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Microbes in the area of the South Shetland Islands

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Abstract Investigations were made on the microbes in the air, bottom sediments, surface seawater in the sea area of the South Shetland Islands during December, 1986～March, 1987.

The results obtained show that: from the air over the South Shetland Islands and the Maxwell Bay, the detection rate of terrigenous microbes was more than 90% and their amount was generally a few CFU/m^3; the detection rate of marine microbes was more than 50% and their amount only 1 CFU/m^3. The amounts of air-borne microbes over the surveyed area were the witness to their diurnal variations. They were influenced to some extent by nearby islands. Air temperature and relative humidity, etc. were factors affecting their quantitative variations.

The bacterial amount of the outshore surface sea water in the Great Wall Bay, Antarctica was about $n \times 10$ CUF/cm^3 ($0 \leqslant n < 10$, the same below), the amount of microbes decreased with the monthly dropping of seawater temperature and showed a state of diurnal variations. The seawater in the Bay has been fairly clean. The microbial community consisted of at least thirteen genera, in which *pseudomonas* was common.

In the intertidal zone of the Deception Island, there were only a few CFU of bacteria per—cubic meter in seawater; and $n \times 10$ CFU/g (w. w) in the surface sediment; and $n \times 10$ CFU/g(w. w) in the volcano ash.

The results reveal the general features of the microbes from the air, sea and land in the South Shetland Islands, Antarctica. It provides data for further study of microbial resources in that area.

Key words South Shetland Islands, Maxwell Bay, Great Wall Bay, Deception Island, microbe.

1 Introduction

An investigation was made on microbes in the area of the South Shetland Islands, Antarctica from December, 1986 to March, 1987. Its main contents included analysis of the air-borne microbes over the sea area of the South Shetland Islands and Maxwell Bay, those from the waters of the Great Wall Bay and the Deception Island. A preliminary understanding of the microbial characteristics of the air, sea and land of these areas has been arrived at, which has laid a preliminary basis for further investigation of the microbial resources in the area of the South Shetland Islands, Antarctica.

2 Material and method

2.1 Culture media

Seawater culture medium: its ingredients: yeast extract, 1 g; peptone, 2 g; $FePO_4$, 0.01 g; refined agar 18 g; aged seawater from the Southern Ocean, 1000 cm^3; pH, 8. It is used for culturing marine microbes.

Fresh water culture medium: its ingredients: beef extract, 3～5 g; peptone, 10 g; nacl, 5 g; refined agar, 18 g; distilled water, 1000 cm^3; pH, 7.2～7.4. It is used for culturing terrigenous microbes.

2.2 *Methods for sampling*

A JWL-4 type air-borne microbe inspecting instrument is used for collecting air-borne microbes. Collecting time is 15 or 30 min. Air flow rate during sampling is 37 dm^3/min.

An impacting type water sampler is used for collecting sea water microbes.

The spread suspension method for microbial samples is performed on the plate of the above-listed seawater culture medium in culture Petri dishes. This procedure is used for the microbes from beach sediments, too.

The detailed method has been described in another paper (Chen *et al.*, 1990).

2.3 *Culture and analysis*

The above-mentioned samples are cultured at 10 ℃ for about 10 days, then, the colonies forming units (CFU) on the culture plates in Petri dishes are counted. The calculating formulas for air-borne microbes are as follows:

$$\text{Counts of air-borne microbes (CFU/m}^3\text{)} = \frac{\text{Average CFU/dish}}{\text{Sampling time (min.)} \times \text{Air flew rate during sampling (dm}^3\text{/min)}} \times 1000$$

and

$$\text{Counts of seawater microbes (CFU/cm}^3\text{)} = \frac{\text{Average CFU/cm}^2 \times \text{Area of each dish (cm}^2\text{)}}{\text{Volume of seawater sample (cm}^3\text{)}}$$

The procedure for determination of the microbial count of sediments is similar to what has been mentioned above, and its unit is CFU/g (fresh, wet). Some colonies were selected, purified, kept in the refrigerator (0 ℃), and brought back home for taxonomic study (Oliver, 1982; Skerman, 1967).

3 Result and discussion

3.1 *Air-borne microbes over the South Shetland Islands*

The inspection of the air-borne microbes over the South Shetland Islands was performed on the Vessel "JiDi".

