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ENVIRONMENTAL RADIOACTIVITY ANNUAL REPORT

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SUMMARY

During 1992 artificial radioactivity in the environment in New Zealand and Rarotonga continued to be at trace levels only, typical of recent years. There has been no overall change in artificial radioactivity levels since 1991.

Average levels measured were: total beta activity in air, 0.14 mBq/m^3; ^{90}Sr deposition, 0.1 Bq/m^2; ^{137}Cs in milk, 0.2 Bq/g K; ^{90}Sr in milk, 0.03 Bq/g Ca. Total beta activity depositions at Hokitika and Rarotonga were 149 Bq/m^2 and 214 Bq/m^2 respectively.

No artificial radionuclides were detected by gamma spectroscopic analysis of high-volume air filters during 1992.

Average atmospheric concentrations of natural ^{7}Be and ^{210}Pb were 2.9 mBq/m^3 and 0.06 mBq/m^3 respectively.

The report includes data on trends in atmospheric radioactivity levels since 1987. Atmospheric ^{7}Be levels appear to have been following a downward trend since 1988; atmospheric beta activity has been increasing slowly since 1990; while atmospheric ^{210}Pb levels have been relatively constant since measurements began in 1989.

National Radiation Laboratory
PO Box 25-099
Christchurch
New Zealand

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CONTENTS

	page
INTRODUCTION	1
1992 MONITORING RESULTS	2
Atmospheric radioactivity	2
Radioactive deposition	2
Radioactivity in milk	3
Environmental radiation	3
DISCUSSION OF RESULTS	3
CONCLUSION	4
OTHER ENVIRONMENTAL WORK	5
Quality assurance	5
Commercial services	5
Miscellaneous	5
ACKNOWLEDGEMENT	5
REFERENCES	6
TABLES OF RESULTS	7
GRAPHS	

INTRODUCTION

The National Radiation Laboratory has been monitoring 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. The emphasis now is more on the need to provide warning of any influx of artificial radioactivity into the New Zealand and South Pacific regions, from any source. The monitoring programme also provides a basis for certification of the radioactivity content of exported foodstuffs.

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 cooperation and information dissemination, particularly during nuclear emergencies. It also takes part in quality assurance programmes run by the WHO, IAEA, the United States Environmental Protection Agency (EPA), the Environmental Surveillance & Study Laboratory (LESE, Tahiti), and the South Pacific Environmental Radioactivity Association (SPERA). The Laboratory is also a member of the WHO/UNEP (United Nations Environment Programme) Global Environmental Radiation Monitoring Programme (GERMON) and submits results quarterly to the GERMON headquarters in France.

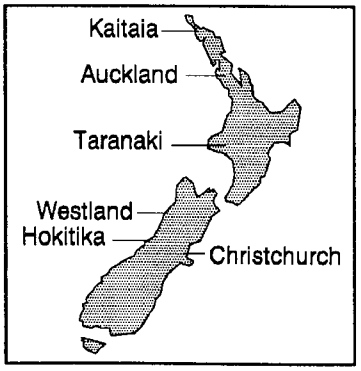
Although the primary purpose of the environmental monitoring programme is to monitor levels of artificial radioactivity, atmospheric measurements are extended to include naturally occurring radioactive materials, for comparative and scientific purposes. The atmospheric monitoring includes measurements of concentrations of lead-210 (^{210}Pb), polonium-210 (^{210}Po), and beryllium-7 (^{7}Be) in the atmosphere. Beryllium-7 is a product of spallation reactions of cosmic radiation within the upper atmosphere, while ^{210}Pb and ^{210}Po are decay products of gaseous radon-222 (^{222}Rn, which diffuses out of soil) and are of lower-atmospheric origin. Levels of potassium-40 (^{40}K) and uranium (^{238}U) and thorium (^{232}Th) decay products are also monitored as indicators of the resuspended dust content of air filters, and to provide an indication of the natural component of any measured radioactivity.

The environmental radioactivity monitoring programme therefore comprises the following measurements:

Atmospheric radioactivity - total beta activity (TBA), fission products, ^{7}Be, ^{210}Pb, ^{210}Po, ^{238}U and ^{232}Th decay products, and ^{40}K levels are monitored with weekly sample collections of surface air at Kaitaia, Hokitika and Rarotonga;

Radioactive deposition - total beta activity deposition is monitored at Hokitika and Rarotonga, with weekly sample collection, while strontium-90 (^{90}Sr) deposition is monitored with monthly collections at Kaitaia, Hokitika and Rarotonga;

Radioactivity in milk - ^{90}Sr and caesium-137 (^{137}Cs) concentrations are monitored in dairy milk powders with monthly sample collection from three New Zealand regions: Auckland, Taranaki and Westland.



