CENTRAL LABORATORY

FOR RADIOLOGICAL PROTECTION

CLRP

BI-ANNUAL REPORT
1992 - 1993

CLRP CENTRAL LABORATORY FOR RADIOLOGICAL PROTECTION

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OPERATIONAL AND RESEARCH ACTIVITIES
OF CENTRAL LABORATORY FOR RADIOLOGICAL PROTECTION

WARSAW
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Editors:
J. Suski
T. Wardaszko
J. Rostek
Technical editor:
J. Zajdel

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tel.: 11-16-16
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fax: 11-16-16
telex 81 23 81 PL CLOR
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FOREWORD

This bi-annual report covering the period of 1992 - 1993 is the second one in the intended series of periodic sources of information on the activities of the Central Laboratory for Radiological Protection (CLRP), both operational and scientific. It summarizes briefly all aspects of them, thus giving a short overview of what are the practical measures being undertaken to ensure for best possible state of radiological protection in Poland, and what are the directions of research works aimed at broadening the knowledge of different kinds of radiation risks to the population and at better understanding the mechanisms which govern the behavior of radionuclides in the environment.

The CLRP is a medium-size institution - with a staff totalling to about 140 - which, by its statute, is responsible, on a national scale, for radiation protection of the population as well as of those groups of the population which are professionally exposed to radiations. Fulfilling of tasks related to this aim is accompanied by a vast international co-operation which ensures for conformity of our procedures, regulations and directions of research works with those in other countries. In particular, recommendations of internationals bodies, to most of which Poland is an actively collaborating member, have been implemented in our national regulations and standards in the field of radiation protection. Our contribution to further progress in this area is well recognized by scientific and professional communities abroad.

Our accomplishments would not have been possible without steady encouragement and incentive of subseqent presidents of the National Atomic Energy Agency and, particularly, of the present President, Professor J. Niewodniczański.

It is a our pleasure to thank all the bodies contributing to financing our activities: first of all, the above-mentioned National Atomic Energy Agency; also, the State Committee of Scientific Research and the State Inspectorate of Environmental Protection, as well as the Polish-American Maria Skłodowska-Curie Joint Fund II should be gratefully acknowledged in this regard.

Professor S. Sterliński
Director

1. GENERAL INFORMATION

The Central Laboratory for Radiological Protection (CLRP) was called into being on 13th July 1957. At present it is subordinated to the National Atomic Energy Agency. Warsaw is its main site, but a small branch is located in the city of Katowice. According to its statute, the CLRP is the institution which is responsible for radiation protection on a national scale.

The main directions of activities of the CLRP are:
- environmental radioactivity monitoring
- supervision and control of the users of radioactive sources (except medicine)
- personal dosimetry
- calibration and periodical control of dosimetric equipment
- education and training
- scientific research as well as development works and implementations.

The CLRP also performs duties of:
* Radioactive Contamination Monitoring Center
* Emergency Service Center
* National Contact Point in the International Notification System of a Nuclear Accident and Radiological Emergency
* Radiation Protection Center for Standardization.

2. ORGANIZATION

The Central Laboratory for Radiological Protection has a staff of 139, of which 58 have university level background. The CLRP employs 5 professors, 1 associate professor and 18 senior researchers of whom 7 have Ph. D. degree.

Menagement of the CLRP:

Director	–Professor Sławomir Sterliński
Deputy Director	– Professor Jan Jagielak
Deputy Director	– M.Sc. Władysław Opłotny.

The CLRP is divided into following departments and divisions:

1. Radiation Hygiene Department
   Head: Professor Zofia Pietrzak-Flis

2. Dosimetry Department
   Head: Professor Jan Jagielak

3. Radioactive Contamination Department
   Head: M.Sc. Dariusz Grabowski

4. Personal Dosimetry Department
   Head: M.Sc. Alojzy Koczyński

5. Supervision and Controls Department
   Head: M.Sc. Roman Tańczyk

6. Division of Education, Information and Standardization
   Head: M.Sc. Jolanta Rostek

7. Section of International Co-operation
   Head: Dr Melania Pogorzelska-Lis

The Scientific Council (26 persons) was elected in 1991 by the staff the CLRP:

Chairman of the Scientific Council	– Professor Zbigniew Szot
Deputy Chairmen	– Professor Zofia Pietrzak-Flis
	– M.Sc. Dariusz Grabowski

Members:

1. M.Eng. Maria Bysiek
2. M.Sc. Hanna Dzikiewicz-Sapiecha
3. Professor Tadeusz Florkowski
4. Elżbieta Grabowska
5. Dr. Danuta Grzybowska
6. M.Sc. Janusz Henschke
7. Professor Jan Jagielak
8. Professor Jerzy Jankowski
9. M.Sc. Alojzy Koczyński
10. Dr. Maria Kowalska
11. Dr. Ludwika Kownacka
12. M.Sc. Paweł Krajewski
13. Dr. Walenty Kurowski
14. Dr. Adam Mierzwiński
15. M.Sc. Wojciech Muszyński
16. Elżbieta Ostrowska
17. M.Sc. Magdalena Petrykowska
18. Dr. Melania Pogorzelska-Lis
19. Grażyna Ewa Puławska
20. M.Sc. Szczęsny Rosiński
21. Antoni Słodownik
22. Dr. Lucjan Sponar
23. Professor Sławomir Sterliński

3. OPERATIONAL ACTIVITIES

3.1 MONITORING OF ENVIRONMENTAL RADIOACTIVE CONTAMINATION

3.1.1 CENTER OF RADIOACTIVE CONTAMINATION MEASUREMENTS

The monitoring of radioactive contamination of the environmental components and foodstuffs in Poland is being carried out by the Service of Radioactive Contamination Measurements supervised by the National Atomic Energy Agency.

The Service comprises:

– a network of measuring stations acting within the Meteorological Stations, Voivodship Sanitary-Epidemiological Stations, Veterinary Hygiene Establishments, Environmental Protection Inspectorates and others;

– the Center of Radioactive Contamination Measurements in the CLRP. It supervises and co-ordinates all activities of measuring stations (elaborates measurement programs and unifies measurement methods, sets equipment, initiates and conducts intercalibrations, collects and analyses measurement results, elaborates reports on radiological hazard level).

The monitoring of radioactive contamination is conducted with regard to air (aerosols), total fallout, atmospheric precipitation, surface water, tap water, sewage, soil, plants, foodstuffs.

12 meteorological stations perform duty of alarm stations for the case of extraordinary increase of radioactivity level.

3.1.2 THE AIR MONITORING SYSTEM

The air monitoring system consists of:

– 12 field stations of the Institute of Meteorology and Water Management, and

– 6 ASS-500 stations (constructed at CLRP) run by different institutes, under supervision of CLRP.

Twelve field stations constitute an early warning network and function as alarm stations; masurements of gross beta activity of air samples are carried out on a daily cycle. In addition to it, six high volume air sampling stations type ASS-500 work on a weekly cycle. This enables performing spectrometric measurements of natural and artificial radionuclides deposited on filters in wide range of their concentrations, beginning from 0.5 $\mu Bq/m^3$.

3.1.2.1 MONITORING OF AIR RADIOACTIVITY IN THE SYSTEM OF EARLY WARNING

D. Grabowski, W. Muszyński, B. Rubel, G. Smagała, J. Wilgos
Radioactive Contamination Department

In the frame work of the Service for Measurement of Radioactive Contaminations 12 field stations of the Institute of Meteorology and Water Management have been designated as alarm stations; they form the system of early warning on nuclear accident or emergency radiological situation in the national environmental radioactivity monitoring system (fig 1). The field stations carry out routine continuous environmental surveys of gamma dose rate as well as radioactivity of air aerosols and fallout. Routine measurements are performed daily but in the case of emergency the frequency of sampling can be increased.

The air aerosols samples are collected on the filter from the height of 2 m above the ground level. Air volume is about 200-300 m^3 per 24-hours-day.

Gross beta measurements of samples are performed twice:

– at T_0 – immediate measurement,

– at T_1 – after one hour.

The ratio of results of these two measurements gives information on environmental radiological situation.

In normal radiological situation mainly natural short-lived radionuclides-daughters of ^{222}Ra and ^{220}Ra contribute to the activity of filter and their concentration can range from several mBq m^{-3} to a few Bq m^{-3}, depending on weather conditions. Hence, the result of the second measurement is much lower because of the radioactive decay. Analysis of measured values indicates that the ratio T_1:T_0 is less than 0.8 for normal radiological conditions.

During an emergency situation also artificial long-lived radionuclides are collected on the filter, so the values for immediate and after 1 hour gross beta air activities are similar. Such results indicate emergency radiological situation. Information on the rapid increase of air contamination in April 1986 was submitted by the alarm station in Mikołajki before any other notification on nuclear accident in Chernobyl.

In the period of 1987-1993 there has not been registered any emergency radiological situation in Poland.

Investigations and assessments of long-term changes of the air contamination level are based on the values of measurements performed after 120 hours from collecting of the sample.The levels of radioactive air contamination for period

1987–1993 are similar to those registered in the period 1981–1985. The average gross beta air activities in Poland for period 1985–1993 are presented in the table.

Annual mean gross beta air activity in Poland

years	gross beta activity mBq m^{-3}
1981–1985	<1
1986	964
1987–1993	1

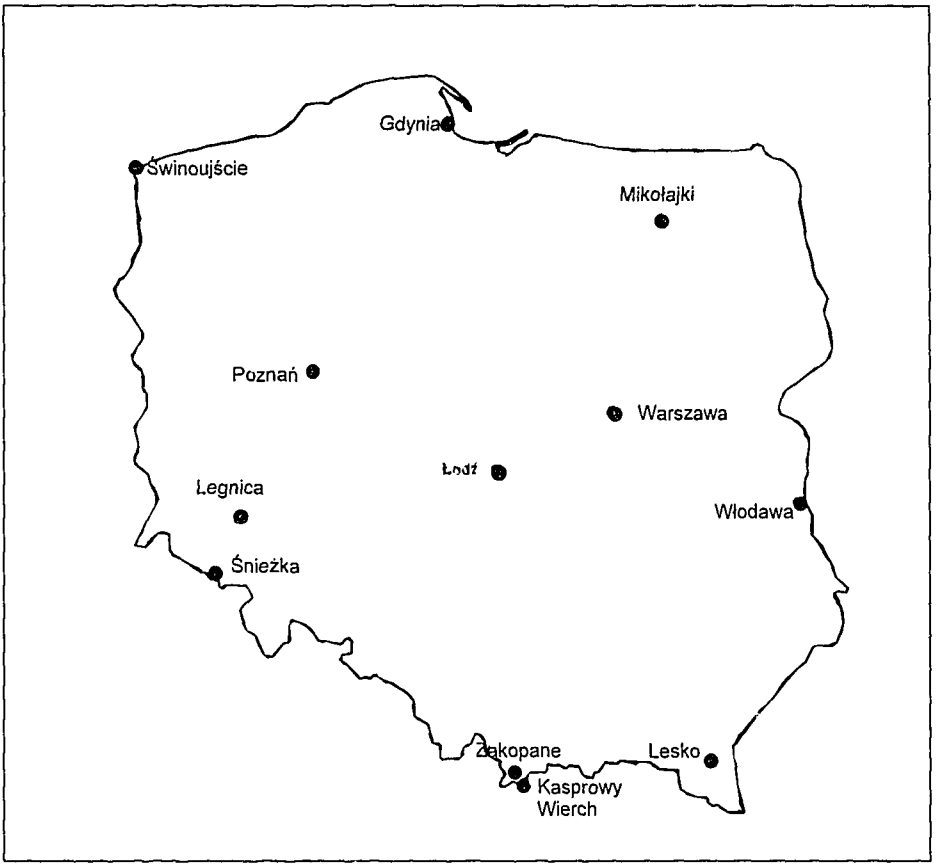

Fig. 1. Network of alarm stations

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3.1.2.2 AEROSOL RADIOACTIVITY MEASUREMENTS USING ASS-500 STATIONS

Aerosol Sampling Stations, type ASS-500, constructed at CLRP, are being used for the routine environmental air monitoring. At present, in Poland the monitoring network sonsists of six ASS-500 stations. They are localized in Warsaw, Świder, Białystok, Katowice, Cracow and Lublin. In December 1993 two further stations (in Gdynia and Wrocław) were installed.

The system works on the basis of a weekly cycle. The concentrations of radionuclides are calculated for the end of the sampling period. Weekly reports from all stations are sent to the CLRP, where monthly, quarterly and yearly reports are prepared for the National Atomic Energy Agency and the National Inspectorate for Environmental Protection. Monthly reports are transmitted by fax to laboratories carrying out similar investigations in Germany, Switzerland, Finland and Italy. These laboratories send, also,their results to CLRP.

3.1.3 RADIOLOGICAL MAP OF POLAND

At CLRP a project on „Radiological map of Poland" has been carried out since 1988. Our system gives the following possibilities:

- creation of the base of computerized radiological data for the whole country
- obtaining a set of radiological maps of Poland.

The measurements are carried out using the network of meteorological stations (311 points) of the Institute of Meteorology and Water Management located all over Poland.

For each point the following measurements have been made:

– gamma dose rate by means of thermoluminescent detectors

– outdoor ^{222}Rn concentration by means solid state track detectors

– natural radionuclides and concentration in $^{134, 137}Cs$ 10 cm deep soil layer, with application of spectrometric methods.

Our results can be demonstrated in form of the maps produced by the method of circle cartodiagrams and in the „Sinus" system which enables extrapolation of point values onto the whole area of the country.

3.1.4 APPLICATION OF THE MOBILE RADIOMETRICAL LABORATORY FOR ENVIRONMENTAL MONITORING

The Mobile Radiometrical Laboratory (MRL) was mainly employed to monitor the enhanced natural ionizing radiation in selected regions of Poland. The measurements were carried out at the decommissioned uranium mine vicinity, at glass and copper works area and also in their surroundings. The main goal of the monitoring program was to determine the impact of radiation on the population and workers. The final results and conclusions formulated in three expertises are presented below.

1.Preliminary estimation of radiological situation in the vicinity of the former uranium mine „Rudki" (near Kielce).

The environmental monitoring consisted of the following measurements:

a. ionizing radiation (cosmic and terrestrial) dose-rate monitoring for the route Ostrowiec-Rudki (former uranium mine area) – Rudki (municipal area) – Święty Krzyż with application of the microprocessor system „ARDREMS",

b. terrestrial radiation dose-rate measurements in the selected areas performed with portable gamma dosemeters,

c. natural radionuclides (^{40}K, ^{226}Ra, ^{228}Ac) concentration measurements for soil, bottom sediment and water samples with application of the semiconductor detector (HPGe),

d. ^{226}Ra concentration with the application of emanation method in drinking water, water sormpled from melioration trench and from river Pokrzywianka.

The following results have been obtained :

– the dose rate values were in the range 60.2–111.8 nGy h^{-1} which are typical for the highland territory of Poland;

– the highest dose rates were detected at the meadow situated on the former sedimentation pool (86-112 nGy h^{-1}) and at the vegetable garden area situated on the previous flotation waste-heap (77.4– 95.7 nGy h^{-1});

– the results of natural radionuclide concentrations for all analysed samples were typical for Poland territory, since the value of ^{226}Ra concentration for soil sample taken from garden area was the highest value measured in Poland (172 Bq kg^{-1});

– concentration of ^{226}Ra in all water samples was below 110 Bq m^{-3} and lower than derived limit for drinking water.

Basing on measurement results the following final conclusions have been formulated :

– external exposure for Rudki population is not affected by the former uranium mine,

– measurements of ^{226}Ra concentrations in plant samples taken from vegetable garden area have been recommended, to estimate the internal exposure for the local population.

2. The radiological environmental monitoring at the copper works „Głogów" area, the municipal area and surroundings of Głogów city, the recultivated area of Ruszowice (former clay and gravel mine).

The radiological monitoring consisted of:

a. gamma radiation dose-rate „in situ" measurements with portable dose-rate meters, in the area of interest,

b. measurements of ^{226}Ra, ^{228}Ac, ^{40}K concentration in raw materials, wastes and soil samples applying HPGe spectrometer and NaJ(Tl) spectrometer „AZAR-90",

c. surface activity of beta radiation measurements at copperworks area.

The background ionizing radiation dose rate values have varied in the range of:

copperworks area	43.5–165.3 nGy h^{-1}
city area and surroundings	76.6–92.2 nGy h^{-1}
recultivated area of Ruszowice	87.9–100.9 nGy h^{-1}.

The natural radionuclide concentration values for soil samples taken from investigated area are comparable to typical values for Poland. Analysis of several processed material samples taken from the different work sites of copper works have indicated that the highest concentrations of natural radionuclides were in copper sludges; they varied in the range:

^{40}K	710–991 Bq kg^{-1}
^{226}Ra	239–333 Bq kg^{-1}
^{228}Th	42–71 Bq kg^{-1}.

The levels of occupational exposure (Table 1.) were estimated basing on „in situ" measurements for 35 different work sites classified into three groups.

Table 1. Annual external ionizing radiation doses estimated on the field monitoring for differend worksites at copperworks „Głogów"

Worksite characteristics	Critical organ	Annual eff. dose equivalent [mSv]
Isotope gauges (shaft furnace) Occupational control	whole body	1,58
Processed materials with enhanced natural isotope concentrations	whole body, 0,23–3,05 hands	0,23–3,05
Processed materials with enhanced natural isotope concentrations	whole body, 0–0,28 hands	0–0,28

The following conclusions have been formulated:

– the periodical occupational control should be organized for the workers dealing with the enhanced natural radionuclide concentration,

– copper sludges and aggregates should not be used as a construction materials for dwellings.

3. The analysis of occupational exposure at the „Thomson Polkolor" glass-works.

The measurement program consisted of:

a. the natural radionuclide concentration measurements of the processed material samples containing zirkon silicate and potassium carbonate,

b. gamma dose-rate measurements around the trucks carrying the zircon silicate and at the driver's cab,

c. estimation of the occupational exposure of workers at the „Thomson Polkolor" glass-works for 42 different work sites basing on: gamma dose-rate measurements performed with portable gamma dosemeters,

d. beta activity measurements on the surface of the sacks with raw materials and of floors,

e. measurements of potential alpha energy concentration for radon daughters in the air.

The following final results have been obtained:

– ^{226}Ra concentration in the zirkon silicate powder – 3350 Bq kg^{-1},

– ^{40}K concentration in the potassium carbonate – 17050 Bq g^{-1},

– the dose-rate values in the range 79–4176 nGy h^{-1},

– beta surface activity values in the range 0.28–6.94 Bq cm^{-2},

– potential alfa energi concentration for radon daughters in the range 16.5–88.5 MeV l^{-1}.

The results of the occupational exposure analysis are presented below.

Table 2. Annual effective P dose equivalent for workers at the „Thomson Polkolor" glass-works

Place & type of performed work	Critical organ	Annual eff. dose equivalent [mSv]
Internal transport Store	whole body lungs, hand	0,41
Hand-unpacking of materials with enhanced natural isotope concentrations	whole body lungs, hand	0,53
Control room Weight room	whole body lungs	0,44
Furnace room No. 1	whole body lungs	0,83
Furnace room No. 2	whole body lungs	0,46

As values of annual effective dose equivalent are below 1 mSv, the occupational hazard is not stated.

3.2 CONTROL OF OCCUPATIONAL EXPOSURE

Control of occupational exposure is carried out by CLRP for about 343 institutions. They are divided into four groups:

1. Industrial - 161 establishments with about 1600 radiation workers.
2. Scientific - 83 institutions with about 2100 radiation workers.
3. Medical - 58 institutions with about 2000 radiation workers.
4. Other - 41 institutions with about 300 radiation workers. The total number of persons covered by individual dose monitoring in 1992 was 5830 and in 1993 was 5653. The monitoring was based on film and TL methods: for gamma, beta and thermal neutrons dosimetry the Kodak Personal Monitoring Film Type 2 and TL LiF:Mg,Ti sintered detectors were used, while neutrons monitoring was performed by means of the Kodak NTA nuclear emulsion. The dosemeters are worn for either 1 or 3 months periods. As regards extremity dosimetry, the hand doses were recorded using TL dosemeters. For dose evaluation the dosimetric program developed in our laboratory was used. Statistical analysis of the data on individual doses registered over the last two years is given in the chapter „Analysis of the occupational exposure. „Annual results".

