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ENVIRONMENTAL RADIOACTIVITY IN NEW ZEALAND AND RAROTONGA

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SUMMARY

During 1996, 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 the Auckland, Waikato, Taranaki and Westland regions. Average levels measured were: total beta activity in air, 0.1 mBq/m^3; ^{90}Sr deposition, 0.1 ± 0.2 Bq/m^2; ^{137}Cs in milk, 0.09 Bq/g K; ^{90}Sr in milk, 0.025 Bq/g Ca. Total beta activity depositions at Hokitika and Rarotonga were 175 Bq/m^2 and 193 Bq/m^2 respectively. Annual total ^{210}Pb and ^{7}Be depositions at Hokitika were 112 and 6120 Bq/m^2 respectively.

No artificial radionuclides were detected by gamma spectroscopic analysis of high-volume air filters during 1996, with weekly sampling periods. The annual-average atmospheric ^{137}Cs concentration, assessed by analysis of yearly air-filter aggregates, was 0.03 ± 0.01 μBq/m^3 in New Zealand, and < 0.02 μBq/m^3 at Rarotonga.

Average atmospheric concentrations of natural ^{7}Be and ^{210}Pb were 3.2 mBq/m^3 and 0.07 mBq/m^3 respectively.

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 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 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.

The signing of the Comprehensive Test-Ban Treaty by the United Nations member countries, in September 1996, introduced an additional purpose for the environmental monitoring operations. Verification of treaty compliance is now an important international issue, and the NRL monitoring stations at Kaitaia and Rarotonga are likely to become part of the global verification network. Since late 1996, atmospheric radioactivity data from each of the three NRL monitoring stations has been transmitted, on a weekly basis, to the Prototype International Data Centre (PIDC) in Washington, along with data from many other stations

world-wide. Data from all stations may be viewed on the world-wide-web, on the PIDC home page: *http://www.cdidc.org*.

In order to maintain a high standard of capability in radiochemical analysis, NRL takes part in quality assurance programmes run by the WHO, IAEA, the South Pacific Environmental Radioactivity Association (SPERA), and the US Environmental Measurements Laboratory. International analytical intercomparison 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.

Since the initial scaling-down in 1985, the monitoring programme has been adjusted periodically in order to ensure that it satisfies current requirements. Further minor adjustments were made during 1996, as announced in the 1995 Annual Report[6], and described again in this report.

2. MONITORING PROGRAMME

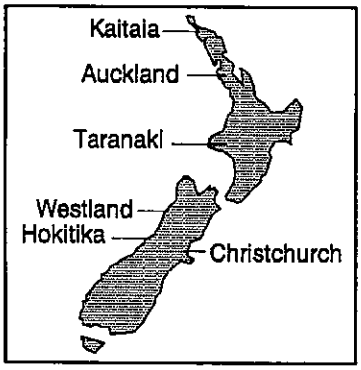
The environmental radioactivity monitoring programme comprised the following measurements during 1996.

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 activities 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 deposition was monitored at Hokitika and Rarotonga, with weekly sample collection; while ^{90}Sr deposition was monitored with monthly collections at Kaitaia, Hokitika and Rarotonga, for the first 6 months of the year, and at Hokitika only thereafter. 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: ^{90}Sr and ^{137}Cs concentrations, together with calcium and potassium levels, were monitored in dairy milk powders with monthly sample collection from three New Zealand regions: Auckland, Taranaki and Westland, with the Auckland region being replaced by Waikato mid year.

Environmental radiation: outdoor environmental gamma radiation levels were 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 1996, and compares them with those reported[6] for 1995. 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[7].

2.1 Changes during 1996

As announced in the 1995 Annual report[6], the following changes were made to the monitoring programme during 1996.

1. Strontium-90 deposition measurements were terminated mid-year at Kaitaia and Rarotonga, with this measurement being performed only at Hokitika since July 1996.

2. Strontium-90 measurements in milk powder were terminated mid-year in the Auckland and Taranaki regions. Since July 1996, this measurement has been performed only at Hokitika, with that region chosen because of its relatively high rainfall, with the resulting highest milk-^{90}Sr levels in New Zealand[7].

3. Caesium-137 measurements in milk powder have continued on a monthly basis in all 3 regions. Because of the mid-year closure of the East Tamaki Dairy Company, which had for many years provided the "Auckland" samples, sampling shifted to the AnchorProducts Te Rapa factory, in the Waikato region. From July 1996, the monitored regions are therefore Waikato, Taranaki, and Westland.

