

Protecting workers from radon – experiences from Austria

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Content

Protecting workers from radon – experience from Austria



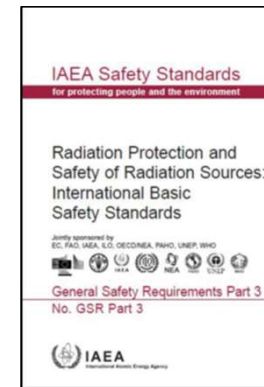
- Requirements of radon in workplaces in IAEA General Safety Requirements (GSR) Part 3
- Introduction of AGES and Austria
- Examples of radon monitoring of workplaces in Austria
 - General workplaces
 - Specific workplaces
- Conclusions – challenges, lessons learned, future tasks

Radon in the workplace

IAEA General Safety Requirements GSR Part 3

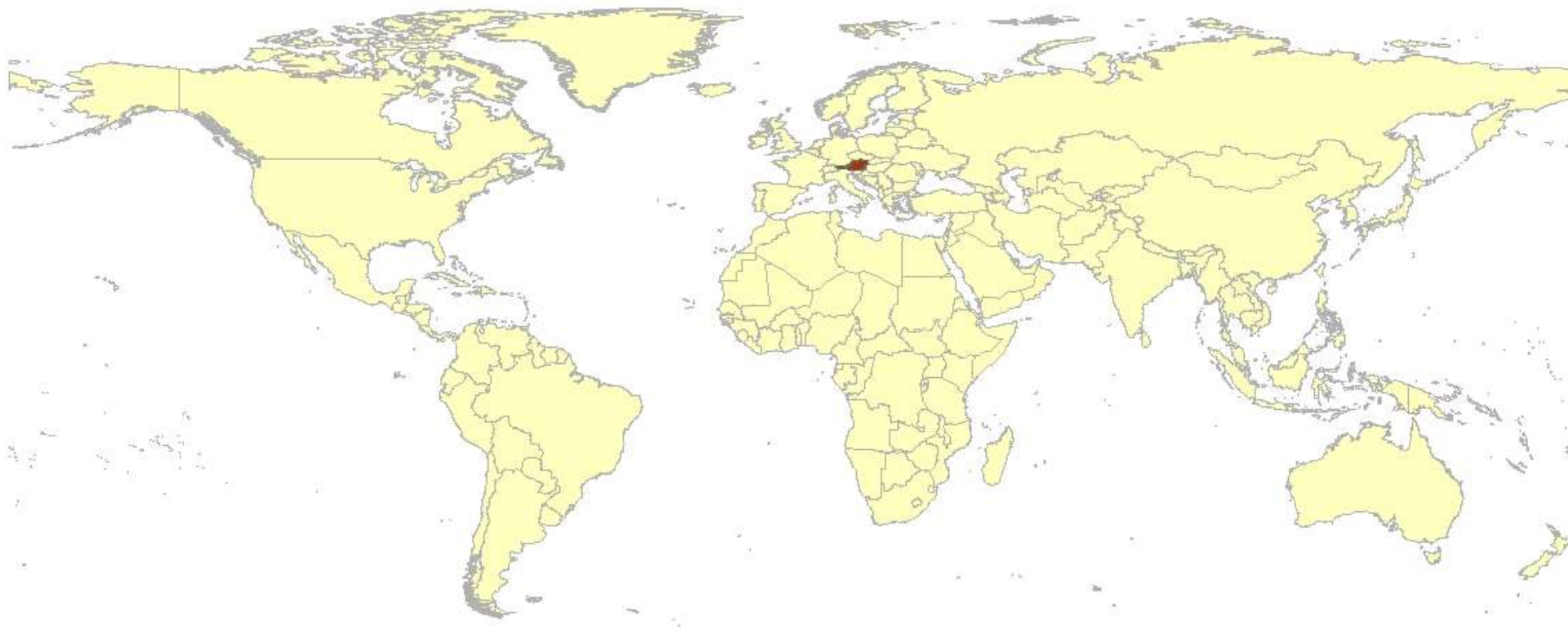
Requirement 52: Exposure in workplaces

- Exposure due to radon in workplaces:
 - Regulatory body or relevant authority shall establish a **strategy** for protection against exposure due to radon in workplaces (including appropriate reference level)
 - **Reference level (RL)** shall be set at a value that does not exceed an annual average activity concentration of 1000 Bq/m³
 - Employers shall ensure that ALARA (as lowest as reasonable achievable) and **optimization** are applied
 - If (despite all reasonable efforts by the employer to reduce) radon activity concentration remains above RL: requirements of **planned exposure situation** shall apply (Section 3)
 - Planned exposure situation: registration or licencing, dose assessment, monitoring, information and training, record keeping, etc.; Dose limit: effective dose of 20 millisievert per year (mSv/a)