The results are shown in Table 1. From Table 1, it can be calculated that the detection rate of air-borne microbes in the investigated area was 58.3%, and the number of the microbes averaged 0.776 CFU/m^3 with a maximum of 4 CFU/m^3. The detection rate of the air-borne terrigenous microbes was 91.7%, and their number averaged 5.56 CFU/m^3. These results show that the number and detection rate of the terrigenous microbes were both higher than those of the marine ones, which probably suggests that many air-borne microbes of the sea area of the South Shetland Islands are closely related with those of the nearby islands.

The results from the correlation analysis of number of the above two air-borne microbes and the relevant air temperature or relative humidity showed that the number of the marine microbes has little correlation with the air temperature but remarkably the number of terrigenous microbes has a negative correlation with the corresponding air temperature ($R = -0.687$, $n = 12$), indicating that the air-borne terrigenous microbes over that sea area are adaptable to low air temperature.

Table 1. Air-borne microbial numbers over the sea of the South Shetland Islands

Sampling date	Sampling location	Microbial numbers (CFU/m^3)		Air condition	
		Marine	Terrigenous	Temperature (0C)	Relative humidity (%)
Jan. 17, 1987	61°51′S, 56°53′W	0	4	7.5	91
Jan. 18, 1987	60°54′S, 58°04′W	0	0.67	4.2	87
Jan. 19, 1987	62°22′S, 57°40′W	0	2	5.8	88
Jan. 20, 1987	62°59′S, 60°40′W	0.67	6.7	8.5	92
Jan. 21, 1987	63°03′S, 60°31′W	3.3	6.7	8.8	94
Jan. 30, 1987	61°21′S, 53°45′W	0.67	13.3	1.2	96
Jan. 31, 1987	60°24′S, 54°03′W	0	4.7	4.4	93
Feb. 1, 1987	60°50′S, 56°34′W	0	10	5.8	86
Feb. 11, 1987	60°51′S, 56°52′W	0.67	12	4.2	93
Feb. 12, 1987	61°11′S, 56°15′W	4	2.7	5.0	97
Feb. 13, 1987	61°39′S, 56°32′W	0	4	2.5	95
Feb. 14, 1987	61°45′S, 56°15′W	0	0	9.8	91

3.2 The air-borne microbes over the sea area of the Maxwell Bay

The sampling records of the air-borne microbes over the area of the Maxwell Bay as listed in Table 2 show the quantity of the air-borne microbes over that area throughout the austral summer, i.e. the detection rate of the air-borne marine microbes was 53.7%,

Table 2. List of air-borne microbial numbers of the Maxwell Bay*

Sampling	Air-borne microbial number(CFU/m³)		T** (℃)	Sampling	Air-borne microbial number(CFU/m³)		T** (℃)
Date and Time	Marine	Terrigenous		Date and Time	Marine	Terrigenous	
Dec. 27, 1986	1.3	1.3	6	Jan. 25, 1987	2.7	0.67	2.5
Dec. 28, 1986	2.7	1.3	5	Jan. 26, 1987	2	0	2.0
Dec. 29, 1986	9.3	14.7	3	Jan. 27, 1987	0	0	2.7
Dec. 30, 1986: 15 : 00	0	6	10	Jan. 28, 1987	3.5	4.7	0.9
Dec. 30, 1986. 20 : 00	3.3	—	2.0	Jan. 29, 1987	0.67	0.67	−0.2
Dec. 31, 1986	9.3	13.3	4.8	monthly mean	1.68	9.24	7.25
monthly mean	4.32	7.32	5.13	Feb. 2, 1987	0	24.7	6.7
Jan. 1, 1987	6.7	5	6.5	Feb. 3, 1987	1.3	3.3	0.6
Jan. 2, 1987	0.67	0.67	6.2	Feb. 4, 1987	0	3.3	2.8
Jan. 3, 1987. 15 : 30	0	0.67	8.0	Feb. 5, 1987	0.67	4	3.5
Jan. 3, 1987. 22 : 15	1.3	2	3.5	Feb. 6, 1987	0	2	3.0
Jan. 4, 1987. 03 : 15	0	0	3.1	Feb. 7, 1987	0	0.67	1.2
Jan. 4, 1987. 10 : 00	4.7	0.67	4.1	Feb, 8, 1987	0	4.7	3.0
Jan. 4, 1987. 15 : 30	1.3	2.7	7.1	Feb. 9, 1987	0.67	0.67	1.5
Jan. 5, 1987	1.3	1.3	7.5	Feb. 10, 1987	0.67	2	5.5
Jan. 6, 1987	3.3	8.3	2.5	Feb. 15, 1987	0	1.3	3.5
Jan. 7, 1987	0	0.67	6.8	Feb. 16, 1987	0	3.3	5.2
Jan. 8, 1987	2	1.3	8.8	Feb. 17, 1987	0.5	1.3	4.3
Jan. 9, 1987	0	9.3	5.2	Feb. 18, 1987	0	0.67	3.5
Jan. 10, 1987	10.7	10	0.2	Feb. 19, 1987	0.67	0.67	2.8
Jan. 11, 1987	0	100	5.6	Feb. 27, 1987. 02 : 00	2.7	2.7	0
Jan. 12, 1987	0	20.7	6.5	Feb. 27, 1987. 20 : 00	4	1.3	4
Jan. 13, 1987	0	5.3	10	monthly mean	1.12	1.61	3.33
Jan. 14, 1987	0.67	2	5.5	Mar. 11, 1987	0	2	3.5
Jan. 15, 1987	3.3	2.7	3.8	Mar. 12, 1987	0	35.3	5.4
Jan. 16, 1987	0.67	7.3	3.0	Mar. 13, 1987	0	5.3	1.8
Jan. 22, 1987	0	2	3.4	Mar, 14, 1987	0	2.7	0
Jan. 23, 1987	0	7.3	4.0	Mar. 15, 1987	0	8	3.8
Jan. 24, 1987	0	4.7	2.5	monthly mean	0	10.66	2.90

