WHO Guidelines for Drinking-water Quality

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Acknowledgements

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The WHO is the UN agency with a specific public health mandate as the directing and coordinating authority of international health work.
The WHO 3-level structure

- 194 Member States
- Ministries of Health

- Headquarters
- Geneva

- 6 Regional Offices

- 150 Country Offices

- IARC, Lyon
Objective: attainment by all peoples of the highest possible level of health
"Health is a complete state of physical, mental and social well-being, and not merely the absence of disease or infirmity"

WHO's Constitution (1948)
22 March: World Water Day
Celebrated every year to take action on water issues

- One of the targets of the MDGs was to reduce by half the proportion of population without access to improved drinking-water supplies by 2015.

- While this MDG target was met, today there are still about 1.8 billion people using water that is not safe in terms of microbial contamination and over 663 million people living without an improved water supply close to home.
Water quality

The quality of water, whether used for drinking, domestic purposes, food production or recreational purposes, has an important impact on health.

Prüss-Ustün et al. 2014
“Preventing diarrhoea through better water, sanitation and hygiene”
http://apps.who.int/iris/bitstream/10665/150112/1/9789241564823_eng.pdf
All UN Member States agreed to try to achieve the SDGs by 2030.
2030 Sustainable Development Agenda

Resolution adopted by the General Assembly on 25 September 2015

70/1. Transforming our world: the 2030 Agenda for Sustainable Development

Preamble

This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in greater freedom. We recognize that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development.

All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want and to halt and reverse our planet. We are determined to take the bold and transformative steps which are urgently needed to shift the world on to a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind.

The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what they did not achieve. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental.

The Goals and targets will stimulate action over the next 15 years in areas of critical importance for humanity and the planet.

17 Goals, 169 targets, 230 global indicators
Goal 6: Ensure availability and sustainable management of water and sanitation for all

- 6.1 Drinking water
- 6.2 Sanitation and hygiene
- 6.3 Water quality
- 6.4 Water scarcity
- 6.5 Water resource management
- 6.6 Ecosystems

Means of implementation:

- 6.a International cooperation and capacity development
- 6.b Local participation
Goal 6: Global monitoring initiatives

**6.1 Drinking water**

**6.2 Sanitation and hygiene**

**6.3 Water quality**

**6.4 Water scarcity**

**6.5 Water resource management**

**6.6 Ecosystems**

**6.5.1**

**6.5.2**

**6.4.1**

**6.4.2**

**6.3.1**

**6.3.2**

**6.2.1**

**6.1.1**

**6.a International cooperation and capacity development**

**6.b Local participation**

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**JMP**: WHO/UNICEF Joint Monitoring Programme

**GEMI**: Global Expanded Monitoring Initiative (WHO is a partner)

**GLAAS**: Global Analysis and Assessment of Sanitation and Drinking-Water (implemented by WHO)
Global indicator for drinking-water

**PRIORITY INDICATOR: 6.1.1**

% of population using **safely managed** drinking-water services

Water Safety Plans are a tool to achieve the SDGs.

"The most effective means of consistently ensuring the safety of a drinking-water supply."

**WHO Guidelines for Drinking-water Quality**
Which are the sources of radionuclides (RN) in the environment (and water)?

- **Natural RN** are ubiquitously found in the environment, in particular $^{40}$K and RN from the thorium & uranium radioactive decay series (including radon gas).
  - Human activities may create/alter exposure pathways, modify the concentrations and enhance exposure to natural occurring radioactive material (NORM) e.g. uranium mining and other extractive industries, oil & gas industry, fertilizer (phosphate) industry, coal industry, building industry, others.

- **Artificial RN** can enter in the environment through:
  - Releases either unintended (e.g. nuclear emergencies – mainly caesium & radioactive $^{131}$I, $^{137}$Cs) or intentional releases (malevolent acts)
  - Fallout (e.g. nuclear weapon testing)
  - Discharges from licensed facilities (e.g. nuclear or medical facilities)
What are the radiation risks at low doses?

- Information at low doses is scarce, and uncertainty high
  - For prolonged exposures, increased cancer risk in humans has been reported at doses exceeding around 50-100 mSv.
  - UNSCEAR currently review existing data for preparing a report ("Cancer epidemiology of exposures at low dose-rates due to environmental radiation").

