NRL - F/65
ISSN 0111-6193

ENVIRONMENTAL RADIOACTIVITY ANNUAL REPORT

1985

ISSN 0110-9944

NATIONAL RADIATION LABORATORY

P.O.Box 25 099, Christchurch

New Zealand

MARCH 1986

SUMMARY

Strontium-90 deposition in New Zealand, Fiji and Rarotonga during 1985 was below the limit of detection at most monitoring stations, with a mean annual deposition of <0.1 MBq km^{-2} – the lowest recorded level since monitoring commenced in 1960.

The total beta activity in air continued to be less than the limit of detection at all stations.

Strontium-90 and caesium-137 levels in dairy milk were similar to 1984 levels with annual means of 0.036 Bq gCa^{-1} and 0.27 Bq gK^{-1} respectively.

High-volume air samplers were installed at Kaitaia and Hokitika during 1985 and future air and rainwater monitoring will be conducted at those sites and Rarotonga only.

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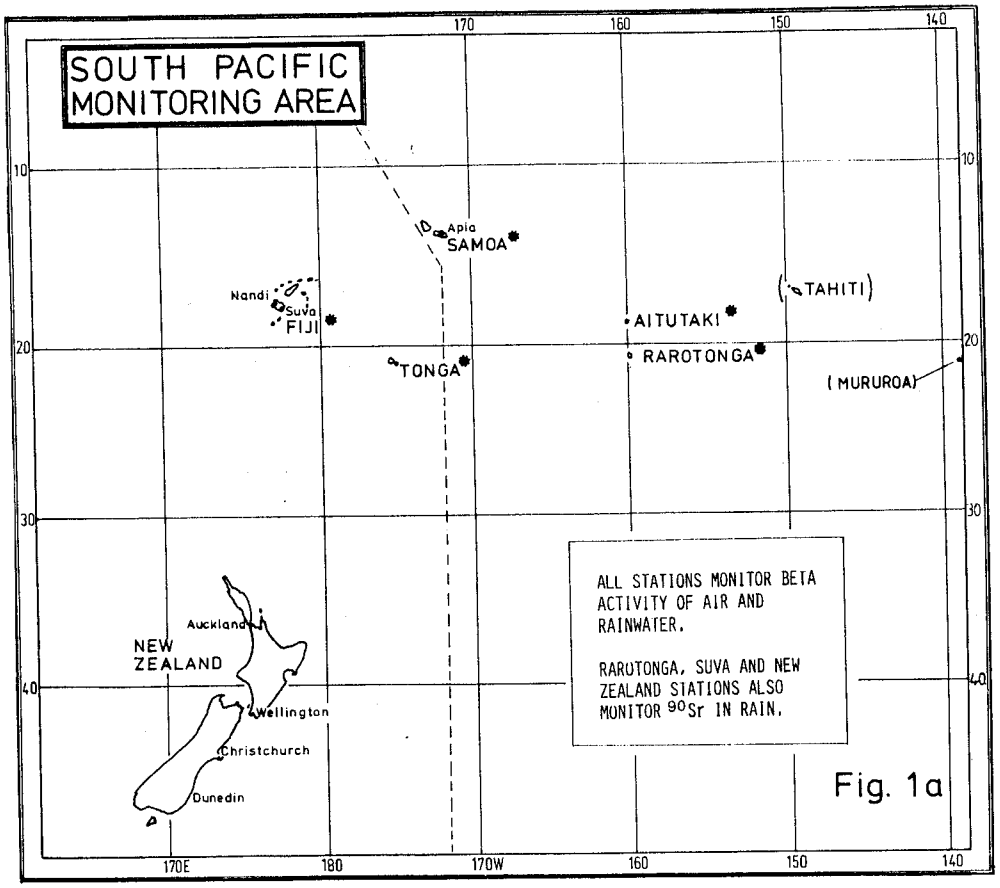
SOUTH PACIFIC
MONITORING AREA
170
160
150
140
10
20
30
40
Apia
SAMOA
Nandi
Suva
FIJI
TONGA
AITUTAKI
TAHITI
RAROTONGA
(MURUROA)
NEW
ZEALAND
Auckland
Wellington
Christchurch
Dunedin
ALL STATIONS MONITOR BETA
ACTIVITY OF AIR AND
RAINWATER.
RAROTONGA, SUVA AND NEW
ZEALAND SIATIONS ALSO
MONITOR 90Sr IN RAIN.
170E
180
170W

