MINISTRY OF HEALTH
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NRL-F/74

ENVIRONMENTAL RADIOACTIVITY

ANNUAL REPORT

1994

NATIONAL RADIATION LABORATORY
MINISTRY OF HEALTH
CHRISTCHURCH, NEW ZEALAND

NRL F/74
ISSN 0111-6193

ENVIRONMENTAL RADIOACTIVITY ANNUAL REPORT 1994

ISSN 0110-9944

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P O Box 25-099
Christchurch
New Zealand

March 1995

SUMMARY

During 1994 artificial radioactivity in the environment in New Zealand and Rarotonga continued to be at trace levels only, typical of recent years during which there has been no significant change in the radioactivity status of the environment.

Atmospheric and deposited radioactivity was monitored at Kaitaia, Hokitika and Rarotonga and milk radioactivity was monitored in Auckland, Taranaki and Westland. Average levels measured were: total beta activity in air, 0.13 mBq/m^3; ^{90}Sr deposition, 0.2 ± 0.2 Bq/m^2; ^{137}Cs in milk, 0.08 Bq/g K; ^{90}Sr in milk, 0.02 Bq/g Ca. Total beta activity depositions at Hokitika and Rarotonga were 213 Bq/m^2 and 174 Bq/m^2 respectively. Annual total ^{210}Pb depositions at Kaitaia and Hokitika were 44 and 124 Bq/m^2 respectively.

No artificial radionuclides were detected by gamma spectroscopic analysis of high-volume air filters during 1994, with weekly sampling periods. Annual average atmospheric ^{137}Cs concentrations, assessed by analysis of yearly air filter aggregates, at the New Zealand and Rarotonga monitoring sites were 0.04 ± 0.02 and 0.03 ± 0.02 μBq/m^3 respectively.

Average atmospheric concentrations of natural ^{7}Be and ^{210}Pb were 3.1 mBq/m^3 and 0.07 mBq/m^3 respectively.

The report includes data on trends in atmospheric radioactivity levels since 1987.

1. INTRODUCTION

The National Radiation Laboratory (NRL) has monitored environmental radioactivity levels in the New Zealand and South Pacific regions since 1960, as described in earlier reports in this series[1,2]. Monitoring was initially conducted for radioactive fallout from nuclear weapons tests in the Northern Hemisphere, and then for fallout from the French testing programme in the Tuamotu Archipelago. When the French atmospheric testing programme was terminated in 1974 monitoring continued for residues from atmospheric tests and in order to detect any venting from the underground tests.

By the mid-1980s levels of weapons-test debris in the atmosphere and rainwater had decreased to near the limits of detection for the monitoring techniques then in use, and the extensive monitoring network was scaled down[3] to three monitoring sites, with two in New Zealand and one in the Cook Islands. The sensitivity of atmospheric monitoring at these sites was increased with the installation of high-volume air samplers[4].

The present monitoring programme is intended to provide warning of any influx of radioactivity into the New Zealand and South Pacific regions from any source, to monitor trends in levels, and to facilitate public protection planning in the event of any significant pollution incident. The Chernobyl nuclear reactor disaster of 1986 highlighted the need for sensitive environmental monitoring, particularly in major food-producing countries. The monitoring programme also provides the basis for certification of the radioactivity content of foodstuffs, both exported and consumed locally. It also serves as the basis of consumer and commercial advisory services concerning radioactivity, and is the basis of comparisons of the environmental radioactivity status of the South Pacific region with that of other regions.

Through its environmental monitoring operations, NRL is involved in international networks which have been set up by the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO) to improve co-operation and information dissemination, particularly during nuclear emergencies (through the Convention on Early Notification of a Nuclear Accident). The Laboratory is also a member of the WHO/UNEP (United Nations Environment Programme) Global Environmental Radiation Monitoring Programme (GERMON) and submits monitoring results quarterly to the GERMON headquarters in France; and it is a WHO Collaborating Centre for environmental radiation measurement. The Laboratory thus acts as an international point of contact for the South Pacific region in all matters pertaining to environmental radioactivity.

In order to maintain a high standard of capability in radiochemical analysis NRL takes part in quality assurance programmes run by the WHO, IAEA, and the United States Environmental Protection Agency (EPA). Results of analytical intercomparisons undertaken during 1994 are included in this report.

Although the environmental monitoring programme is designed primarily to detect and monitor levels of artificial radioactivity, measurements include naturally occurring radioactive materials, for comparative and scientific purposes. The

atmospheric monitoring therefore includes measurements of concentrations of lead-210 (^{210}Pb), polonium-210 (^{210}Po), beryllium-7 (^{7}Be) and sodium-22 (^{22}Na) in the atmosphere. Beryllium-7 and ^{22}Na are cosmogenic nuclides (ie, products of spallation reactions of cosmic radiation within the upper atmosphere) while ^{210}Pb and ^{210}Po are decay products of gaseous radon-222 (^{222}Rn, which diffuses out of soil) and are of lower-atmosphere origin. Lead-210 deposition is also monitored, together with that of strontium-90 (^{90}Sr).

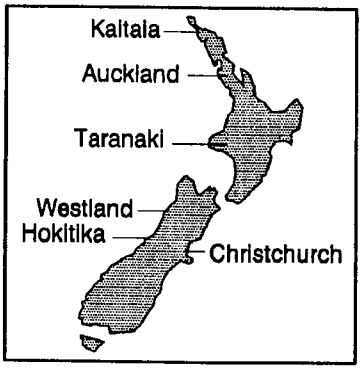
The 1993 report[5] provided full discussion of trends in atmospheric caesium-137 (^{137}Cs) levels, radionuclides which contribute to the measured atmospheric beta activity, the age of aerosols collected in the NRL monitoring network, current concentrations of ^{137}Cs in New Zealand soils, and radiation exposure due to fallout (both natural and artificial) in diet.