* Two sampling positions: one located at 62°18′06″S, 58°23′09″W from Dec. 27, 1986～Jan. 29, 1987; the other at 62°14′08″S, 58°35′04″W from Feb. 2～Mar. 15, 1987. ** T: Air temperature.

its amount averaged 1.53 CFU/m³, the highest one was 10.7 CFU/m³, on 10th Jan., 1987. The detection rate of the air-borne terrigenous microbes was 94.3%, their quantity averaged 6.45 CFU/m³ and the highest one was 100 CFU/m³ on the 11th Jan., 1987. It seems that only the detection rate of the marine microbes in the Maxwell Bay was slightly lower as compared with that of the air-borne terrigenous ones over the South Shetland

Islands. But both the kind and amount of the microbes in the bay were more than the latter, which may be ascribed to its geographic location not far from the King George Island, where plenty of people lived and other organisms were more abundant.

The air-brone microbes over the Maxwell Bay were different in quantity in different months. The relationship between the air-borne terrigenous microbial number and air temperature was similar to that of the South Shetland Islands. The air-borne marine microbial number showed the trend of decreasing month by month with the air temperature decreasing month by month.

Fig. 1 was drawn by using the data of the observation for five times running from 3rd to 4th Jan. , 1987. It shows that quantatively the peak of marine air-borne microbes in the air over the bay was at 10 : 00, and that of the terrigenous microbes at 15 : 30. Large numbers of them also appeared at 22 : 15 but they counted least at 3 : 15 before dawn. It seems that there is little correlation between their appearance and air temperature.

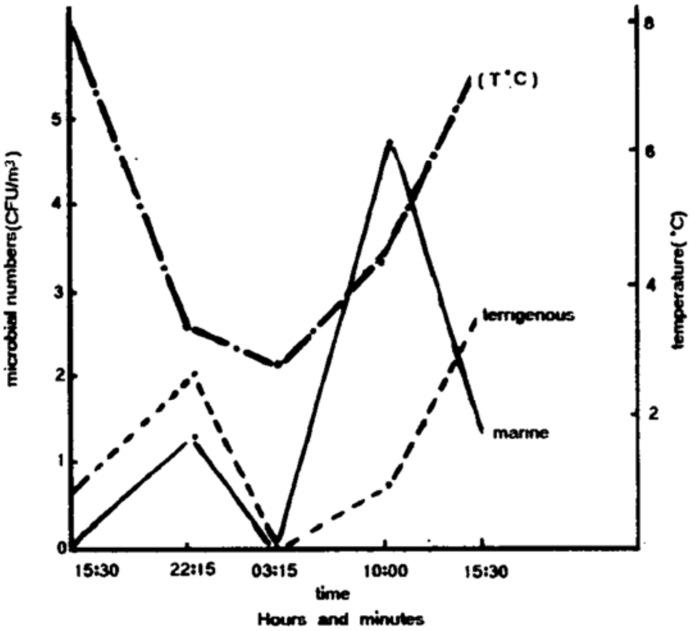

Fig. 1. Diurnal variation of air-borne microbial numbers of the Maxwell Bay.