3.2.1 ANALYSIS OF THE OCCUPATIONAL EXPOSURE ANNUAL RESULTS

A. Koczyński, E. Mazgajska, D. Łach
Personal Dosimetry Department

A personnel monitoring service in 1992-93 has been carried out for about 6000 radiation workers. It was based on film and thermoluminescent methods. For whole body photon, beta and thermal neutrons the Kodak Personal Monitoring Film Type 2 was used, while fast neutron monitoring was performed by means of the Kodak NTA nuclear emulsion. As regards extremity dosimetry, the hand doses were recorded using TL dosimeters with LiF:Mg, Ti sintered detectors.

The results of measurements are summed up for each calendar year (Table 1). To facilitate the estimation of occupational radiation hazards in the country, the results are grouped according to the dose values and type of establishment. Annual doses smaller then 0.1 of dose limits for occupational radiation exposure were received by 97% of radiation workers controlled both in 1992 and 1993. Annual doses greater than limit (50 mSv per year) were received by 2 persons each year in industrial establishments. Analysis of these cases is given in Table 2. Annual collective and mean annual dose equivalents calculated for persons employed in different establishments and for the whole population being monitored are shown in Table 3.

Table 1. Number of persons covered by individual dose monitoring in 1992-93 in establishment types and whole body annual dose ranges

Establishment type	Year of control	Annual dose equivalent (mSv)							Total	% *
		<= 3	3–5	5–15	15–50	50–120	120–250	> 250		
SCIENTIFIC	1992	2216	28	9	1	0	0	0	2254	99.6
	1993	2043	17	14	3	0	0	0	2077	99.2
INDUSTRIAL	1992	1433	85	86	26	2	0	0	1632	93.0
	1993	1422	76	69	25	2	0	0	1594	94.0
MEDICAL	1992	1868	50	39	2	0	0	0	1959	97.9
	1993	1868	40	35	2	0	0	0	1945	98.1
OTHER	1992	313	6	9	0	0	0	0	328	97.3
	1993	320	6	5	0	0	0	0	331	98.5
ALL TYPES	1992	5830	169	143	29	2	0	0	6173	97.0
	1993	5653	139	123	30	2	0	0	5947	97.4

* percent of persons having received annual doses < 5 mSv

Table 2. Analysis of cases of individual doses above 50 mSv in industrial establishments in 1992–93

Causes of irradiation	Number of cases (received dose)	
	1992	1993
Deteriorated condition of work (difficult access to gammagraphy unit)	1 (54 mSv)	1 (60 mSv)
Enhanced exposure in separate measurement periods giving annual total dose > 50 mSv	1 (74 mSv)	1 (62 mSv)

Table 3. Annual collective and mean annual dose equivalents calculated for persons employed in different establishment types and for the whole population being monitored in 1992–93

Establishment type	Number of persons		Annual collective dose equivalent [man Sv]		Annual mean dose equivalent [mSv]	
	1992	1993	1992	1993	1992	1993
SCIENTIFIC	2254	2077	2.299	2.040	1.02	0.98
INDUSTRIAL	1632	1594	3.329	3.274	2.04	2.05
MEDICAL	1959	1945	2.233	2.166	1.14	1.11
OTHER	328	320	0.341	0.351	1.04	1.06
THE WHOLE MONITORED POPULATION	6173	5947	8.087	7.832	1.31	1.32

3.3 CONTROL OF USERS OF RADIOACTIVE SOURCES

1. Register for users of radioactive sources
2. Inspections and enforcement
3. Participation in licencing procedure
4. Surveillance of suppliers of radioactive sources
5. Controls of radioactive sources turnover
6. Attestation
7. Dispatch Center of Emergency Service (DCES)
8. Polish Point of Contact (PPC) in the international notification system of nuclear accidents and radiological emergencies

3.3.1. REGISTER FOR USERS OF RADIOACTIVE SOURCES

In the late 1993, approximately 1820 users of radioactive sources being applied in medicine,research and industry as well as dealers of radioactive sources were registered at the CLRP.

In industry and research approximately 1400 users make use of small radiation sources in level gauges ,thickness gauges and other equipment containing sealed sources. About 140 institution use radioisotopes in industrial radiography.

There are over 200 suppliers and service branches dealing with sealed radiation sources. At present research and medical institutions include about 430 laboratories using unsealed radioactive sources. There are 46 high energy particle accelerators and 56 cesium and cobalt teletherapy or irradiation units. More over, there are about 20 users of radium and iridium sources for ginecological oncology.

In CLRP documents are collected relating to the licensing and activities of the above users. Towards the end of 1993 sum of activity of sealed sources (about 20000 sources) was:

a. cesium and cobalt teletherapy and irradiation units:
- ^{60}Co 6250 TBq (169 000 Ci),
- ^{137}Cs 425 TBq (115 000 Ci),

b. in industry and research:
- ^{60}Co 96 TBq (2600 Ci),
- ^{137}Cs 35 TBq (940 Ci),
- ^{90}Sr 3 TBq (82 Ci),
- ^{241}Am 18 TBq (473 Ci),
- ^{239}Pu 4 TBq (110 Ci),

c. radium sources for ginecological oncology – 0.3 TBq (8.2 Ci),

d. the depleted uranium as shields in gammagraphical apparatus and in irradiation units-7900 kg.

3.3.2 INSPECTIONS AND ENFORCEMENT

Inspections are carried out by personnel authorized by the President of the National Atomic Energy Agency.

The users of radioactive sources are routinely inspected on fixed schedule with the frequency depending on the hazard due to the radiation sources begin applied. The main objective of most inspections is the prevention of excessive radiation exposure and verification of data on the users of sources. Some inspections are of intervention type. They are carried out on request of the state agencies or users themselves.

An inspection team is obliged to write a report on site of the inspection.Such inspection reports containing the findings are prepared by the inspectors in the presence of the users . Thus, the findings on any unsafe situations are promptly brought to the attention of users.

Every new institution or installation is inspected prior to its commissioning and also on subsequent occasions. In 1992-1993, CLRP has made 700 inspections at the radioactive sources users.

3.3.3 PARTICIPATION IN LICENCING PROCEDURE

Every licence stipulates specific terms and conditions. These include the period of validity,specific surveillance requirements and information to be reported to the CLRP and other authorities on the safety status of the licensed institution.

The licencing procedure is done in two stages:

– analysis of the technical documentation of application for use of radioactive source (about 2000 documents). Since early 1993 CLRP does not participate in licencig procedures as regards analysis of technical documentation.

– inspection and approval of the facilities and equipment.

After successful completing both stages,the proposal of the licence is being prepared for acceptation by the President of the National Atomic Energy Agency. In 1992-93, about 1000 applications for licence were analysed and 40 licensing inspections were carried out.

Another task of CLRP is the decommissioning of radiological laboratories. It requires dosimetric monitoring of all facilities to check whether or not contaminations by radioactive substances have been left.

3.3.4 SURVEILLANCE OF SUPPLIERS OF RADIOACTIVE SOURCES

The „Users" who are mainly engaged in trading with radioactive sources are obliged to receive from CLRP an acceptation of each order obtained from radiological laboratories.A request for purchase or supply of radioactive sources cannot be processed without prior formal acceptation by CLRP.

The control of each purchase or supply of radioactive source is aimed at :

– elimination of cases of purchasing by or supplying to unauthorized users
– enforcement on users to comply with the conditions of licence
– general control of movement of radioactive sources in Poland.

3.3.5 CONTROLS OF RADIOACTIVE SOURCES TURNOVER

Until 1990 the bulk of radioactive sources turnover was handled by the Isotope Research and Development Center at Swierk. The controls of turnover were then carried out by CLRP officer staying at the Center. Since 1991 the isotope commerce started to be run by a number of individual dealers;they are obliged to present obtained customers orders to CLRP for authorization.

In 1992–1993, radiation sources turnover controls are still being made at the IRDC Swierk – which remained the most significant dealer in this area – by a CLRP officer, under agreement between CLRP and IRDC.

3.3.6 ATTESTATION

According to the agreement between the President of National Atomic Energy Agency and President of the then Polish Committee for Standardization, Measures and Quality Control, the CLRP performs investigation, attestation, testing and certificate issueing for radiometers and different radiation monitors and equipment used in radiation protection or containing radioactive sources.

In 1992–93 about 5000 attestations were issued for dosimetric instruments and 47 for other radiological devices.

3.3.7 DISPATCH CENTER OF EMERGENCY SERVICE (DCES)

The scope of round-the-clock activity of DCES is:

a. Receiving notices on radiological accidents
b. Giving the "first-aid" advices and recommendations concerning the radiological accident
c. Supervising the removal of the effects of radiological accidents
d. Notification the Police on the radiological emergency, if necessary.

In order to perform these tasks, the officer of DCES and a team of technicians-dosimetrists are on permanent duty in CLRP. Their means of communication include the emergency telephone (number 111515). A car and dosimetric equipment (portable radiation monitors, containers, manipulators) are at their disposal.

The officer on duty is obliged to make a decision on dispatching the emergency team.If necessary,he should consult his decision with the head of DCES or the director of CLRP.

In spite of strict control of the supply, use and disposal of radioactive materials, a number of incidents have taken place in the past two years. In 1992–93 160 radiological accidents have been registered. In 52 cases the emergency teams supervised the removal activities. The most serious accidents consisted in blocking

of the source in gammagraphy units. In some cases,source were lost, stolen or misplaced.

In 1993 CLRP began to collaborate with National Fire Guard in preventing accidents involving radiation hazard.

CLRP continues its collaboration with the Border Guard in preventing uncontrolled exportation and importation of radiation sources.

3.4 CALIBRATION AND ATTESTATION OF DOSIMETRIC INSTRUMENTS

According to the agreement between the President of National Atomic Energy Agency and President of Polish Committee for Standardization, Measures and Quality Control, CLRP performs investigations, type testing and calibrations certificate issuing for radiometers, radiation monitors and different equipment used in Poland for radiation protection. All instruments are tested in gamma radiation fields of sources: ^{60}Co; ^{137}Cs; ^{226}Ra and ^{241}Am in the intensity range from background level to about 3.2 mSv per hour. The relationship between a given irradiation conditions (distance) and calibration dose rate on the calibration bench have been fixed by Polish primary standard laboratory.

In the years of 1992-93, about 3910 dosimetric instruments were calibrated. About 70% of them were the dose and dose rate meters, about 25% the contamination monitors and about 5% the personal dose and dose rate signallers. In this period about 10 attestations were issued for new dosimetric instruments.

3.5 POLISH POINT OF CONTACT IN THE INTERNATIONAL NOTIFICATION SYSTEM OF NUCLEAR ACCIDENTS AND RADIOLOGICAL EMERGENCIES

The service of the Polish Point of Contact (PPC) is being carried out round the clock by the officers in the point of contact and experts on „call" duty. For economy reasons, the officer on duty in the point of contact is at the same time the officer on duty in the Dispatch Center of Emergency Service. In the framework of the activities of the PPC the following contacts took place:

An information was received from the IAEA, Vienna, about accident in Siberian Chemical Factory near Tomsk. In this Factory an explosion of tank containing uranium solution occured on April 6th, 1993. This chemical explosion caused a fire of the roof. Radioactive substances were released through the venti-

lation system to the atmosphere. The incident was qualified as level "3" in 7-level International Scale of Nuclear Events.

Exercises on communication efficiency in case of a nuclear accident between Emergency Assistance Service of the IAEA and PPC have been carried out. They were based on a hypothetical PWR reactor accident in the nuclear power station in Fort Calhoun, U.S.A. The PPC received 3 telex messages giving information about development of situation on June 30, 1993. Confirmation of receipt of these messages was required. Moreover, the World Meteorological Organization in Geneva asked for confirmation on messages transferred in meteorological network of communication according to convention on early notification on nuclear accidents, to control the proper action of this network.

3.6 HAZARD FROM THE NATURAL RADIONUCLIDES INDOORS

3.6.1 INVESTIGATION OF RADIOACTIVITY OF RAWS AND BUILDING MATERIALS

A. Żak
Dosimetry Department

The Central Laboratory for Radiological Protection supervises the operation of laboratories investigating natural radionuclides concentration in raws and building materials, organizes training of the personnel and collects results of the measurements. Since 1980 till 1993 the results of the measurements of 7510 samples were stored in our computer data base.

In the years covered by this report (1992-1993) the results for 959 samples were stored. In Table 1 numbers of samples investigated in 1992 and 1993 at different laboratories are presented. Number of samples of different types of materials sent to our laboratory are presented in Table 2. The group of industrial wastes is the most numerous because in this group radionuclide concentrations most frequently exceed permissible limits. The group of final building materials is also very numerous because their activity content is directly linked with the hazard to inhabitants and therefore these materials are investigated more intensively. The minimum, average and maximum values of natural radioisotopes concentrations measured in samples of raw and building materials and the values of qualification coefficients f1 and f2 in 1992 are presented in Table 3.

The lowest values of natural isotopes concentration appear in some natural raws (marble, chalk, gypsum, limestones) and therefore control of these samples is not obligatory. The slag remaining after copper production process and certain sorts

of phosphogypsum distinguish themselves particularly unfavourably and they are generally eliminated from all applications associated with housing.

The following two criteria of usability of a building material in housing and public building construction have been assumed:

$f1 = 0.00027\ S_K + 0{,}0027\ S_{Ra} + 0{,}0043\ S_{Th} \leq 1$

$f2 = S_{Ra} \leq 185\ Bq\ kg^{-1}$

Radionuclide concentration in natural raw and building materials does not usually exceed limits for coefficients f1 and f2. On the contrary the results for fly ash samples frequently have values higher than the permissible coefficients f1 and f2 (Fig. 1). The coefficient f1 value for boiler slag samples (Table 3) exceeds significantly the limit value.

In Fig. 2 the annual average value of coefficients f1 and f2 for fly ashes and smoke-box dust which were obtained in the period of 1980 - 1992 are presented. It can be seen in the figure that in recent years the average values of the qualification coefficients f1 and f2 for this sort of raws are going up.

Investigations of the materials being utilized most frequently in building industry such as lightweight and cellular concretes and building ceramics confirm the growth tendency in the average values of f1 and f2 coefficients in recent years in Poland (Figs. 3 and 4).

Table 1. Numbers of samples investigated in 1992–1993 at laboratories supervised by CLRP

Name of laboratory investigating raws and materials	Number of samples	
	1992	1993
Design and Research Office of Building Ceramic Industry in Toruń	219	–
Central Laboratory for Radiological Protection in Warsaw	160	122
Central Laboratory of Concrete Industry „CEBET" in Warsaw	152	–
Power Plant Łaziska in Łaziska Górne	60	160
Establishment of Technology and Management of Power Plant Waste „Energopomiar" in Katowice	40	30
EKOFIZ Laboratory in Słupsk	12	–
Institute of Building Materials Technology of Civil Engineering Department, Gdańsk Technical University	2	–
Voivodship Inspectorate of Environmental Protection in Cracow	–	2
Total	645	314

Table 2. Number of samples of different type of materials

Type of samples	Number of samples
Building raw materials of natural origin	59
Other materials of natural origin	26
Industrial wastes	277
Environmental samples	45
Final products to be used in building industry	238
Total	645

Table 3. Concentrations of natural radionuclides and values of qualification coefficients f1 and f2 measured in selected building raws and materials in 1992.

Name of building raw or materials	Number of samples	Concentration of radionuclides (S_K, S_{Ra}, S_{Th}) *) Bq kg^{-1}									Values of coefficients *					
		potassium ^{40}K			radium ^{226}Ra			thorium ^{228}Th			f_1			f_2 Bq kg^{-1}		
		NATURAL ORIGIN RAWS														
Lime	3	<1 -	42	-77	12-	22	-34	4-	8	-11	0.09-	0.10	-0.11	12-	22	-34
Sand	17	13-	162	-686	<1-	9	-27	1-	7	-27	0.01-	0.09	-0.34	<1-	9	-27
Silt stock	18	411-	729	-1241	33-	43	-72	33-	49	-65	0.39-	0.52	-.070	33-	43	-72
Clay	7	383-	582	-770	36-	66	-130	33-	63	-85	0.42-	0.61	-0.81	36-	66	-130
Clump	16	79-	760	-1237	2-	49	-80	5-	57	-93	0.04-	0.58	-0.82	2-	49	-80
		INDUSTRIAL ORIGIN RAWS														
Fly ash	182	80-	678	-972	11-	132	-223	24-	93	-159	0.18-	0.95	-1.39	11-	132	-223
Boiler slag	67	178-	532	-844	25-	85	-161	31-	81	-183	0.08-	0.72	-1.30	25-	85	-161
Metallurgical slag	1		135			121			37			0.53			121	
		BUILDING MATERIALS														
Cement	1		340			46			29			0.34			46	
Light weight cellular concrete	68	115-	436	-706	8-	88	-159	5-	46	-87	0.09-	0.55	-0.91	8-	88	-159
Building ceramic **)	139	117-	703	-1117	3-	54	-158	2-	52	-106	0.07-	0.56	-0.96	3-	54	-158
Total	519															

* Values: minimum – average – maximum

** Bricks, hollow ceramic bricks, roof tiles, shapes etc.

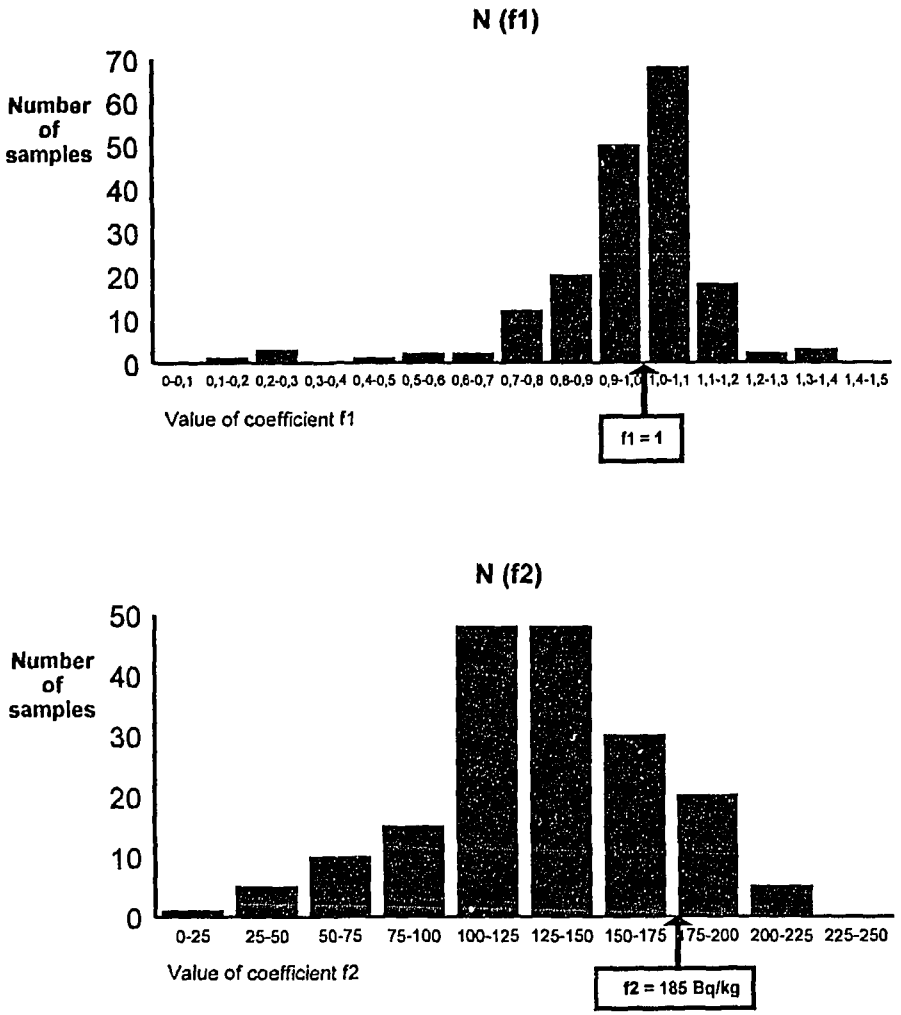


Fig. 1. Histogram of values of coefficients f_1 and f_2 for 182 samples of fly ashes

