

COMMISSION OF THE EUROPEAN COMMUNITIES

**EXPOSURE OF THE POPULATION TO
NATURAL RADIATION**

DIRECTORATE-GENERAL FOR SOCIAL AFFAIRS
Directorate of health protection

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Directorate-General
for Social Affairs

Health Protection
Directorate

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EXPOSURE OF THE POPULATION
TO NATURAL RADIATION

Report on a meeting of experts
on 12 June 1974 in Luxembourg

There has been a great deal of research on natural radioactivity since its discovery by Becquerel in 1896. This topic has been treated from different angles in numerous studies; with regard to the exposure of the population the most important aspects are as follows :

- Geological studies of the earth's surface (prospecting)
- Breakdown of exposure into the various (terrestrial and cosmic) components of natural radiation and their local and temporal variations
- Exposure of man (external and internal irradiation) as a result of radioactivity in building materials (urban environment)
- Internal exposure of man as a result of natural radioactivity in air, water and food
- Epidemiological studies and statistical assessments of genetic and somatic damage as a function of the natural radiation burden.

Relevant publications are widely scattered in the subject literature. As they describe results obtained with various methods and instruments, sometimes include radiation exposure caused by fallout and are often expressed in different units, they offer only limited comparability.

It would be most difficult to gain a representative picture of the actual radiation exposure of the population of a larger region from these findings.

Now that the state of the art allows releases of radioactive effluents from those nuclear installations most in the public eye, i.e. nuclear power stations, to be kept at such levels that the corresponding exposure levels are orders of magnitude below the dose limits specified by the health authorities and laid down in the legislation on radiation protection of the Member States, the natural level of radiation is used more and more as a basis of comparison when the effect of a nuclear plant on the environment has to be assessed. Making available information on environmental hazards to an "environmentally conscious" public requires a sufficient knowledge of the natural radiation level and its local and temporal variations. If at some time in the future the concept of group or collective dose, now being developed, is to serve any useful purpose and if general estimates (*) of population exposure are no longer considered to be sufficient, better knowledge of the above parameters is imperative.

CONCLUSIONS OF THE DISCUSSION

Against this background, which is becoming increasingly important in view of the rapid increase in the Community of the nuclear energy capacity expected in the near future, and also in order to clarify some questions raised in this connection in the context of the Commission's nuclear action programme, a group of experts from various European countries was convened. In their meeting in Luxembourg they tried to take stock of the situation regarding natural radiation exposure (see Appendix I for list of participants). To this end, the delegates described the measurement programmes in the field of natural radioactivity completed or planned in their countries. An outline of this information is to be found in Appendices II and III.

(*) For general estimates of exposure to natural radiation and the resultant health effects see the BEIR Report [1] and UNSCEAR Report [2] information in accordance with the present state of scientific knowledge in the field.

The results of the discussions may be summarized as follows :

- In almost all countries, attempts have been made to compile inventories and review reports of measurement data on natural radioactivity and, in particular, the resultant exposure of the population (Appendix II).
- The measurement data were obtained using various methods and instruments; some of the results are only available in counts/sec; comparison therefore still presents certain problems.
- In some countries (Federal Republic, Italy, Switzerland), very extensive survey programmes have been planned or commenced. Information on these may be found in Appendix III. Some of these projects aim to determine the natural radiation level with a high density of measurement points using sensitive dose-rate meters. Measurements in buildings have a certain priority in the programmes; they aim at determining the effects of building materials on population exposure.
- There have also been attempts to map regional exposure rate due to natural radiation [3] [4] [5] .

Taking all these factors into account, the experts reached the following conclusions which they are presenting to the Commission as guidance for further work in this field.