4. Weekly monitoring of TBA deposition at Rarotonga was terminated at the end of 1996.

From the end of 1996, the environmental monitoring programme thus comprises the following measurements:

- high-volume atmospheric radioactivity monitoring at Kaitaia, Hokitika, and Rarotonga
- deposition monitoring at Hokitika, including ^{90}Sr, ^{210}Pb, ^{7}Be, and total-beta activity
- quarterly reporting of milk ^{90}Sr levels in Westland
- monthly reporting of milk ^{137}Cs levels in the Waikato, Taranaki, and Westland regions.

3. 1996 MONITORING RESULTS

Monitoring results for 1996 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 1996 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 particulate artificial radionuclides were detected by gamma-spectroscopic analysis of the weekly air filters from any monitoring site during 1996.

Caesium-137 was detected at trace levels on the annual filter aggregates from Kaitaia and Hokitika at annual-average levels of 0.03 ± 0.01 $\mu Bq/m^3$ and 0.04 ± 0.01 $\mu Bq/m^3$ respectively. It was not detected on the aggregated air filters from Rarotonga (minimum detectable activity 0.02 $\mu Bq/m^3$).

3.1.2 Total beta activity

Weekly-average atmospheric TBA levels during 1996 were similar at all 3 monitoring sites, and ranged from 0.04 mBq/m^3 to 0.22 mBq/m^3 (Table 1), with an overall annual-average of 0.1 mBq/m^3, as in 1995[6].

Atmospheric TBA was due mainly 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 1996, with weekly-average concentrations in the range 1.1 - 6.6 mBq/m^3, and with an overall annual-average concentration of 3.2 mBq/m^3, similar to that recorded in 1995[6] - 2.9 mBq/m^3.

Sodium-22 was detected on the yearly aggregates of air filters at an overall annual-average concentration of 0.25 $\mu Bq/m^3$ (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 0.02 to 0.23 mBq/m^3, with an overall annual-average concentration of 0.07 mBq/m^3.

3.1.4 Trends in radioactivity levels

The annual trend in ^7Be levels continued to demonstrate the normal cycles of summer maxima and winter minima in New Zealand (Figures 1 and 2). At Rarotonga there was an apparent shift in peak time to summer, rather than spring (Figure 3). The summer (1996) ^7Be peak at Hokitika was the highest recorded since 1987, continuing an apparent increasing trend since 1992.

Total-beta activity measurements during 1996 appear to have confirmed that there was a transient peak in TBA levels during the period 1992 - 1994, as described in the 1995 report[6], which was particularly evident at Hokitika (Figure 2). The

timing and duration of the peak strongly suggest stratospheric fallout from the Mount Pinatubo eruption as the source, as discussed earlier[6]. During 1996, TBA levels closely followed ^{210}Pb levels, again particularly at Hokitika, confirming the major contribution ^{210}Pb makes to the measured beta activity.

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 TBA deposition for 1996 at Hokitika was 175 ± 6 Bq/m^2 with 333 cm of rainfall, similar to that recorded in 1995[6]: 208 Bq/m^2 with 355 cm rainfall. The average weekly deposition was 3.7 Bq/m^2, with a range of 0.8 - 11.1 Bq/m^2. The average weekly TBA concentration in rainwater at Hokitika was 0.2 Bq/L, with a range of 0 - 2 Bq/L.

At Rarotonga, the total deposition was 193 ± 13 Bq/m^2 with 130 cm of rain, which was similar to that recorded in 1995[6]: 180 Bq/m^2 with 212 cm of rain. The average weekly deposition at Rarotonga was 4.2 Bq/m^2, with a range of 0.6 - 9.0 Bq/m^2. The average weekly TBA concentration in rainwater at Rarotonga was 0.7 Bq/L, with a range of 0 - 10 Bq/L.

3.2.2 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 all monitoring sites during 1996 with an annual total at Hokitika of 0.1 Bq/m^2 (Table 2), typical of recent years.

An anomalous result was recorded in the first semester at Kaitaia, where the total deposition for the period as 0.3 Bq/m^2, with 55 cm rainfall. This deposition is more typical of a total year's deposition. Strontium-90 deposition in the same period at Rarotonga was undetectable (less than 0.1 Bq/m^2).

3.2.3 Natural radionuclides

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[8].

The total ^{210}Pb deposition at Hokitika during 1996 was 112 Bq/m^2, representing 65% of the deposited TBA, as in 1995[6].