2. MONITORING PROGRAMME

The environmental radioactivity monitoring programme comprises the following measurements.

Atmospheric radioactivity: atmospheric monitoring is regarded as the most important component of the monitoring programme because any radioactive pollution reaching the region will inevitably have been transported in the atmosphere and the high-sensitivity monitoring would provide early warning of any influx or changing trend in environmental radioactivity levels. Total beta activity (TBA), fission product, ^{7}Be, ^{210}Pb and ^{210}Po levels are monitored with weekly sample collections of surface air at Kaitaia, Hokitika and Rarotonga. In addition, air filters collected during the year are bulked annually for sensitive measurements of average levels of any other radionuclides which may have been present – for example, ^{137}Cs and ^{22}Na.

Radioactive deposition: TBA deposition is monitored at Hokitika and Rarotonga, with weekly sample collection, while ^{90}Sr deposition is monitored with monthly collections at Kaitaia, Hokitika and Rarotonga. Lead-210 deposition is also monitored on a monthly basis as an adjunct to the ^{90}Sr measurements. Weekly large-area rain collections for ^{210}Pb and ^{7}Be deposition measurements were commenced at Hokitika in July 1994.



Radioactivity in milk: ^{90}Sr and ^{137}Cs concentrations, together with calcium and potassium levels, are monitored in dairy milk powders with monthly sample collection from three New Zealand regions: Auckland, Taranaki and Westland.

Environmental radiation: outdoor environmental gamma radiation levels are monitored continuously in Christchurch as part of the GERMON programme, using both real-time and integrating monitoring methods.

This report summarises results of the above measurements during 1994. Earlier reports in this series give information on terms of reference, reference levels and potential health hazard[1,2], and technical information and the design of the programme[3,4].

The history of fallout monitoring in New Zealand has recently been reviewed[6].

3. 1994 MONITORING RESULTS

Monitoring results for 1994 are summarised in Tables 1, 2 and 3. Results of weekly measurements of atmospheric and deposited radioactivity are given in Table 4.

Radioactivity units used throughout this report are becquerels (Bq), millibecquerels (mBq) and microbecquerels (μBq): 1 Bq = 1 nuclear transformation per second.

3.1 Atmospheric radioactivity

Atmospheric monitoring is conducted at Kaitaia, Hokitika and Rarotonga where centrifugal fan pumps draw air through 500 cm^2 filters (Carl Freudenberg, type FA2311) at a flow rate of approximately 3 m^3/min, with a weekly sample volume of approximately 30 000 m^3. The filters are analysed by high-resolution gamma spectroscopy for gamma-emitting artificial and natural radionuclides; by gas-flow proportional counting for TBA; and radiochemically for ^{210}Pb and ^{210}Po. Annual filter aggregates representing air volumes of approximately 1.6×10^6 m^3 are analysed using high-resolution gamma spectroscopy.

The minimum detectable activities for a fission product such as ^{137}Cs in the weekly and annual filter analyses are 0.5 and 0.02 μBq/m^3 (average concentration) respectively.

Atmospheric radioactivity monitoring results for 1994 are summarised in Table 1, while results of weekly measurements are given in Table 4.

3.1.1 Artificial radionuclides

No particulate artificial radionuclides were detected by gamma spectroscopic analysis of the weekly air filters from any monitoring site during 1994.

Caesium-137 was detected at trace levels on the annual filter aggregates from Kaitaia and Hokitika at annual average levels of 0.04 ± 0.02 μBq/m^3, and 0.03 ± 0.02 μBq/m^3 at Rarotonga.

3.1.2 Total beta activity

Weekly average atmospheric TBA levels during 1994 were very similar at all 3 monitoring sites and ranged from 0.04 mBq/m^3 to 0.3 mBq/m^3 (Table 1) with an overall average of 0.13 mBq/m^3, similar to the 1993[5] average of 0.15 mBq/m^3.

Atmospheric TBA is now due predominantly to natural radionuclides as described in the 1993 report[5].

3.1.3 Natural radionuclides

Cosmogenic nuclides

Beryllium-7 continued to be the most significant radionuclide detected on the air filters during 1994, with weekly average concentrations in the range 0.7 - 6.3 mBq/m^3, with an overall average of 3.1 mBq/m^3, similar to that recorded in 1993[5] of 2.9 mBq/m^3. The annual trend in ^{7}Be levels continued to demonstrate the normal cycles of summer maxima and winter minima in New Zealand (Figs 1 and 2) and a spring maximum at Rarotonga (Fig. 3).

Sodium-22 was detected on the yearly aggregates of air filters at an overall annual average concentration of 0.25 μBq/m^3 (Table 1).

Radon decay products

Lead-210 and ^{210}Po were measured on the weekly air filters and levels were similar at all 3 monitoring sites, as indicated in Table 1. Lead-210 levels ranged from 0.01 to 0.30 mBq/m^3, with an overall average 0.07 mBq/m^3. Polonium-210 levels ranged from less than 1 to 39 μBq/m^3 with an overall average of 7 μBq/m^3.

3.1.4 Annual trends

Annual trends in atmospheric concentrations of ^{7}Be, TBA and ^{210}Pb since 1987 are illustrated in Figs 1 - 3 which show 5-week moving average concentrations.

At Rarotonga (Fig 3) ^{7}Be, TBA and ^{210}Pb levels appear to follow very similar trends within each year, suggesting a common atmospheric source region for all species. Beryllium-7 is known to be produced mainly in the upper troposphere and stratosphere so it seems the TBA and ^{210}Pb are also of upper-atmospheric origin. This supports the earlier suggestion[5] that other cosmogenic radionuclides make a significant contribution to TBA. A high-altitude source of ^{210}Pb suggests long range transport from distant land masses, as would be expected at such a remote location.

