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RADON RESEARCH IN MULTI DISCIPLINES: A REVIEW

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IAP 2007: 12.091 Credit Course: January 17 - 25, 2007

Session 5, January 25, 2007

COURSE OUTLINE

- I. Fundamentals of radon physics: review
- II. Radon research in geology
- III. Radon research in radiation biology
- IV. Radon research in medicine
- V. Radon research in health physics

Earth & Planetary Science

**Radon research in multi disciplines -
summary**

Student Presentations

Radioactivity Laboratory demonstration

DETAILED COURSE WORK

The course work involves the following:

1. January 17, 18, 19, 22, 25 1-3 PM
5 sessions each of 2 hours - 25%
2. Study Assignments – 4 - 20%
3. Project
Literature Survey – Writing a report - 30%
4. Project Presentation - 25%

Required percentage to pass this course is 95%

Grading: P/F

Session 5

- *Student Presentation*
- *Radon Research In Radiation Health Physics and Planetary Science*
- *SUMMARY*
- *Lab Demonstration*

Objective 1 - 2

- 1. Introduction**
- 2. Examples of recent radon research in Health Physics:**
 - 2.1 Radon concentrations in caves**
 - 2.2 Radon concentrations in pyramids**
 - 2.3 Radon concentrations in tunnel drilling**
 - 2.4 Radon concentrations in landed buildings and high rises**
 - 2.5 Radon presence on moon and mars**