- No epidemiology evidence- the current **system of radiation protection** is based on the **assumption** of a linear relationship between exposure and cancer risk, with no dose level below which there is no risk (i.e. **linear non-threshold: LNT model**).
Radiation cancer risks

- The nominal risk coefficient derived by ICRP for whole population for radiation protection purposes is $5 \% \text{ per Sv}$. This means: 5 additional fatal cancers per 100,000 people exposed to 1 mSv. This would be not detectable compared with the baseline cancer mortality risk (around 25% risk of dying from cancer i.e. 25,000 out of 100,000 people).

- Low dose radiation cancer risks are uncertain.

- May be very small and lower than estimated.

- A precautionary approach is then adopted.
What are the health risks from radionuclides in drinking water?

- Neither epidemiological studies nor experimental data are informative enough to quantify the health effects resulting from exposure to naturally-occurring radionuclides, including radon, in water.

- In addition, no experimental studies were performed on cancer in animals following an oral exposure to radon and its progeny.
Experimental studies about health risks

Some animal and in-vitro studies

- Uranium
  - Biological effects on kidney and bone
- Radium
  - Effects on bone sarcomas ($^{228}$ Ra) and head and neck sarcomas ($^{226}$ Ra)
- Radon
  - Very few experimental studies, uncertainties on internal dose assessment (transit time through gastrointestinal tract and whole-body radon retention)
Health Effects of Naturally Radioactive Water Ingestion: The Need for Enhanced Studies

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1Service de Radiobiologie et Epidémiologie, and 2Service d’Etudes et Expertise en Radioprotection, Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, France

BACKGROUND: Radiological pollution is a potentially important aspect of water quality. However, relatively few studies have been conducted to document its possible health effects.

OBJECTIVE: In this commentary we discuss available epidemiological findings and related data from experimental studies concerning the health effects of naturally radioactive water ingestion.

DISCUSSION: Despite modest epidemiological evidence of uranium nephrotoxicity and radium effects on bone, available data are not sufficient to quantify the health effects of naturally occurring radionuclides in water. Methodological limitations (exposure measurement methods, control for confounding, sample size) affect most studies. Power calculations should be conducted before launching new epidemiological studies focusing on late pathological outcomes. Studies based on biomarkers of exposure and adverse effects may be helpful but should involve more specific molecules than biomarkers used in previous studies. Experimental data on ingestion of drinking water are limited to uranium studies, and there is some disagreement between these studies about the nephrotoxicity threshold.

CONCLUSION: Further experimental and enhanced epidemiological studies should help to reduce uncertainties resulting from dose estimation to dose–response characterisation.

Review of epidemiological studies on possible effects of natural radionuclides in DW (I)

Table 1. Available epidemiological studies on the possible effects of naturally occurring radionuclides in drinking water.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Radionuclide</th>
<th>Average concentration in water</th>
<th>Outcome</th>
<th>No. of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mao et al. 1995*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>19.6 µg/L</td>
<td>Biomarkers of renal (glomerular) damage</td>
<td>140 cases</td>
</tr>
<tr>
<td>Zamora et al. 1998*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>100 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>50 cases</td>
</tr>
<tr>
<td>Kurttio et al. 2002*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>131 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>325 cases</td>
</tr>
<tr>
<td>Kurttio et al. 2005*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>124 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>268 cases</td>
</tr>
<tr>
<td>Kurttio et al. 2006a</td>
<td>Cross-sectional</td>
<td>U</td>
<td>25 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>193 cases</td>
</tr>
<tr>
<td>Selden et al. 2009*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>180 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>454 cases</td>
</tr>
<tr>
<td>Zamora et al. 2009*</td>
<td>Cross-sectional</td>
<td>U</td>
<td>88 µg/L</td>
<td>Biomarkers of renal (tubular) damage</td>
<td>54 cases</td>
</tr>
<tr>
<td>Petersen et al. 1966*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>170 mBq/L</td>
<td>Bone cancer mortality</td>
<td>267 cases</td>
</tr>
<tr>
<td>Bean et al. 1982*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>&gt;110 mBq/L</td>
<td>Cancer incidence</td>
<td>1,596 cases</td>
</tr>
<tr>
<td>Lyman et al. 1985*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>&gt;165 mBq/L</td>
<td>Leukemia incidence and mortality</td>
<td>873 incident/690 mortality cases</td>
</tr>
<tr>
<td>Fuortes et al. 1990*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>NR</td>
<td>Leukemia incidence</td>
<td>700 cases</td>
</tr>
<tr>
<td>Hess et al. 1983</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>NR</td>
<td>Cancer incidence</td>
<td>33,928 cases</td>
</tr>
<tr>
<td>Collman et al. 1988</td>
<td>Ecological</td>
<td>$^{222}\text{Rn}$</td>
<td>NR</td>
<td>Cancer mortality</td>
<td>Total cancer cases NR (1,758 leukemias)</td>
</tr>
<tr>
<td>Collman et al. 1991*</td>
<td>Ecological</td>
<td>$^{222}\text{Rn}$</td>
<td>NR</td>
<td>Cancer mortality</td>
<td>2,706 cases (1,194 leukemias)</td>
</tr>
<tr>
<td>Kjellberg and Wiseman 1995*</td>
<td>Ecological</td>
<td>$^{222}\text{Rn}$</td>
<td>NR</td>
<td>Stomach cancer incidence and mortality</td>
<td>NR</td>
</tr>
<tr>
<td>Cech et al. 2007*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>&gt;110 mBq/L</td>
<td>Orofacial cleft defect births</td>
<td>167 cases</td>
</tr>
<tr>
<td>Cech et al. 2008*</td>
<td>Ecological</td>
<td>$^{226}\text{Ra}$</td>
<td>&gt;110 mBq/L</td>
<td>Orofacial cleft defect births</td>
<td>300 cases</td>
</tr>
</tbody>
</table>

