NRL
National Radiation Laboratory

Environmental Radioactivity in New Zealand and Rarotonga

- Annual Report

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MINISTRY OF HEALTH
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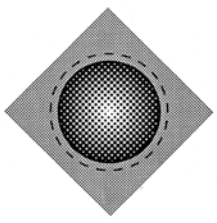
Environmental Radioactivity in New Zealand and Rarotonga – Annual Report



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National Radiation Laboratory

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Summary

During 1999, 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 radioactivity was monitored at Kaitaia, Hokitika and Rarotonga; deposited radioactivity was monitored at Hokitika; and milk radioactivity was monitored in the Waikato, Taranaki and Westland regions. Average levels measured were: total beta activity in air, 0.1 mBq/m^3; ^{90}Sr deposition, 0.2 ± 0.2 Bq/m^2; ^{137}Cs in milk, 0.07 Bq/g K; ^{90}Sr in milk, 0.01 Bq/g Ca. Total beta activity deposition at Hokitika was 144 Bq/m^2. Annual total ^{210}Pb and ^{7}Be depositions at Hokitika were 86 and 4300 Bq/m^2 respectively.

No artificial radionuclides were detected by gamma spectroscopic analysis of high-volume air filters during 1999, with weekly sampling periods. The annual-average atmospheric ^{137}Cs concentration in the region, assessed by analysis of yearly air-filter aggregates, was 0.03 μBq/m^3.

Average atmospheric concentrations of natural ^{7}Be and ^{210}Pb were 2.8 mBq/m^3 and 0.07 mBq/m^3 respectively.

This will be the final Annual Report in this current format. Next year the Environmental Radioactivity Annual Report will be incorporated into the NRL Annual Report.

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 1985, 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 (Kaitaia and Hokitika) and one in the Cook Islands (Rarotonga). The sensitivity of weekly atmospheric monitoring at these sites was increased with the installation of 150 m^3 per hour 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 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.

The National Radiation Laboratory 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 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.

Following the signing of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) by the United Nations member countries, in September 1996, verification of treaty compliance is now an important international issue with monitoring becoming part of the global verification network. New Zealand signed the CTBT on 27 September 1996, and ratified the CTBT on 19 March 1999, with the passing of the Nuclear Test Ban Act. Article 1 of the Treaty states:

1. Each State Party undertakes not to carry out any nuclear weapons test explosion or other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control.

2. Each State Party undertakes, furthermore, to refrain from causing, encouraging, or in any way participating in the carrying out of any nuclear weapon test explosion or any other nuclear explosion.

To enforce the Treaty, the International Monitoring System (IMS) has been designed to provide, on a global scale, passive monitoring capable of detecting and locating nuclear explosions. The four monitoring techniques are seismic, radionuclide, infrasound and hydroacoustic.

Since late 1996, atmospheric radioactivity data from each of the three NRL atmospheric monitoring stations have been transmitted, on a weekly basis, to the Prototype International Data Centre (pIDC) in Washington, along with data from many other stations world-wide. 1999 data from all stations may be viewed on the world-wide-web, on the pIDC home page: *http://www.pidc.org*. The International Data Centre in Vienna, part of the CTBT Organisation, began receiving data from the International Monitoring System early in 2000.

In 2000 and in accordance with the Comprehensive Nuclear-Test-Ban Treaty, stations at Kaitaia and Rarotonga will be upgraded to daily monitoring with a greater sensitivity resulting from the installation of 900 m^3 per hour high-volume air samplers and on-site gamma detectors. A new station at Chatham Islands will also be installed.

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 US Environmental Measurements Laboratory (US EML). International analytical inter-comparison exercises are undertaken whenever the opportunity arises.

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), beryllium-7 (^{7}Be) and sodium-22 (^{22}Na) in the atmosphere. Beryllium-7 and ^{22}Na are cosmogenic nuclides (products of spallation reactions of cosmic radiation within the upper atmosphere), while ^{210}Pb is a decay product of gaseous radon-222 (^{222}Rn), which diffuses out of soil. Lead-210 and ^{7}Be depositions are also monitored at one New Zealand site, together with artificial strontium-90 (^{90}Sr) deposition.

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 comprised the following measurements during 1999.

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, and ^{210}Pb levels were monitored with weekly collections of particulates from surface air at Kaitaia, Hokitika and Rarotonga. In addition, air filters collected during the year were bulked annually for sensitive measurements of average levels of any other radionuclides which may have been present – for example, ^{137}Cs and ^{22}Na.

The atmospheric monitoring involved the use of centrifugal-fan pumps to 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 were 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. Annual filter aggregates representing air volumes of approximately 1.6×10^6 m^3 were analysed using high-resolution gamma spectroscopy.

The minimum detectable concentrations for a fission product such as ^{137}Cs in the weekly and annual filter analyses were 0.5 and 0.02 $\mu Bq/m^3$ (average concentration) respectively.

Radioactive deposition: TBA and ^{90}Sr depositions were monitored at Hokitika with weekly and monthly sample collection respectively. Lead-210 and ^{7}Be deposition was monitored on a weekly basis at Hokitika, using a large-area (1 m^2) rain collector.

Radioactivity in milk: Caesium-137 concentrations were monitored in dairy milk powders with monthly sample collection from three New Zealand regions: Waikato (100 km south of Auckland), Taranaki and Westland. Strontium-90 in milk was monitored in the Westland region only.

