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LABORATORY FACILITIES ASSOCIATED WITH RADON MEASUREMENTS AT THE NUCLEAR ENG. LABORATORY OF NTUA

ERRICCA-2 Kick-off Meeting

25-26 February, 2002, BRE-UK, London

D.J.Karangelos, P.K.Rouni, N.P.Petropoulos, M.J.Anagmostakis, E.P.Hinis and S.E.Simopoulos, NTUA, Greece

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THE NUCLEAR ENGINEERING LABORATORY - NTUA

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CONTENTS

- NTUA Radon Chambers:
  - Radon exhalation measurements
  - Radon instrument calibrations
  - Material tests
- Other radon exhalation measurement techniques and relevant instrumentation.
- Radon in air, water and soil measurement techniques and instrumentation.
- Research activities, industrial collaborations and recent publications

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THE NTUA RADON CHAMBERS

RADON CHAMBERS (I)

Radon Chambers enable controlled environment in terms of temperature, humidity, air-exchange rate, radon concentration, particle concentration, aerosol size distribution, radon progeny concentration etc, thus providing a tool for conducting thorough experimental studies on radon and radon progeny.

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RADON CHAMBERS (II)

Radon Chamber experiments include:

- radon exhalation measurements,
- instruments check and calibrations,
- materials tests,
- studies on radon progeny behavior,
- attachment processes to aerosol particles

Most of such experiments
are Chamber volume depended

THE NTUA RADON CHAMBERS

- Radon chamber 1.8 m^3
- Radon chamber 8.5 m^3

– Designed and constructed in Greece by the NTUA Nuclear Engineering Laboratory, made of stainless steel, air-tight and radon-tight.

– Computer controlled environmental conditions (Temperature 12-45 ^oC, Humidity 15–95%).

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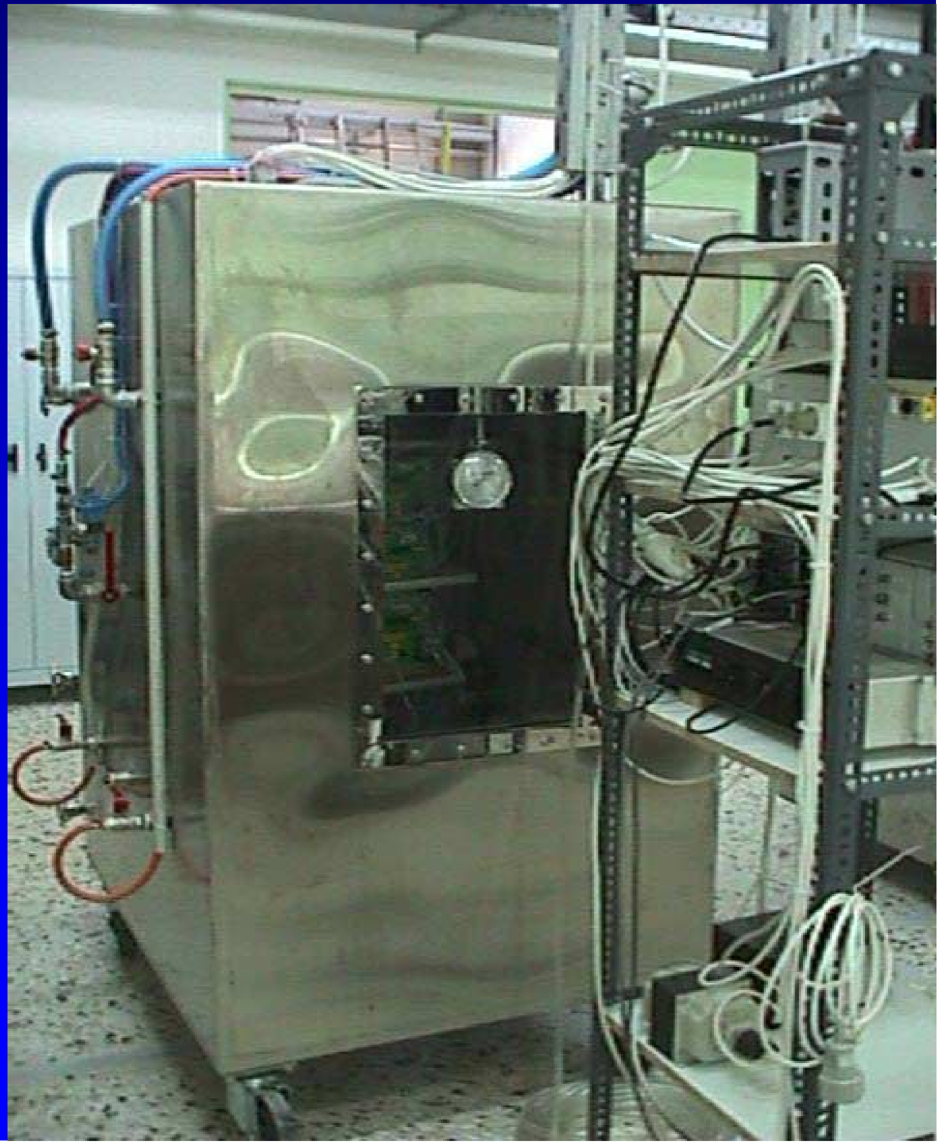
THE 1.8m^3 RADON CHAMBER



