



#### INCLL ARE RADON PRIORITY AREAS, IDENTIFIED ON SURVEY IN DWELLINGS, REPRESENTATIVE OF RADON LEVELS IN WORKPLACES?

#### <u>R.Trevisi<sup>1</sup></u>, F.Leonardi<sup>1</sup>, G.Buresti<sup>1</sup>, S. Bucci<sup>2</sup>, G.Cinelli<sup>3</sup>, V.Gruber<sup>4</sup>, J.Gutierrez Villanueva<sup>5</sup>, T.Heinrich<sup>6</sup>, O.Holmgren<sup>7</sup>, and P. Bossew<sup>8</sup>

<sup>1</sup> INAIL/DiMEILA, Italy

- <sup>2</sup> ARPA Toscana, Italy
- <sup>3</sup> European Commission, Joint Research Centre (JRC), Italy
- <sup>4</sup> AGES/Abteilung Radon und Radioökologie, Austria
- <sup>5</sup> Radonova Laboratories AB, Sweden
- <sup>6</sup> Staatliche Betriebsgesellschaft Für Umwelt Und Landwirtschaft, Germany
- <sup>7</sup> STUK, Finland
- <sup>8</sup> BfS/German Federal Office for Radiation Protection, Germany





#### Indoor Rn - Differences between dwellings and workplaces

Workplaces differ from dwellings in terms of:

- **Building structure**: multi-storey buildings with large entrance hall and wide use of open-spaces.
- Microclimatic conditions: high humidity, presence of dust or aerosols, high temperature, etc.
- Wide presence of air-conditioning systems or forced ventilation;
- Large use of rooms at ground floor or basement;
- Occupancy factors: not continuous usage pattern (closure during nights, weekends, holidays, etc.);
- Inhomogeneity: different characteristics depending on the work activities.



Compared with dwellings, workplaces are an inhomogeneous category, often characterized by relatively larger spatial and temporal variations in radon levels.



### Within the same area, radon levels in dwellings and in workplaces are generally different?

- ✓ Few of the surveys investigated indoor radon levels both in dwellings and workplaces.
- ✓Extensive indoor radon surveys in workplaces are scarse and usually mainly addressed to specific workplaces (such as schools, spas, mines).

In general, the identification of radon priority areas (RPA) is based on surveys carried out in dwellings, **but international/national regulations set specific requirements to control radon exposure in workplaces located within such areas**.





INCIL

### **Council Directive 2013/59/Euratom - BSS**



Article 54

#### Radon in workplaces

1. Member States shall establish national reference levels for indoor radon concentrations in workplaces. The reference level for the annual average activity concentration in air shall not be higher than 300 Bq m<sup>-3</sup>, unless it is warranted by national prevailing circumstances.

#### 2. <u>Member States shall require that radon measurements are</u> carried out:

(a) in workplaces within the areas identified in accordance with Article 103(3), that are located on the ground floor or basement level, taking into account parameters contained in the national action plan as under point 2 of Annex XVIII, as well as



(b) in specific types of workplaces identified in the national action plan taking into account point 3 of Annex XVIII.

3. In areas within workplaces, where the radon concentration (as an annual average), continues to exceed the national reference level, despite the action taken in accordance with the principle of optimisation as set out in Chapter III, Member States shall require this situation to be notified in accordance with Article 25(2) and Article 35(2) shall apply.

#### Article 103

#### Radon action plan

1. In application of Article 100(1), Member States shall establish a national action plan addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water. The action plan shall take into account the issues set out in Annex XVIII and be updated on a regular basis.

2. Member States shall ensure that appropriate measures are in place to prevent radon ingress into new buildings. These measures may include specific requirements in national building codes.

3. Member States shall identify areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level.

# RADON Are RPA (defined of the basis of radon levels in dwellings) representative of radon in workplaces?



- ✓ Dwellings seem more suitable than workplaces to represent radon distribution (less internal variability, more uniform building structure, more uniform living habits) in a territory (mapping).
- A study, carried out in Serbian primary schools, put in evidence the equivalence of Rn levels in dwellings and schools in terms of **similar geographical pattern**, so that data about schools can be used in the elaboration of maps on indoor Rn concentrations in dwellings, but **can the schools be considered also as "representative" of all kinds of workplaces?**

 Indexemplaces vs. DWellings
 Bossew P et al. Geographical distribution of the annual mean radon concentrations in primary schools of Southern Serbia - application of geostatistical methods. J. Environ. Radioact. 127: 141-148. (2014)

 RPA WORKPLACES VS. DWELLINGS
 Zunic ZS et al. The relation between radon in schools and in dwellings: a case study in a rural Southern Serbia. J. Environ. Radioact., 167: 188-200 (2017).

# Wetro Within the same area, radon levels in dwellings and provider ECM in workplaces are generally different? (cont.)

✓ Few surveys have been designed to investigate the distribution of radon in workplaces and in dwellings, obtaining different results. Some examples:

An extensive survey carried out in Italy (Tuscany) considered about 2000 dwellings and 1200 workplaces (different kind) distributed among 287 municipalities.

 Table 1. Gross data distribution results for dwellings and workplaces.