At the New Zealand monitoring sites relationships between trends are less clear. At Hokitika (Fig 2) during 1994 there were distinct similarities between trends in the three species, suggesting significant upper-atmospheric input, perhaps with input from low-altitude air masses masking the upper-atmospheric trends in earlier

years. This suggests there might have been some change in atmospheric circulation processes in 1994.

Atmospheric TBA at Hokitika also appears to have undergone a slow, transient increase commencing in 1991 and peaking in 1993, as described earlier[5]. This is presumably due to some cyclic natural phenomenon, possibly involving solar activity cycles, although it does not seem to have affected ^{7}Be levels to the same extent.

At Kaitaia (Fig 1) there have again been periods when there were similarities in annual variations among the three species although the pattern is less clear than at the other monitoring sites.

As more data are collected in future the short- and long-term trends and their causes should become more obvious.

3.2 Radioactive deposition

Results of measurements of TBA, ^{90}Sr and ^{210}Pb deposition in New Zealand and Rarotonga are summarised in Table 2.

3.2.1 Total beta activity

The total TBA deposition for 1994 at Hokitika was 213 ± 7 Bq/m^2 with 314 cm of rainfall, similar on a rainfall-normalised basis to that recorded in 1993[5]: 172 Bq/m^2 with 260 cm rainfall. The mean weekly deposition was 4.1 Bq/m^2, with a range of 0 - 25 Bq/m^2. The mean weekly concentration of beta emitting nuclides in rainwater at Hokitika was 0.5 Bq/L, with a range of 0 - 9 Bq/L.

At Rarotonga the total deposition was 246 ± 10 Bq/m^2 with 174 cm of rain, which was less than that recorded in 1993[5]: 334 Bq/m^2 with 184 cm of rain. The mean weekly deposition at Rarotonga was 4.7 Bq/m^2, with a range of 0 - 23 Bq/m^2. The mean weekly concentration of beta emitting nuclides in rainwater at Rarotonga was 1.2 Bq/L, with a range of 0 - 5 Bq/L.

3.2.2 Strontium-90

Strontium-90 deposition is measured in six-monthly aggregates of strontium recovered from the monthly rainwater collections.

Strontium-90 deposition continued to be near the limit of detection at all monitoring sites during 1994 with an annual total at each site of 0.2 ± 0.2 Bq/m^2 (Table 2), as is typical of recent years.

These ^{90}Sr deposition results may be contrasted with TBA deposition which is of natural origin[5], and with the peak ^{90}Sr deposition recorded in 1964 when the national average was 130 Bq/m^2.

3.2.3 Lead-210

Lead-210 and its decay product ^{210}Po are the most significant source of natural dietary radiation exposure due to terrestrial radionuclides (excluding ^{40}K), together contributing over 80% of exposure from this source[7]. Lead-210 deposition is measured in New Zealand together with that of ^{90}Sr in order to allow assessment of natural radiation exposure from this source as described in the 1993[5] report.

During 1994 monthly average ^{210}Pb depositions at Kaitaia and Hokitika were 4.4 and 10.3 Bq/m^2 respectively, with annual total depositions of 44 and 124 Bq/m^2, and an annual average rainwater concentration of 0.05 Bq/L, similar to levels recorded in 1993[5].

3.3 Radioactivity in milk

The presence of ^{137}Cs and ^{90}Sr in soil, as described in the 1993 report[5], leads to their presence in milk. Results of milk monitoring during 1994 are summarised below and in Table 3.

3.3.1 Caesium-137

Caesium-137 levels in cows' milk were assessed by gamma spectroscopic analysis of monthly samples of milk powder. Results are summarised as quarterly averages in Table 3, with units of Bq per gram of potassium (Bq/g K) and Bq per kilogram of milk powder (Bq/kg).

The 1994 average ^{137}Cs levels were: Auckland 0.04 Bq/g K or 0.6 Bq/kg powder; Taranaki 0.17 Bq/g K or 2.1 Bq/kg powder; Westland <0.04 Bq/g K or <0.5 Bq/kg powder. The three-region mean was 0.08 Bq/g K or 1.0 Bq/kg powder, which is lower than the 1993 mean of 0.15 Bq/g K or 1.5 Bq/kg powder[5].

Concentrations of ^{137}Cs in milk continue to be higher in the Taranaki region due to the local effect of volcanic soils[8].

3.3.2 Strontium-90

Strontium-90 levels in cows' milk were measured by radiochemical analysis of 3-month aggregated samples. Results are shown in Table 3, with units of Bq per gram of calcium (Bq/g Ca) and Bq/kg powder.

In contrast with ^{137}Cs concentrations in milk, ^{90}Sr levels are relatively uniform in the three monitored regions. The 1994 average ^{90}Sr levels were: Auckland 0.021 Bq/g Ca or 0.28 Bq/kg powder; Taranaki 0.025 Bq/g Ca or 0.33 Bq/kg powder; Westland 0.026 Bq/g Ca or 0.35 Bq/kg powder. The three-region mean was 0.024 Bq/g Ca or 0.32 Bq/kg powder, similar to the 1993[5] mean of 0.02 Bq/g Ca or 0.3 Bq/kg powder.

3.4 Environmental radiation

Environmental gamma radiation levels, due to cosmic, atmospheric and terrestrial gamma radiation, were monitored continuously through 1994 using a monitor installed on the Laboratory roof. This monitoring is conducted primarily as part of the WHO/UNEP GERMON programme.

The annual average environmental radiation during 1994 was 90 nanogray per hour, or 0.8 milligray per year, similar to the level reported in 1993[5].

An integrating measurement package comprising thermoluminescent dosemeters and films for 3-month exposure periods, provided by the WHO as part of the GERMON programme, is also used to assess environmental radiation levels. These packages are analysed quarterly by the WHO in France. Results of the integrating measurement and the continuous monitoring were similar during 1994.

