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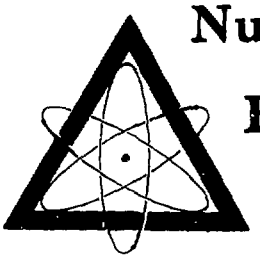

Nuclear Energy Board

ENVIRONMENTAL RADIOACTIVITY SURVEILLANCE PROGRAMME 1988-89

S. Sequeira, D. Pollard,
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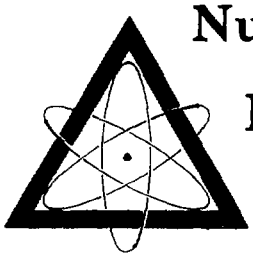

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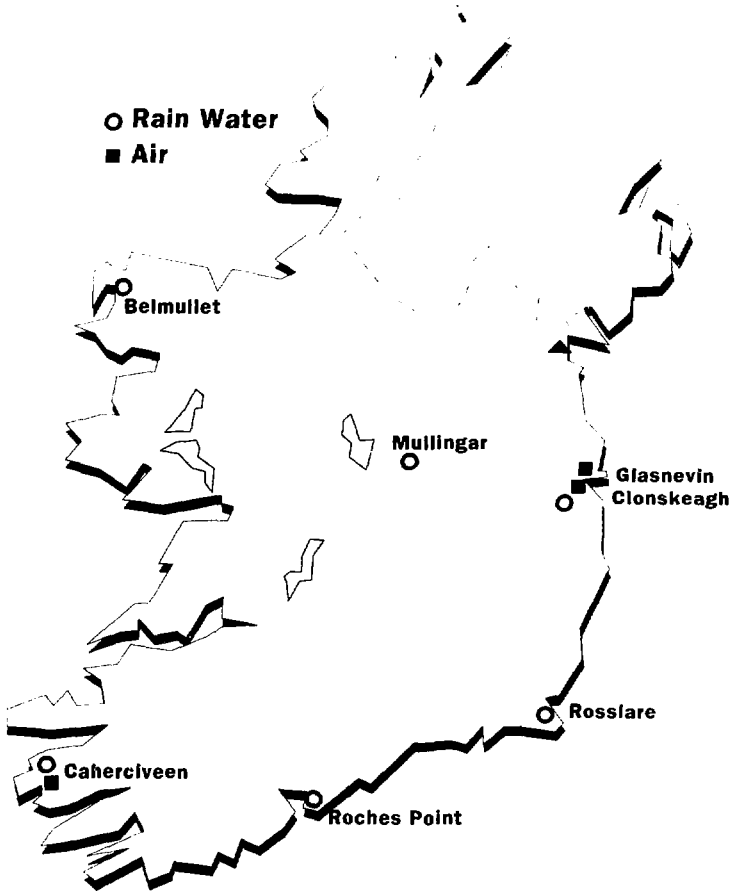
1. INTRODUCTION

The Nuclear Energy Board measures radionuclides in air, rainwater, total fallout, drinking water supplies and milk as part of its programme to monitor radioactivity in the Irish environment. This is undertaken in conjunction with the Meteorological Service of the Department of Transport and Tourism, the Department of the Environment and the Department of Agriculture and Food. The processing of samples and the measurement of the radioactivity concentrations are carried out in the laboratory of the Nuclear Energy Board. The programme is summarised in Table 1 and the sampling locations around the country shown in Figure 1. This report presents the results of measurements made during 1988 and 1989.

Each Member State of the European Community undertakes environmental radioactivity monitoring programmes in accordance with the provisions of Article 36 of the 1957 Treaty of Rome establishing the European Community. This programme fulfils Irish obligations in this regard and the results are included in routine reports of radioactivity concentrations in the Community.

FIGURE 1
Air and Rainwater Sampling Locations



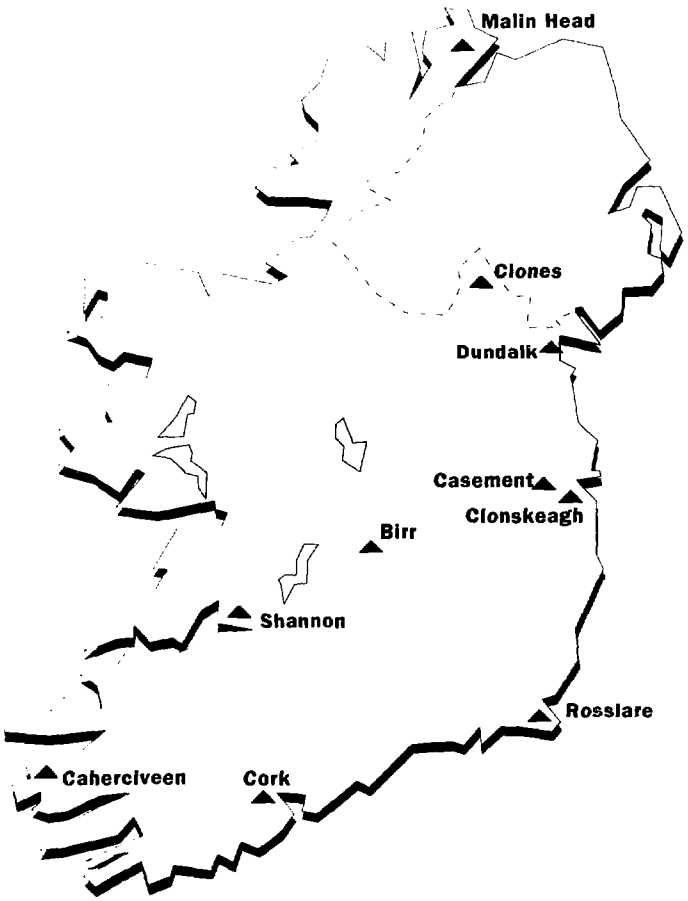
2. EXTERNAL GAMMA DOSE RATE

Ten continuous external gamma dose rate monitoring stations were in operation during 1989 as part of the National Nuclear Emergency Plan. The locations of these stations are shown in Figure 2. Of the ten, eight are located at synoptic stations operated by the Irish Meteorological Service, one at a Department of Defence site in Dundalk and one at the premises of the NEB in Clonskeagh.

