Radiological Environmental Monitoring in Hungary Effectuated by the Radiological Monitoring and Data Acquisition Network: Results for Year 2015

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Abstract

The Radiological Monitoring and Data Acquisition Network (RAMDAN) acts within the organizational frame of the National Public Health and Medical Officer Service (NPHMOS). According to the Ministerial Decree 8/2002 (III.12.) of the Ministry of Health, the tasks of the network are to fulfil all the duties associated with the health issues of environmental radiation protection and radiation hygiene under normal conditions and in radiological emergency, as well. Annually about 3000 samples including environmental ones, feeding material, foodstuff and drinking water are examined. Environmental monitoring strategy and major properties of the network are described. Based on measurement results, inhalation and consumption rates and inhalation and ingestion dose coefficients, the average effective dose to the Hungarian population from man-made sources in year 2015 was assessed to be 5.5 μSv. The average effective dose to the Hungarian population from natural radiation sources in a year was about 3.1 mSv. None of the measurement results in 2015 required intervention by the radiohygiene service.

Key Words: environmental radioactivity, radiological environmental monitoring, effective dose to the public.

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ABBREVIATIONS:

NPHMOS	National Public Health and Medical Officer Service
NPHC	National Public Health Center
NRDRR	National Directorate for Radiobiology and Radiohygiene
RAMDAN	Radiological Monitoring and Data Acquisition Network
IAEA	International Atomic Energy Agency
EURDEP	European Radiological Data Exchange Platform
HAEA	Hungarian Atomic Energy Authority

INTRODUCTION

Regular radiological monitoring is performed in order to ensure the radiation protection of the public and the environment. According to the IAEA Basic Safety Standards (2015) each country is responsible for the establishment, implementation and maintenance of an appropriate monitoring and surveillance programme to the satisfaction of the regulatory body.

In Hungary, following the instructions of the minister of health, a national radiological monitoring network was established in 1975. The name of this network is Radiological Monitoring and Data Acquisition Network (RAMDAN, in Hungarian ERMAH). Since 1978 the network has measured regularly and routinely the radioactivity in the environment and food. The primary purpose of monitoring was the assessment of health effects affecting the public due to nuclear weapon tests. After 1982, when a nuclear power plant was placed in operation in Hungary, a further aim of environmental radiological monitoring was to follow the emissions, to detect changes and evaluate long term trends in environmental radiological levels as a result of human activities.

Based on the authorization received by the Law CXVI on Nuclear Energy (1996) the Minister of Health re-regulated the tasks and activities of the RAMDAN in Decree Nr. 8/2002. According to this Decree the RAMDAN provides radiological monitoring in Hungary both in normal circumstances and in case of nuclear or radiological emergency. The monitoring should include measurements of radiation fields, on-site and laboratory measurements of radionuclide activity concentrations in environmental samples relevant to human exposure, primarily in air, drinking water and foodstuffs. The measurement results should provide sufficient data for analysis and evaluation of human radiation exposure. The prescriptions of the Decree fulfil the requirements described in directives and regulations of EURATOM Treaty. All data are provided to the National Environmental Radiation Monitoring System and further to the EURDEP.

At its establishment the RAMDAN consisted of 10 laboratories, nowadays 7 laboratories belong to the network (see *Figure 1.*). The network includes a high level radiological laboratory at the National Public Health Institute (formerly: National Public Health Center, National Research Directorate for Radiobiology and Radiohygiene, NRDRR) performing all the measurements that require special sample preparation and high sensitivity or special methodology, and six regional laboratories belonging to the Public Health Departments of the Regional Government Offices. The structure of the network organization follows the organization of national administration. In general, three counties belong to a regional laboratory. The Budapest Laboratory has only one county under its supervision, because in Pest County there are three special facilities requiring extra monitoring (two experimental reactors and a radiological waste repository).

