NRL
National Radiation Laboratory

Environmental Radioactivity in New Zealand and Rarotonga - Annual Report

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NRL-F/80
2000

MINISTRY OF HEALTH
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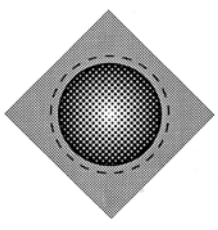

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Published in August 2001 by
National Radiation Laboratory
Ministry of Health
PO Box 25099, Christchurch, New Zealand

ISSN 0111-6193

National Radiation Laboratory Web site: http://www.nrl.moh.govt.nz

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Summary

During 2000, the atmospheric radioactivity monitoring facilities at Rarotonga and Kaitaia were upgraded to a daily monitoring programme in accordance with the Comprehensive Nuclear-Test-Ban Treaty. Also, in accordance with the Treaty, a new station was commissioned on Chatham Islands while no upgrade took place for the existing station at Hokitika.

Artificial radioactivity in the environment in New Zealand and Rarotonga monitored during 2000 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, Rarotonga and Chatham Islands (from 1 April 2000); 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 233 Bq/m^2. Annual total ^{210}Pb and ^{7}Be depositions at Hokitika were 109 and 3414 Bq/m^2 respectively.

No artificial radionuclides were detected by gamma spectroscopic analysis of high-volume air filters during 2000, with daily and weekly sampling periods. The annual-average atmospheric ^{137}Cs concentration in the Hokitika 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. Lead-212 levels ranged from 0.02 to 11.5 mBq/m^3.

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].

Following the signing of the Comprehensive Nuclear-Test-Ban Treaty (CTBT)[5] by the United Nations member countries in September 1996, verification of treaty compliance is now an important international issue. 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.

To enforce the Treaty, the International Monitoring System 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. The planned radionuclide monitoring network will consist of 80 particulate radionuclide stations. These stations are to be distributed over 39 countries and their territories, and include stations located at Kaitaia and Chatham Islands, New Zealand, and Rarotonga, Cook Islands.

In 2000 and in accordance with the CTBT, stations at Rarotonga and Kaitaia were upgraded and a new station was commissioned in the Chatham Islands. These stations are now capable of daily monitoring with a greater sensitivity resulting from the installation of 900 m^3 per hour high-volume air samplers. Hokitika is not included in the radionuclide monitoring network and was not upgraded.

The upgrade for the Rarotonga station, located at the Rarotonga Meteorological station, was completed during the week of 31 January 2000. In a dedicated building and compound, a facility capable of detecting low levels of anthropogenic radionuclides was established. The building houses a gamma detector system, instrument state of health sensors, communication hardware, uninterruptible power supply (UPS), air conditioning, filter press and work space. A computer management system assists the operator in daily station operations. Located in the secure

compound is a 900 m^3 per hour high-volume air sampler and a satellite communication dish (VSAT).

The upgrade for the Kaitaia station, located at the Kaitaia airport, was completed during the week of 24 January 2000. The Kaitaia station is a split station with equipment located at Kaitaia and at the National Radiation Laboratory, Christchurch. At Kaitaia, the 900 m^3 per hour high-volume air sampler, communication equipment, instrument state of health sensors, associated hardware and the computer management system are present. The gamma detector system and associated equipment and operating systems are located at the National Radiation Laboratory.

A new station at the Chatham Islands airport was installed in the week of 24 January 2000 and is a replica of the Rarotonga station.

Equipment at these stations are monitored by the computer management system, which automatically records data and transmits it via a dedicated satellite link to the CTBT's International Data Centre (IDC) in Vienna for analysis.

In conjunction with radionuclide detection, meteorological "back-tracking" provides information on any radionuclide source location through analysis of wind patterns in the preceding days and weeks of measurement. Meteorological stations operating to World Meteorological Organisation (WMO) standards are located at each site.

The present monitoring programme, consisting of daily and weekly atmospheric radioactivity monitoring, wet and dry deposition radioactivity monitoring and the monitoring of radioactivity in milk, is intended to provide warning of any influx of radioactivity into the New Zealand and South Pacific regions from any source and to monitor trends in levels. 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 for 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 a WHO Collaborating Centre for environmental radiation measurement and acts as an international point of contact for the South Pacific region in 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 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), lead-212 (^{212}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 and ^{212}Pb are the decay products of gaseous radon-222 (^{222}Rn) and radon-220 (^{220}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[6] 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 2000.