Environmental radiation - outdoor environmental gamma radiation levels are monitored continuously in Christchurch as part of the GERMON programme.

This report summarises results of the above measurements. Earlier reports in this series give information on terms of reference, reference levels and potential health hazard[1,2], technical information[3,4], and the design of the programme[3,5].

1992 MONITORING RESULTS

Monitoring results for 1992 are summarised in Tables 1 and 2, while fluctuations in atmospheric radioactivity during 1992 and preceding years are illustrated in Figs 1 - 3. Radioactivity units used throughout this report are becquerels (Bq) and millibecquerels (mBq): 1 Bq = 1 nuclear decay event per second.

Atmospheric radioactivity

Atmospheric radioactivity monitoring results are summarised in Table 1. The monitoring was conducted at Kaitaia, Hokitika and Rarotonga where centrifugal fan pumps drew air through filters (Microdon FA2311) at a flow rate of approximately 3 m^3/min. The filters were changed once per week, with a weekly sample volume of approximately 30 000 m^3, and analysed by high-resolution gamma spectroscopy for artificial gamma-emitting radionuclides and natural radionuclides; by gas-flow proportional counting for TBA; and radiochemically for ^{210}Pb and ^{210}Po.

Artificial radionuclides

No artificial radionuclides were detected by gamma spectroscopic analysis of air filters from any monitoring site during 1992 (the limit of detection for individual radionuclides is of the order of 1 microbecquerel per m^3, for weekly average levels).

Total beta activity

The TBA, due mainly to the natural radionuclide ^{210}Pb (and its decay product bismuth-210, ^{210}Bi), ranged from <0.04 to 0.33 mBq/m^3, with an overall average of 0.14 mBq/m^3, similar to the 1991[6] average, 0.11 mBq/m^3. When corrected for the estimated contribution by beta emissions due to natural ^{232}Th and ^{238}U decay products (including ^{210}Pb and ^{210}Bi) and ^{40}K on the filters, the average TBA level was 0.04 mBq/m^3 (Table 1).

Natural radionuclides

Beryllium-7 levels ranged from 0.9 to 5.8 mBq/m^3, with an overall average of 2.9 mBq/m^3.

Lead-210 levels ranged from 0.01 to 0.26 mBq/m^3, with an overall average 0.06 mBq/m^3.

The variation of TBA, ^{7}Be and ^{210}Pb levels with time is illustrated in Figures 1 - 3, which show 5-week moving-average values for each site during the period 1987 - 1992.

Radioactive deposition

Total beta activity

The 1992 TBA deposition at Hokitika was 149 ± 7 Bq/m^2, with 2594 mm of rainfall. At Rarotonga the deposition was 214 ± 18 Bq/m^2, with 1394 mm of rain (Table 1).

Strontium-90

Strontium-90 deposition has been at such low levels in recent years that it has been necessary, since 1986, for strontium recovered from the monthly rainwater collections to be aggregated into two 6 monthly measurements per year, in order that any ^{90}Sr present may be detected.

During 1992, ^{90}Sr deposition continued to be at the limits of detection, typical of recent years: Kaitaia 0.1 Bq/m^2 Hokitika 0.1 Bq/m^2, and Rarotonga 0.2 Bq/m^2 (Table 1), the same levels as

reported for 1991[6]. These ^{90}Sr depositions may be contrasted with the TBA deposition, mainly of natural origin, recorded above.

Radioactivity in milk

Caesium-137

Caesium-137 levels in cows' milk were assessed by gamma spectroscopic analysis of 3-month aggregates of monthly samples. Results are shown in Table 2, with units of Bq per gram of potassium (Bq/g K) and Bq per kilogram of milk powder (Bq/kg).

The 1992 average ^{137}Cs levels were: Auckland 0.11 Bq/g K; Taranaki 0.39 Bq/g K; Westland 0.14 Bq/g K. The three-region mean was 0.21 Bq/g K or 2.7 Bq/kg powder.

Strontium-90

Strontium-90 levels in cows' milk were measured by radiochemical analysis of 3-month aggregated samples. Results are shown in Table 2, with units of Bq per gram of calcium (Bq/g Ca) and Bq/kg powder.

The 1992 average ^{90}Sr levels were: Auckland 0.03 Bq/g Ca; Taranaki 0.03 Bq/g Ca; Westland 0.03 Bq/g Ca. The three-region mean was 0.03 Bq/g Ca or 0.4 Bq/kg powder.

Environmental radiation

Participation in the WHO/UNEP GERMON programme required the installation of an environmental gamma radiation monitor to provide a continuous record of environmental gamma radiation levels. Since installation (on the roof of the Laboratory) in mid-1992 the radiation level has been virtually constant at 100 nanogray per hour, or 0.9 milligray per year, due to cosmic and terrestrial gamma radiation.