4. SUMMARY

Measurements of artificial radioactivity levels in the atmosphere and rainwater in New Zealand and Rarotonga during 1994 indicated that the atmosphere contained only residual traces of global weapons test fallout, with no detectable influx of fresh fission products. Levels of ^{90}Sr and ^{137}Cs in milk continued to be measurable at trace levels only, with ^{137}Cs levels being lower than those recorded in 1993. Overall, the 1994 results were very similar to those reported for 1993[5] as indicated in the comparison of New Zealand site averages below:

	1994	1993
TBA in air, mBq/m^3	0.13	0.15
TBA in rain, Bq/m^2	213	172
^{90}Sr in rain, Bq/m^2	0.2 ± 0.2	0.1 ± 0.2
^{90}Sr in milk powder, Bq/kg	0.3	0.3
^{137}Cs in milk powder, Bq/kg	1.0	1.5

Caesium-137 was detected on yearly aggregates of air filters at Kaitaia and Hokitika at an average level of 0.04 ± 0.02 $\mu Bq/m^3$, and 0.03 ± 0.02 $\mu Bq/m^3$ at Rarotonga.

During 1994 the trend of summer maximum and winter minimum ^{7}Be levels continued in New Zealand, while the annual trend at Rarotonga showed the usual spring maximum.

5. OTHER ENVIRONMENTAL WORK

5.1 Quality assurance

Quality assurance is an essential feature of any measurement laboratory's operations. The National Radiation Laboratory has for many years participated in international analytical intercomparisons performed by agencies in other countries including the WHO, IAEA, and the EPA.

During 1994 results were reported for 15 intercomparisons involving 49 analyses, as presented in Table 5 which lists known and measured values.

Analytical performance was generally very satisfactory, with a mean measured/known ratio of 0.97 (standard deviation 0.12). Poorest performance was achieved in measurements of total alpha and beta activity before the old *Wide-β* counter was replaced (see Section 5.3).

5.2 Commercial and advisory services

There was a continuing demand for export certificates and radioactivity tests in 1994. During the year 660 export certificates were issued (a 40 % increase over the previous year) and 384 commercial analyses performed.

The number of enquiries during 1994 from members of the public and commercial interests regarding radioactivity in consumer products and foodstuffs and environmental issues was normal.

5.3 New equipment installation

A new gas-flow proportional alpha and beta detector was delivered in 1994, replacing the Beckman *Wide-β* which has been in service since 1961 and was beginning to experience increasingly frequent breakdowns and erratic results. The new instrument – a Tennelec LB4100W – has four 5cm-diameter detectors which measure alpha and beta activities simultaneously.

5.4 Test-ban treaty negotiations

Dr Matthews assisted the Ministry of Foreign Affairs and Trade by attending two meetings of experts at the United Nations headquarters in Geneva during 1994. The expert group met to consider techniques for verifying compliance with the proposed comprehensive test-ban treaty currently being negotiated.

5.5 Conference

Dr Matthews attended the biennial Environmental Radioactivity Workshop of the South Pacific Environmental Radioactivity Association (SPERA) at the Australian National University, Canberra, in February 1994. He is the current President of SPERA.

5.6 Publication

The following paper was accepted for publication during 1994:

K. M. Matthews. Measurements of residual traces of ^{137}Cs in the atmosphere in New Zealand. *Journal of Environmental Radioactivity*, **26**, 1995.

ACKNOWLEDGEMENT

The New Zealand Meteorological Service, which had been the mainstay of the NRL sample collection network since 1960, finally ceased its involvement in the monitoring operations with its withdrawal from Kaitaia during 1994 (and earlier at Hokitika). The National Radiation Laboratory is extremely indebted to the Meteorological Service for all the assistance its staff so efficiently provided during our 35-year association. The Laboratory now welcomes the assistance of Mr B Buckby of North Weather Ltd with continued monitoring at Kaitaia, and thanks Mr M Crompton of West Weather Ltd, Hokitika, for his excellent service during 1994. The Laboratory gratefully acknowledges also the continued help of the Rarotonga Meteorological Service with monitoring in the Cook Islands, and Managers of the East Tamaki Co-operative Dairy Co. (Auckland), Kiwi Co-operative Dairies Ltd (Hawera), Scenicland Milk and Cream (Greymouth) and Westland Co-operative Dairy Co. (Hokitika) for their assistance with the milk monitoring programme. The Laboratory also gratefully acknowledges the help of the US EPA and WHO in providing intercomparison services.

The Laboratory's Environmental Radioactivity Section organised the monitoring and analysed the samples. This report was written by the Section Head, Dr K M Matthews, who was assisted technically by Ms M-J Okey.

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Table 1: A summary of atmospheric radioactivity levels measured during 1994

Atmospheric radioactivity, weekly measurements

Monitoring site:	KAITAIA	HOKITIKA	RAROTONGA
TBA			
Range, mBq/m^3	0.05 - 0.30	0.04 - 0.28	0.05 - 0.29
Mean, mBq/m^3	0.14	0.12	0.13
Cosmogenic ^{7}Be			
Range, mBq/m^3	1.9 - 6.3	0.7 - 4.9	1.4 - 6.1
Mean, mBq/m^3	3.5	2.6	3.3
Radon decay products			
^{210}Pb, range mBq/m^3	0.02 - 0.30	0.01 - 0.26	0.01 - 0.14
mean mBq/m^3	0.08	0.06	0.06
^{210}Po, range $\mu Bq/m^3$	<1 - 27	<1 - 27	<1 - 39
mean $\mu Bq/m^3$	6	6	9