Beryllium-7 deposition Hokitika during 1996 totalled 6120 Bq/m^2.

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 1996 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 1996 average ^{137}Cs levels were: Auckland 0.06 Bq/g K or 0.8 Bq/kg powder; Taranaki 0.16 Bq/g K or 2.0 Bq/kg powder; Westland 0.04 Bq/g K or 0.6 Bq/kg powder. The three-region mean was 0.09 Bq/g K or 1.1 Bq/kg powder – essentially the same as in 1995[6].

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. Results are shown in Table 3, with units of Bq per gram of calcium (Bq/g Ca) and Bq/kg powder.

The 1996 average ^{90}Sr levels were: Auckland 0.02 Bq/g Ca or 0.3 Bq/kg powder; Taranaki 0.03 Bq/g Ca or 0.3 Bq/kg powder; Westland 0.02 Bq/g Ca or 0.3 Bq/kg powder. The three-region mean was 0.025 Bq/g Ca or 0.3 Bq/kg powder – essentially the same as in 1995[6].

3.4 Environmental radiation

Environmental gamma radiation levels, due to cosmic, atmospheric and terrestrial gamma radiation, were monitored continuously through 1996 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 dose-rate during 1996 was 80 nanogray per hour, or 0.7 milligray per year, the same as the level reported in 1995[6].

An integrating measurement package comprising thermoluminescent dosemeters and films for 3-month exposure periods, provided by the WHO as part of the GERMON programme, was also used to assess environmental radiation levels. These packages were analysed quarterly by the WHO in France. Results of the integrating measurement and the continuous monitoring were similar during 1996.

4. SUMMARY

Measurements of artificial radioactivity levels in the atmosphere and rainwater in New Zealand and Rarotonga during 1996 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 1995.

The 1996 average levels of atmospheric, deposited, and milk radioactivity were: TBA in air, 0.1 mBq/m^3; TBA deposition, 175 Bq/m^2 (Hokitika) and 193 Bq/m^2 (Rarotonga); ^{90}Sr deposition, 0.1 Bq/m^2 (Hokitika); ^{137}Cs in milk, 0.09 Bq/g K; ^{90}Sr in milk, 0.025 Bq/g Ca.

Overall, the 1996 results were very similar to those reported for 1995[6] as indicated in the comparison of New Zealand site averages below:

	1996	1995
TBA in air, mBq/m^3	0.10	0.09
TBA in rain, Bq/m^2	175	208
^{90}Sr in rain, Bq/m^2	0.1	0.2
^{90}Sr in milk powder, Bq/kg	0.3	0.3
^{137}Cs in milk powder, Bq/kg	1.1	1.0

No artificial radionuclides were detected by gamma-spectroscopic analysis of high-volume air filters during 1996, with weekly sampling periods. Caesium-137 was detected on yearly aggregates of air filters at Kaitaia and Hokitika at an average level of 0.03 ± 0.01 μBq/m^3, but was not detected at Rarotonga.

For naturally occurring radionuclides, the average atmospheric concentrations of ^{7}Be and ^{210}Pb were 3.2 mBq/m^3 and 0.07 mBq/m^3 respectively, while the total annual depositions of the 2 radionuclides at Hokitika were 6120 Bq/m^2 and 112 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.

Unfortunately, during 1996 there were no intercomparison exercises available in which NRL could participate. The Laboratory has, however, been accepted for inclusion in a programme maintained by the USEML, and the first intercomparison exercise is scheduled for March 1997.

5.2 Commercial and advisory services

There was a continuing demand for export certificates and radioactivity tests in 1996. During the year 781 export certificates were issued and 860 commercial analyses performed.

The number of enquiries during 1996 from members of the public and commercial interests regarding radioactivity in consumer products and foodstuffs and environmental issues was normal.

5.3 Test-ban treaty negotiations

Dr Matthews continued to assist the Disarmament Division of Ministry of Foreign Affairs and Trade by giving further technical advice related to the Comprehensive Test-Ban Treaty during 1996. A group of technical experts held an informal meeting in Christchurch in May 1996, chaired by Dr Matthews, to discuss issues related to atmospheric radionuclide monitoring in treaty compliance-verification.

5.4 IAEA Mururoa project

The Laboratory was contracted by the IAEA to analyse sediments from Mururoa and Fangataufa Atolls as part of the international radiological study of the atolls. The analyses were for plutonium and americium isotopes, and gamma-emitting radionuclides.