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THE 8.5m^3 RADON CHAMBER

THE 8.5m^3 RADON CHAMBER

ENVIRONMENTAL MONITORING IN THE RADON CHAMBERS

- Thermometers
- Thermocouples
- Hair Hygrometers
- Relative Humidity Transducers
- Pressure Transducers

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ENVIRONMENTAL MONITORING AND CONTROL OF THE RADON CHAMBERS

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RADON CONCENTRATION ESTABLISHMENT

Two Certified dry ^{226}Ra radon sources

(100% emanating power)

- PYLON 102.8 kBq
- CZECH METROLOGICAL INSTITUTE 274.3 kBq

radon is introduced in the chambers using in-line external circulation and internal circulation

CZECH SOURCE IN-LINE CIRCULATION CONTAINER

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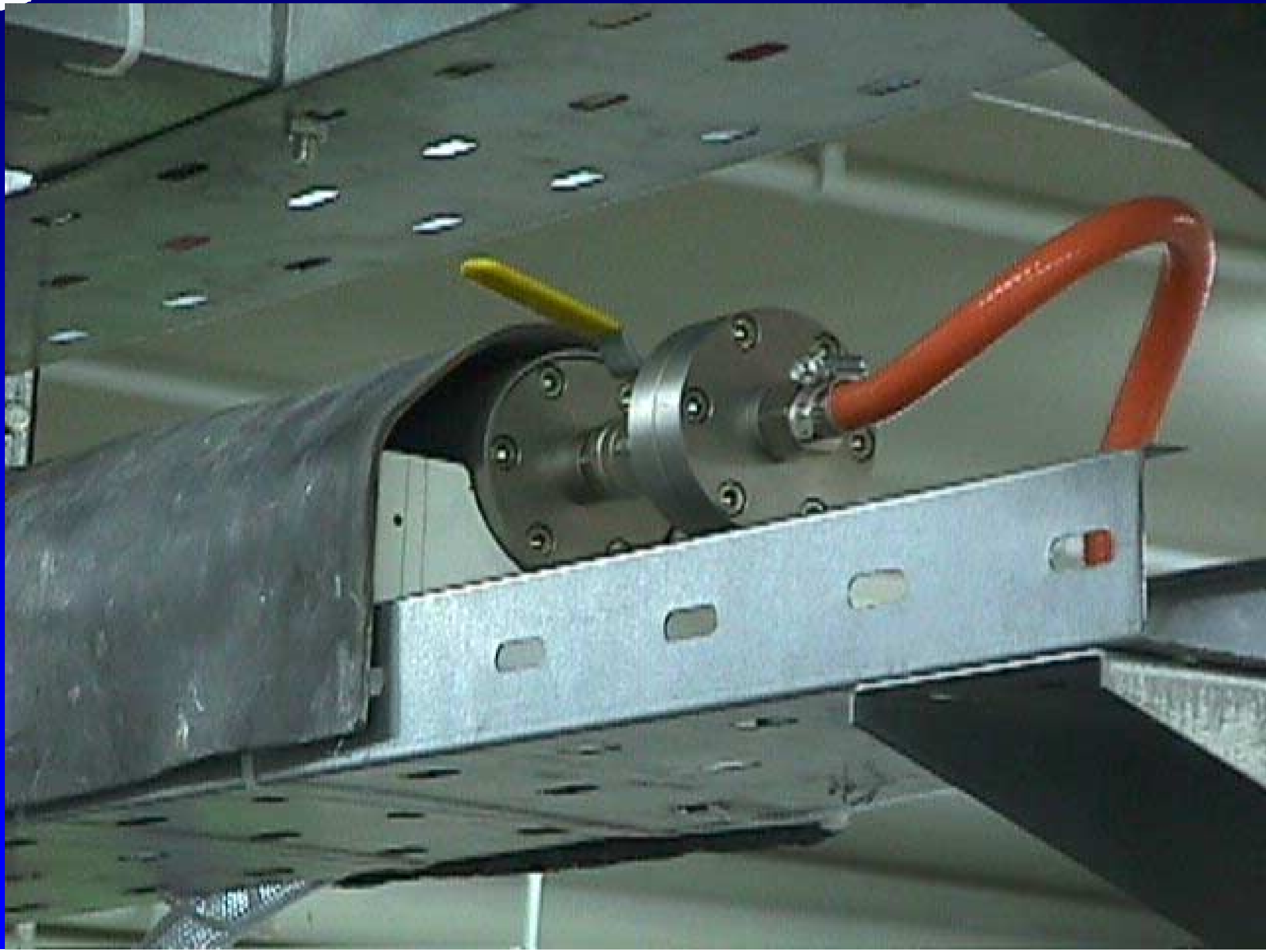

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MINIMIZING BACKGROUND TECHNIQUE