Atmospheric radioactivity, annual measurement: annual average concentration

Fission product ^{137}Cs			
^{137}Cs, $\mu Bq/m^3$	0.04 ± 0.02	0.04 ± 0.02	0.03 ± 0.02
Cosmogenic ^{22}Na			
^{22}Na, $\mu Bq/m^3$	0.31 ± 0.03	0.20 ± 0.03	0.28 ± 0.03

Table 2: A summary of ^{90}Sr, ^{210}Pb and total beta activity deposition measurements at Kaitaia, Hokitika and Rarotonga during 1994

Deposited radioactivity (Bq/m^2)

	Kaitaia	Hokitika	Rarotonga
TBA		213 ± 7	246 ± 10
^{90}Sr	0.2 ± 0.2	0.2 ± 0.2	0.2 ± 0.2
^{210}Pb	44	124	
Rainfall, cm	105	314	174

Table 3: Caesium-137 and strontium-90 levels in cows' milk during 1994

Results are expressed as Bq ^{137}Cs per gram potassium, Bq ^{90}Sr per gram calcium, and as Bq per kilogram of milk powder, for each quarter year period in the 3 regions. The 95% confidence intervals are of the order of 10% and 20% of the stated results for ^{137}Cs and ^{90}Sr respectively.

Caesium-137

Qtr	Auckland		Taranaki		Westland	
	Bq/g K	Bq/kg	Bq/g K	Bq/kg	Bq/g K	Bq/kg
1	<0.04	<0.5	0.30	4.0	<0.04	<0.5
2	<0.04	<0.5	0.17	0.8	<0.04	<0.5
3	0.08	0.3	0.14	1.7	<0.04	<0.5
4	0.05	0.9	0.07	0.9	<0.04	<0.5
Mean	0.04	0.6	0.17	2.1	<0.04	<0.5

Strontium-90

Qtr	Auckland		Taranaki		Westland	
	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg
1	0.020	0.26	0.025	0.33	0.026	0.36
2	0.018	0.24	0.024	0.33	0.024	0.34
3	0.023	0.30	0.027	0.35	0.025	0.31
4	0.023	0.31	0.023	0.32	0.029	0.37
Mean	0.021	0.28	0.025	0.33	0.026	0.35

Table 4: A summary for 1994 of weekly measurements of radioactivity in the atmosphere and precipitation

ATMOSPHERE AND RAINWATER MONITORING SUMMARY 1994											
	Atmospheric concentrations, mBq/m3									TBA deposition	
	KAITAIA			HOKITIKA			RAROTONGA			Bq/m2	
Week	TBA	Be-7	Pb-210	TBA	Be-7	Pb-210	TBA	Be-7	Pb-210	Hokitika	Rarotonga
1	0.23	4.69	0.13	0.13	3.15	0.04	0.10	2.08	0.03	24.69	23.30
2	0.21	5.73	0.09	0.11	3.37	0.01	0.12	1.76	0.02	2.23	3.17
3	0.23	6.30	0.05	0.10	3.27	0.03	0.14	1.43	0.01	9.42	3.29
4	0.14	5.07	0.03	0.20	4.25	0.03	0.21	3.04	0.04	3.60	15.17
5	0.14	4.67	0.04	0.10	1.80	0.01	0.13	1.94	0.02	3.34	0.15
6	0.12	4.44	0.03	0.17	3.20	0.06	0.17	3.07	0.04	2.96	0.70
7	0.09	2.32	0.05	0.25	4.87	0.08	0.17	2.20	0.05	4.17	8.63
8	0.14	2.79	0.04	0.07	2.41	0.03	0.14	3.11	0.05	3.33	4.06
9	0.15	3.29	0.04	0.12	3.63	0.05	0.14	1.79	0.04	7.32	2.59
10	0.13	4.25	0.04	0.14	3.98	0.04	0.07	1.61	0.03	1.20	11.46
11	0.11	3.89	0.04	0.08	2.02	0.02	0.09	2.24	0.02	4.82	5.92
12	0.08	3.24	0.03	0.15	3.32	0.08	0.09	2.25	0.04	0.00	3.56
13	0.30	4.68	0.26	0.20	4.62	0.16	0.12	3.66	0.04	1.86	4.80
14	0.14	2.43	0.04	0.14	2.25	0.07	0.08	2.25	0.02	4.98	3.95
15	0.09	3.33	0.06	0.14	3.19	0.06	0.08	2.42	0.03	1.03	3.02
16	0.18	3.55	0.08	0.09	2.25	0.05	0.10	3.70	0.06	3.67	4.10
17	0.26	4.11	0.24	0.28	4.08	0.26	0.11	3.96	0.04	1.64	1.47
18	0.30	3.95	0.30	0.10	2.76	0.05	0.11	3.35	0.03	2.69	5.22
19	0.08	2.41	0.03	0.11	2.06	0.08	0.09	2.84	0.04	1.13	7.93
20	0.16	2.97	0.08	0.09	2.40	0.04	0.14	4.20	0.05	8.18	2.09
21	0.24	4.14	0.22	0.12	2.49	0.10	0.11	3.54	0.07	6.99	0.00
22	0.11	2.92	0.06	0.16	3.72	0.07	0.18	4.09	0.10	0.48	2.21
23	0.11	2.57	0.05	0.12	1.93	0.07	0.13	4.06	0.04	1.35	3.60
24	0.06	1.85	0.03	0.09	1.93	0.04	0.12	3.59	0.05	1.75	1.08
25	0.12	2.85	0.07	0.08	1.66	0.06	0.15	3.58	0.06	7.37	2.94
26	0.13	2.73	0.07	0.08	1.95	0.02	0.18	3.57	0.07	1.45	0.00
27	0.15	2.54	0.04	0.12	1.99	0.09	0.06	1.68	0.03	3.44	1.32
28	0.14	2.83	0.12	0.10	2.67	0.07	0.07	1.81	0.02	3.20	0.97
29	0.05	1.88	0.02	0.07	1.40	0.02	0.10	3.81	0.04	2.17	2.86
30	0.11	2.08	0.04	0.07	0.92	0.03	0.29	4.77	0.06	1.25	13.24
31	0.13	2.57	0.04	0.09	1.64	0.06	0.15	4.23	0.08	1.65	0.66
32	0.08	2.07	0.05	0.06	1.86	0.03	0.08	1.49	0.02	4.27	5.42
33	0.07	2.39	0.03	0.04	1.35	0.01	0.13	4.84	0.08	1.61	3.06
34	0.09	2.37	0.05	0.28	1.34	0.05	0.10	3.39	0.05	2.50	3.37
35	0.09	2.08	0.07	0.07	1.52	0.04	0.18	4.02	0.08	5.65	22.91
36	0.17	2.95	0.10	0.09	1.86	0.04	0.18	3.71	0.10	4.58	3.48
37	0.20	3.62	0.19	0.17	2.77	0.10	0.23	5.33	0.14	7.33	2.55
38	0.09	3.48	0.03	0.13	0.69	0.04	0.20	5.88	0.10	4.33	2.79
39	0.15	4.03	0.07	0.09	2.19	0.04	0.20	6.13	0.12	0.63	3.41
40	0.11	2.73	0.06	0.14	2.25	0.08	0.24	4.12	0.14	1.97	3.50
41	0.09	3.13	0.03	0.06	2.56	0.03	0.17	5.19	0.12	3.33	3.05
42	0.11	3.37	0.05	0.07	2.13	0.01	0.17	5.35	0.12	4.91	4.24
43	0.11	3.37	0.05	0.14	3.04	0.10	0.11	3.55	0.06	4.75	4.08
44	0.13	3.61	0.08	0.14	3.20	0.06	0.13	4.83	0.09	8.97	1.25
45	0.17	5.51	0.10	0.09	2.92	0.04	0.12	4.38	0.08	7.41	9.52
46	0.13	4.09	0.08	0.08	2.96	0.04	0.10	3.10	0.06	5.54	6.42
47	0.11	4.02	0.04	0.08	2.79	0.02	0.08	1.79	0.04	6.34	2.72
48	0.16	4.48	0.07	0.11	3.27	0.07	0.12	5.10	0.07	3.07	4.24
49	0.22	5.15	0.19	0.12	3.07	0.07	0.13	4.33	0.06	4.47	3.54
50	0.15	3.62	0.10	0.10	2.43	0.03	0.05	1.81	0.05	1.37	2.39
51	0.18	6.04	0.16	0.06	2.90	0.03	0.05	1.97	0.04	3.03	8.49
52	0.10	4.87	0.06	0.08	3.11	0.03	0.06	1.92	0.05	3.48	2.50