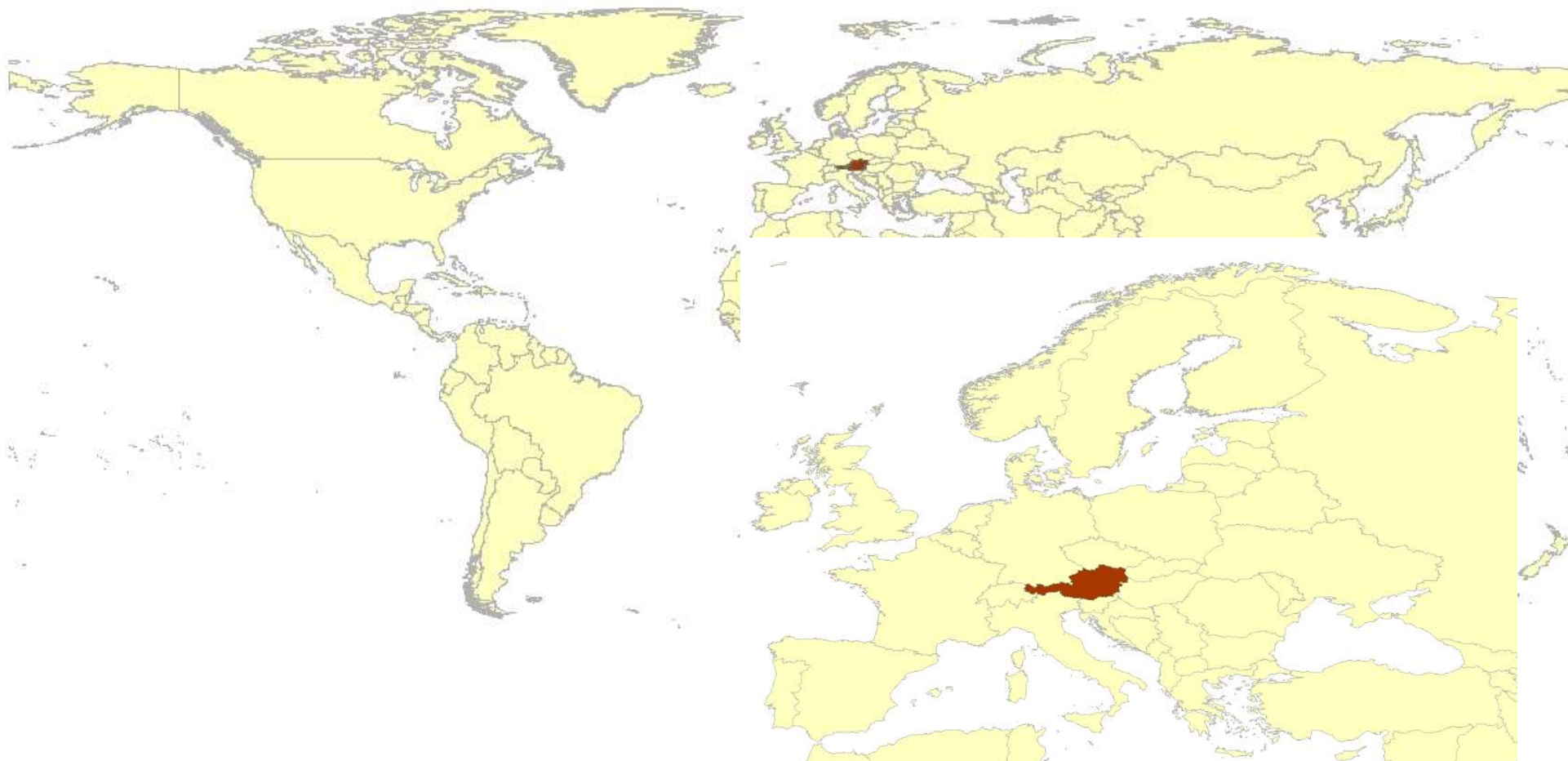
Experiences from Austria

Austria, Europe



Experiences from Austria

Austria, Europe



Experiences from Austria

Austria, Europe



Radon Situation in Austria

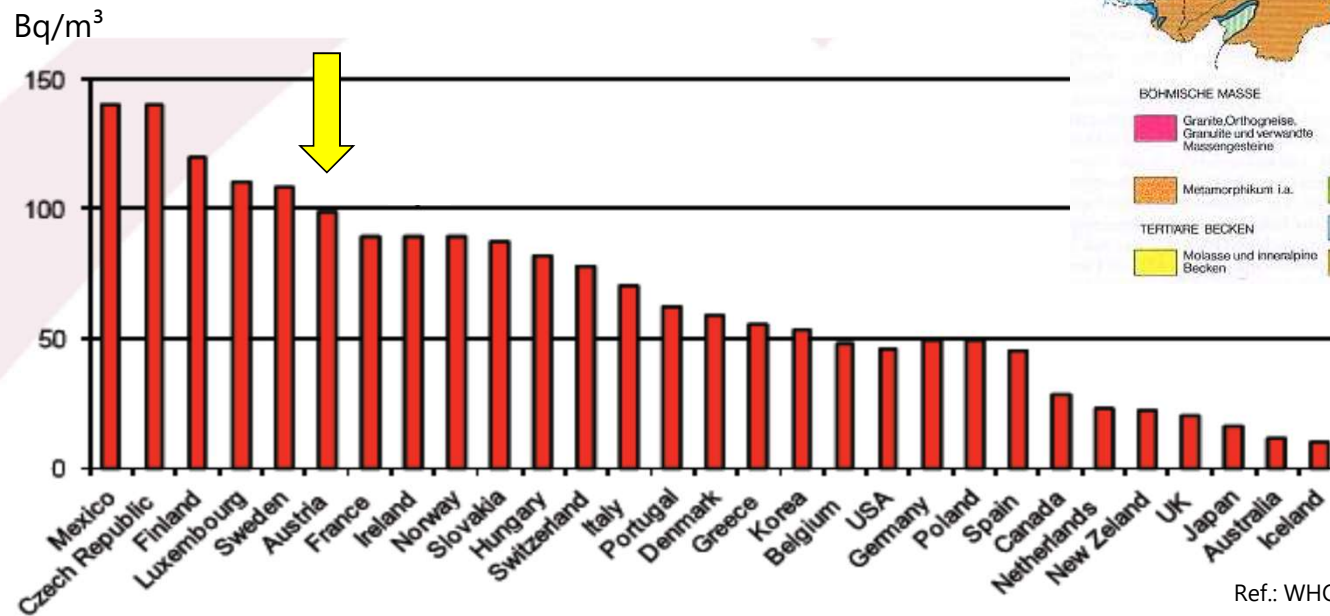
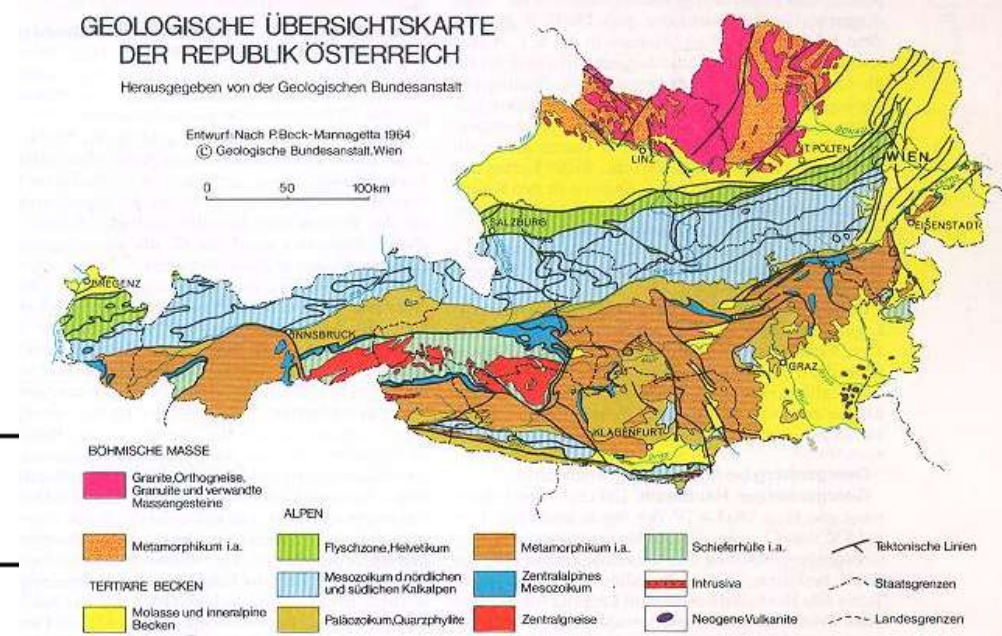
„High radon country“

Population: 8.8 million

Area: 83,879 km²

9 federal states -

Radon situation diverse (geology dependent)



Radon Work in Austria

National Radon Centre



- ↪ Embedded in the Austrian Agency for Health and Food Safety (AGES)
- ↪ Financed by the Austrian Ministry of Sustainability and Tourism (BMNT)
- ↪ Responsible for national radon work in Austria
 - Advising BMNT (e.g. implementation of new directive)
 - Preparing and monitoring **national radon action plan**
 - Austrian **radon map**, delineation of „radon areas“
 - **Information**, radon awareness, risk communication
 - **Training** and education (e.g. building professionals)
 - **Consultancy and advisory service** for population & authorities
 - **Radon measurements** in dwellings and workplaces (accredited lab ISO 17025)
 - Specific **projects** on relevant topics (national, international)
 - Cooperation with **national and international boards** (WHO, IAEA, HERCA, ERA, ISO etc.)



Radon in the Workplace

Legal background in Austria



- ☞ Recommended levels for **indoor radon concentration** (since 1992):
 - *400 Bq/m³ action level for existing buildings*
 - *200 Bq/m³ target level for new buildings*
 - **300 Bq/m³ for all buildings (since 2018)**
- ☞ No legal obligation to measure radon in **“general” workplaces** in the past
- ☞ Obligation to measure **“workplaces with potentially elevated radon exposures”** (since 2008)
 - *waterworks, underground workplaces, visitor mines and caves, radon spas*
- ☞ New: implementation of European basic safety standards (EU-BSS); not fully implemented in Austria yet
 - Reference level for dwellings and workplaces: 300 Bq/m³
 - Obligation to measure radon in
 - *„General” workplaces in basement and groundfloor rooms in delineated „radon areas”*
 - *Specific workplaces with potentially elevated radon exposures*
 - If radon concentration > RL (despite optimisation): notification to authority and
 - dose assessment: < 6mSv/a – information; >6 mSv/a – permanent monitoring, radon protection officer; limit: 20 mSv/a

Radon in the Workplace – Experience in Austria



Overview

☞ **General workplaces, public buildings** (no legal obligation yet)

- Kindergartens and childcare centers (~ 800; regional) – 1999-2003
- Schools (~ 350, Upper Austria) – 2002
- Administrative buildings – town halls (~ 440, Upper Austria) – 2008

☞ **Specific workplaces – pilot studies**

- Pilot study: waterworks (45, Upper Austria) – 2004-2006
- Pilot study: spas (3, Upper Austria) – 2005-2006
- Pilot study: visitor mines and show caves (9, Austria) – 2008-2010

☞ **Specific workplaces – implementation of NatStrV** („Authorized laboratory“)

- water supplies (~ 40, Austria)
- visitor mines (3, Austria)
- radon spas (~ 5, Salzburg)

General Workplaces and Public Buildings

„Healthy Air for Upper Austria’s Kids“

Include radon in indoor air programmes for higher acceptance!