### Review of epidemiological studies on possible effects of natural radionuclides in DW (II)

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Radionuclide</th>
<th>Average concentration in water</th>
<th>Outcome</th>
<th>No. of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moss et al. 1995</td>
<td>Case–control</td>
<td>Gross α</td>
<td>300 mBq/L</td>
<td>Osteosarcoma incidence</td>
<td>167 cases/989 controls with other cancers, matched on age, sex, and race</td>
</tr>
<tr>
<td>Guse et al. 2002</td>
<td>Case–control</td>
<td>$^{226+230}$Ra</td>
<td>NR</td>
<td>Osteosarcoma incidence</td>
<td>319 osteosarcoma cases/3,198 general population controls matched on age, sex, and ZIP code</td>
</tr>
<tr>
<td>Finkelstein 1994*</td>
<td>Case–control</td>
<td>$^{226}$Ra</td>
<td>26 mBq/L</td>
<td>Bone cancer mortality</td>
<td>283 cases/265 controls (died of any other disease) matched on age, sex, and year of death</td>
</tr>
<tr>
<td>Finkelstein and Kreiger 1996*</td>
<td>Case–control</td>
<td>$^{226}$Ra</td>
<td>26 mBq/L</td>
<td>Bone sarcoma incidence and mortality</td>
<td>583 cases/754 controls with (or died of) any other disease matched on age, sex, and year of death or diagnosis</td>
</tr>
<tr>
<td>Hirunwatthanakul et al. 2006*</td>
<td>Case–control</td>
<td>$^{226}$Ra</td>
<td>NR</td>
<td>Digestive cancer incidence</td>
<td>32 cases/136 randomly selected healthy controls</td>
</tr>
<tr>
<td>Witmans et al. 2008*</td>
<td>Case–control</td>
<td>U</td>
<td>$\approx 1$ μg/L</td>
<td>Non-Hodgkin lymphoma incidence</td>
<td>88 cases/132 controls matched on age and sex</td>
</tr>
<tr>
<td>Seiler 2004</td>
<td>Case–control</td>
<td>U</td>
<td>$\approx 2$ μg/L</td>
<td>Leukemia incidence</td>
<td>16 wells as cases, 100 other community wells as controls</td>
</tr>
<tr>
<td>Auvinen et al. 2002</td>
<td>Case–cohort</td>
<td>U</td>
<td>0.45 Bq/L, 30 mBq/L, 500 Bq/L</td>
<td>Leukemia incidence</td>
<td>35 cases/274 controls matched on age and sex</td>
</tr>
<tr>
<td>Auvinen et al. 2005</td>
<td>Case–cohort</td>
<td>U</td>
<td>0.45 Bq/L, 30 mBq/L, 500 Bq/L</td>
<td>Stomach cancer incidence</td>
<td>107 cases/371 controls matched on age and sex</td>
</tr>
<tr>
<td>Kurtio et al. 2006b</td>
<td>Case–cohort</td>
<td>U</td>
<td>0.45 Bq/L, 30 mBq/L, 500 Bq/L</td>
<td>Urinary cancer incidence</td>
<td>112 cases (61 bladder, 51 kidney)/274 controls matched on age and sex</td>
</tr>
</tbody>
</table>

NR, not reported.
*Statistically significant increase in the health damage of interest.
The System of Radiological Protection

- Three principles
  - Justification
  - Optimization
  - Limitation

- Three categories of exposure
  - Public
  - Occupational
  - Medical

- Three exposure situations
  - Planned
  - Existing
  - Emergency
The radionuclides present in drinking water may result in exposure of the public.