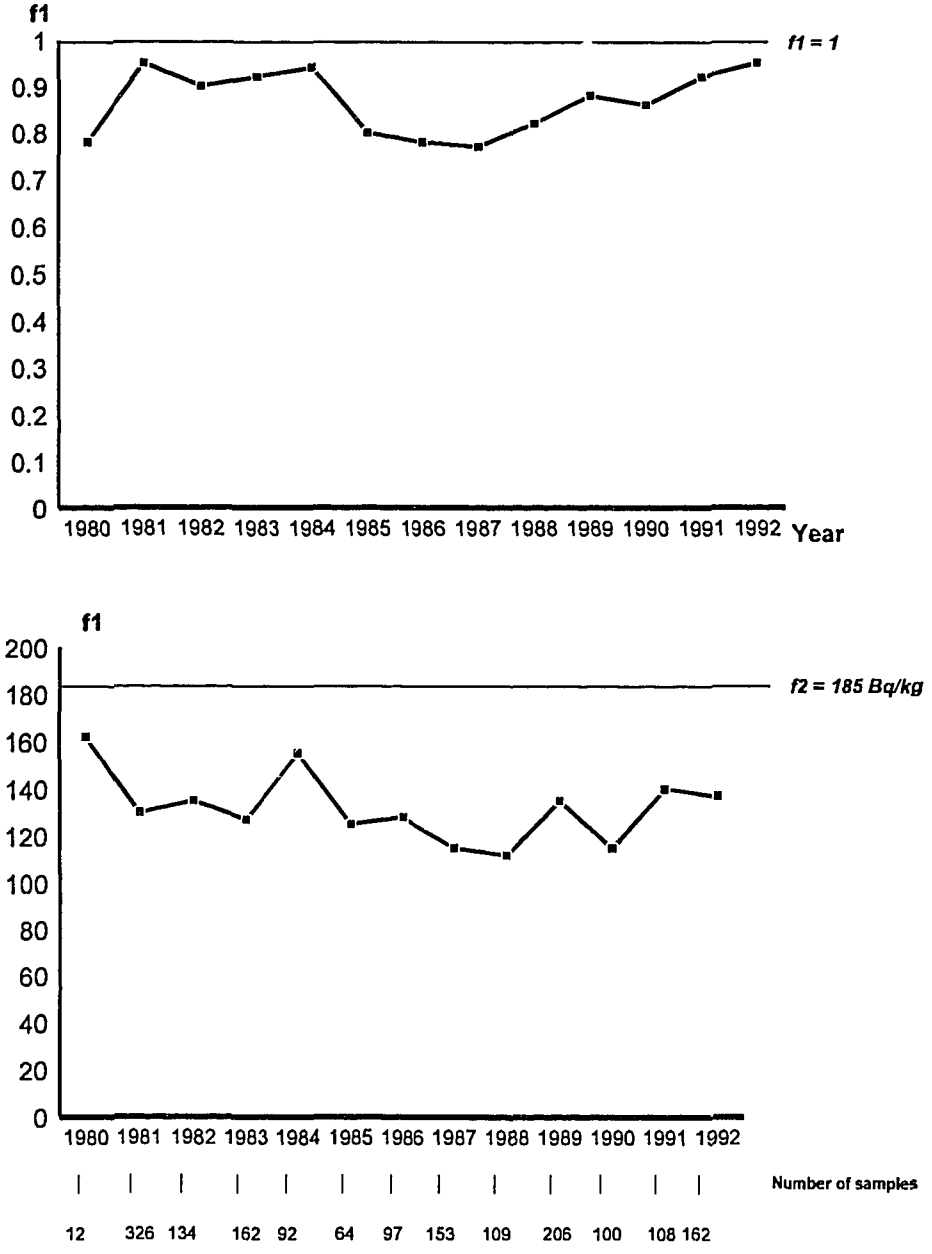


Fig.2. Average values of coefficients f_1 and f_2 for fly ashes and smoke-box duet

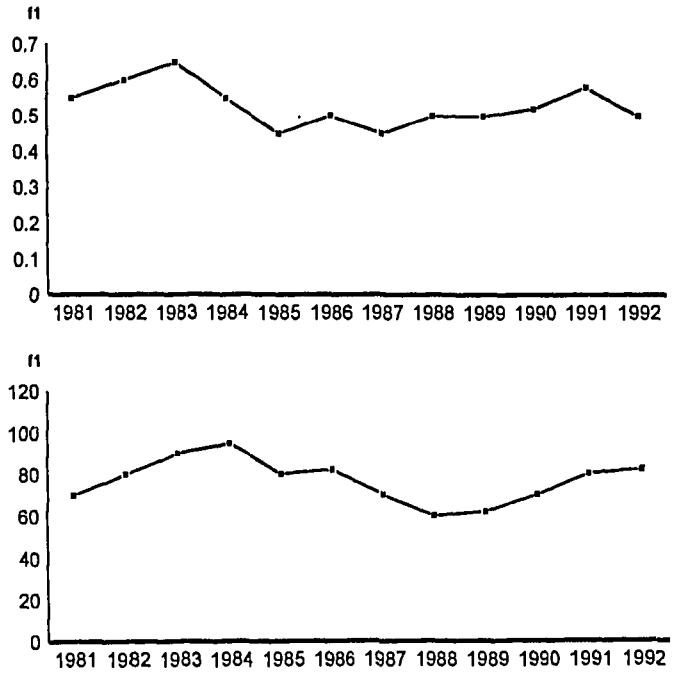


Fig. 3. Average values of coefficients f_1 and f_2 for lightweight and cellular concretes in years 1981–1992

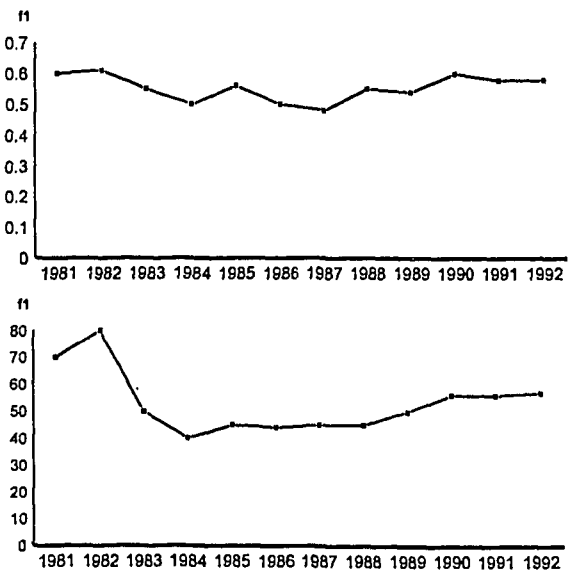


Fig. 4. Average values of coefficients f_1 and f_2 for building ceramic products (bricks, ceramic hollow bricks etc.) in years 1981–1992

3.6.2 RADON INDOORS

The investigations of radon concentrations indoors have been initiated at our laboratory as early as in 1968. Since the National Atomic Energy Agency in its regulation of 1988 set up the limit of the equivalent radon concentration indoors (equal 100 Bq/m^3) CLRP has undertaken the national scale survey project for radon in buildings. A method of solid state track detector (CR–39) in a diffusion chamber has been used.

The results are analyzed to look for dependence of radon concentration on: the kind of building material, number of floors, kind of foundation.

3.7 TECHNICAL AND ORGANIZATION ASSUMPTIONS FOR ESTABLISHING THE SECONDARY STANDARD DOSIMETRY LABORATORY (SSDL) AT CLRP

A DESIGN OF THE SSDL FOR RADIATION PROTECTION IN POLAND

H. Dzikiewicz-Sapiecha, K. J. Zawanowski

The Central Laboratory for Radiological Protection (CLRP) has initiated upgrading of the existing Calibration Laboratory in view of establishing of the Polish national SSDL to obtain an appointment of the SSDL as member in the IAEA/WHO network. The project will be completed in a few years, depending on the financial support which is solicited from the IAEA. The SSDLs equipped with secondary standards calibrated against the primary standards of laboratories participating in the international measurement system are established for indirect calibration.

The technical and organization assumptions for the SSDL at CLRP have been prepared according to the criteria for establishment of a SSDL (recommendations of an Expert Group).

The following basic requirements for SSDL should be emphasized:

– the work of the laboratory should be independent in character and free from any external influence which could adversely affect the quality or impartiality of the service it offers,

– an SSDL must be able to provide calibration services for specified radiations generated over specific energy ranges, at either therapy or protection levels, or both;

– duplicate secondary standard instrumentation should be provided to cover each of the energy and dose-rate ranges for which services are offered.

– laboratory staff should possess adequate qualifications and experience in measurement procedures and practice appropriate to their responsibilities.

The national regulations as well as the recommendations of ICRU, ICRP and IEC on the operational units and calibration techniques in radiation protection were taken into consideration for preparation of the SSDL technical assumptions.

EXISTING CALIBRATION LABORATORY AT CLRP

The Calibration Laboratory (CL) at the CLRP was established in 1960. The calibration activity has been focused on the personal dosemeters and field monitoring instrumentation. The CL has been authorized by the Polish Committee for Standarization, Measures and Quality Control since 1967 to test and calibrate radiation instruments.

The CLRP started to certify the prototypes and standard models of X and gamma radiation ratemeters, warning assemblies and monitors in 1973. Calibration Laboratory has been working under supervision of the Polish Primary Standard Dosimetry Laboratory. Approximatly 2000 instruments have been calibrated per year by the CL. The calibration facilities as well as dosimetric instrumentation of the CL should be modernized, since the CL equipment has been extensively used for more than twenty years without any upgrading and actually the technical parameters do not fulfill the present state of the art.

THE TASKS OF THE SSDL AT CLRP

The following activity is planned for the SSDL:

A. Routine calibration of radiation protection instruments and issuing calibration certificates:

1. type test carried out in compliance to the national and IEC standards including measurements of:

– response as a function of radiation energy, – response to radiation as a function of azimuthal and longitudinal angle,

– scale limit for each measuring range;

2. calibration of the radiation protection instruments, film and TL dosemeters with the aid of the X and gamma radiation of energy between 10 keV and 1.3 MeV and beta radiation. The calibration will take into account respective quantities of: air kerma, equilibrium absorbed dose in air, directional and ambient dose equivalents, superficial and personal dose equivalents;

3. documentation and archive files of all procedures and the calibrations result.

B. Research works for research and development program:

– basic principles of radiation metrology, implementation of ICRU operational units in practice,

– dosimetric assistance to other CLRP groups.

C. Training in radiation measurement and calibration techniques appriopriate to the users.

D. Co-operation with the IAEA/WHO network, reporting to the Secretariat on the status of Laboratory secondary standards, radiations sources, calibration performed and related activities.

TECHNICAL ASSUMPTIONS FOR THE SSDL AT CLRP

The exsiting CL premises can be adapted for the future SSDL with an addition of a few laboratory compartments. Some civil engineering adaptations of Laboratory premises will be required. The following new installations are essential:

– appropriate stability of the mains voltage supply and water supply for cooling system,

– air conditioning with temperature and humidity control,

– radiation safety installations and adequate shielding to reduce the exposure to external radiation from irradiations facilities to an acceptable minimum. The installation and implementation of the following new irradiation facilities is proposed:

– X-ray calibration installation (highly stabilized X-ray generator with range to 320 kV,transmission monitoring system, calibration bench with the additional devices);

– ^{137}Cs irradiation unit for high dose rate measurements, (gamma irradiator complete with the shielding container, preset timer, remote-control panel, alternators 1:10 and 1:100, radiation source 7400 GBq (200 Ci) of cesium-137, precision calibration cart and 8 m long calibration bench);

– ^{60}Co irradiation unit for high dose-rate measurements (gamma irradiator, complete with the shielding container, preset timer remote control panel, connection cable, alternators 1:10, radiation source 3700 GBq (100 Ci) of cobalt-60 ;

– ^{60}Co and ^{137}Cs irradiation units for low dose-rate measurements (gamma irradiator with accesories as listed above and several numbers of radiation sources with different activities),

– Facilities of irradiation with beta ray secondary standard sources (^{147}Pm, ^{204}Tl, $^{90}Sr/^{90}Y$); Instrumentation and accesories.

The SSDL should be equipped with a large number of measuring instruments and accessories to carry out many types of calibrations.

The following instrumentation is proposed:

– Reference dosemeters with different types of ionizing chambers used as the secondary standards.

– Secondary Standard Dosemeter System for radiation protection level and environmental dosimetry.

– Field dosemeters.

– Set of PCs linked in local network.

The following accessories are proposed:

– diode laser alignment devices for a precision positioning the detectors in the beam axis for X-ray, ^{137}Cs and ^{60}Co irradiation facilities,

– flashing-warning system,

– sets of closed circuit TV surveillance system,

– temperature compensated barometers,

– higrometer for determination of the relative air humidity,

– precision mercury thermometers.

The request of assistance has been prepared and submitted to the IAEA Technical Cooperation Programme. The assistance has been solicited for period of 1995-1997.

3.8 TRAINING, INFORMATION AND STANDARDIZATION

Among the statutory duties of the Central Laboratory for Radiological Protection there are also:

– tranining in radiation protection

– serving as a Center of Scientific, Technical and Economic Information

– serving as a Center of Standardization in the field of nuclear safety and radiation protection

The main aim of training is to create radiation protection inspectors, i.e.persons qualified to inspect practices applying radioactive substances. In 1992, 416 and in 1993, 381 persons were qualified as radiation protection inspectors. Until now as many as 11624 inspectors have got a certificate. If necessary, additional training courses for firemen, border guards, customs officers or for staff of laboratories belonging to the radioactive contamination measurements network are organized.

The Center of Information is involved in:

– publication of scientific reports, guides, training materials, popular papers on radiation protection

– exchange of materials between many information centres in Poland and foreign centres

The Center has its own library containing 5043 volumes and 2690 other items. The library is a subscriber of 39 Polish and 14 foreign journals.

The CLRP is the branch center for standardization in the radiation protection area. The Center of Standardization is thematically involved in the following problems:

– general problems (nomenclature, classification, units and symbols)

– requirements for radiological laboratories and for equipment and installations necessary for safe handling, storing and transportation of radioactive substances and for radioactive wastes disposal

– methods of dosimetric measurements

For the above mentioned subjects new Polish standards are being prepared and the existing ones reviewed and amended in the process of their adaptation to European Community standards.

In 1992-93 three Polish Standards were worked out and prepared for publication.

PN-92/J-08001 Radiation protection. Transport packagings for radioactive materials.

PN-93/J-..... Nuclear technique. Radioactive materials storages. Radiation protection requirements.

PN-ISO 7205 Radionuclide gauges. Gauges designed for permanent installation.

Program for introduction of Radiation Protection ISO /International Organization for Standardization/ standards into Polish standards has been prepared.

43 drafts of ISO and 8 drafts of IEC /International Elektrotechnical Commission/ standards were obtained for commenting in the country and national opinion on the drafts has been worked out for these international organisations. 5 drafts of Polish standards prepared by other domestic standardization centers were commented.

3.9 INTERNATIONAL CO-OPERATION

3.9.1 COMMON RESEARCH AND TECHNICAL UNDERTAKINGS

1. Participation in intercalibration measurements of the concentration of natural radionuclides in the region of uranium tailings. The measurements were organized by Bundesamt für Strahlenschutz, Germany

2. Exchange of information on continuous monitoring systems of radioactive contamination of environment and discussion on the possibility of information exchange in case of nuclear accident ;in Institut für Atmosphärische Radioaktivität, Freiburg, and Institut für Strahlenhygiene, Neuherberg/München.

3. Preparation of common report on two-years co-operation with the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany. Discussion on futher co-operation program.

4. Discussion in the IAEA, Vienna, on criteria of the membership of the standardization laboratory of the CLRP in the IAEA/WHO Secondary Standard Dosimetry Laboratories network; consultations on the technical outfit of the Laboratory, also at SSDL, Seibersdorf.

5. Participation in works of Program Committee of the Seminar „The Dynamic Behaviour of Radionuclides in Forests", Stockholm, May 18-22, 1992.

6. Co-operation with ENEA/DISP, Italy, on radiological monitoring of air in 1993, with continuation in 1994.

7. Prolongation of research contract No 6161/R1/RB "Radon in buildings and atmospheric air in Poland" - during a visit at the IAEA, Vienna.

8. Final Report - CEC Contract NB 17 0016-C/MB, Bundesamt für Strahlenschutz , Neuherberg, Germany, March 1992.

3.9.2 PRELIMINARY ARRANGEMENTS ON CO-OPERATION

1. Discussion on co-operation with the Joint Nuclear Research Institute in Dubna (Russian Federation) regarding the use of reactors IBR-2 for common works concerning the neutron activation analysis and investigations on radiation damage of semiconductor devices.

2. Determination of the subject of common work with Experimental Botany Institute in Minsk (Byelorussian Republic) on Transfer of $^{239,240}Pu$ to Papilionaceae family plants.

3. Establishing of the program of co-operation with Radiation Protection and Environmential Protection Institute in Madrid on the monitoring of environment, during a seminar in Warsaw.

4. Discussions on environmental monitoring problems during the meeting of the Technical Committee, Radiation Safety Section, Division of Nuclear Safety, IAEA, in Vienna.

5. Discussions with Byelorussian scientists on initiation of co-operation on environmental radioactive contamination and installation of a measurement station ASS-500 in Byelorussia.

3.9.3 STANDARDIZATION

The Central Laboratory for Radiological Protection took in 1992 and 1993 active part in preparation by the IAEA new Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources.

3.9.4. LECTURES BY INVITED SCIENTISTS

1. **Seminar**, Oct. 21, 1993.
Two lectures by scientists from V.G. Khlopin Radium Institute, Laboratory of Environmental Radioactive Contamination Monitoring, St. Peterburg, Russia:
1.1. Gavrilov V.M.: Radiation Levels in North-Western Russia in years 1985–1992.
1.2. Ivanova L.M.: Radiation Levels in Eastern Baltic Sea in years 1985–1992.
2. **Seminar,** Nov. 15, 1993. Two lectures by scientists from Institute for Radiological and Environmental Protection, Madrid, Spain:
2.1. Gutierez J.: Radiological Protection and Monitoring of Radioactive Environmental Contamination in Spain.
2.2. Travesi A.: Environmental Contamination by Plutonium after Airplane Crash at Palomares, Spain.
3. **Seminar**, Dec. 15, 1993.
Lecture by A. I. Zabolotnyj, scientist from Institute of Experimental Botany, Minsk, Byelorussia.
Topic: Retention by Plants of Radionuclides Released during the Chernobyl Reactor Accident: Interpretation from Plant Physiology Viewpoint.

4.RESEARCH ACTIVITES

4.1 RADIOACTIVITY OF GROUND-LEVEL AIR IN POLAND IN 1992 AND 1993: RESULTS OBTAINED FROM ASS-500 SAMPLING STATIONS

M. Bysiek, M. Biernacka, K. Isajenko, J. Jagielak, A. Sosińska, W. Bekiert
Dosimetry Department

In 1992 in Poland the monitoring network of the ASS-500 stations consisted of 5 stations. They were localized in Warsaw, Białystok, Katowice, Cracow and Świder. In the middle of May 1993 the sixth station in Lublin began to work. The system was working on a weekly cycle basis and the concentrations of radionuclides were calculated for the end of the sampling period. Immediately after getting the measurement results weekly reports were sent to the Central Laboratory for Radiological Protection, where monthly, quarterly and annual reports were prepared for the National Atomic Energy Agency and for the National Inspection of Environmental Protection.

The results for the monitored territory of Poland consisted of mean monthly concentrations of ^{137}Cs, ^{134}Cs, ^{7}Be, ^{40}K, ^{210}Pb, ^{226}Ra and ^{228}Ra, the standard errors of the means, the minimum and maximum values of concentrations and of the number of measurements. In the reports the results obtained by the stations for the particular weeks were also presented.

It was observed that as regards ^{137}Cs two periods of higher monthly mean values took place: in May and in June in 1992 and in May and November in 1993. The monthly mean concentration of ^{7}Be, the tracer of air masses descending from the stratosphere, was highest in June and July in 1992 and in May in 1993. ^{210}Pb was measured only in 1993 at 2 stations situated in Central Poland (Warsaw and Świder) and the monthly means revealed the highest values in early spring (March) and late autumn (November). Practically, in 1992 and 1993 no big changes of the monthly medians of the weekly mean ^{40}K concentrations were observed. In about 30 cases in 1992 weekly means of ^{40}K concentrations were between 50 and 90 $\mu Bq\ m^{-3}$ and in about 20 cases in 1993 they were between 50 and 180 $\mu Bq\ m^{-3}$. All these weekly means were mainly reported by the station in Katowice.

A summary of the annual mean concentrations of radionuclides in air [$\mu Bq\ m^{-3}$] for Poland in 1992 and 1993 is given in Table 1.

Table 1. Annual summary of air contaminations in Poland, 1992–1993.