☞ Motivation – survey in Upper Austria:

- Children and teenagers are often in specific need of protection
- Higher radon potential in areas of Upper Austria
- Group rooms/classrooms often in direct contact with surrounding soil („earthbound“)

☞ Programme „Healthy Air for Upper Austria’s Children“

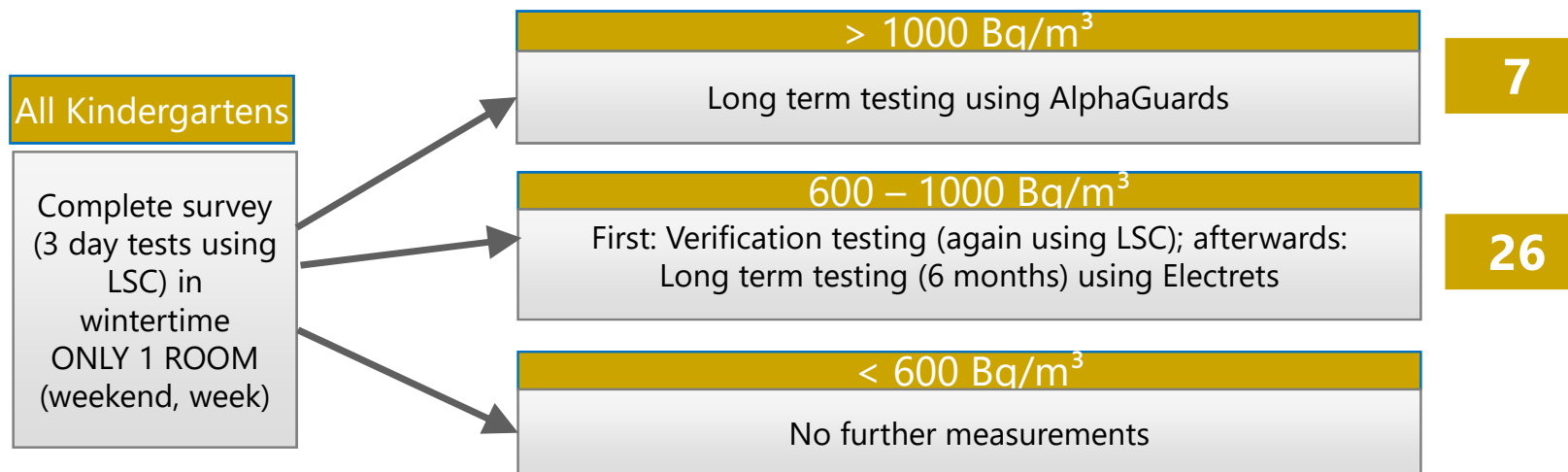
- Radon
- Chemical indoor parameters
- Smell
- Mould
- Acoustics
- Tightness of building, draught



Radon Survey in Kindergartens

First survey - Upper Austria, 1999-2001

- radon measurements in about 650 kindergartens
- short-term and long term radon measurements

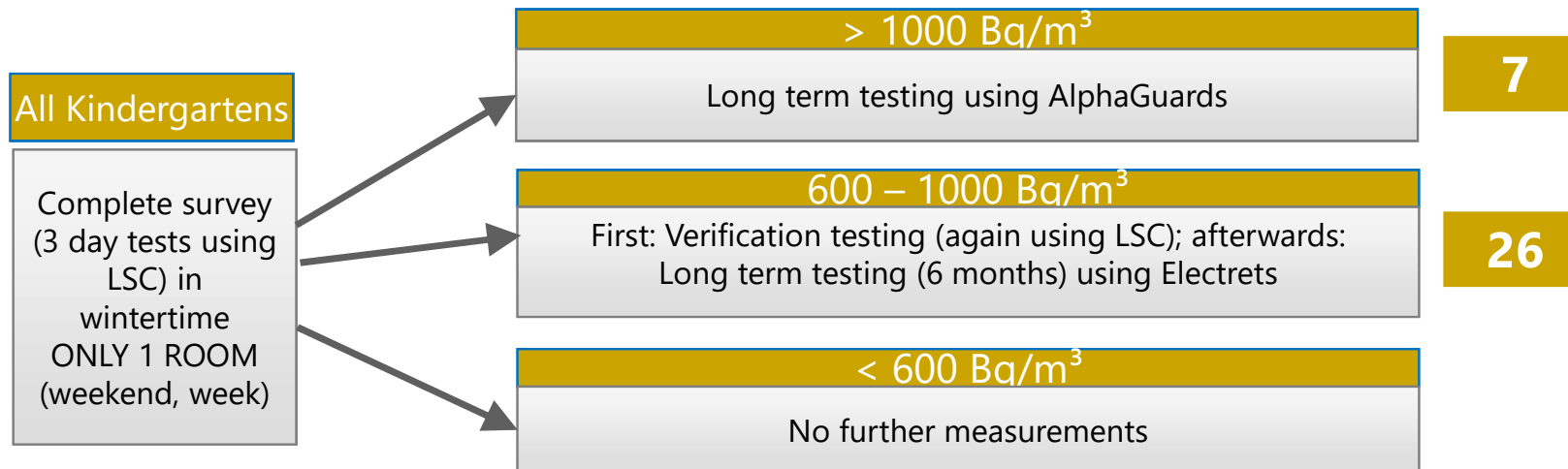


LSC - Liquid Scintillation Counting

Radon Survey in Kindergartens

First survey - Upper Austria, 1999-2001

- radon measurements in about 650 kindergartens
- short-term and long term radon measurements



New survey necessary (long term measurements, new RL)!

Radon Survey in Schools



Only in radon areas, earthbound rooms

- Indoor air quality programme, 2002
- First step: survey (questionnaire) about building characteristics, acoustics, indoor air quality (40 questions)
- 793 of 926 replied
- Selection of schools with earth bound rooms in „radon areas“ (according to Austrian radon map) and in municipalities next to „radon areas“

Region	Schools	With earthbound rooms
Upper Austria (total)	793	608
Upper Austria (only radon prone areas)	202	163
In villages next to radon prone areas	228	175

+ 30 „control group“
(earthbound, not „radon area“)

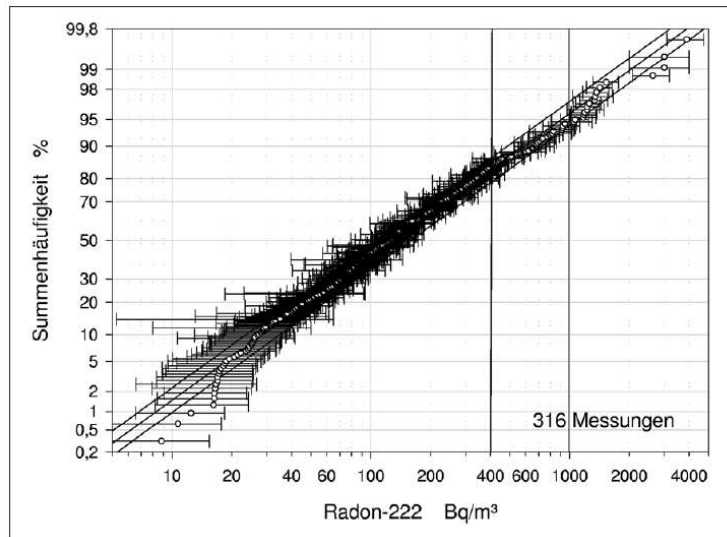
- Measurements in 368 schools
- Passive detectors, long-term 3-5 months**

Radon Survey in Schools

More schools with higher radon concentration in „radon areas“

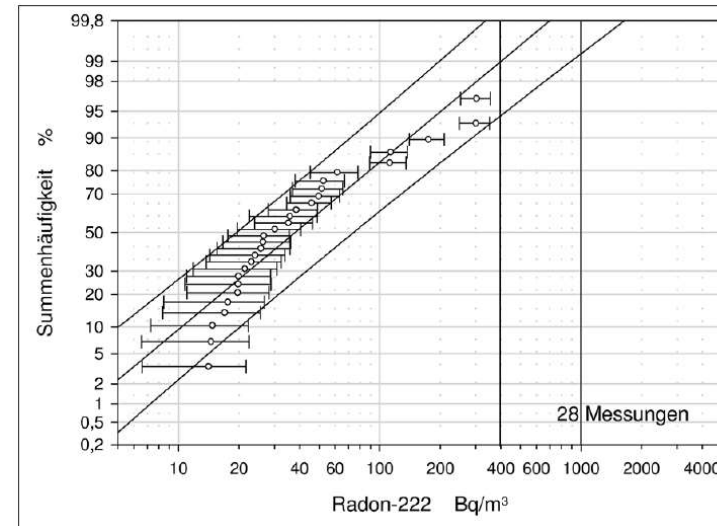


Schools, radon areas



- 64 (20%) schools $> 400 \text{ Bq/m}^3$
 - 23 (6%) schools $> 1000 \text{ Bq/m}^3$
- 90 (29%) schools $> 300 \text{ Bq/m}^3$