Environmental radiation: Outdoor environmental gamma radiation levels were monitored in Christchurch as part of the GERMON programme, using an integrating monitoring method (TLDs). NRL's participation in this programme was suspended by WHO/UNEP in December 1999.

The continuous monitoring of environmental gamma radiation levels used a monitor installed on the Laboratory roof. This monitoring was conducted primarily as part of the WHO/UNEP GERMON programme. The annual-average environmental radiation dose-rate measured during 1996[6] and 1997[7] was 80 nanogray per hour, or 0.7 milligray per year. With little variation in dose from year to year the programme was suspended in January 1998[8], with the ability to reinstate the programme when required.

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]. A review of the history of fallout monitoring in New Zealand is available[9].

3 1999 Monitoring results

Monitoring results for 1999 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 radioactivity monitoring results for 1999 are summarised in Table 1, while results of weekly measurements are given in Table 4. Trends in radioactivity levels during the year are illustrated in Figures 1 - 3.

3.1.1 Artificial radionuclides

No artificial radionuclides were detected by gamma-spectroscopic analysis of weekly air filters collected from each monitoring station during 1999.

Caesium-137 was detected at trace levels on the annual filter aggregates from Kaitaia and Rarotonga at annual-average levels of 0.02 ± 0.01 μBq/m^3, equivalent to the minimum detectable concentration of 0.02 μBq/m^3. At Hokitika, the average ^{137}Cs concentration was 0.04 ± 0.01 μBq/m^3. The detection limits are very far below those of health significance and those of concentrations of naturally occurring radionuclides in air. The detection limit for Cs-137 is one thousand millionth (10^{-9}) that of an average indoor radon concentration.

3.1.2 Total beta activity

Weekly-average atmospheric TBA levels during 1999 were similar at all 3 monitoring sites, and ranged from 0.03 mBq/m^3 to 0.23 mBq/m^3 (Table 1), with an overall annual-average of 0.10 mBq/m^3, as recorded in recent years (1996[6], 1997[7] and 1998[8]).

Atmospheric TBA was almost entirely due 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 1999, with weekly-average concentrations in the range 0.9 - 6.4 mBq/m^3, and with an overall annual-average concentration of 2.8 mBq/m^3, 25% lower compared to the level recorded in 1998[8] (3.7 mBq/m^3).

Sodium-22 was detected on the yearly aggregates of air filters at an overall annual-average concentration of 0.27 μBq/m^3 (Table 1).

Lead-210

Lead-210 was measured on the weekly air filters at levels which were similar at all 3 monitoring sites, as indicated in Table 1. Levels ranged from 0.01 to 0.23 mBq/m^3, with an overall annual-average concentration of 0.07 mBq/m^3, as recorded in 1997[7] and 1998[8].

3.1.4 Trends in radioactivity levels

The annual trend in ^{7}Be levels continued to demonstrate the normal cycles of summer maxima and winter minima in New Zealand (Figures 1 and 2) and in Rarotonga (Figure 3).

Total-beta activity measurements during 1999 followed similar trends to ^{210}Pb, the ^{210}Bi decay product of which is the main contributor of beta activity.

3.2 Radioactive deposition

Results of measurements of TBA, ^{90}Sr, ^{210}Pb and ^{7}Be deposition at Hokitika are summarised in Table 2.

3.2.1 Total beta activity

The TBA deposition for 1999 at Hokitika was 144 ± 8 Bq/m^2 with 280 cm of rainfall. This was the lowest recorded level within the last five years (see below table) and was 33% lower than that recorded in 1998[8]: 216 Bq/m^2 with 317 cm rainfall.

	1999	1998	1997	1996	1995
Annual Rainfall (cm)	280	317	257	333	355
TBA in rain (annual), Bq/m^2	144	216	200	175	208
^{7}Be in rain (annual), Bq/m^2	4300	6410	5320	6120	6550
^{210}Pb in rain (annual), Bq/m^2	86	134	122	112	136

No artificial radionuclides were detected by gamma-spectroscopic analysis.

The average weekly deposition was 2.8 Bq/m^2, with a range of 0.6 - 6.4 Bq/m^2. The average weekly TBA concentration in rainwater at Hokitika was 0.3 Bq/L, with a range of 0.03 - 5.9 Bq/L.

3.2.2 Natural radionuclides

Lead-210 and its decay product ^{210}Po are the most significant sources of natural dietary radiation exposure due to terrestrial radionuclides (excluding ^{40}K), together contributing over 80% of exposure from this source[10].

The total ^{210}Pb deposition at Hokitika during 1999 was 86 Bq/m^2, 36% lower than that recorded in 1998[8]. The total ^{210}Pb deposition at Hokitika during 1999 represented 60% of the deposited TBA, similar to that recorded in 1998[8].

Beryllium-7 deposition at Hokitika during 1999 totalled 4300 Bq/m^2. This was the lowest recorded level within the last five years (see above table) and was 33% lower than that recorded in 1998[8]: 6410 Bq/m^2.

3.2.3 Strontium-90

Strontium-90 deposition was 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 Hokitika during 1999, with an annual total of 0.2 ± 0.2 Bq/m^2 (Table 2), typical of recent years.

