NRL

National Radiation Laboratory

Environmental Radioactivity in New Zealand and Rarotonga - Annual Report

R Pilviö

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MINISTRY OF HEALTH

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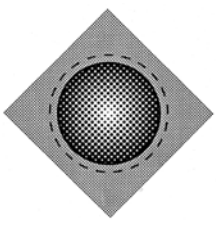

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Summary

Artificial radioactivity in the environment in New Zealand and Rarotonga monitored during 2001 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 Hokitika (until 16.9.2001), Kaitaia, Rarotonga and Chatham Islands; deposited radioactivity was monitored at Hokitika; and milk radioactivity was monitored in the Waikato, Taranaki and Westland regions. The average weekly total beta concentration in deposition in Hokitika was 4.4 ± 2.6 Bq/m^2. The annual average levels measured were:

Total beta concentration in air in Hokitika:	**0.116 ± 0.046 mBq/m^3**
^{137}Cs in milk in Waikato:	**0.61 ± 0.29 Bq/kg**
^{137}Cs in milk in Taranaki:	**1.25 ± 0.81 Bq/kg**
^{137}Cs in milk in Westland:	**0.44 ± 0.13 Bq/kg**

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 hydro acoustic. 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 the air sampling was stopped in September 2001.

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 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, Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) and the US Environmental Measurements Laboratory (US EML). 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) and beryllium-7 (^{7}Be) in the atmosphere. Beryllium-7 is a cosmogenic nuclide (a product of spallation reactions of cosmic radiation within the upper atmosphere), while ^{210}Pb is the decay products of gaseous radon-222 (^{222}Rn), which diffuses out of soil. Lead-210 and the artificial strontium-90 (^{90}Sr) deposition were monitored at one New Zealand site until September 2001.

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 of the following measurements during 2001:

Atmospheric radioactivity: Atmospheric monitoring is regarded as the most important component of the monitoring programme because any radioactive pollution reaching the region would 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 concentration (TBC), fission products, ^{7}Be, and ^{210}Pb levels were monitored with weekly collections of particulates from surface air at Hokitika until September 2001. Daily collections of particulates were performed at Kaitaia, Rarotonga and Chatham Islands stations.

Atmospheric monitoring involves two different air sampling systems. At Kaitaia, Rarotonga and Chatham Islands 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 2 to 6 μBq/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 TBC; and radiochemically for ^{210}Pb. The minimum detectable concentration for a fission product such as ^{137}Cs in the weekly filter analyses was 0.5 μBq/m^3 (average concentration).

Radioactive deposition: TBC 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 deposition was monitored on a weekly basis at Hokitika, using a large-area (1 m^2) rain collector until September 2001. Beryllium-7 measurements were used as a quality control for the performance of the sampling system.

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 2001 Monitoring results

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

No significant concentrations of artificial radionuclides were detected by gamma-spectroscopic analysis of daily or weekly air filters collected from each monitoring station during 2001.

The air sampling at Hokitika was continued until 16.9.2001. The TBC at Hokitika during 2001 ranged from 0.04 mBq/m^3 to 0.22 mBq/m^3 with an overall annual average of 0.116 ± 0.046 mBq/m^3. Atmospheric TBC was almost entirely due to natural radionuclides, as described in the 1993 report[6].

Beryllium-7 continued to be the most significant radionuclide detected on the air filters during 2001. Lead-210 levels were similar at all 4 monitoring sites. The annual average concentrations of ^{7}Be and ^{210}Pb in air filters from Hokitika (until 16.9.2001), Kaitaia, Rarotonga and Chatham Island are presented in Table 1.

Table 1. The annual average concentrations of ^{7}Be and ^{210}Pb in air filters in 2001 at four monitoring stations.

Sampling site	^{7}Be (mBq/m^3)	^{210}Pb (μBq/m^3)
Hokitika	2.46 ± 0.83	99 ± 57
Kaitaia	3.4 ± 1.5	81 ± 62
Rarotonga	3.4 ± 1.7	73 ± 43
Chatham Island	2.3 ± 1.2	49 ± 44

The annual trend in ^{7}Be levels continued to demonstrate the normal cycles of summer maxima and winter minima in all four monitoring stations. Total-beta activity measurements 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

No artificial radionuclides were detected in the deposition samples by gamma-spectrometric analysis. The TBC deposition for 2001 at Hokitika was 224 Bq/m^2 with 2771 mm of rainfall. The average weekly deposition was 4.4 ± 2.6 Bq/m^2.