The background dose rate for each station is shown in Figure 3. The variation between stations was significant with a range of 0.0829 μSv/h (Malin Head) to 0.119 μSv/h (Dundalk).

The only significant variations from background noted during the year were increases in the dose rate during heavy rainfall. These increased levels had a decay rate consistent with their being due to washout of radon daughters. These were noted, in particular, at Casement in February and March, Malin Head in October and at Rosslare and Cork in November. The highest increase was noted at Malin Head in October where the dose rate immediately after heavy rain rose by approximately 70% of the background level. Figure 4 shows the maximum dose rate recorded for each station for each month.

FIGURE 2
Gamma Dose Rate Monitors



3. AIRBORNE DUST

Methods of Sampling and Analysis

Airborne dust was sampled at three locations, two in Dublin at Clonskeagh and Glasnevin and one at Cahirciveen, Co Kerry. The dust was collected by drawing air through a 48 mm Whatman No. 41 filter paper as follows:-

Location	Volume of Air per sample (m^3)	Duration of Sampling (hrs.)	Frequency of sampling
Clonskeagh	300	168	one per week
Glasnevin	70	24	four per week
Cahirciveen	75	24	seven per week

The filter was covered with a layer of thin cellulose acetate adhesive tape and analysed for gross beta activity on a gas flow proportional counter utilising a 90% argon, 10% methane mixture. The results reported are of analyses carried out at least three days after the collection of the samples had been completed to permit the decay of shortlived naturally occurring radionuclides to non-detectable levels. The results, therefore, indicate the level of air contamination due to man-made radionuclides. Each sample was counted for a period of one hour. The gross beta activity concentration was calculated by comparing the sample count rate with the count rate from a series of standard filter papers impregnated with potassium-40. The potassium-40 standards were prepared by saturating the filter papers with known amounts of potassium chloride in solution and then allowing them to dry. The gross beta channel background of the counter is low, 1.2 ± 0.1 counts per minute. The 95% detection limit for a one hour count is 25 millibecquerels (mBq) and a typical activity concentration corresponding to the detection limit is 0.5 millibecquerels per cubic metre (mBq m^{-3}).

Results

The ranges of gross beta activity concentrations in airborne dust at Dublin and Cahirciveen are given in Table 2. In most cases the gross beta activity was below the level of detection. The levels observed in 1989 were lower than those in 1988 both at Dublin and Cahirciveen. The highest gross beta activity concentration detected in 1988 was 3.5 mBq m^{-3} and in 1989 1.9 mBq m^{-3}.

4. TOTAL FALLOUT

Methods of Sampling and Analysis

Total fallout samples were collected at Glasnevin, Co. Dublin and Cahirciveen, Co. Kerry weekly by the water pot method in which a water surface is maintained in the bottom of a plastic collection vessel to ensure retention of dry material and precipitation. 500 ml of distilled water were placed in the vessel and samples collected over a period of one week. Distilled water was added as required to offset evaporation losses and to rinse out the samples at the end of the sampling period. The samples were reduced by evaporation to about 25 ml and then dried, using an IR lamp, on flat bottomed stainless steel planchettes, 52 mm in diameter. The samples were analysed for gross beta activity using the same procedure employed for the air filters except that the standard used was a potassium-40 standard in the solid form prepared by evenly dispersing solid potassium chloride on a stainless steel planchette. A typical value corresponding to a 95% detection limit was 0.034 becquerels per square metre per day (Bq m^{-2} d^{-1}).

Results

The gross beta activities from fallout at Dublin and Cahirciveen are presented in Table 3 which give the total activity deposited each month together with the annual deposition.

The gross beta activities of total fallout for the period 1985-1989 are given below. They show that the sustained increase detected in 1986 due to the Chernobyl accident has disappeared and that the levels are similar to those before the accident.

Year	Gross beta activity of fallout, Bq m^{-2}	
	Dublin	Cahirciveen
1985	109	36
1986	7847	5949
1987	146	73
1988	92	78
1989	48	59

5. RAINWATER

Methods of Sampling and Analysis

Rainwater samples were collected monthly at the seven stations shown in Table 1 using two funnels, 12.5 and 25 cm in diameter, connected to two polythene containers.

Sampling was started on the first day of each month and continued until the first day of the following month at which time the container was removed and the sample sent for analysis. The samples from either or both polythene containers were taken as the monthly sample with the preferred sample volume being at least one litre.

The sample from the NEB was measured monthly whereas those from the other stations were bulked on a quarterly basis and reduced in volume to about 200 ml. These were then measured on a high resolution germanium detector system which has a measured relative efficiency of 30.9% at the 1.33 MeV cobalt-60 line. The corresponding resolution is 1.90 keV. The detector is housed in a copper cadmium lined lead castle of thickness 10 cm. A typical detection limit for caesium-137 using this procedure is 0.03 becquerels per litre (Bq l^{-1}). A 20 ml aliquot from each of the concentrated bulked samples was evaporated to dryness and analysed for gross beta activity using the same procedure employed for the total fallout samples. A typical value corresponding to a 95% detection limit for this method is 0.018 Bq l^{-1}.

Results

The values for the deposition of radioactivity in rainwater at the 7 stations are given in Tables 4A-4G. The rainfall for these periods is also included.