3.3 Radioactivity in milk

Results of milk monitoring during 1999 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 monthly 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 1999 average ^{137}Cs levels were: Waikato kg 0.06 Bq/g K or 0.8 Bq/kg powder; Taranaki 0.11 Bq/g K or 1.5 Bq/kg powder; Westland 0.05 Bq/g K or 0.7 Bq/ powder. The three-region mean was 0.07 Bq/g K or 1.0 Bq/kg powder, similar to that reported in 1998[8].

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

3.3.2 Strontium-90

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

The 1999 average ^{90}Sr level was 0.01 Bq/g Ca or 0.2 Bq/kg powder, similar to that reported in 1998[8].

3.4 Environmental radiation

Environmental gamma radiation levels, due to cosmic, atmospheric and terrestrial gamma radiation, were monitored through 1999 using an integrating measurement package comprising thermoluminescent dosemeters and films for 3-month exposure periods. This package was provided by the WHO as part of the GERMON programme. These packages were analysed quarterly by the WHO in France. Results, along with results from 1998 of the integrating measurement monitoring will be published in the 2000 Annual Report.

4 Summary

Measurements of artificial radioactivity levels in the atmosphere and rainwater in New Zealand and Rarotonga during 1999 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 levels being virtually the same as those recorded in 1998.

The 1999 average levels of atmospheric, deposited, and milk radioactivity were: TBA in air, 0.1 mBq/m^3; TBA deposition, 144 Bq/m^2 (Hokitika); ^{90}Sr deposition, 0.2 ± 0.2 Bq/m^2 (Hokitika); ^{90}Sr in milk powder, 0.2 Bq/kg; ^{137}Cs in milk powder, 1.0 Bq/kg.

Overall, the 1999 results were similar to those reported for 1996[6], 1997[7] and 1998[8] as indicated in the comparison of New Zealand site averages below, with the exception of the annual deposition results for total beta activity and naturally occurring radionuclides. This may be due to the lower than normal rainfall at Hokitika coupled with unusual weekly dry periods (<1 mm) throughout the year.

	1999	1998	1997	1996
TBA in air (weekly), mBq/m^3	0.10	0.10	0.10	0.10
TBA in rain (annual), Bq/m^2	144	216	200	175
^{90}Sr in rain (annual), Bq/m^2	0.2	0.2	0.3	0.1
^{90}Sr in milk powder (3-monthly), Bq/kg	0.2	0.2	0.3	0.3
^{137}Cs in milk powder (monthly), Bq/kg	1.0	1.0	1.3	1.1

No artificial radionuclides were detected by gamma-spectroscopic analysis of high-volume air filters during 1999, with weekly sampling periods. Caesium-137 was detected on yearly aggregates of air filters at an overall average level of 0.03 ± 0.01 µBq/m^3.

For naturally occurring radionuclides, the average atmospheric concentrations of ^{7}Be and ^{210}Pb were 2.8 mBq/m^3 and 0.07 mBq/m^3 respectively, while the total annual depositions of the 2 radionuclides at Hokitika were 4300 Bq/m^2 and 86 Bq/m^2 respectively.

5 Other environmental radioactivity 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 1999 the Laboratory participated in four exercises, three conducted by the US EML and one by WHO, involving analysis of air filters, soil, vegetation, water and dried milk powder, for alpha-, beta-, and gamma-emitting radionuclides. Results are shown in Tables 5a, b, c & d. Overall, results were satisfactory, although there seems to be a downward bias in NRL gross alpha and beta results which is to be addressed by recalibration of detectors. Further problems were encountered with the ^{90}Sr analysis, which led to erroneous results, as indicated in 1998. The ^{90}Sr technique was designed for the ultra low levels of ^{90}Sr found in New Zealand conditions. Discussions with US EML concluded that the matrix of the sample, in combination with high levels of strong beta emitting radionuclides, was not appropriate for evaluating this technique. A new technique, capable of fulfilling both the needs of measuring ^{90}Sr in the New Zealand environment and the high levels found in US EML intercalibration samples is currently being assessed.

5.2 Commercial and advisory services

There was a continuing demand for export certificates and radioactivity tests in 1999. During the year 866 export certificates were issued and 517 commercial analyses performed.

5.3 The Comprehensive Nuclear-Test-Ban Treaty

In September 1999 installation of three International Monitoring Stations under NRL jurisdiction began at Kaitaia and Chatham Island, New Zealand and one at Rarotonga, Cook Islands. Details of these installations will be given in the 2000 Annual Report.

NRL continued to assist the International Security and Arms Control Disarmament Division of the Ministry of Foreign Affairs and Trade by giving further technical advice related to the Comprehensive Nuclear-Test-Ban Treaty during 1999.

Acknowledgement

The National Radiation Laboratory gratefully acknowledges the assistance of Mr Bruce Buckby of North Weather Ltd in Kaitaia, and Mr Mark Crompton of West Weather Ltd, Hokitika, and their excellent service during 1999. The Laboratory gratefully acknowledges also the continued help of the Rarotonga Meteorological Service with monitoring in the Cook Islands, particularly Mr Nga Rauraa and Mr Roro Taia. The Managers of the Anchor Products Te Rapa Factory (Waikato), Kiwi Co-operative Dairies Ltd (Hawera) and Westland Co-operative Dairy Co. (Hokitika) are also thanked for their assistance with the milk monitoring programme.

The Radiochemistry Laboratory Group of the Environmental Radioactivity Section organised the monitoring and analysed the samples. This report was written by Dr Rick Tinker, Senior Radiochemist, who was assisted by Dr Riitta Pilvio and assisted technically by Ms Mary Jane Okey.