- Existing measurement data on population exposure in the Community should be presented in a review report (possibly including a cartographic presentation). This report should also include data from Switzerland and Austria because of their geographical situation (surrounded by Member States).
- The information thus obtained on average exposure in various areas of the Community and possibly on certain extreme values should be satisfactory in the first instance.
- It is more important to make a start on such a report and complete it within the foreseeable future than to attempt to make good any gaps, which certainly exist, or to achieve a high degree of accuracy in the

data or in their correlation between the different countries. If such a start were made, all further measurements could systematically be inserted into this basic scheme; moreover some progress towards harmonization between different laboratories in the Member States would be achieved.

- Before seeking solutions for problems concerning measuring techniques and methods, the Commission should request the Member States, for example when they send measurement results for the review report mentioned, to state :
 - what techniques and methods were used for the measurements,
 - what instruments and methods are most used or recommended for which type of measurement in the Member State,
 - what special problems exist with measurement techniques in the field of natural radioactivity and natural radiation and which of these should be given priority in future research perhaps with aid from the Commission.

- A very small group of experts might be appointed to discuss the aspects of measurement techniques mentioned and, in particular, to investigate whether and what kind of research or development should be recommended or launched. Proceeding in this way should be more effective and allow one to reach conclusions more quickly than conferences or seminars.

Note : The Secretariat has now received much of the information at present available on external radiation levels in the member states together with Switzerland and Austria. The data are widely varied as to the types of instrument used, the nature and extent of the measurement grid, the degree of geological extrapolation already employed, the period in which the measurements were made and the form of presentation. It is, therefore, intended to commission a study of the results, with a view to producing an overall cartographic presentation of the data, correlated so far as is possible, together with a report highlighting deficiencies and making recommendations which, with their respective priorities, might form a basis for the formulation of a future field programme.

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LIST OF PARTICIPANTS
AT THE MEETING ON THE EXPOSURE OF THE POPULATION
TO NATURAL RADIATION ON 12 JUNE 1974

<u>Belgium</u>	Mrs BARUH Mr. BOUQUIAUX Mr. GRANDJEAN	{ Ministère de la Santé Publique Institut d'Hygiène et d'Epidémiologie Bruxelles Institut Royal Météorologique de Belgique, Uccle
<u>Denmark</u>	Mr. AARKROG	Research Establishment Risø
<u>F.R. Germany</u>	not represented	
<u>France</u>	Mr. MADELMONT Mr. MORONI	Commissariat à l'Energie Atomique - Département Protection Sanitaire - Fontenay-aux-Roses Service Central de Protection contre les Rayonnements Ionisants - Le Vésinet
<u>Italy</u>	Mr. ILARI Mr. CIGNA	{ Comitato Nazionale per l'Energia Nucleare Divisione Protezione Sanitaria et Controlli Roma
<u>Netherlands</u>	Mr. OP DE KAMP Mr. ACKERS	Ministerie van Volksgezondheid en Milieuhygiëne R.C.N. Petten
<u>Switzerland</u>	Mr. HUNZINGER	Service Fédéral de l'Hygiène Publique, Berne
<u>United-Kingdom</u>	Mr. WEBB	National Radiological Protection Board, Harwell
<u>Ireland</u>	not represented	

Representatives of the Commission of the European Communities

	Dr. RECHT	Director of Health Protection
<u>Secretariat</u>	Mr. HAMPE Mr. LUYKX Mr. DUTAILLY Mr. VAN BOCKSTAEL	{ Directorate of Health Protection -"- -"- -"-

SYSTEMATIC STUDIES CARRIED OUT IN THE DIFFERENT COUNTRIES

A) Belgium

Organizations involved :

Institut d'Hygiène et d'Epidémiologie

also :

Institut Géologique

Institut Royal Météorologique

Systematic measurements :

- radioactivity of water :

measurements carried out by the Institut d'Hygiène et d'Epidémiologie

total alpha, total beta and K-40

Ra-226 : measurements on ground water samples have been carried out every 3 months since 1958;

maximum concentration found in water widely used as drinking water : 4 pCi/l

Ra-222 : measurements carried out since 1972 of around 50 sources of mineral waters and ground water;

concentration normally lower than 1,000 pCi/l (5 to 6,000 pCi/l in some sources of mineral water and 30,000 pCi/l in one source of ground water).