Fig. 1a

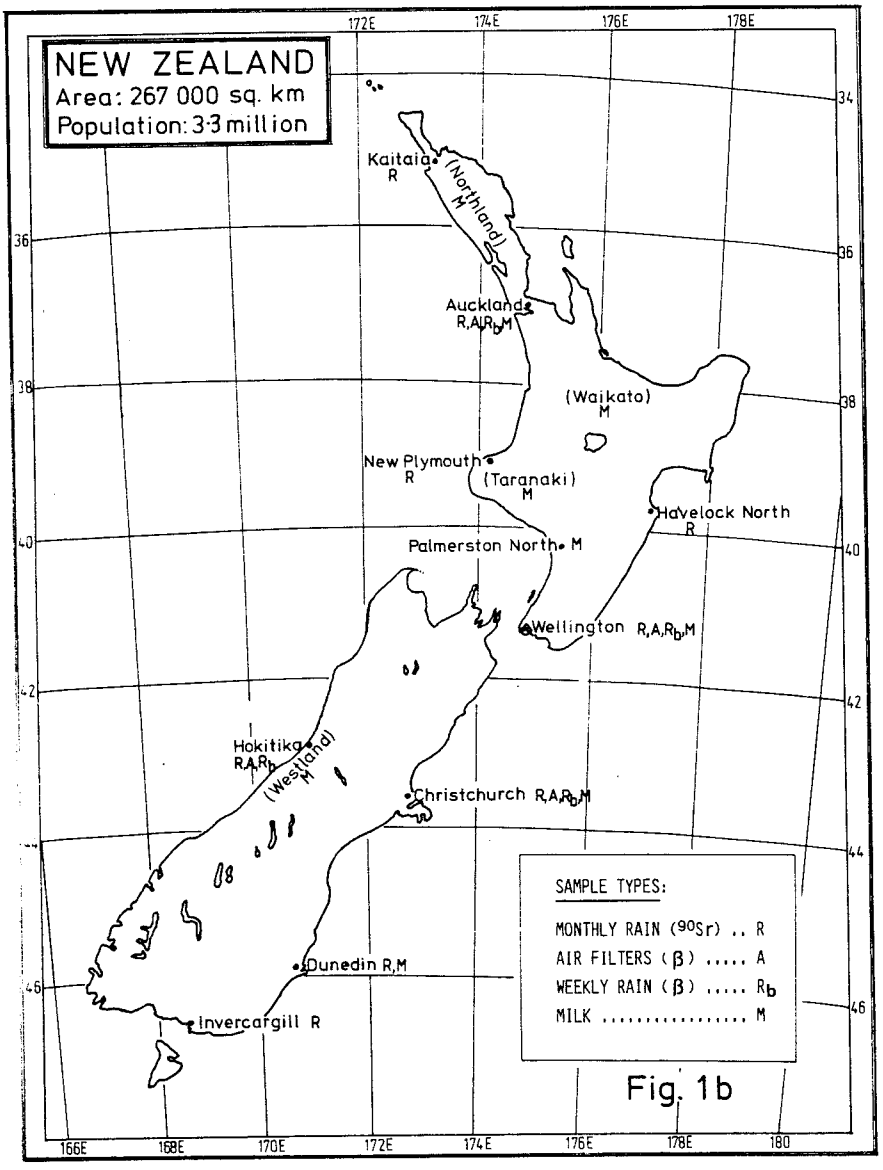
NEW ZEALAND
Area: 267 000 sq. km
Population: 3·3 million
172E
174E
176E
178E
34
36
38
40
42
44
46
Kaitaia
R
(Northland)
M
Auckland
R,A,Rb,M
(Waikato)
M
New Plymouth
R
(Taranaki)
M
Havelock North
R
Palmerston North M
Wellington R,A,Rb,M
Hokitika
R,A,Rb
(Westland)
M
Christchurch R,A,Rb,M
Dunedin R,M
Invercargill R
SAMPLE TYPES:
MONTHLY RAIN (90Sr) .. R
AIR FILTERS (β) ..... A
WEEKLY RAIN (β) ..... Rb
MILK ..... M
166E
168E
170E
172E
174E
176E
178E
180