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 installed at a private address in Christchurch. Replacement packages are provided by WHO every 3 months and the exposed ones returned to France for analysis. Results of the integrating measurement and the continuous monitoring were identical during 1992.

DISCUSSION OF RESULTS

Atmospheric radioactivity trends since 1987, as illustrated in Figs 1 - 3, have some interesting features. While ^{7}Be levels at Kaitaia and Hokitika (Figs 1 and 2) have continued to show their typical annual variation each year, with peaks in summer in New Zealand and spring in Rarotonga, and troughs in winter, there appears to have been a slight downward trend since 1988 (when the record began). Annual average ^{7}Be levels, as shown in Fig 4a, indicate a discontinuity in 1988 at Kaitaia and Hokitika when the average was higher than in later years, with less significant variation since. The downward trend has also been observed in results from the US Environmental Measurements Laboratory's monitoring network, during the period 1985 to 1990, and has been attributed to a decrease in the cosmic-ray neutron flux associated with changes in solar activity[7]. This trend is not apparent at Rarotonga (Fig 3), however, where there appears to have been an upward trend in ^{7}Be levels since mid 1989 (Figs 3 and 4a).

In contrast to trends in ^{7}Be levels at the New Zealand sites, the atmospheric total beta activity appears to have been increasing steadily since 1990 at all 3 sites (Figs 1 - 3). Reasons for this are not clear but the frequent coincidence between TBA and ^{7}Be peaks suggests an upper atmosphere source. Annual average TBA levels at Kaitaia and Hokitika have had an upward trend since

1987 as illustrated in Fig 4b, while at Rarotonga any trend has been evident only since 1990. Radionuclides contributing to the trend are evidently present in amounts too small to be detected by the gamma spectroscopic analysis of filters (assuming they are also gamma emitters). Delayed fallout from the Chernobyl reactor accident is a possible source though it would be expected to have appeared earlier.

It is not known whether or not this trend, like the fluctuation in ^{7}Be levels, is cyclic in nature. Prior to 1986, before the installation of high-volume air samplers, the limit of detection was 0.3 mBq/m^3 at New Zealand monitoring sites and 1.1 mBq/m^3 at Rarotonga, so there has been a lack of data on TBA levels since 1976 (when levels had decreased to the detection limits following the cessation of atmospheric weapon tests) until the high-volume air samplers were deployed.

Atmospheric lead-210 levels have continued to be scattered around a fairly constant mean level but ^{210}Pb peaks have also coincided with TBA and sometimes ^{7}Be peaks suggesting that ^{210}Pb of stratospheric origin has been detected at those times. Since 1989 annual average ^{210}Pb levels have always been in the range 0.05 - 0.07 mBq/m^3. It would appear, therefore, that any trend in TBA levels is unlikely to be due to changes in natural radioactivity levels - volcanic ash from recent eruptions, for example, would be expected to cause increases in both ^{210}Pb and TBA, rather than just the latter.

Observations of trends in radioactivity levels, and attempts to identify the cause of the higher TBA levels will continue.

Radioactivity deposited in rainwater, as indicated by total beta activity deposition during 1992, was at the same level as in 1991 at Hokitika, but double the 1991 level at Rarotonga. The 1991 *Environmental Radioactivity Annual Report*[6] misreported the deposition results for that year. Hokitika and Rarotonga depositions in 1991 were reported as 240 and 73 Bq/m^2 respectively, whereas the correct values were 135 and 105 Bq/m^2, compared to 149 and 214 Bq/m^2 in 1992, respectively. Total rainfalls were similar in both years. Transient increases in deposited TBA have been recorded before, at Hokitika[8].

Milk radioactivity and strontium-90 deposition levels continue to fluctuate around the limit of detectability, with no change since 1991.

CONCLUSION

Artificial radioactivity levels in the New Zealand and South Pacific environments, as indicated by measurements of atmospheric, deposited, and milk radioactivity, remained at trace levels only during 1992, consistent with an environment containing residual global weapons-test fallout.

The 1992 results were very similar to those reported for 1991[6] as indicated in the comparison of New Zealand site averages below:

	1992	1991	
TBA air	0.14	0.11	mBq/m^3
TBA rain	149	135*	Bq/m^2
^{90}Sr rain	0.1	0.1	Bq/m^2
^{90}Sr milk	0.4	0.4	Bq/kg
^{137}Cs milk	2.7	2.6	Bq/kg

* Corrected 1991 data - see text above.

There was no detectable influx of fresh fission products into the region during 1992.

