12th INTERNATIONAL WORKSHOP GARRM
(on the GEOLOGICAL ASPECTS OF RADON RISK MAPPING)
September 16th – 18th (19th), 2014
Prague, Czech Republic

Soil features and indoor radon concentration prediction: radon in soil gas, pedology, permeability and ^{226}Ra content

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INTRODUCTION

❖ Mapping geogenic radon

- The radon concentration mapping looks for determining the potential risks of this gas inside dwellings and other indoor environments and to assess areas available for new constructions;

- These maps serve as a management tool for authorities assisting them in making decisions on priority areas.

INTRODUCTION

❖ Soil Radon Potential "RP" and Soil Radon Index "RI"

- As higher permeability enables the increase the migration of radon in soil gas and its transportation from the soil into the building (Neznal et al, 2004);

- The "RP" allows estimate the radon concentration in soil gas with permeability relationship.

INTRODUCTION

❖ Soil Radon Potential "RP" and Soil Radon Index "RI"

$$RP = \frac{C - C_0}{- log\,(P) + log\,(P_0)}$$

where "**C" is the radon concentration in soil gas (kBq.m-^{3})**, and **"P" is the permeability of the soil (m^2)**; **"C_0"** and **"P_0"** are **1.0 kBq.m^{-3} and 1.0 x 10^{-10} m^2**, respectively.

- RI" is an index indicating the level of radon release risk from the bedrock, surface material, and/or from soil and depends on the "RP" value.

- **"RP" < 10**, then "RI" is **low**; if **10 ≤ "RP" < 35**, then "RI" is **medium**; if **35 ≤ "RP"**, then "RI" is **high**.

INTRODUCTION

❖ Geological Radon Potential - GEORP

- The indicator establish the percentage of dwellings located in a given area that exceeds regulators action levels (Talbot et al, 1998);

"Low" potential: GEORP is below 5%
"Moderate" potential: GEORP is 5 - 10%
"High" potential: GEORP above 10%

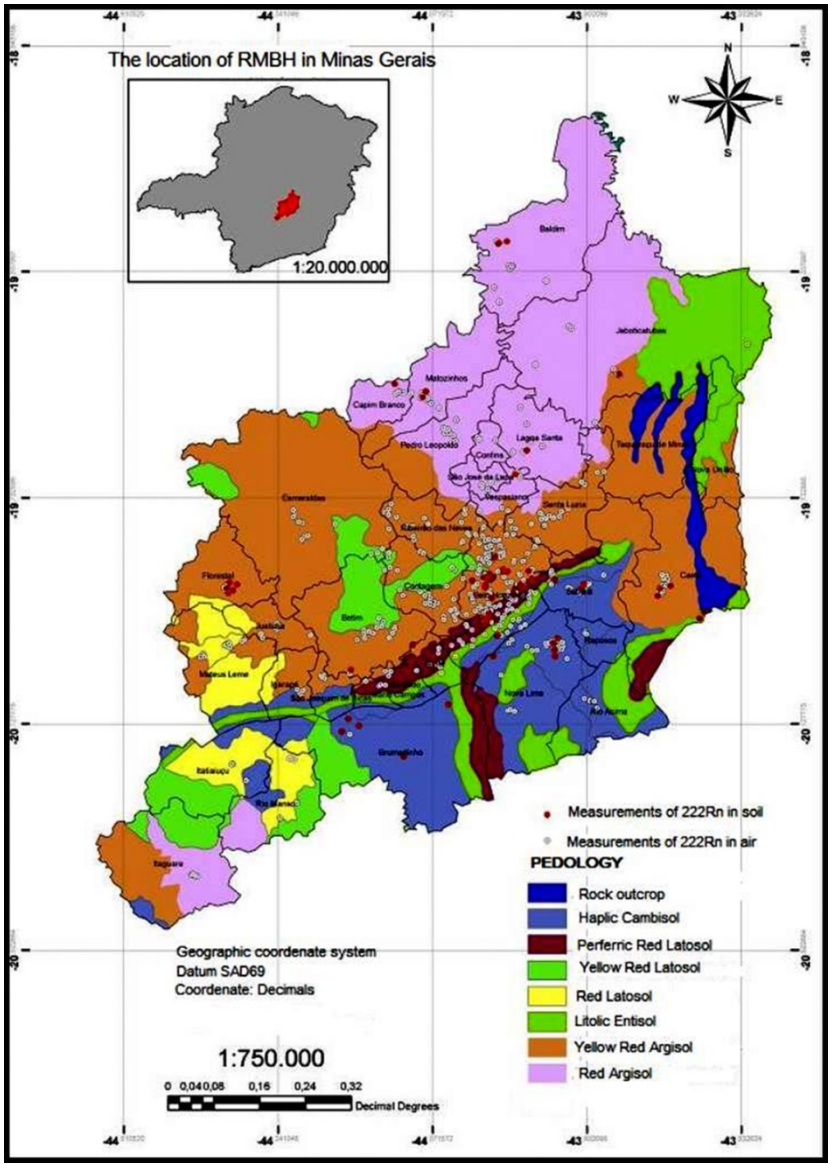
This work used the data relating to the indoor radon concentrations in dwellings of RMBH (Brazil).