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Table 1: A summary of atmospheric radioactivity levels measured during 1999

Atmospheric radioactivity, weekly measurements

Monitoring site:	KAITAIA	HOKITIKA	RAROTONGA
TBA			
Range, mBq/m^3	0.05 - 0.18	0.03 - 0.23	0.05 - 0.15
Mean, mBq/m^3	0.10	0.10	0.09
Cosmogenic ^{7}Be			
Range, mBq/m^3	1.7 - 6.4	1.5 - 5.8	0.9 - 5.8
Mean, mBq/m^3	3.2	2.6	2.7
Radon decay product ^{210}Pb			
Range, mBq/m^3	0.01 - 0.16	0.03 - 0.23	0.02 - 0.14
Mean, mBq/m^3	0.07	0.08	0.06

Atmospheric radioactivity, annual measurement: annual average concentration

Fission product ^{137}Cs			
^{137}**Cs**, $\mu Bq/m^3$	0.02 ± 0.01	0.04 ± 0.01	0.02 ± 0.01
Cosmogenic ^{22}Na			
^{22}**Na**, $\mu Bq/m^3$	0.31 ± 0.02	0.26 ± 0.02	0.23 ± 0.02

Table 2: A summary of ^{90}Sr, ^{210}Pb and total beta activity deposition measurements at Hokitika during 1999

Deposited radioactivity (Bq/m^2)

	Hokitika
TBA	144 ± 8
^{90}Sr	0.2 ± 0.2
^{210}Pb	86 ± 9
^{7}Be	4300 ± 130
Rainfall, cm	280

Table 3: Caesium-137 and strontium-90 levels in cows' milk during 1999

Results are expressed as Bq ^{137}Cs per gram potassium, Bq ^{90}Sr per gram calcium, and as Bq per kilogram of milk powder. 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

Month	Waikato		Taranaki		Westland	
	Bq/g K	Bq/kg	Bq/g K	Bq/kg	Bq/g K	Bq/kg
1	0.08	1.11	0.11	1.42	0.08	1.02
2	0.12	1.55	0.19	3.21	0.08	1.24
3	0.10	1.21	0.23	2.66	0.07	0.90
4	0.09	0.92	0.16	2.70	0.06	0.73
5	< 0.01*	< 0.5*	0.13	1.53	0.04	0.58
6	< 0.01*	< 0.5*	No Sample		No Sample	
7	< 0.01*	< 0.5*	0.04	0.73	No Sample	
8	0.03	0.40	0.03	0.36	0.03	0.45
9	0.05	0.78	0.06	1.05	0.03	0.42
10	0.07	0.99	0.10	1.53	0.05	0.71
11	0.08	1.16	0.10	1.71	0.04	0.62
12	0.07	1.06	0.09	1.49	0.05	0.77
Mean	0.06	0.77	0.11	1.5	0.05	0.74

* Liquid milk sample

Strontium-90

Quarter	Westland	
	Bq/g Ca	Bq/kg
1	0.021	0.304
2	0.010	0.155
3	0.010	0.158
4	0.009	0.136
Mean	0.013	0.188

Table 4: A summary for 1999 of weekly measurements of radioactivity in the atmosphere and precipitation