Schools, control group

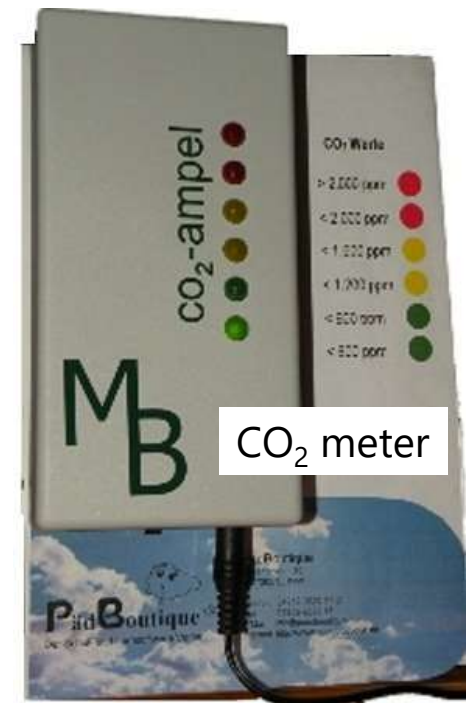
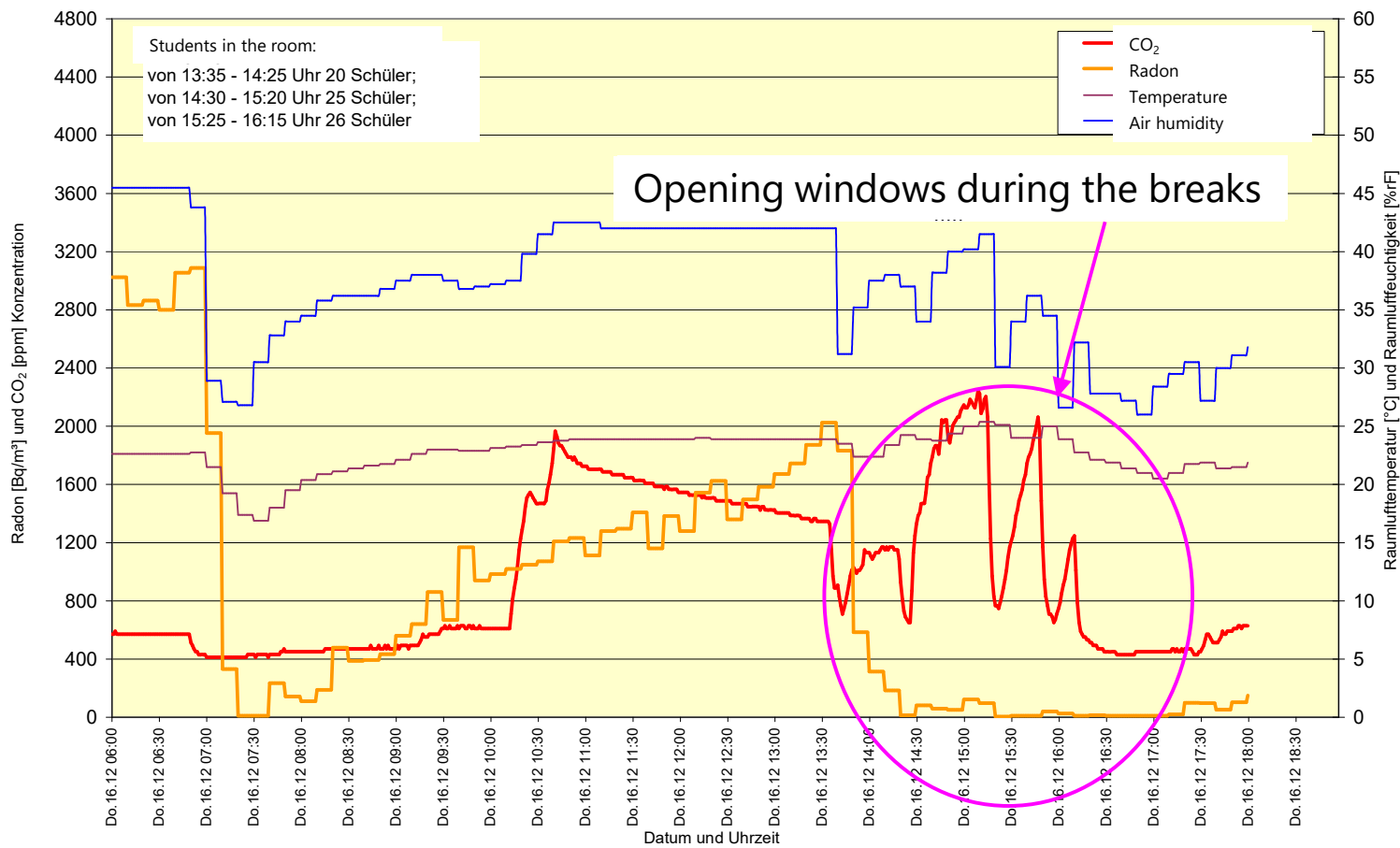


- 2 (7%) schools $> 300 \text{ Bq/m}^3$

Graded approaches depending on radon level for mitigation were applied!
(immediate actions (ventilation plan, new utilisation concept), mitigation within next years etc.)

CO₂ and Radon in Schools and Kindergartens

Solving the CO₂ problem would (often) also solve the radon problem!!



Time Sensitive Radon Testing

How well do passive measurements reflect radon concentration during working hours?

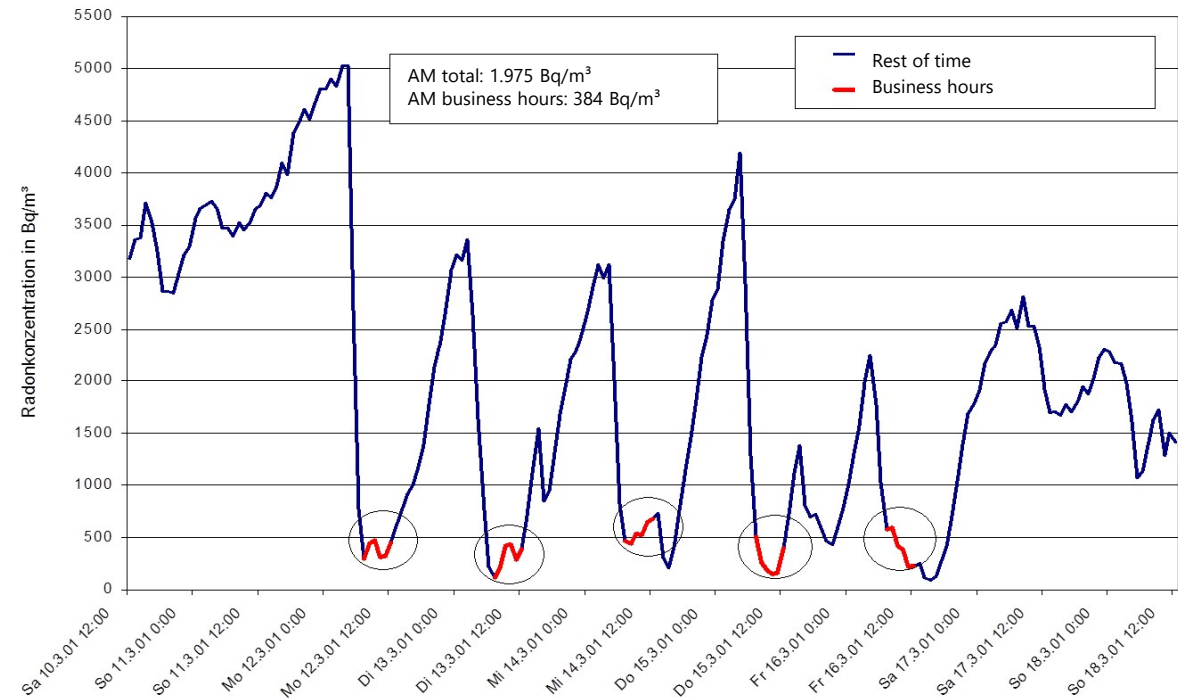


- ☞ Mean radon concentrations reflect the radon exposure during operating hours on average quite well, however, deviations by a **factor of 3** are possible (in both directions) according to Austrian measurements, depending on
 - Ventilation habits
 - Operating hours (e.g. only mornings or all day long)
- ☞ Generally higher radon concentrations at weekends
- ☞ Passive long term measurements – good first evaluation (cheap, simple)!
- ☞ If higher concentrations are detected, detailed analysis possible (e.g. only during working hours)