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 1996. The Laboratory gratefully acknowledges also the continued help of the Rarotonga Meteorological Service with monitoring in the Cook Islands, particularly Mr Nga Rauraa. The 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) are also thanked for their assistance with the milk monitoring programme.

Special grateful acknowledgement is due to the East Tamaki Dairy Company which provided the Auckland milk powder samples for over 30 years until its shut-down during 1996; and to the AnchorProducts Te Rapa Factory for agreeing to supply samples from now on in place of those formerly from Auckland.

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

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Table 1: A summary of atmospheric radioactivity levels measured during 1996

Atmospheric radioactivity, weekly measurements

Monitoring site:	KAITAIA	HOKITIKA	RAROTONGA
TBA			
Range, mBq/m^3	0.05 - 0.21	0.04 - 0.18	0.04 - 0.22
Mean, mBq/m^3	0.11	0.09	0.09
Cosmogenic ^{7}Be			
Range, mBq/m^3	1.8 - 6.6	1.1 - 5.9	1.4 - 6.2
Mean, mBq/m^3	3.5	2.8	3.3
Radon decay product ^{210}Pb			
^{210}Pb, range mBq/m^3	0.03 - 0.21	0.02 - 0.16	0.02 - 0.23
mean mBq/m^3	0.08	0.07	0.06

Atmospheric radioactivity, annual measurement: annual average concentration

Fission product ^{137}Cs			
^{137}Cs, $\mu Bq/m^3$	0.03 ± 0.01	0.04 ± 0.01	< 0.02
Cosmogenic ^{22}Na			
^{22}Na, $\mu Bq/m^3$	0.24 ± 0.01	0.22 ± 0.01	0.28 ± 0.01

Table 2: A summary of ^{90}Sr, ^{210}Pb and total beta activity deposition measurements at Kaitaia, Hokitika and Rarotonga during 1996

Deposited radioactivity (Bq/m^2)

	Kaitaia	Hokitika	Rarotonga
TBA		175 ± 6	193 ± 13
^{90}Sr	0.3 ± 0.1*	0.1 ± 0.2	< 0.1
^{210}Pb		112 ± 6	
^{7}Be		6120 ± 120	
Rainfall, cm	55*	333	130

* 6 months' measurement only.

Table 3: Caesium-137 and strontium-90 levels in cows' milk during 1996
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. Note that the July sample was the last obtained from Auckland, with Waikato samples thereafter.

Caesium-137

Month	Auckland/Waikato		Taranaki		Westland	
	Bq/g K	Bq/kg	Bq/g K	Bq/kg	Bq/g K	Bq/kg
1	0.06	1.1	0.27	3.7	0.04	0.6
2	0.05	1.0	0.28	3.7	0.07	1.0
3	0.04	0.7	0.23	2.9	0.05	0.7
4	0.04	0.6	0.19	1.8	0.06	0.9
5	< 0.1	< 1	0.19	1.9	0.04	0.5
6	< 0.1	< 1	0.06	0.8	<0.04	<0.5
7	< 0.1	< 1	0.05	0.7	<0.04	<0.5
8	0.05	0.7	0.10	1.3	<0.04	<0.5
9	0.06	0.8	0.15	1.9	<0.04	<0.5
10	0.05	0.8	0.10	1.6	0.04	0.7
11	0.07	1.1	0.14	2.2	0.05	0.8
12	0.09	1.3	0.12	1.9	0.06	0.8
Mean	0.06	0.8	0.16	2.0	0.04	0.6

Strontium-90

Quarter	Auckland/Waikato		Taranaki		Westland	
	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg
1	0.020	0.33	0.031	0.34	0.026	0.31
2	0.023	0.36	0.030	0.25	0.024	0.28
3					0.024	0.32
4					0.021	0.26
Mean	0.022	0.35	0.030	0.30	0.024	0.29

Table 4: A summary for 1996 of weekly measurements of radioactivity in the atmosphere and precipitation

