
| 8 | Langhovde (Yukidori Valley) | Mosses | 21.2 | 0.34 | $1.3\times10^5$ | $3.7\times10^7$ | $4.8\times10^3$ | $1.8\times10$ |
| 9 | Langhovde (Yatude Valley) | Mosses, lichen, algae | 9.3 | 0.41 | $4.0\times10^5$ | $9.7\times10^7$ | $1.5\times10^5$ | $2.2\times10$ |
| 10 | Akarui Point | Mosses | 14.7 | 0.48 | $1.3\times10^5$ | $2.6\times10^7$ | $2.3\times10^4$ | $<10$ |
| 11 | Tensoku Rock | Mosses, algae | 8.1 | 1.86 | $2.7\times10^6$ | $1.5\times10^7$ | $2.7\times10^4$ | $7.0\times10^2$ |
| 12 | Ongulkalven | Algae | 61.0 | 3.42 | $7.6\times10^7$ | $2.2\times10^9$ | $<10^3$ | $2.8\times10^3$ |

* Water percentages based on oven-dried soil.

Point 1: This sampling point is situated at an altitude of 10 m above sea level near the mouth of the Yukidori Valley, Langhovde. The sample was taken from a grayish sandy silt layer at a depth about 30 cm below the surface. No sign of macroscopic organisms and their remains were found around the sampling point and in the soil. However, the percentages of soil water and total carbon were higher than we expected. The total number of isolated bacteria was the smallest throughout the samples studied.

Point 2: Lake Hunazoko, a small saline lake, is located near the beachline in Skarvsnes. According to the geochemical studies by JARE, the chlorine contained in the lake water amounts to 116.6 g per kg water (WATANUKI *et al.*, 1977). The sample chiefly comprising algae and silt was taken from the lake shore which was formerly the bottom of the lake. Abundant diatoms and blue-green algae were found in the sample. Although the values of total carbon and soil water are very high, the total number of bacteria is smaller than that of the other samples except the one from Point 1. Probably, the cultural methods with fresh water were unfavorable for halophilic bacteria.

Point 3: This point is located at a considerably dried bank in the Yatude Valley, Langhovde. Macroscopic organisms were not found in the nearest margin of the point. The values of total carbon and soil water and total number of bacteria in this sample were the second smallest throughout the samples studied. But the ratio of spore-forming bacteria was relatively high.

Point 4: This point, located in the neighborhood of Point 3, is moistened by melt water which flowed from snow drift in the summer. The ground surface was covered with moss community composed of such species as *Ceratodon purpureus* (dominant) and *Bryum inconnexum*. A polygonal crack was found in the colony of the moss community. Compared with those of Point 3, the values of total carbon and soil water are high. The total numbrer of bacteria is also larger than that of Point 3.

Points 5, 6 and 7: A large moss community chiefly comprising *Ceratodon purpureus* and *Bryum inconnexum* was found near the end of the Naka-no-tani Valley in Langhovde, and this area is called Koke Strand (moss plain) (MATSUDA, 1964, 1968). This moss community is thought to be maintained by the water from snow drift and nutriments from the excreta of the snow petrel which nested in the debris near the community (MATSUDA 1964, 1968; YAMANAKA and SATO, 1977). Three samples were collected from the Koke Strand area. Points 5 and 6 are situated at the upper side and the lower side of the moss community respectively, on the gentle slope of the Koke Strand area. Point 7 is located at the central part of the moss community (Fig. 2). At