	Mean $\pm \sigma/\sqrt{n}$ *)	Range	n	Maximum of concentration	
	μBqm^{-3}	μBm^{-3}		Location	Period
	1992	**)			
^{137}Cs	5.5 ± 0.4	0.6 – 53.3	217	Katowice	9–16.03
^{134}Cs	1.5 ± 0.2	0.3 – 3.5	19	Katowice	9–16.03
^{7}Be	2820. ± 110	80. – 10790	220	Warsaw	1–8.06.
^{40}K	46.1 ± 1.9	1. – 168.0	212	Białystok	26.09. – 06.10.
^{226}Ra	37.7 ± 3.2	0.3 – 190.0	140	Cracow	10–17.02.
^{228}Ra	5.7 ± 0.5	02. – 24.0	116	Cracow	30.12.91–06.01.92
	1993				
^{137}Cs	3.8 ± 0.2	<0,4 – 34,5	281	Białystok	17–24.05
^{134}Cs	0.5 ± 0.02	<0,24 – 4,5	281	Katowice	25.01–1.02
^{7}Be	2730. ± 80	660 – 7560	281	Warsaw	12–19.04
^{40}K	32.4 ± 1.4	<5 – 182,0	226	Katowice	11–18.01
^{210}Pb	462. ± 41	122 – 2412	95	Warsaw	1–8.03
^{226}Ra	29.0 ± 3.3	2,7 – 548,4	260	Katowice	9–16.08
^{228}Ra	4.0 ± 0.2	0,4 – 23,0	260	Katowice	8 –15.11

*) n – number of results obtained by all stations

**) This highest ^{137}Cs concentration was accompanied by a rather low value of ^{137}Cs concentration in total dust, 0.25 Bq g^{-1}.

The weekly mean concentrations of ^{137}Cs in 1992 and 1993 at the Warsaw and Białystok stations, which observed the highest values in Poland, are presented in Figs 1 and 2.

At the Warsaw station in 1992 only one period of high ^{137}Cs concentration [$\mu Bq\ m^{-3}$] was observed (May, weeks 20 - 25), in 1993 two periods were noticed (April/May, weeks 15-20; and November, weeks 44-47). At the Bialystok station in 1992 four periods of high ^{137}Cs concentration were observed (January, weeks 1-5; April to June, weeks 16-19 and 20-25; September, week 36), in 1993 two periods were noticed at the same time as for the Warsaw station.

^{137}Cs concentrations in total dust [Bq g^{-1}] confirmed the above mentioned periods.

The weekly mean concentrations of ^{210}Pb in 1993 at the Warsaw and Świder stations are presented in Fig. 3. It can be noticed that the peak values [$\mu Bq\ m^{-3}$] at both stations occurred in the same weeks (early spring and late autumn), but at different levels, with higher at the Warsaw station. ^{210}Pb concentrations in total dust [Bq g^{-1}] gave for the peak values similar results for both stations (18–21 Bq g^{-1}). For the lower concentrations which occurred in the warmer seasons, the Świder data were 1.5 times higher than the Warsaw data.

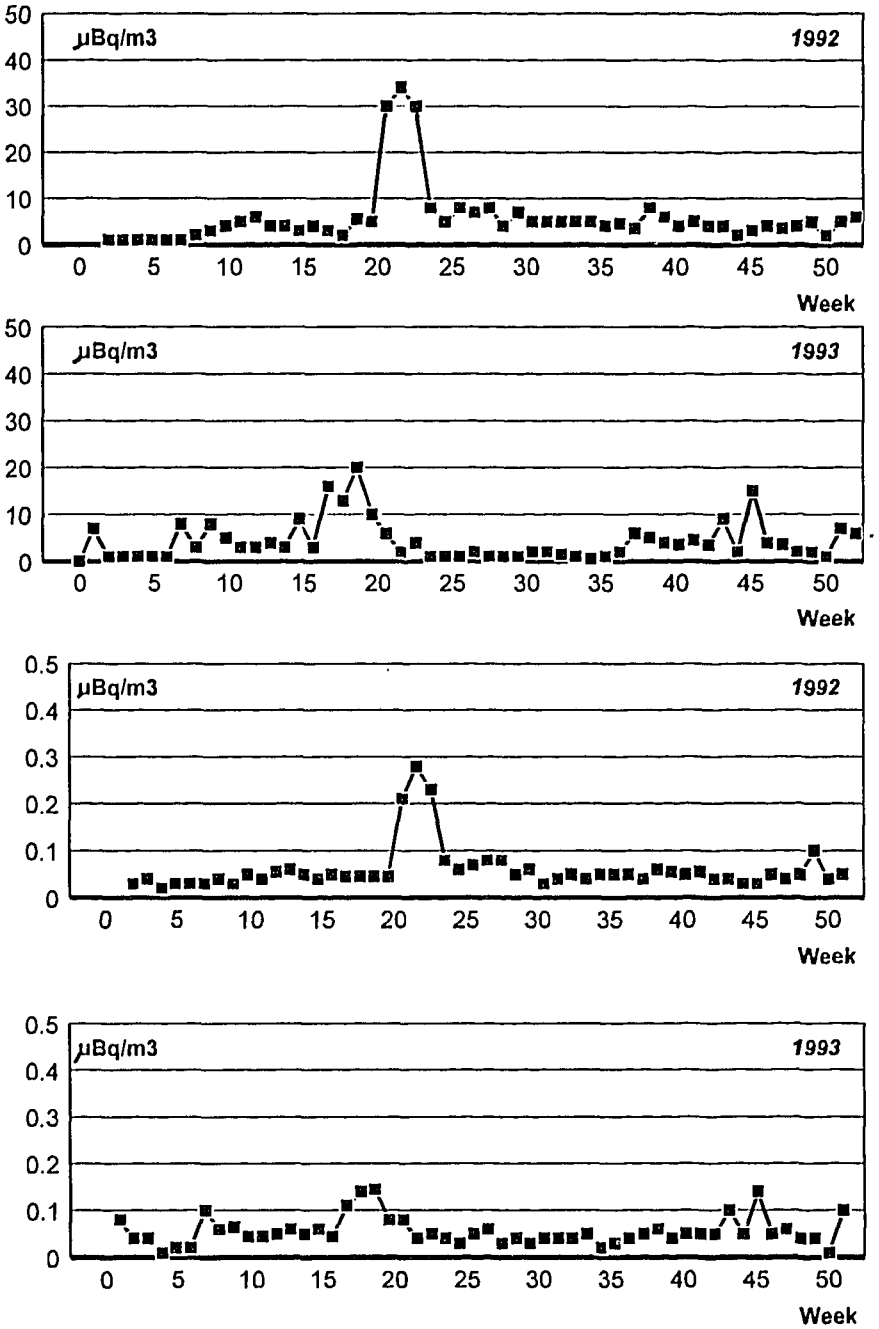


Fig. 1. ^{137}Cs concentrations in air [µBq m^{-3}] and in total dust [Bq g^{-1}] at the Warsaw station, 1992–1993

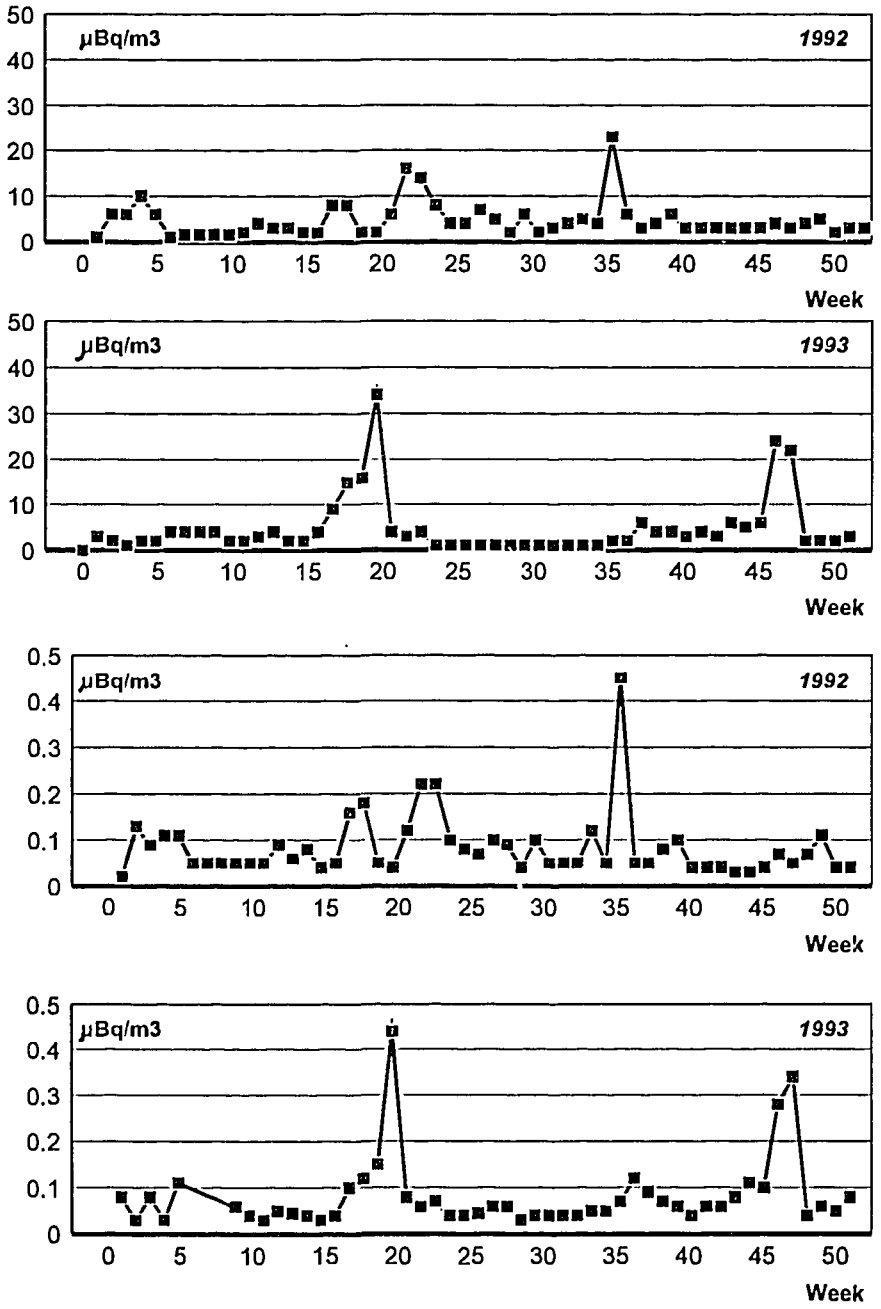


Fig. 2. ^{137}Cs concentrations in air [µBq m^{-3}] and in total dust [Bq g^{-1}] at the Białystok station, 1992–1993

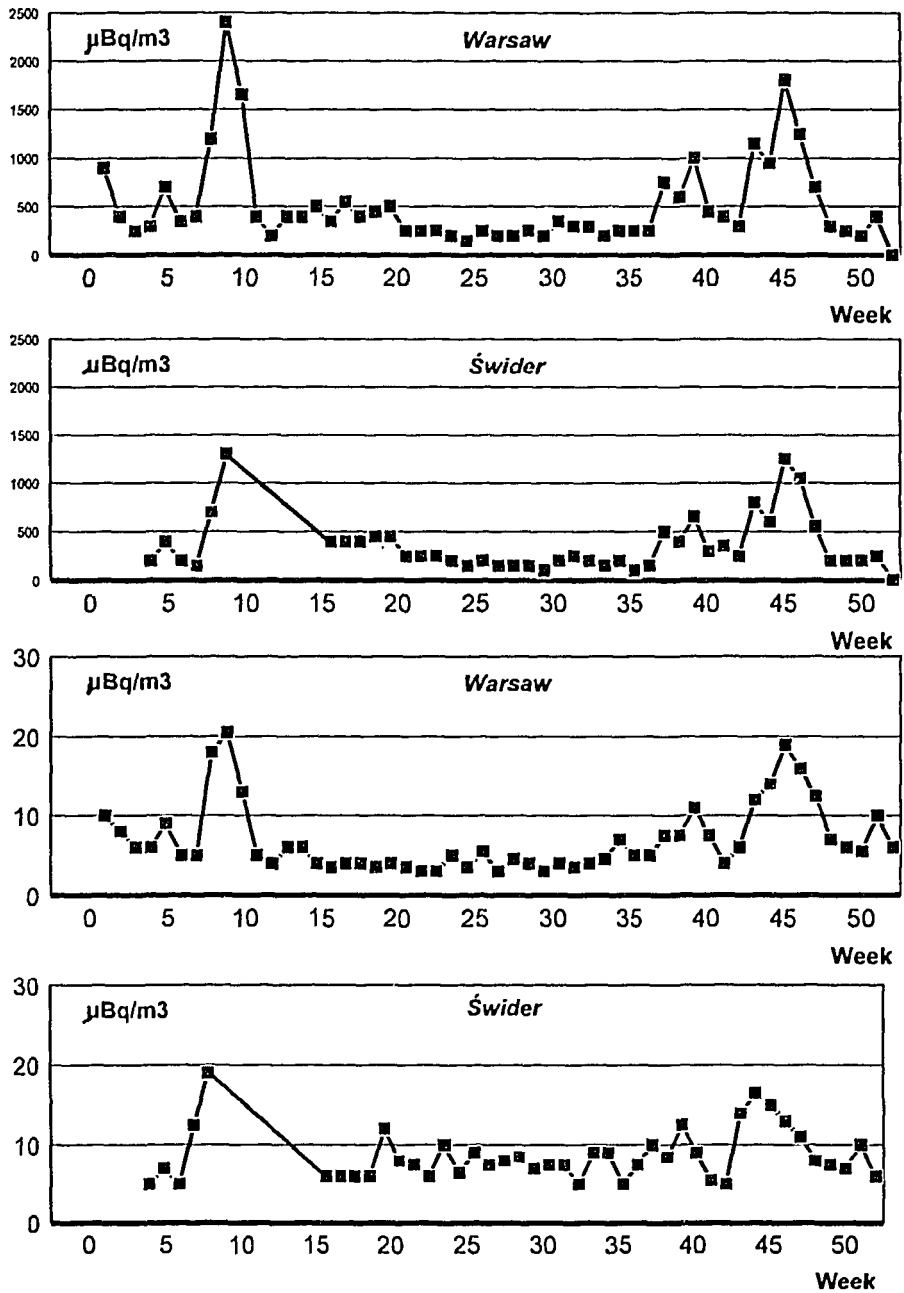


Fig. 3. ^{210}Pb concentrations in air [µBq m^{-3}] and in total dust [Bq g^{-1}] at two stations in Central Poland, 1993

4.2 RADIOACTIVITY OF THE ENVIRONMENT AND FOOD IN POLAND IN 1992–1993*

D. Grabowski, W. Kurowski, W. Muszyński, B. Rubel, G. Smagała, J. Świętochowska, J. Wilgos
Radioactive Contamination Department

The analysis of the level of radioactive contamination in environmental and food samples was carried out in Poland in 1992–1993. The results were compared to the data from the period 1985–1986. Since the Chernobyl accident gradual decrease of contamination level has been observed. The gamma dose rate and the contamination of air, fallout, tap and surface water were at the level of 1985. The only contamination enhanced in relation to pre-Chernobyl period was the content of cesium isotopes in soils; as a consequence, food contamination was higher, particularly the animal food. At present, the source of additional dose is ingestion of artificial isotopes with food as a result of food contamination. No significant regional differences in the distribution of the level of cesium over the territory of Poland has been registered. Milk can be assumed as the main contributor of cesium to the diet; its share is about 40% of annual intake of cesium. The average effective dose equivalent resulting from the contaminated food consumption, was estimated to be at the level of 15 μSv per caput of the Polish population in 1992 and less then 414 μSv in 1993.

Mean activity of ^{134}Cs, ^{137}Cs, ^{90}Sr in annual fallout in Poland
[Bq m^{-2} year]

	^{134}Cs	^{137}Cs	^{90}Sr
1985	–	6	2
1986	753	1511	22
1992	0,2	3,8	<1,2
1993	0,1	3,7	<1,2

* Raport CLOR nr 124/D, 1993 and Raport CLOR nr 127/D (in print)

Mean activity of ^{137}Cs in foodstuffs in Poland for periods 1985–1986 and 1992-1993 [Bq kg^{-1}]

	1985	1986	1992	1993
milk	0,3	5,2	1,1	1,0
meat	0,8	16,4	2,5	2,1
poultry	0,3	3,1	1,0	0,8
fish	0,3	6,3	1,6	1,5
eggs	–	2,4	0,7	0,6
potatoes	0,2	1,2	0,5	0,4
vegatables	0,7	5,0	0,5	0,5
fruits	0,4	8,2	0,5	0,5
cereala	0,6	7,4	0,2	0,2

Annual mean intake of ^{134}Cs, ^{137}Cs, ^{90}Sr via ingestion in Poland [Bq/year]

	^{134}Cs	^{137}Cs	^{90}Sr
1985	–	325	110
1986	2054	4324	131
1992	<74	605	<110
1993	<72	518	<110

Per caput annual effective dose equivalent due to radionuclides intake via ingestion in Poland [μSv]

	^{134}Cs	^{137}Cs	^{90}Sr
1985	–	4	6
1986	34	54	7
1992	1	8	<6
1993	<1	6	<6

4.3 STUDIES ON RADIOACTIVE CONTAMINATION OF THE BALTIC SEA

D. Grzybowska, M. Suplińska
Radiation Hygiene Department

Since 1985 the Central Laboratory for Radiological Protection with co-operation of the Institute of Meteorology and Water Management, Sea Division, performs regular monitoring of radioactivity in southern Baltic. The program involves annual sampling and radioactivity determinations in water, bottom sediments, plankton and benthic animals from several stations in the Baltic Sea. The fish samples were obtained commercially.

The water samples were analyzed by Institute of Meteorology and Water Management in Gdynia.

The cores of sediment samples taken by the gravity corer were cut into 1 cm thick slices to 5 cm depth and into 2 cm thick slices to 20 cm depth. The cores from 6 sampling stations in 1992 and 4 in 1993 were taken. The concentrations of ^{134}Cs, ^{137}Cs, ^{40}K, ^{226}Ra, ^{238}Pu and $^{239,240}Pu$ in samples have been measured.

For gamma activity measurements γ-spectrometric system based on a HPGe detector and multichannel analyzer Canberra-90 was used. ^{226}Ra, ^{238}Pu, $^{239,240}Pu$ were determined by radiochemical methods. ^{226}Ra was determined by emanation method (measurement of ^{222}Rn in scintillation chambers) preceded by separation of radium.

Plutonium was separated by ion exchange technique and electro-deposited on stainless steel disk; alpha activity was measured by a spectrometric system which consisted of an ORTEC silicon surface barrier detector connected to multichannel analyzer Canberra-90.

The present report covers monitoring program for two years; samples were taken in the years 1992 (2.06–7.07) and 1993 (8.07–16.07) in the region of southern Baltic during the sampling cruises of RV „Hydromet" and RV „Baltica".

Gamma emitting nuclides originating from Chernobyl fallout (^{134}Cs and ^{137}Cs) were found and measured in all taken bottom sediment cores. ^{134}Cs occurred in four to seven uppermost centimeters. The deepest occurrance of ^{137}Cs was in the slice from 18–20 cm. The maximum concentration for both radioisotopes were in the 0–1 cm and 1–2 cm layers.

The results for 1992–1993 exhibit a great range of ^{137}Cs concentration in bottom sediments, from 117 to 395 Bq kg^{-1}_{dw} into the 2 cm uppermost layers. In 1993 we observed the second peak concentration in the 7–9 cm layer in the sample profile from station P-1 in Gdańsk Deep (177-183 Bq kg^{-1}_{dw}).The highest values

were observed by us in bottom sediment samples from Gulf of Gdańsk, the lowest in the cores taken in open sea area.

In 1993, the highest activity concentration of ^{137}Cs was detected in the surface layer of station P-116 in the Gulf of Gdańsk – 385 Bq kg^{-1}.

^{40}K concentrations were in the range 560–1065 Bq kg^{-1}_{dw} and ^{226}Ra 29–49 Bq kg^{-1}_{dw}.

In general, radioactive cesium continued to accumulate in bottom sediments and slowly increased. In some cases the amount of ^{137}Cs seems to have decreased but this was most probably due the unsuccefull sampling.

The maximum plutonium concentration in 1992 was found in the station P-110 (Gulf ofGdańsk) in 4–5 cm layer and was 5.55 Bq kg^{-1} for $^{239,240}Pu$. The concentration range in this core sample was from 0.04 to 5.55 Bq kg^{-1}_{dw}.

The maximum plutonium concentration P-1 (Gdańsk Deep) was found in the upper layer and the concentrations in the first three layers were similar: 2.42; 2.08; 1.84. Plutonium concentration of these layers was 1.55 Bq kg^{-1}.Then the plutonium concentration decreased continuously to the value of 0.11 Bq kg^{-1}in the lowest analyzed layer.