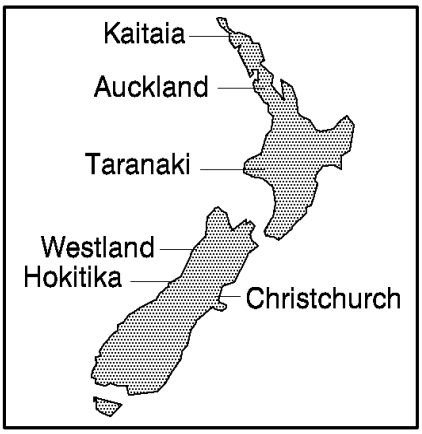
Atmospheric radioactivity: Atmospheric monitoring is regarded as the most important component of the monitoring programme because any radioactive pollution reaching the region will inevitably have been transported in the atmosphere, and the high-sensitivity monitoring would provide early warning of any influx or changing trend in environmental radioactivity levels. Total beta activity (TBA), fission products, ^{7}Be, and ^{210}Pb levels were monitored with weekly collections of particulates from surface air at Kaitaia, Hokitika and Rarotonga. On 1 April 2000 daily collections began at Kaitaia and Rarotonga and at the new Chatham Islands station. In addition, air filters collected from Hokitika 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.

Atmospheric monitoring involves two different air sampling systems. At Kaitaia, Chatham Islands and Rarotonga a Physik-Technik-Innovation (PTI) ASS-500 air sampler is used to draw air through 2025 cm^2 filters (Petrianov filter, type FFP-15-1.5) at a flow rate of approximately 13 m^3/min, with a daily sample volume of approximately 19,000 m^3. These filters are analysed by high resolution gamma spectrometry (Canberra Hyper-pure n-type germanium BEGE50 detector) for gamma-emitting artificial and natural radionuclides. The minimum detectable concentration for a fission product such as ^{137}Cs in the daily filter analyses ranged from 0.5 to 4 $\mu Bq/m^3$.

At Hokitika a centrifugal-fan pump is used 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. These filters are analysed by high-resolution gamma spectroscopy (Tennelec Hyper-pure p-type germanium detector) for gamma-emitting artificial and natural radionuclides; by gas-flow proportional (Tennelec LB41110 counter) counting for TBA; and radiochemically for ^{210}Pb. The Hokitika 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 (small area rain collector 0.2 m^2) and monthly (rain collection pot 0.3 m ϕ) 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.



3 2000 Monitoring results

Monitoring results for 2000 are summarised in Tables 1, 2 and 3. Results of daily and weekly measurements of atmospheric radioactivity are given in Figures 1, 2, 3 and 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 2000 are summarised in Table 1, while trends in radioactivity levels during the year are illustrated in Figures 1 - 4.

3.1.1 Artificial radionuclides

No artificial radionuclides were detected by gamma-spectroscopic analysis of daily or weekly air filters collected from each monitoring station during 2000.

Caesium-137 was detected at trace levels on the annual filter aggregates from Hokitika at annual-average level of 0.03 ± 0.01 μBq/m^3, close to the minimum detectable concentration of 0.02 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 at Hokitika during 2000 ranged from 0.04 mBq/m^3 to 0.39 mBq/m^3 (Table 1a), with an overall annual-average of 0.10 mBq/m^3, as recorded in recent years (1996[7], 1997[8], 1998[9] and 1999[10]).

Weekly-average atmospheric TBA levels at Rarotonga and Kaitaia during the first two months of sampling for 2000 ranged from 0.04 mBq/m^3 to 0.12 mBq/m^3 (Table 1a).

Atmospheric TBA was almost entirely due to natural radionuclides, as described in the 1993 report[6].

3.1.3 Natural radionuclides

Cosmogenic nuclides

Beryllium-7 continued to be the most significant radionuclide detected on the air filters during 2000, with daily and weekly-average concentrations in the range 0.02 – 15 mBq/m^3, (Table 1a and b). The overall annual-average concentration was 2.8 mBq/m^3.

Sodium-22 was detected on the yearly aggregates of air filters from Hokitika at an overall annual-average concentration of 0.19 μBq/m^3 (Table 1a).

Lead-210

Lead-210 was measured on the daily and weekly air filters at levels that were similar at all 4 monitoring sites, as indicated in Table 1a and b. Levels ranged from 0.01 to 0.54 mBq/m^3, with an overall annual-average concentration of 0.07 mBq/m^3, as recorded in 1997[8], 1998[9] and 1999[10].

Lead-212

Daily air filter sampling has provided an opportunity to study the levels and trends of the short-lived Pb-212 radionuclide (half-life 10.6 hours). Lead-212 was measured on the daily air filters at levels ranging from 0.02 to 1.48 mBq/m^3 at Kaitaia and Chatham Islands (average 0.33 mBq/m^3) and 0.02 to 11.5 mBq/m^3 at Rarotonga (average 2.7 mBq/m^3).