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.[7] The average weekly deposition of ^{210}Pb in Hokitika until 16.9.2001 was 3.7 ± 2.9 Bq/m^2.

Strontium-90 deposition was measured in six-monthly aggregate of strontium recovered from the monthly rainwater collections for the first half of year 2001. No ^{90}Sr was detected in the deposition. The MDC for this measurement was 7 mBq/sample.

3.3 Radioactivity in milk

Caesium-137 levels in cows' milk were assessed by gamma spectroscopic analysis of monthly samples of milk powder. Results are summarised in Table 2.

Table 2. Annual average ^{137}Cs concentrations in milk powder for Waikato, Taranaki and Westland for 2001.

Region	^{137}Cs (Bq/kg)
Waikato	0.61 ± 0.29
Taranaki	1.25 ± 0.81
Westland	0.44 ± 0.13

The ^{90}Sr levels in cows' milk were extremely low and the concentrations were below the MDC of 26 mBq/kg of milk powder.

4 Quality Management

Quality management is an essential feature of any measurement laboratory's operations. In December 2001 NRL was awarded a certificate of approval for its quality management system to the quality standard 'AS/NZS ISO 9001:2000. Quality management systems – requirements".

During 2001 the Environmental Laboratory participated in five intercomparison exercises, conducted by the CTBTO and the US EML, involving analysis of air filters, soil, vegetation and water. Results are shown in Tables 3-6.

Table 3. Results of the intercomparison exercise QAP54 organised by the US EML. For evaluation A = acceptable, W = acceptable with warning and N = not acceptable.

Sample	Radionuclide	NRL value	Reference value	Evaluation
Air filter (Bq/filter)	^{54}Mn	6.3 ± 0.3	6.52 ± 0.28	A
	^{60}Co	18.1 ± 0.9	19.44 ± 0.50	A
	^{134}Cs	2.1 ± 0.1	2.83 ± 0.16	W
	^{137}Cs	8.2 ± 0.4	8.76 ± 0.34	A
Soil (Bq/kg)	^{40}K	466 ± 14	468 ± 25	A
	^{137}Cs	1820 ± 20	1740 ± 90	A
	^{212}Bi	59.0 ± 9.0	42.0 ± 4.1	A
	^{212}Pb	41.1 ± 0.9	41.5 ± 2.2	A
	^{214}Bi	26.0 ± 2.0	32.6 ± 1.4	W
	^{214}Pb	26.0 ± 2.0	34.3 ± 1.6	N
	^{228}Ac	27.0 ± 2.0	42.7 ± 1.7	W
	^{234}Th	38.0 ± 6.0	46.6 ± 3.5	A
	^{241}Am	17.8 ± 1.3	14.80 ± 0.51	A
Vegetation (Bq/kg)	^{40}K	880 ± 40	603 ± 32	N
	^{60}Co	29.5 ± 1.5	30.4 ± 1.2	A
	^{137}Cs	760 ± 40	842 ± 42	A
Water (Bq/L)	^{60}Co	88.0 ± 4.0	98.2 ± 3.6	W
	^{90}Sr	3.2 ± 0.1	4.4 ± 0.2	W
	^{137}Cs	63.0 ± 3.0	73.0 ± 3.7	W
	U	0.71 ± 0.08	2.12 ± 0.09	N
	Gross alpha	1240 ± 130	1900 ± 190	W
	Gross beta	1340 ± 140	1297 ± 100	A

Table 4. Results of the intercomparison exercise QAP55 organised by the US EML. For evaluation A = acceptable, W = acceptable with warning and N = not acceptable.