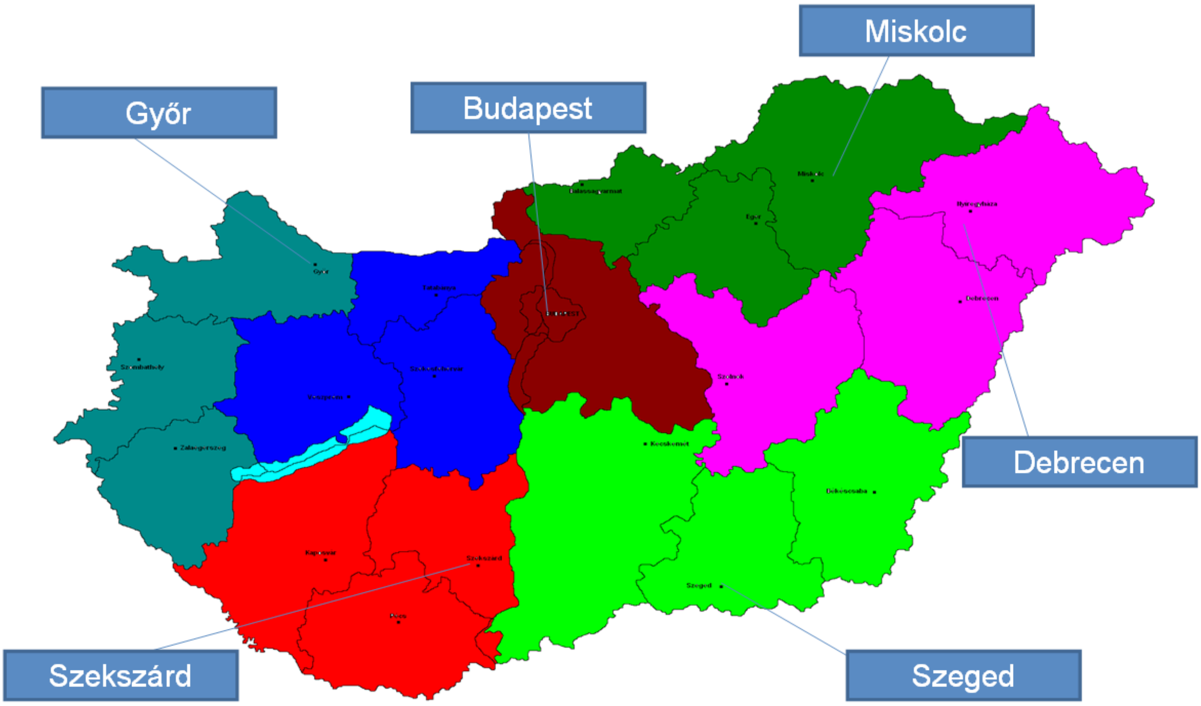

Figure 1. Cities where RAMDAN Laboratories work and the counties belonging to them

The regulatory body for radiation protection of the public in Hungary until the end of year 2015 was the National Public Health and Medical Officer Service, which operated under the State Secretary of Health in the frame of the Ministry of Human Capacities. In 2016 the Hungarian Atomic Energy Authority took over the regulatory supervision and responsibilities concerning the radiation protection of the public.

NRDRR plays a central role in the operation of RAMDAN giving professional guidance to the Network. This means namely: plans the annual sampling and measuring programme, works out a uniform sampling and measuring methodology for the RAMDAN laboratories, operates the RAMDAN Information Centre (RAMDAN IC), which collects and processes the measurement results, evaluates the radiation conditions of the environment and determines the radiation burden of the population. The results are published in yearly reports. Beside this RAMDAN takes part regularly in Radiological Emergency Preparedness exercises coordinated by the Hungarian Atomic Energy Authority.

METHODS

Environmental sampling

The annual sampling and measuring programme of RAMDAN was designed to provide sufficient data for analysis and evaluation of human radiation exposure from both external and internal exposure pathways. Under normal conditions the exposure pathways are usually permanent and well defined. For external pathways we monitor the external gamma-dose rate, air (aerosol and fallout), soil and sediments, plants, surface water bodies. For internal pathways we monitor drinking water, unprocessed food (fruits and vegetables) and processed food (milk, dairy products, meat, etc.). Vegetables sampled and analysed are: onion, cucumber, potato, cabbage, carrot, etc. Fruits sampled and analysed are: apple, banana, cherry, strawberry, peach, orange, grape, etc. Meat analysed: beef, chicken, fish and pork. The annual monitoring programme is yearly elaborated by NRDRR and is approved by the Chief Medical Officer.

The sampling frequency is variable for different types of samples. External dose rate is measured weekly, the aerosol samples are taken also weekly. Monthly samples are taken from drinking water and food samples. Food samples are purchased from the highest turnover stores and only the consumable parts are measured. The selection of food samples to be analysed are based on consumption data offered by the Hungarian Statistical Office. Some samples are taken quarterly or twice a year.

In *Table I* an overview of the yearly sampling programme is presented. The upper part of the table contains the environmental samples, the lower part the food samples analysed. The sampling frequencies and the measurements performed on these samples are also presented. With this sampling schedule the ratio of different kinds of samples is however balanced in function of their importance as it can be seen in *Table II*. Because of the importance of the air it is the most examined environmental element having 32% of all samples. Drinking water samples and milk samples are 11% – 11%. Other food samples like bread, meat and vegetables and fruits are 6%.