Table 5: A summary of results of international analytical intercomparisons during 1994 or late 1993, comprising all results received during 1994.

The Laboratory's analytical result (mean of 3 analyses) is compared with the "known" value as stated by the organiser. Units were varied and are not given in the table. (TAA = total alpha activity, TBA = total beta activity.)

Organiser	Sample	Type	Nuclide	NRL mean	Known
EPA	water	gamma	^{131}I	74	79
EPA	Air filter	alpha	TAA	33	35
		beta	TBA	59	56
			^{90}Sr	20	20
		gamma	^{137}Cs	19	15
EPA	water	gamma	^{60}Co	49	50
			^{65}Zn	136	134
			^{106}Ru	228	223
			^{134}Cs	39	40
			^{137}Cs	53	49
			^{133}Ba	89	94
EPA	water	alpha	TAA	14	32
		beta	TBA	12	10
EPA	water	alpha	Uranium	49	53
EPA	water	alpha	TAA	87	86
			Uranium	24	25
		beta	TBA	81	117
			^{90}Sr	14	14
		gamma	^{60}Co	19	20
			^{134}Cs	31	34
			^{137}Cs	31	29
WHO	milk	gamma	^{134}Cs	46	50
			^{137}Cs	193	194
			^{40}K	63	51
EPA	water	alpha	uranium	25	25
EPA	milk	beta	^{90}Sr	20	20
		gamma	^{131}I	117	120
			^{137}Cs	49	49
			K	1.8	1.7

EPA	water	alpha	TAA	38	40
			uranium	15	15
EPA	water	beta	TBA	44	53
			^{90}Sr	10	10
		gamma	^{60}Co	10	10
			^{134}Cs	8	10
			^{137}Cs	9	10
EPA	water	alpha	TAA	13	14
		beta	TBA	15	15
EPA	water	gamma	^{60}Co	29	30
			^{65}Zn	155	150
			^{106}Ru	174	175
			^{134}Cs	50	54
			^{137}Cs	40	40
			^{133}Ba	72	79
EPA	water	gamma	^{131}I	113	117
EPA	air filter	alpha	TAA	20	19
		beta	TBA	47	47
			^{90}Sr	17	19
		gamma	^{137}Cs	10	9