The mean annual values for deposited radioactivity, derived from the individual values observed at each station, were as follows:

	Radioactivity Bq m^{-2}		
Year	Gross Beta	Cs-134	Cs-137
1988	<140	<55	<59
1989	< 97	<18	<23

The external gamma doses from deposited caesium isotopes in 1988 and 1989 were <3.5 μSv and <1.3 μSv respectively. These were calculated using the International Atomic Energy Agency (IAEA) conversion factor for external gamma doses integrated to one year for Cs-134 and Cs-137 (1). These factors are applicable for estimating the doses to people permanently out of doors; appropriate conversion factors need to be applied to take account of shielding by the types of buildings in which time is spent and the length of time spent indoors.

6. WATER SUPPLIES

Methods of Sampling and Analysis

One litre samples of drinking water were collected routinely at Dublin and Cahirciveen.

The samples were evaporated, dried and analysed for gross beta activity using the same procedure employed for the total fallout samples. A typical activity concentration corresponding to a 95% detection limit was 20 mBq l^{-1}.

In 1989 the Nuclear Energy Board in conjunction with the Department of the Environment initiated a systematic nationwide testing programme of radioactivity in drinking water supplies. During 1989, as part of this programme, water supplies in Dublin, Cork and Donegal were monitored. The protocol for the collection of samples for the nationwide monitoring programme was as follows:-

Samples were collected from pre-treatment sources and from treated supplies. Eight litres of water were collected from each sampling point. Samples were acidified with nitric acid (20 mls of concentrated nitric acid per litre of sample) to minimise the adsorption of radioactivity on the walls of the bottle.

The samples were analysed for gross beta activity and specific gamma emitting radionuclides using the same procedure employed for rainwater.

Results

The ranges of gross beta activity concentrations in the drinking water samples from Dublin and Cahirciveen are given in Table 5. The maximum concentrations for both Dublin and Cahirciveen in 1989 were lower than in 1988. In all cases the concentrations were well below the World Health Organisation (WHO) published guidelines values for radioactivity in drinking water i.e. 1.0 Bq l^{-1} of gross beta activity, 4.0 Bq l^{-1} of Cs-134 and 6.0 Bq l^{-1} of Cs-137 (2). These represent concentrations below which water does not require further radiological investigation.

The results for radioactivity in water at Dublin, Cork and Donegal are given Tables 6-8. In most cases the concentrations were below the detection limit. There was no appreciable difference between the concentrations in the public supplies and their corresponding sources. The concentrations of radioactivity in all the samples were well below the WHO published guidelines values mentioned above.

7. MILK

Methods of Sampling and Analysis

The routine monitoring of radioactivity in milk was commenced in April 1989 and was carried out in conjunction with the Department of Agriculture and Food.

Milk was sampled monthly at 9 creameries and dairies around the country. Four litres of milk were sent from each station every month, two of which were preserved with 5 g of sodium metabisulphite. On receipt of the samples, 5 ml of 37-41% formaldehyde were added to the non-preserved sample which was then set aside for strontium-90 analysis. The other sample was used for high resolution gamma spectroscopy. All the samples were stored at 4° C and milk from each station was bulked and analysed separately on a quarterly basis.

The concentrations of specific gamma emitting radionuclides in the bulked samples were measured on the system described in section 4 using 500 g marinelli beakers.

The procedure for measuring strontium-90 was as follows: yttrium carrier solution was added to the milk sample. The sample was boiled to dryness on a hot plate and then ashed overnight at 450° C in a muffle furnace. The ash was digested in concentrated nitric acid, evaporated to dryness and maintained at 450° C in a furnace for one hour to completely oxidise the sample. The residue was dissolved in hot 1.0M hydrochloric acid, the solution allowed to cool, the pH adjusted to 1.0 and the yttrium extracted with di-(2 ethylhexyl) phosphate in toluene. The yttrium was back extracted into 3.0M nitric acid and precipitated as the hydroxide by making the solution strongly alkaline with ammonia. The yttrium hydroxide pellet was separated by centrifugation, redissolved in acid and counted on a liquid scintillation counter using Cherenkov counting. The activity of yttrium-90 was measured at intervals over a period of several days and the initial activity concentration at the time of precipitation calculated. Procedural losses were then determined by measuring the amount of yttrium carrier remaining in the samples using a complexometric method with xylenolorange as indicator.

Validation of the methodology was confirmed by analysing IAEA intercomparison milk powder samples: the results obtained were in good agreement with the expected values.

Detection levels and confidence intervals were derived using statistics applicable to detection of low levels of radioactivity (3). These were 0.1 Bq l^{-1}, 0.2 Bq l^{-1} and 0.05 Bq l^{-1} for caesium-134, caesium-137 and strontium-90 respectively.

Results

Activity concentrations of potassium-40, strontium-90, caesium-134 and caesium-137 at each sampling station are given in Table 9.

No caesium-134 was detected in any of the milk samples. Caesium-137 was only detected in the samples from Monaghan, Cork, Roscommon, Kerry and Tipperary (2nd quarter), and Roscommon (3rd quarter); all these measured concentrations were only very slightly higher than the minimum detectable limit. The levels of strontium-90 were comparable to those obtained in the UK during 1987 (8). However, in all cases none of the radionuclides were present in sufficient amount to be considered significant from a radiological protection viewpoint.

A review of radioactivity concentrations in milk since the Chernobyl accident in 1986 demonstrates the continuing fall in levels from 1986 following Chernobyl, through 1987 and 1988 (4,5,6). The national quarterly means for Sr-90, Cs-134 and Cs-137 were well below the Generalised Derived Limits (GDLs) for milk based on the 1.0 mSv limit on annual effective dose equivalent recommended by the NRPB (7). These GDLs are listed below:

Radionuclide	GDL (Bq kg^{-1})	Critical Age Group
Sr-90	30	For infants aged 1 year
Cs-134	200	Adults
Cs-137	300	Adults

Data on the consumption of milk in Ireland for 1988-89 compiled by An Bord Bainne is given below.