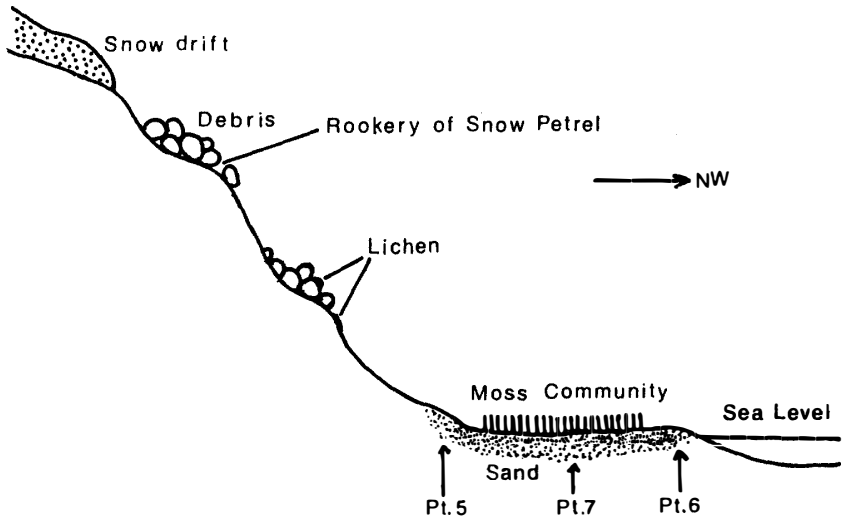


*Fig. 2. Schematic profile of the sampling points of soil at Koke Strand, Langhovde.*

Point 5, the soil was considerably arid from the surface to a depth of 10 cm, but arid soil was found only near the surface at Point 6. The soil was moist at Point 7 which was covered with moss community.

Throughout the samples of the present study, the lowest values of total carbon and water content respectively were found in the sample from Point 5. Probably, the area around Point 5 is well drained, and water and melting nutrients may have flowed away from the surface soil. On the other hand, the value of total carbon was relatively high at Point 6. The total numbers of bacteria in samples from Points 5 and 6 were not so large, if not very small. A large number of bacteria were found from Point 7, especially the value of Gram negative group being the highest. These phenomena may be closely correlated with the abundance of total carbon and soil water.

Point 8: This point covered with well-developed moss community (mostly *Ceratodon purpureus*) is located near the mouth of the Yukidori Valley, Langhovde. The soil of this point is moistened by a water current from snow drift in the summer. Compared with the total carbon values from the other points covered with macroscopic plant community, the value of total carbon from Point 8 was relatively low. But a considerable number of bacteria were found.

Point 9: This point is located on the steep slope having the mean inclination of 30°, on the right bank of the Yatude Valley, Langhovde. Various plant communities are developed in the area; moss community composed of *Ceratodon purpureus*, *Bryum inconnexum* and *B. argenteum*; lichen community of *Omphalodiscus antarcticus*, *O. decussatus*, *Buellia frigida*, *Xanthoria mawsonii*, *Usnea sulphurea*, *Alectoria minuscula*, *Caloplaca elegans* var. *pulvinata* and *Physcia caesia*; and alga community of *Prasiola crispa* subsp. *antarctica*. A rookery of the snow petrel was found in the blocks of moraine and a nest of the south-polar skua was also found near Point 9. Although water and nutrients should have been supplied sufficiently from both snow drift and the rookery, the values of total carbon and soil water of the sample from Point 9 were relatively low. The inclination of the slope near Point 9 is so steep that the both water and nutrients may have been rather hard to remain in the surface soil. Bacteria were detected in quantity, and Gram negative ones were also abundant.