Environmental radioactivity is mainly of natural origin with the major measured component of atmospheric radioactivity being ^{7}Be. During 1992 the usual trend of summer maximum and winter minimum ^{7}Be levels continued, though levels overall have been showing a slight downward trend at New Zealand sites since 1988. Atmospheric total beta activity seems to have been increasing slowly since 1987 although levels are far below those recorded at the time of the cessation of atmospheric weapon tests. Lead-210 levels, comprising much of the measured beta activity, showed relatively little variation.

OTHER ENVIRONMENTAL WORK

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, EPA and more recently LESE and SPERA. New Zealand's remoteness causes some problems in these exercises because short-lived radionuclides such as iodine-131 have sometimes passed through several half-lives before arrival and accuracy is compromised by the low level of radioactivity remaining. Results of intercomparisons have not usually been published in the Annual Reports. A special report[9] summarising results to 1982 was published in that year. Commencing with this 1992 Annual Report intercomparison results will be reported each year.

During 1992 the Laboratory participated in 11 intercomparisons. Results for 9 of these are presented in Table 3 which lists known and measured values and their ratio. Result collations from the remaining 2 - a wine sample from France analysed for gamma-emitting nuclides, and coral samples from the Marshall Islands analysed for plutonium - had not been received from the organisers at the time of writing.

Analytical performance has generally been satisfactory with a mean measured/known ratio of 0.99 (standard deviation 0.08). Performance in all intercomparisons was well within accuracy limits specified by the organisers.

Commercial services

There was a continuing demand for export certificates and radioactivity tests in 1992. During the year 593 export certificates were issued and 307 commercial analyses performed. The number of enquiries in 1992 from members of the public regarding radioactivity of consumer products, foodstuffs and environmental issues was normal.

Miscellaneous

The South Pacific Environmental Radioactivity Association's 1992 Workshop on Environmental Radioactivity was attended at the University of Otago, Dunedin, in August. A report on the meeting was published in *Radiation Protection News and Notes*[10].

Publications during 1992 and relevant to environmental radioactivity include a comprehensive review of all measurements conducted by the Laboratory in the South Pacific since 1960[11]; a paper commenting on regulations proposed by the EPA concerning limits to the radon content of drinking water[12]; and a Workshop paper on measurement of radon in water[13].

ACKNOWLEDGEMENT

The assistance given by the New Zealand Meteorological Service, the Rarotonga Meteorological Service, and Managers of milk processing plants, is gratefully acknowledged. The Laboratory also gratefully acknowledges the help of the various international organisations providing intercomparison services. The Laboratory's Environmental Radioactivity Section organized the monitoring and analysed the samples. This report was written by the Section Head, Dr K M Matthews, who was assisted technically by Ms M-J Okey.

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Table 1: A summary of atmospheric and deposited radioactivity levels measured during 1992.

Atmospheric radioactivity (mBq/m^3)

		Kaitaia	Hokitika	Rarotonga
TBA:	range	0.06 - 0.33	0.05 - 0.26	<0.04 - 0.28
	mean	0.14	0.13	0.14
Corrected TBA*				
	range	0 - 0.28	0 - 0.16	0 - 0.17
	mean	0.06	0.03	0.03
^{7}Be	range	1.3 - 5.8	0.9 - 4.6	0.9 - 5.7
	mean	2.9	2.4	3.4
^{210}Pb	range	0.01 - 0.24	0.01 - 0.20	0.01 - 0.26
	mean	0.06	0.05	0.06
Fission products		nil	nil	nil

Deposited radioactivity (Bq/m^2)

	Kaitaia	Hokitika	Rarotonga
TBA		149 ± 7	214 ± 18
^{90}Sr	0.1 ± 0.2	0.1 ± 0.2	0.2 ± 0.4
Rainfall, cm	143	259	139

* Corrected TBA is the total beta activity remaining after subtraction of estimated contributions by natural radionuclides of the ^{232}Th and ^{238}U decay series (in resuspended dust, and including ^{210}Pb and ^{210}Bi) and ^{40}K.

Table 2: Caesium-137 and strontium-90 levels in cows' milk during 1992.

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

Caesium-137

Qtr	Auckland		Taranaki		Westland	
	Bq/g K	Bq/kg	Bq/g K	Bq/kg	Bq/g K	Bq/kg
1	0.09	1.3	0.66	9.4	0.19	2.7
2	0.14	1.6	0.39	4.2	0.14	1.6
3	0.11	1.3	0.20	2.2	0.12	1.4
4	0.09	1.3	0.30	3.2	0.10	1.4
Mean	0.11	1.4	0.39	4.8	0.14	1.8

Strontium-90

Qtr	Auckland		Taranaki		Westland	
	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg	Bq/g Ca	Bq/kg
1	0.03	0.35	0.04	0.52	0.03	0.45
2	0.03	0.36	0.03	0.48	0.03	0.44
3	0.03	0.36	0.03	0.33	0.03	0.42
4	0.02	0.30	0.02	0.25	0.03	0.33
Mean	0.03	0.34	0.03	0.40	0.03	0.41

Table 3: A summary of performance in international analytical intercomparisons during 1992, comparing the Laboratory's analytical result and the "known" value as stated by the organiser. The "ratio" is the ratio of the NRL result (the mean of three analyses) to the known value. Units were varied and are not given in the table.