Age Group	Milk Consumption, litres		
	Daily	Monthly	Annually
Children 0-2 years	0.466	14.17	170.09
Children 2-6 years	0.460	13.99	167.92
Adults	0.403	12.27	147.20
All	0.426	12.96	155.49

Based on these consumption rates and on the activities detected in milk the calculated committed effective dose equivalents are given below. The doses were very low and of no radiological significance.

Age Group	Dose Equivalent (µSv)		
	Cs-134	Cs-137	Sr-90
0-2 yrs	<0.29	<0.67	<1.4
6-10 yrs	<0.29	<0.62	<0.55
Adults	<0.25	<0.53	<0.34

8. CONCLUSIONS

At present, the levels of artificially produced radionuclides in the Irish air and water environments are not significant from a radiological point of view. Up until 1986 such activity originated mainly from atmospheric nuclear weapons tests. No overground tests have been reported since the last recorded explosion in China in October 1980. The Chernobyl accident in April 1986 led to an increase in airborne dust, total fallout, rainwater and milk radioactivity concentrations, but water supplies were unaffected (4).

However, by the end of 1986 and throughout 1987 a return to pre-Chernobyl levels was observed (5,9).

9. ACKNOWLEDGEMENTS

The valuable assistance provided by the officers of the Meteorological Service, the Department of the Environment and the Department of Agriculture and Food in providing and processing samples is acknowledged with gratitude.

10. REFERENCES

1. INTERNATIONAL ATOMIC ENERGY AGENCY. Derived Intervention Levels for Application in Controlling Radiation Doses to the Public in the Event of a Nuclear Accident or Radiological Emergency. Safety Series No. 81 (1986). (Vienna).

2. WORLD HEALTH ORGANISATION. Guidelines for Drinking Water Quality (1984). (Geneva).

3. SUMMERLING, T J and DARBY, S C. Statistical Aspects of the Interpretation of Counting Experiments Designed to Detect Low Levels of Radioactivity. Chilton, NRPB-R113 (1981). (London, HMSO).

4. CUNNINGHAM, J D., MAC NEILL, G. and POLLARD, D. Chernobyl: Its Effect on Ireland. Nuclear Energy Board (1987). (Dublin).

5. NUCLEAR ENERGY BOARD. Monitoring of Radioactivity in Foodstuffs in Ireland, 1987. (1988). (Dublin).

6. NATIONAL RADIOLOGICAL PROTECTION BOARD. Revised Generalised Derived Limits for Radioisotopes of Strontium, Iodine, Caesium, Plutonium, Americium and Curium. Chilton - GS8 (1987). (London, HMSO).

7. SMITH, D M., WELHAM, D., BULLOCH, K A., CARMICHAEL, L. and CLARK, I.E. Environmental Radioactivity Surveillance Programme: Results for 1987. Chilton, NRPB-R229 (1989). (London, HMSO).

8. SEQUEIRA, S., MC RANDALL, M., HAYDEN, E. and CUNNINGHAM, J.D. Radioactivity Monitoring in Ireland of Air, Deposition and Water 1982-1987. Nuclear Energy Board (1989). (Dublin).

GLOSSARY OF TERMS

Activity
Quantity of a radionuclide. It describes the rate at which spontaneous decays occur in it. It is measured in becquerels (Bq).

Dose
A general term denoting a quantity of radiation. It can be qualified as *absorbed dose, dose equivalent* or *effective dose equivalent.*

Absorbed Dose
Quantity of energy imparted by ionising radiation to the unit mass of matter such as tissue. It is measured in grays (Gy). One Gy produces different biological effects on tissue depending on the type of radiation.

Dose Equivalent
The quantity obtained by multiplying the *absorbed dose* by a factor representing the different effectiveness of the various types of radiation in causing harm to tissues. It is measured in sieverts (Sv). One Sv produces the same biological effect irrespective of the type of radiation.

Organ Dose Equivalent
Dose equivalent imparted to a given organ or tissue. It is measured in sieverts (Sv).

Effective Dose Equivalent
Weighted sum of the *dose equivalents* to the various organs and tissues. The weighting factor for each organ or tissue expresses the fractional contribution of the risk of death or serious genetic defect from irradiation of that organ or tissue to the total risk from uniform irradiation of the whole body. It is measured in sieverts (Sv).

Collective Dose Equivalent
Total dose over a population group exposed to a given source. It is represented by the product of the average dose equivalent to the individuals in the group by the number of persons comprising the group. It can be expressed as *collective organ dose equivalent* or *collective effective dose equivalent.* It is measured in man-sieverts (manSv).

Committed Dose
Total dose (expressed as *organ dose equivalent* or *effective dose equivalent)* gradually delivered to an organism during a given period of time by the decay of a radionuclide fixed in the organism following its intake into the body. The integration time is usually taken as 50 years for workers and 70 years for members of the public.

RADIATION QUANTITIES AND UNITS

For many years special measurement units for quantities of interest in radiation protection were used, which were not coherent with the International System of Units (SI). These old units, rad, rem and curie, have been superseded in the last few years by a new set of units which are coherent with the SI system.

These new units are the gray for the absorbed doses, the sievert for the dose equivalent and the becquerel for the activity of radioactive materials. The relationships between the new SI units and those previously used are shown in the following table.

Quantity	New Name and Symbol	Old Unit and symbol	Conversion Factors
Absorbed dose	gray (Gy)	rad (rad)	1 Gy = 100 rad 1 rad = 10^{-2} Sv
Dose equivalent	sievert (Sv)	rem (rem)	1 Sv = 100 rem 1 rem = 10^{-2} Sv
Activity	becquerel (Bq)	curie (Ci)	1 Bq = 2.7 x 10^{-11} Ci 1 Ci = 3.7 x 10^{10} Bq

In addition multiples and sub-multiples of the above units are frequently used. The most common ones are the following with their correspondence to old units.