The maximum plutonium concentration in 1993 was found in station P-110 (Gulf of Gdańsk) in 5–7 and 7–9 cm layer and was, respectively, 7.65 and 8.4 Bq kg^{-1} for $^{239,240}Pu$. The concentration range in this core sample was from 0.6 to 8.4 Bq kg^{-1}.

The $^{239,240}Pu$ concentration in the three first layers in station P-1 (Gdańsk Deep) sample was comparable (3.25; 3.49; 3.27). The maximum $^{239,240}Pu$ concentration in P-1 sample was found in 3-4 and 4-5 cm layers and was 4.13 and 4.3 Bq kg^{-1}.

The ^{238}Pu concentration in all analyzed samples in 1993 ranged from 0.04 to 0.19 B kg-1.

The ratio of the ^{238}Pu and $^{239,240}Pu$ in the layers for both core samples were spread from 0.1 to 0.6. The value of the ^{238}Pu and $^{239,240}Pu$ ratio shows that Chernobyl accident did not introduce plutonium to Gdańsk Basin.

Benthic animals were cought in coastal area during the sampling cruise. The concentration of ^{137}Cs in marine species (crustaceans and molluscs) were very low, from 7–14 Bq kg^{-1} wet weight in crustaceans and 1–2 Bq kg^{-1} in molluscs body. During last year we observed slow decrease of ^{137}Cs concentrations, but we observed also a difference in the activities measured in samples independently of sampling location.

The only gamma nuclides detected in fish flesh in 1993 were ^{40}K and ^{137}Cs. The ^{137}Cs concentration in Baltic herring ranged from 8.4 to 9.4 Bq kg^{-1} wet weight, in Baltic flounder and cod from 11.2 to 14.5 and 12.9-13.4 Bq kg^{-1}, respectively.

The mean concentration for all investigated specimens was 11.4 Bq kg^{-1}.The mean values in the year 1991 and 1992 were, respectively, 12.5 and 12.4 Bq kg^{-1}. In fish samples the cesium concentration was generally lower than in preceeding years.

Assuming the statistical consumption in Poland in 1992 – 6.4 kg fish flesh per year per person, the effective dose equivalent for member of population in Poland was less than 1 μSv from this source of radiocesium.

All obtained results for the years 1992–1993 demonstrate a slow decrease of cesium concentrations in some investigated components of Baltic Sea environment and increase of ^{137}Cs concentration accumulated in bottom sediments.

The radiation situation in the Baltic Sea in 1992–1993 was still determined by the contamination originating from the Chernobyl accident and by the transport by water currents of radioactive substances from the Gulf of Finland and Gulf of Bothnia into the basin of Baltic Sea proper.

4.4 SYSTEMATIC MEASUREMENTS OF GAMMA RADIATION BACKGROUND AND EARTH SURFACE RADIOACTIVE CONTAMINATION

J. Henschke, M. Biernacka, J. Jagielak, A. Koczyński, K. Mamont-Cieśla, Sz. Rosiński, A. Sosińska
Dosimetry Department

Our investigations are being performed in the frame of Polish environmental monitoring system. The measurements for realization of this project were carried out in 1992– 1993 in the network, located all over Poland, of meteorological stations (311 points) of the Institute of Meteorology and Water Management.

Our investigation give the following possibilities:

- to create the base of computer-stored radiological data for the whole country,
- to obtain a set of radiological maps of Poland.

The results can be presented in form of maps produced in „Sinus" or circle cartodiagram systems. The program „Sinus" extrapolates 311 results of the point measurements to the closest vicinity covering the whole area of Poland. The circle cartodiagram program merely visualizes results of the investigations in the very measurements and sampling points.

At each point the following measurements were performed:

- gamma radiation dose rate,
- ^{222}Rn concentration in the air.

In the same sites soil samples were collected to determine concentration of the natural radionuclides and cesium isotopes by means of the spectrometric analysis.

Gamma dose rate was measured using three thermoluminescent detector sets mounted 1 m above the earth surface. The annual gamma dose was calculated on the basis of measurements carried out in two six-month periods.

^{222}Rn concentration was estimated by the method of track detectors settled in diffusion chambers. The detectors were also exposed during two six-month periods.

Each sample of soil from the 10 cm surface layer was taken by a knife-edge pipe in six points laying at the circumference of a circle of 2 m radius and in the centre of the circle. The measurements of the radionuclide concentrations in soil samples were made using spectrometers with HPGe detectors located in low-background lead shielding houses. The time of each measurement was 60 000 s.

The program of environmental investigations also included measurements performed in selected places using our mobile radiometric laboratory. These measurements were carried out by means of high pressure ionization chamber and an „in situ" method using portable spectrometer with a HPGe detector.

The mean values of concentrations of natural radionuclides in Poland are [Bq kg^{-1}]: ^{226}Ra - 24.6 ; ^{228}Ac - 20.2 and ^{40}K - 402. For comparison, the mean world concentrations of these radionuclides are respectively: 16, 26 and 370 Bq kg^{-1}.

The highest mean district concentrations of ^{226}Ra and ^{228}Ac occur in the south of Poland. It results from the geological structure of our country. For instance in Jelenia Góra district the mean values of ^{226}Ra and ^{228}Ac concentrations are respectively: 58.2 and 40.2 Bq kg^{-1}.

The mean values of ^{134}Cs and ^{137}Cs concentration in Poland are 0.25 and 4.24 kBq m^{-2}, respectively. The values of caesium soil concentration range from 0.01 to 3.38 kBq m^{-2} for ^{134}Cs and from 0.51 to 49.9 kBq m^{-2} for ^{137}Cs. The radiological map of the ^{137}Cs concentration distribution are presented in Fig.1. Such distribution of ^{137}Cs concentrations was mainly due to the weather conditions - in particular rainfall - in Poland in May 1986, i.e. in the period directly after the Chernobyl accident.

All results refer to soil samples in October and November 1992.

The mean gamma dose rate of the outdoor radiation for the exposition from October 1992 to June 1993 in Poland is 38.3 nGy h^{-1} (without cosmic radiation). The mean values for individual measurement points range from 13.9 to 72.8 nGy h^{-1}.

The contribution of each radionuclides to external radiation dose rate can be calculated on the basis of spectrometric measurements of the soil samples taken in these places. For instance, at the points in which ^{137}Cs concentration are the

highest in Poland, the gamma dose rate due to caesium isotopes is twice as much as the gamma dose rate due to natural isotopes.

The mean value of outdoor ^{222}Ra concentration in air in Poland is 5.1 Bq m^{-3}. The mean values for individual points are in the range from 0.7 to 12.6 Bq m^{-3}. These results relate also to the exposition period from October 1992 to June 1993.

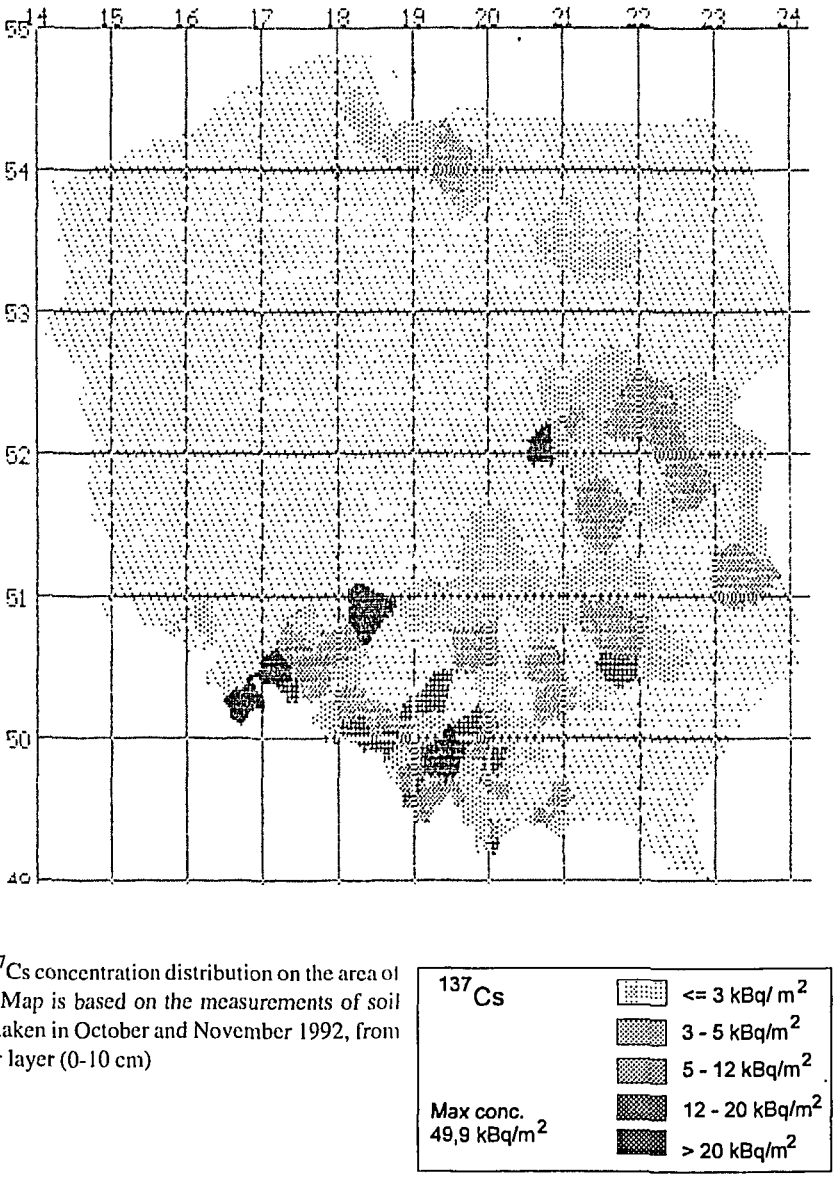


Fig. 1. ^{137}Cs concentration distribution on the area of Poland. Map is based on the measurements of soil samples taken in October and November 1992, from the upper layer (0-10 cm)

4.5 TENTH INTERNATIONAL INTERCOMPARISON OF ENVIROINMENTAL DOSIMETERS

A. Koczyński, A. Chęć
Personal Dosimetry Department

INTRODUCTION

The tenth in a series of intercomparisons of environmental dosimeters was organized jointly by Idaho State University and two U.S. Department of Energy environmental laboratories.

About 150 sets of environmental dosimeters, mainly TL were sent to the organizers of this intercomparison. The study was conducted between December 21, 1992 and April 5, 1993. The objective of the study is to assess the state of the art of environmental dosimetry as indicated by statistical analyses of the results and to allow participants to directly compare their performance with the performance of their counterparts in other laboratories and with the delivered exposure.

DESCRIPTION OF THE STUDY

The study involved both field and laboratory irradiations. Each participant sent eight dosimeters to the study site. Two dosimeters were designated for each of four categories: „CONTROL", „LOW GAMMA", „HIGH GAMMA" and „FIELD". Upon receipt, all dosimeters were placed in a low background storage room. On December 21 the dosimeters labelled „FIELD" were transported to a secure location at the Idaho National Engineering Laboratory Site and deployed in close proximity to each other approximately one meter from the ground. The altitude of the field site was 1487 m. Temperatures ranged from -32.8^{0}C to +12.8^{0}C.

During the February 25-26 period, the dosimeters labelled „LOW GAMMA" and „HIGH GAMMA" were removed from the storage room and exposed to radiation from ^{137}Cs in an approximate „point source in free air" geometry at a distance of one meter. Low density, low atomic number materials were used to position the dosimeters for irradiation.

On April 5, 1993, the „FIELD" dosimeters were recovered for a total field exposure time of 105 days. The field dosimeters were then reunited with the other dosimeters and the complete sets of eight dosimeters mailed back to the participants. A questionnaire was sent to each participant requesting their dosimeters results and information about the methods used.

The dose received in the low background storage room by the control dosimeters while the field dosimeters were deployed was provided to the participants so

that net field doses could be calculated. The storage room dose of 68+-4 mGy was estimated based upon ion chamber measurements.

REFERENCE DOSE DETERMINATION

The field dose delivered to the dosimeters was derived from simultaneous ion chamber measurements. Three calibrated recording high pressure argon ion chambers supplied by the U.S. Department of Energy Environmental Measurements Laboratory were operated continuously at the field site during the course of the field exposure. The total field dose of 237 ± 14 μGy was estimated.

The Cs-137 source used for laboratory gamma exposures was calibrated with transfer chambers calibrated with another Cs-137 source which was traceable to the U.S. National Institute for Standards and Technology. The transfer chambers and quality assurance (QA) dosimeters provided by the DOE Environmental Measurements Laboratory were exposed concurrently with each laboratory exposure of participants dosimeters. The delivered doses of Cs-137 radiation were 227 ± 11 μGy for the „LOW GAMMA" dosimeters and 637 ± 17 mGy for the „HIGH GAMMA" dosimeters. The delivered doses and the results of the QA dosimeters are included in Table 1.

RESULTS OF THE INTERCOMPARISON

Doses measured by the field and laboratory dosimeters were determined as follows:

NET FIELD DOSE = (FIELD dose) – (CONTROL dose – 68 mGy)

NET LAB DOSE = (LAB dose) – (CONTROL dose)

In the first equation, the value, 68 mGy, is the dose that the CONTROL dosimeters received in storage while separated from the FIELD dosimeters during field deployment. Because the LAB dosimeters were separated from CONTROL dosimeters only briefly on the day irradiations were performed, this correction is not needed in the second equation.

The total uncertainty reported includes both statistical uncertainty at the 95% confidence level and systematic uncertainties. The corrections were made for TL-fading. Results received from participants were entered into a commercial spreadsheet program and the participants' calculations checked for accuracy. Basing on an examination of the data and the recalculations, the organizers either accepted the participants' net results or proposed different values. These „best" net results and values calculated by participant are reported on „Summary Report of Participant's Reported Data and Organizer's Re-calculations" sheet.

The results of the intercomparison are summarized in Table and in Figures 2–3.

Reference
De Planque, G. and Gesell, T.F. (1986). Environmental measurements with thermoluminescence dosimeters – trends and issues. Radiation Protection Dosimetry 17, 193-200.

REMARK

Unfortunately the organizers did not send back our dosimeters by air mail but by ship so they were travelling to us long time (more than a month) probably in elevated temperature and TLD-fading was higher then we evaluated.

Table 1. Summary of intercomparison results.

Category	Participants Results (μGy)					Estimated Delivered Doses (μGy)		Results from QA Dosimeters (μGy)	
	Number	Mini-mum	Maxi-mum	Mean Dose	Standard Deviation (1σ)	Dose	Uncer-tainty*	Dose	Uncer-tainty*
FIELD	149	50	414	231	45	237	14	None	None
LOW GAMMA	149	37	374	219	41	227	11	232	10
HIGH GAMMA	150	206	869	611	89	637	17	644	24

* The listed uncertainties include both systematic and random (2s) uncertainties. In order to avoid possible underestimating the total uncertainty, the systematic and 2s random uncertainties were simply added rather than combined in quadrature.

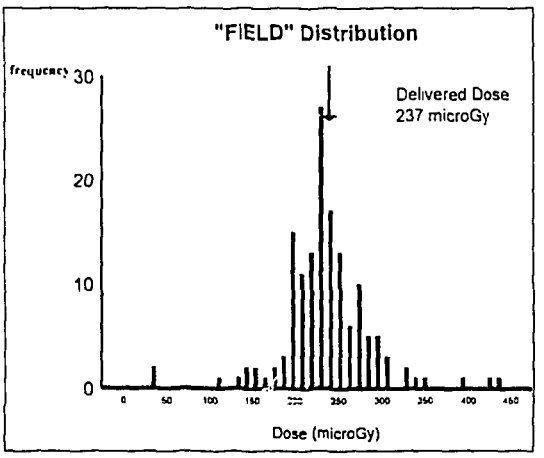


Fig. 1. Distribution of „Best" net field doses.

Fig. 2. Distribution of „Best" net low gamma doses

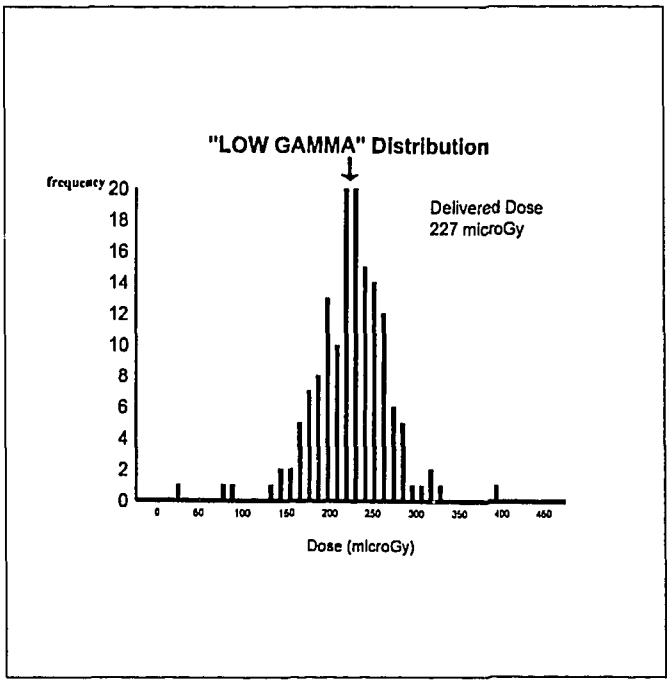
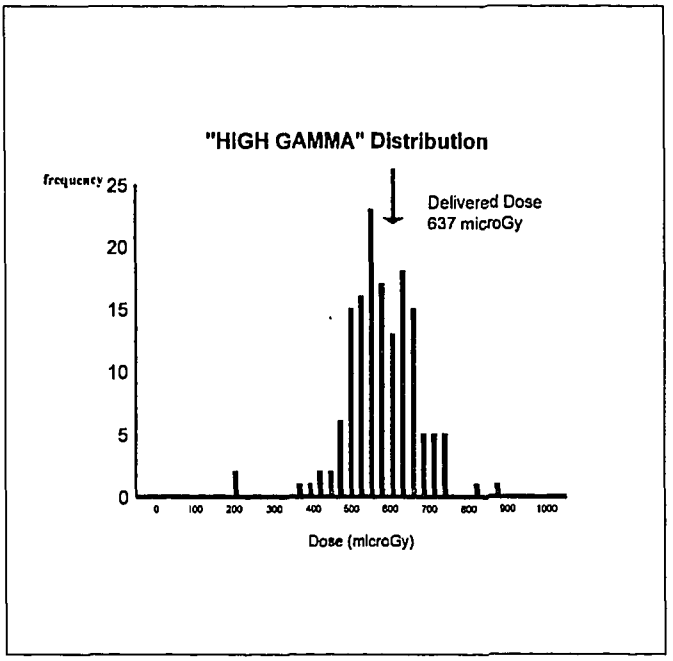


Fig. 3. Distribution of „Best" net high gamma doses.



Summary Report of Participant's Reported Data and Organizer's Re-calculations

Name: *Dr. Alojzy Koczyński*
Dosimeter Type: LiF
Serial Number: 140

1. Gross Values Reported by Participant

Control 1:	282	Field 1:	422
Control 2:	262	Field 2:	412
Low Gamma 1:	436	High Gamma 1:	797
Low Gamma 2:	466	High Gamma 2:	803

2. Net Values Reported by Participiant

Field: 213
Low Gamma: 179
High Gamma: 528

3. Re-calculation of Reported Net Values by Organizers

Field: 213
Low Gamma: 179
High Gamma: 528

4. Comments

None

5. "Best" Values to be used in subsequent analyses. The following are the "best" values in the judgement of the organizers and will be used by the organizers in all subseqent analyses unless the participiant objects by September 30, 1993.

Field: 213
Low Gamma: 179
High Gamma: 528

4.6 TRITIUM-INDUCED NEOPLASTIC TRANSFORMATION OF C3H10T1/2 CELLS*

M. Kowalska
Radiation Hygiene Department

In the year 1993 a study of biological effects of tritium was again developed at the CLRP.

A studied endpoint is a conversion of a normal cell in culture into a cell possessing a tumorigenic phenotype, called neoplastic transformation. As a cell neoplastic transformation assay system the C3H10T1/2 mouse-embryo derived line was chosen. This line has been widely used for studying radiation-induced neoplastic transformation since it allows a closely quantitative determination of the dose-effect relationship for this endpoint. Three tritiated compounds of different intracellular localization were selected as a source of tritium. They are: tritiated water which is expected to produce a random distribution of tritium inside the cell, tritiated lysine incorporated mostly in the lysine-rich histones in the vicinity of DNA and tritiated thymidine specifically incorporated into DNA.