Sample	Radionuclide	NRL value	Reference value	Evaluation
Soil	^{40}K	588 ± 15	623.33 ± 33.04	A
(Bq/kg)	^{137}Cs	666.8 ± 8.3	612.33 ± 30.62	A
	^{212}Bi	61.8 ± 8.5	62.067 ± 5.152	A
	^{212}Pb	60.2 ± 1.9	58.33 ± 3.13	A
	^{214}Bi	46.9 ± 1.8	36.9 ± 1.53	W
	^{214}Pb	48.5 ± 1.7	39.67 ± 1.72	A
	^{228}Ac	53.9 ± 3.6	59.57 ± 2.09	A
	^{234}Th	104.0 ± 8.2	100.067 ± 6.204	A
	^{241}Am	5.86 ± 0.83	4.432 ± 0.312	A
Vegetation	^{40}K	886 ± 16	898.67 ± 48.23	A
(Bq/kg)	^{60}Co	37.11 ± 0.92	35.300 ± 1.436	A
	^{137}Cs	1150 ± 15	1030.0 ± 51.8	A
	^{241}Am	8.99 ± 0.97	6.915 ± 0.419	A
Water	^{60}Co	220.3 ± 3.8	209.00 ± 7.59	A
(Bq/L)	^{137}Cs	50.46 ± 0.97	45.133 ± 2.467	A
	^{234}U	0.883 ± 0.052	1.166 ± 0.062	N
	^{238}U	0.884 ± 0.052	1.169 ± 0.056	N
	Gross alpha	1486 ± 55	1150 ± 115	N
	Gross beta	11580 ± 480	7970 ± 800	W

Table 5. Results of the intercomparison exercises MAPEP-01-S8 (soil) and MAPEP-00-W8 (water) organised by the US EML. For evaluation A = acceptable, W = acceptable with warning and N = not acceptable.

Sample	Radionuclide	NRL value	Reference value	Evaluation
Soil	^{40}K	631 ± 14	652.0	A
(Bq/kg)	^{54}Mn	212.2 ± 4.4	203.0	A
	^{57}Co	104.8 ± 3.5	103.0	A
	^{60}Co	1300 ± 23	1270	A
	^{65}Zn	403 ± 14	382.0	A
	^{134}Cs	75.9 ± 3.0	91.1	A
	^{137}Cs	1222 ± 20	1240	A
Water	^{54}Mn	1.9 ± 0.5	2.87	A
(Bq/L)	^{57}Co	100 ± 2	95.5	A
	^{60}Co	2.1 ± 0.4	2.19	A
	^{65}Zn	5.7 ± 1.0	4.59	A
	^{134}Cs	295 ± 5	283	A
	^{137}Cs	99 ± 2	94.4	A
	^{234}U	0.77 ± 0.08	0.99	W
	^{238}U	0.81 ± 0.08	1.02	W
	^{241}Am	1.3 ± 0.4	1.06	W

Table 6. Results of the Proficiency test exercise organised by the CTBTO. For evaluation A = acceptable, W = acceptable with warning and N = not acceptable.

Sample	Radionuclide	NRL value	Reference value	U-test
Air filter (Bq/filter)	^{95}Zr	15.95 ± 0.09	15.95 ± 0.49	A
	^{95}Nb	6.81 ± 0.12	5.82 ± 0.23	N
	^{99}Mo	7.51 ± 0.24	5.60 ± 0.10	N
	^{103}Ru	18.84 ± 0.33	18.11 ± 0.76	A
	^{132}Te	6.75 ± 0.16	5.21 ± 0.22	N
	^{132}I	6.31 ± 0.18	5.37 ± 0.10	N
	^{137}Cs	0.21 ± 0.01	0.21 ± 0.00	A
	^{140}Ba	69.10 ± 0.90	65.81 ± 1.05	W
	^{140}La	79.00 ± 0.95	75.82 ± 0.91	W
	^{141}Ce	49.83 ± 0.37	48.58 ± 0.54	A
	^{144}Ce	8.22 ± 0.15	8.27 ± 0.40	A
	^{144}Pr	8.90 ± 2.60	8.27 ± 0.40	A
	^{147}Nd	25.60 ± 0.85	24.89 ± 1.94	A

Overall, results were satisfactory. All unacceptable results have been reviewed to find out the reasons for discrepancies.

Acknowledgement

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The Environmental Laboratory of the NRL organised the monitoring and analysed the samples.

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