Table I.

Overview of the sampling and measuring programme of the Radiological Monitoring and Data Acquisition Network

Sampled medium	Sampling frequency	Measurements performed
Air particulates	Weekly	Gross beta, Gamma spectrometry
Fall-out (wet and dry)	Monthly Composite Sample	Gross beta, Gamma spectrometry
Soil	Monthly	Gross beta, Gamma spectrometry
River and lake water	Monthly	Gross beta, Gamma spectrometry, ^{3}H analysis
Grass and feed	Quarterly	Gross beta, Gamma spectrometry
External gamma dose	Weekly	External gamma dose
Meat	Monthly	Gross beta, Gamma spectrometry
Cereals and bread	Monthly	Gross beta, Gamma spectrometry
Fruits and vegetables	Monthly	Gross beta, Gamma spectrometry
Milk, dairy products	Monthly	Gross beta, Gamma spectrometry, Sr-90 analysis
Drinking water	Monthly	Gross alpha, Gross beta, Gamma spectrometry, Sr-90 analysis, ^{3}H analysis

Table II.

Type and percentage of samples analysed by RAMDAN in a year

Type of sample	Ratio (%)
Air (aerosol and fallout)	32
Surface water	19
Drinking water	11
Milk and dairy products	11
Bread and cereals	6
Vegetables and fruits	6
Meat and egg	6
Soil	4
Grass and feed	4
Mixed diet	1

Sample measurements

Measurements performed on every sample are gross beta counting and gamma-spectrometric measurement. Every laboratory operates low background beta-counter and high purity germanium semiconductor detector for gamma-spectrometry. ^{90}Sr analysis is effectuated on water samples, milk and dairy products. Drinking water samples are measured for tritium and gross alpha activity concentration too, according to Council Directive 2013/51/EURATOM. At this moment the gross alpha measurements and the ^{3}H analyses of all samples are effectuated at the high level radiological laboratory operating in the National Public Health Institute, NRDRR. The laboratories take part regularly with good results in inter-comparison exercises organized by the IAEA and EC JRC.

The air is the most important environmental element, because in case of any radiological or nuclear event the emitted contamination is firstly measurable in aerosol samples. Four of the seven RAMDAN laboratories operate a medium volume aerosol sampling device, sampling is effectuated weekly (this means the sampled volume is 20,000-25,000 m^3 in a week) and the samples are analysed by long measuring time gamma-spectrometry. These conditions permit the detection limits for the gamma-emitting man-made radionuclides like ^{131}I or radio-caesium to be in the magnitude of µBequerel. RAMDAN detected the contamination in aerosol samples occurred after the Fukushima accident in 2011 (Masson et al., 2011).

Because of the very low activities in environmental and food samples some pre-concentration steps are necessary before the radiological measurements. A higher amount of sample is taken and a volume reducing preparation step is included. Initial quantity of food samples are 1-2 kilograms. The sample preparation proceeding consists of ashing at 405 ^{0}C. Surface and drinking water samples are prepared by volume reducing evaporation then ashing at 380 °C. Soil samples are dried at 110 ^{0}C, then milled and homogenized.

Data collection

The obtained measurement results are electronically collected by the RAMDAN Information Centre, operated by the NRDRR, the professional coordinator of RAMDAN. Data are checked, evaluated and statistically processed in order to estimate the radiation dose to the public. Results are published in yearly reports (Kövendiné Kónyi J. et al., 2016). The processed data are transferred into the Information Centre of the National Environmental Radiological Monitoring System (NERMS). Some of the data are published regularly on the homepage of the NRDRR. The reporting levels for drinking water, milk and other food samples applied by the Network are the reporting levels fixed in the EEC Recommendation 2000/473/Euratom.

RESULTS AND DISCUSSION

The RAMDAN laboratories analysed a total of 2,857 samples in 2015, the annual sampling and measuring programme was fulfilled by every laboratory.

The gross beta and ^{137}Cs measurement results of environmental samples are presented in Table III. The gross beta activity of environmental samples was in the same order of magnitude as in previous years and it was mainly of natural origin. As for the man-made ^{137}Cs we should mention that it was measurable in all soil samples due to fallout after the Chernobil accident. The average activity concentration was about 7.0 Bq*kg^{-1} dry weights in soil, with higher values up to 20 Bq*kg^{-1} in the northern and north-western parts of the country where the fallout after the Chernobyl accident was higher (Sztanyik, 1992). On windy days the soil dust was taken in the air and ^{137}Cs appeared in the air or fallout samples. These measurement data were not taken into account as their number was under 3% of all samples.