Week	Atmospheric concentrations, mBq/m^3									Weekly deposition TBA, Bq/m^2	
	KAITAIA			HOKITIKA			RAROTONGA				
	TBA	Be-7	Pb-210	TBA	Be-7	Pb-210	TBA	Be-7	Pb-210	Hokitika	Rarotonga
1	0.09	6.56	0.08	0.14	5.44	0.11	0.09	3.90	0.07	0.8	2.8
2	0.08	4.86	0.06	0.18	3.97	0.16	0.06	1.36	0.05	3.2	5.0
3	0.08	2.42	0.13	0.15	3.52	0.08	0.09	1.80	0.06	1.1	3.2
4	0.10	3.82	0.04	0.12	5.89	0.09	0.07	2.03	0.04	2.8	4.5
5	0.18	4.10	0.13	0.17	5.44	0.16	0.05	1.77	0.03	6.2	2.5
6	0.18	5.38	0.16	0.10	2.98	0.06	0.07	2.30	0.04	5.8	3.6
7	0.12	4.37	0.06	0.09	3.82	0.08	0.08	3.24	0.04	3.8	7.6
8	0.07	2.52	0.04	0.11	4.42	0.07	0.09	4.28	0.05	2.8	5.2
9	0.17	5.00	0.13	0.15	4.06	0.13	0.07	2.79	0.06	8.0	1.8
10	0.12	4.21	0.06	0.11	4.00	0.08	0.05	1.36	0.04	1.7	4.1
11	0.10	3.32	0.07	0.06	3.87	0.04	0.06	3.48	0.04	6.6	5.5
12	0.14	5.51	0.07	0.07	2.51	0.04	0.07	2.80	0.05	3.6	8.5
13	0.13	3.94	0.06	0.11	3.31	0.11	0.07	2.99	0.05	0.9	2.4
14	0.13	4.10	0.12	0.08	2.35	0.05	0.09	4.51	0.04	7.4	4.7
15	0.15	4.98	0.06	0.07	2.47	0.07	0.11	3.40	0.05	4.4	5.8
16	0.19	4.29	0.18	0.09	2.53	0.10	0.08	2.90	0.05	2.3	4.0
17	0.17	5.10	0.18	0.12	3.52	0.13	0.04	1.57	0.02	3.2	4.4
18	0.10	3.44	0.06	0.08	2.77	0.08	0.06	2.57	0.03	1.8	5.7
19	0.13	3.16	0.09	0.06	2.20	0.05	0.11	2.66	0.04	3.0	4.7
20	0.14	2.68	0.05	0.08	2.50	0.04	0.08	3.57	0.04	2.8	5.9
21	0.08	2.49	0.04	0.08	1.66	0.08	0.09	3.41	0.04	2.6	4.8
22	0.08	1.82	0.05	0.07	2.00	0.05	0.06	2.92	0.05	3.7	2.5
23	0.10	4.13	0.06	0.06	2.46	0.06	0.06	3.08	0.05	1.8	5.3
24	0.06	2.49	0.04	0.07	2.16	0.05	0.07	1.80	0.04	2.4	3.3
25	0.07	2.61	0.06	0.09	3.03	0.09	0.05	2.64	0.05	0.8	2.6
26	0.06	2.56	0.10	0.04	1.28	0.04	0.04	4.49	0.06	2.2	2.9
27	0.06	2.18	0.03	0.10	2.51	0.03	0.08	3.43	0.09	0.9	3.6
28	0.06	2.09	0.05	0.07	1.86	0.08	0.08	3.88	0.05	1.0	3.9
29	0.09	2.48	0.08	0.06	1.11	0.07	0.13	5.44	0.07	1.9	4.4
30	0.10	2.73	0.09	0.06	1.51	0.06	0.12	4.60	0.08	0.9	5.5
31	0.08	3.01	0.08	0.10	3.96	0.07	0.09	3.70	0.05	3.0	3.5
32	0.09	3.10	0.08	0.05	1.49	0.04	0.10	3.91	0.06	3.4	5.3
33	0.09	3.13	0.06	0.08	1.92	0.07	0.14	4.26	0.12	3.8	4.4
34	0.06	1.95	0.02	0.10	2.63	0.08	0.10	3.90	0.09	3.9	0.7
35	0.09	2.78	0.07	0.06	1.49	0.03	0.09	2.56	0.06	1.7	1.5
36	0.10	2.72	0.10	0.05	1.61	0.05	0.10	4.64	0.05	7.7	3.3
37	0.21	4.25	0.21	0.08	2.45	0.04	0.11	4.66	0.09	6.4	3.4
38	0.14	3.35	0.11	0.12	2.64	0.10	0.07	1.45	0.06	2.9	no result
39	0.11	2.17	0.11	0.10	2.63	0.14	0.08	3.21	0.06	1.8	3.9
40	0.10	2.99	0.07	0.08	2.12	0.08	0.12	4.87	0.08	10.3	4.3
41	0.17	3.66	0.11	0.08	1.85	0.05	0.10	3.83	0.08	11.0	6.1
42	0.13	3.97	0.06	0.08	3.95	0.06	0.07	2.77	0.05	7.9	4.4
43	0.12	3.46	0.07	0.07	2.57	0.05	0.06	3.02	0.03	4.4	2.8
44	0.08	2.26	0.04	0.04	2.24	0.04	0.11	3.40	0.09	2.7	7.7
45	0.11	3.01	0.06	0.08	2.14	0.04	0.08	3.12	0.07	2.6	8.3
46	0.17	4.40	0.14	0.06	2.46	0.04	0.17	5.18	0.10	6.7	2.9
47	0.15	4.29	0.15	0.05	1.73	0.01	0.22	4.73	0.23	4.7	2.4
48	0.16	4.32	0.08	0.05	2.97	0.03	0.11	2.49	0.12	6.2	4.4
49	0.13	3.62	0.10	0.08	2.25	0.03	0.11	3.46	0.07	2.5	3.7
50	0.13	3.73	0.09	0.11	2.75	0.05	0.06	2.39	0.06	4.5	6.3
51	0.06	3.47	0.03	0.06	3.10	0.05	0.07	6.21	0.08	5.2	4.0
52	0.05	4.17	0.06	0.08	3.76	0.09	0.05	4.72	0.06	1.9	9.0