Other measurements carried out :

- cartographic survey

set up around 1958 by the Institut Géologique with the aid of a portable scintillation counter;

- radioactivity in air (radon, thoron, etc.)

recording of hourly variations in activity at a single point (Centre de Physique du Globe de Dourbes - Institut Royal Météorologique);

- radioactivity of building materials

as the amount of artificial gypsum used in construction work is very low in this country, this aspect is considered of minor importance;

- surveys on radiation background carried out before a nuclear site is set up.

B) Denmark

Organization involved :

Health Physics Department, Research Establishment Risø/
Danish AEC

Systematic measurements :

- background radiation [6]
- soil analysis (U and Th families; K) [6]
measurements carried out since 1962 at around 60 points (11 agronomic research stations and local survey stations around the sites of future nuclear installations) [6]
measurement technique used simultaneously for the two types of measurements : NaI scintillation monitor [6]
thermoluminescent dosimeters (LiF) [7]
- radioactivity of building materials and radiation within buildings monitored since 1974 [7,8]

C) France

Organizations involved :

Service Central de Protection contre les Rayonnements
Ionisants (S.C.P.R.I.)
Commissariat à l'Energie Atomique - Département Protection Sanitaire

Systematic measurements (SCPRI, for 15 years) :

- cartographic survey
about to be implemented on the basis of spectrometric measurements
- dosimetric surveys
at 130 points
- activity of natural internal contaminants
samples measured :
 - air (aerosols)
 - rainwater and dry fallout
 - surface water, ground water and irrigation water
 - food chain : vegetables, milk, cereals, diet of 8 communities

- sampling points

spread over the entire country, from 8 (food chain) to several hundred (surface water and ground water)

- measurements carried out

K, Ra, U, Th, and Be-7 for most of the samples; sometimes Pb-210 (mineral waters) and Rn

The most important results are given below :

Samples		Radionuclides	
		Ra-226	U
surface water	usually	< 1 pCi/l	< 1 $\mu\text{g/l}$
	maximum	15-40 pCi/l	100 $\mu\text{g/l}$
ground water	usually	< 1 pCi/l	< 0.5 $\mu\text{g/l}$
	maximum	19 pCi/l	17 $\mu\text{g/l}$
sea water			3 $\mu\text{g/l}$
fresh fish (fresh water)	usually	< 1 pCi/kg	< 1 $\mu\text{g/kg}$
	maximum	100-200 pCi/kg	100 $\mu\text{g/l}$
(sea water)			< 0.5 $\mu\text{g/kg}$
diet, ingestion			0.5-2.4 $\mu\text{g/d}$

Also, for Be-7, usually :

aerosols : 0.05 pCi/m³ air
rainwater : 20-30 pCi/l
soil deposits : 15 mCi/km²/y

Other measurements carried out :

- systematic measurement of cosmic radiation conducted from 25 aircraft
- surveys carried out before setting up a nuclear installation

Note :

All the data gathered by SCPRI are stored on punched cards; with a suitable program, these could be extracted and processed by computer.

A report on natural irradiation and contamination in the environment is in the course of publication [17] .

D) Italy

Organization involved :

Comitato Nazionale per l'Energia Nucleare (CNEN)
 Direzione Centrale Sicurezza Nucleare e Protezione Sanitaria and
 Dipartimento Ricerche Sicurezza Nucleare e Protezione Sanitaria

Systematic measurements :