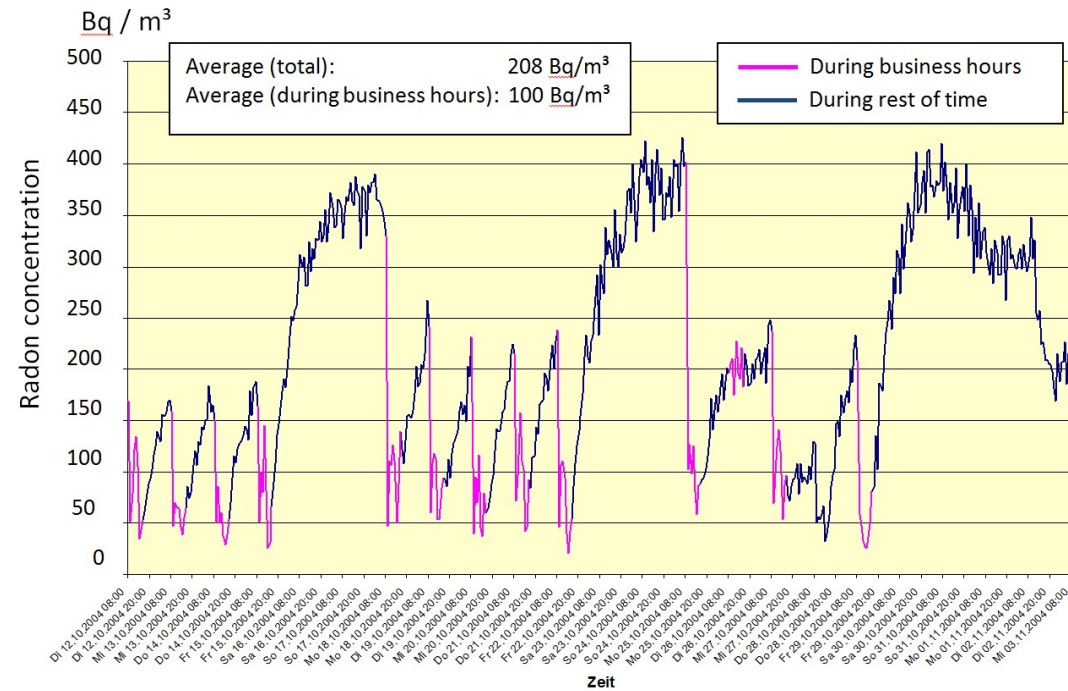
Mitigation Examples

Schools – Installation of a ventilation system (overpressure)



Mitigation Examples

Schools – Installation of a sub-slab depressurization system



Room	Floor	Before mitigation	After mitigation
Cushion room	Basement	3.134 Bq/m ³	208 Bq/m ³
Group room 1	Basement	857	190 Bq/m ³
Building Plot	Basement	-	251 Bq/m ³

Radon in Administrative Buildings

Raising radon awareness for regulators!

Measurements in 3 to 5 rooms (offices)/building for 6 months, passive detectors, questionnaires

Max. radon concentration	Number of buildings	%
< 400 Bq/m ³	370	87
400 – 1000 Bq/m ³	46	11
> 1000 Bq/m ³	7	2



Radon in Administrative Buildings

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Max. radon concentration	Number of buildings	%
< 400 Bq/m ³	370	87
400 – 1000 Bq/m ³	46	11
> 1000 Bq/m ³	7	2

Measures necessary!



Specific Workplaces

Gruber, V., Ringer, W.: Radon Exposure at Specific Workplaces in Austria – Experiences and Future Challenges, Radiat Prot Dosimetry (2017), 177 (1-2), 7-11

Radon in Waterworks (or Water Supply)

Radon-exposed workers in Austria



- 45 waterworks (selected according to geology and water volume)
- 142 measurements, active, Electret
- All areas in waterworks (well houses, water storage basins, treatment facilities, offices)

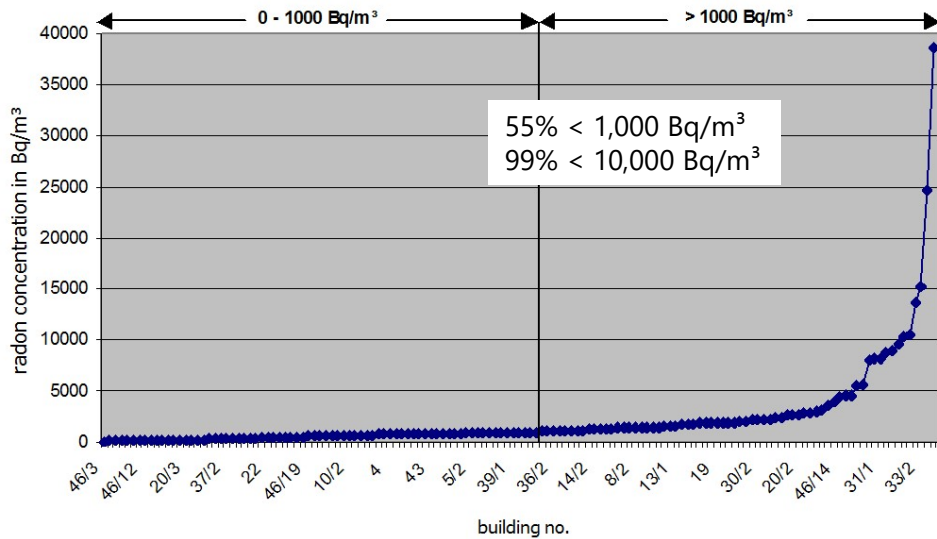


Radon in Waterworks (or Water Supply)

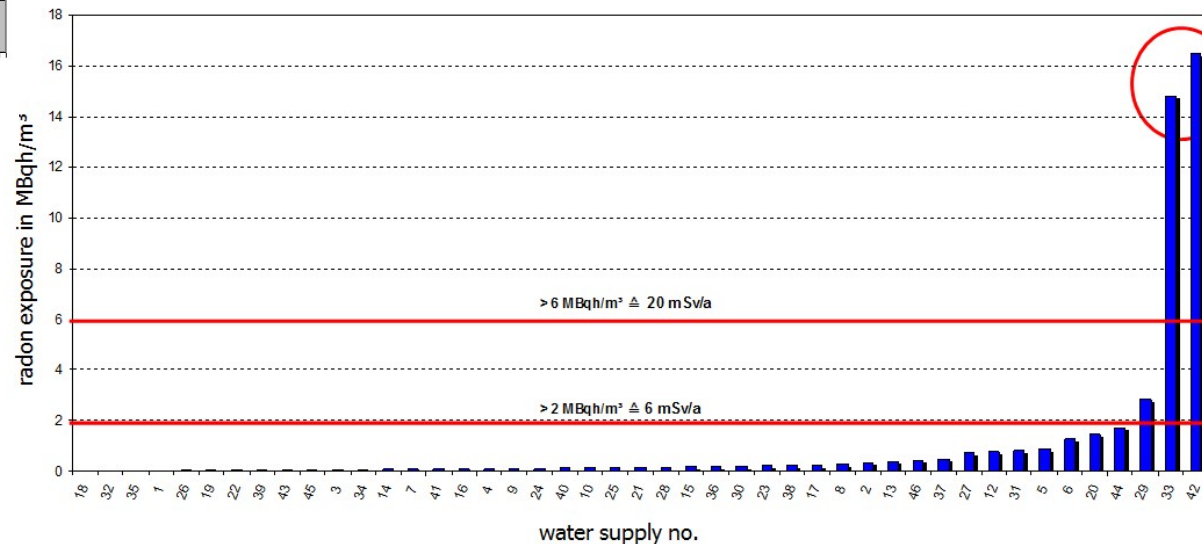
In 3 waterworks - workers with radon exposure above 6 mSv/a



radon concentration (142 measurements)