Session 5

January 25, 2007

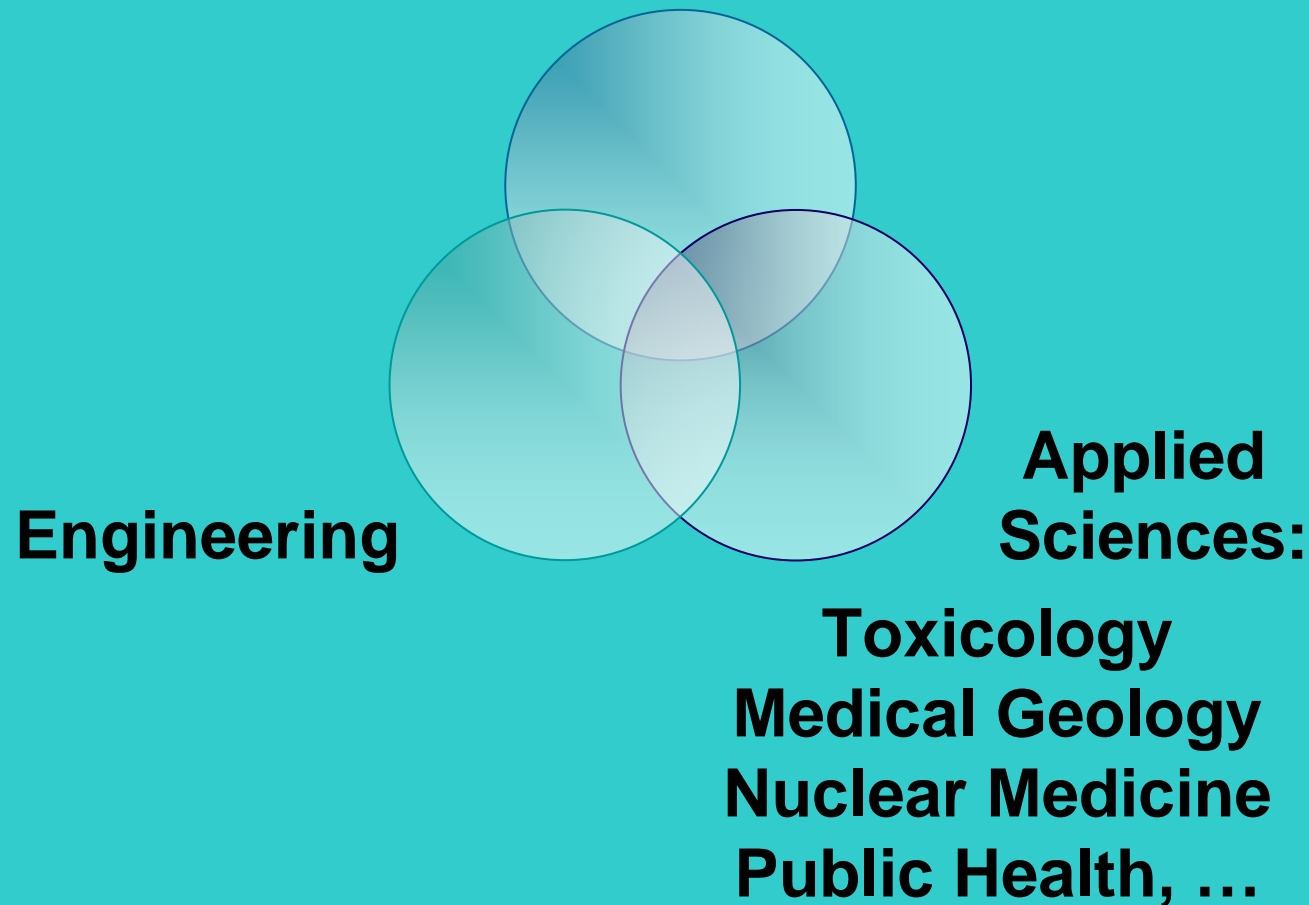
Objective 1 - 2

3. Radon research in multi disciplines –
Summary
4. Students Presentation and Report
5. Laboratory Demonstration.

1. Introduction

Health Physics Research

Physical, Life, Earth Sciences



1. Introduction

Health Physics Research ...

- ❑ **Investigating** interaction of radiation with matter and living systems
- ❑ **Studying** environmental radioactivity levels
- ❑ **Studying** the radiation effects on biological systems on earth and in space
- ❑ **Studying** the correlation of radiation exposure to health effects
- ❑ **Developing** radiation detection instruments to establish radiation protection standards
- ❑ **Modeling** of the transport of radioactive materials in the environment, the design of radiologically safe processes for operating diagnostic radioactive tools.

2. Some examples of recent radon research in Health Physics.

2.1 Radon concentrations in caves

2.2 Radon concentrations in pyramids

2.3 Radon concentrations in tunnel drilling

2.4 Radon concentrations in landed buildings and high rises

2.5 Radon presence on moon and mars

2.1 Radon concentrations in caves

Visiting caves out of artistic and scientific curiosity is becoming very popular . A variety of scientists such as anthropologists, geologists are studying caves for scientific purposes. Artists and public are interested deeply in ancient cave paintings and cave formations and structures. The awareness of radon as a carcinogen prompted surveys measuring radon concentrations in the caves and exposure levels to the workers as well as visitors.

2.1 Radon concentrations in caves

Some examples of the caves where radon surveys are being conducted are:

- A. Altamira caves, Spain
- B. Nerja caves, Spain
- C. Creswell Crags caves, UK
- D. Mendips caves, UK
- E. Carlsbad caves, USA

2.1 Radon concentrations in caves

A. Altamira caves, Spain

- **Location: $43^{\circ} 22' 57''$ N, $4^{\circ} 06' 58''$ W near the town of Santillana del Mar in Cantabria, Spain.**
- **Proximity to Mt. Vispieres.**
- **Cave formation from calcareous rocks; sedimentary rock type.**
Calcareous means – rich in calcium carbonate.

2.1 Radon concentrations in caves

A. Altamira caves, Spain

Annual effective dose is measured for guides and visitors in tourist caves.

Inside the cave, monitored ^{222}Rn levels are:
range 186 Bq m^{-3} to 7120 Bq m^{-3} ,
annual average of 3562 Bq m^{-3} .

Effective dose is accurately estimated using three different equilibrium factors 0.5, 0.7 and 1.0 and recommended dose conversions factors.

Effective dose is within the international guidelines.

Ref: Lario et al 2005.

2.1 Radon concentrations in caves

B. Nerja caves, Spain

□ **Location: 36° 43' 50"N, 33°52'35" W**

□ **Proximity: Southern Spain**

□ **Cave formation: of dolomites.**

Dolomite – calcium magnesium carbonate

Survey consisted of daily, monthly and seasonal variations of ^{222}Rn concentrations in air.

^{222}Rn concentrations in spring-summer are higher than autumn-winter

Mean concentration 168 Bq/m³.

The radiation exposure levels for workers and tourists are within the ICRP recommendations.

Ref: Duenas, C. et al 2005.

Papachristodoulou, C. A et al 2004.

2.1 Radon concentrations in caves

C. Creswell Crags caves, UK

Location: 53.263009 N, 1.199399W

Formation : limestone gorge

Radon gas levels are 27-7800 Bq m⁻³ , the levels increasing with increasing distance into the caves from the entrance regions with less ventilation.

The exposure levels are in general below the Action Level in the workplace 400 Bq m⁻³ and above the Action Level for domestic properties 200 Bq m⁻³ in the UK .

Seasonal variation of summer to winter ratio is 1-10.

