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The ^{137}Cs activity and its geographical significance in terrestrial ecosystem of Great Wall Station, Antarctica

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Abstract The radioactive isotope ——^{137}Cs is one of the important tracers for studying the physical processes and the human impacts on the environment. Based on the investigation results of the terrestrial ecosystem of Great Wall Station, Antarctica, it was shown that there are some artificial radioactive elements ——^{137}Cs in Antarctic terrestrial ecosystem. The sequence of ^{137}Cs specific activities is as follows: crustaceous lichen > fruticose lichen> surface-moss> surface soil, and the crustaceous lichen is one of the most sensitive ways in monitoring the impact of the long-term diffusion of ^{137}Cs on the environment.

Key words Antarctica, terrestrial ecosystem, ^{137}Cs activity.

1 Introduction

The radioactive isotopic element ——^{137}Cs (cesium-137) is a fallout product from the atmospheric nuclear testing and the nuclear accidents; its radioactive half-life is 30.17 a. When falling on the earth's surface, ^{137}Cs are rapidly and firmly adsorbed by the fine soil grain and the biota. ^{137}Cs have been regarded as one of the most important environmental tracers for monitoring the modern physical geographic processes and environmental changes. And so the distribution characteristics and chemical action of ^{137}Cs in the terrestrial ecosystem have been attention (Hermanson 1990; Higgitt *et al*. 1994). In this paper, the values of ^{137}Cs specific activity are measured for the crustaceous lichen, the fruticose lichen, the moss and the soil profiles in the terrestrial ecosystem of the Great Wall Station area, the distribution characteristics of ^{137}Cs in the environment are analyzed, the difference of ^{137}Cs activities between the crustaceous lichen in the northern China and that in Antarctica and their geographical significance are also discussed.

2 Sample collection and measurement

The antarctic sampling location is shown in Fig. 1. The climate of Chinese Great Wall Station area belongs to the subantarctic oceanic type (Zhao 1995). The annual average temperature is about - 2.1℃ and during one year there are 4 months in which the mean monthly temperature reaches 0℃ to 5℃. The annual average atmospheric relative humidity is about 90%, the annual average precipitation is about 630 mm. The compo-

nent of plant community is simple, the dominant species are cryptograms bryophyta, lichens and algae. Bryophyta occur extensively in the wet habitat on flat or gently sloping ground where the freeze-thaw disturbances are relative weak, and the cover degree may reach 100% in some favorable areas. Lichens occur extensively on the surface of bedrock and gravel, and the foliose lichens occur only on the bedrock in the coastal areas. Usnea and Usnea Antarctica are the dominant species of fruticose lichens. Usnea communities are widely and extensively developed in the study area. The crustaceous lichen communities are widely and extensively developed on the surface of the steep bare bedrock in Chinese Great Wall Station area. But Usnea Antarctica communities are mainly developed in the coastal area. In the coastal area there are some breeding sites of penguins and seals (Zhao and Li 1996).