A research laboratory for handling the cells was organized at the CLRP and provided with professional equipment. Culture conditions and transformation assay for the C3H10T1/2 cell line was adopted as well as two batches of serum were tested for the lowest possible background of spontaneous transformation and for suitability for radiation-induced neoplastic transformation.

A preliminary experiment with tritiated water is in progress.

* Grant No. 6P20710804 of the State Committee of Scientific Research

4.7 VERTICAL DISTRIBUTIONS OF CONCENTRATIONS OF RADIONUCLIDES AND STABLE Pb IN TROPOSPHERIC AND LOWER STRATOSPHERIC AIR

L. Kownacka, M. Suplińska
Radiation Hygiene Department

The vertical distributions of the concentrations of ^{210}Pb, ^{226}Ra, stable Pb and fission products have been studied since 1973 above north-eastern part of Poland [1].

We have studied the vertical distribution of concentrations of fission products introduced formely into the stratosphere by nuclear explosions and introduced to the troposphere by Chernobyl accident on April 26, 1986, as well as of ^{210}Pb, ^{226}Ra and stable Pb the sources of which are permanently located near or at the ground level. Violent volcanic eruptions also contribute to the atmospheric inventory of natural radionuclides and are acting as stratospheric sources. We determined also the concentration of ^{7}Be, a cosmogenic radionuclide, in all samples.

The measurements of concentrations of ^{7}Be, ^{90}Sr, $^{134, 137}Cs$, ^{210}Pb, ^{226}Ra and stable Pb were carried out in 1992 and 1993 in particulate samples collected at the altitudes 0, 1, 3, 6, 9, 12, 15 km and near the ground level. In 1992, in two vertical distributions we also took additional samples at altitudes 0.5 and 2 km, in order to study concentrations of radiocesium at the level of 1 km which after the Chernobyl accident were, according to our observations, higher.

During the period of this study samples which formed 9 vertical profiles of concentrations of nuclides have been collected by us. The samples of each series were obtained in relatively short period of time, namely during about 5 hours, under stable weather conditions, in cloudless region of the sky. Thus, the effects of advection of new air masses to the sampling region were greatly reduced.

The high altitude samplers were constructed inside the fuel tanks of the LIM-type aircraft. Those for sampling up to 12 km were suspended underneath the wing and the one for 15 km was situated underneath the fuselage. The active surface of the filter in the „wing" device is 1640 cm^2 [2]. The active surface of the filter in „fuselage" sampler is 1380 cm^2. The samplers are powered and operated from the pilot cockpit.

During the horizontal flights of the aircraft particulate samples were collected by means of the ram pressure on the filter fastened to the grid inside the tanks. We used the chlorinated PVC Petrianov filter FPP-15-1.5 which is characterized by great mechanical strength, high efficiency and small aerodynamic drag for high flow velocities. The samplers were calibrated in the wind tunnel of the Institute of Aviation in Warsaw. Assuming the standard atmospheric conditions the amount of air passing through the filter in unit time was measured for each simulated altitude. The volume of air samples ranged from about 100 m^3 STP at 15 km to about 2700 m^3 STP at 3 km (STP - standard temperature and pressure at the earth surface, i.e. 760 mm Hg and 15°C). The error of air volume determinations was 5-12%, depending on the altitude.

The ground level sampler, described by Bilkiewicz et al. [3], was equipped with filter holder, air blower and a gas meter. The active surface of the filter is 1250 cm^2.

The samples were analysed by γ-spectometry method using HPGe detector and multi-channel analyser Canberra 90. Because the measured activites in our air

filters were low we used radiochemical methods for their determinations. The detailed procedures for determining the concentration of radionuclides are described elsewhere [3]. Stable lead was determined by polarography [4].

The vertical distributions of concentrations of ^{7}Be in all situations were typical for cosmogenic radionuclides. The concentrations of ^{90}Sr in most measurements were below the lower limit of detection. The vertical profiles of radiocesium present the typical pattern observed since 1987; concentrations at 1 km altitude are higher than those at the ground level; they decrease with altitude. The concentrations and vertical distributions of ^{210}Pb and ^{226}Ra are similar to what was observed previously [5], the concentrations of stable Pb in 1992 are higher. The source was the Mt. Pinatubo volcano eruption (June 1991) after which the top of cloud reached the altitude of 30 km [6]. The examples of vertical distributions of radionuclides and stable Pb are presented in Figure 1.

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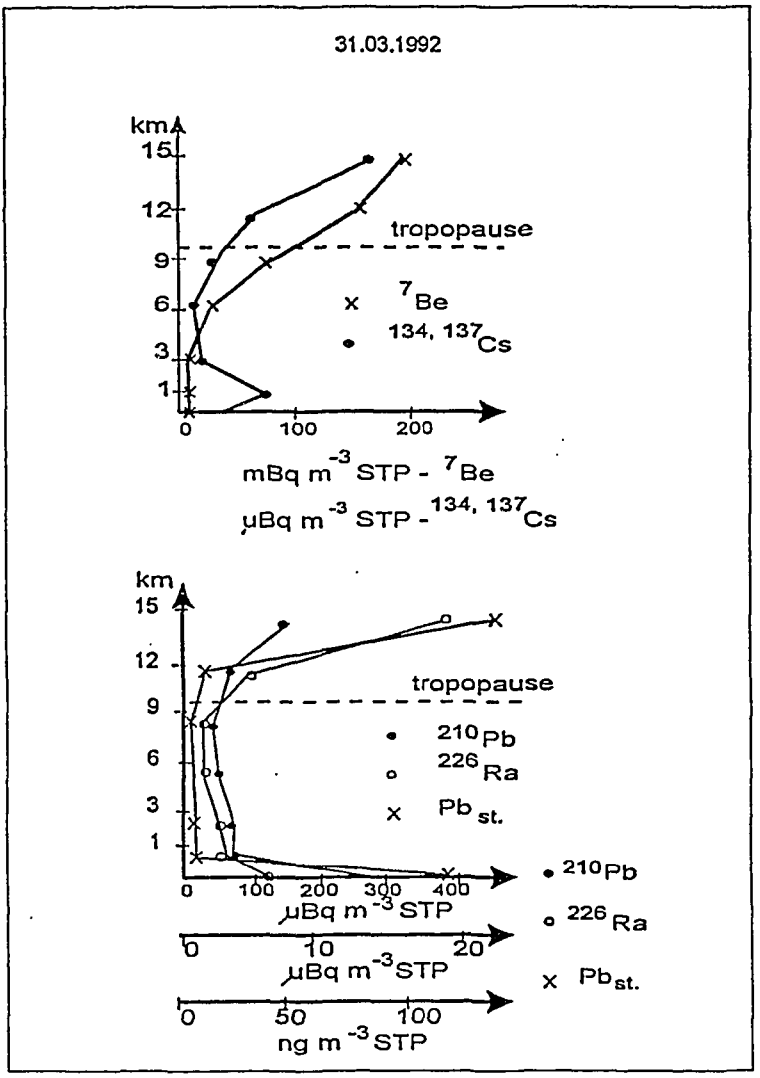

Fig. 1. The example of vertical distributions of radionuclides and stable Pb in the atmosphere

4.8 COMPUTER MODEL FOR THE TRANSFER OF RADIONUCLIDES IN TERRESTRIAL ECOSYSTEM

P. Krajewski
Radiation Hygiene Department

GENERAL MODEL DESCRIPTION

INTENDED PURPOSE OF THE MODEL IN RADIATION RISK ASSESSMENT

The model **CLRP-C**oncentration **L**evels **R**apid **P**redictions- was created in 1989 as a part of research project „LONG-LIVED POST-CHERNOBYL RADIOACTIVITY AND RADIATION PROTECTION CRITERIA FOR RISK REDUCTION" performed in co-operation with U.S. Environmental Protection Agency. The aim of this project was to examine the fate of long-lived radionuclides in the terrestrial ecosystem e.g. ^{134}Cs and ^{137}Cs. In the following years the CLRP model was developed for ^{131}I on the basis of Polish post-Chernobyl data. Structural features of the CLRP model are presented in Figure 1. Concentrations of radionuclides in the particular components of terrestrial ecosystem e.g. in soil, vegetation, animal tissues and animal products are calculated as a function of time following deposition from the atmosphere. On the basis of these data the whole body content of radionuclide as a function of time is calculated; the dose to a specific organ for a radionuclide may be estimated as an integral of the resultant dose rate over a sufficient period of time. In addition, the model allows estimation of inhalation dose from time – integrated air concentration and external dose from total deposition using simple conversion factors. The program is designed to allow the simulation of many different radiological situations (chronic or acute releases) and dose affecting countermeasures.

UNIQUE FEATURES OF MODEL STRUCTURE

Dynamic processes in the model include foliar interception, weathering; plant growth and root uptake, leaching and radioactive decay. The model considers seasonal changes in the biomass of vegetation and animal diets, as well as specific plowing and crop-harvest dates. Human dietary data are included to permit calculation of time -dependent radionuclide ingestion rates for adult, youngster 10 years old, youngster 5 years old , child 1 year old and child 3 months old.

The CLRP model has been implemented as a set of EXEL 4.0 worksheets that simulate the transport of radionuclides through agricultural ecosystems to humans.

All dynamic processes are described by exponential formulas and are solved numerically.

INTENDED ACCURACY OF THE MODEL PREDICTION

CLRP model is deterministic and yields single estimates of specified variables.

Intended performance of the model is the standard that specifies that model should not under-predict the true value by more than factor of three. Justification of standard model performance has been carried out on the basis of post-Chernobyl data for Poland. Further modification of the CLRP model will be made to run the model stochastically to provide distributional output and perform uncertainty analysis.

The model performance has been tested in the frame of the IAEA/CEC Co-ordinated Programme on Validation of Models for Transfer of Radionuclides in Terrestrial, Urban and Aquatic Environments and Acquisition of Data for that Purpose (VAMP).

The main activity of the Multiple Pathways Assessment Working Group in 1992-1993 was the second model testing exercise using the Chernobyl fallout data of Southern Finland. The future scenario will be the Hanford I-131 release, which is being investigated in Hanford Environmental Dose Reconstruction Project.

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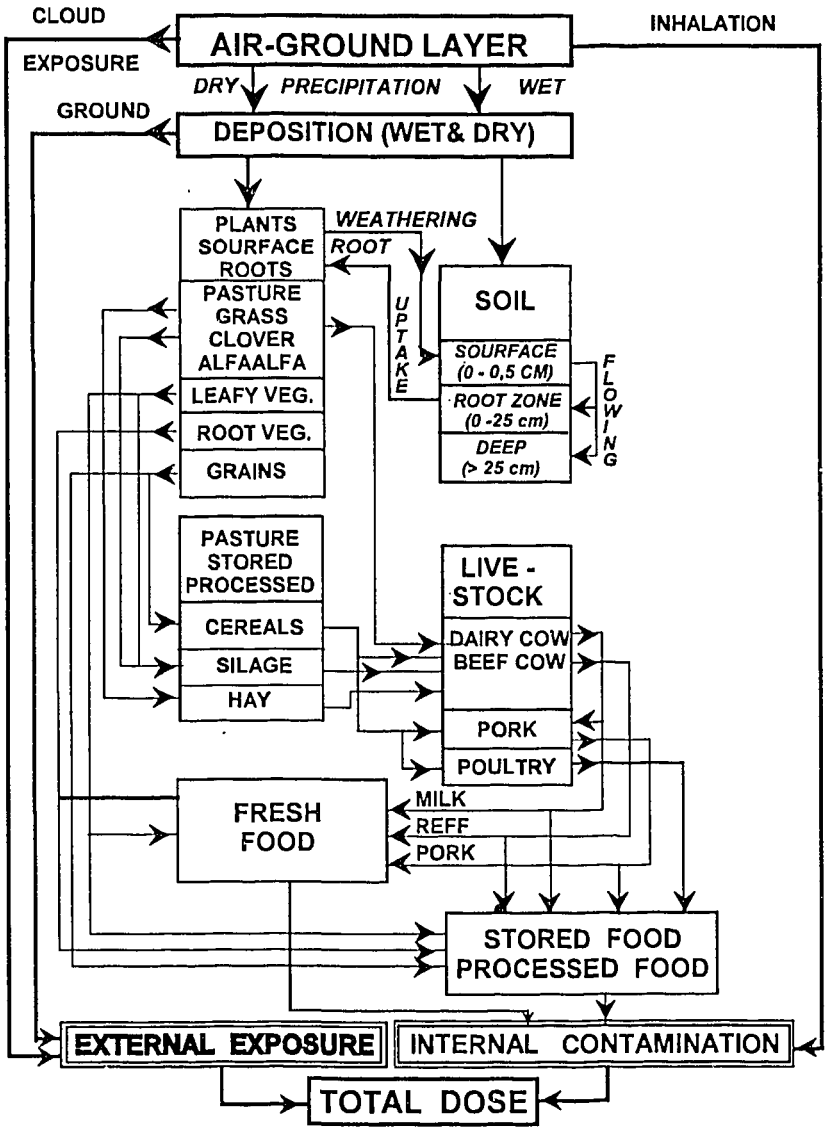


Fig. 1. Structural features of the CLRP model

4.9 STUDY OF RADON CONCENTRATIONS INDOORS AND ESTIMATION OF HAZARD TO INHABITANTS IN POLAND

K. Mamont-Cieśla, S. W. Rosiński, A. Sosińska, M. Bysiek, J.Henschke, J. Jagielak
Dosimetry Department

The reported work is a subsequent stage of the national scale indoor radon project in Poland. The measurements of radon concentrations are being performed by means of diffusion chambers with track detector CR-39.

In Fig. 1 we are presenting results of 10 calibration exposures in our radon calibration chamber (of the volume of 320 l) connected with a Pylon source of activity 3.71 10^6 pCi with the error of 4 % at 99 % confidence level.

Alpha tracks on an area of 4.16 mm^2 (corresponding to 16 fields of view) are counted automatically by the computerized track detector reader (S.W.Rosiński „Computerized track detector reader", former issue of this Annal, 1992).

On the basis of the exposure series the following calibration equation was obtained:

$$E = -48.0 + 29.6\,N$$

where E is exposure in Bq m^{-3} h and N is a number of defects per sq mm. Low level detection limit of this method assumed as 3 standard deviations for „background" is equal 34 kBq h m^{-3} what corresponds, at the exposure time of 6 months to the radon concentration of 8 Bq m^{-3}.

After one year indoor exposure about 1000 radon detectors distributed in dwellings in 3 districts: Wrocław, Katowice and Białystok (marked in Fig. 2) were picked up, etched and counted. The computer data base in Excel system has been created. In Fig. 3 are shown statistical parameters such as: arithmetic and geometric means, mediane and modal values for 4 groups of results: for each of 3 districts and for 3 districts all together.

In Fig. 4 there are histograms representing statistical distributions of radon concentration for 3 groups of buildings: with cellars, without cellars and all. In Figures 5-8 are presented results of radon concentrations vs. number of floor, type of building material, type of building structure (with or without cellar).

CONCLUSIONS

From the Figures 5-8 we can draw the following conclusions: mean value of radon concentration

1. is higher in houses without cellar than in houses with cellar.

2. decreases when number of floors increases. It is true for each of 5 „type of material" groups of building.

3. is the highest in the group of buildings constructed of wood and red brick and is the lowest in the group of concrete building (called „prefabricate").

The highest values – equal to or above 200 Bq m^{-3} – constitute about 2 per cent of all results. Most of the enhanced radon concentration values (with maximum of 500 Bq m^{-3}) occur in Kotlina Kłodzka in the southern part of Wrocław region.

Regression Analysis – Linear model: Y = a+bX

Dependent variable: -14 DROP ke		Independent variable: -14 DROP kd/4.16		
Parameter	Estimate	Standard Error	T Value	Prob. Level
Intercept: a	-48.0461	8.61817	-5.57498	.00000
Slope: b	29.5864	0.688844	42.9508	.00000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	Prob. Level
Model	7405461.8	1	7405461.8	1845	.00000
Error	389386.85	97	4014.30		
Total (Corr.)	7794848.6	98			

Correlation Coefficient = 0.974703 R-squared = 95.00 percent

Stnd Error of Est. = 63.3585

$$E = -48.05 + 29.59\ N$$

where E – exposure in kBq m^{-3} h

N – number of defects per mm^2

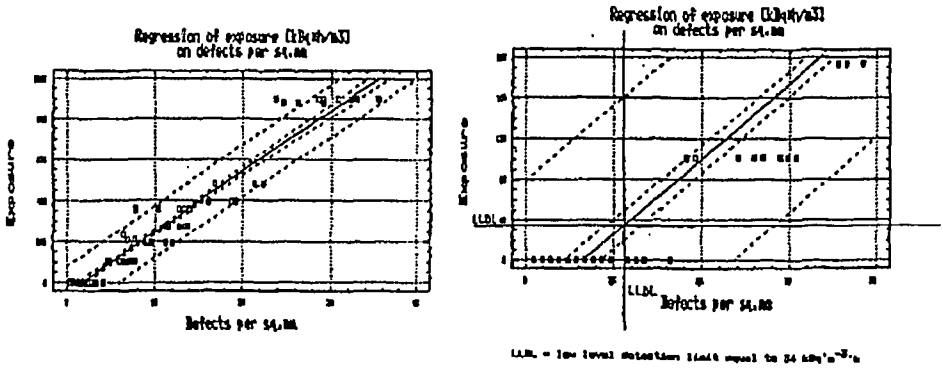


Fig. 1. Regression of exposure v.s. defects density

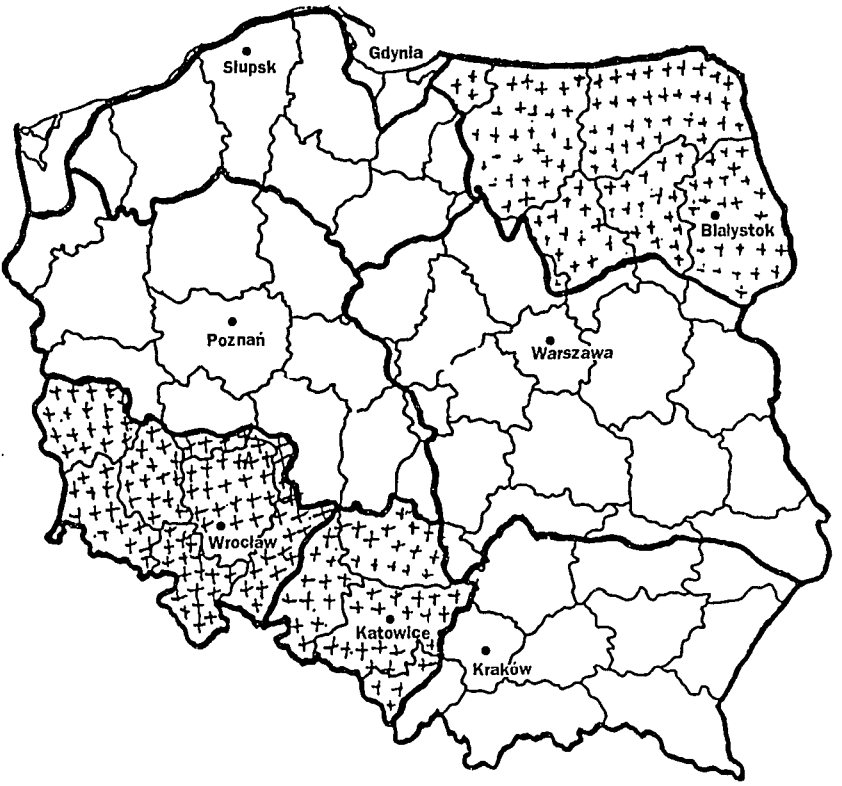


Fig. 2. Division of Poland according to the Institute of Meteorology and Water Management. Marked districts are object of this report.