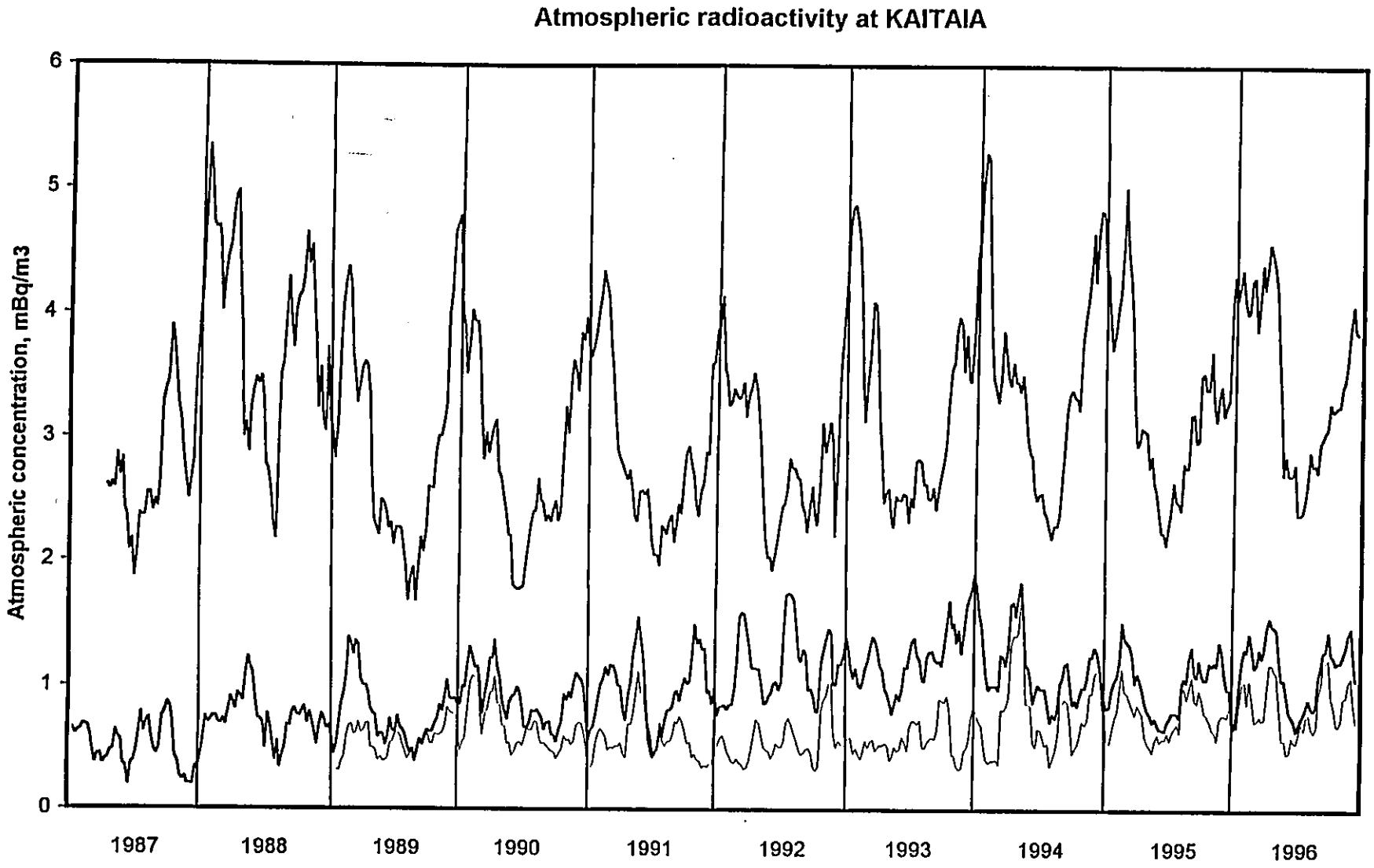

Fig 1 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Kaitaia** during the period 1987 to 1996. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