These exposures are managed as existing exposure situations(*).

Situation that already exists when a decision on control has to be taken

(*) except during radiological and nuclear emergencies
Public exposure & existing exposure situation – what does it mean?

- In existing exposure situations:
  - **Dose limits** are not applied
  - **Dose constraints** are not applied
  - **Reference levels** are established.
BSS requirements regarding exposure due to radioactivity in food and water (5.22 and 5.23)

- The regulatory body or other relevant authority shall establish specific **reference levels** for exposure due to radioactivity in **food, drinking water**, and other commodities, **each of which** shall typically be expressed as, or be based on, an annual effective dose that does not exceed a value of about **1 mSv**

- They have to consider the guideline levels for:
  - Radionuclides contained in drinking water published by the WHO (i.e. **GDWQ**)
  - Radionuclides in food traded internationally published by the Joint FAO/WHO Codex Alimentarius Commission (i.e. **Codex Alimentarius**)

[World Health Organization logo]
Reference level – what does it mean?

The BSS: “…a reference level (RL) that generally does not exceed a value of approximately 1 mSv”

RL is a level of dose above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented.
The WHO GDWQ adopted a conservative approach for both natural radionuclides and human-made radionuclides, with an individual dose criterion (IDC) of 0.1 mSv from 1 year’s consumption of drinking-water, regardless the origin of the radionuclides.

This IDC represents a very low level of health risk, and should not be interpreted as mandatory.

Regulatory authorities may establish a national standard at the IDC level or greater, but generally less than the BSS reference level of 1 mSv per year, depending on the prevalent circumstances.
GDWQ and optimization

- When implementing **OPTIMIZATION**, each situation will be different, and non-radiological factors, such as the **costs of remediation** and the **availability of other drinking-water supplies**, will need to be taken into account in reaching a final decision.

- When considering what action to take in assessing and managing radiological risks, care should be taken **to ensure that scarce resources are not diverted away from other, more important public health concerns**.
When developing national standards for DW

- To adapt WHO GDWQ to local circumstances.

- To consider health benefits from having the drinking-water supply; cost-effectiveness; health priorities; environmental conditions; water supply capacity.

- To consider the requirements of the new International BSS regarding the establishment of dose reference levels.

- To consider protection strategies that are proportional to the health risks (graded approach).
Radioactivity & Drinking-water: >10 years of increasing global collaboration...

2004: 3rd edition of the WHO GDWQ

2007: technical collaboration between WHO WSH & WHO RAD

2008: Working Group established to review Chapter 9 (WHO WSH + WHO RAD, WHO CC experts, IAEA experts)

2009-2010: Chapter 9 is revised /updated

2011: 4th Edition of WHO GDWQ is published

2012-2014: support implementation & expert group meetings

2013: FAO, WHO, IAEA WG produced a discussion paper on radioactivity in food and DW

2014: International Technical Meeting on radioactivity in food and DW (Vienna), sub-regional meeting on radioactivity in DW (Rio)

2014: Final edition of the new BSS published, supporting safety guides developed

2015-2017: guidance on interpretation and use of the GDWQ, Q&As, cases studies, information products, First Addendum

2015-2017: IAEA-FAO-WHO cooperation continues: publication & dissemination of TECDOC 1788, regional workshops on public protection,…

2016: BSS revision started

2007: New ICRP Recommendations (ICRP 103) published

2012: Interim Edition of BSS adopted by the 8 cosponsoring organizations

2013: Interim Edition of BSS adopted by the 8 cosponsoring organizations

2014: Final edition of the new BSS published, supporting safety guides developed

2015-2017: plans for 5th Ed. GDWQ by 2020

2015-2017: guidance on interpretation and use of the GDWQ, Q&As, cases studies, information products, First Addendum
Key take home messages

- Radiological risks are normally small compared with the risks from microorganisms and chemicals that may be present in drinking-water.

