

Peer Review of the RPII's Environmental Monitoring Programme 2009

Foundation Document

H. Monitoring of Radioactivity in Drinking Water

1. Introduction

Monitoring of radioactivity in drinking water has been undertaken by the RPII since 1982, initially screening only for gross beta activity. In 1996, the programme expanded to include screening for gross alpha and gross beta activity. Tritium was also routinely measured between 2001 and 2007 and a pilot project was undertaken during 2004 looking at radon in water. During this time the RPII has built up a substantial database of results concerning radioactivity in Irish drinking water.

2. Related Legislation

National and European legislation relevant to the RPII Environmental Monitoring Programme is outlined in Supplementary Document A.

Of particular relevance to continuous monitoring of drinking water are:

- The Drinking Water Directive (DWD), Council Directive 98/83/EC
- Article 35/ 36 of the Euratom Treaty
- Commission Recommendation on the protection of the public against exposure to radon in drinking water supplies (2001/928/Euratom)
- The Radiological Protection Act, 1991, hereafter referred to as the Act

2.1 The DWD

The DWD sets limit values for a range of parameters in drinking water including radioactivity. Parametric values have been set for tritium and total indicative dose (TID). Practical arrangements (including: monitoring frequencies, methods and locations) for assessing compliance with the standards set in the DWD were to have been set out in an Annex in accordance with Article 12 of the Directive. The Annex covering radioactivity parameters, however, has not yet been finalised by the European Commission. In the absence of this Annex, the RPII uses the assessment methodology set out in the World Health Organisation recommendations on drinking water (WHO, 1993). In accordance with this methodology, water samples are tested for gross alpha and gross beta activity. If these measurements are below the screening values of 100 and 1000 mBq/l respectively then the sample is judged to be in compliance with the parametric value for TID. Where the screening level is exceeded individual radionuclide concentrations are determined and the TID is calculated in accordance with the WHO methodology.

This Directive has been transposed into Irish law by S.I. No. 278 of 2007 (European Communities (Drinking Water) (No. 2) Regulations 2007). Under the terms of these Regulations the onus is on local authorities in Ireland to monitor drinking water for the range of parameters included. However, since the annex setting out details for radioactivity monitoring has not been completed, it is unclear what responsibilities currently apply to local authorities.

In 2008 a Council Directive was drafted under EURATOM treaty laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption was published. This draft directive is coherent with the DWD's approach to microbiological and physico-chemical parameters and includes the same radiological parameters. This draft Directive is still under consideration within the Commission.

2.2 The Euratom Treaty

Article 35 of the Euratom Treaty requires Member States to carry out continuous monitoring of the levels of radioactivity in air, soil and water. The Commission Recommendation on the application of Article 36 (2000/473/Euratom) sets out guidance for Member States as to how they should discharge their obligations under Articles 35/36. Regarding drinking water the Recommendation specifies that 'monitoring of levels of radioactivity in drinking water should be such as to ensure compliance with the parametric values for radioactivity set in the DWD'. Furthermore, the Recommendation sets out a practical methodology for assessing compliance with these standards. This methodology is equivalent to that set out in the World Health Organisation guidelines on drinking water (WHO, 1993). This methodology is described in Annexe 1.

2.3 Commission Recommendation on radon in drinking water supplies

Commission Recommendation on the protection of the public against exposure to radon in drinking water supplies (2001/928/Euratom) is also of relevance. This recommends that Member States should carry out representative surveys to determine the scale and nature of exposures caused by radon and long-lived radon decay products in domestic drinking water supplies.

2.4 The Act

The general functions of the Institute as set out in Section 7 of the Radiological Protection Act, 1991 including to monitor activity in of food, drinking water and the environment (7.—(1) (a)) and to monitor exposure of individuals (7.—(1) (b)).

3. Aims and Objectives

The aims and objectives of the RPII Monitoring Programme are laid out in the overview document.