The presence of Pb-212 in the daily air filters is the result of thorium-232 (Th-232, half-life 1.4×10^{10} years) in the surface soils surrounding the air sampler. Thorium-232 decays to gaseous Rn-220, which diffuses out of soil into the local atmosphere. The rapid decay of Rn-220 (half-life 55 sec) to Pb-212 results in only ground and localised levels of Pb-212. Particle reactive Pb-212 rapidly attaches to aerosol particles that are collected on air filters.

As part of the installation and upgrade process, Th-232 levels in surface soils were measured at all three sites within a 100 m radius of the air sampler. Thorium-232 levels ranged from 4 to 11 Bq/kg at the Kaitaia station and 1 to 13 Bq/kg at the Chatham Island station. At the Rarotonga station Th-232 levels were significantly higher ranging from 8 to 247 Bq/kg in turn giving rise to higher atmospheric Pb-212 levels.

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). This same cycle was observed at the newly commissioned station at Chatham Island (Figure 4).

Total-beta activity measurements during 2000 at Hokitika 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 2000 at Hokitika was 233 ± 8 Bq/m^2 with 303 cm of rainfall.

	2000	1999	1998	1997	1996	1995
Annual Rainfall (cm)	303	280	317	257	333	355
TBA in rain (annual), Bq/m^2	233	144	216	200	175	208
^{7}Be in rain (annual), Bq/m^2	3414	4300	6410	5320	6120	6550
^{210}Pb in rain (annual), Bq/m^2	109	86	134	122	112	136

No artificial radionuclides were detected by gamma-spectroscopic analysis.

The average weekly deposition was 4.5 Bq/m^2, with a range of 1.3 – 12.8 Bq/m^2. The average weekly TBA concentration in rainwater at Hokitika was 0.2 Bq/L, with a range of 0.03 – 1.4 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 uranium and thorium series radionuclides, together contributing over 80% of exposure from this source[12].

The total ^{210}Pb deposition at Hokitika during 2000 was 109 Bq/m^2, 21% higher than that recorded in 1999[10]. The total ^{210}Pb deposition at Hokitika during 1999 represented 48% of the deposited TBA, lower than the 60% fraction recorded in 1999[10].

Beryllium-7 deposition at Hokitika during 2000 totalled 3414 Bq/m^2. This was the lowest recorded level within the last six years (see above table), continuing the downward trend recorded in 1999[10].

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 2000, 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 2000 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 2000 average ^{137}Cs levels were: Waikato 0.06 Bq/g K or 0.8 Bq/kg powder; Taranaki 0.12 Bq/g K or 1.7 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 1999[10].

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 2000 average ^{90}Sr level was 0.01 Bq/g Ca or 0.15 Bq/kg powder, similar to that reported in 1999[10].

3.4 Environmental radiation

The GERMON environmental monitoring programme, sponsored by WHO, was suspended in 2000 by GERMON. Environmental gamma radiation levels, due to cosmic, atmospheric and terrestrial gamma radiation, were monitored from 1992 to 1999 using an integrating measurement package comprising thermoluminescent dosemeters and films for 3-month exposure periods. Throughout this programme only background levels of radiation were detected (average 0.8 mGy/year) using a monitor installed on the Laboratory roof.

4 Summary

Measurements of artificial radioactivity levels in the atmosphere and rainwater in New Zealand and Rarotonga during 2000 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 1999[10].

Overall, the 2000 results were similar to those reported in previous years as indicated in the comparison of New Zealand site averages below.

	2000	1999	1998	1997	1996
TBA in air (weekly), mBq/m^3	0.10	0.10	0.10	0.10	0.10
TBA in rain (annual), Bq/m^2	233	144	216	200	175
^{90}Sr in rain (annual), Bq/m^2	0.2	0.2	0.2	0.3	0.1
^{90}Sr in milk powder (3-monthly), Bq/kg	0.15	0.2	0.2	0.3	0.3
^{137}Cs in milk powder (monthly), Bq/kg	1.0	1.0	1.0	1.3	1.1

No artificial radionuclides were detected by gamma-spectroscopic analysis of high-volume air filters during 2000, with daily and weekly sampling periods. Caesium-137 was detected on the yearly aggregates of air filters collected from Hokitika at an average level of 0.03 ± 0.01 $\mu Bq/m^3$.

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 3414 Bq/m^2 and 109 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 2000 the Laboratory participated in two exercises, conducted by the US EML, involving analysis of air filters, soil, vegetation and water, for alpha-, beta-, and gamma-emitting radionuclides. Results are shown in Tables 4a and b. Overall, results were satisfactory. Further problems were encountered with the ^{90}Sr analysis, which led to erroneous results, as indicated in 1998 and 1999. 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.