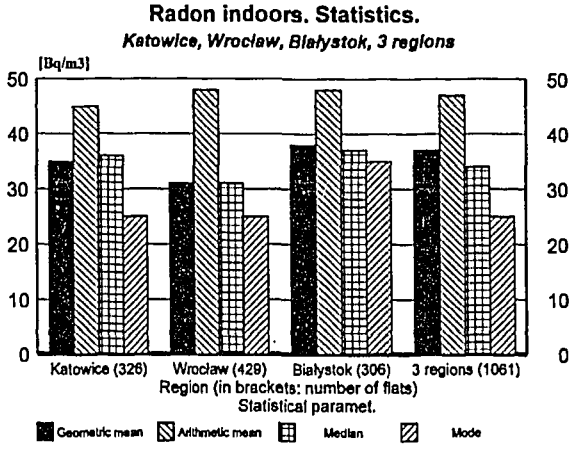


Fig. 3. Statistical parameters

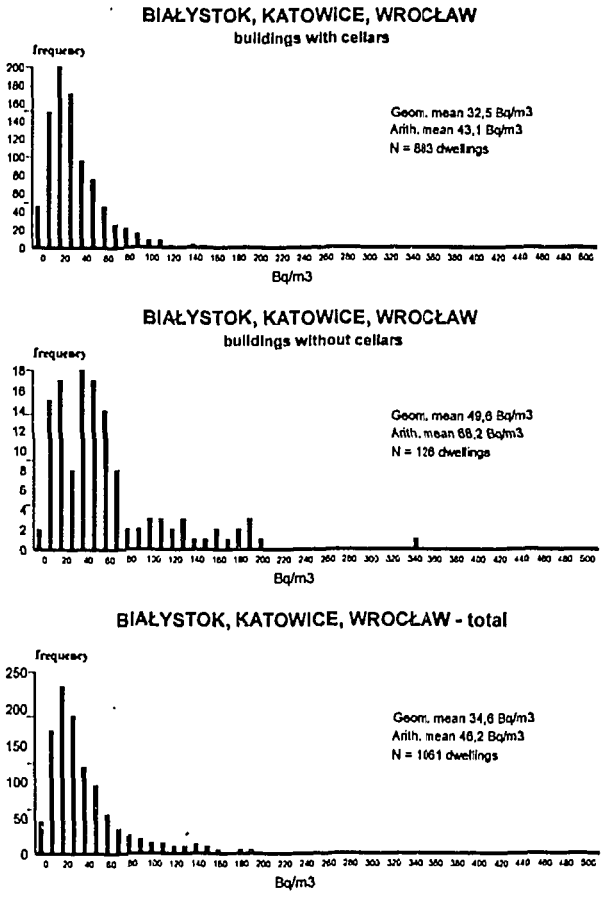


Fig. 4. Histograms of radon concentration in dwellings

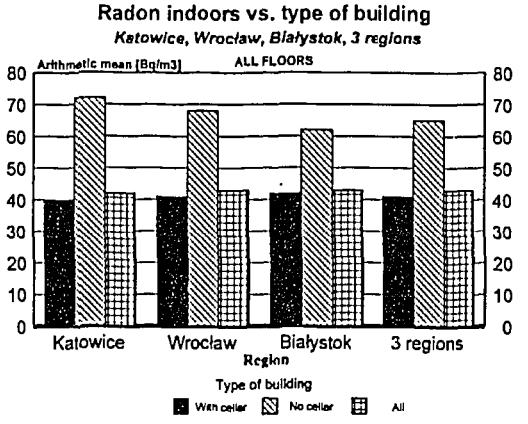


Fig. 5. Rn concentrations vs. type of building (with cellar, without cellar, all)

Fig. 6. Rn concentration vs. floor number

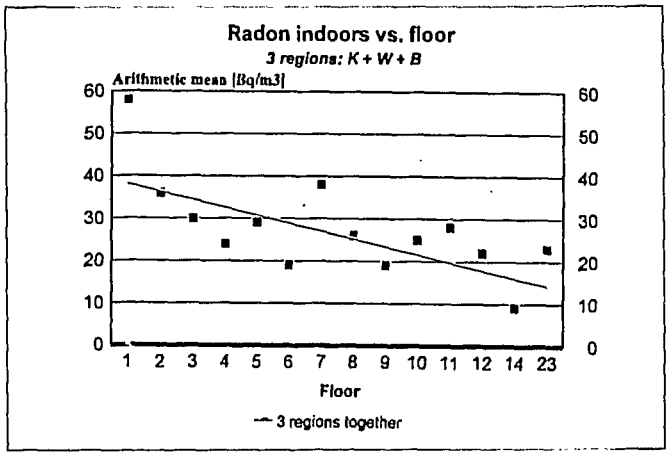


Fig. 7. Rn concentration vs. floor number

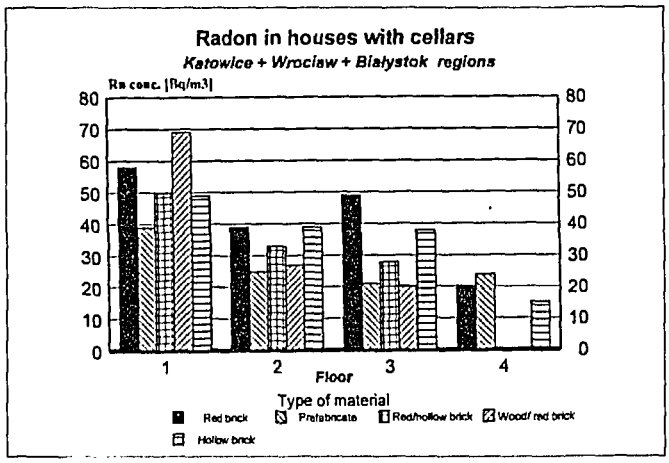
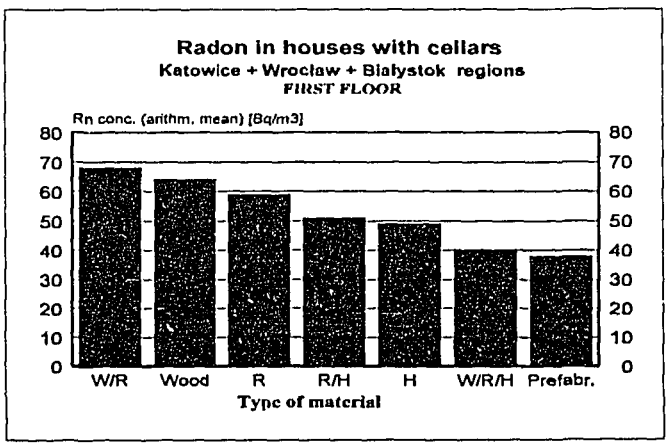


Fig. 8. Rn concentration vs. type of material W/R-wood/red brick; R/H- red/hollow brick; H- hollow brick; W/R/H - wood/red/ hollow;



4.10 MIGRATION OF RADIOCESIUM IN FOREST ENVIRONMENT

Z. Pietrzak-Flis, I. Radwan, L. Rosiak
Radiation Hygiene Department

The forest environment as a potential source of radiation to man has been emphasized in several reports. Studies on the retention, circulation and distribution of radionuclides in forest environment are needed in order to gain knowledge of factors of significance in assessing the doses to man.

This study was performed in order to determine behavior of radiocesium in different types of forest environment. The National Reservation Park of Kampinos Forest was chosen for the study; two main types of forest soil can be distinguished there: dry podzol soil mainly with conifers and wet peat soil mainly with deciduous trees.

The following parameters were determined:

- vertical distribution of radiocesium in different layers of podzol and peat soils
- concentration of radiocesium in chosen species of mushrooms and vascular plants at the same site
- transfer factors from soil to mushrooms and plants

Samples of subsequent horizons of soil, up to 10 cm of depth, mushrooms and vascular plants were collected in these sites for each area. The following horizons were taken into consideration: L–litter, Of–litter partially decomposed, Oh – strongly decomposed organic, Oh/Ah – organic intermixed with mineral, Ah – mineral soil. Samples of particular layers of soil were collected from an area of 50x50 cm^2 using a metal frame. From the same area two species of mushroom (*Xerocomus badius* and *Paxillus involutus*) and three species of vascular plants (*Muscus, Vacinum myrtillus* and *Calluna*) were taken.

All samples were weighed, dried and ashed at a temperature below 450°C. ^{134}Cs, ^{137}Cs and ^{40}K were determined by γ-spectrometry. ^{134}Cs was detectable only in L – horizon of soil and in mushrooms. The highest concentration of ^{137}Cs was observed for litter; the maximum reached 300 Bq kg^{-1}_{dw}. Organic horizons contained more ^{137}Cs than the mineral ones. This concentration distribution confirm the known fact that vertical migration of radiocesium is slow.

The concentration of ^{137}Cs in *Xerocomus badius* and *Paxillus involutus* were in the range 2720–5530 Bq kg^{-1}_{dw} and 1030–6290 Bq kg^{-1}_{dw}, respectively. Concentration of this radionuclide in *Muscus*, *Vacinum myrtillus* and *Calluna* were much lower and were on the average 150.5 Bq kg^{-1}_{dw}, 88.4 Bq kg^{-1}_{dw} and 134.7 Bq kg^{-1}_{dw}, respectively.

Transfer factors soil - mushrooms were determined as a ratio of Cs concentration in dry mushrooms to the average concentration in dry soil of L + Of horizons, because the vegetative mycelium takes up radionuclides mainly from these organic soil components. These transfer factors ranged from 9.7 to 65.0 for *Xerocomus badius* and from 6.1 to 48.3 for *Paxillus involutus*.

The study is in progress.

4.11 TRANSFER OF ^{210}Pb AND ^{210}Po VIA ROOT SYSTEM AND ABOVE-GROUND INTERCEPTION*

Z. Pietrzak-Flis, M. Skowrońska-Smolak
Radiation Hygiene Department

Effect of atmospheric deposition of ^{210}Pb and ^{210}Po on their transfer to plants used as food (potatos, vegetables, cereals) and as fodder (grass, alfalfa) has been studied. The plants were grown on an open field (exposure to deposition from the air and to resuspension from soil) and simultaneously in a polyethylene tent with an underground irrigation system (isolation from the wet deposition and resuspension from water splash of soil, and partly from dry deposition). Total deposition was collected throughout the vegetative periods. ^{210}Pb and ^{210}Po were determined in the total deposition, soil and plants.

In the above-ground parts of the plants grown on the open field the activity concentrations of ^{210}Pb and ^{210}Po were about two times (for alfalfa, kale, wheat grain) up to 18.9 times (for grass) higher than those for the plants grown in the tent. This indicates that the atmospheric deposition is the main source of ^{210}Pb and ^{210}Po in the above ground parts of plants. The highest activity concentration of ^{210}Pb were found in barley straw (16.66 Bq kg^{-1}dw), wheat straw (12.67 Bq kg^{-1}dw), then in spinach (7.74 Bq kg^{-1}) and grass (6.99 and 6.43 Bq kg^{-1}dw). In wheat grains the activity concentration of ^{210}Pb was the lowest among all the plants grown on the open field. In the case of root vegetables (potato, carrot, turnip) the activity concentrations of both radionuclides in the plants were similar for the field and tent conditions. For the field conditions the concentrations of the radionuclides in the root vegetables were usually lower than those in above-ground ones (the exception was wheat grain for ^{210}Pb, whereas kale and grains for ^{210}Po).

* Paper presented at XXIII Annual Meeting of European Society for New Methods in Agricultural Research, Halle, September 5 - 9, 1993

The difference between the activity concentrations in the plants in the field and in the tent was taken as a measure of the contamination via above-ground parts of plants. The contributions from the above-ground interception were from zero for potato up to 95 per cent for grass. To evaluate the amount of radionuclides incorporated in the plants and deposited on their surface, the plants were washed in distilled water and then the radionuclides were determined in the plants and in the wash out. The deposited radionuclides (which were determined in the rinse) constituted similar amount as that absorbed by the plants. This was observed both for the open field and tent plants. On the basis of ^{210}Pb and ^{210}Po levels in plants and soil the transfer factors (TF) have been calculated. TF relates the activity in plant (Bq kg$^{-1}_{dw}$) to that in a well-mixed soil volume to a depth of 20 cm (Bq kg$^{-1}_{dw}$ soil). The evaluation of TF was made only for the tent conditions but not for the field, since in the latter case the transfer occurred mainly through the above-ground parts.

The conclusions from the study are as follows:

1. Above-ground interception contributes a major portion of the contamination of leaves and stems. Depending on the plant, this contribution ranged from 56% up to 95%. For root vegetables, the major contribution came from soil (from 80% to 100%).

2. The surface contamination by ^{210}Pb and ^{210}Po constituted from 33% to 59% of their total content in plants. This contamination can be easily removed by washing.

3. Transfer factors for ^{210}Pb from soil to plants were from 0.01 up to 0.11; for ^{210}Po they were lower by about a half of the value for ^{210}Pb..

4.12 INTAKE WITH FOOD OF ^{234,238}U, ^{228,230,232}Th AND ^{226}Ra BY INHABITANTS OF WAŁBRZYCH DISTRICT

Z. Pietrzak-Flis, M. Skowrońska-Smolak, M. Suplińska
Radiation Hygiene Department

The intake of ^{234,238}U, ^{228,230,232}Th and ^{226}Ra with food has been estimated from measurements of these radionuclides in 19 food types collected in Wałbrzych district in 1992. This area has been selected because of the high level of natural radionuclides in the soil. Collected samples included milk, meat, cereals, vegetables and fruits. The samples were dried, ashed at 550^{o} C, then spiked with ^{229}Th and 232U tracer and barium solutions for determination of the yield of analysis of thorium, uranium and radium. U and Th samples were processed separately to avoid contaminating the Th fraction with ^{228}Th which is present in the U tracer. The ashed

samples were digested with concentrated HNO_3. Th was separated using anion exchange resin (Dowex 1 X 8, 100-200 mesh) and U by extraction into TBP with kerosene. Th and U were electrodeposited on stainless steel discs. The activity of thorium and uranium isotopes was measured on an alpha spectrometer. ^{226}Ra was determined by Rn emanation method.

Average concentrations of the radionuclides in some foodstuffs are given in Table 1. Data for vegetables represent mean value for 8 root and leafy vegetables grown in the Walbrzych district, while data for fruits represent mean value for apples, cherry, red and black currants.

On the basis of the thorium, uranium and ^{226}Ra concentrations in foodstuffs and of data on the consumption rates of these foodstuffs, the annual consumption of natural radionuclides has been estimated. The total annual intake estimated from food consumption in Bq are 3.53 (^{234}U), 2.81 (^{238}U), 4.56 (^{228}Th), 1.51 (^{230}Th), 1.23 (^{232}Th) and 22.2 (^{226}Ra). The annual intake with food of these radionuclides by the Walbrzych inhabitant was calculated on the assumption that all the consumed food products came from that district.

Table 1. Average concentrations of ^{234}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}Th and ^{226}Ra in some foodstuffs [mBq kg^{-1}]

Foodstuff	^{234}U	^{238}U	^{228}Th	^{230}Th	^{232}Th	^{226}Ra
Milk	3.69+	3.26+	2.64+	1.15+	1.19+	1.23+
	0.29	0.40	0.25	0.30	0.27	0.14
Beef	6.99	5.63	4.90	3.04	3.61	1.18
	0.070	0.54	0.45	0.29	0.31	0.39
Pork	1.31+	1.62+	1.35+	0.75+	0.60+	1.75+
	0.27	0.30	0.25	0.28	0.31	0.81
Wheat flour	5.28+	4.72+	13.35+	1.36+	2.03+	37.0+
	0.35	0.29	0.90	0.34	0.45	2.9
Potatoes	8.80+	7.96+	3.52+	3.22+	2.14+	13.7+
	0.60	0.54	0.28	0.33	0.41	1.5
Vegetables	7.38+	6.73+	10.8+	4.22+	2.86+	109.5+
	6.60	5.26	9.59	3.42	2.21	50.7
Fruits	5.14+	4.82+	5.98+	2.71+	2.31+	29.1+
	4.01	5.07	4.14	3.16	2.68	2.1

4.13 TRANSFER OF ^{137}Cs TO PLANTS FROM TWO TYPES OF SOIL

M. Skowrońska-Smolak, Z. Pietrzak-Flis
Radiation Hygiene Department

Transfer of ^{137}Cs from soil to plants was studied on two types of soil: on sandy soil (I) and sandy loam soil (II). The study was performed on an experimental field in the period of 1991 (Soil I) and of 1992 - 1993 (Soil II). Transfer of ^{137}Cs from Soil I was examined for plants: spring barley, spring wheat, red beet, lettuce and kale; transfer from soil II was examined for winter barley, grass, alfa, potato tubers, red beet, radish, bean, spinach and lettuce. ^{137}Cs and potassium in plants and soil were determined using gamma spectrometric method. The soils were characterized by particle size distribution and such chemical properties as pH_{H2O}, pH_{KCl}, content of organic matter, Ca, Mg and exchangeable K.

The concetration of ^{137}Cs in the Soil I was over five times lower than in Soil II, being equal to 8.84 ± 0.32 Bq kg^{-1} and 50.38± 2.21 Bq kg^{-1}, respectively. The soils differed in their chemical characteristics and texture. Soil I contained 6.47 ± 0.21 g kg^{-1} of potassium, 0.147 ± 0.015 g kg^{-1} of exchangeable potassium, 2.21 ± 0.32 g kg^{-1} Ca, 0.055 ± 0.013 g kg^{-1} Mg , and 1.733% of organic matter. Soil II contained 10.87 ± 0.22 g kg^{-1} potassium, 0.082 ± 0.007 g kg^{-1} exchangeable potassium, 1.62± 0.16 g kg^{-1} Ca, 0.097 ± 0.009 g kg^{-1} Mg and 2.307% of organic matter; pH_{H2O} of Soil I was equal to 7.40, and of Soil II- 6.56.2

The lowest concentrations of ^{137}Cs for both soils were observed in cereals (spring wheat - 0.67 ± 0.06 Bq kg^{-1}_{dw} and spring barley - 0.33 ± 0.08 Bq kg^{-1} for Soil I, and winter barley - 0.79 ± 0.20 Bq kg^{-1}_{dw} for Soil II). The highest concentrations of this isotope were found in red beet leaves (9.11 + 1.38 Bq kg^{-1} for Soil I and 16.44 ± 1.14 Bq kg^{-1}_{dw} for Soil II). Transfer of ^{137}Cs to plants from the sandy loam soil was from about 2 up to about 7 times lower than from the sandy soil. This is demonstrated in Table 1 in which concentrations of ^{137}Cs in three species of plants grown on Soil I and Soil II and soil-to-plant transfer factors (TF) are presented . (TF denotes the ratio of ^{137}Cs in dry weight plants to dry weight soil of 20-cm thick upper layer). The lower transfer of ^{137}Cs from Soil II to plants in comparision with Soil I might be associated with the presence of clay which is known to strong bind Cs. A strong binding of Cs can also be inferred from the lower concentration of exchangeable potassium in Soil II.

Table 1. Concentrations of ^{137}Cs in three species of plants grown on Soil I and Soil II and soil-to-plant transfer factors (TF)

Plant	Soil_I		Soil_II	
	137Cs Bq kg_{dw}^{-1}	TF	137Cs Bq kg_{dw}^{-1}	TF
Barley grain, 0.33 ± 0.08	0.0373	0.79 ± 0.20	0.0157	
Barley straw	1.15 ± 0.20	0.1301	1.82 ± 1.41	0.0361
Lettuce	4.55 ± 0.22	0.5147	10.44± 1.46	0.2072
Red beet roots	3.84 ± 0.45	0.4344	3.24 ± 0.47	0.0643
leaves &stems	9.11 ± 1.38	1.0305	16.44 ± 3.02	0.3263

4.14 INVESTIGATION OF LEVELS OF ^{226}RA AND ^{222}RN IN FRESH WATERS

T. Wardaszko, D. Grzybowska
Radiation Hygiene Department

Of the four radium isotopes occurring in nature, ^{226}Ra is the most significant from the point of view of radiological protection because of its longest half-life, so it is this radium isotope to which much attention has been paid at our laboratory. Similarly, we dealt with only ^{222}Rn out of the three Rn i sotopes belonging to natural series.

For determination of ^{226}Ra concentrations in water we have been applying de-emanation method consisting in chemical separation of radium from water sample and subsequent transferring newly-formed radon to a scintillation chamber. The water sample, usually 10 dm^3 in volume, was condensed to about 200 cm^3 by evaporation; radium was then separated using co-precipitation with barium carrier with subsequent dissolution of the precipitate in alcaline solution of EDTA.

For the measurement of ^{222}Rn cocentration, the water sample of 30 cm^3 was introduced into bubbler and immediately de-emanated into an evacuated scintillation chamber for alpha activity measurement on reaching equilibrium between ^{222}Rn and its short-lived daughters.

Such system gives for ^{226}Ra the detection limit of 0.7 mBq per sample or 0.07 mBq per dm^3 of water, the blanks giving 1,1 to 1,85 mq per sample (to be deducted from sample result). For ^{222}Rn which is measured without enrichment,

out of a small quantity of water (30 cm^3) finding place in a bubbler, the detection limit is 25 mBq dm^{-3} of water.