Of particular relevance for monitoring of radioactivity in drinking water are:

- To assess doses to individuals and the population from radionuclides in the environment. (Objective No 1)
- To maintain the capacity to facilitate a rapid assessment of environmental contamination in the event of a nuclear or radiological incident so that effective countermeasures to protect the Irish public can be implemented. (Objective No. 3)
- To provide up to date and accurate information on radiation levels in the environment to Government and the public. (Objective No. 4)
- To support the RPII's role to provide high quality scientifically-based advice as an input to Government policy. (Objective No. 5)

4. The RPII Drinking Water Programme

4.1 Continuous monitoring

Testing of public water supplied is organised on a rotational basis so that all supplies serving a population in excess of 10,000 are sampled at least once every four years. The way in which this rotation was organised was changed in 2007. Prior to 2007 samples from Cork, Dublin, Galway and Limerick were tested on an annual basis while supplies from outside these counties were sampled on a 4 year rotation. From 2007 the rotation was organised on a county basis so that each county was addressed at least once every four years. In each county all supplies serving in excess of 10,000 are sampled and in counties with no single supply of this size the largest supply in the county is sampled.

The monitoring programme is undertaken with the assistance of the Environmental Protection Agency (EPA), which maintains a national database of water supplies in the country. Sampling is undertaken on behalf of the RPII by local authorities.

In applying this sampling strategy, it is estimated that the RPII's monitoring programme will screen the public water to approximately 65% of the population. (Environmental Protection Agency, 2008, Central Statistics Office, 2009). In Ireland, the majority of drinking water (83.7%) originates from surface water (i.e. rivers and lakes) with the remainder originating from groundwater (8.8%) and springs (7.5%). An overview of drinking water supplies in Ireland, sourced from Environmental Protection Agency (2009), is provided in Annex 2.

Where possible, drinking water is sampled at the point at which the treated water is released into the distribution network. The samples are then sent by the local authority contact to RPII for analysis. Results are reported in the Radioactivity Monitoring of the Irish Environment reports of the RPII.

All samples are tested for gross alpha and gross beta activity and compared with the WHO screening levels of 0.1 Bq/l and 1.0 Bq/l respectively¹. For samples found to exceed the screening levels, individual radionuclide concentrations are determined and an assessment is made against a Total Indicative Dose (TID) of 0.1 mSv/y. In the past 10 years, 6 samples from major supplies (i.e. excluding small ground water supplies) exceeded the gross alpha screening limit. In all cases to date, where one of the screening levels were exceeded, subsequent analyses showed the TID to be less than the parametric value set in the DWD. In most cases, where elevated total alpha concentrations were detected, specific analyses showed this to be attributable to uranium.

In addition to large supplies, the RPII has tested a limited number of samples from small ground water sources. In the case of these samples a larger proportion were found to exceed the screening level for total alpha. However, in all cases to date subsequent analyses of these samples also indicated compliance with the DWD parametric value for TID. The RPII is currently undertaking a systematic national programme to assess levels of radioactivity in small ground water sources.

Tritium measurements were carried out as part of the programme between 2001 and 2007. No detectable tritium activity concentrations were measured. Given that there is no nuclear programme in Ireland and that previous monitoring has established that the levels of tritium are well below the parametric value specified in the DWD, these measurements are no longer carried out as part of the routine monitoring.

In 2003 a pilot study to assess the distribution and concentrations of radon in private ground water supplies was completed in Co. Wicklow. Wicklow was chosen for this study because high indoor radon levels in homes had been identified throughout the county; the underlying geology is predominantly granite (with elevated uranium content); and there are an estimated 1200 to 5000 private ground water supplies in use in the county. Radon activity concentrations were measured in the private ground water supplies of 166 houses in Co. Wicklow. Four supplies had activity concentrations in excess of the Recommended EC action level of 1000 Bq/l and 15 had activity concentrations between 500 and 1000 Bq/l. Further discussion of this project is included in Foundation Document C.

At present radon in drinking water is not measured as part of the monitoring programme although it is offered by the RPII as an analytical service.

In addition to the RPII monitoring programme, some requests are received from local authorities and commercial clients to measure radioactivity in drinking water and to assess compliance with the DWD. These assessments include gross alpha and gross beta screening and tritium determination. The results of these analyses are sent directly to the local authority or the client.

¹ WHO (1993). See Annex 1 for more details.

4.2 Groundwater Project 2008- 2010

Given the focus on supplies serving large population centres, routine sampling has mainly been concentrated on supplies derived from either surface waters or large aquifers. As a consequence the current state of knowledge concerning radioactivity in water supplies derived from surface waters is generally comprehensive. On the other hand relatively little is known about radioactivity in either small ground water supplies or private wells. Similarly little is known about geographical variations in radioactivity in water supplies.