The GEORP indicator was calculated based on the percentage of dwellings that exceeds the first action level of the U.S EPA: **148.0 Bq.m^{-3}**.

- **RMBH** - located in the central-western portion of Minas Gerais, Brazil and comprising 34 cities;

- The soils of RMBH were classified on taxonomic classes (pedologies):

✓ *Red Ultisol*
✓ *Yellow Red Ultisol*
✓ *Haplic Cambisol*
✓ *Red Latosol*
✓ *Perferric Red Latosol,*
✓ *Yellow Red Latosol*
✓ *Litholic Neosol*



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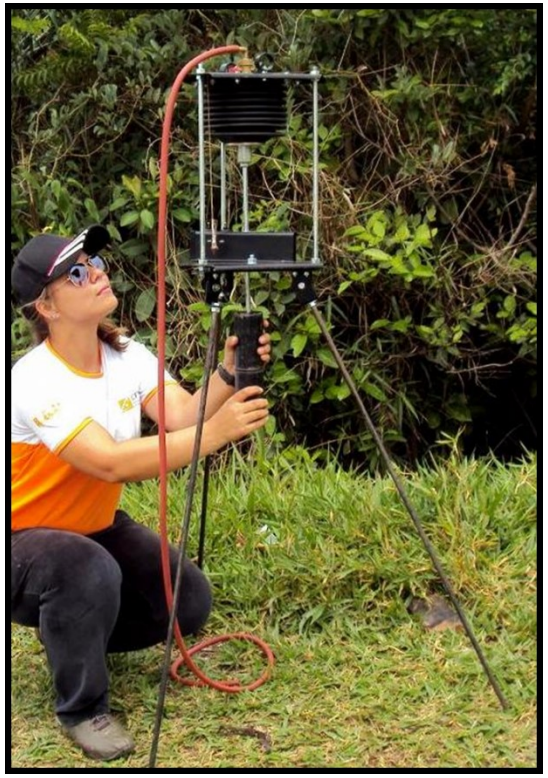
MATERIALS AND METHODS

The radon concentrations in soil gas were determined by using the *Alpha*GUARD® detector model PQ2000 PRO, SAPHYMO GmbH, Germany. This detector is an ionization chamber, where a volume of air is ionised by alpha particles.

The soil permeability was determined by using the RADON-JOK® permeability instrument, RADON V.O.S ®, Czech Republic.



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MATERIALS AND METHODS

- The soil samples were collected about 0.70 meters deep and, after crushed, the samples were put in 0.5 liter sealed Marinelli's (to establish secular radioactive equilibrium between ^{226}Ra and their decay products);

- The ^{226}Ra concentration was determined by gamma spectrometry (HPGe).