Acknowledgement

The National Radiation Laboratory gratefully acknowledges the assistance of Mr Bruce Buckby of North Weather Ltd, Kaitaia: Mr Mark Crompton of West Weather Ltd, Hokitika; the Rarotonga Meteorological Service, in particular, Mr Roro Taia; and Mr Ross Morrison of Roskat Enterprises Ltd, Chatham Islands.

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 and Mr David Wales.

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Table 1a: A summary of atmospheric radioactivity levels measured weekly during 2000

Atmospheric radioactivity, weekly measurements

Monitoring site:	KAITAIA weekly sampling halted 1/3/2000	HOKITIKA	RAROTONGA weekly sampling halted 1/3/2000

TBA

Range, mBq/m^3	0.04 - 0.11	0.04 - 0.39	0.04 - 0.12
Mean, mBq/m^3	0.06	0.10	0.07

Cosmogenic ^{7}Be

Range, mBq/m^3	2.1 – 4.8	0.9 – 4.9	1.8 – 3.5
Mean, mBq/m^3	3.1	2.5	2.5

Radon decay product ^{210}Pb

Range, mBq/m^3	0.03 - 0.12	0.03 - 0.51	0.03 - 0.12
Mean, mBq/m^3	0.07	0.08	0.06

Atmospheric radioactivity, annual measurement: annual average concentration

Fission product ^{137}Cs

^{137}Cs, $\mu Bq/m^3$	N/A	0.03 ± 0.01	N/A

Cosmogenic ^{22}Na

^{22}Na, $\mu Bq/m^3$	N/A	0.19 ± 0.02	N/A

Table 1b: A summary of atmospheric radioactivity levels measured daily during 2000

Atmospheric radioactivity, daily measurements

Monitoring site:	KAITAIA commenced 1/4/2000	CHATHAM ISLANDS commenced 1/4/2000	RAROTONGA commenced 1/4/2000
Cosmogenic ^{7}Be			
Range, mBq/m^3	0.02 – 15.13	0.03 – 6.5	0.22 – 7.89
Mean, mBq/m^3	3.36	2.29	3.31
Radon-222 decay product ^{210}Pb			
Range, mBq/m^3	0.01 – 0.54	0.01 – 0.27	0.01 – 0.16
Mean, mBq/m^3	0.08	0.05	0.07
Radon-220 decay product ^{212}Pb			
Range, mBq/m^3	0.02 – 1.48	0.02 – 1.06	0.02 – 11.51
Mean, mBq/m^3	0.36	0.31	2.71

Table 2: A summary of ^{90}Sr, ^{210}Pb and total beta activity deposition measurements at Hokitika during 2000

Deposited radioactivity (Bq/m^2)

	Hokitika
TBA	233 ± 8
^{90}Sr	0.2 ± 0.2
^{210}Pb	109 ± 4
^{7}Be	3414 ± 117
Rainfall, cm	303

Table 3: Caesium-137 and strontium-90 levels in cows' milk during 2000

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	0.11	1.43	0.15	2.34	0.05	079
2	0.07	0.78	0.16	2.72	0.05	0.64
3	0.08	0.95	0.14	2.24	0.06	0.79
4	No Sample*		0.17	2.40	0.06	0.92
5	No Sample*		0.13	1.59	No Sample*	
6	No Sample*		No Sample*		No Sample*	
7	No Sample*		No Sample*		No Sample*	
8	0.03	0.45	0.04	0.61	No Sample*	
9	0.03	0.38	0.11	1.52	0.03	0.50
10	0.04	1.10	0.08	1.04	0.05	0.74
11	0.04	0.51	No Sample		0.04	0.75
12	0.06	0.75	0.08	1.14	0.04	0.67
Mean	0.06	0.79	0.12	1.73	0.05	0.72

* No liquid milk samples were made available during these months.

Strontium-90

Quarter	Westland	
	Bq/g Ca	Bq/kg
1	0.016	0.22
2	0.009	0.14
3	0.006	0.085
4	0.011	0.15
Mean	0.010	0.15