	Atmospheric concentrations, mBq/m^3									Weekly deposition TBA, Bq/m^2
	KAITAIA			HOKITIKA			RAROTONGA			
Week	Be-7	TBA	Pb-210	Be-7	TBA	Pb-210	Be-7	TBA	Pb-210	Hokitika
1	4.77	0.11	0.08	2.81	0.09	0.04	1.88	0.09	0.06	5.6
2	4.24	0.14	0.15	3.00	0.14	0.06	1.76	0.08	0.05	4.3
3	2.45	0.13	0.05	3.55	0.23	0.10	2.36	0.08	0.06	6.4
4	N/A	N/A	N/A	3.55	0.12	0.12	2.16	0.07	0.04	3.0
5	5.22	0.18	0.09	5.77	0.18	0.10	3.55	0.12	0.08	5.3
6	4.86	0.11	0.05	3.78	0.11	0.08	1.29	0.08	0.05	3.1
7	4.12	0.16	0.06	5.54	0.22	0.22	1.42	0.05	0.06	2.7
8	4.56	0.15	0.11	5.83	0.17	0.14	2.52	0.10	0.08	5.5
9	4.27	0.13	0.08	3.66	0.10	0.09	2.61	0.08	0.07	3.5
10	6.41	0.16	0.08	3.86	0.09	0.05	2.91	0.10	0.07	3.6
11	N/A	N/A	N/A	3.51	0.14	0.07	2.04	0.15	0.07	1.3
12	2.52	0.14	0.06	2.04	0.08	0.06	0.91	0.05	0.03	3.6
13	4.62	0.17	0.14	4.06	0.16	0.08	1.93	0.06	0.02	3.6
14	3.74	0.08	0.05	2.61	0.04	0.05	3.10	0.08	0.06	2.7
15	N/A	N/A	0.04	2.22	0.06	0.07	N/A	N/A	0.04	2.8
16	2.40	0.07	0.06	2.38	0.05	0.06	2.52	0.08	0.06	1.8
17	1.77	0.08	0.07	3.06	0.20	0.19	1.65	0.05	0.03	1.2
18	2.29	0.08	0.07	2.04	0.09	0.11	3.30	0.08	0.09	1.0
19	2.17	0.09	0.05	2.65	0.09	0.08	3.78	0.14	0.06	1.8
20	2.95	0.07	0.05	2.45	0.06	0.08	2.58	0.12	0.05	1.8
21	3.28	0.11	0.06	1.68	0.06	0.09	2.39	0.09	0.07	4.2
22	3.10	0.13	0.11	2.18	0.16	0.15	2.34	0.06	0.03	2.5
23	4.01	0.08	0.08	1.88	0.09	0.10	1.56	0.05	0.06	2.4
24	2.54	0.08	0.09	2.10	0.12	0.11	2.46	0.06	0.06	3.4
25	2.33	0.10	0.05	1.57	0.04	0.04	3.60	0.12	0.07	0.6
26	1.88	0.09	0.07	1.46	0.08	0.07	2.34	0.10	0.07	4.0
27	2.15	0.08	0.05	1.86	0.11	0.09	1.70	0.04	0.04	2.1
28	1.98	0.05	0.04	2.08	0.09	0.07	1.59	0.05	0.05	2.1
29	2.97	0.08	0.06	1.75	0.09	0.07	3.90	0.09	0.07	1.9
30	N/A	N/A	N/A	1.75	0.06	0.08	3.77	0.08	0.07	1.0
31	1.56	0.05	0.01	1.28	0.03	0.04	3.19	0.11	0.06	1.8
32	2.06	0.05	0.05	1.77	0.07	0.07	3.53	0.11	0.10	1.6
33	N/A	0.13	N/A	1.94	0.10	0.09	1.88	0.08	0.04	2.7
34	1.89	0.06	0.07	1.69	0.04	0.03	5.82	0.15	0.14	1.6
35	2.31	0.09	0.04	1.46	0.07	0.06	3.10	0.11	0.08	0.9
36	2.43	0.10	0.09	2.58	0.12	0.11	3.31	0.13	0.07	1.5
37	3.23	0.12	0.12	2.61	0.10	0.14	2.58	0.08	0.09	2.1
38	2.17	0.08	0.05	2.06	0.08	0.07	3.55	0.11	0.07	1.8
39	1.99	0.05	0.05	2.76	0.14	0.10	3.49	0.10	0.07	1.0
40	2.54	0.09	0.08	3.58	0.09	0.07	4.27	0.11	0.08	2.9
41	3.93	0.09	0.16	2.25	0.10	0.09	2.33	0.06	0.05	3.3
42	2.92	0.12	0.11	3.07	0.13	0.12	3.99	0.08	0.09	5.4
43	3.78	0.13	0.11	2.63	0.14	0.04	2.65	0.07	0.06	2.9
44	3.06	0.10	0.04	1.96	0.08	0.07	0.89	0.06	0.02	5.1
45	3.35	0.16	0.07	2.14	0.06	0.05	2.07	0.11	0.06	4.5
46	2.03	0.08	0.06	1.94	0.06	0.04	3.27	0.09	0.07	2.9
47	2.92	0.06	0.05	2.37	0.09	0.03	2.37	0.09	0.06	1.0
48	3.19	0.06	0.03	1.87	0.07	0.05	3.07	0.12	0.00	1.9
49	3.05	0.10	0.07	3.79	0.08	0.07	2.62	0.07	0.04	2.5
50	4.00	0.12	0.12	2.88	0.07	0.04	2.38	0.12	0.08	2.0
51	4.56	0.15	0.16	2.14	0.05	0.05	5.17	0.07	0.08	1.4
52	4.48	0.09	0.03	2.04	0.09	0.02	1.83	0.05	0.06	1.4

Results for intercomparison exercises during 1999

Table 5a: Intercomparison Results - MAPEP-99-S6 and MAPEP-99-W6

Matrix	Analyte	NRL value	MAPEP value	Evaluation (NRL / MAPEP)
Soil	K-40	803 ± 42	652	1.2 (W)
(Bq/kg)	Mn-54	393 ± 20	345	1.1 (A)
	Co-57	343 ± 18	360	1.0 (A)
	Co-60	135 ± 10	131	1.0 (A)
	Zn-65	3210 ± 160	2840	1.1 (A)
	Sr-90	8.7 ± 2		(N)
	Cs-134	626 ± 32	752	0.8 (A)
	Cs-137	329 ± 17	331	1.0 (A)
	U-234, 233	28 ± 6	157	0.2 (N)
	U-238	156 ± 16	40.7	3.8 (N)
	Pu-238	31 ± 2	27.5	1.1 (A)
	Pu-239, 240	52 ± 3	48.1	1.1 (A)
Water	Mn-54	239 ± 13	229	1.0 (A)
(Bq/L)	Co-57	355 ± 19	358	1.0 (A)
	Zn-65	1662 ± 86	1560	1.0 (A)
	Sr-90	28 ± 0.4	39.5	0.7 (W)
	Cs-137	655 ± 34	637	1.0 (A)
	U-234, 233	2.5 ± 0.2	2.67	0.9 (A)
	U-238	21 ± 1	21.2	1.0 (A)
	Pu-238	4.8 ± 0.1	1.45	3.3 (N)
	Pu-239, 240	4.5 ± 0.1	4.04	1.1 (A)