MATERIALS AND METHODS

Indoor radon concentration

- The radon concentrations inside dwellings were determined by using Eletret Ion Chamber - E-PERM electret, Rad Elec, Inc.
- Measurements were performed with the SST (S - Short Term chamber and ST - Short term Eletrect) in the closed condition, for at least two days, according to US.EPA protocol.

RESULTS AND DISCUSSIONS

- The radon concentrations in soil gas in RMBH: **large variation** (different geological settings, physical parameters and climatic factors that influence radon concentrations);

- Pedologies: **Red Ultisol, Red Yellow Ultisol, Haplic Cambisol, Red Yellow Latosol** and **Red Latosol**: radon concentration in soil gas ~ **22.0 kBq.m^{-3};**

- The activity concentrations of ^{226}Ra ranged from **12.4 ± 2.5** to **23.7 ± 3.4 Bq.kg^{-1}**, are in agreement with to mean values for typical soils (UNSCEAR, 2000).

MAIN CONCLUSIONS

- Approximately **40%** of the soils measured presented **high permeability** (10^{-11} m^2);
- The **Litholic Neosols** presented the lowest radon concentrations in soil gas;
- The **Perferric Red Latosols** presented **significant radon concentrations in soil gas.** Approximately 53% this areas can be classified as "High Risk", according to the Swedish Criteria;
- **Perferric Red Latosols:** also presented **high indoor radon concentration** and the **highest "RI**", which can be attributed to influence of the permeability on the indoor radon concentration;
- **Perferric Red Latosols: the highest ^{226}Ra content** and **high GEORP** (26.5%), suggesting a positive influence of the radon concentration in soil gas in indoor concentrations.
- The preliminary results can indicate an influence of the iron formations present at Perferric Red Latosols in the retention of uranium minerals;

RESULTS AND DISCUSSIONS

Pedology	*Arithmetic Mean [^{222}Rn] in the air (Bq.m^{-3})*	*Arithmetic Mean [^{222}Rn] in soil gas (kBq.m^{-3})*	*N (air)*	*N (soil)*	*[^{226}Ra] in soil (Bq.kg^{-1})*	*Range of soil permeability (K) (m²)*	*RP*	*RI*	*GEORP (%)*	*GEORP Classifi-cation*
Red Ultisol	142.0 ± 23.0	28.0 ± 3.0	60	14	22.0 ± 0,3	(10^{-12}- 10^{-11})	18,5	MEDIUM	18.0	HIGH
Yellow Red Ultisol	113.0 ± 8.0	24.0 ± 2.0	252	65	24.0 ± 3.0	(10^{-14}- 10^{-11})	16.0	MEDIUM	16,5	HIGH
Haplic Cambisol	98.0 ± 9,0	22.0 ± 6.0	63	15	18.0 ± 3.0	(10^{-14}- 10^{-11})	17.0	MEDIUM	16.0	HIGH
Red Latosol	137.0 ± 12.0	14.0 ± 3.0	16	04	15.0 ± 6.0	(10^{-11})	13.0	MEDIUM	37.5	HIGH
Perferric Red Latosol	130.0 ± 17.0	61.0 ± 9.0	68	15	50.0 ± 13.0	(10^{-14}- 10^{-11})	49.0	HIGH	26.5	HIGH
Yellow Red Latosol	82.0 ± 7.0	24.0 ± 12.0	20	04	22.0 ± 1.0	(10^{-12}- 10^{-11})	15.0	MEDIUM	5.0	MODE-RATE
Litholic Neosol	101.0 ± 11.0	14.0 ± 3,0	21	05	12.0 ± 3.0	(10^{-12}- 10^{-11})	7.5	LOW	19.0	HIGH