Dose Equivalent:

1 Sievert (1 Sv)	= 100 rem
1 millisievert (1 mSv)	= 100 millirem (100 mrem)
1 microsievert (1 μSv)	= 0.1 millirem (0.1 mrem)

Activity:

1 becquerel (1 Bq)	= 2.7 x 10^{-11} Curie (Ci)	= 27 picocurie (pCi)
1 kilobecquerel (1 KBq)	= 2.7 x 10^{-8} Ci	= 27 nanocuries (nCi)
1 megabecquerel (1 MBq)	= 2.7 x 10^{-5} Ci	= 27 microcuries (μCi)
1 gigabecquerel (1 GBq)	= 2.7 x 10^{-2} Ci	= 27 millicuries (mCi)
1 terabecquerel (1 TBq)	= 27 Ci	

TABLE 1
Sampling Programme for 1988-89

Material	Location	Analysis
Airborne Dust	Glasnevin, Dublin Cahirciveen, Co Kerry	Gross Beta
Total Fallout	Glasnevin, Dublin Cahirciveen, Co Kerry	Gross Beta
Rainwater	Belmullet, Co Mayo Clonskeagh, Co Dublin Dublin Airport Mullingar, Co Westmeath Roches Point, Co Cork Rosslare, Co Wexford Cahirciveen, Co Kerry	Gross Beta, High resolution gamma spectroscopy
Drinking Water and Water Supplies	Glasnevin, Dublin Cahirciveen, Co Kerry Cork Supplies Dublin Supplies Donegal Supplies	Gross Beta, High resolution gamma spectroscopy,
Milk	Dublin Kilkenny Waterford Cavan Tipperary Cork Roscommon Monaghan Kerry	High resolution gamma spectroscopy Strontium - 90

TABLE 2
Gross Beta Activity in Airborne Dust 1988-89

Month	Activity Concentration (mBq m^{-3})			
	Dublin		Cahirciveen	
	1988	1989	1988	1989
January	<0.3 - 1.7	<0.3 - 1.9	<0.3 - 1.5	<0.3 - 1.8
February	<0.3 - 1.5	<0.3 - 0.7	<0.3 - 2.6	<0.3
March	<0.3 - 1.1	<0.3	<0.3 - 1.8	<0.3 - 0.4
April	<0.3 - 2.2	<0.3 - 0.4	<0.3 - 2.4	<0.3 - 0.5
May	<0.3 - 3.1	<0.3 - 0.8	<0.3 - 2.3	<0.3 - 0.5
June	<0.3 - 1.9	<0.3	<0.3 - 1.7	<0.3
July	<0.3 - 2.3	<0.3 - 0.6	<0.3 - 2.4	<0.3 - 0.5
August	<0.3 - 3.0	<0.3	<0.3 - 3.0	<0.3 - 1.4
September	<0.3 - 3.5	<0.3 - 0.5	<0.3 - 2.1	<0.3 - 0.8
October	<0.3 - 1.6	<0.3 - 0.4	<0.3 - 3.3	<0.3 - 1.1
November	<0.3 - 2.1	<0.3 - 1.0	<0.3 - 2.0	<0.3 - 1.1
December	<0.3 - 0.5	<0.3 - 1.0	<0.3 - 0.7	<0.3 - 0.6

TABLE 3
Gross Beta Activity of Fallout 1988-89

Month	Activity Deposited, (Bq m^2)			
	Dublin		Cahirciveen	
	1988	1989	1988	1989
January	8	4	6	5
February	11	4	9	6
March	6	5	6	6
April	8	5	7	2
May	8	4	10	6
June	9	5	2	12
July	8	1	4	2
August	7	2	12	5
September	9	3	4	3
October	10	4	8	5
November	5	6	5	4
December	3	5	5	3
Annual Total	92	48	78	59

TABLE 4A
Deposition of Radioactivity at Clonskeagh 1989

Period	Rainfall (mm)	Activity Deposited, (Bq m^{-2})		
		Gross Beta	Cs-134	Cs-137
January	27.5	<2.4	<1	<1
February	42.6	4.5	<1	<1
March	54.7	14.3	<1	<1
April	79.3	15.3	<1	<1
May	13.4	<1.2	<1	<1
June	67.8	6.4	<1	<1
July	9.6	<1.0	<1	<1
August	86.0	<3.8	<1	<1
September	25.1	<1.5	<1	<1
October	63.4	<4.5	<1	<1
November	40.0	3.6	<1	<1
December	55.9	20.1	<1	<1
Annual	565.3	<78.6	<12	<12

TABLE 4B
Deposition of Radioactivity in Rainwater at Belmullet 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	452.7	429.2	163.0	50.9	<25	<9	<27	<9
2nd Quarter	150.8	181.3	22.6	<12.2	<6	<3	<7	<4
3rd Quarter	403.0	254.0	43.5	56.9	<21	<7	<22	<8
4th Quarter	260.9	438.8	31.3	<33.0	<16	<8	<17	<8
Annual	1267.4	1303.3	260.4	<153	<68	<27	<73	<29

TABLE 4C
Deposition of Radioactivity in Rainwater at Glasnevin, Dublin 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	235.1	124.8	38.5	15.5	<13	<3	<14	<7
2nd Quarter	135.2	160.5	16.6	<11.7	<6	<3	<6	<3
3rd Quarter	175.9	120.7	15.3	18.0	<9	<7	<8	<9
4th Quarter	143.1	159.3	<2.6	21.4	<4	<2	<3	<2
Annual	689.6	565.3	<73.0	<96.6	<32	<15	<31	<21