3. 3 The outshore surface water microbes of the Great Wall Bay

3. 3. 1 Quantity and its variation

Investigations were made on the outshore surface seawater bacteria in the Great Wall Bay for 12 times and the data were obtained mainly at two fixed stations, i. e. , one located at 62°18′06″S, 58°21′09″W from the 27th to the 28th Jan. , 1987; and the other at 62°14′68″S, 58°55′04″W from 2nd to 3rd Feb. , 1987. The results showed that their number ranged from 0 to 515 CFU/cm^3 with an average of about 376 CFU/cm^3. The number was obviously less than that of the inshore surface-sea water of the Great Wall Bay by one order of magnitude, or less than that of beach seawater of the Bay by two orders of magnitude; and more than that of the water of the Southern Ocean by one order of magnitude (Chen *et al.* , 1990), but less than that of the clean seawater of the

Jiaozhou Bay, by three orders of magnitude (Chen, 1981). All of this showed that the seawater of the Great Wall Bay is pretty clean at present.

Fig. 2 shows the diurnal variations of the microbial number of the outshore surface seawater of that Bay, i. e. its numerical peak appeared mostly at 2 : 00, and its low level at 20 : 00. The microbial numbers in the outshore surface water decreased day by day as time went on, which was inferred to be related to the seawater temperature changes and was consistent with the monthly variation of marine microbial number in the air as shown in Table 3. So it is suggested that there is a some what close relationship between marine microbes in the air and in seawater.

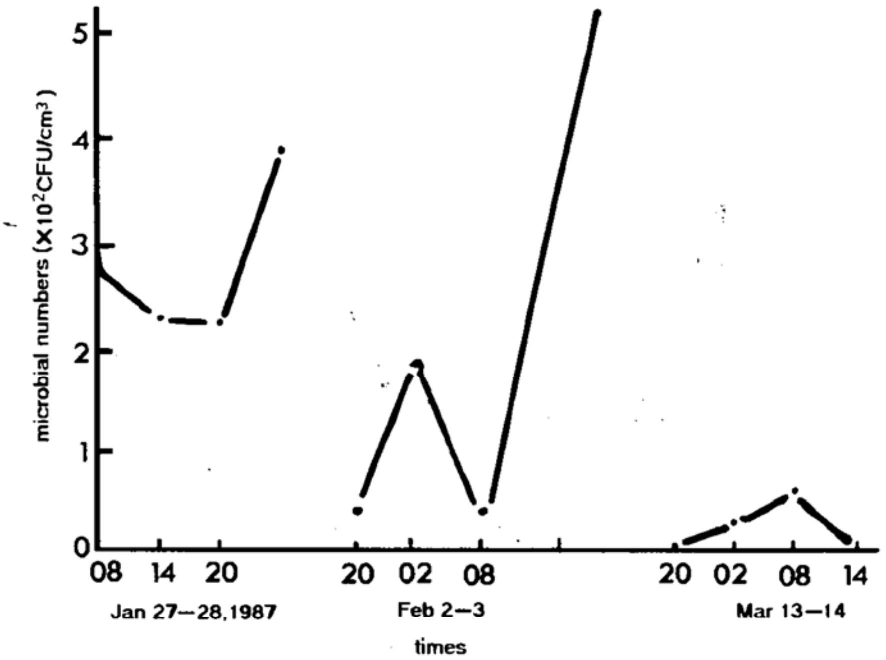

Fig. 2. Variation for three days and nights in number of surface water microbes.

3. 3. 2 *Outline of the microbial genera from the Great Wall Bay*

A taxonomic study was made on 41 bacterial strains picked out randomly from among isolated ones from the Great Wall Bay. The results show that they belong to 13 genera and one family, i. e. *Pseudomonas* 10 strains, *Acinetobacter* 7, *Flexibacter* 7, *Photobacterium* 3, *Flavobacterium* 2, *Xanthomonas* 2, *Cytophaga* 2, *Neisseria* 2, *Alcaligenes* 1, *Staphylococcus* 1, *Sarcina* 1, *Arthrobacter* 1, *Lactobacillus* 1 and *Enterobacteriaceae* 1 strain.

From the above, it can be seen that *Pseudomonas* sp. is in the majority, next come *Acinetobacter* and *Flexibacter*. This bacterial composition is not in common with that from the beach nearby Great Wall Station, Antarctica (Chen *et al.*, 1992).