Results for intercomparison exercises during 2000

Table 4a: Intercomparison Results - EML-QAP 53

Matrix	Analyte	NRL Value	EML Value	Evaluation (NRL / EML)
Air filter	Mn-54	48 ± 5	43.2 ± 1.3	1.11 (A)
(Bq/filter)	Co-57	12.8 ± 1.4	14.55 ± 0.46	0.88 (A)
	Co-60	8.9 ± 1.0	8.43 ± 0.48	1.06 (A)
	Cs-137	8.0 ± 0.8	7.41 ± 0.36	1.08 (A)
	Gross Alpha	3.0 ± 0.3	2.35 ± 0.15	1.27 (W)
	Gross Beta	1.8 ± 0.2	1.52 ± 0.15	1.18 (A)
Soil	K-40	700 ± 50	713 ± 38	0.98 (A)
(Bq/kg)	Sr-90	30 ± 3	50.4 ± 2.0	0.60 (N)
	Cs-137	1100 ± 70	1020 ± 51	1.08 (A)
	Bi-212	85 ± 19	80.5 ± 6.6	1.06 (A)
	Pb-212	84 ± 7	79.3 ± 4.3	1.06 (A)
	Bi-214	95 ± 5	83.3 ± 4.2	1.14 (A)
	Pb-214	114 ± 7	86.3 ± 4.3	1.32 (W)
	Ac-228	65 ± 5	80.2 ± 3.6	0.81 (W)
	Th-234	170 ± 30	148 ± 10	1.15 (A)
	Am-241	9.6 ± 2.5	8.27 ± 0.70	1.16 (A)
Vegetation	K-40	1150 ± 130	639 ± 34	1.8 (N)[1]
(Bq/kg)	Co-60	34 ± 4	32.8 ± 1.3	1.04 (A)
	Cs-137	890 ± 90	867 ± 44	1.03 (A)
Water	Co-60	70 ± 4	73.7 ± 2.9	0.95 (A)
(Bq/L)	Sr-90	3.4 ± 0.3	4.53 ± 0.12	0.75 (W)
	Cs-137	63 ± 3	67.0 ± 3.5	0.94 (A)
	Gross Alpha	800 ± 80	1070 ± 100	0.75 (W)
	Gross Beta	950 ± 100	950 ± 90	1.00 (A)

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

[1] With background subtraction 765 Bq/kg

Table 4b: Intercomparison Results - MAPEP-00-S7

Matrix	Analyte	NRL value	MAPEP value	Evaluation (NRL / MAPEP)
Soil	K-40	632 ± 15	652	0.97 (A)
(Bq/kg)	Mn-54	1030 ± 20	1023	1.01 (A)
	Co-57	940 ± 50	949	0.99 (A)
	Co-60	1130 ± 60	1180	0.96 (A)
	Zn-65	1570 ± 40	1540	1.02 (A)
	Sr-90	225 ± 12	304	0.74 (W)
	Cs-134	768 ± 9	1047	0.73 (W)
	Cs-137	910 ± 20	930	0.98 (A)
	Am-241	59 ± 5	61.1	0.97 (A)

