ENEA

Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Dose assessment methodologies for the public on the basis of the environmental radioactivity data in the European Union

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EURATOM ARTICLE 35-36 EXPERTS' MEETING 2018

European Commission

Introduction

Results of the project :

“REMME & DARP:
Radioactivity Environmental Monitoring Measurements Evaluation and Dose Assessment for Radiation Protection purposes“

In the framework of the
Collaboration Agreement between
the Italian National Agency for New Technology, Energy and Sustainable Economic Development (ENEA)
Radiation Protection Institute (IRP) and
The Joint Research Centre
Radioactivity Environmental Monitoring* (REM) Group
(march 2016- march 2017)

*Directorate G, Nuclear Safety & Security , Unit G.10 –Knowledge for Nuclear Safety, Security & Safeguards

Environmental monitoring

Principal objectives of a monitoring programme are:

(a) To verify compliance with authorized discharge limits and any other regulatory requirements for the normal operation of a practices with ionizing radiation sources;

(b) To provide information and data for dose assessment purposes

(c) To check the conditions of operation and the adequacy of controls on discharges from the source and to provide a warning of unusual or unforeseen conditions

PROTECTION OF THE PUBLIC AND OF THE ENVIRONMENT

Environmental monitoring

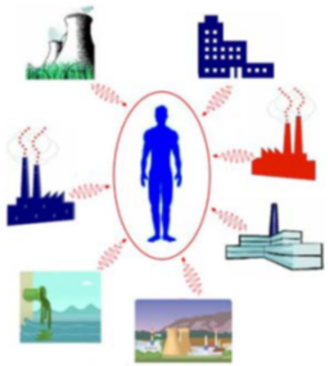
The type of monitoring programme, as well as its scale and extent, is generally commensurate with the source characteristics:

- discharge rates and radionuclide composition,
- different exposure pathways,
- magnitudes of expected and potential doses to individuals.

Every facility should be prepared to conduct emergency monitoring at an appropriate level.

Regulating radiation safety is a national responsibility, however, radiation risks may transcend emission source location.

Regional monitoring programs increase the capacity to control hazards, to respond to emergencies and to moderate any dangerous consequences.