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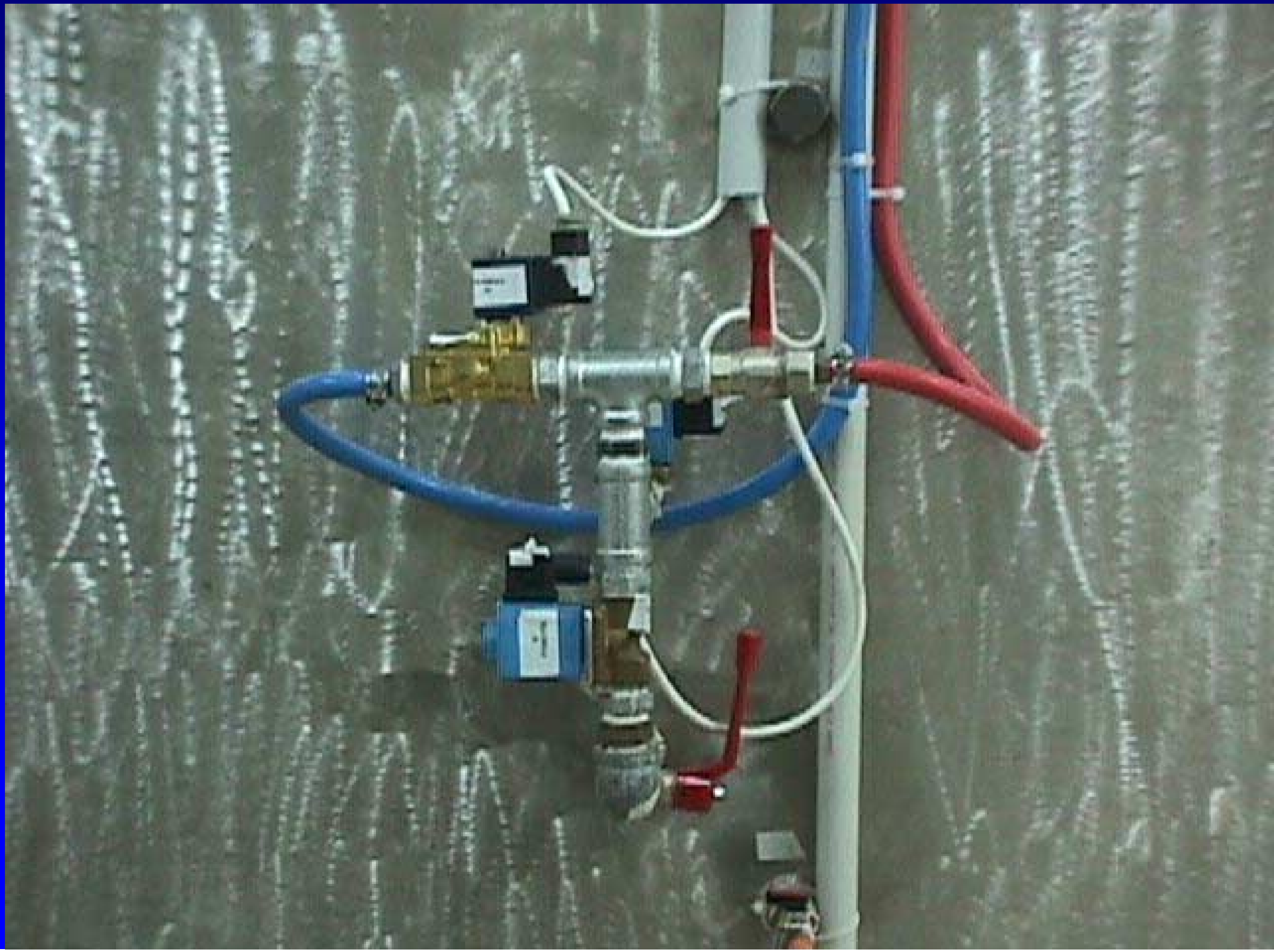
PIPING DETAIL



RADON CONCENTRATION MONITORING (I)

- In-situ continuous Radon progeny concentration measurements, using NaI detectors placed inside the chambers.
- Grab sampling, using controlled flow-rate, of a small portion 2 – 10% of chamber gas through filters, which are then analysed for Radon progeny using alpha or/and gamma spectroscopy.

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RADON CONCENTRATION MONITORING (II)

Continuous or quasi-continuous Radon concentration measurements, using active instrumentation, placed either inside the chambers or in-line connected to them.

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QUASI-CONTINUOUS RADON CONCENTRATION MONITORING

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QUASI-CONTINUOUS RADON CONCENTRATION MONITORING

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RADON EXHALATION MEASUREMENTS

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RADON EXHALATION MEASUREMENT PRINCIPLE