Organiser	Sample	Measure-ment	Nuclide	Known value	NRL mean	Ratio
EPA	Air filter	Alpha	TAA	7.0	8.0	1.14
		Beta	TBA	41.0	36.0	0.88
			Sr-90	15.0	14.0	0.93
		Gamma	Cs-137	10.0	11.7	1.17
EPA	Milk	Beta	Sr-90	29.0	26.7	0.92
		Gamma	I-131	78.0	90.7	1.16
			Cs-137	39.0	41.3	1.06
			K-40	1.71	1.75	1.02
SPERA	Milk	Gamma	Cs-134	0.34*	0.32	0.94
			Cs-137	2.12	2.08	0.98
			K-40	0.59	0.58	0.98
SPERA	Fish	Gamma	Pb-210	22.1	21.0	0.95
			Cd-109	26.4	24.5	0.93
			Mn-54	6.1	5.9	0.97
			Co-60	14.7	14.4	0.98
			K-40	0.6	0.6	1.00
EPA	Water	Alpha	Uranium	4.0	4.1	1.03
EPA	Water	Gamma	I-131	45.0	62.3**	
EPA	Milk	Beta	Sr-90	15.0	12.7	0.85
		Gamma	I-131	100.0	102.3	1.02
			Cs-137	15.0	12.3	0.82
			K-40	1.75	1.72	0.98
EPA	Air Filter	Alpha	TAA	30.0	31.7	1.06
		Beta	TBA	69.0	68.7	1.00
			Sr-90	25.0	23.7	0.95
		Gamma	Cs-137	18.0	18.0	1.00
EPA	Water	Alpha	Uranium	15.2	15.4	1.01

Mean ratio of NRL/Known Value ± s.d.: 0.99 ± 0.08

Notes: * The "known" value in the SPERA intercomparison is actually the mean of all participating laboratories' results.

** The anomalously high result was attributed to accidental contamination of a sample container by an iodine-131 standard which was in use in the Laboratory at the time.