- Except in extreme circumstances, the radiation dose resulting from the ingestion of radionuclides in drinking-water is much lower than that received from other sources of radiation.
A flagship normative publication of WHO

“Immediate and wide recognition as essential aids to the improvement of water quality and treatment”

Demand for the document is among the highest and most sustained of all WHO publications
# WHO Guidelines for Drinking-water Quality

## Aim
- Protection of human health
  - Support setting of national standards and regulations

## Target Audience
- Regulators + (water suppliers, practitioners . . .)

## Approach
- Best available evidence - science and practice
- Risk-benefit philosophy (advisory in nature)
- Local adaptation considering overall health protection strategies
  - Social, cultural, economic and environmental context
- Preventive incorporating multiple barriers
- Incremental improvement

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[Guidelines for Drinking-water Quality](#)

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[World Health Organization](#)
Core Recommendations
Framework for Safe Drinking-water

- Establish national water quality standards on relevant waterborne hazards
- Undertake site-specific local risk assessment and management from catchment to consumer
- Verify water safety through independent tests and audits

Health-based targets
(National regulatory body)

Water Safety Plan
(Water utility)

Independent surveillance
(Surveillance agency)
Radioactivity in Drinking-water: awareness has increased

Radium salt in water

Marketing for ‘radioactive’ water
Today we will focus on Chapter 9
Chapter 9 of GDWQ

- Criteria with which to assess safety of drinking-water with respect to radionuclide content
- Methodology to assess potential health risks
- Guidance on actions to reduce radionuclides in drinking-water
- For situations where there could be ingestion of radionuclides in drinking-water over extended periods of time (years – lifetime)
Radioactivity in drinking-water

- No distinction between criteria for natural and artificial radionuclides. However, management may differ (point of control and ability to control)

- Natural radionuclides usually of greater concern for drinking-water

- When considering actions to take in assessing and managing radiological risks, care should be taken to ensure that scarce resources are not diverted away from other, more important, public health concerns

- Need guidelines to be transparent and understandable by people managing water supplies who are not necessarily experts in radiation protection

- Guidance is based on a screening approach
Screening Approach

- Most situations activity concentrations very low
- Detailed analysis of radionuclides not normally justified for routine monitoring
- Radionuclide analysis can be resource intensive and costly
- Screening is a practical approach
Screening Values

- Screening values based on committed effective dose of 0.1 mSv from 1 year’s consumption of 2 litres per day
  
  0.5 Bq/litre for gross alpha activity

  1.0 Bq/litre for gross beta activity

- Values considered to be sufficiently precautionary.

- Will pick up radon daughters that can be important contributors to ingestion doses.

- Vast majority of supplies easily meet the screening values.
Monitoring programmes

- Monitoring strategy needs to take account of local conditions.
  - New water supplies vs. existing supplies
  - Are measured concentrations consistently below screening levels?
  - Are there sources of potential radionuclide contamination nearby?
  - Are concentrations expected to be changing rapidly with time?

- Taking into account available resources and potential risks, graded approach to sampling frequency commensurate with
  - the size of the population served
  - the expected variability of radionuclide concentrations; samples should be representative of water drunk over a year
  - the availability and results of historical monitoring records
Screening values are exceeded. What next?

- Check the screening measurements and collect further samples
- Identify potential radionuclides in drinking-water
- Measure the individual radionuclides
- Compare activity concentrations of radionuclides with Guidance Levels
Guidance Levels

- Activity concentrations in individual radionuclides in drinking-water that would lead to 0.1 mSv/year (IDC)

- Consider all radionuclides that could contribute to dose

- Exceeding the IDC of 0.1 mSv/y DOES NOT mean that the drinking-water is unsuitable for drinking. However, further investigation is required.

Table 9.2 Guidance levels for common natural and artificial radionuclides for members of the public