- ✓ Enclose the sample / structural module in a container, *or*
- ✓ attach tightly a container on the structural module surface,

and

follow up the radon concentration growth inside the container

FOLLOW UP THE RADON CONCENTRATION GROWTH INSIDE THE CONTAINER

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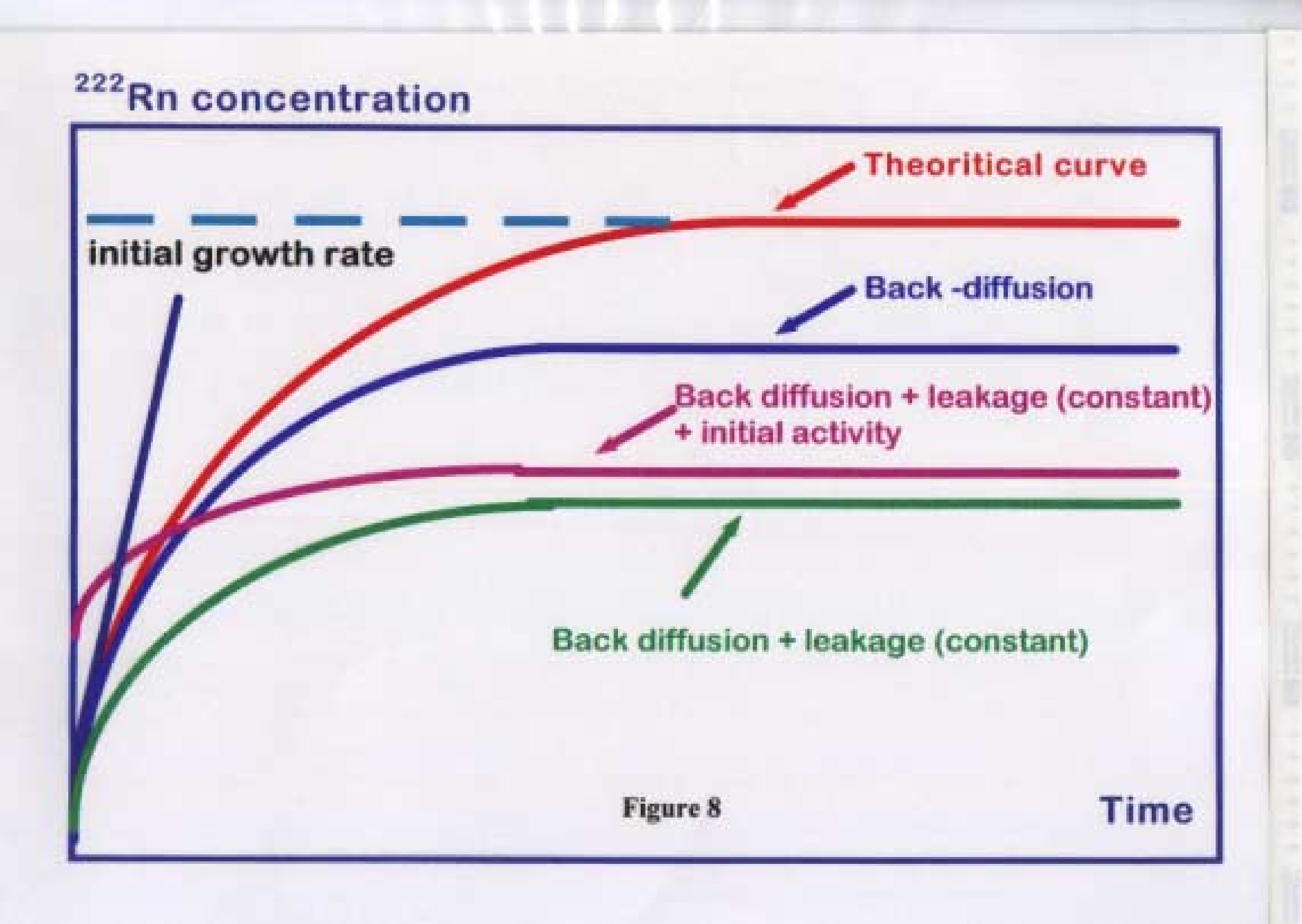

MATHEMATICALLY EXPRESSED…

$$\mathbf{C = C_o exp(-\lambda t)+E[1-exp(-\lambda t)](\lambda V)^{-1}} \quad (1)$$

C Radon concentration (Bqm^{-3}) in the container at growth time t(h)

E exhalation rate (Bqh^{-1})

λ Radon decay constant (h^{-1})

$\boldsymbol{C_o}$ initial Radon concentration (Bqm^{-3}) in the container at time t(0h) – i.e. the background

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…OR FOR SHORT GROWTH TIME

Equation (1)

is approximated then as:

$$C=E(\lambda V)^{-1}$$

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RADON EXHALATION MEASUREMENTS

- From raws and building materials
- From industrial by-products
- From structures

and also

- From the ground surface

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STRUCTURAL MODULE SPECIMENS

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THE 8.5 m^3 RADON CHAMBER

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OTHER USES OF THE RADON CHAMBERS

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RADON CHAMBERS USES

Study of:

- the effectiveness of remediation techniques, such as : *Epoxy sealants*, *Membranes*, *and Concrete* as radon barriers
- Aging of structures and membranes.
- Effects of environmental conditions (temperature, pressure) on radon exhalation rate.
- Instruments calibrations and checks

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RADON INSTRUMENTATION CALIBRATION

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INSTRUMENT CALIBRATION AND CHECK

Radon in the Living Environment,
19-23 April 1999, Athens, Greece

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THE EFFECT OF HUMIDITY ON THE RADON COUNTING EFFICIENCY OF INTEGRATED INSTRUMENTS

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ABSTRACT

INTERCOMPARISON OF INSTRUMENTS AND TECHNIQUES

Radon in the Living Environment,
19-23 April 1999, Athens, Greece

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BUILDING MATERIALS RADON EXHALATION RATE: ERRICCA INTERCOMPARISON EXERCISE RESULTS

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RADON EXHALATION MEASUREMENTS USING SMALL CHAMBERS

RADON EXHALATION MEASUREMENTS USING SMALL CHAMBERS

- Cheap solutions
- Useful when: small quantities of the materials are available, or for existing constructions.
- Control and monitoring of environmental parameters is needed.
- The instrument is outside the chamber (radon leaks, detector chamber size effect, instrument continuously connected to the chamber.
- Fast results, not so accurate.