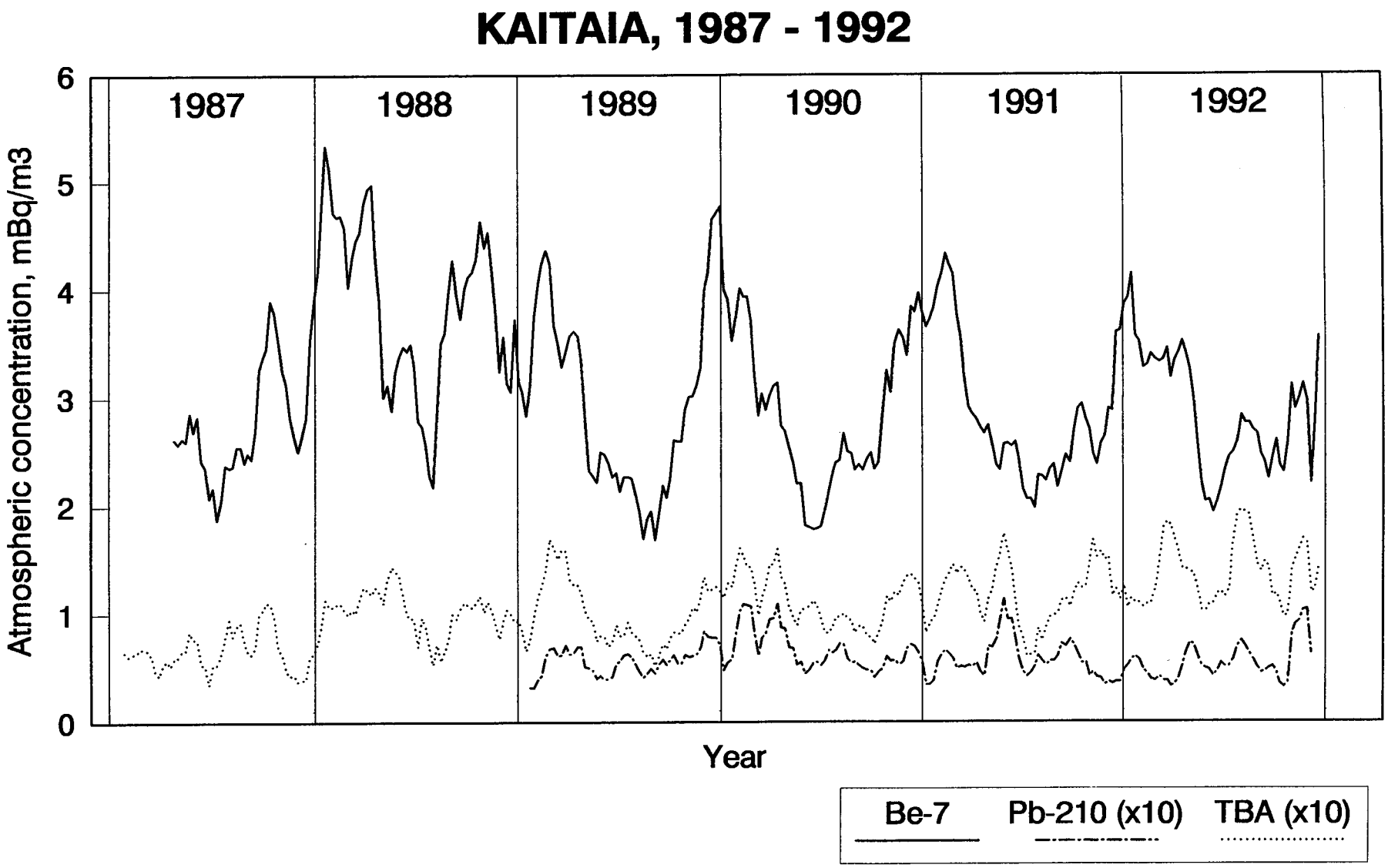

Fig 1 Five-week moving-average atmospheric concentrations of beryllium-7, lead-210 and total beta activity (TBA) at **Kaitaia** during the period 1987 to 1992. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