The average activity of ^{3}H in surface water samples was 1.9 ± 40% (0.08-4.1) Bq*dm^{-3}. The highest value was measured in the Danube river water sample taken under the Paks NPP at Mohács.

The external gamma-dose was measured 568 times, the average value calculated for the country was 110 ± 3% nSv*hour^{-1}, values varying from 85 to 180 nSv*hour^{-1}.

Table III.

Number of measurements and mean activity of gross beta and ^{137}Cs in environmental samples analysed by RAMDAN in year 2015

Sample and unit	Number of samples	Gross beta activity	^{137}Cs activity
Aerosol mBq*m^{-3}	665	1.2 ± 40% (0.2-2.4)	< 0.002
Fallout Bq*m^{-2}*month^{-1}	187	20 ± 20% (2.0-58.5)	< 0.10
Soil Bq*kg^{-1}	174	500 ± 8% (450-580)	6.95 ± 5% (2.5-20.0)
Grass and feed Bq*kg^{-1}	102	690 ± 20% (300-1200)	2,35 ± 5%
Surface waters (river water and lake water) Bq*dm^{-3}	174	0.18 ± 20% (0.06-0.27)	< 0.40

Table IV. contains the results of the food sample measurements. The rounded values of gross beta counting and ^{137}Cs activities are presented. There were no measured values for man-made ^{137}Cs in the analysed samples. Based on regular country-wide survey the value of specific activity of ^{137}Cs in all kinds of foodstuff samples analysed was below 0.1 $Bq*kg^{-1}$ fresh weight. The gross beta activity was mainly due to the ^{40}K of natural origin. The gross beta activities in the main environmental components, as well as in food samples, showed minor fluctuations and remained at the same level in recent years.

Table IV.

Number of measurements and activity of gross beta and ^{137}Cs in food samples analysed by RAMDAN in year 2015

Sample	Number of measurements	Gross beta activity ($Bq*kg^{1}$)	^{137}Cs activity ($Bq*kg^{-1}$)
Meat: chicken, pork, beef, fish	103	75-105 ± 10%	< 0.05
Bread	83	38-58 ± 10%	< 0.05
Cereals: barley, wheat, corn, rice	22	20-110 ± 10%	< 0.05
Vegetables: potato, onion, cabbage, paprika, tomato, spinach, salad, carrot, pumpkin, cucumber	54	50-160 ± 10%	< 0.05
Fruits: apple, pear, cherry, grapes, peach, raspberry, banana, orange	55	30-100 ± 10%	< 0.05
Egg	30	30-50 ± 10%	< 0.05
Milk (Bq/dm^3)	144	30-60 ± 10%	< 0.05
Dairy products: cheese, cottage cheese, sour cream	101	30-50 ± 10%	< 0.1
Mixed food	14	31-56 ± 10%	< 0.1

In a separate table (Table V.) the results of the measurements performed on drinking water samples are presented. The total number of drinking water samples analysed was 301. According to the Hungarian legislation based on Council Directive 2013/51/Euratom we did gross alpha, gross beta counting, ^{3}H and ^{90}Sr determination and gamma-spectrometric measurements. All measurement results obtained were under the screening levels.

Table V.

Mean activity of gross alpha, gross beta, ^{3}H, ^{90}Sr and ^{137}Cs in drinking water samples analysed by RAMDAN in year 2015

Measurement	Gross alpha	Gross beta	^{3}H	^{90}Sr	^{137}Cs
Mean activity $Bq*dm^{-3}$	0.02 (0.007-0.07)	0.1 (0.02-0.22)	0.92 (0.3-3.0)	0.02 (0.005-0.05)	< 0.01

The effective dose to the members of the public due to artificial radiation sources was estimated based on the measurement results, inhalation and consumption rates and inhalation and ingestion dose coefficients. As the activity concentration of the ^{137}Cs in most samples was under the detection limit of the measurement technique applied, in the calculations the detection limits were taken into account. This conservative calculation method resulted in overestimation of the committed effective dose. The calculated committed effective dose to the Hungarian population from man-made sources in year 2015 was assessed to be 5.5 mSv/year. The average effective dose to the Hungarian population from natural radiation sources was about 3.1 mSv/year. None of the measurement results in 2015 required intervention by the radiohygiene service.

The radiation dose to the Hungarian population from man-made sources was found to be very low. Nevertheless, the maintenance of the Radiological Monitoring and Data Acquisition Network plays an important role in the public information and in maintenance of good laboratory practices. The significance of proper laboratory practice is determinant in case of radiological emergency situations.

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