Evaluation: **A = Acceptable**
W = Acceptable with Warning
N = Not Acceptable

Table 5b: Intercomparison Results - EML-QAP 51

Matrix	Analyte	NRL Value	EML Value	Evaluation (NRL / EML)
Air filter	Mn-54	9.2 ± 0.5	7.91 ± 0.45	1.2 (A)
(Bq/filter)	Co-57	7.6 ± 0.4	7.730 ± 0.033	1.0 (A)
	Co-60	7.0 ± 0.4	6.35 ± 0.41	1.1 (W)
	Sr-90	0.59 ± 0.02	0.336 ± 0.014	1.8 (W)
	Cs-137	7.1 ± 0.4	6.43 ± 0.42	1.1 (A)
	Pu-238	0.098 ± 0.005	0.097 ± 0.007	1.0 (A)
	Pu-239	0.140 ± 0.007	0.136 ± 0.011	1.0 (A)
	Gross Alpha	2.58 ± 0.07	2.77 ± 0.26	0.9 (A)
	Gross Beta	2.82 ± 0.06	2.66 ± .026	1.1 (A)
Soil	K-40	1070 ± 70	780 ± 27	1.4 (W)
(Bq/kg)	Sr-90	44 ± 4	13.00 ± 0.47	3.4 (W)
	Cs-137	231 ± 13	204 ± 5	1.1 (A)
	Pu-239	52 ± 3	3.2 ± 0.5	16 (N)
Vegetation	K-40	780 ± 60	513 ± 20	1.5 (N)
(Bq/kg)	Co-60	19.6 ± 1.2	17.6 ± 1.0	1.1 (A)
	Cs-137	470 ± 20	440 ± 20	1.1 (A)
	Pu-239	4.7 ± 0.2	4.30 ± 0.46	1.1 (A)
Water	Co-60	54 ± 3	52.4 ± 2.2	1.0 (A)
(Bq/L)	Sr-90	3.09 ± 0.11	1.72 ± 0.10	1.8 (N)
	Cs-137	80 ± 4	76.0 ± 3.4	1.1 (A)
	Pu-238	0.80 ± 0.04	0.79 ± 0.08	1.0 (A)
	Pu-239	0.89 ± 0.05	0.87 ± 0.10	1.0 (A)
	Gross Alpha	1150 ± 40	1580 ± 20	0.7 (W)
	Gross Beta	850 ± 30	740 ± 40	1.1 (A)

Evaluation: **A = Acceptable**
W = Acceptable with Warning
N = Not Acceptable

Table 5c: Intercomparison Results - EML-QAP 52

Matrix	Analyte	NRL Value	EML Value	Evaluation (NRL / EML)
Air Filter	Mn-54	30.0 ± 1.1	27.2 ± 0.8	1.1 (A)
(Bq/filter)	Co-57	4.7 ± 0.1	5.31 ± 0.22	0.9 (A)
	Co-60	5.7 ± 0.1	5.32 ± 0.26	1.1 (A)
	Sr-90	0.17 ± 0.01	0.242 ± 0.005	0.7 (W)
	Cs-137	6.4 ± 0.2	6.1 ± 0.3	1.0 (A)
Soil	K-40	706 ± 26	811 ± 29	0.9 (W)
(Bq/kg)	Cs-137	350 ± 14	339.0 ± 9.3	1.0 (A)
Vegetation	K-40	340 ± 13	521 ± 20	0.7 (N)
(Bq/kg)	Co-60	60 ± 2	52.8 ± 1.0	1.1 (A)
	Cs-137	1370 ± 50	1380 ± 20	1.0 (A)
Water	Co-60	52 ± 2	48.9 ± 1.8	1.1 (A)
(Bq/L)	Sr-90	2.6 ± 0.2	3.39 ± 0.12	0.8 (W)
	Cs-137	106 ± 5	103 ± 4	1.0 (A)

Evaluation: **A = Acceptable**
W = Acceptable with Warning
N = Not Acceptable

Table 5d: Intercomparison Results - IRC-WHO 64 L 300

Matrix	Analyte	NRL value	WHO value	Evaluation (NRL / WHO)
Milk Powder	K-40	533 ± 30	507 ± 65	1.00
(Bq/kg)	Mn-54	30.5 ± 2	32.7 ± 3.7	0.90
	Sr-90	25.2 ± 0.8	30.8 ± 3.1	0.80
	Ag-110m	36 ± 2	46.4 ± 6.2	0.80
	Cs-137	67.5 ± 4	72.1 ± 4.4	0.90