Effective dose is

visitors is 0.0016 mSv/visit

guides is 0.4 mSv/annum

researchers is 0.06 mSv/visit.

Ref: Gillmore et al 2002.

2.1 Radon concentrations in caves

D. Mendips caves, UK

- Location: 51° 20' 4.92" N, 2° 37' 4.92" W
- Formation: limestone gorge

Measured radon levels are as high as 12,500 Bq m⁻³ in many parts of the cave system, architecture and aeration.

Estimated Annual doses to certain groups to be as high as 120 mSv.

Ref: Sperrin et al., 2000.

2.1 Radon concentrations in caves

E. Carlsbad caverns, USA

- Location: 32.10N, 104.35W.
- Formation: limestone

Measured radon concentrations are
1792 Bq/m³,
equivalent to 48 pCi/ L,
means 12 times 4 pCi /L action level;

2.1 Radon concentrations in caves

E. Carlsbad caverns, USA ...

The ratio of activity concentration among radon and its daughters; for

^{222}Rn : ^{218}Po : ^{214}Pb : ^{214}Bi is

1 : 0.5 : 0.4 : 0.35.

The unattached fractions of radon daughters ; for

^{218}Po , ^{214}Pb , ^{214}Bi are

80%, 35%, and 20%.

Exposure to radon daughters would be 2.3 WLM/y, based on 2000 hour/year.

Annual effective dose is 24 mSv/y, 4 mSv higher. 10.5 mSv/WLM, twice the recommended ICRP level.

Ref: Sung Cheng; Chuan-Jong Tung, 2000,
Papachristodoulou, C. A et al 2004.

2.2 Radon concentrations in pyramids - Mexico

^{220}Rn and ^{222}Rn are measured in Teotihuacan's archeological region in Mexico.

This distinctive conditions of the measurements are :
high humidity,
air currents in the labyrinths,
constant temperature inside galleries and tunnels of the pyramid,
variation in temperature between the day and the night outside of the pyramid body.

These tunnels are not for public use, anthropologists spend 3 to 5 months at a time.

The ^{222}Rn concentrations found in both the pyramids were within ICRP action level.

Ref: Espinosa, G. et al 2005.

2.3 Radon concentrations in tunnel drilling

- ❑ **Underground tunnel drilling is on the rise for many purposes such as public transportation, interconnection of large complex buildings, streets, high energy physics research.**
- ❑ **Radon level can therefore be on the high side during tunneling especially where ventilation is poor, and uranium-rich bed rocks.**
- ❑ **The situation seems to be worse in Hong Kong where large area is granitic containing larger amount of uranium when compared to the global mean.**

2.3 Radon concentrations in tunnel drilling

- A maximum concentration of over 30,000 Bq/m³ was recorded
- (1 Bq/m³ = 0.027 picoCuries/L)
- Radon concentration in tunnel environment is dependent on
 - ◇ groundwater ingress,
 - ◇ ventilation provision
 - ◇ geology.

Ref: Li and Chan 2004.

2.4 Radon concentrations in high rise buildings.

- About 50 % natural radiation dose received by human beings comes from radon and its progeny. This is a well established fact now.
- Many countries and radiological authorities have established the radon action levels to limit the indoor radon concentrations.
- However, the parameters that effect the action levels are
 - different sources of indoor radon,
 - different types of buildings
 - social and economic factors.

2.4 Radon concentrations in high rise buildings

Ex: Radon concentrations Landed Buildings vs High Rises

	Landed (Bq/m ³)	High-rise (Bq/m ³)
Average	13	11
Standard deviation	8	4.5
Median	12	11

Based on Ref: Leung JKC et al 1999.

2.4 Radon concentrations in high rise buildings.

- **The United States Environmental Protection Agency (EPA, 1986, 1987) recommendation:**
 - if a short-term result is $> 140 \text{ Bq/m}^3$, a follow-up measurement is needed to determine the long-term average concentration.
 - if the long-term average is still $> 150 \text{ Bq/m}^3$, action is recommended to lower the concentration.

- **The World Health Organization (WHO, 1988) recommendation:**
 - a single value of 200 Bq/m^3 for general application,
 - with a maximum of 800 Bq/m^3 .

2.4 Radon concentrations in high rise buildings.

- ❑ **40 Bq/m³** is the **world mean radon concentration in homes** is quoted by the International Commission on Radiological Protection (ICRP, 1992).
- ❑ Considerable variation exists in the concentration of about 5 Bq/m³, to levels in excess of 500 Bq/m³
- ❑ Action level of 200 Bq m⁻³ was recommended for existing buildings and 150 Bq m⁻³ for newly built buildings. (European action levels)
- ❑ No specific action levels are established for dwellings and offices housed in high-rise buildings.
- ❑ Further research and action are needed.