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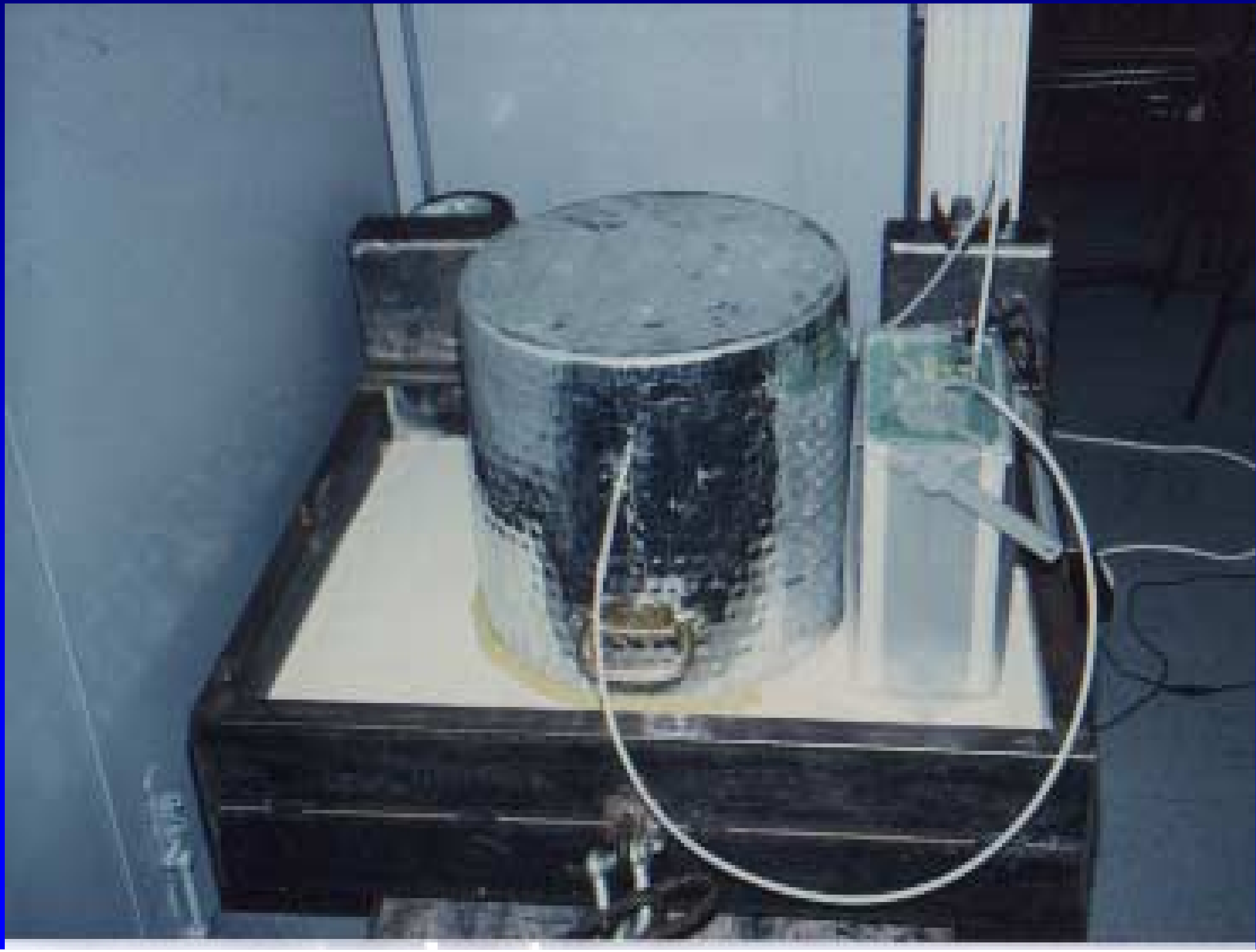
RADON EXHALATION FROM STRUCTURES



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RADON EXHALATION FROM RAW MATERIALS