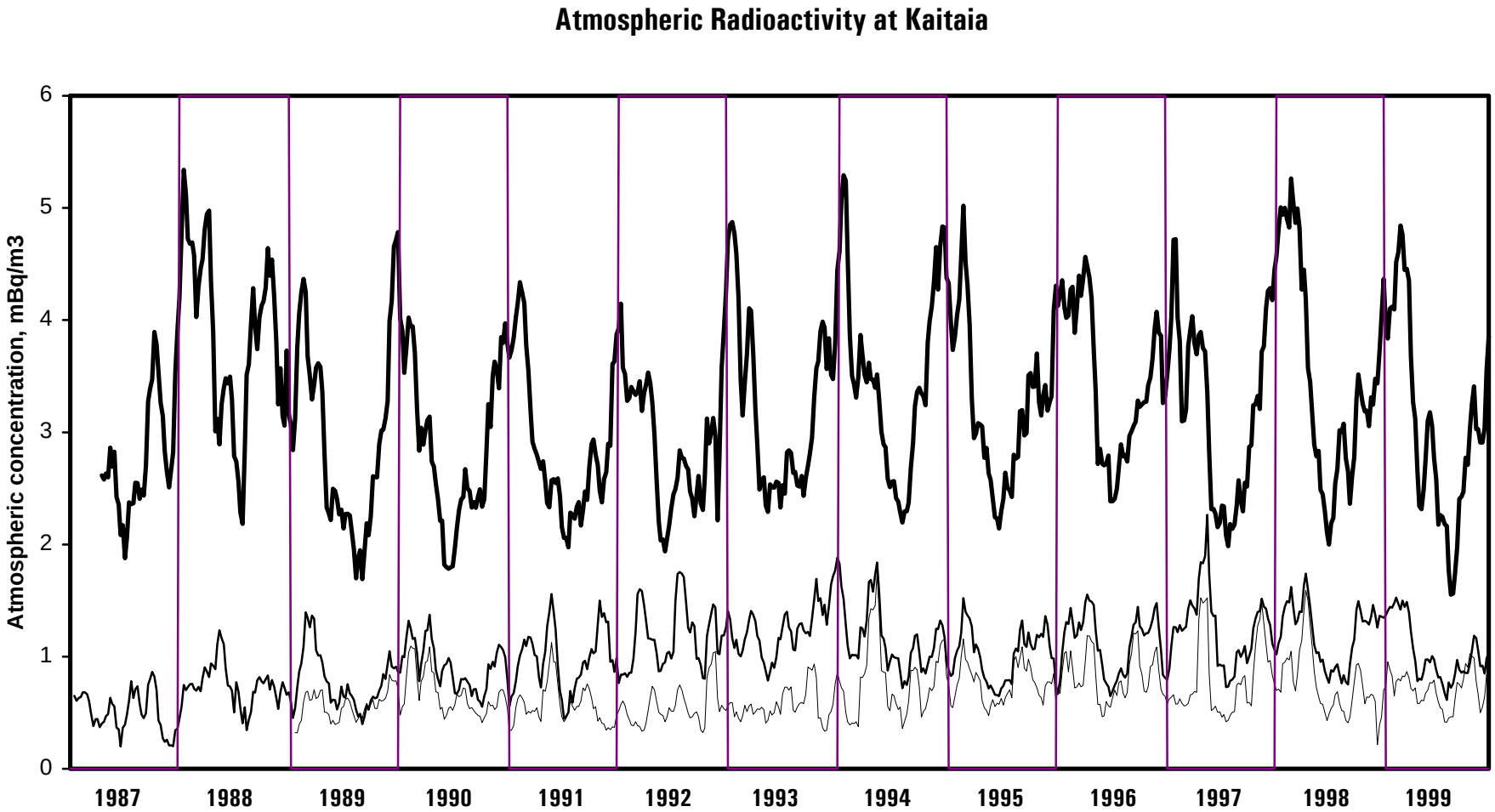

Fig 1 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Kaitaia** during the period 1987 to 1999. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels*