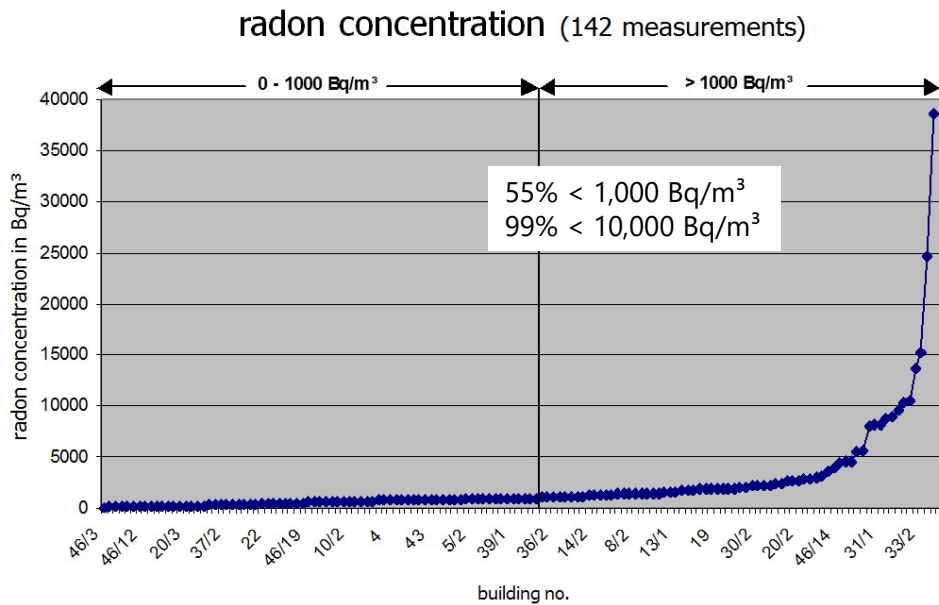


radon exposure



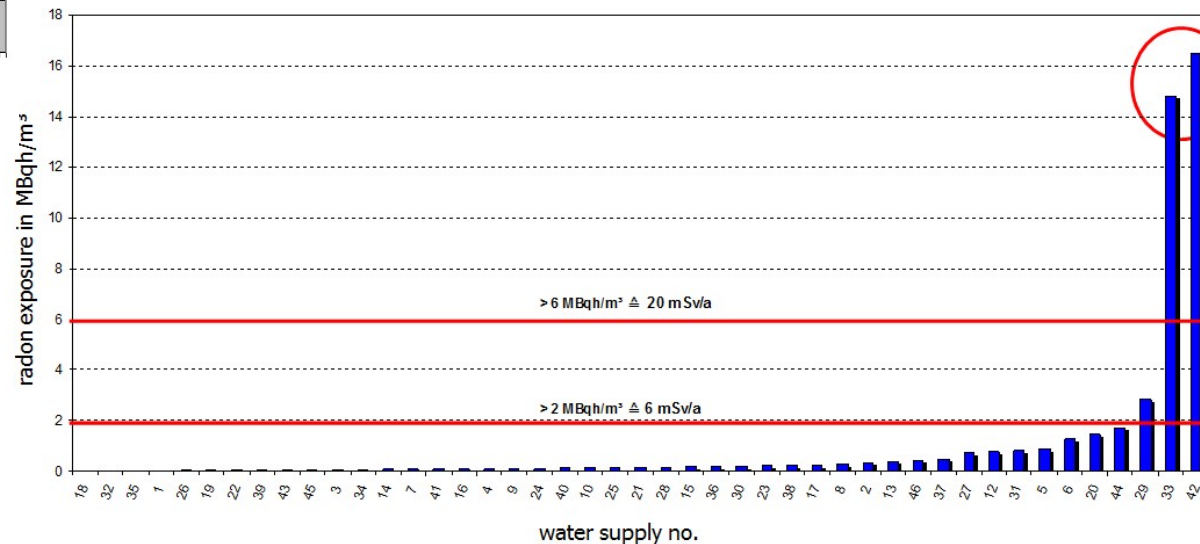
Radon in Waterworks

In 3 waterworks - workers with radon exposure above 6 mSv/a



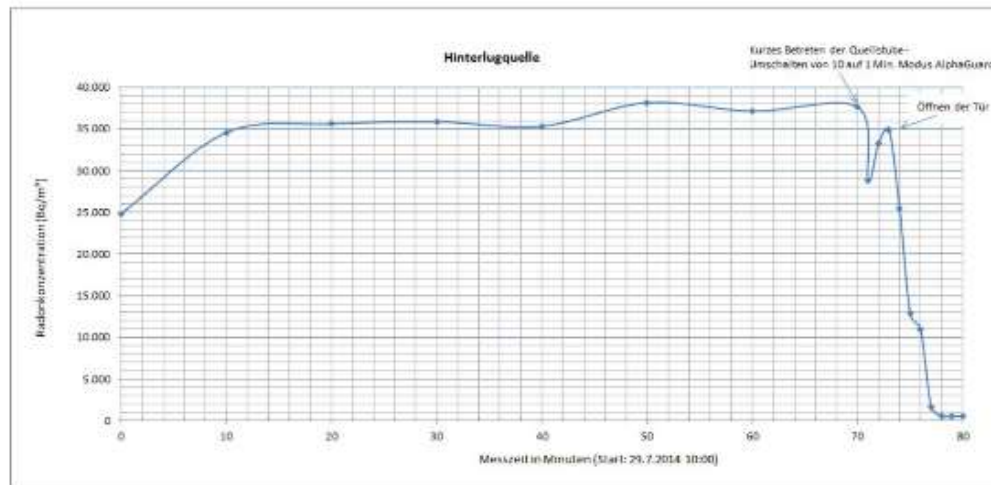
radon exposure

Ringer, W. et al.: Mitigation of Three Water Supplies with High Radon Exposure to the Employees; Radiat Prot Dosimetry, 2008; 130 (1): 26-29

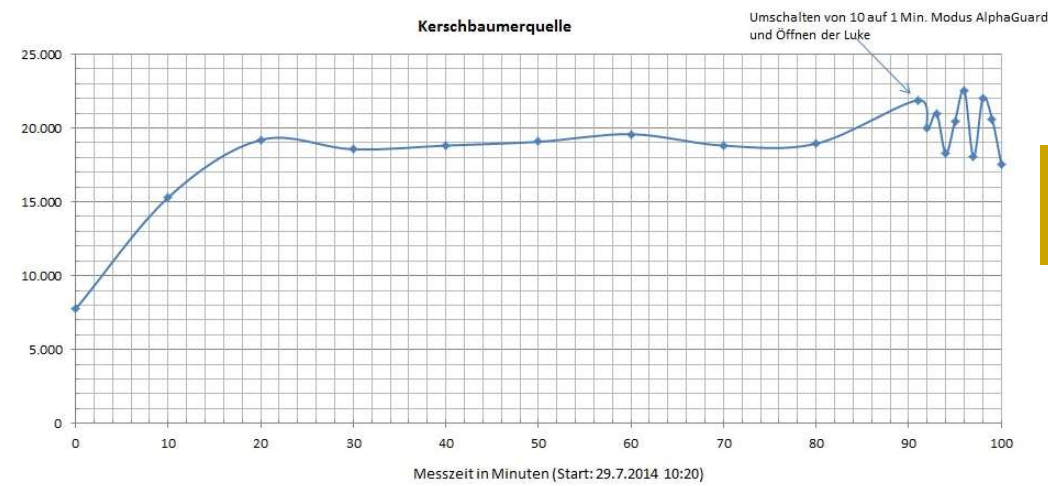


Radon in Waterworks

An example for a simple measure to reduce radon exposure to workers



Open door for 5 minutes before entering!