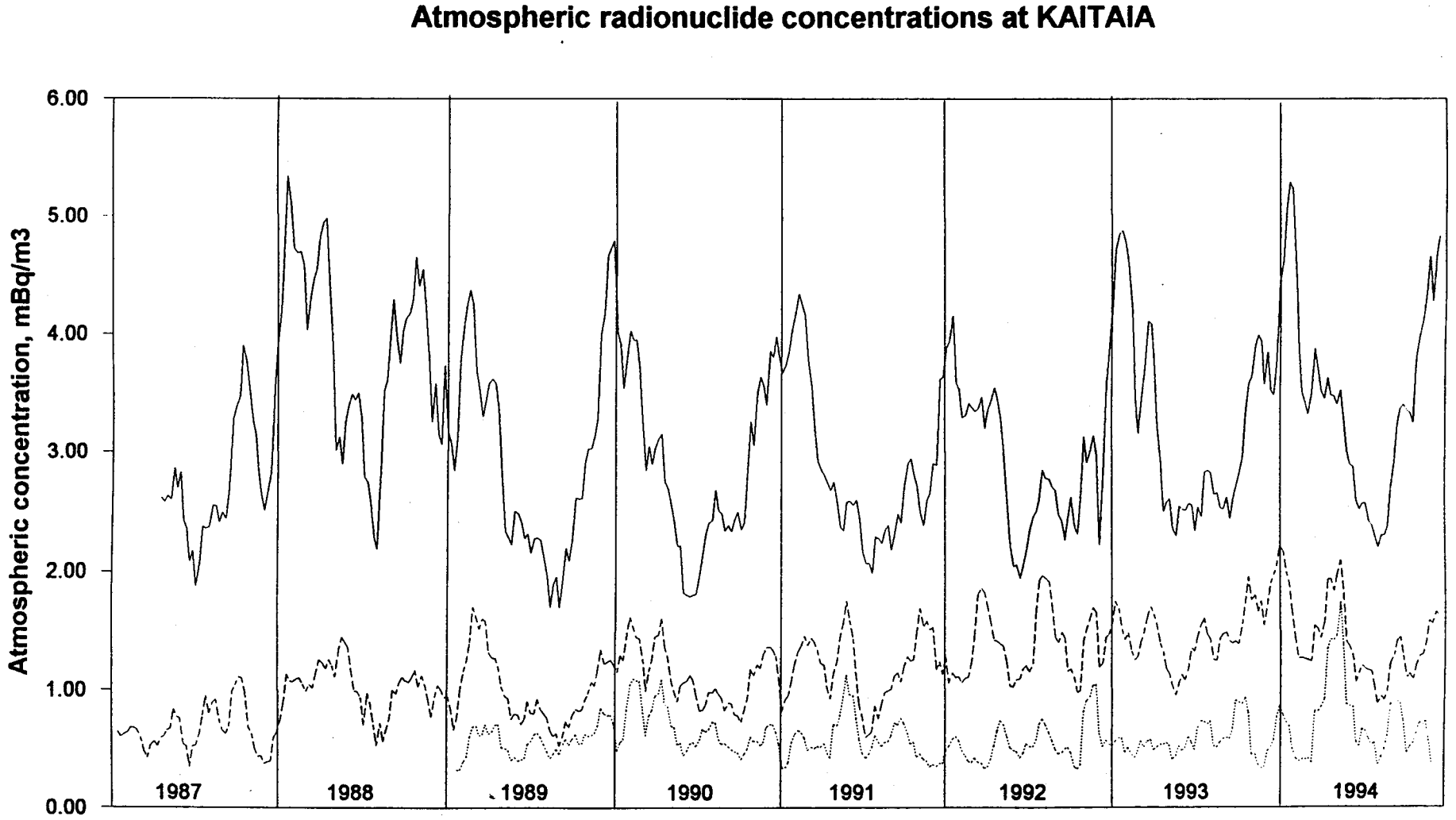

Fig 1 Five-week moving-average atmospheric concentrations of beryllium-7 (solid line), total beta activity (dashed line) and lead-210 (dotted line) at **Kaitaia** during the period 1987 to 1994. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