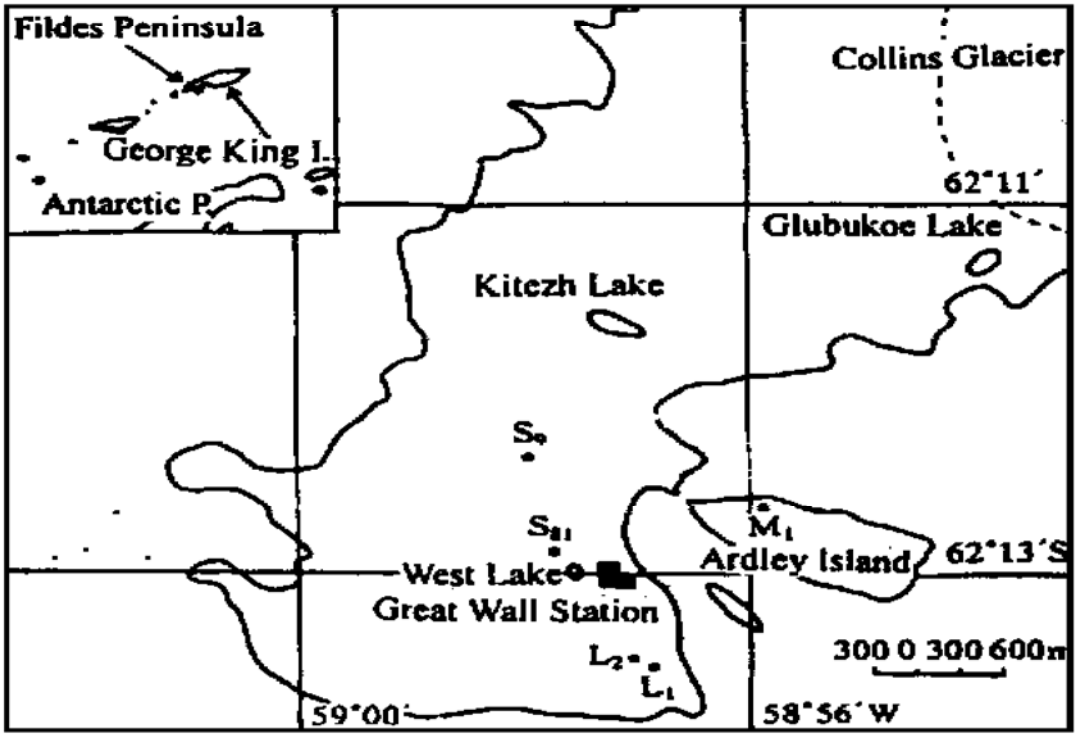

Fig. 1. Map showing the sampling site in Chinese Great Wall Station, Antarctica.

In February 1993, the fruticose lichen Usnea (L_1), the crustaceous lichen (L_2), the mosses (M_1) and the soil profiles (S_9 and S_{81}) of the Fildes Peninsula were collected, the location of the samples was shown in Fig. 1. All samples were oven-dried and pulverized, and then were weighed kept with polyethylene bags respectively in the laboratory of Great Wall Station. In the summer of 1994, we also collected two crustaceous lichen samples in northern China, i. e. L_3 is in Wuling Shan National Natural Protection Region, Hebei Province (latitude: 40°34′N, longitude: 117°29′E, elevation: 1900 m). L_4 is in Mianchi County, Henan Province (latitude: 35°10′N, longitude: 111°52′E, elevation: 200 m). These samples were little affected by the modern industry. The samples were measured using GEM series HPGe (high-purity Germanium) coaxial detector system (ADCAM-100) made by EG & G Ortec Company in USA. The measuring time for every sample was 3.5×10^5 s, and the results are shown in Table 1.

Table 1. The measurement results of ^{137}Cs specific activity[a] of the samples in Great Wall Station area

Samples	^{137}Cs activity/(Bq kg^{-1})	Samples	^{137}Cs activity/(Bq kg^{-1})
Soil S_9 0 – 4 cm	14.83±1.56	M_1 Moss 0 – 5 cm	25.07±2.14
Soil S_9 4 – 12 cm	< 0.93	M_1 Moss 5 – 8 cm	< 1.10
Soil S_9 12 – 26 cm	< 0.93	L_1 Lichen Fr.	29.04±8.29
Soil S_{81} 0 – 5 cm	6.14±0.62	L_2 Lichen Cr.	58.07±14.52
Soil S_{81} 5 – 17 cm	< 0.93	L_3 Lichen Cr. China	294.69±35.81
Soil S_{81} 17 – 26 cm	< 0.93	L_4 Lichen Cr. China	311.78±25.14
X. J.[b] uncropped soil 0 – 10 cm	37.30±3.90	X. J.[b] cropped soil 0 – 10 cm	16.90±8.70
X. J.[c] uncropped soil 0 – 10 cm	19.7±7.90	X. J.[c] cropped soil 0 – 10 cm	6.40±2.00

a) The ^{137}Cs specific activity (Feb. 1993) was calculated with the radioactive half-life of 30.17 a.