Fig. 1b

INTRODUCTION

This report continues the series of reports on environmental radioactivity monitoring in the New Zealand and South Pacific areas, published since 1961.[1,2]

The National Radiation Laboratory has been conducting this monitoring since 1960, for radioactive fallout initially arising from Northern Hemisphere nuclear tests and later from the French testing programme which commenced in the Tuamotu Archipelago in 1966. In 1974 France terminated atmospheric nuclear tests and began testing underground in June 1985. The Laboratory's monitoring programme continued in order to monitor levels from pre-1975 tests and any venting to the atmosphere of fission products from the underground test series. During 1985 the full monitoring programme conducted over previous years was continued, though fallout levels have been so low over recent years[3] that it is expected that this will be the last year of full programme operation. The programme consisted of continuous air and rainwater beta (β) activity monitoring at 5 Pacific island and 4 New Zealand stations; the measurement of strontium-90 (^{90}Sr) in rainwater at 9 New Zealand and 2 Pacific island stations; and ^{90}Sr and caesium-137 (^{137}Cs) levels in dairy milk from 9 New Zealand regions.

Monitoring and sample collecting stations are shown in Fig. 1, a and b.

In the 1984 Annual Report[3] proposed changes in the fallout monitoring programme were described. The main feature of the changes was the reduction in air and rainwater monitoring to three stations only – Kaitaia, Hokitika and Rarotonga – and the installation of high-volume air sampling pumps at those stations. The new pumps, described below, were installed at Hokitika in August 1985 and at Kaitaia in November, with Rarotonga to follow early in 1986. The fallout monitoring programme described above was therefore supplemented with this high-volume air sampling during the last quarter of 1985.

Earlier annual reports[1] and special reports on French atmospheric tests[2] give information on terms of reference, potential health hazard, reference levels, and technical information. The following reference levels, against which reported levels may be compared, have been adopted for New Zealand: mixed fission products between 10 and 80 days old (total β activity), in rain – 220 becquerels (Bq) per litre, in air – 11 Bq per cubic metre; ^{90}Sr in milk – 10 Bq per gram of calcium (Ca); ^{137}Cs in milk – 260 Bq per gram of potassium (K). One litre of milk contains approximately 1.2 g Ca and 1.4 g K.

Detection limits quoted in this report are upper 95% confidence limits calculated from the formula: $L_D = 4.65\sqrt{B}$, where L_D is the detection limit in net counts and B is the background count during the counting interval.[4]

MONITORING PROCEDURES

Procedures for measurements of total β activity in air, total β activity in rain, ^{90}Sr deposition, ^{90}Sr and ^{137}Cs in milk, which were used during 1985 and previous years, were described in the 1984 Annual Report.[3]

The new high-volume air pumps deployed at Kaitaia, Hokitika and Rarotonga (1986) are described here.

The high-volume pump unit is shown in Fig. 2 and comprises a centrifugal fan pump (Secomak 575/1), a plastic (PVC) filter cartridge and cartridge holding assembly, and a venturi tube attached to the pump exhaust. The unit is housed in an aluminium-clad weatherproof enclosure. All components except the pump were produced in the NRL workshop.