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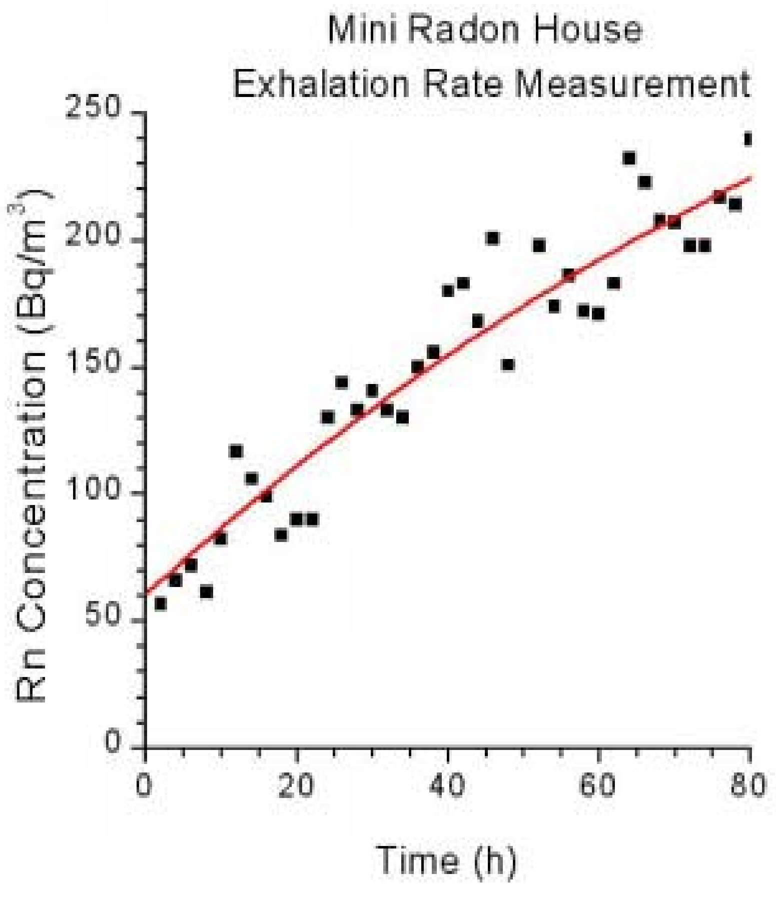
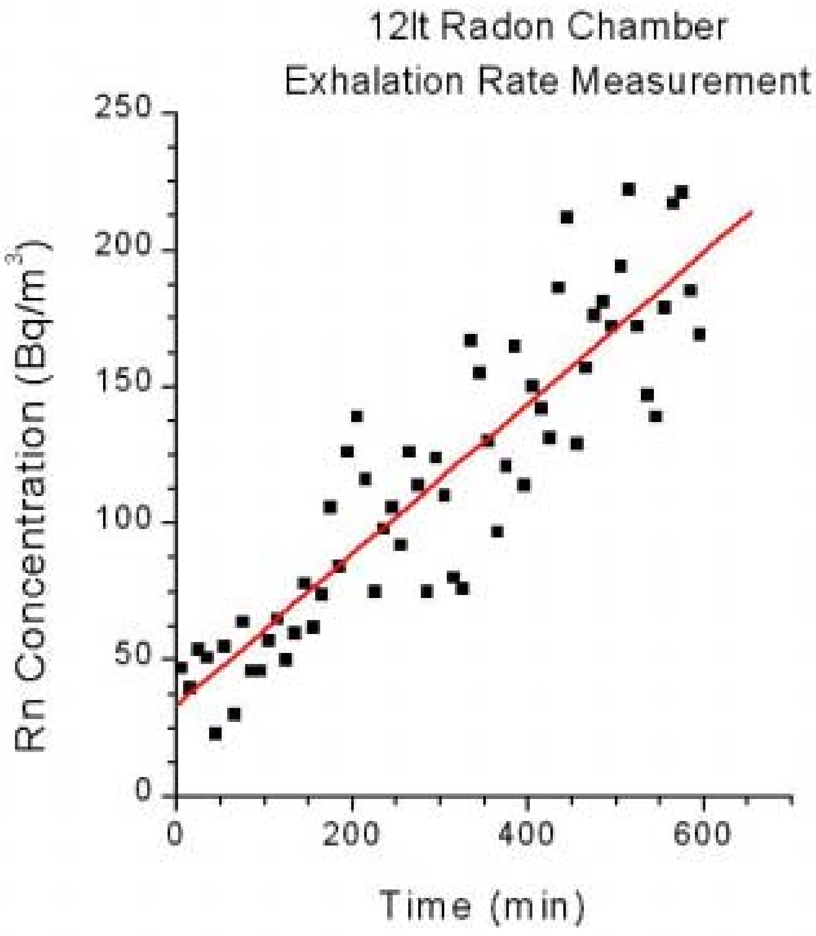
COMPARISON OF RADON EXHALATION RATE MEASUREMENTS FROM LIGNITE (~300Bq/kg ^{226}Ra)





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COMPARISON OF RADON EXHALATION RATE MEASUREMENTS FROM LIGNITE (~300Bq/kg ^{226}Ra)

Chamber	Sample Quantity (gr)	Duration (h)	Exhalation rate (mBq/kgr·sec)	Standard Error
MRH (1.8m^3)	8120	120	0.22	0.008
(11.65 lt)	300	10	0.20	0.012
(5.4 lt)	250	3	0.2	0.04

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OTHER RADON MEASUREMENTS

RADON MEASUREMENTS

- Mines
- Underground facilities and tunneling
- Waterworks
- Building materials industry
- Industrial Processes with NORM and TENORM materials (Phosphate Industry, Power Plants)