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

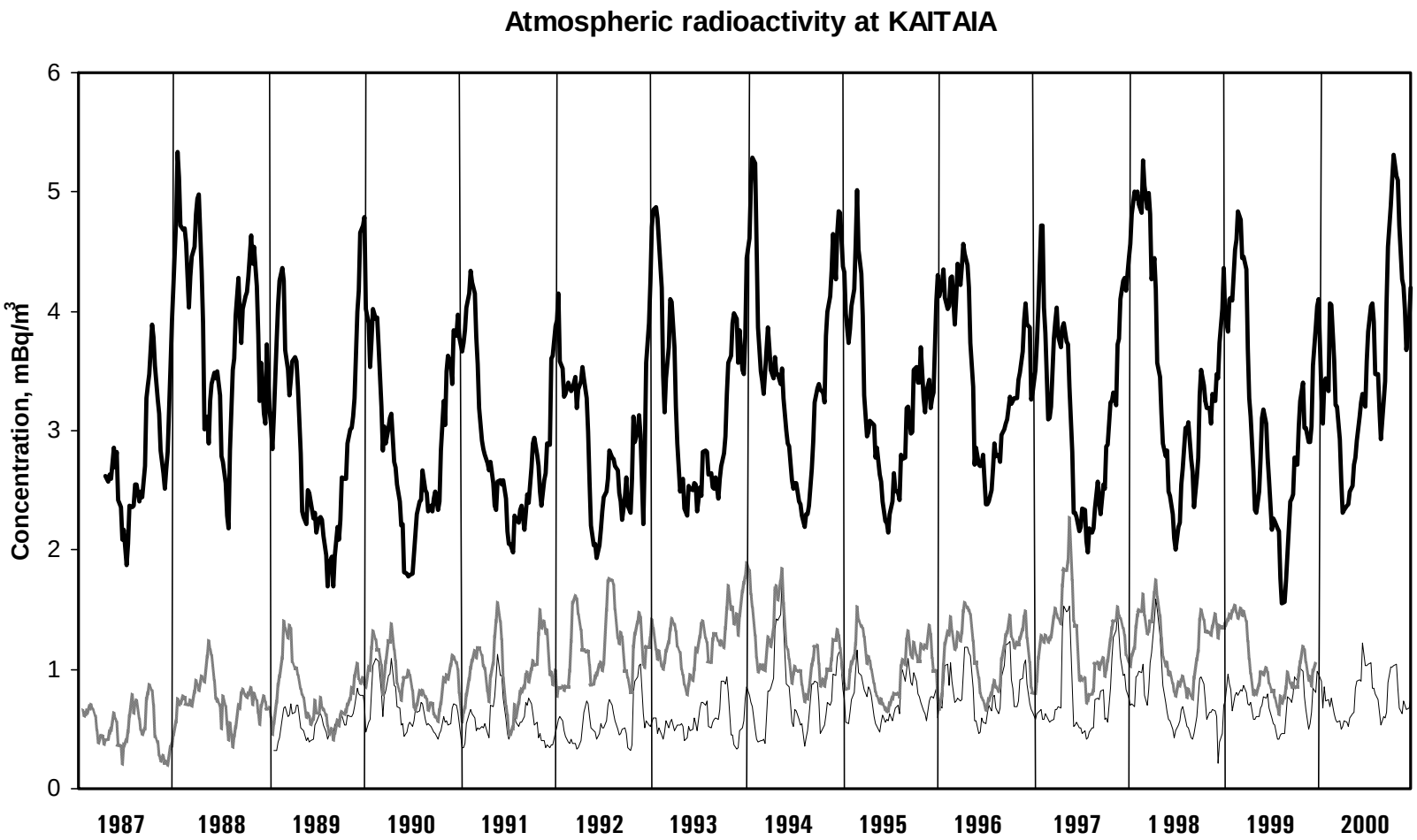

Fig 1 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Kaitaia** during the period 1987 to 2000. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