To address this, a national study of radioactivity in groundwater commenced in 2008 and will run for three years. This project is being carried out with the co-operation of the EPA who will measure chemical parameters including uranium for the same sources. It has been shown previously by Sequeira et al (1999) that in Irish groundwater supplies uranium may dominate the total alpha activity concentration and so it is useful to have uranium and radioactivity data for the same samples. Results from an initial pilot study have been reported in the RPII Report, Radioactivity Monitoring of the Irish Environment 2007 (Fegan et al, 2008).

In 2008, samples from 94 locations were collected and analysed at RPII for gross alpha and gross beta activity. Some 86 samples were below the WHO screening level for gross alpha and all were below the gross beta level. For those samples where the gross alpha activity was close to or exceeded the screening level, uranium concentrations were requested from the EPA. These have been used to determine if the alpha activity can be accounted for by uranium in the groundwater. To date, the uranium activity concentration has been found to account for between approximately 20 and 70% of the gross alpha activity.

5. Issues for Consideration by the Peer Review Group

The terms of reference are laid out in the overview document. Of particular relevance to monitoring of radioactivity in drinking water are:

- To consider whether the RPII is meeting the stated aims and objectives of the programme.
- To consider whether the aims and objectives of the programme are sufficiently broad to cover: legal requirements, international obligations and international best practice.
- To consider the adequacy of the programme with respect to accuracy of public dose assessment and demonstration of compliance with relevant standards.
- To consider the adequacy of the programme with respect to the need to provide accurate, up to date and scientifically based advice to Government.
- To suggest information gaps or research need going forward and to identify research needs to underpin and support the drinking water programme.

References

Environmental Protection Agency, 2008. Personal Communication.

Environmental Protection Agency, 2009. The Provision and Quality of Drinking Water in Ireland, A Report for the Years 2007-2008. Wexford: Environmental Protection Agency.

European Commission, 2000. Commission Recommendation 2000/437/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure to the population as a whole. Official Journal of the European Communities, L191, 27.7.2000, p 37-51.

European Commission, 2001. Commission Recommendation 2001/928/Euratom of 20 December 2001 on the protection of the public against exposure to radon in drinking water supplies. Official Journal of the European Communities, L330, 28.12.2001, p 85-88.

European Communities, 1998. Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Official Journal of the European Communities, L330, 5.12 1998, p 32-54.

Fegan, M., Dowdall, A., Hanley, O., Hayden, E., Kelleher, K., Long, S., Smith, V., Somerville, S., Wong, J., Pollard, D., 2007. Radioactivity Monitoring of the Irish Environment. RPII-08/02. Dublin: Radiological Protection Institute of Ireland.

ICRP, 1996. Age-dependent doses to members of the public from intake of radionuclides: Part 5. Compilation of Ingestion and Inhalation Dose Coefficients. Annals of the ICRP, 26, ICRP Publication 72. Oxford: Pergamon Press.

Ireland, 1991. Radiological Protection Act, Number 9 of 1991. Dublin: Stationery Office.

Ireland, 2000. Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000, Statutory Instrument No. 125 of 2000. Dublin: Stationery Office.

Ireland, 2007. European Communities (Drinking Water), (No 2) Regulations, 2007, Statutory Instrument No. 278 of 2007. Dublin: Stationery Office.

Sequeira, S., Pollard, D., Smith, V., Howett, D., Hayden, E., Fegan, M., Dowdall, A., Brogan, C., O'Colmáin, M., Cunningham, J.D., 1999. Environmental Radioactivity Surveillance Programme, 1997 and 1998. RPII-99/2. Dublin: Radiological Protection Institute of Ireland.

WHO, 1993. Guidelines for drinking water quality. Geneva: World Health Organisation.

WHO, 2006. Guidelines for drinking water quality. Vol. 1 Recommendations: Addendum 3rd edition Geneva: World Health Organisation.

Appendix 1: Screening Levels for Drinking Water

The Drinking Water Directive (European Communities, 1998) on the quality of water intended for human consumption sets out standards for radioactivity in drinking water. With regard to radioactivity, the directive sets parametric standards for tritium and total indicative dose as set out below. This Directive has been transposed into Irish law in Statutory Instrument 278 of 2007 (Ireland, 2007). Practical arrangements for monitoring compliance with these standards are to be set out in Annexes to the Directive, which are currently being finalised by the European Commission. In the absence of these Annexes, the RPII has applied the methodology for screening drinking water as set out by the World Health Organisation recommendations on drinking water (WHO, 1993).