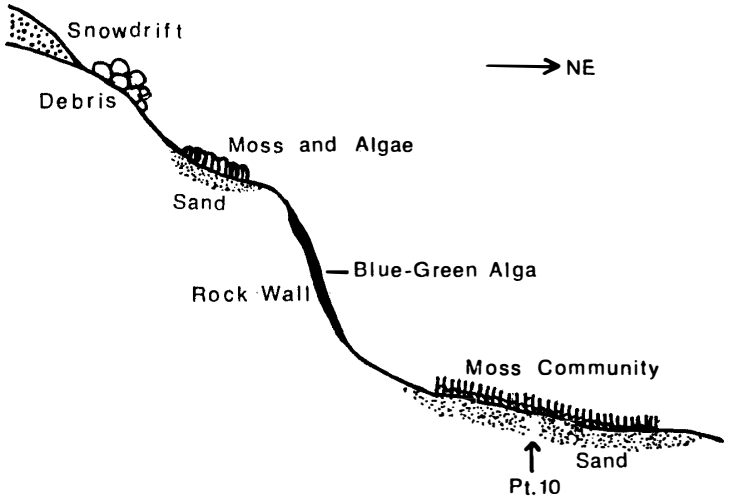


*Fig. 3. Schematic profile of the sampling point of soil at Akarui Point.*

Point 10: This point is located at Akarui Point and is covered with moss community composed of *Ceratodon purpureus* and *Bryum inconnexum*. As shown in Fig. 3, a community of blue-green alga was found on the surface of rock which was located at the upper side of the moss community. A water current from snow drift flowed firstly through the alga community, then it supplied water to the moss community. The sample was collected from the surface soil beneath the moss community. The total number of bacteria was the same as that of Point 8.

Point 11: This point is situated in a small ice-free area called Tensoku Rock. The field work of the area was made in early spring, 1974. At that time, mosses were in a dried-up condition and the status of moss community was not so good. But water may be supplied from the end of the continental ice sheet in the summer. Algae (probably blue-green algae) were found macroscopically in the soil collected from this point. The high value of total carbon in this sample should be connected with the occurrence of the above-mentioned algae. The environmental conditions around Point 11 may be favorable to the existence of soil bacteria.

Point 12: A small island called Ongulkalven is located about 5 km away from Syowa Station, and a small rookery of the Adélie penguin is found in the island. Point 12 is situated at the lower side of the rookery, and in the summer it is flooded with melt water containing the excreta of the Adélie penguin. The point is covered with the *Prasiola crispa* subsp. *antarctica* community. The value of $P_2O_5$ of the surface soil sample was 295.90 mg per 100 g dry soil. The value of total carbon was also extremely high. A large number of bacteria were detected and they were composed of almost the same species. It is characteristic that Gram negative bacteria were found only in small quantities, though the soil water was plentiful.

## 4. Conclusion

As the soils in Antarctica seem to be in the primitive stage of the soil forming

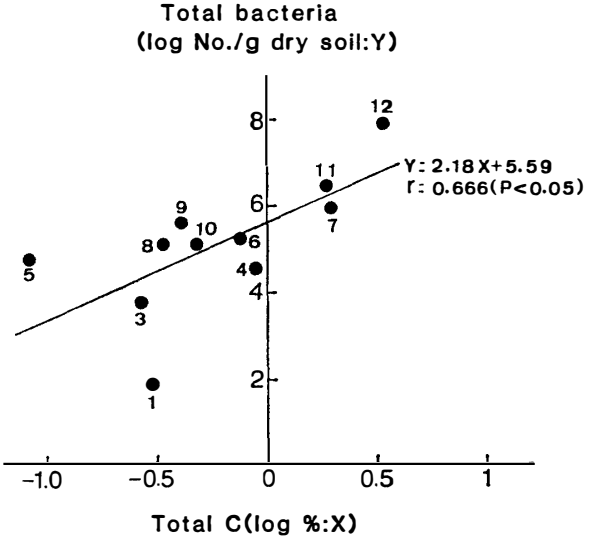


*Fig. 4. Relationship between the amount of carbon and the number of bacteria among eleven soil samples.*

processes, it is assumed that the amount of soil organic matter (energy and carbon sources) might control the abundance of soil bacteria. Judging from the present study, the number of total bacteria seems to be controlled by soil carbon (organic matter) (Fig. 4) except a few soil samples near Syowa Station, which differed from the findings of other workers in the Dry Valleys area where the shortage of water limits life (HOROWITZ *et al.*, 1972). Compared with the cases of the Dry Valleys (CAMERON *et al.*, 1970b), the values of total bacteria of the present study were high, which seems to indicate that the environmental conditions such as soil water, nutrients and temperature are more favorable to bacteria than those of the Dry Valleys area.

Since the distribution of the Gram negative bacteria was indefinite throughout the samples, the correlation between the number of Gram negative ones and the environmental factors (soil humidity and nutrients) could not be clarified.

The sample collected from Lake Hunazoko (Point 2) was omitted from consideration (Fig. 4) because the number of bacteria could not be determined with accuracy.

The ratios of spore-forming bacteria were low.

The present study is a preliminary one and further detailed investigations on this problem are necessary.

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