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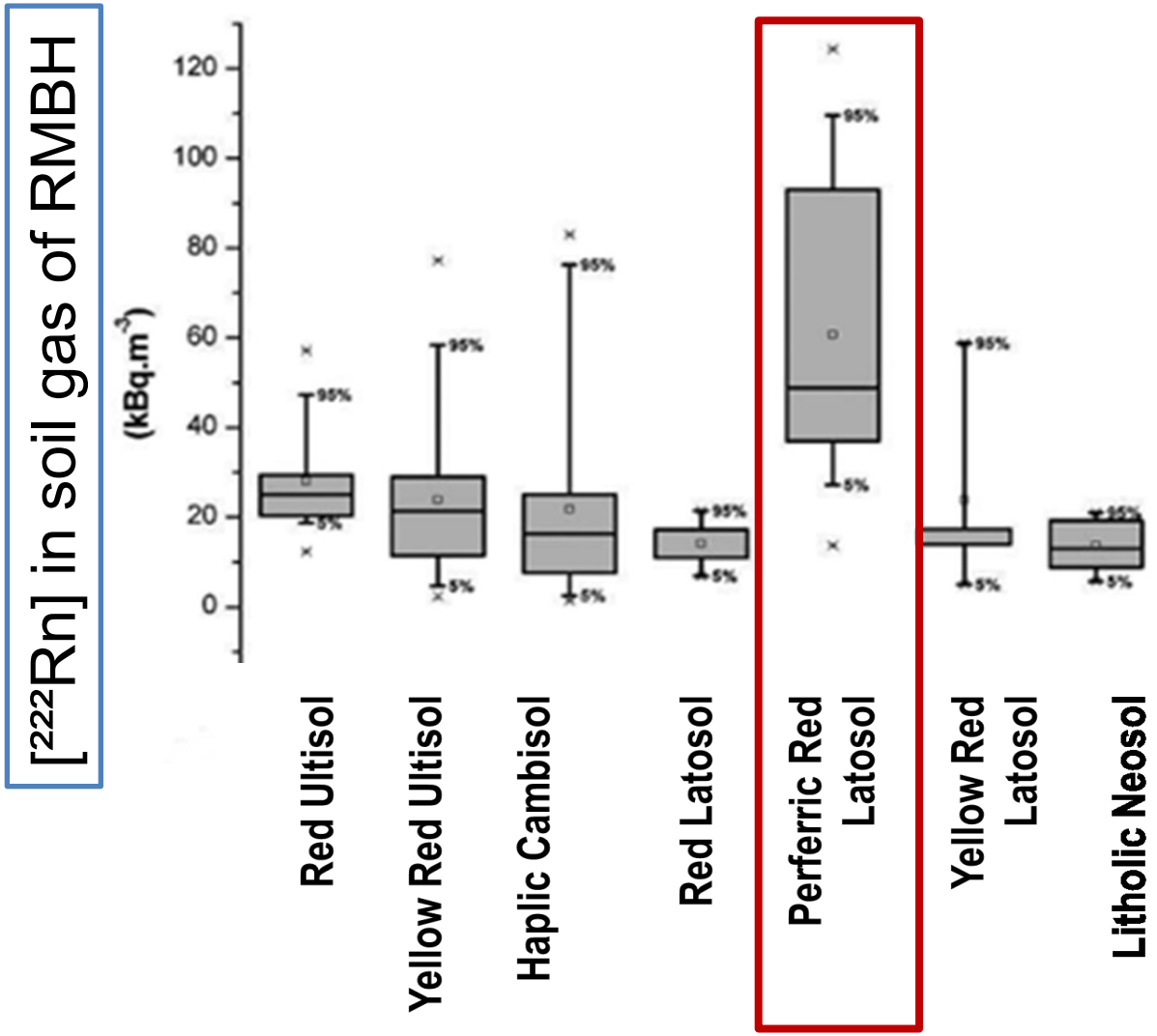