2.5 Radon existence on Moon and Mars

According to the scientists Gorenstein, Golub and Bjorkholm, from the times of Apollo missions:

- spatial and temporal variations of radon emissions were seen on the Moon,
- radon may be a trace component associated with other higher quantities of gases released to the lunar surface,
- enhancement of ^{210}Po was observed in excess of ^{222}Rn activity,
- radon and daughter product provided information on the gas releasing processes.

Ref: Gorenstein et al 1974.

2.5 Radon existence on Moon and Mars ...

According to Meslin et al 2006:

The ^{210}Po surface activity

- on rocks and soils at the landing site is $< 3.1 \times 10^{-4}$ Bq/cm²,
- On the dust capturing magnet is $4.6 \pm 2.4) \times 10^{-3}$ Bq/cm² at 2 sigma value.

They infer that

- the global average ^{222}Rn exhalation rate is significantly greater on Mars than on the Moon.

Supporting the hypothesis that

- on Mars, radon emanation could be enhanced by the presence of water in the soil.

Ref: Meslin et al 2006

3. *Radon research in
multi disciplines*

A Summary



Radon research in multi disciplines – A Summary

Currently, there is tremendous interest about radon and its daughter products and their effects on public health. There seems to be no place on the earth that is not tested for radon by the scientists; and not surveyed by no public health official. World Health Organization has recognized radon as a carcinogen.



Radon research in multi disciplines – A Summary ...

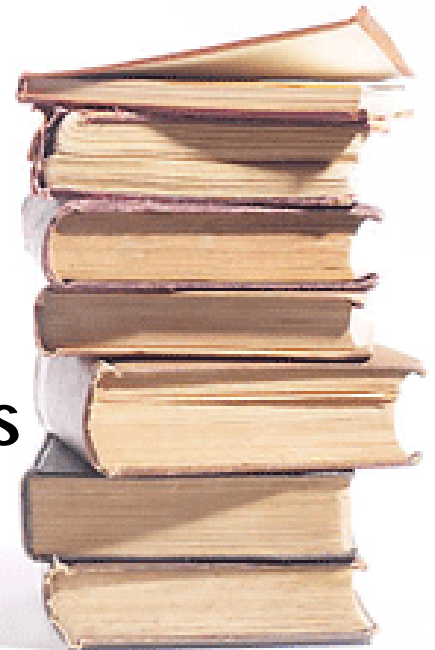
In this course, I highlighted some topics of recent radon research in fields such as geology, planetary science, radiation biology and health physics and medicine.



Radon research in multi disciplines – A Summary ...

In geological studies, radon probing is becoming popular to study the fractures and faults of geologic regions and correlation studies with earthquakes and tsunamis.

Scientists are continuing to study radon concentrations in volcanic regions, which have been showing positive as well as negative correlations.



Radon research in multi disciplines – A Summary

- In Planetary Sciences: from Apollo missions to Mars Surveyor landings, in a time span of more than 30 years, isotopes of radon and daughter products continue to play a key role in understanding the gas releasing processes of the outer planets.



Radon research in multi disciplines- A Summary ...

As a multidisciplinary approach, radiation biology, radiation health physics and medicine are becoming increasingly aware of environmental radon as a source of ionizing radiation by alpha particles, causing cancerous as well as non-cancerous damage. (Neelaprasad et al, 2006).



Radon research in multi disciplines – A Summary

- Radon at very low levels, interferes in the high energy physics studies that require ultra low background environments.
- Radon background interference was well studied and mitigated in the solar neutrino studies conducted at the Sudbury Neutrino Observatory, Canada.



Radon research in multi disciplines –

Summary ...

There is a strong need for the development of high sensitive continuous monitoring radon detectors for the compliance of action levels and guidelines.

(Ila and Jagam 2006)

The economics of radon as a public health hazard is summarized.

(Leela et al 2006).



*Radon research in multi disciplines –
A Summary ...*

Radon can be found in the
outer planets, on our planet
and deep under ground.

Hence radon is omnipresent !!

End





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Key words

- Radon ; Dosimetry ; High rise building ; Natural radioactivity ; Radiation protection ; Indoor pollution ; Socioeconomic study ; Simulation ; Public health ; radon in show and recreational caves, and site special scientific interest.