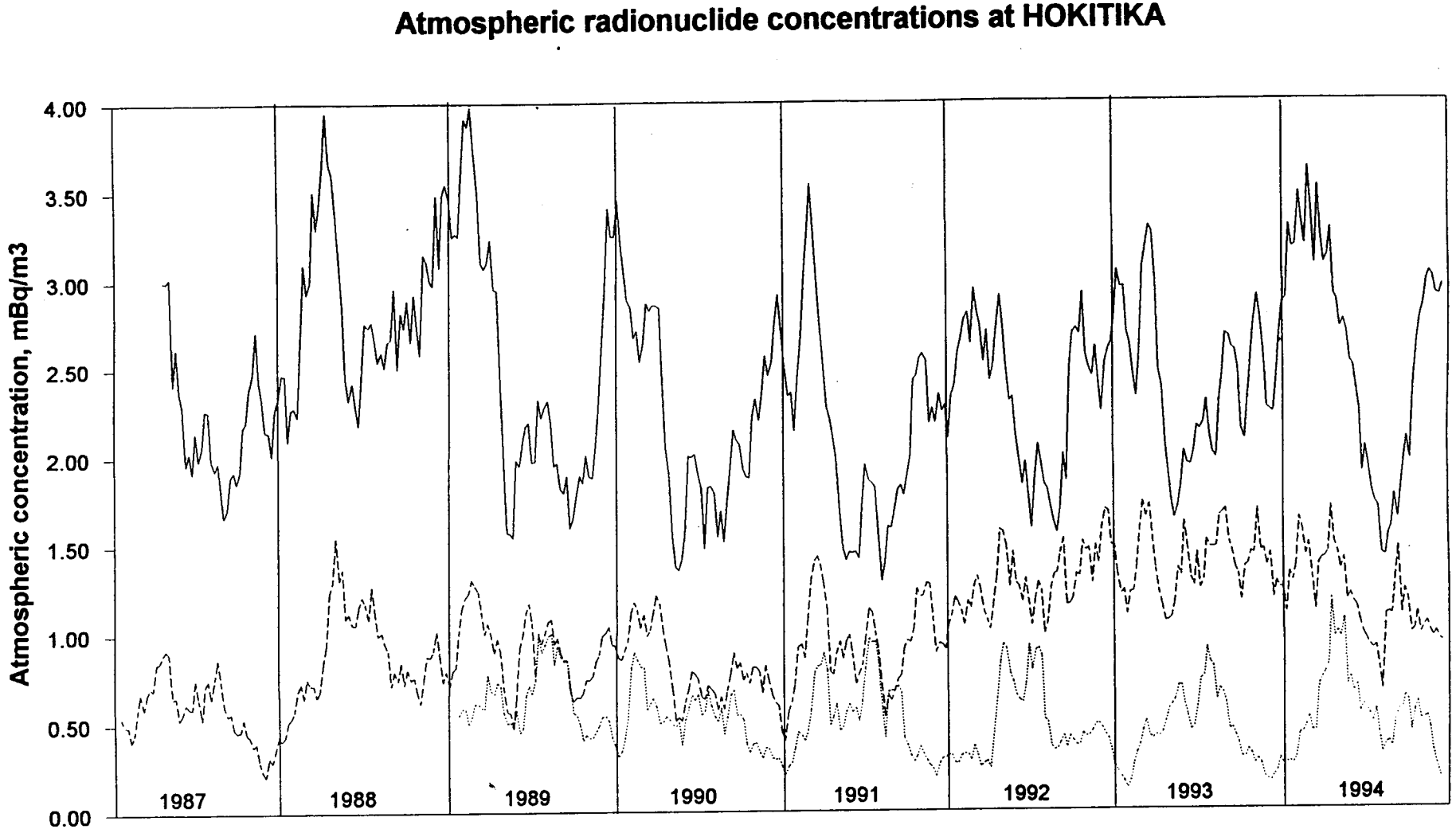

Fig 2 Five-week moving-average atmospheric concentrations of beryllium-7 (solid line), total beta activity (dashed line) and lead-210 (dotted line) at **Hokitika** during the period 1987 to 1994. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

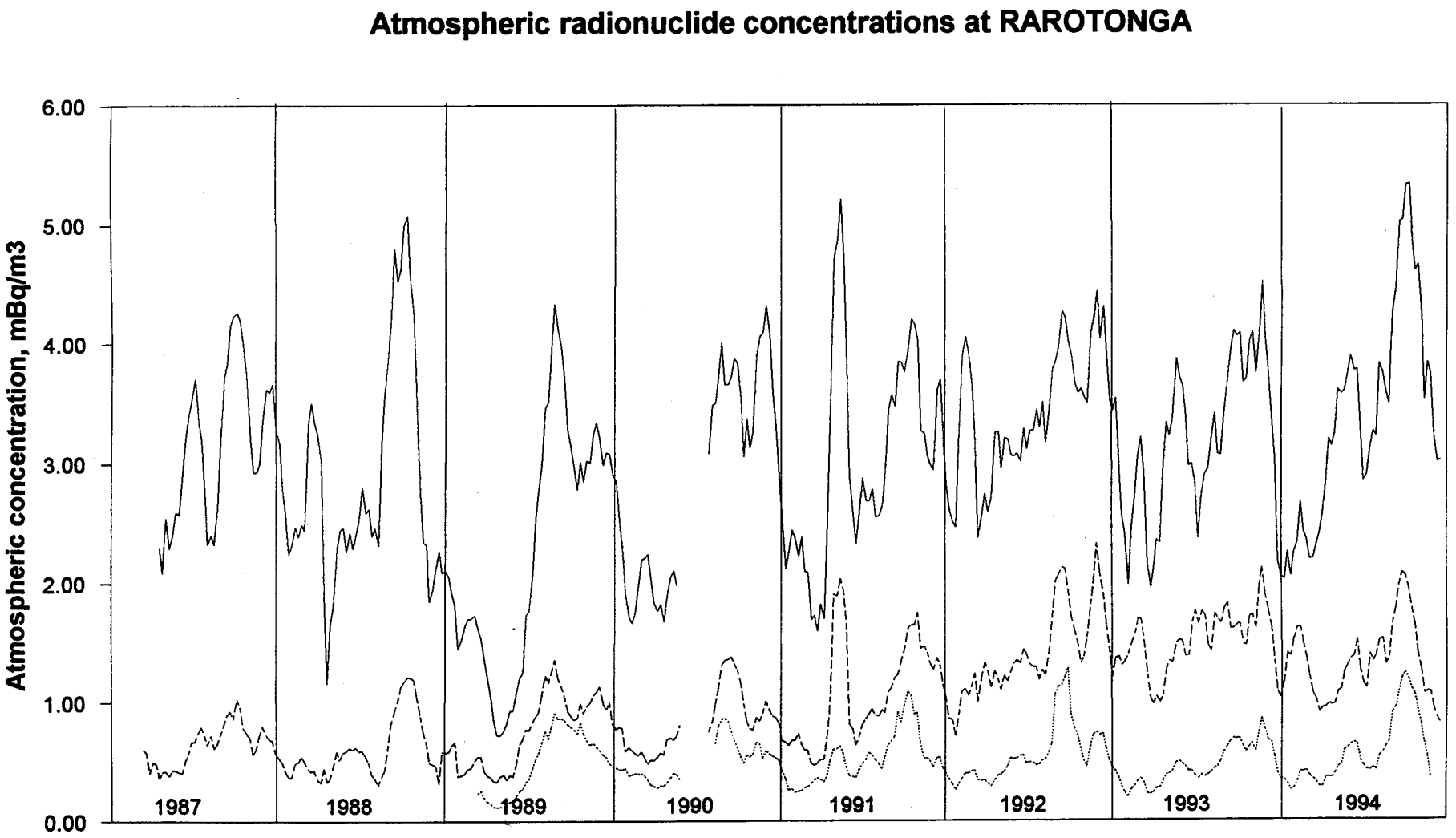

Fig 3 Five-week moving-average atmospheric concentrations of beryllium-7 (solid line), total beta activity (dashed line) and lead-210 (dotted line) at **Rarotonga** during the period 1987 to 1994. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*