<table>
<thead>
<tr>
<th>Category</th>
<th>Radionuclide</th>
<th>Dose coefficient (Sv/Bq)</th>
<th>Guidance level (Bq/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naturally occurring radioactive isotope that starts the uranium decay series</td>
<td>Uranium-238</td>
<td>$4.5 \times 10^{-4}$</td>
<td>10</td>
</tr>
<tr>
<td>Naturally occurring radioactive isotopes belonging to the uranium decay series</td>
<td>Uranium-234</td>
<td>$4.9 \times 10^{-4}$</td>
<td>1</td>
</tr>
<tr>
<td>Thorium-230</td>
<td>$2.1 \times 10^{-7}$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Radium-226</td>
<td>$2.8 \times 10^{-7}$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lead-210</td>
<td>$6.9 \times 10^{-7}$</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Polonium-210</td>
<td>$1.2 \times 10^{-4}$</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Naturally occurring radioactive isotope that starts the thorium decay series</td>
<td>Thorium-232</td>
<td>$2.3 \times 10^{-7}$</td>
<td>1</td>
</tr>
<tr>
<td>Naturally occurring radioactive isotopes belonging to the thorium decay series</td>
<td>Radium-228</td>
<td>$6.9 \times 10^{-7}$</td>
<td>0.1</td>
</tr>
<tr>
<td>Thorium-228</td>
<td>$7.2 \times 10^{-4}$</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

WHO Guidelines for drinking-water quality provide guidance values for a number of radionuclides.
Implementation of DWQ guidance levels

- Both the screening levels and guidance levels (GLs) are highly conservative. Although the majority of water supplies comply with them, occasionally, guidance levels might be consistently exceeded (one radionuclide or a combination of radionuclides)

- National authorities should consider if appropriate to implement remedial actions or to place some restriction. **One key consideration is the extent to which the GLs are exceeded**
Perception and Trust

- There is usually little choice in drinking-water.
- Providing alternative sources can be logistically very difficult and affects subsequent actions.
- Discontinuing a source MUST be justified in terms of overall benefit + MUST have another safe water supply option
- Important because it may drive consumers to more “acceptable” but less safe water sources
- Measurements/dose assessments need to be correct and appropriate for the situation
Screening levels and guidance levels are conservative and should not be interpreted as mandatory limits. Exceeding a guidance level should be taken as a trigger for further investigation, but not necessarily as an indication that the drinking-water is unsafe.
Radon in water

- High radon concentrations may be found in groundwater supplies but seldom in surface drinking-water supplies
  - Surface water - No problem with $^{222}$Rn
  - Groundwater
    - Dug wells in soil aquifer – minor problem with $^{222}$Rn
    - Drilled wells in bedrocks - High to very high $^{222}$Rn concentrations can be encountered in uranium-rich bedrock

- Straightforward and effective techniques exist to reduce the concentration of radon in drinking-water supplies
Radon dissolved in water can be released and contribute to increase radon concentration in indoor air.

- The % of radon that is released from water in the home varies depending on local conditions, and will occur only while the water is being discharged through the tap or shower.
- Rule of thumb: 1000 Bq/l in water can give rise to 100 Bq/m$^3$ in indoor air

Although ingested radon may deliver a radiation dose, the main route of entry into the body is via inhalation.

- > 90% radon dose from inhalation rather than ingestion [UNSCEAR, 2000]
Managing radon in drinking water

- WHO Guidelines for drinking-water quality do not provide a guidance level for radon.

- As exposure from radon in water is mostly from inhalation, it is more appropriate to measure/manage the radon concentration in indoor air rather than in drinking-water.

- Where remedial measures are in place to manage radon levels in indoor air, it is advisable to measure radon in drinking-water if the drinking-water supply comes from a near-by groundwater source.
Further guidance on GDWQ Chapter 9

- Radiological aspects of drinking-water involve 2 areas of expertise (drinking-water quality and radiation protection) and regulators are often different: multidisciplinary approach is needed.

- Radiological parameters in GDWQ are very conservative and it can be difficult for end-users to understand how to manage exceedances of criteria and how to communicate radiation health risks

=> Q&As are being developed to assist countries with the interpretation and application of the GDWQ
Questions and Answers

• Existing exposure Situations
• Broad topic areas:
  • Background and purpose of GDWQ
  • Approach adopted by WHO for assessing public health risk from radionuclides in drinking-water
  • Measuring radionuclides in drinking-water
  • How to apply the GDWQ methodology for radionuclides in drinking-water

• Some of the key topics will be addressed in the breakout sessions

1 Background and purpose of the WHO Guidelines for Drinking-Water Quality

1.1 Q: Are radionuclides in drinking water likely to be a public health risk?

A: The health risks associated with the presence of radionuclides in drinking-water are generally low compared to those from micro-organisms and chemicals. Any health risks for radionuclides in drinking-water will not be acute or immediate. Except in extreme circumstances, the radiation dose resulting from the ingestion of radionuclides in drinking-water is much lower than that received from other sources of radiation (see below).