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RADON MEASUREMENTS IN AND AROUND INDUSTRIAL INSTALLATIONS

RADON MEASUREMENTS IN THE SOIL

- Radon is soil gas
- Radon exhalation rate from ground surface

in

- Mines
- Industrial by products deposition fields (fly-ash, slug)

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RADON IS SOIL GAS

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RADON EXHALATION MEASUREMENTS FROM THE SOIL

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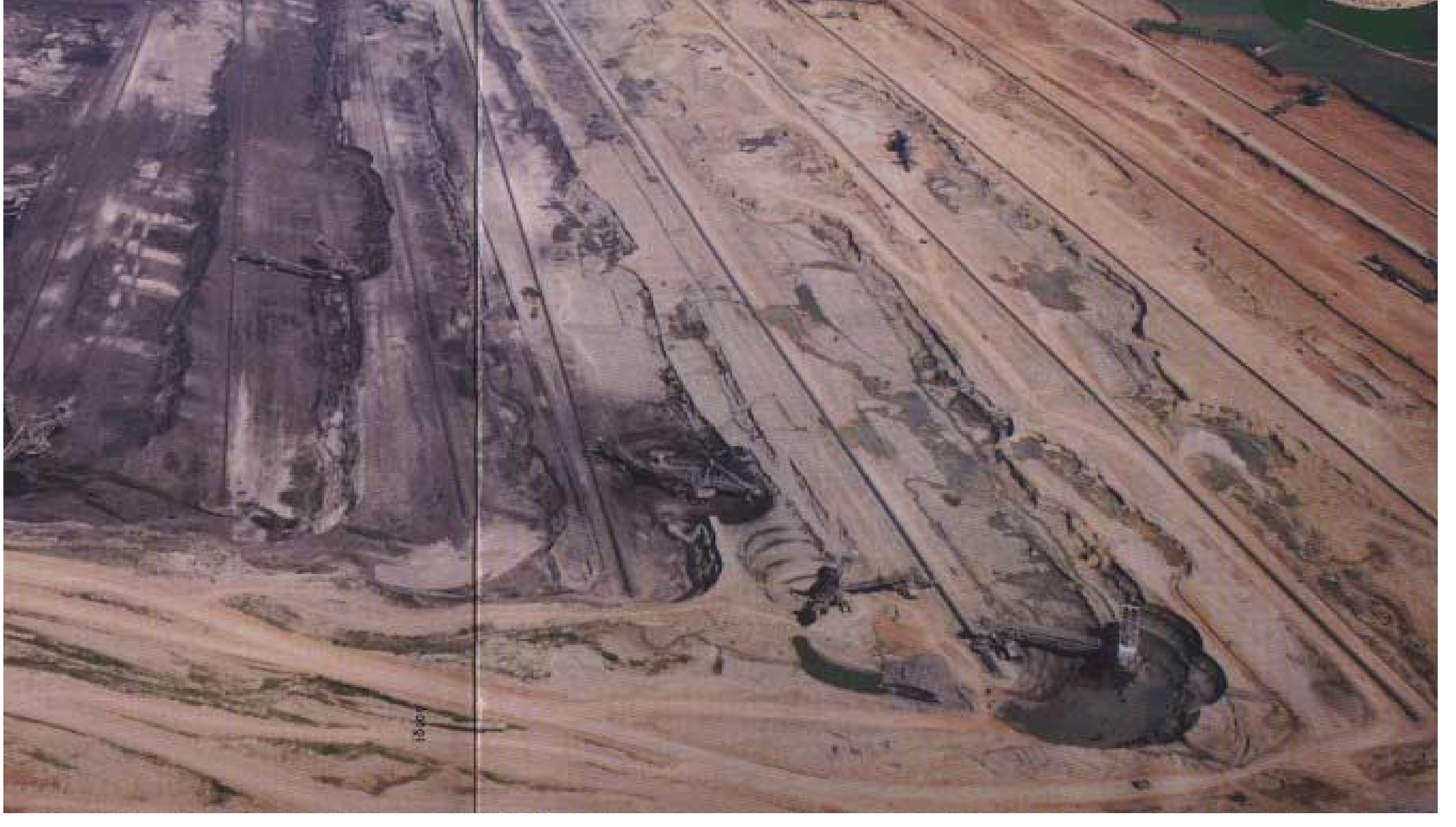
RADON MEASUREMENTS IN MINES



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SURVEY OF THE MEGALOPOLIS LIGNITE FIELD BASIN

ELSEVIER

The Science of the Total Environment 272 (2001) 261–272

the Science of the Total Environment

www.elsevier.com/locate/scitotenv

Radioenvironmental survey of the Megalopolis lignite field basin

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RADON MEASUREMENTS IN FLY-ASH DEPOSITION FIELDS

Measurements in discarded fly-ash deposition fields

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Location	Description	Gamma-ray dose-rate (nSv/h)	^{222}Rn exhalation rate ($mBqs^{-1}m^{-2}$)	^{222}Rn in soil gas ($kBqm^{-3}$)	^{222}Rn air concentration (Bqm^{-3})
Deposition field 1	Restored in mid 70's, planted	140	18 ± 18	13 ± 5	26 ± 18
Deposition field 2	Restored in mid 80's, planted	300	24 ± 50	42 ± 3	42 ± 24
Deposition field 3	Not restored, active (exhausted lignite mine)	450	2 ± 0.1	17 ± 1	19 ± 12
Nearby reference point	Undisturbed field	300	180 ± 120	600 ±100	45 ± 28