TABLE 4D
Deposition of Radioactivity in Rainwater at Mullingar 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	348.3	269.2	26.5	<6.4	<18	<5	<18	<6
2nd Quarter	128.5	130.6	21.8	<9.6	<9	<2	<10	<3
3rd Quarter	290.7	166.7	<7.0	<11.6	<17	<3	<17	<4
4th Quarter	204.6	248.1	<4.9	<17.4	<10	<4	<11	<4
Annual	972.1	814.6	<60.2	<45	<54	<14	<56	<17

TABLE 4E
Deposition of Radioactivity in Rainwater at Roches Point 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	364.2	287.1	14.6	17.5	<19	<9	<20	<9
2nd Quarter	177.7	125.7	8.5	<10.1	<5	<2	<6	<3
3rd Quarter	268.2	171.6	<6.4	26.9	<16	<3	<19	<9
4th Quarter	291.5	371.9	49.5	18.7	<16	<5	17±11	<10
Annual	1101.6	956.3	<79.0	<73.2	<56	<19	<62	<31

TABLE 4F
Deposition of Radioactivity in Rainwater at Rosslare 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	296.8	233.1	36.8	11.1	<18	<5	<19	<5
2nd Quarter	142.1	141.5	19.6	<9.4	<5	<2	<6	<3
3rd Quarter	260.5	113.6	56.3	<8.4	<16	<2	<16	<3
4th Quarter	168.4	344.9	27.6	NA	<9	<4	<9	<5
Annual	867.8	833.1	140.3	—	<48	<13	<50	<16

NA = Not assayed

TABLE 4G
Deposition of Radioactivity in Rainwater at Cahirciveen 1988-89

Period	Rainfall (mm)		Activity Deposited (Bq m^{-2})					
			Gross Beta		Cs-134		Cs-137	
	1988	1989	1988	1989	1988	1989	1988	1989
1st Quarter	479.5	512.8	78.6	29.0	<27	<10	<31	<12
2nd Quarter	252.0	197.1	27.2	<13.4	<13	<3	<15	<4
3rd Quarter	329.8	239.1	44.8	<15.8	<18	<3	<21	<3
4th Quarter	458.1	426.9	77.0	58.7	<15	<5	<15	<6
Annual	1519.4	1375.9	227.6	<116.9	<73	<21	<82	<25

TABLE 5
Gross Beta Activity of Drinking Water Samples from Dublin and Cahirciveen, 1988-89

Month	Gross Beta Activity Concentrations (mBq l^{-1})			
	Dublin		Cahirciveen	
	1988	1989	1988	1989
January	<20 - 128	43 - 60	65 - 143	21 - 38
February	<20 - 143	34 - 86	53 - 105	21 - 11
March	<20 - 150	47 - 68	<20 - 397	<20 - 210
April	<20 - 173	47 - 121	<20 - 163	<26 - 251
May	<20 - 156	<20 - 37	<20 - 144	<20 - 57
June	38 - 164	46 - 102	<20 - 262	<20 - 128
July	<20 - 173	<20 - 39	<20 - 53	<20 - 52
August	<20 - 119	<20 - 98	<20 - 252	<20 - 109
September	<20 - 151	67 - 110	33 - 178	<20 - 90
October	<20	<20 - 40	<20 - 106	<20 - 54
November	25 - 111	43 - 79	24 - 105	45 - 64
December	43 - 67	43 - 86	32 - 48	<20 - 91

TABLE 6
Radioactivity Levels in Dublin Water Supplies, 1989

Supply	Description	Activity Concentration (mBq l^{-1})			
		Gross Beta	K-40	Cs-134	Cs-137
Ballyboden	Pre-treatment	160	<470	<30	<30
	Treated	110	<320	<30	<30
Ballymore	Pre-treatment	80	<460	<30	<30
	Treated	50	<260	<20	<20
Leixlip	Pre-treatment	60	<300	<30	<30
	Treated	<20	<490	<30	<30
Roundwood	Pre-treatment	<20	<460	<30	<30
	Treated	<20	<370	<30	<30

TABLE 7
Radioactivity Levels in Cork Water Supplies 1989

Supply	Description	Activity Concentration (mBq l^{-1})			
		Gross Beta	K-40	Cs-134	Cs-137
Harbour & City supply from R. Lee at Inniscarra	Pre-treatment	90	<210	<10	<10
	Treated	70	<130	<10	<10
River Lee at City waterworks Lee Road	Pre-treatment	100	<200	<10	<10
Infiltration Gallery (ground water) from River bank	Pre-treatment	110	<190	<10	<10
River Lee/ Gallery mixed from low level resevoir	Treated	100	<160	<10	<10

TABLE 8
Radioactivity Levels in Donegal Water Supplies, 1989

Supply	Description	Activity Concentration (mBq l^{-1})			
		Gross Beta	K-40	Cs-134	Cs-137
Gleneely Boring	Pre-treatment	90	<260	<10	<20
Lough Finn	Pre-treatment	80	<410	<20	<30
Lough Nameeltoga	Pre-treatment	120	<310	<20	60 ± 10
Carrigart Supply	Treated	100	<260	<10	60 ± 10
Lough Muck	Pre-treatment	60	<380	<10	<20
Fintown Supply	Treated	100	<210	<10	30 ± 20
Lough Keel	Pre-treatment	70	190 ± 5	<10	30 ± 10
Rosses Supply	Treated	50	<270	<20	40 ± 10
Lough Anna	Pre-treatment	70	<280	<10	20 ± 10
Glenties/Ardara Supply	Treated	<21	<390	<20	<30
River Eske	Pre-treatment	90	<110	<10	<10
Donegal Supply	Treated	70	<200	<10	<20
Lough Derkmore	Pre-treatment	120	<140	<10	40 ± 10
Lettermacward Supply	Treated	70	<600	<50	<30