3. 4 *The microbes of the Deception Island*

Deception Island (62°59′04″S, 60°40′34″W) is located 13 km from the southern side of the Livingston Island. It is an active volcano island, and the island arc takes the shape

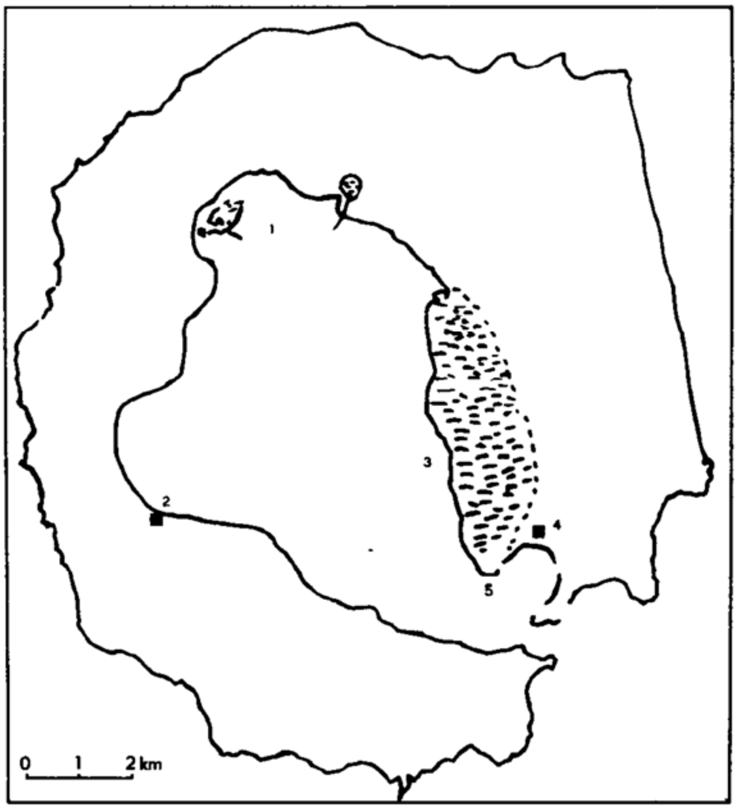

Fig. 3. The map of sampling stations in the Deception Island. 1. Volcano's ejecting point in 1967. 2. Marina De Gunea Station of Argentina. 3. Area covered with volcanic ashes, Feb. , 1969. 4. Skur Station of Chile. 5. Whaler's Bay.

of a horse's hoof. The surface water within the bay was calm when we arrived at the island, and the temperature was about 10°C. This volcano erupted once again in August, 1970. The remaining traces of the dark brown volcanic lava flowning into sea still came clearly into view.

Table 3. Microbial numbers in the intertidal zone of the Deception Island

Sampling location	Microbial number	Description of samples
Skur Station of Chile	4258.3 CFU/g	Volcanic rocks, magn and ashes, fine-medium sands mainly, brown colour, light, dry, 10°C
Marina De Gunea Station of Argentina	2.5 CFU/cm^3	Surface water in tidal zone, pH 7.2, 10°C
Marina De Gunea Station of Argentina	4753 CFU/g	Surface sediment samples were fresh and wet 10°C

* Sampling date: Jan. 21, 1987. Microbial numbers were determined according to culture Petri dish method, the sediment samples were fresh and wet.

Fig. 3 shows a map of sampling stations in the Deception Island and Table 3 lists the analytic results of the samples of microbes. From the table , it can be seen that some microbes exist in the cooling volcanic ashes , but their quantities were less than those in the virgin soil of Great Wall Station by one order of magnitude (Chen *et al.* ,1992),and more than those of surface seawater of the island by three orders of magnitude,and less than those of the intertidal waters of Great Wall Station by three orders,even though it was said that the waters nearby the tidal zone of the island contained a high biomass.

4 Conclusion

The results of the investigations of the air-borne microbes over the sea areas of the South Shetland Islands and the Maxwell Bay indicate that detection rates of the air-borne microbes of the two areas were fairly high. The relationship between the number of terrigenous microbes and air temperature seems to be inconsistent. The change in the number of microbes in the air of the South·Shetland Islands was also not conformable to the variation of air temperature. The density of bacteria in the outshore seawater of the Great Wall Bay was about 3.76×10^2 CFU/cm^3,and was lower in quantity than that in the micro-algae-bearing beach water of the Great Wall Bay and higher than that of waters of the Southern Ocean. The results indicate the water of the Great Wall Bay is quite clean.

The microbial numbers from the air and seawater both showed a certain trend of diurnal variations. *Pseudomonas* sp. was common among the bacteria from the waters of the Great Wall Bay. Besides,more than 12 genera of bacteria were identified.

The acqtive volcanic island arc — Deception Island assumes a specific geographical landscape,its terrestrial and beach microbes are not present in large numbers. The results indicate that it is still less subjected to the effects of human activities.

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