- survey of extreme values of exposure to natural radiation [9] :
 - selection of sampling points based on geological composition of the soil
 - measurements carried out :
 - gamma exposure due to the radionuclides of the uranium and thorium families and to potassium
 - contribution of cosmic radiation based on measurement above a lake, then extrapolated as a function of latitude and altitude
 - measuring technique : either with ionization chambers or by gamma spectrometry
 - results : from 0.7 μ R/h for ophiolites { contribution of cosmic to 40-55 μ R/h for vulcanites } radiation deducted corresponding to exposure limits of 12 to 475 mrad/year
- cartographic survey of the exposure of the population to natural radiation [4] :
 - selection of measuring points based solely on population distribution (1 point per 40,000 inhabitants)
 - measuring technique : ionization chambers
 - results (arithmetic mean of measured values)
 - regional extremes :
 - Val d'Aoste : 49 mrad/year
 - Latium : 153 mrad/year
 - Campania : 174 mrad/year
 - (average for the country : 99 mrad/year)
- geological survey
 - uranium in natural waters, mainly surface waters, of Piedmont, Trentino, Friuli, Tuscany, Sardinia, Lazio, Calabria, Sicily : 0.1 to tens of μ g/l averaging around 1 μ g/l
 - uranium in river sediment : < 1 ppm to tens of ppm

- uranium, thorium and potassium in quaternary vulcanites from northern Lazio
 - uranium : 6-60 ppm, average about 20 ppm
 - thorium : 60-300 ppm, average about 100 ppm
 - potassium : 4-10 %, average about 8 %
- radon geochemistry : measurements of Rn in surface water, ground water, spa water and other natural waters range from a few pCi/l to tens of thousands of pCi/l, the high values being found in particular in hot springs. The work continues.

Other measures :

- radioactivity of 64 sources of mineral water [10] :
 - content of Ra-226, Po, Pb-210
(2 waters with Ra-226 content > 10 pCi/l)
 - calculation of the collective dose resulting from the consumption of these waters and the dose absorbed by children consuming powdered milk dissolved in mineral water [11]
- radioactivity of several samples of construction materials typical of regions with the highest natural radiation levels
- background radiation in Rome and in 15 buildings in the city [9]
 - average $23.8 \mu\text{R/h}$, or 200 mrad/year
- surveys carried out before setting up a nuclear installation
- surveys of natural radioactivity in 18 mines [12]

E) Netherlands

Organization involved :

Ministerie van Volksgezondheid en Milieu Hygiëne

Measurements carried out :

- radioactivity of air, water, fish and vegetables
- radon content of natural gas
- radium content of plaster (by-products of phosphate production)
- exposure doses as a function of the nature of the soil or around the sites of future nuclear power plants
- gamma radiation of blast furnace slag used as ballast for roads

measuring techniques :

- gamma spectrometry with NaI crystals
- thermoluminescent dosimeters

results :

- natural gas, Rn content ≈ 10 pCi/m³
- plaster by-products, Ra content : 15-60 pCi/g
- average exposure on clay and sandy soils : 6 μ R/h and 3.1 μ R/h
- exposure on roads with slag ballast 40-80 μ R/h

Note : the possibility is envisaged of lowering by a factor of 3 to 4 the Ra content of plaster by-products used in construction work

F) United Kingdom

Organizations involved :

Medical Research Council
National Radiological Protection Board
Institute of Geological Sciences

Hazards to man due to ionizing radiation have been studied [13] and measurement programmes covering the various components of background radiation have been in effect for around twenty years. The conclusion was drawn very early that one of the predominant factors of human exposure was radiation due to building materials.

Measurements carried out :

- background radiation, radioactivity of air and rainwater monitored for some years by the monitoring network for radioactive fallout; this network has been reduced to a minimum in the course of the last few years
- radioactivity of building materials :
 - Ra content of plaster by-products used in construction work (≤ 25 pCi/g)
 - average annual exposure to members of the public to Rn (dose equivalent to lung : 500 mrem)
- assessment of doserates from terrestrial (non-cosmic) sources [14] :
 - by county 30-150 mrad in air/year giving a typical average gonad doserate of 38 mrad/year
 - collective U.K. gonad doserate 2.1×10^6 manrad/year

G) Switzerland

Organization involved :

Federal Office of Public Health - Section for Radiation Protection

Systematic measurements carried out :