TABLE 9
Radioactivity in Milk 1989

County	Activity Concentration (Bq kg^{-1})											
	2nd Quarter				3rd Quarter				4th Quarter			
	K-40	Sr-90	Cs-134	Cs-137	K-40	Sr-90	Cs-134	Cs-137	K-40	Sr-90	Cs-134	Cs-137
Kilkenny	46.9 ± 3.0	NM	<0.1	<0.4	30.4 ± 3.3	0.061 ± 0.036	<0.1	<0.2	24.3±1.7	0.066 ± 0.029	<0.1	<0.1
Cavan	44.6 ± 2.8	NM	<0.1	<0.2	25.0 ± 2.4	0.066 ± 0.035	<0.1	<0.4	26.3±1.6	0.084 ± 0.029	<0.1	<0.1
Monaghan	47.6 ± 2.9	NM	<0.2	0.6 ± 0.1	35.0 ± 2.5	<0.049	<0.1	<0.4	30.4 ± 2.3	0.063 ± 0.036	<0.1	<0.1
Cork	47.8 ± 2.5	NM	<0.1	0.4 ± 0.1	23.3 ± 2.5	0.080 ± 0.030	<0.2	<0.4	32.6 ± 2.4	0.132 ± 0.032	<0.1	<0.1
Roscommon	49.6 ± 1.9	NM	<0.1	0.5 ± 0.1	30.8 ± 2.6	0.081 ± 0.038	<0.1	0.5 ± 0.2	17.3 ± 1.8	0.047 ± 0.027	<0.1	<0.3
Kerry	48.7 ± 1.9	NM	<0.1	0.3 ± 0.1	29.3 ± 2.9	0.091 ± 0.039	<0.2	<0.5	16.0 ± 1.9	0.064 ± 0.027	<0.1	<0.1
Tipperary	51.6 ± 2.8	NM	<0.1	0.3 ± 0.1	31.2 ± 2.8	0.065 ± 0.032	<0.2	<0.4	21.8 ± 3.3	0.063 ± 0.027	<0.2	<0.1
Waterford	47.6 ± 2.8	NM	<0.2	<0.3	21.2 ± 2.4	<0.060	<0.1	<0.3	29.5 ± 3.0	0.057 ± 0.028	<0.2	<0.3
Dublin	47.6 ± 1.9	NM	< 0.1	<0.2	34.1 ± 2.6	0.087 ± 0.034	<0.1	<0.4	26.0 ± 2.0	<0.046	<0.1	<0.3
National Mean	48.0	NM	<0.1	<0.1	28.9	<0.071	<0.1	<0.4	21.9	<0.069	<0.1	<0.2

NM Not measured

FIGURE 3
Average Gamma Dose Rates from Environmental Monitoring Sites, 1989

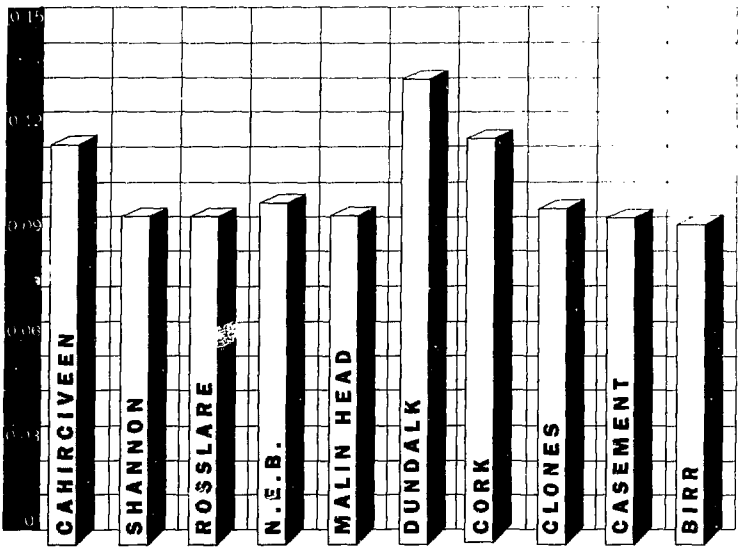
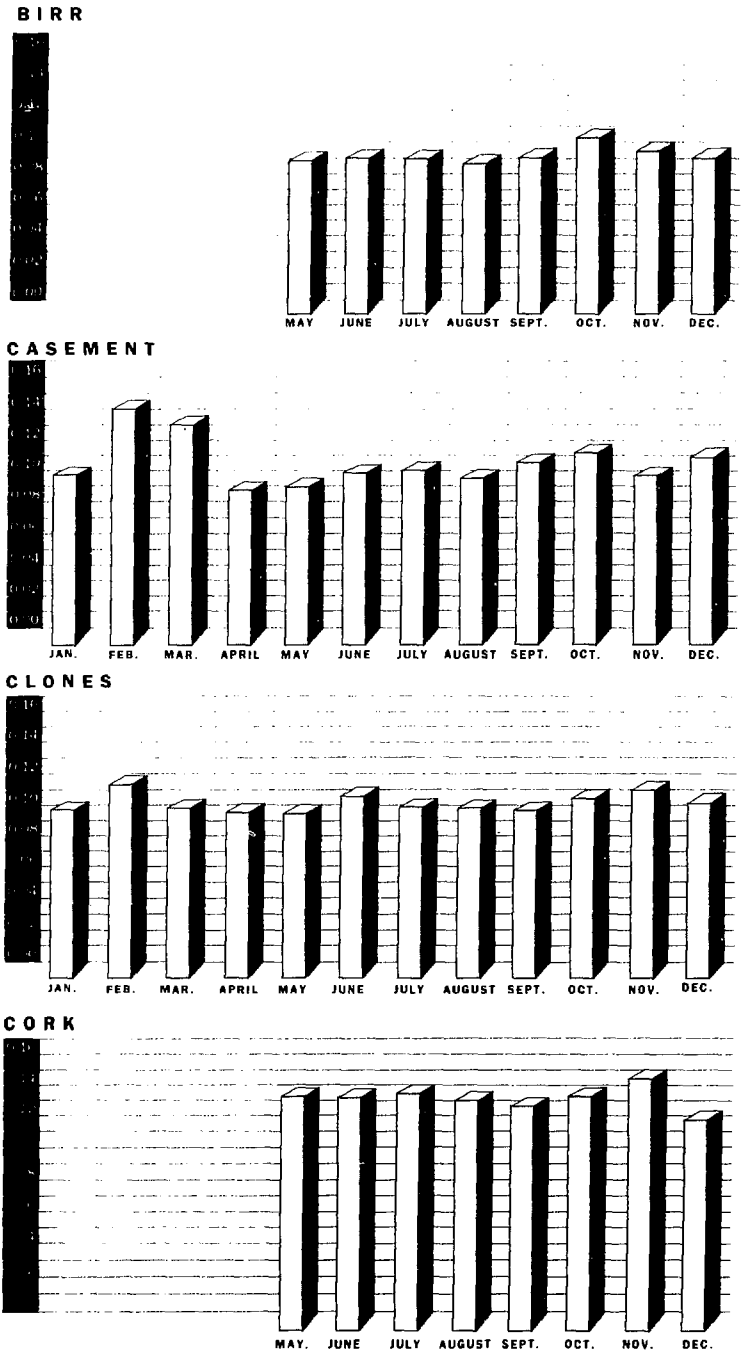