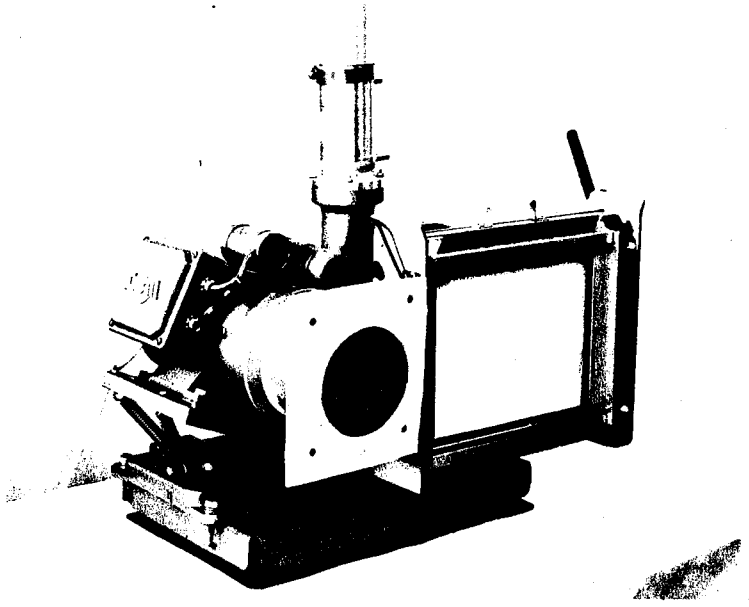

Fig. 2. A high-volume pump unit.

The pump draws air through a 250 x 200 mm polycarbonate filter (polycarbonate microfibres sandwiched between two supporting layers of polypropylene non-woven material) at a flow rate of approximately 4 m^3 per minute. The filters are Carl Freudenberg Microdon type LM 2030 which have been rated by UKAEA Harwell[5] to have a 92.5% efficiency for 0.3 μm particles (BSS 3929).

The flow rate is indicated by the pressure drop across the venturi tube, measured by a water-filled manometer. The venturi/manometer units were calibrated at the Laboratory before the pumps were deployed in the field.

The pumps run continuously with one filter change per week. Flow rates are measured at the start and end of the week and the mean is used to calculate the volume of air sampled (approx. 40000 m^3). Filters are airmailed to the Laboratory for analysis.

The aim of filter analysis is to detect and quantify gamma-emitting artificial radionuclides, particularly fission products, on the filter using a high-resolution gamma spectroscopy system (comprising a hyperpure germanium detector, 4096 channel pulse height analyser, with computer analysis of spectra). The 0.1 - 1.6 MeV energy range is used for analysis, with a counting time of 48 h. A 40 mm diameter core is taken from the filter for total β activity measurement, before the filter is pressed into a 45 mm x 8 mm disc to provide optimum gamma counting geometry.

Radionuclides routinely searched for in spectrum analysis and their approximate limits of detection (Bq m^{-3}) are:

Caesium-137	^{137}Cs	5×10^{-7}
Cerium-144	^{144}Ce	10^{-6}
Iodine-131	^{131}I	3×10^{-7}
Ruthenium-106/Rhodium-106	$^{106}Ru/^{106}Rh$	4×10^{-6}
Ruthenium-103	^{103}Ru	5×10^{-7}
Zirconium-95/Niobium-95	$^{95}Zr/^{95}Nb$	3×10^{-7}
Barium-140	^{140}Ba	2×10^{-6}
Antimony-125	^{125}Sb	2×10^{-6}

Naturally occurring beryllium-7 (^{7}Be) is also monitored.

The limit of detection for total β activity (using the 40 mm diameter core sample) is 0.04 millibecquerels (mBq) per cubic metre.