b) They are the ^{137}Cs specific activities (1983 – 1984) of the soils in Milan Town, Xinjiang of China, which represent the artificial radioactivities in the surrounding area of the nuclear test base.

c) They are the ^{137}Cs specific activities (1983 – 1984) of the soils in Bachu Town, Xinjiang of China, which represent the artificial radioactivities in the contrasted area.

3 Results and discussion

It is shown that there are some ^{137}Cs in the Antarctic terrestrial ecosystem, which is coincided with the results of Pereira and kirchhoff (1988) and Baeza *et al.* (1994), and so human nuclear activities have released ^{137}Cs. ^{14}C elements and made an effect on the modern biota in Antarctica. But from these results in Table 1, the ^{137}Cs specific activities of L_3 and L_4 are more than that of L_2; it is obvious that the artificial radioactivity levels in northern China are 4 times more than that in Chinese Great Wall Station area. In antarctic free ice regions, the ^{137}Cs of the soils is concentrated in the surface layer (0 – 5 cm), which shows that the ^{137}Cs has been adsorbed and subsided in the surface soil.

Baeza *et al.* (1994) reported that the ^{137}Cs specific activities of the fruticose lichen, the moss and the alga in Livingston Island are (17.2±0.3), (3.6±0.1) and < 0.12 Bq/kg (fresh wt) respectively. The measuring results of this paper show that the ^{137}Cs specific activity in the crustaceous lichen is the highest among the samples of Chinese Great Wall Station area, i.e. L_2= (58.07±14.52) Bq/kg (dry wt). The sequence of ^{137}Cs specific activity is as follows: crustaceous lichen> fruticose lichen> surface-moss> surface-soil. It was shown that the ^{137}Cs specific activity in Antarctic crustaceous lichen is 2 times more than that of Antarctic fruticose lichen, surface moss and surface soil, and it is more than that of the uncropped soil (0 – 10 cm) in the surrounding area of Xinjiang nuclear test site. The ^{137}Cs specific activity of the crustaceous lichen in northern China (L_3 and L_4) are more than (294.69±35.8) Bq/kg. which are 7 times more than that of the uncropped soil (0 – 10 cm) in the surrounding area of Xinjiang nuclear test site. The ^{137}Cs specific activity of surface soil in Nagasaki (1978) is only (77.7±26.7) Bq/kg (Xu *et al.* 1986). It is obvious that crustaceous lichen has the effect of biological concentration on the aerosol that contains some radioactive dust. This concentration mechanism is related to the physiological characteristic and the habitat of crustaceous lichen: First crustaceous lichens occur extensively on the surface of bare bedrock and gravel where the landform is very steep slope, and so snow and ice in Antarctica free-ice region almost never cover it. Second the production rate of the lichen is very low. Third the mode of the crustaceous lichen obtaining nutriment from the environment is the surface-adsorption processes. The best known features of crustaceous lichen are its very slow growth rate, considerable longevity and extraordinarily wide distribution, which make it to easily

absorb the enrichment of the airborne substances (Chen 1984). Crustaceous lichen may therefore be widely used for monitoring the effect of the long-term diffusion of the nuclides.

Hawksworth (1976) and Higgitt *et al.* (1994) respectively reported that the ^{137}Cs landing on the soil surface has been adsorbed by the colloidal particle of the soil. And so the ^{137}Cs in the terrestrial ecosystem of Antarctic free-ice region would be an important tracer for monitoring the erosion-depositing processes, freezing-thawing and its mud-rock flowing processes. ^{210}Pb chronology and ^{137}Cs measurements in the lake sediment cores are very important in dating of Antarctic environmental changes during last 200 a.

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