Table 1: Parametric values for radioactivity from S.I. 278 of 2007

Parameter	Parametric Value
Tritium	100 Bq/l
Total indicative dose ^a	0.10 mSv/year

^a Excluding tritium, potassium-40, radon and radon decay products.

In accordance with the WHO methodology the recommended screening levels for gross alpha and gross beta activity are 100 and 1000 mBq/l, respectively, while the level for tritium is 100 Bq/l. If the radioactivity concentrations of water supplies are below the screening values then the water is considered to be in compliance with Statutory Instrument 278, which states that the dose arising from one year's consumption of drinking water should not exceed 0.1 mSv. Hence the drinking water is considered acceptable for human consumption and any action to reduce the radioactivity is deemed unnecessary.

If the radioactivity concentrations exceed these screening levels then individual radionuclide concentrations are determined and, if necessary, the dose arising from each component calculated. An effective annual dose is calculated from the measured activity concentration and ICRP 72 dose coefficients for ingestion of radionuclides. If the effective dose calculated does not exceed 0.1 mSv/year, then no further action is required for that drinking water. Where the effective dose is exceeded, then this should be regarded as an indication that further investigation, including additional sampling is needed.

The dose calculation includes contributions from all natural and artificial radionuclides with the exception of tritium, potassium-40, radon and radon decay products. The total indicative dose represents less than 5% of the average effective dose normally attributable annually to natural background radiation. A consumption rate of 2 litres per day is assumed. The ingestion dose coefficients used are set out in Table 2.

Table 2: Data Used to Screen Drinking Water Alpha Activities

Radionuclide	Ingested Dose Coefficient for Adults (Sv/Bq) (ICRP,1996)	Activity per Nuclide (mBq/l) equivalent to 0.1 mSv
Polonium-210	1.2×10^{-6}	117
Radium-226	2.80×10^{-7}	500
Thorium-232	2.3×10^{-7}	600
Uranium-234	4.9×10^{-8}	
Uranium-235	4.7×10^{-8}	3000
Uranium-238	4.5×10^{-8}	

The WHO methodology applies to routine operational conditions of existing or new water supplies. It is not intended to apply to a water supply contaminated during an emergency involving the release of radionuclides into the environment.

Note that the WHO published revised Guidelines in 2004. In this edition, the screening level for gross alpha activity was raised to 0.5 Bq/l while the screening level for gross beta remained the same. The screening level for gross alpha activity of 0.1 Bq/l has continued to be adopted by RPII in line with the DWD.

Annex 2: Drinking Water Supplies in Ireland (Environmental Protection Agency, 2009)

To ensure that relevant water quality standards are met each water supply must be monitored on a regular basis. Minimum monitoring frequencies for drinking water depend on the size of the supply in question, and the monitoring frequency is legally set out in the Regulations concerning drinking water. Though the Regulations specify two types of supplies (“public” and “private”), in practice there are four distinct categories of water supply in Ireland, of which the latter three would be classified as “private” in the context of the Regulations. These categories are listed below:

- **Public Water Supplies (PWS).** These are local authority operated schemes (though these may be run by a private contractor on behalf of the local authority). They supply water to the majority of households in Ireland.
- **“Public” Group Water Schemes (PuGWS).** These are schemes where the water is provided by the local authority but responsibility for distribution of the water rests with the group scheme. These schemes tend to be supplied off larger public water supplies.
- **“Private” Group Water Schemes (PrGWS).** These are schemes where the owners of the scheme (usually representatives of the local community) source and distribute their own water. Combined; the ‘public’ and ‘private’ group water schemes supply water to around 10% of the population of Ireland.
- **Small Private Supplies (SPS).** This is a large group of different types of supply comprising industrial water supplies (such as those used in the brewing industry) to boreholes serving commercial premises (e.g. pubs, hotels etc) and public buildings (e.g. schools, nursing homes).
- **Exempted supplies.** These are supplies serving less than 50 persons and not supplying water as part of a public or commercial activity. The majority of these are private wells serving individual houses. These supplies serve approximately 10% of the population.

In Ireland, the majority of drinking water (83%) originates from surface water (i.e. rivers and lakes) with the remainder originating from groundwater (11%) and springs (6%). This is particularly so for public water supplies whereas group water schemes and small private supplies tend to be slightly more reliant on groundwater or spring water.