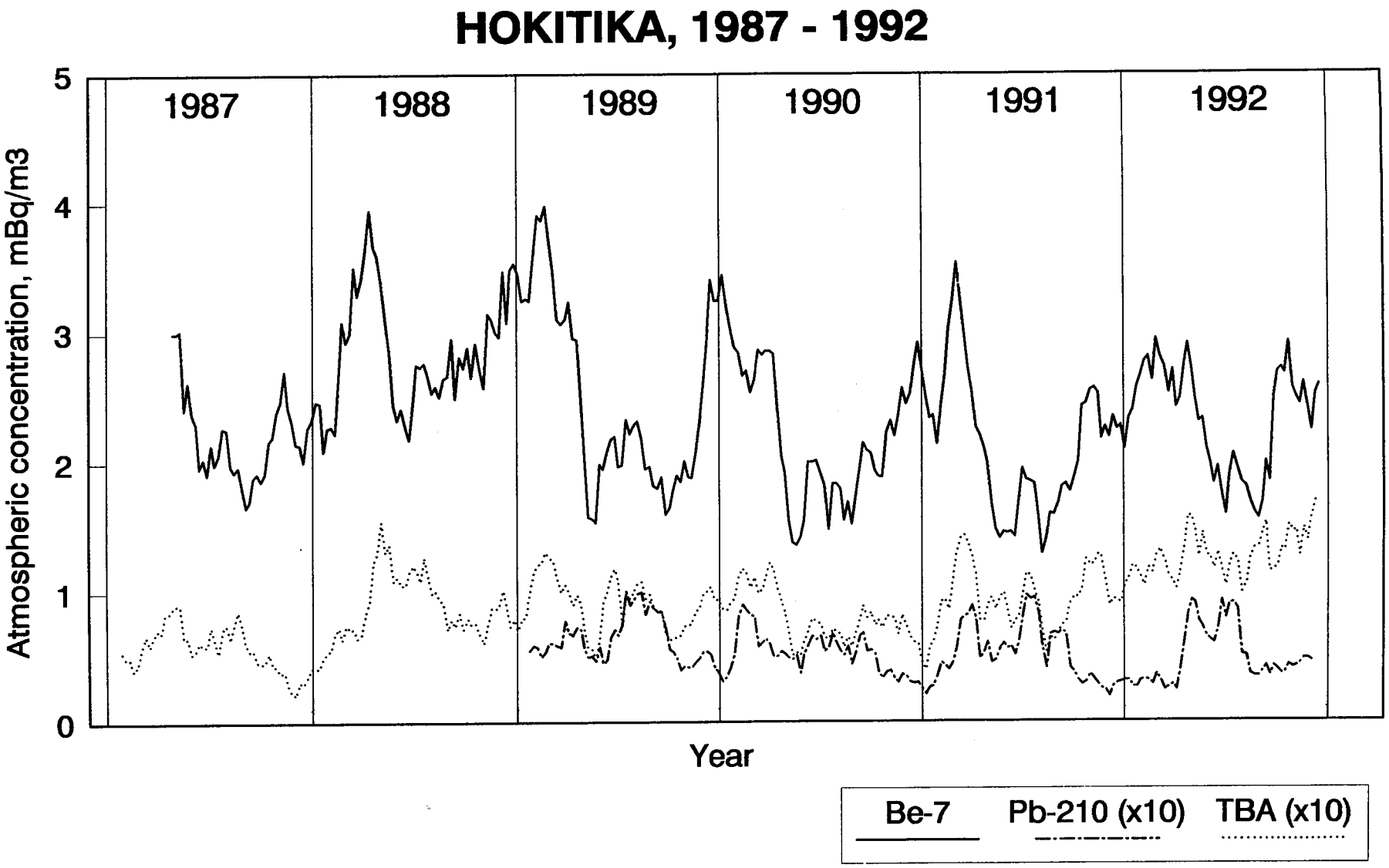

Fig 2 Five-week moving-average atmospheric concentrations of beryllium-7, lead-210 and total beta activity (TBA) at **Hokitika** during the period 1987 to 1992. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

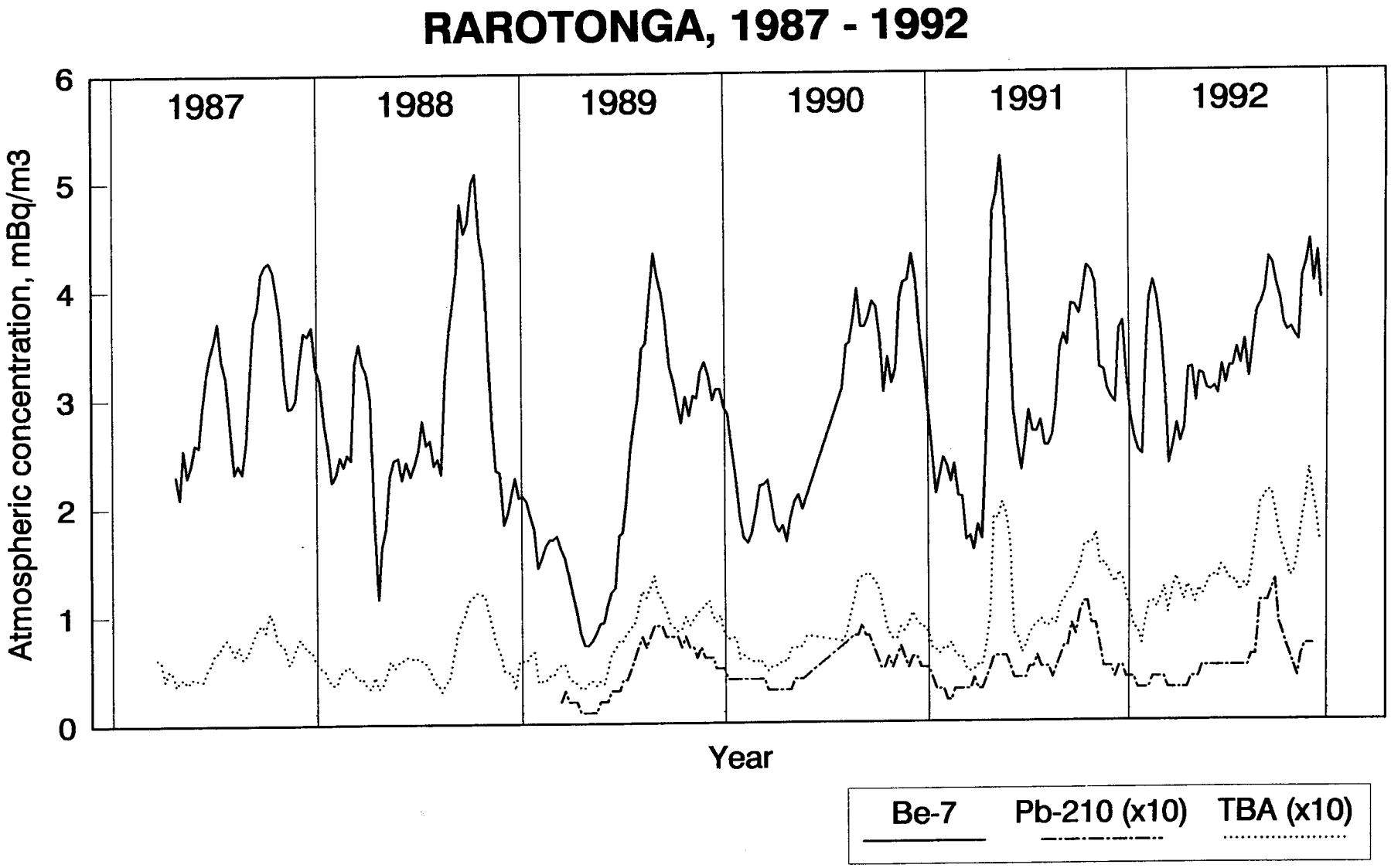

Fig 3 Five-week moving-average atmospheric concentrations of beryllium-7, lead-210 and total beta activity (TBA) at **Rarotonga** during the period 1987 to 1992. *A scaling factor of 10 has been applied to ^{210}Pb and TBA levels.*