FIGURE 4
Maximum Recorded Dose Rates from Gamma Dose Rate Monitoring Stations, 1989
microsieverts per hour



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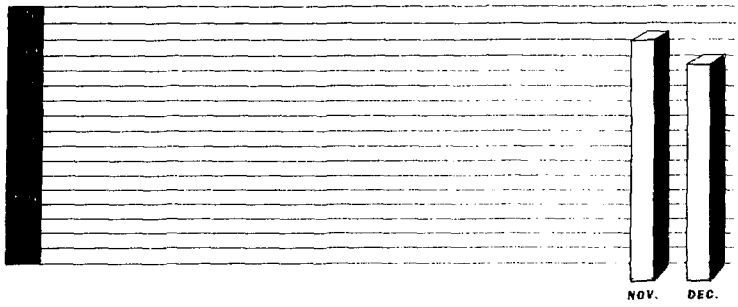
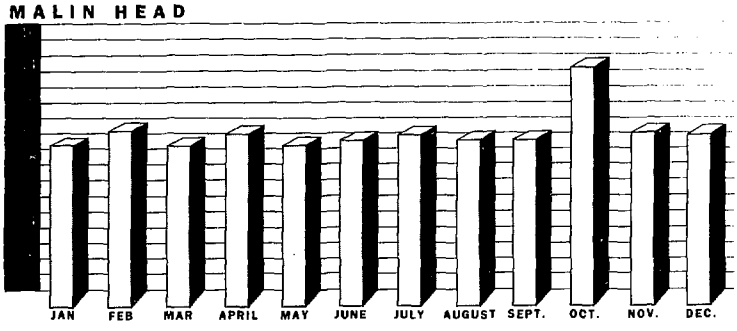
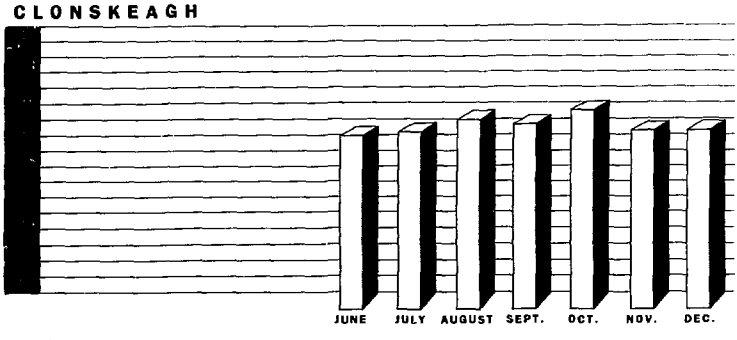


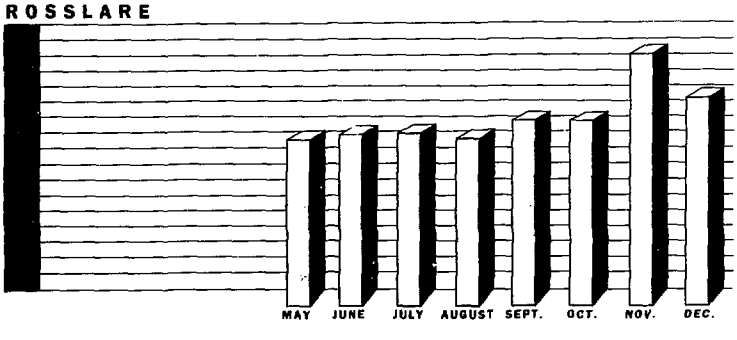
MALIN HEAD



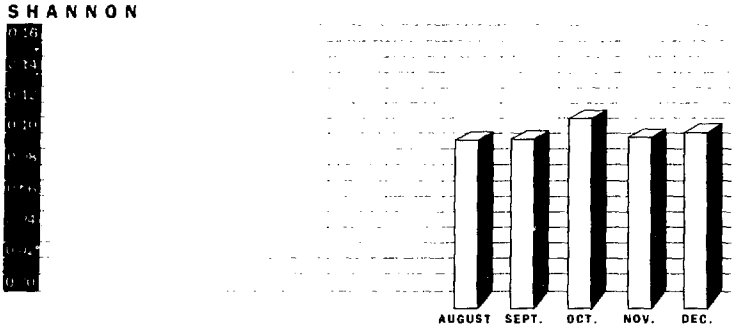
CLONSKEAGH



ROSSLARE



SHANNON



CAHIRCIVEEN