Does not always work – depending on design of building

Experience from Waterworks in Austria

Some conclusions

- ☞ Mitigation is (usually) quite cost-effective
- ☞ Identification of radon source(s) before mitigation (radon assessment), e.g. water treatment techniques like vaporizer, cascade, etc.
- ☞ No employee above 6 mSv/a after some (simple) measures (reduce occupancy hours in relevant building, ventilation)
- ☞ Highest doses during (annual) cleaning of reservoirs → measures: more workers for less time; increase ventilation; remove source!
- ☞ **Familiarize the workers with “radon measures” - include in work instructions, regular information and reminders!**



Radon in Visitor (or Tourist) Mines and Caves

Pilot study

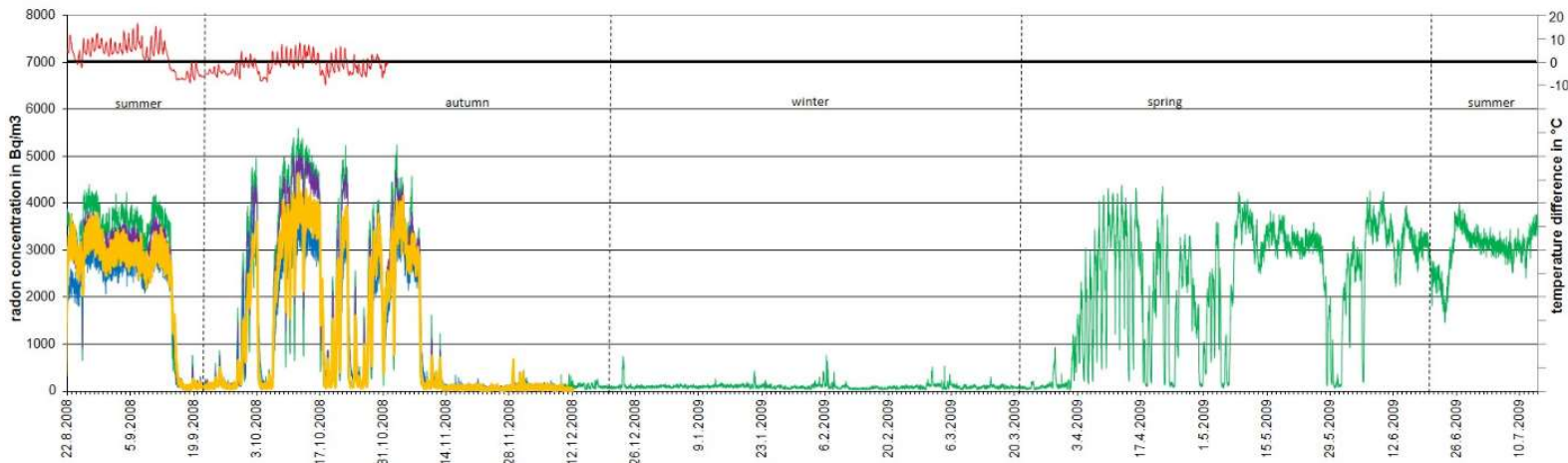
- ↷ 6 visitor mines, 3 caves (selected by geology, "mining product", number of visitors, opening hours)
- ↷ active measurements for 6 months up to 1 year (several locations within mine/cave)
- ↷ radon, thoron, equilibrium factor, air pressure, temperature



Gruber, V., Ringer, W., Gräser, J., Aspek, W., Gschnaller, J.: Comprehensive investigation of radon exposure in Austrian tourist mines and caves, Radiat Prot Dosimetry, 162(1-2), 78-82 (2014)

Examples - Radon Concentration in Visitor Mines

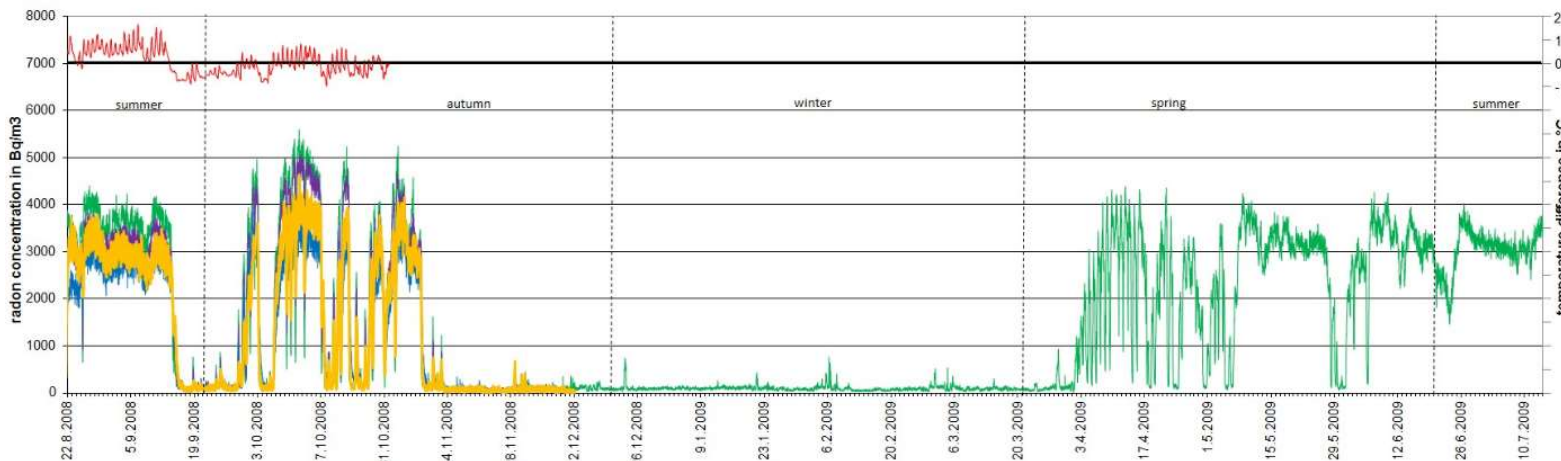
Radon concentrations normally lower in winter than in summer!



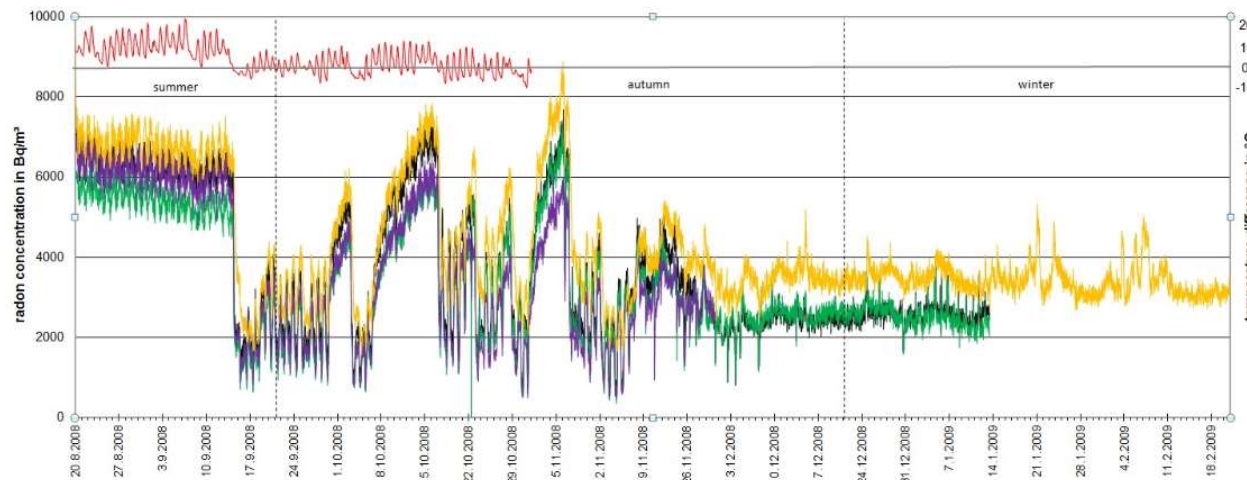
Iron-ore mine,
1 year measurement
constant temperature about 8°C