- cartographic survey of natural radiation [5] :
 - selection of measuring points based on tectonic and geological data; measurements carried out on various soils, rocks, artificial surfaces (asphalt, concrete, paving stones, etc..) in towns and villages, and buildings
 - results
 - from 2-3 $\mu\text{R/h}$ on sedimentary rocks (limestone)
 - up to 30 $\mu\text{R/h}$ on metamorphic rocks (gneiss)
 - (exceptionally, individual results of 52 and 82 $\mu\text{R/h}$ were obtained)
- radiation inside buildings [5] (only a few measurements were carried out) :
 - total background radiation 10 $\mu\text{R/h}$ (average of 8 measurements)

measurement technique :

- tissue-equivalent ionization chamber

The average dose rate to the Swiss population from natural external radiation is 122 mrad/year, 31 mrad/year of which is due to cosmic radiation; depending on the zone, the local average dose rate varies between 44 and 285 mrad/year.

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H) Federal Republic of Germany

The Bundesministerium des Innern, Bonn is responsible for overall coordination.

Organizations involved :

	A	B	C	D	E
A	Measurements inside and outside buildings				
B	Measurements of radioactivity in construction materials				
C	Measurements of internal and external exposure from phosphatic fertilizers				
D	Measurements of radioactivity in water				
E	Measurements of radioactivity in air				
1.	x		x		x
2.	x		x		x
3.					x
4.					x
5.					x
6.					x
7.					x
8.					x
9.					x
10.		x			
11.		x			
12.		x			
13.		x			
14.		x			
15.	x				

Measurements carried out :

- 3,000 measurements in houses
 - 25,000 measurements in the open air
 - systematic measurements of construction materials
 - systematic measurements of phosphatic fertilizers
- { 1973-74
 { since 1973

Reports on the above will be published in Ref. [15]. Provisional results for construction materials appeared in Ref. [16].

- systematic results of measurements of air and water appear in the annual reports "Umweltradioaktivität und Strahlenbelastung" published by the Bundesministerium des Innern.

I) Grand Duchy of Luxembourg

Organization involved :

Service de Radioprotection - Direction de la Santé Publique

Measurements carried out :

Ra-226, Rn-222, natural uranium and potassium in mineral waters

Ra-226	3.5 - 270 pCi/l
Rn-222	947 - 3,065 pCi/l
U _{nat}	1.3 - 7.8 µg/l
K	25 - 130 mg/l

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STUDIES ENVISAGED ON NATURAL RADIATION EXPOSURE

A) Denmark

- a study has been in progress since 1974 on gamma-exposure and Rn-doses within and outside buildings
- a study is envisaged of exposure resulting from the use of fossil fuels

B) Federal Republic of Germany

Bundesministerium des Innern, Bonn

- supplementary measurements
 - . in houses
 - . in the open air
 - . in construction materials
- measurements of external and internal exposure resulting from the use of phosphatic fertilizers;
- consideration of measurements being extended to include radon dose contributions.

C) France

a) SCPRI

- improved quality and increased number of measuring methods for external irradiation
- completion of the radioactivity map

b) CEA (in collaboration with SCPRI)

- study of the radioactivity of building materials
- measurements of radon and thoron in food vectors

D) Italy

a) CNEN

- a study of radon
 - . atmospheric concentration
 - . equilibrium with daughters
 - . deposition of daughters in and doses to the respiratory system
 - . accumulation and metabolism of and doses from long-lived daughters (Pb-210 and Po-210)

- . comparison of exposure from Ra in building materials with that from spas.

b) CNEN, in collaboration with the National Nutrition Institute

- a study is envisaged of the exposure of the population, both by ingestion and by external radiation (inside and outside buildings), in two regions with comparable socio-economic conditions (Latium and Tuscany) but in which the exposure to natural radiation is significantly different.

E) United Kingdom

- study of the correlation between natural activity in the diet and in tissues based on postmortems
- individual monitoring programme on selected individuals
- regional radiometric surveys

F) Switzerland

- new programme of exposure measurements inside and outside of dwellings.

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