People typically receive a radiation dose of about 0.3 mSv each year due to radionuclides of natural origin in the diet; of this about 5% comes from drinking-water. A dose of 0.3 mSv is typically 10% of the average annual radiation dose from all sources received by an individual (information compiled by UNSCEAR” (United Nations Scientific Committee on the Effects of Atomic Radiation), [UNSCEAR, 2000].
Case Studies

- Reference information to share country experiences of different circumstances and decision making for management of radionuclides in drinking-water

- Illustrate application of GDWQ and lessons learnt

<table>
<thead>
<tr>
<th>Country/region</th>
<th>Description of area/site + any useful background information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Situation/problem</td>
<td>Background information on area and drinking water distribution Type of water source affected? Scale of problem / size of water supply? Public or private supplies? How long has there been a problem? When first identified?</td>
</tr>
<tr>
<td>Radionuclides of concern</td>
<td>Radionuclides of concern? How were these identified? What measurements were used to identify the problem, eg. screening, individual radionuclides?</td>
</tr>
<tr>
<td>Regulatory authority responsible for radioactivity in drinking-water and Criteria/standards used to identify problem</td>
<td>Describe regulatory system for drinking water and radiation protection. Who regulates radioactivity in drinking water supplies (development of criteria/standards and enforcement)? Is this agency different than the one who regulates microbial and chemical parameters and other aspects of water quality? What criteria/standards are used for radionuclides in drinking water?? Who manages drinking-water supplies? Describe the monitoring regime of radionuclides in drinking water that is carried out (by who, when, how often)?</td>
</tr>
</tbody>
</table>
Muchas gracias!

Thank you very much!
Additional/supporting information in GDWQ
Examples of the efficacy of different water treatment processes are provided

<table>
<thead>
<tr>
<th>Element</th>
<th>Coagulation</th>
<th>Sand filtration</th>
<th>Activated carbon</th>
<th>Precipitation softening</th>
<th>Ion exchange</th>
<th>Reverse osmosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strontium</td>
<td>xx</td>
<td>xx</td>
<td>x</td>
<td>xxxxx</td>
<td>xxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Iodine</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>x</td>
<td>xxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Caesium</td>
<td>xx</td>
<td>xx</td>
<td>x</td>
<td>xx</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Radium</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xxxxx</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Uranium</td>
<td>xxxxx</td>
<td>x</td>
<td>xx</td>
<td>xxxxx</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Plutonium</td>
<td>xxxxx</td>
<td>xx</td>
<td>xxx</td>
<td>x</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Americium</td>
<td>xxxxx</td>
<td>xx</td>
<td>xxx</td>
<td>x</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Tritium</td>
<td>Not possible to remove (some removal by aeration of water, not quantified)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* x = 0–10% removal; xx = 10–40% removal; xxx = 40–70% removal; xxxxx = > 70% removal.
Examples of methods for measurement of specific radionuclides and references are provided.

Table 1. Summary of methods used for drinking water analysis.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Analytical method</th>
<th>Volume (l)</th>
<th>Detection limit (mBq l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross α</td>
<td>Phosphate precipitation, liquid scintillation counting</td>
<td>0.3</td>
<td>20</td>
</tr>
<tr>
<td>Uranium</td>
<td>Kinetic phosphorescence analysis</td>
<td>0.02</td>
<td>0.7</td>
</tr>
<tr>
<td>$^{238}$U, $^{234}$U, $^{235}$U</td>
<td>Extraction chromatography, alpha spectrometry</td>
<td>0.3</td>
<td>5–10</td>
</tr>
<tr>
<td>$^{228}$Ra</td>
<td>Co-precipitation with barium sulphate and transfer into carbonate, extraction chromatography, low-level beta counting ($^{228}$Ac)</td>
<td>10</td>
<td>1–2</td>
</tr>
<tr>
<td>$^{226}$Ra</td>
<td>Co-precipitation with barium sulphate, emanation, gross alpha-counting (radon and daughters, scintillation chamber)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>$^{210}$Pb, $^{210}$Po</td>
<td>Spontaneous deposition (Bi and Po) on Ni-disks, low-level beta counting ($^{210}$Bi), alpha counting ($^{210}$Po)</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>$^{222}$Rn</td>
<td>Liquid scintillation counting</td>
<td>0.015</td>
<td>1000</td>
</tr>
</tbody>
</table>