Examples - Radon Concentration in Visitor Mines

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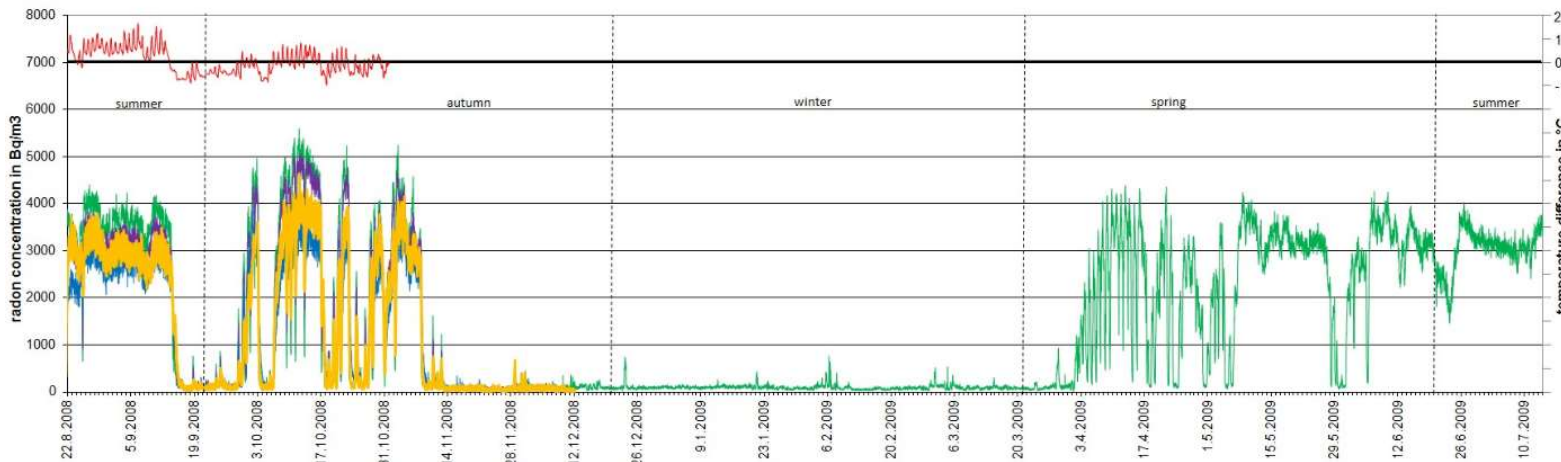
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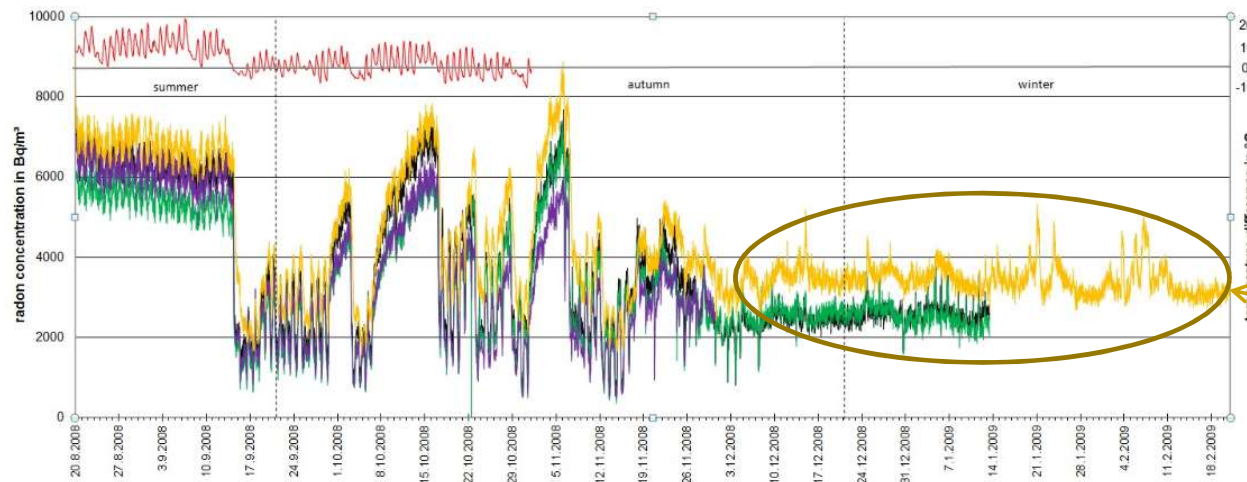
Silver mine,
6 months measurement
constant temperature about 9°C

Examples - Radon Concentration in Visitor Mines

Radon concentrations normally lower in winter than in summer!



Iron-ore mine,
1 year measurement
constant temperature about 8°C



Silver mine,
6 months measurement
constant temperature about 9°C

Closing of gallery door
during winter, to prevent
cooling of the mine

Radon Concentration and Doses in Visitor Mines and Caves



In mines, concentration is higher than in caves

Object	Mean radon concentration [Bq/m ³] without winter
Show caves	960
Salt mine	1300
Iron ore mines	3000
Silver mines	4200
Copper Mine	4900

Range of average radon concentration:
200 – 16.000 Bq/m³

Max. radon concentration:
60 kBq/m³
in silver mine

Main impact factors:

- Geology („mining product“)
- Structure of cavities
- Temperature difference outside/inside (seasonal variations)
- Artificial ventillation/ weather doors

	Mean annual dose of highest [mSv/a]
Show caves	0.9
Salt mine	1.1
Iron ore mines	1.9
Silver mines	3.3
Copper mine	5.4

Max. dose: 15.5 mSv/a
in copper mine

Radon Concentration and Doses in Visitor Mines and Caves



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The „Good Radon“

Situation of workers in radon spas in Austria



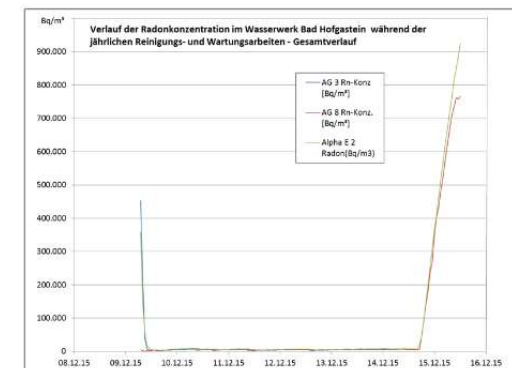
- Radon spas included in legislation -> employees in radon spas controlled
- Most of employees < 6 mSv/a (radon concentration not very high due to mechanical ventilation systems (moisture))
- Some workers permanently controlled with personal dosimeters (> 6 mSv/a, but < 20 mSv/a) (technicians - baths, radon water treatment) -> doses clearly reduced with simple measures (reduce occupancy time, tightness of doors, ventilation etc.)



The „Good Radon“

Situation of workers in radon spas in Austria

- Radon spas included in legislation -> employees in radon spas controlled
- Most of employees < 6 mSv/a (radon concentration not very high due to mechanical ventilation systems (moisture))
- Some workers permanently controlled with personal dosimeters (> 6 mSv/a, but < 20 mSv/a) (technicians - baths, radon water treatment) -> doses clearly reduced with simple measures (reduce occupancy time, tightness of doors, ventilation etc.)
- Water supplies for radon spas: very high radon concentrations can occur (> 2 MBq/m³) -> cleaning of water storage basins -> with increased temporal ventilation – doses < 6 mSv/a for workers



Radon in Workplaces

Conclusions, challenges, lessons learned



- ☞ Schools, kindergartens – often buildings with earthbound rooms (classes), higher radon concentration
- ☞ Mechanical ventilation can solve CO₂ and radon problem
- ☞ Challenge: „**Detector placing**“ – especially in schools, kindergartens, public buildings (best not visible to kids/visitors)
- ☞ Challenge „**Communication**“:
 - Who needs to be informed about measurements (all employees, cleaning staff, parents, etc.)?
 - Who needs to be informed about results? How to inform them best?
 - Better acceptance if open communication (e.g. via trusted people)
- ☞ Challenge „**Responsibility**“: Who is responsible for measurements/mitigation? (building owner vs. tenant, employer)
- ☞ Re-evaluation/Repeating of measurements/survey can be necessary, as available methods and requirements change!

Radon in Workplaces

Conclusions, challenges, lessons learned

- NatStrV since 2008 for specific workplaces – still many not measured!
- Increase awareness of employers (and workers) – co-operation with stakeholders
- Specific information – website, folders, info campaigns
- Measurement protocols for radon in workplaces are necessary for comparable/reliable results!
- Efficient and simple measurement methods and measures are necessary!



AGES
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Dosisbestimmung mittels Personenexposimetern

Allgemeine Angaben, welche für eine korrekte Auswertung benötigt werden:

Untersuchter Betrieb: _____
Name und Vorname des Beschäftigten: _____
Funktion des Beschäftigten: _____
Tatsächliche durchgeführte Wochenarbeitszeit: _____

Beginn des Messzeitraumes

Datum: _____
Personenexposimeter Nummer: _____
Referenzexposimeter Nummer: _____

Während des Messzeitraumes

Lagerorte des Referenzexposimeters (Beschreibung): _____

Gemeinnutz/Unfallschutz (z.B. Stichtage): _____

Ende des Messzeitraumes

Datum: _____
War der Messzeitraum besonders untypisch? Gab es außerordentliche Partner?



Protect Workers from Radon

Present and future tasks



- ↪ Transpose requirements (IAEA, EU) for radon in workplaces in **national legislation**
- ↪ Implement **measurement protocols** for radon measurements
- ↪ **Quality control** for measurement services/mitigation services
- ↪ Develop and establish **efficient and simple measurement methods** for monitoring workplaces
- ↪ Develop and establish **efficient and simple mitigation methods** for workplaces
- ↪ Define clear **responsibilities** (authorities, employers)
- ↪ **Inform** workplaces concerned by regulation about their responsibility (via trusted/efficient channels, e.g. unions)



AGES



Thank you for attending!

Dr. Valeria Gruber

Senior Expert

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