1985 MONITORING RESULTS

Results for 1985 are summarized in Tables 1-4. The precision of measurement, when given, is based on a counting error of 2 Poisson standard deviations (95% confidence level). New Zealand average fallout levels are shown in comparison to levels of earlier years in Fig. 3. The trends in results of previous years were reviewed in the 1984 Annual Report.[3]

1. Total beta activity in air

Monthly average levels of beta activity in air did not exceed the limit of detection at any station where the older low-volume air sampling pumps were used, i.e., <0.3 mBq m^{-3} at New Zealand stations and <1.1 mBq m^{-3} at Pacific island stations, continuing the pattern of results since 1974 (Fig. 3).

The β activity was measurable only at Hokitika and Kaitaia when the high-volume pumps were installed there. The monthly average β activity at Hokitika during August - December was 0.06 - 0.07 mBq m^{-3} and at Kaitaia for both November and December was 0.06 mBq m^{-3}.

2. Total beta activity in rain

The mean annual β activity deposition at New Zealand stations during 1985 was 76 ± 7 megabecquerels (MBq) per square kilometre with a mean concentration in rainwater of 0.07 Bq l^{-1} (Table 1). The maximum quarterly deposition was 58 ± 13 MBq km^{-2} at Hokitika during October - December. These levels were similar to those of 1984 when the New Zealand mean was 64 ± 7 MBq km^{-2}.[3]

Annual depositions at Pacific island stations ranged from 47 MBq km^{-2} at Rarotonga to 118 MBq km^{-2} at Tonga, with concentrations ranging from 0.02 to 0.11 Bq l^{-1}. The island mean was 83 MBq km^{-2}.

The island mean appears to be significantly higher than the 1984[3] mean (45 MBq km^{-2}) due largely to the annual deposition and concentration at Tonga (118 ± 39 MBq km^{-2} and 0.11 Bq l^{-1}) being much higher than those of 1984 (15 ± 39 MBq km^{-2}, 0.01 Bq l^{-1}). Such fluctuations have occurred in the past; for example, the deposition at Aitutaki in 1983 was 141 ± 45 MBq km^{-2} (concentration 0.12 Bq l^{-1}). The cause of these fluctuations is not known but as the β activity is now primarily due to natural ^{210}Pb [3] it is presumably a natural phenomenon. The low-volume air pump at Tonga did not afford sufficient sensitivity to determine whether or not this higher rainwater activity was reflected in higher air β activity — the latter remained below the limit of detection throughout the year.

All the above concentrations were very small fractions of the reference level (220 Bq l^{-1}).

3. Strontium-90 deposition

The ^{90}Sr deposition was below the limit of detection at most stations throughout the year (Table 2). The annual total deposition was measurable only at Kaitaia (0.1 MBq km^{-2}) and at Auckland and Hokitika (0.2 MBq km^{-2}). The New Zealand country-wide mean deposition was <0.1 MBq km^{-2} which was significantly lower than in 1984[3] (0.6 MBq km^{-2}). Annual depositions at Suva and Rarotonga were also <0.1 MBq km^{-2}, and the ^{90}Sr concentration in rainwater was <0.001 Bq l^{-1} at all stations.

^{90}Sr deposition has been monitored quarterly at 11 stations, providing 44 quarterly determinations per year. Over recent years an increasing number of determinations have been less than the detection limit (L_D): in 1983[6] 22% were <L_D; in 1984[3], 68%; in 1985, 91%. It thus appears that the era of ^{90}Sr fallout is virtually over in the South Pacific region and that intensive deposition monitoring is no longer justified.

4. Strontium-90 and caesium-137 in milk

Quarterly average ^{90}Sr levels in milk ranged from 0.010 Bq gCa^{-1} to 0.103 Bq gCa^{-1} with a country-wide annual mean of 0.036 Bq gCa^{-1}, similar to the 1984 mean of 0.043 Bq gCa^{-1},[3] and representing less than 0.4% of the reference level (10 Bq gCa^{-1}).

