Dose assessment

Internal doses caused by incorporation of radionuclides cannot be measured directly. Therefore, for internal dose assessment, biokinetic and dosimetric modeld are needed. Internationally, the ICRP (International Commission on Radiological Protection) biokinetic and dosimetric models have been adopted.

The in vitro and in vivo measurement results are processed by specialized software, aiming at defining the human body exposure to radiation, expressed as dose in specific internal organs or in the whole body (effective dose).

GAEC uses for dose assessment the IMBA (Integrated Modules for Bioassay Analysis, by NRPB and ACJ & Associates) and LUDEP software.

Intercomparisons

GAEC participates in dose assessment intercomparison exercises, organized by the International Atomic Energy Agency and the European Commission. Moreover, participates in radiotoxicological analysis intercomparisons organized by PROCORAD (Association for the Promotion of Quality Control in Radiotoxicological Analysis).

GAEC's aim is to extend the verification and the validation of the measurements and improve the accuracy over the whole range of the methods used.

Information requests can be addressed to GAEC:

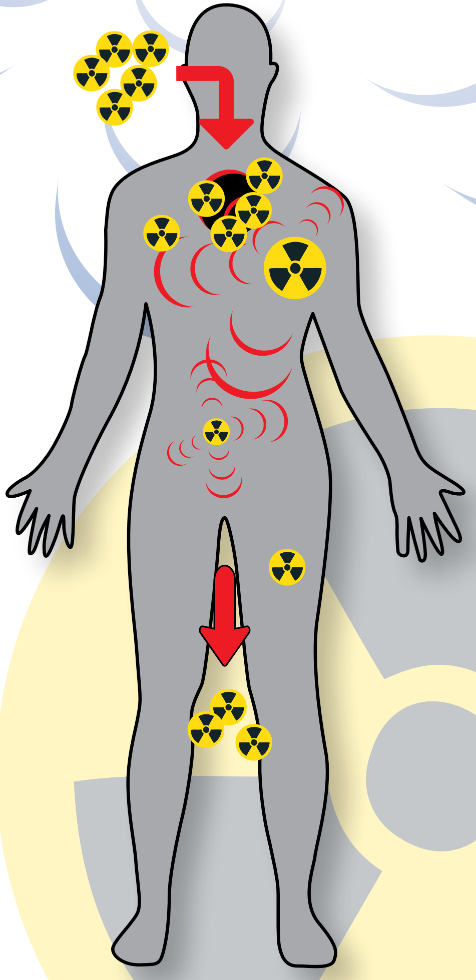
- in case of internal exposure
- in case you are looking for information about radiological contamination.

Contact GAEC in case of a radiological emergency:
Tel: + 30 2106506700
+ 30 2106503540

Greek Atomic Energy Commission
P.O. Box 60092,
Agia Paraskevi
Postal code 15310, Athens
T: +30 2106506700
F: +30 2106506748
Email: info@eeae.gr
www.eeae.gr

Greek Atomic Energy Commission

Radiation exposure due to intake of radionuclides



We live in a world in which radiation is present everywhere, occurring from natural or artificial sources. The exposure is determined by two principal factors: exposure due to radiation of external sources and internal due to radioactive contamination that enters the body and deposits in the human organs. Following the intake, radionuclides deposit in various body organs/tissues and irradiate them until their decay or their excretion. The intake of radionuclides can be obtained by four routes:

- Inhalation of radioactive particles that may be suspended in the air.
- ingestion
- injection
- adsorption.

Inhalation is the main route of intake of radionuclides for occupationally exposed workers.

The Greek Atomic Energy Commission (GAEC) has the appropriate infrastructure for monitoring internal exposure of radionuclides emitting α, β and γ rays; this concerns occupationally exposed workers in places with increased radioactive concentration or workers dealing with open radioactive sources, as well as the general public in cases of radiological emergencies.

Internal exposure measurements are usually applied to workers in the sectors listed below:

- nuclear reactors
- radioisotopes production
- handling of open sources in medical, research and other applications, including radiopharmaceuticals
- handling of volatile radioactive substances and aerosols
- processing with plutonium or other transuranic elements
- mining, treatment and use of minerals and thorium compounds
- uranium mining and exploration
- places with increased natural radioactivity
- response to radiological incidents/accidents.

The extent of incorporated radionuclides, as well as the radiation dose, can be estimated by using the results of monitoring techniques. These results are further analyzed with specified computational algorithms.
In vivo monitoring involves direct measurement of radionuclides deposited in the body or organs like the thyroid, the lungs and the scalp, while in vitro monitoring techniques, involve the indirect measurement of radionuclides in biological samples.