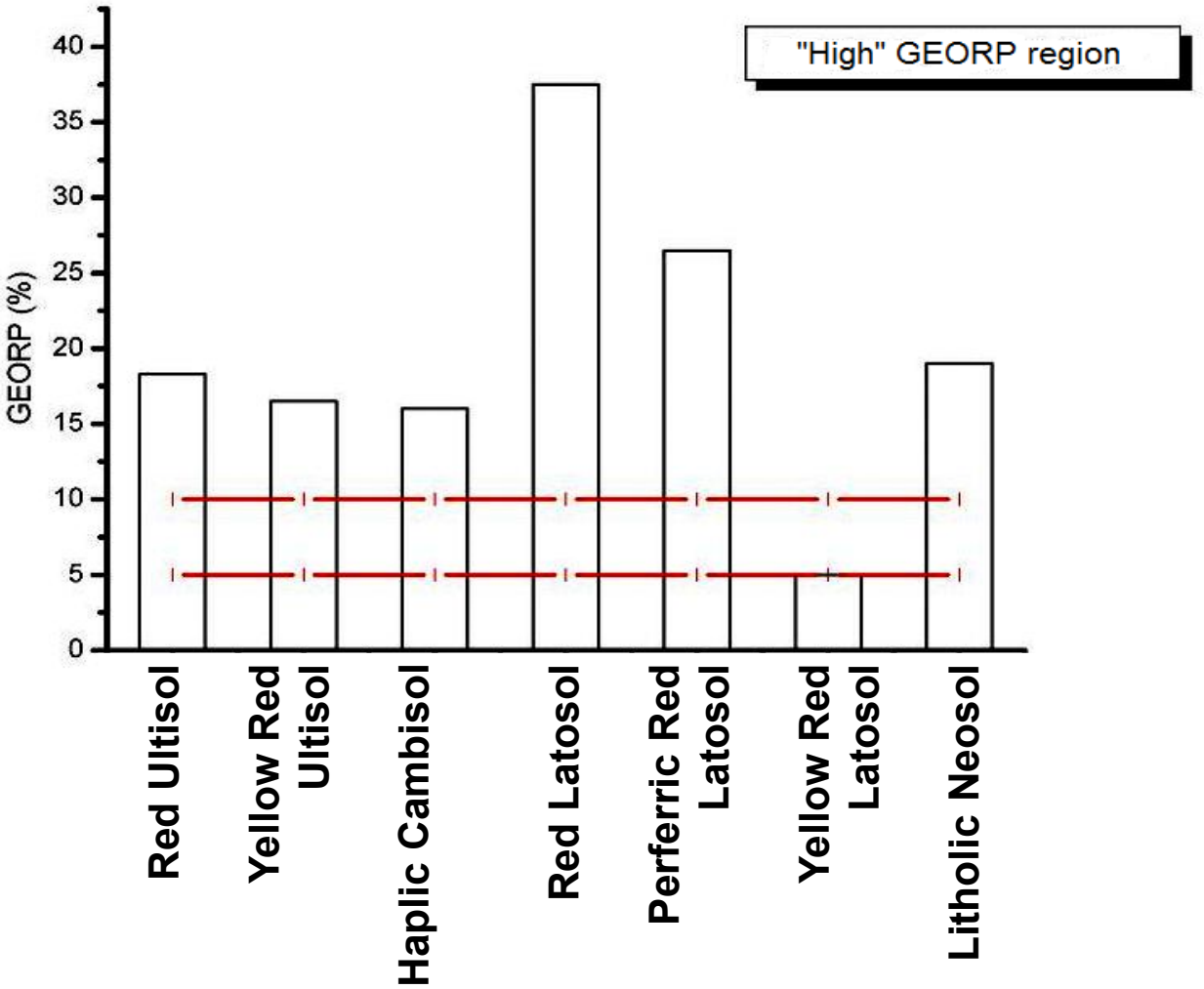
MAIN CONCLUSIONS

- The GEORP for all soils (except Yellow Red Latosol) had percentages above 10% of the US.EPA action level;

- The determination of radon concentration in soil gas proved to be a good indicator for predicting the GEORP for RMBH;

- Similarly, the “RP” is also a **good indicator of the potential risk of radon!**

GEORP´s for pedologies of RMBH



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Thank you!

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