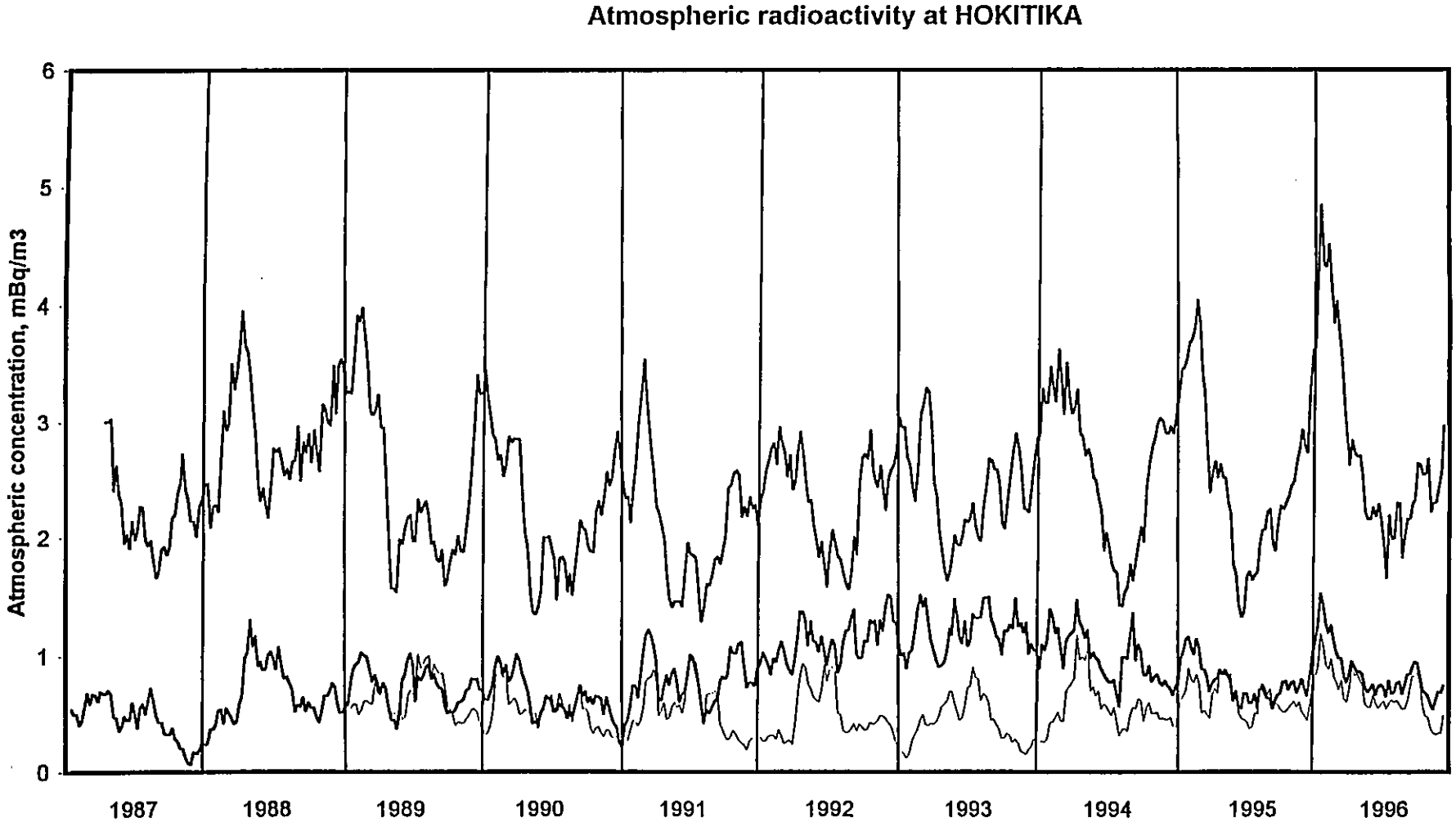

Fig 2 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Hokitika** during the period 1987 to 1996. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