As regards ^{226}Ra, the measurement results were obtained in the years 1974–1992 mainly from water analyses commissioned by different water users. These results can be divided into the following 5 groups according to the origin or type of water:

– surface waters
– well waters
– deep waters (waters from deep boreholes and mine waters)
– tap waters.

The data for above groups are presented in Table 1 which gives the number of determinations in each group and the range of observed concentrations of ^{226}Ra. Detailed data are contained in our publications [1,2].

As can be seen, surface and (shallow) well waters exhibit similar range of observed concentrations of ^{226}Ra, whereas deep boreholes and mine waters have much higher upper value of the range. It must be noted, however, that in this set of data, only 4 of them pertain to mine waters, so the stated range is by no means representative for mines in Poland. Waters from boreholes drilled for hydrogeological purposes in Lower Warta region, all exhibit low ^{226}Ra content; it may be explained by the geological structure of this region where tertiary and quaternary formations prevail, with no occurence of granites.

The ^{226}Ra concentrations in tap waters from several localities in southern and western Poland are low, ranging only to 11 mBq dm^{-3}. Pairs of determinations of this radionuclide at water treatment plants in Lubin (before and after treatment) showed that treatment removed about 60% of ^{226}Ra contained in water. This is in agreement with findings of Samuels [3] who has reported that water treatment eliminated 70% of ^{226}Ra.

The concentrations of ^{222}Rn observed in different types of waters are summarized in Table 2. This radionuclide has been determined systematically in tap water in Warsaw over a period of about 2 years with a frequency of 2 determinations per months. The water comes from Vistula river through a water treatment plant, so what was measured was the remainder after de-emanation during water processing and after partial radioactive decay on the way river-tap. This remainder is fairly constant (SD of about 10 percent), with very few non-typical results.

The data on radon in deep borehole waters are scarse and can only serve as indication of the fact that this type of water may contain much radon and, at the same time, little radium (Table 1). This means that ^{222}Rn present in such waters, as well as in most other waters, is unsupported (not based on ^{226}Ra contained in water); it is flushed out by water from gaps in rocks where it accumulates.

There are data indicating that some mineral waters from springs in health resorts in Poland (and elsewhere) contain much more ^{222}Rn; the concentrations range from several to 1200 Bq dm^{-3} [4], the highest values being characteristic of the spring Jerzy in the health resort Lądek Zdrój in south-western Poland.

Waters from hydrogeological boreholes in Lower Warta region (Table 2, item 3) are characterized by relatively low ^{222}Rn content (Table 1, item 4) related to geological structure of that region, mentioned before.

The comparison of Table 1 and Table 2 shows that, in general, inland waters exhibit much (2–3 orders of magnitude) higher concentrations of ^{222}Rn than of ^{226}Ra. This fact has, however, only very little meaning from the point of view of radiological protection, because ^{226}Ra being a long-lived, alpha-active boneseeker, belongs to highly radiotoxic substances, whereas ^{222}Rn, a short-lived noble gas, does not. In fact, there exist no, international or national, limiting values for ^{222}Rn content in drinking water. This fact may be ascribed to long-standing dispute on whether radon in water is harmful or beneficial for humans.

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Table 1. ^{226}Ra Concentrations in Fresh Waters

Type of waters	No. of determinations	Range of concentrations mBq dm^{-3}
Surface waters	23	1.1 – 43
Well waters	16	3.7 – 25
Deep borehole and mine waters	14	0.8 – 330
Waters from boreholes in Lower Warta region	32	0.2 – 11
Tap waters	10	0.4 – 8.3

Table 2. ^{222}Rn Concentrations in Fresh Waters

Type of waters	No. of determination	Concentration, Bq dm^{-3}		Measured in years
		Mean ± SD	Range	
Tap water in Warsaw (from Vistula River)	32	0,66 ± 0,07	0,37 – 1,69	1980–81 2 determ./month
Deep borehole waters	4	–	0,11 – 58	1979–89
Waters from boreholes in Lower Warta region	14	2,2 ± 2,4	0,07 ± 6,9	1985–86

4.15 TRITIUM IN ENVIRONMENTAL FRESH WATERS

T.Wardaszko I.Radwan
Radiation Hygiene Department

As in previous years, tritium has been determined in Vistula river water and in precipitation. Samples of the former were collected in Warsaw as tap water whereas precipitation samples were obtained from the Institute of Meteorology and Water Management, from 2 locations: Warsaw-Bielany and Karpacz (Mt Śnieżka Meteorological Observatory). Both types of samples were averaged monthly ones.

In order to obtain sufficient lower limit of detection, liquid scintillation counting has been applied, combined with electrolytic enrichment of analyzed waters using a method described by Cameron (1), with modifications. The final samples, mixed with liquid scintillator Instagel, were measured in the LS spectrometer Wallac-LKB type 1410.

This method gave the detection limit of 0.5 Bq dm^{-3} which corresponds to typical natural tritium level in surface waters.

The results for years 1992 and 1993 are presented in Table 1. As can be seen, in these years the concentrations of tritium in both kinds of water were similar, the mean values did not differ much. Also the temporal variation is insignificant; it can only be analysed on the basis of data for a number of years, as was done in (2). Detailed data including monthly values for the years 1992-93 will be published separately.

In 1992 the mean tritium concentration in Vistula river water sampled in Warsaw, representative for Vistula basin upstream of Warsaw, was, as may be seen

in Table 1, 2.2±0.6 Bq/dm3; similar mean value of 2.4±0.5 Bq dm^{-3} was found for 1993. The range was, in both years, from about 1.5 to 4 Bq dm^{-3}.

Tritium levels in precipitation in the same period were in Warsaw slightly lower, with means of 2.1 Bq dm^{-3} in both years. In Karpacz (Mt Śnieżka) the means tend to be, insignificantly, higher.

Similar tritium levels for 1992 in precipitation in Switzerland are reported in [3]; the values for river water in that country are higher which is largely ascribed to industrial activities.

The analysis of data for recent 10 years shows a slowly decreasing tendency of tritium levels in both surface waters and precipitation, with only little change in last 4-5 years. The slow diminution of tritium concentrations in precipitations and, consequently, in surface waters, is related to gradual depletion of stratospheric reservoir of tritium, both by radioactive decay and by seasonal exchange of air masses through the tropopause.

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Table 1. Tritium concentrations (Bq dm^{-3}) in tap water (Vistula river water) and in precipitation in Warsaw and Karpacz – Mt Śnieżka. Mean values ± SD in 1992 and 1993.

Year	Tap water	Precipitation	
		Warsaw	Karpacz
1992	2,2 ± 0,6	2,1 ± 0,8	2,5 ± 0,7
1993	2,4 ± 0,5	2,1 ± 0,6	2,2 ± 0,3 *

*mean for January through June.

5. PUBLICATIONS AND PRESENTATIONS BY THE SCIENTISTS OF THE CLRP

5.1 PUBLISHED PAPERS

1. Hofert M., Koczyński A.: On the Calibration of Film Dosimeters Free in Air and on a Slab Phantom. *Report CERN*-TIS-RP/IR/1992-09.

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10. Jaworowski Z., Segalstad T.V., Ono N.: Do Glaciers Tell a True CO_2 Story? *The Science of the Total Environment*, 1992, **114**, 227-284.

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15. Mamont-Cieśla K.: Radon in apartments (in Polish). *Journ. of Build. Constr.* July 1993, **7**.

16. Orzechowska G.: Method of Determination of ^{241}Am in Human Urine. *Nukleonika*, 1992, **37**, 9-15.

17. Pietrzak-Flis Z., Krajewski P.: Radiocesium in Diet and Man in North-eastern Poland after the Chernobyl Accident. *Health Physics*, in print.

18. Pietrzak-Flis Z., Krajewski P., Mandecka M.: Radiocesium Body Burden of Warsaw Inhabitants in the Period of 1988-1991. *Nukleonika*, 1992, **37**, 71-83.

19. Pietrzak-Flis Z., Krajewski P., Krajewska G., Sunderland N.R.: Transfer of Radiocesium from Uncultivated Soils to Grass after the Chernobyl Accident. *The Science of the Total Environment*, in print.

20. Pietrzak-Flis Z., Orzechowska G.: Plutonium in Daily Diet in Poland after the Chernobyl Accident. *Health Physics*, November 1993, **5**, Vol.65.

21. Rosiński S.W.: A Computerized Track Detector Reader. *Nukleonika*, 1993, **2**, Vol.38.

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5.2 PAPERS PRESENTED AT MEETINGS (symposia, conferences, others)*

1. **The Radiobiological Impact of Hot Beta-Particles from the Chernobyl Fallout: Risk Assessment**, Kiev, August 26 - 30, 1991, Jaracz P., Gierlik E., Królak E., Mirowski S., Saganek A., Wilhelmi Z., Jagielak J., Biernacka M.: Search for Hot Particles from the Chernobyl Fallout in Poland. Published by the IAEA, Vienna, 1992.

* Plm – Polish language meeting

2. **The Dynamic Behaviour of Radionuclides in Forests**, Stockholm, May 17 - 24, 1992, Muszyński W., Rubel B.: Activity of ^{134}Cs and ^{137}Cs in Game and Mushrooms in Poland.

3. **Polish-American Seminar on Long-Lived Post-Chernobyl Radioactivity and Radiation Protection Criteria for Risk Reduction**, Zaborów (PL), September 1–3, 1992:

3.1 Ćwik T.: On Assessments of Population Exposure Caused by Intakes of Radionuclides and Quantities Used in these Assessments,

3.2 Grabowski D., Łada W., Muszyński W., Rubel B., Petrykowska M.: Radiocesium Content in the Forest Mushrooms and Game in Poland in 1985 - 1991.

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3.9 Pietrzak-Flis Z., Orzechowska G.: Plutonium in Daily Diet in Poland after the Chernobyl Accident.

3.10 Suplińska M., Grzybowska D.: Radiocesium and Plutonium in Some Components of Polish Economic Zone of the Baltic Sea.

3.11 Wardaszko T., Grzybowska D.: Tritium, ^{222}Rn and ^{226}Ra in Fresh Waters in Poland.

4. Seminar: **Radioactive Contamination of the Environment of North - Eastern Poland**, Białystok, 5.02.1993 (Plm).

4.1 Biernacka M., Henschke J., Jagielak J., Sosińska A.: Radiological Map of Poland.

238 4.2 Krajewski P.: Radiocesium in Food and Inhabitants of North - Eastern Poland after the Chernobyl Accident.

4.3 Żak A., Biernacka M., Jagielak J.: Radioactivity of Building Materials and their Raw Materials.

5. Seminar: **Radium and Radon as Sources of Radiological Hazard.** Warsaw, February 25-26, 1993. (Plm)

a. Mamont-Cieśla K.: Radon in Buildings - CLRP Measurements;
b. Wardaszko T., Grzybowska D.: Levels of ^{226}Ra i ^{222}Ra in Fresh Waters in Poland,
c. Żak A.: Natural Radioactivity of Building Materials - Results of Attestation Measurements in the years 1980-1991,
d. Żak A.: The Influence of Wall Coatings Emanation Factors for Radon and Thoron.

6. Symposium: **The state of the Environment around Big Fossil - Fuelled Power Stations as Exemplified by the Bełchatów Power Station.** Bełchatów (PL), (Plm) Apr. 29 - 30, 1993. Grabowski D., Kownacka L.: An Analysis of the Impact of Bełchatów Power Station upon the Radiological Situation of its Environs (in Polish).

7. Seminar: **Cycling of ^{137}Cs and ^{90}Sr in natural Ecosystems**, Neuherberg, D, December 8 - 12, 1993, Pietrzak-Flis Z., Radwan I., Rosiak L.: Radiocesium in Soil Mushrooms and Understory Vascular Plants.

5.3 REPORTS OF CLRP

1. Grabowski D., Muszyński W., Petrykowska M., Rubel B., Smagała G., Wilgos J.: **Radioactive Contamination of the Environment and Food in Poland (in Polish)**. Report CLOR nr 124/D, Warsaw, 1993.

2. Suplińska M.: **Review of the Methods for the Determination of Plutonium and Americium in the Marine Environment** Raport CLOR nr 125/D, Warszawa, 1993.

3. Kownacka L., Jaworowski Z., Suplińska M., Wesołek R., Zając B., Romicki Z.: **Measurement of Concentrations of ^{7}Be, ^{90}Sr, ^{134,137}Cs, ^{210}Pb, ^{226}Ra and Stable Pb in the Tropospheric and Lower Stratospheric Air from 1990 to 1992** Raport CLOR nr 126/D, Warszawa, 1993.

4. **Operational and Research Activities of Central Laboratory for Radiological Protection in the Years 1990 - 1991** (partly in Polish). Edited by Division of Education, Information and Standardization, CLRP, Warsaw, 1992.

5.4 INTERNAL REPORTS AND ELABORATIONS

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5. Dzikiewicz-Sapieha H., Henschke J., Jagielak J., Wilk M., Żak A.: Analiza porównawcza wyników kalibracji spektrometrów z detektorem półprzewodnikowym HPGe i scyntylacyjnym NaJ stosowanych w pomiarach środowiskowych przez CLOR i SEGI-PBG. Warszawa, 1992.

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12. Jagielak J., Biernacka M., Bysiek M., Zarucki R.: Opracowanie pt. „Metoda badań promieniotwórczych zanieczyszczeń powietrza za pomocą stacji ASS-500". Warszawa, grudzień 1993.

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20. Żak A.: Ekspertyzy dotyczące badania stężeń naturalnych izotopów promieniotwórczych w odpadach przemysłowych celem oceny ich wpływu na otaczające środowisko. Warszawa, 1992.

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23. Żak A.: Ekspertyza dotycząca badań radioaktywności budynku pozostawionego przez jednostki Armii Radzieckiej. Warszawa, wrzesień 1993.

5.5 PARTICIPATION IN AND CONTRIBUTIONS TO, SCIENTIFIC EVENTS

1. Meeting on IAEA/CEC Co-ordinated Research Programme: **Validation of Models for Predicting Radionuclide Transfer in Terrestial, Urban and Aquatic Environments (VAMP).** Vienna, IAEA, March 1-7, 1992, Krajewski P.

2. Seventh Meeting of the Group of Experts on **Monitoring of Radioactive Substances in the Baltic Sea of the Baltic Marine Environment Protection Commission - Helsinki Commission (EC MORS 7/9).** Helsinki, June 1-5, 1992, Suplińska M.

3. IAEA Advisory Group Meeting on **Intake Coefficients for Radionuclides in Food and Doses from Incorporated Radionuclides.** Preparation of IAEA document, Safety Series, Vienna, IAEA, September 28 - October 2, 1992. Krajewski P.

4. Multiple Pathways Assessment Working Group Meeting on **Validation of Models for Predicting Radionuclide Transfer in Terrestial, Urban and Aqu-**

atic Environments (VAMP). Vienna, IAEA, November 11–15, 1992. Krajewski P.

5. Eighth Meeting of the Group of Experts on **Monitoring of Radioactive Substances in the Baltic Sea (EC MORS 8/10).** Riso, Denmark, March 29 - April 2, 1993. Suplińska M.

6. 42. Session of the **United Nations Scientific Committee on The Effects of Atomic Radiations,** Vienna, May 16-22, 1993. Jaworowski Z.

7. Meeting on IAEA/CEC Co-ordinationated Research Programme: **Validation of Models for Predicting Radionuclide Transfer in Terrestial, Urban and Aquatic Environments (VAMP).** Vienna, IAEA, July 4-9, 1993. Pietrzak-Flis Z.

8. Conference **„XXIX Berlin-Kolloquium",** Berlin, September 7-10. 1993, Wardaszko T.

9. Multiple Pathways Assessment Working Group on **Validation of Models for Predicting Radionuclide Transfer in Terrestial, Urban and Aquatic Environments (VAMP),** Helsinki, October 4-8, 1993. Krajewski P.

10. The Second Conference on **Problems of Preventive Actions and Population Protection Against Disasters and Accidents,** Sofia, September 28 - 29, 1993, Grabowski D., Muszyński W.

5.6 INVITED LECTURES HOLD BY CLRP SCIENTISTS

1. Seminar, June 29, 1993, Kownacka L.: **The Vertical Distribution of Radionuclides in the Atmosphere.** Lawrence Livermore National Laboratory, California, USA.

ERRATA: BI-ANNUAL REPORT 1992–1993, CLOR, Warsaw

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10	10, in 3.1.1	sets equipment	selects equipment
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23	1	source	sources
29	Fig. 2, ordinate axis	f1	f_2
	abscissa axis	134	124
		162	112
		162	182
30	Fig. 3, lower, ordinate axis	f1	f_2
	Fig. 4, lower, ordinate axis	f1	f_2
35	middle of the page	Elektrotechnical	Electrotechnical
36	item 3, in 3.9.2	Environmential	Environmental
39	Table 1, column 3	μBm^{-3}	$\mu Bq\, m^{-3}$
40	Fig. 1, 1 and 2 from below	$\mu Bq/m3$	$Bq\, g^{-1}$
41	Fig. 2, as above	as above	as above
42	Fig. 3, as above	as above	as above
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71	14, from below	6.56.2	6.56.
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	title, in 4.14	^{226}RA, ^{222}RN	^{226}Ra, ^{222}Rn
78	last line before 5.2	Buildung	Building
	item 26, in 5.1	in print	Nukleonika 1993, 38,4
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80	2	i	and
	6	Emanation	on Emanation

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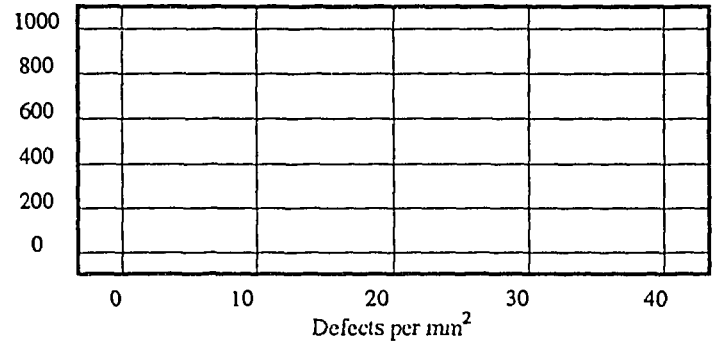
Foodstuff	^{234}U	^{238}U	^{228}Th	^{230}Th	^{232}Th	^{226}Ra
Milk	3.69±0.29	3.26±0.40	2.64±0.25	1.15±0.30	1.19±0.27	1.23±0.14
Beef	6.99±0.07	5.63±0.54	4.90±0.45	3.04±0.29	3.61±0.31	1.18±0.39
Pork	1.31±0.27	1.62±0.30	1.35±0.25	0.75±0.28	0.60±0.31	1.75±0.81
Wheat flour	5.28±0.35	4.72±0.29	13.35±0.90	1.36±0.34	2.03±0.45	37.0±2.9
Potatoes	8.80±0.60	7.96±0.54	3.52±0.28	3.22±0.33	2.14±0.41	13.7±1.5
Vegetables	7.38±6.60	6.73±5.26	10.8±9.59	4.22±3.42	2.86±2.21	109.5±50.7
Fruits	5.14±4.01	4.82±5.07	5.98±4.14	2.71±3.16	2.31±2.68	29.1±2.1

** should be

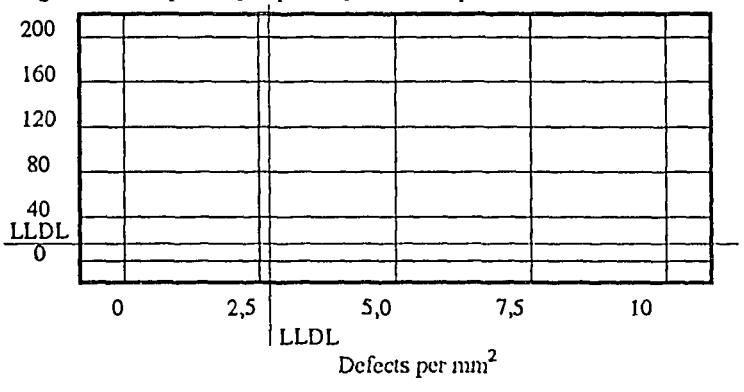
Plant	Soil I		Soil II	
	^{137}Cs Bq kg^{-1}_{dw}	TF	^{137}Cs Bq kg^{-1}_{dw}	TF
Barley grain	0.33 ± 0.08	0.0373	0.79 ± 0.20	0.0157

*** should be

Regression of exposure [kBq m^{-3} h] on defects per mm^2



Regression of exposure [kBq m^{-3} h] on defects per mm^2



LLDL - Lower Level Detection Limit to 34 k Bq m^{-3} h