Quarterly average ^{137}Cs levels in milk ranged from <0.04 Bq gK^{-1} to 1.77 Bq gK^{-1} with a country-wide mean of 0.27 ± 0.09 Bq gK^{-1} (0.1% of reference level), similar to the 1984 mean of 0.17 ± 0.07 Bq gK^{-1}.[3]

Levels of fallout radionuclides in milk have been following the same downward trend as levels in rain since 1970 (Fig. 3). Now that ^{90}Sr is virtually undetectable in rain it is expected to reach similarly low levels in milk within the next few years, as soils become depleted (due to decay and leaching).

5. Lead-210 deposition

Concentrations of lead-210, a naturally occurring radionuclide, in rainwater have been measured in the rainwater samples collected for ^{90}Sr evaluation. During the period 1967-84 the country-wide annual average depositions were in the range 52 ± 12 MBq km^{-2}, with annual station depositions ranging from 23 ± 5 MBq km^{-2} at Christchurch to 122 ± 24 MBq km^{-2} at Hokitika.[3]

During 1985 depositions ranged from 16 MBq km^{-2} at Christchurch to 82 MBq km^{-2} at Hokitika with a country-wide average of 40 MBq km^{-2}.

6. Gamma-emitting radionuclides on high-volume filters

No artificial radionuclides were detected on high-volume air filters from Hokitika and Kaitaia during the third quarter of 1985. Mean ^{7}Be levels at Hokitika and Kaitaia during the period were 3 Bq m^{-3} and 5 Bq m^{-3} respectively.

7. Comparison of New Zealand results with other countries

New Zealand monitoring results are generally similar to those of other countries as shown in the table below. The data are for the third quarter 1985, from a quarterly World Health Organization report.[7]

Fallout levels are similar worldwide because only long-term global stratospheric fallout is involved, with little regional tropospheric variation.

MEAN RESULTS FOR THIRD QUARTER, 1985[7]

Country	β activity in air Bq m^{-3}	β activity in rain MBq km^{-2}	^{90}Sr in rain MBq km^{-2}	^{90}Sr in milk Bq gCa^{-1}	^{137}Cs in milk Bq gK^{-1}
New Zealand	<0.0003	21	<0.1	0.032	0.20
France	<0.001	<35	<4.2	<0.12	<0.17
Sweden			0.13	0.07	0.15
U.S.S.R.				0.067	0.12
U.S.A.	0.00041	15		<0.1	0.08
Japan (2nd Qtr)			0.08	0.058	0.11
Canada	0.00032	67			

FUTURE FALLOUT MONITORING

The very low residual levels of artificial radioactivity in the environment led to the proposal of modifications to the fallout monitoring programme as described in the 1984 Annual Report.[3] These changes were:

(a) the installation of high-volume air pumps at Kaitaia, Hokitika and Rarotonga, with analysis of filters for gamma-emitting radionuclides;

(b) the restriction of ^{90}Sr in rain measurements to Kaitaia, Hokitika and Rarotonga only;

(c) the restriction of total β activity in rainwater and air filter measurements to Rarotonga, Hokitika and Christchurch only;

(d) the restriction of milk monitoring to Auckland, Taranaki and Westland only.

It was decided to establish the suitability of the high-volume pumps by running at least one of them for a year while continuing the normal fallout monitoring programme. The Hokitika pump was installed in August and, subject to continued satisfactory performance, it is now planned to complete the change to the modified programme in July 1986 (at the end of the 2nd quarter monitoring period). Proposal (c) has been modified slightly to include β activity in rainwater at Rarotonga and Hokitika only, and β activity in air at Kaitaia, Hokitika and Rarotonga.

Equipment withdrawn from other stations will be serviced and stored for redeployment if necessary in the future.

MISCELLANEOUS, SPECIAL SURVEYS, PROJECTS

(1) International intercomparisons

The Laboratory took part in one intercomparison during 1985: analysis of a U.S. Environmental Protection Agency milk sample for ^{131}I, ^{137}Cs, ^{90}Sr and K.