Summary parameters	Dwellings	Workplaces	
Ν	1541	1159	
$Min (Bq m^{-3})$	4	4	
First quartile (Bq $m^{-3}$ )	19	21	
Median (Bq $m^{-3}$ )	32	43	
Third quartile (Bq $m^{-3}$ )	65	102	
90th percentile (Bq $m^{-3}$ )	137	260	
$Max (Bq m^{-3})$	4828	9417	

Radiation Protection Dosimetry (2011), Vol. 145, No. 2-3, pp. 202-205

doi:10.1093/rpd/ncr040

#### RADON IN WORKPLACES: FIRST RESULTS OF AN EXTENSIVE SURVEY AND COMPARISON WITH RADON IN HOMES

Silvia Bucci<sup>1,\*</sup>, Gabriele Pratesi<sup>1</sup>, Maria Letizia Viti<sup>1</sup>, Marta Pantani<sup>1</sup>, Francesco Bochicchio<sup>2</sup> and Gennaro Venoso<sup>2</sup>

The results showed radon levels statistically different in two datasets and in particular, higher radon levels in workplaces respect to dwellings. Different radon levels in kind of workplaces. Wetro RADON Within the same area, radon levels in dwellings and provider ECM in workplaces are generally different? (cont.)

✓ Same conclusions were drawn in Japan as well as in Finland

Oikawa S. et al. *A survey of indoor workplace radon concentration in Japan.* J. Environ. Radioact. 87:239-245 (2006) <u>considering schools, hospital, offices, factory</u>

Mäkeläinen I. et al. *Indoor occupancy and radon exposure in Finland*. Radioactivity in the Environment. Elsevier 2005; 7:687-693 (2005)

Conversely, different trends were found in other studies

Espinosa G. et al. *Nationwide survey of radon levels in indoor workplaces in Mexico using Nuclear Track Methodology*. Radiat. Meas. 44:1051-1054 (2009)





### MetroRADON Task 4.1.1.2 Radon dwellings vs workplaces

In the framework of MetroRADON project

# WP4: Radon priority areas (RPAs) and the development of the concept of a "geogenic radon hazard index" (RHI)

During the last meeting held in Warsaw, the subtask **4.1.1.2** "Radon dwellings vs workplaces» was formalized.

#### Main objectives:

- re-analyze data about radon in workplaces and dwellings of some European countries, in order to find possible correlation of the radon distributions of indoor radon levels in workplaces and in dwellings.
- 2. elaboration of a **model** predicting the direction in which radon levels in workplaces and dwellings **could diverge**.

INCIL



## Step 1



- 1.1 Build-up of **reliable** radon datasets (residential and workplaces) coming from surveys carried out in some European countries.
- Build-up of **reliable** radon datasets requires collection of data **comparable** in terms of:
- Position: data referred only rooms located at ground floor.
- Quantity of interest: radon annual average concentration.
- Duration of sampling: long term measurements to evaluate the mean radon activity concentration.
- About workplaces dataset, need to collect data about **different kind of workplaces**.
- 1.2 Development of a procedure to analyze national radon data (residential and workplaces).



# Step 1 (cont.)



1.1 Build-up of reliable radon datasets (dwellings and workplaces) coming from surveys carried out in some European countries.



- ✓ Thanks to the availability of indoor radon data about ground-floor rooms of dwellings from the European Indoor Radon Map-EIRM provided by EC-JRC, participants were asked to provide data about radon in workplaces at ground floor, using the same methodology (privacy of raw data).
- ✓ Analysis of residential and workplaces datasets considering statistic parameters estimated on 10x10 km grid cells.







### MetroRADON Task 4.1.1.2 Radon dwellings vs workplaces

<b>Participants/Countries</b>	Dwellings (raw dataset)	Workplaces (raw dataset)
Austria	6500	1300
Germany	2000	1200
Italy	2000	1200
Finland	100000	7100

Typically, data about *workplaces* are fewer than residential data.

INCIL



# Step 1 (cont.)



	Italy	Finland	Germany	Austria
<i>Duration of measurements/ dwellings</i>	Annual sampling	60-70 days	4 – 12 months	<b>6 months</b> (half winter half summer)
<i>Duration of measurements/ workplaces</i>	Annual sampling	60-70 days	Annual sampling	<b>3 months</b> for schools <b>6 months</b> ( <i>half</i> <i>winter half summer</i> ) for administrative buildings
<i>Workplaces</i> <i>considered</i>	Many kinds of workplaces – no special workpl. ( <i>as</i> <i>mines, spas, etc.</i> )	Many kinds of workplaces – no special workpl. ( <i>as</i> <i>mines, spas, etc.</i> )	Public building ( <i>administrative</i> <i>buildings, schools,</i> <i>kindergartens</i> )	Public building ( <i>administrative</i> <i>buildings, schools,</i> <i>kindergartens</i> )

INCIL



## **Preliminary results (1)**



- ✓It is evident the problem of harmonization of data in order to compare the same quantity as at national level, as among countries.
- ✓ It is ongoing the evaluation of analysing residential and workplaces datasets by using statistic parameters estimated on 10x10 km grid cells. (*Upper Austrian datasets – as pilot*).

## **Future actions**

- Application of the analysis on data grouped using a different grid, i.e. 20x20 km grid cells.
- Application of the analysis on data grouped on the basis of municipality.
- Validation of results achieved on grouped data by comparison with results of analysis on raw datasets (dwellings and workplaces).





## **Preliminary results (2)**









- ✓ Harmonization of in-put data: evaluation of corrective actions to overcome problems concerning the representativeness of measured quantity (*different measurement protocol*).
- ✓ By Finnish data, possibility to increase information on distribution of radon in different kind of workplaces (*as found in Italy*).
- ✓ For future surveys aimed to identify RPA using indoor radon data, elaboration of a sample design considering a mix of buildings (residential and workplace).
- Collection of information about the building characteristics (ventilation, building materials, building typology, dimensions, etc.), daily variation of indoor radon and occupancy time in order to elaborate a model predicting the direction in which radon levels in workplaces and dwellings could diverge.





# Thank you!

r.trevisi@inail.it

+390694181264

INCIL

**RPA** WORKPLACES VS. DWELLINGS