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RADON IN WATER MEASUREMENTS

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RADON IN WATER MEASUREMENTS

- Various analysis techniques
- Caution in the sampling protocol
- Preparation of secondary standards
- Difficulties in Intercomparison
- Remediation techniques in waterworks

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1st AQUA-KIT FOR RADON IN WATER

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2nd AQUA-KIT FOR RADON IN WATER

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THE TWO RADON IN WATER TECHNIQUES

- 1st Aqua-kit may be used for continuous water flow.
- 2nd Aqua-kit needs smaller water volumes.
- 1st Aqua-kit needs calibration and calibration check (membrane).
- Measurement time is ~40min for both techniques.

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NATURAL RADIONUCLIDES DETERMINATION IN BUILDING MATERIALS

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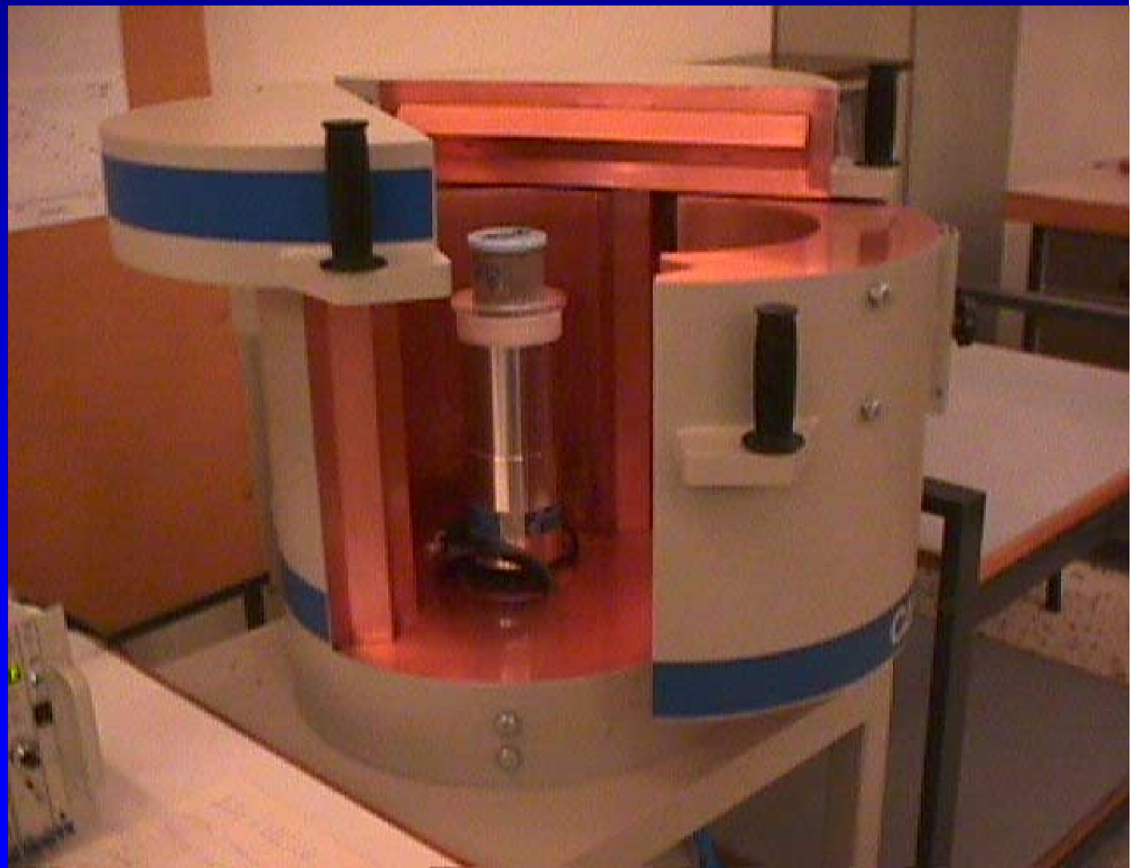
GAMMA SPECTROSCOPIC DETERMINATION OF NATURAL RADIONUCLIDES

- Determination of ^{226}Ra, ^{232}Th, ^{40}K in building materials.
- Calculation of the radiation performance index for building materials.
- Determination of other natural radionuclides



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NATURAL RADIOACTIVITY CONTENT AND RADON EXHALATION RATES OF GREEK BUILDING MATERIALS

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INDOOR AIR

An Integrated Approach

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Photon attenuation, natural radioactivity content and radon exhalation rate of building materials

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CURRENT RADON RELATED COLLABORATION OF NES-NTUA WITH THE INDUSTRY

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- Determination of the natural radioactivity and radon exhalation rate from domestic and imported zeoliths and perlite.
- Dependence of the fly-ash natural radioactivity and the radon exhalation-rate, from the fly-ash grain size and the sampling point inside lignite burning power plants.
- Determination of the natural radioactivity and radon exhalation rate from biofuel ashes.
- Determination of the fly-ash content in the various fractions of cement, during the cement production process.