(2) Natural radionuclides in New Zealand coals

The survey of uranium, thorium and potassium concentrations in coals was initiated in 1985 with the analysis of coals from the Southland region. This survey is continuing in 1986.

(3) Relationship between air and rain levels of beryllium-7

The relative efficiencies of high-volume air and high-volume rainwater sampling for fallout monitoring are being assessed by comparing ^{7}Be levels in samples collected concurrently by the two techniques. This project will be completed in 1986.

(4) Natural radiation survey

A survey of natural radiation exposure in New Zealand has commenced with measurements of alpha activity in air and gamma radiation exposure in randomly selected houses throughout the country.

(5) Publication

Matthews, K. M.; Potipin, K. "Extraction of fallout ^{210}Pb from soils and its distribution in soil profiles." J. Environmental Radioactivity, 2, 319-331 (1985).

ACKNOWLEDGEMENT

We gratefully acknowledge the assistance given by the staff of this and other Government Departments, especially the New Zealand Meteorological Service and managers of milk processing plants. Without their co-operation this monitoring would not have been possible. The Laboratory's Environmental Radioactivity and Chemistry Section organized the monitoring and analysed the samples. This report was written by the Section Head, Dr K M Matthews. He was assisted technically by Miss M-J Okey.

A. C. McEwan
Director

Published with the authority of the Director-General of Health.

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TABLE 1 - Total Beta Activity in Rain: 1985 (Weekly Collections):

Cumulative Rainfall (mm)
Cumulative Deposition (MBq km^{-2})
Weighted Mean Concentration (Bq l^{-1})

New Zealand Stations	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1985
Auckland					
mm	342	314	265	272	1193
MBq km^{-2}	19 ± 7	19 ± 7	24 ± 7	20 ± 7	82 ± 14
Bq l^{-1}	0.06 ± 0.02	0.06 ± 0.02	0.09 ± 0.03	0.07 ± 0.02	0.07 ± 0.01
Wellington					
mm	260	425	384	389	1458
MBq km^{-2}	13 ± 7	21 ± 6	18 ± 7	25 ± 7	77 ± 14
Bq l^{-1}	0.05 ± 0.03	0.05 ± 0.01	0.05 ± 0.02	0.06 ± 0.02	0.05 ± 0.01
Hokitika					
mm	417	473	636	526	2052
MBq km^{-2}	39 ± 7	28 ± 12	51 ± ±4	58 ± 13	176 ± 24
Bq l^{-1}	0.09 ± 0.02	0.06 ± 0.03	0.08 ± 0.02	0.11 ± 0.02	0.09 ± 0.01
Christchurch					
mm	100	81	155	188	524
MBq km^{-2}	9 ± 6	7 ± 5	12 ± 7	11 ± 6	39 ± 12
Bq l^{-1}	0.09 ± 0.06	0.08 ± 0.06	0.08 ± 0.04	0.06 ± 0.03	0.07 ± 0.02
Weighted Means					
MBq km^{-2}	19 ± 3	15 ± 3	21 ± 4	21 ± 4	76 ± 7
Bq l^{-1}	0.07 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.08 ± 0.01	0.07 ± 0.01
Pacific Islands Stations					
Nandi, Fiji					
mm	1085	427	121	245	1878
MBq km^{-2}	22 ± 15	31 ± 15	11 ± 13	24 ± 13	88 ± 28
Bq l^{-1}	0.02 ± 0.01	0.07 ± 0.04	0.09 ± 0.11	0.10 ± 0.05	0.03 ± 0.01
Samoa					
mm	1364	628	251	299	2542
MBq km^{-2}	18 ± 22	39 ± 21	6 ± 19	20 ± 17	83 ± 40
Bq l^{-1}	0.01 ± 0.02	0.06 ± 0.03	0.03 ± 0.08	0.07 ± 0.06	0.03 ± 0.02
Tonga					
mm	455	232	110	259	1056
MBq km^{-2}	56 ± 21	21 ± 19	17 ± 19	24 ± 18	118 ± 39
Bq l^{-1}	0.12 ± 0.05	0.09 ± 0.08	0.16 ± 0.17	0.09 ± 0.07	0.11 ± 0.04
Aitutaki					
mm	383	451	130	660	1624
MBq km^{-2}	12 ± 20	24 ± 21	11 ± 18	31 ± 17	78 ± 38
Bq l^{-1}	0.03 ± 0.05	0.05 ± 0.04	0.08 ± 0.14	0.05 ± 0.03	0.05 ± 0.02
Rarotonga					
mm	628	700	296	756	2380
MBq km^{-2}	17 ± 15	20 ± 16	6 ± 13	4 ± 13	47 ± 29
Bq l^{-1}	0.03 ± 0.02	0.03 ± 0.02	0.02 ± 0.04	0.01 ± 0.02	0.02 ± 0.01