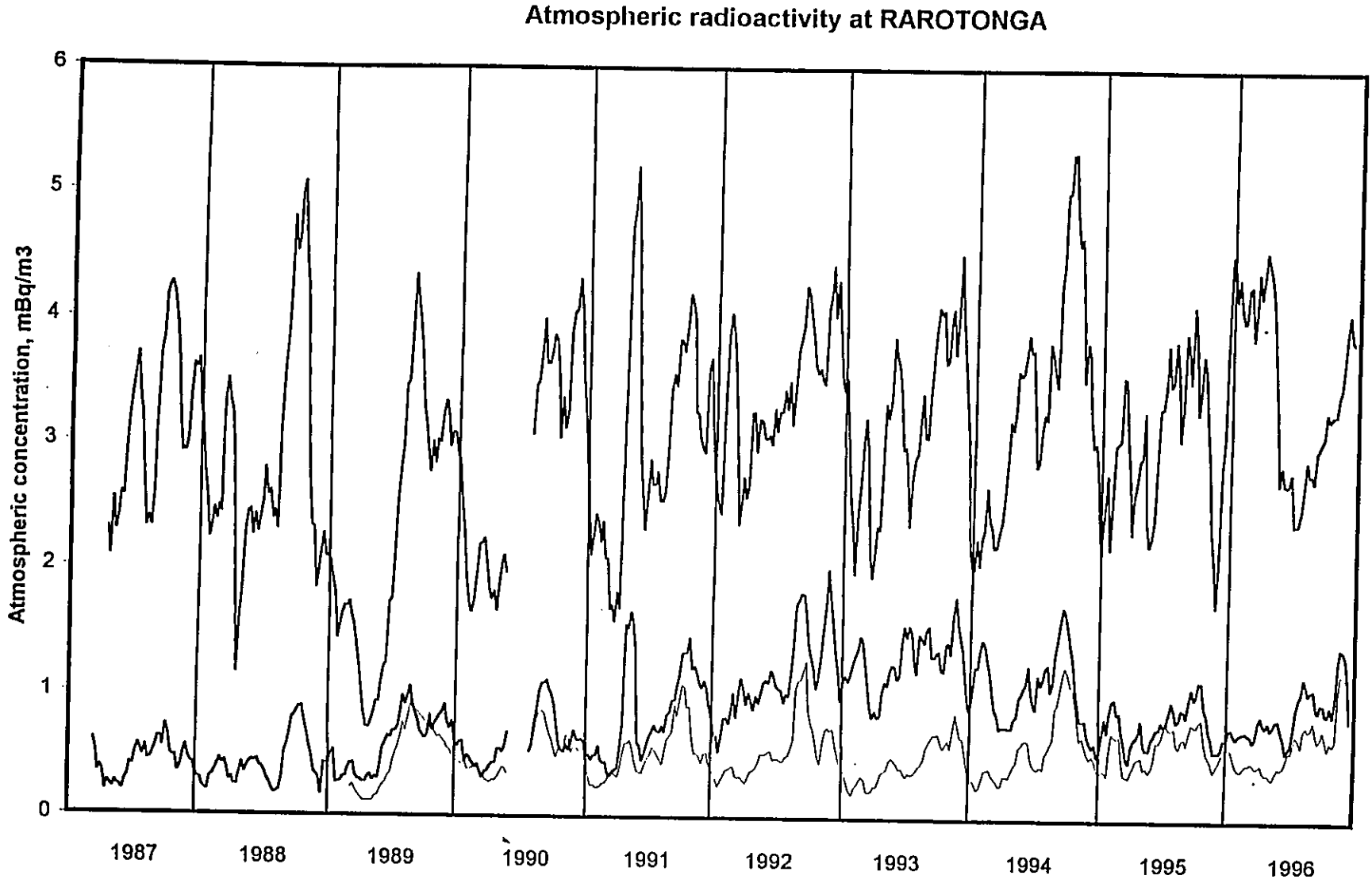

Fig 3 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Rarotonga** during the period 1987 to 1996. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*