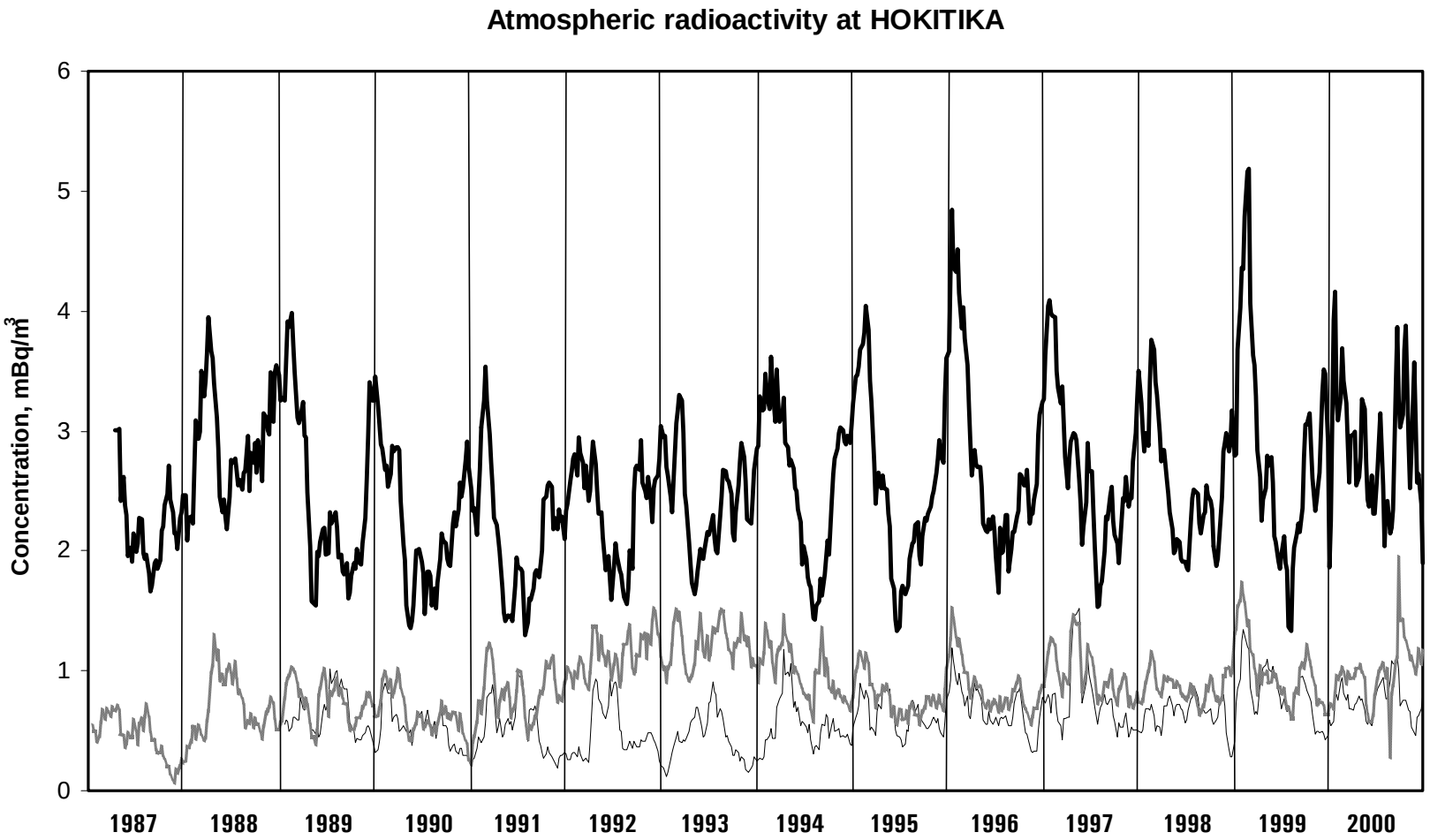

Fig 2 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Hokitika** during the period 1987 to 2000. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

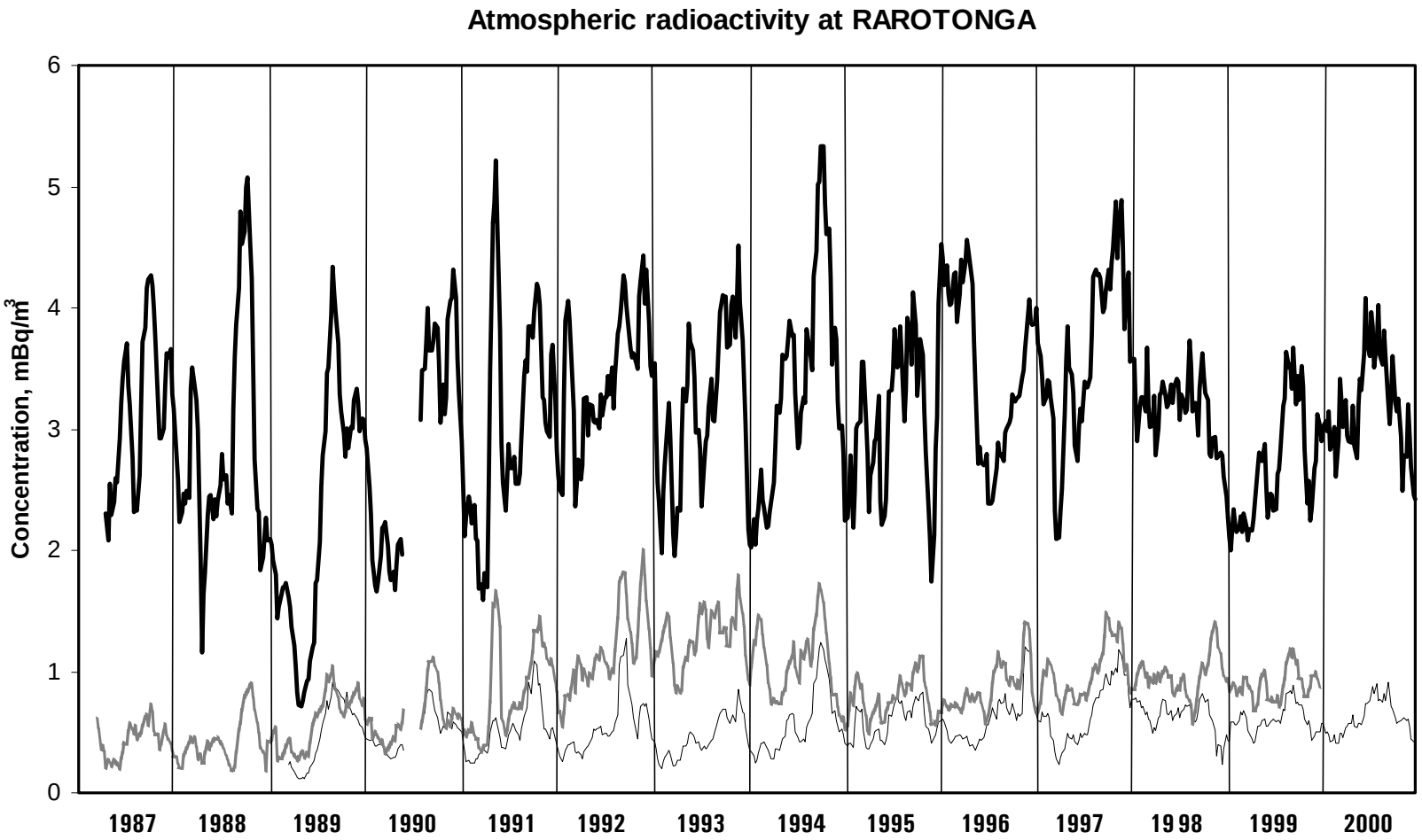

Fig 3 Five-week moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), total beta activity (middle solid line) and lead-210 (pale line) at **Rarotonga** during the period 1987 to 2000. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