Measurements of biological samples (in vitro)

The biological samples commonly used for internal exposure assessment are urine, nose blows, blood, breath and faeces. In specific cases, hair, teeth and nail samples can also be analyzed.
GAEC has a fully equipped laboratory available to perform radioanalytical measurements. A quality assurance programme is applied.
Methods used are α- and γ- spectrometry.

α-spectrometry

When alpha emitters identification is required, α-spectrometry is employed. In this category belong the actinides (thorium, uranium, plutonium, americium and curium), as well as polonium-210 and radium-226 (table 1). In the case of uranium, this method allows the determination of its origin (natural, depleted, enriched). The equipment used in GAEC`s laboratory is a fully automated and integrated alpha spectroscopic system (Alpha Analyst, Canberra), consisting of 12 Passivated Implanted Planar Silicon (PIPS) detectors with 600 mm^2 active area. To transfer the data from the AAnalyst to an external database, a computer software was developed. This software reads automatically the ASCII report files from the AAnalyst and transforms the data to an appropriate format; the data are stored in the above mentioned database.

Table 1: Radionuclides detected through α-spectrometry in GAEC's laboratory

Thorium	^{232}Th	^{230}Th	^{228}Th	
Uranium	^{238}U	^{236}U	^{235}U	^{234}U
Plutonium	$^{239/240}$Pu	^{238}Pu		
Americium	^{241}Am			
Curium	^{244}Cm	^{243}Cm		
Radium	^{226}Ra			
Polonium	^{210}Po			

Dose assessment after internal exposure

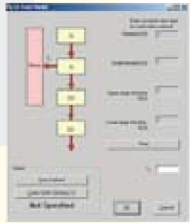
In-vitro measurements

In-vivo measurements

Environmental measurements

Dose assessment

(Biokinetic models)



For this detection method a previously performed radiochemical separation of the radionuclides from the sample is required. Depending on the sample type, it usually involves three steps:

- sample preparation and preconcentration, achieved by: evaporation, microwave digestion, wet and dry ashing.
- chemical separation of the radionuclide achieved by: liquid-liquid extraction and anion/cation exchange.
- preparation of the source of counting by: electrodeposition onto stainless steel plates; in the case of ^{210}Po by spontaneously deposition onto Ni-plates.

The addition of isotopic tracers (^{232}U, ^{229}Th, ^{242}Pu, ^{243}Am, ^{209}Po) permits the calculation of the chemical final yield.

γ-spectrometry

γ-spectrometry is a detection method for radioisotopes emitting γ-radiation, like caesium, (^{137}Cs), cobalt (^{57}Co, ^{60}Co), iodium (^{131}I, ^{129}I, ^{125}I), etc. GAEC is equipped with two high resolution γ-spectroscopy systems with HPGe detectors (CANBERRA) of 70% and 50% relative efficiency. All samples are measured in polyethylene beakers with a volume of 260 ml. The efficiency is determined by a standard multinuclide source, having the same geometry and density with the measured samples. GENIE 2000 (CANBERRA) software is used for the analysis of the obtained spectra. GAEC is accredited by the Hellenic Accreditation Council (ESYD) under the terms of the ELOT EN ISO/IEC 17025 Standard, to carry out tests, as specified in the Scope of the Accreditation: "Radioactivity measurements in samples by gamma spectroscopic analysis, based on a High Purity Germanium detector (HPGe) with relative efficiency 70%".

α and β radiation measurements by Liquid Scintillation Counting

Gross alpha/beta counting can be carried out with the Liquid Scintillation Counter with minimal sample preparation to a low detection limit. Isotopes emitting β radiation of low energy (^{3}H, ^{14}C) are efficiently detected by this method. GAEC has an Ultra Low Level Liquid Scintillation Counter (Quantulus).

For evaluating the radioactive material intake or for additional individual monitoring, samples from the environment can serve as an indication. Radionuclides released to the environment from different sources may enter the atmosphere, surface or groundwater, drinking water and the food chain. For monitoring workers occupationally exposed due to intake of radionuclides, physical samples can also be analyzed. These samples include air samples, surface wipes and smears, and other materials from the workplace.

In vivo measurements

In vivo radiation measurements are performed in GAEC by using a whole body counter and a thyroid uptake system.
The whole body radiation counting is used for determining the radionuclide concentration in the human body emitting gamma radiation.
The whole body counter has a scanning bed geometry and is equipped with two detectors; HPGe of 25% relative efficiency and a sodium iodide (NaI) detector. The detecting system is placed into shielding.
The whole body measurement system is calibrated with a human body phantom or Monte Carlo simulation codes.