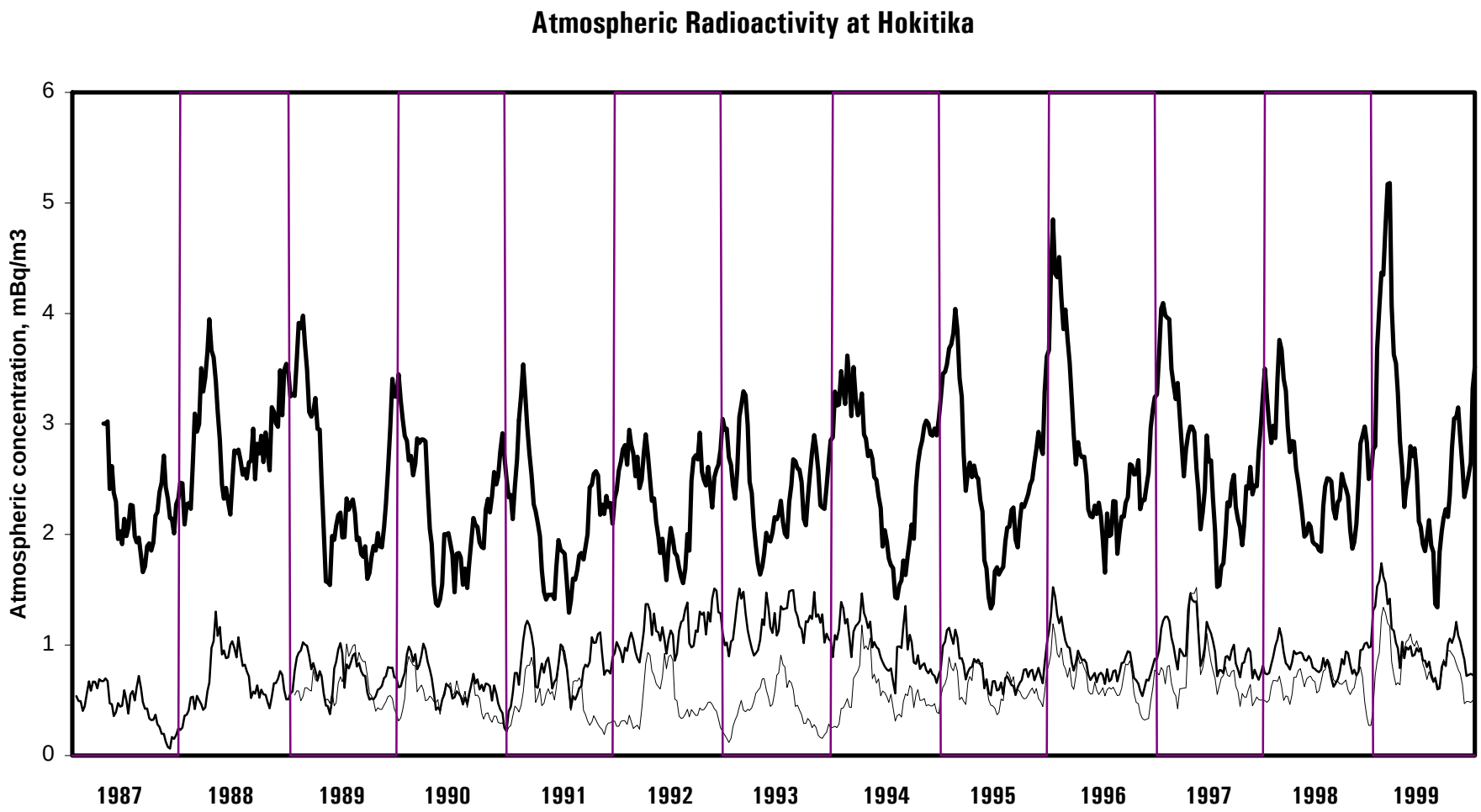

Fig 2 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Hokitika** during the period 1987 to 1999. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

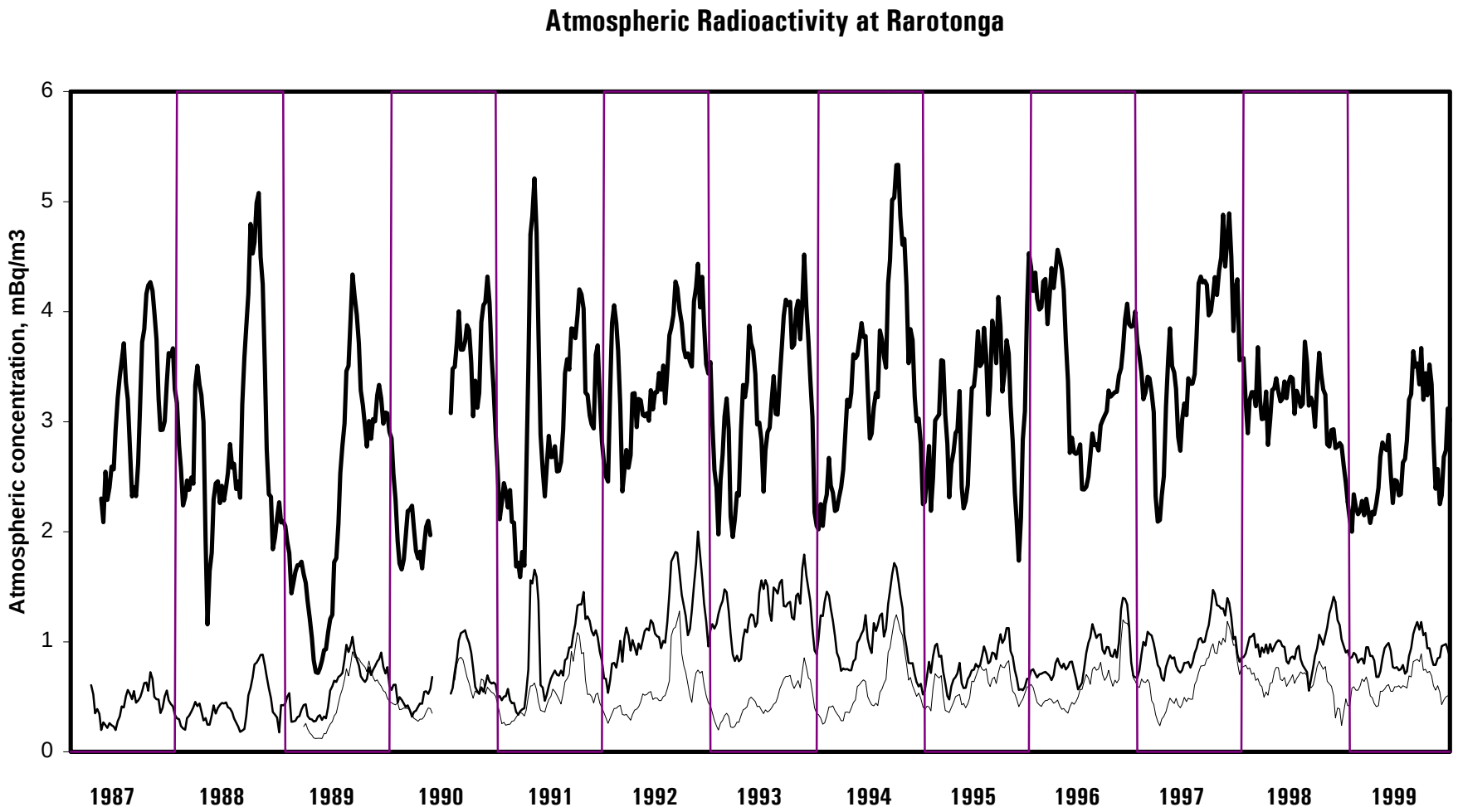

Fig 3 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Rarotonga** during the period 1987 to 1999. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*