TABLE 2 - Strontium-90 in Rain: 1985:

Rainfall (mm)
Deposition (MBq km^{-2})
Concentration (Bq l^{-1})

New Zealand Stations		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Av
Kaitaia	mm	330	404	452	333	1519	
	MBq km^{-2}	0.1	<0.1	<0.1	<0.1	0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Auckland	mm	396	339	306	167	1208	
	MBq km^{-2}	0.2	<0.1	<0.1	<0.1	0.2	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
New Plymouth	mm	324	398	377	288	1387	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Havelock North	mm	217	233	275	166	891	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Wellington	mm	255	434	385	306	1380	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Hokitika	mm	457	523	693	666	2339	
	MBq km^{-2}	0.1	<0.1	0.1	<0.1	0.2	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Christchurch	mm	101	81	150	193	525	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Dunedin	mm	94	90	88	140	412	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Invercargill	mm	281	283	230	219	1013	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Average	mm	273	309	328	275	1185	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Pacific Islands Stations							
Suva, Fiji	mm	877	622	433	491	2423	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001
Rarotonga	mm	581	711	228	528	2048	
	MBq km^{-2}	<0.1	<0.1	<0.1	<0.1	<0.1	
	Bq l^{-1}	<0.001	<0.001	<0.001	<0.001		<0.001

The counting error for deposition results was approximately ±0.08 MBq km^{-2}.

TABLE 3 - Strontium-90 in Milk 1985: (Bq gCa^{-1})

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Av
Northland	0.047	0.053	0.034	0.047	0.045
Auckland	0.023	0.025	0.027	0.032	0.027
Waikato	0.050	0.017	0.031	0.042	0.035
Taranaki	0.103	0.051	0.051	0.052	0.064
Palmerston North	0.027	0.023	0.025	0.026	0.025
Wellington	0.033	0.034	0.025	0.041	0.033
Westland	0.063	0.053	0.055	0.062	0.058
Christchurch	0.013	0.010	0.015	0.023	0.015
Dunedin	0.015	0.016	0.021	0.021	0.018
Average	0.042	0.031	0.032	0.038	0.036

The counting error was approximately ±0.002 Bq gCa^{-1}.

TABLE 4 - Caesium-137 in Milk 1985: (Bq gK^{-1})

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Av
Northland	0.31	0.16	0.22	0.25	0.24
Auckland	0.20	0.20	0.09	0.12	0.15
Waikato	0.51	0.54	0.31	1.77	0.78
Taranaki	1.02	0.83	0.47	0.48	0.70
Palmerston North	<0.04	<0.04	0.15	0.04	0.07
Wellington	0.10	0.18	0.14	0.06	0.12
Westland	0.21	0.18	0.24	0.19	0.21
Christchurch	0.08	0.10	0.12	0.05	0.09
Dunedin	<0.04	0.04	0.04	<0.04	0.04
Average	0.28	0.25	0.20	0.33	0.27

The counting error was approximately ±0.03 Bq gK^{-1}.

FIGURE 3: TRENDS IN FALLOUT LEVELS IN NEW ZEALAND