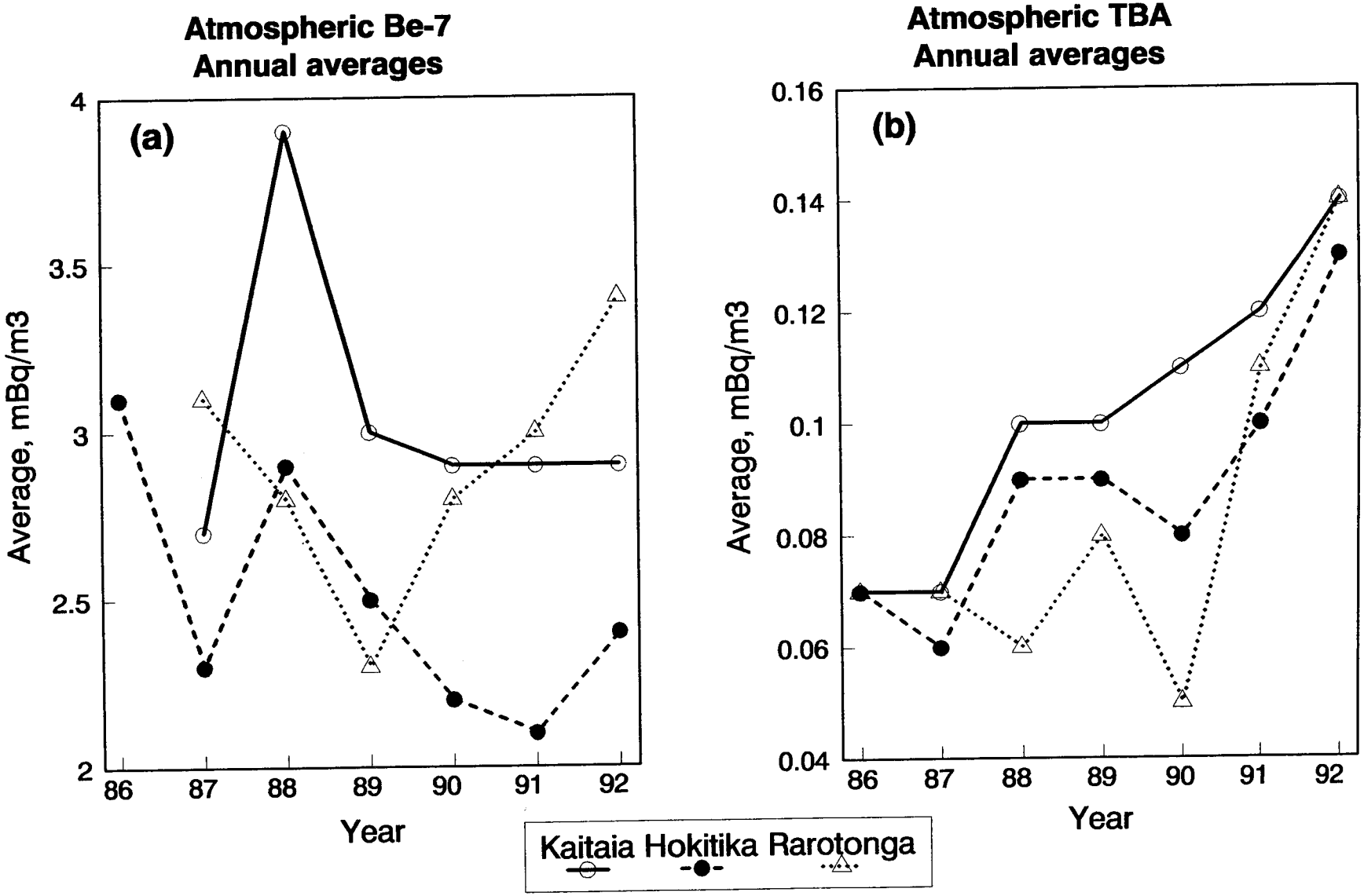

Fig 4 Trends in mean annual atmospheric beryllium-7 and total beta activity levels at Kaitaia, Hokitika and Rarotonga during the period 1986 to 1992.