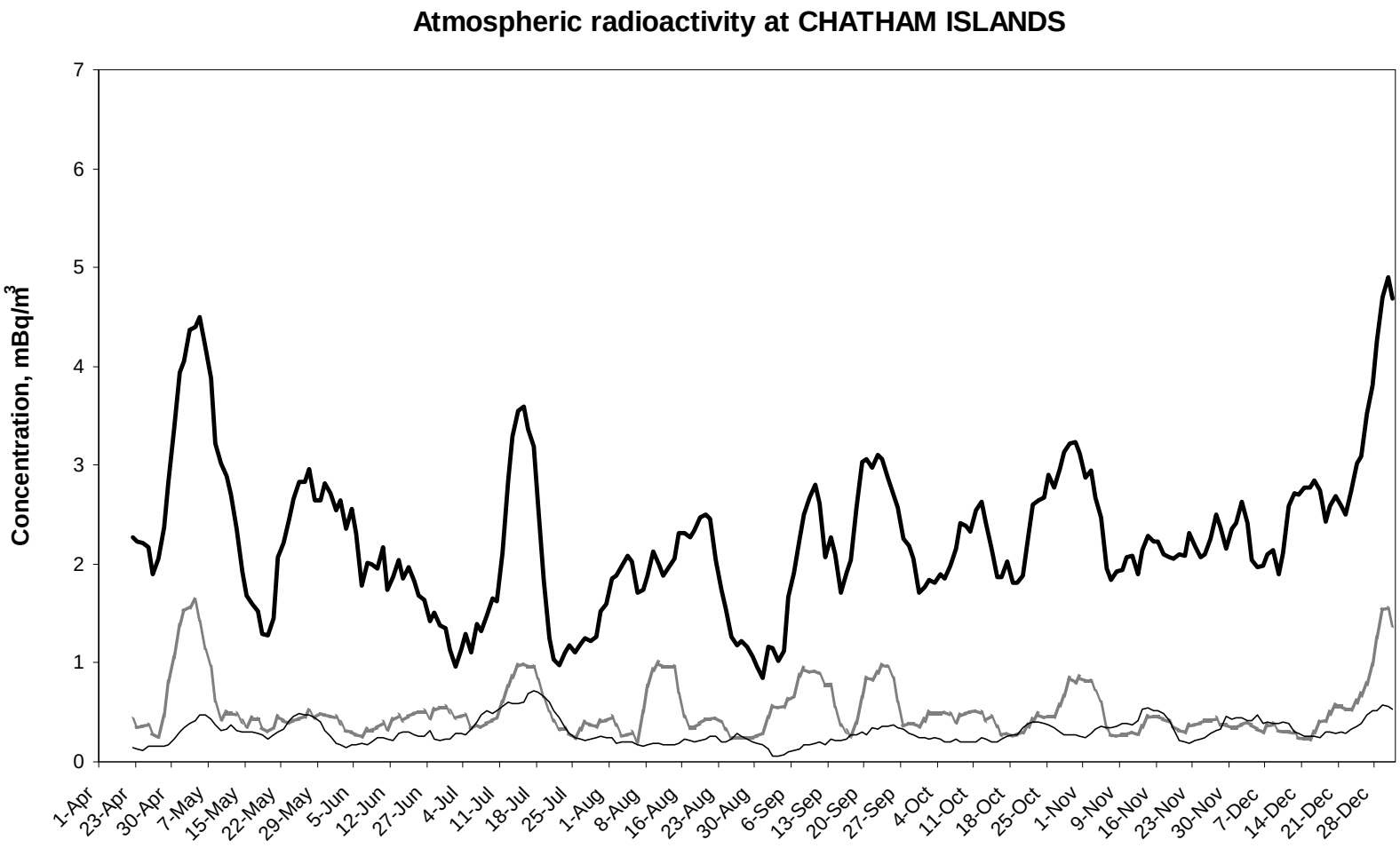

Fig 4 Seven-day moving-average atmospheric concentrations of beryllium-7 (upper heavy solid line), lead-210 (middle solid line) and lead-212 (pale line) at **Chatham Islands** during the period from 1 April to December 31, 2000. *A scaling factor of 10 has been applied to ^{210}Pb levels.*