National Report

Country	Ref. Year	Pub. Freq.	Print Pub. Year	Report	Internet- link
AT	2011-2012		Jul-13	RADIOAKTIVITÄT UND STRAHLUNG IN ÖSTERREICH 2011 UND 2012	http://bmg.gv.at/cms/home/attachments/0/5/4/CH1238/CMS1253800995913/radioaktivitaetsbericht_11_12_zusammengefuehrt.pdf
BE	2014	annually	Sep-15	RADIOLOGICAL MONITORING IN BELGIUM SUMMARY REPORT 2014	http://www.fanc.fgov.be/GED/00000000/4000/4060.pdf
BG	2013			НАЦИОНАЛНИЯТ ДОКЛАД ЗА СЪСТОЯНИЕТО И ОПАЗВАНЕТО НА ОКОЛНАТА СРЕДА	http://eea.government.bg/bg/soer/2011/soerbg1r.pdf
CY	2004-2009		2010	ΜΕΤΡΗΣΕΙΣ ΡΑΔΙΕΝΕΡΓΕΙΑΣ ΣΤΟ ΠΕΡΙΒΑΛΛΟΝ ΤΗΣ ΚΥΠΡΟΥ 2004 - 2009	http://www.mlsi.gov.cy/mlsi/dli/dliup.nsf/44E28D6B2820F4C4C2257E2D003ADC5E/$file/ENV_RAD_2004_09_FINAL.pdf
CZ	2014	annually	2015	ZPRÁVA O VÝSLEDCÍCH ČINNOSTI SÚJB PŘI VÝKONU STÁTNÍHO DOZORU NAD JADERNOU BEZPEČNOSTÍ JADERNÝCH ZAŘÍZENÍ A RADIAČNÍ OCHRANOU ZA ROK 2014	https://www.sujb.cz/fileadmin/sujb/docs/zpravy/vyrocni_zpravy/ceske/VZ_SUJB_2014_cast_II_fin.pdf
DE	2013	annually	Jul-15	UMWELTRADIOAKTIVITÄT UND STRAHLENBELASTUNG JAHRESBERICHT 2013	https://doris.bfs.de/jspui/bitstream/urn:nbn:de:0221-2015072112949/1/JB2013.pdf
DK	2015	six months	2015	RADIOACTIVITY IN THE RISØ DISTRICT JANUARY-JUNE 2015	http://orbit.dtu.dk/files/119459540/Radioactivity_in_the_Ris_District_January_June_2015.pdf
EE	2014	annually	May-15	KESKKONNA IONISEERIVA KIIRGUSE SEIRE 2014. AASTA TULEMUSED	http://keskkonnaamet.ee/public/kiirgus/kiirgusseire_aruanne_2014.pdf
ES	2013	annually	2014	PROGRAMAS DE VIGILANCIA RADIOLÓGICA AMBIENTAL RESULTADOS 2013	https://www.csn.es/documents/10182/1001013/Programa%20de%20vigilancia%20radiol%C3%B3gica%20ambiental.%20Resultados%202013
FI	2014	annually	2015	YMPÄRISTÖN SÄTEILYVALVONTA SUOMESSA	http://www.julkari.fi/bitstream/handle/10024/126942/stuk-b190.pdf?sequence=1
FR	2015	annually	2015	BILAN DE LA SURVEILLANCE DE LA RADIOACTIVITÉ EN POLYNÉSIE FRANÇAISE EN 2014 SYNTHÈSE DES RÉSULTATS DU RÉSEAU DE SURVEILLANCE DE L'IRSN	http://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN_Surveillance-Polynesie-2014_SESURE-2015-34_FR.pdf
	2015	annually	2015	EXPOSITION DE LA POPULATION FRANÇAISE AUX RAYONNEMENTS IONISANTS	http://www.irsn.fr/FR/expertise/rapports_expertise/radioprotection-homme/Pages/Exposition-population-francaise-rayonnements-ionisants-2015.aspx#.VgCZ1p1wZaQ
	2011-20the reported data could be not exhaustive14		2015	BILAN DE L'ÉTAT RADIOLOGIQUE DE L'ENVIRONNEMENT FRANÇAIS DE JUIN 2011 À DÉCEMBRE 2014	http://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN_surveillance_France_2011-2014.pdf
GB	2014	annually	Oct-15	RADIOACTIVITY IN FOOD AND THE ENVIRONMENT, 2014	https://www.food.gov.uk/science/research/radiologicalresearch/radiosurv/rife/radioactivity-in-food-and-the-environment-rife-report-2014
GR				-	-
HR	2014	annually	2015	PRAĆENJE STANJA RADIOAKTIVNOSTI ŽIVOTNE SREDINE U REPUBLICI HRVATSKOJ	At the moment reports are available on request.
	2014	annually	2015	IZVJEŠTAJ O ISPITIVANJU PRAĆENJE-PRAĆENJE STANJA RADIOAKTIVNOSTI ŽIVOTNE SREDINE U REPUBLICI HRVATSKOJ TIJEKOM 2014	At the moment reports are available on request.

The reported data could be not exhaustive

National Report

Country	Ref. Year	Pub. Freq.	Print Pub. Year	Report Title	Internet- link
HU	2013	annually	Apr-15	A HATÓSÁGI KÖRNYEZETI SUGÁRVÉDELMI ELLENŐRZŐ RENDSZER 2013	http://www.hakser.hu/eredmenyek/2013/hakser2013.pdf
IE	2014	annually	Jun-14	RADIATION DOSES RECEIVED BY THE IRISH POPULATION 2014	http://www.epa.ie/radiation/publications/rad/RPII_Radiation_Doses_Irish_Population_2014.pdf
	2010-2011		Nov-12	RADIOACTIVITY MONITORING OF THE IRISH ENVIRONMENT 2010–2011	http://www.epa.ie/radiation/publications/rad/RPII_Env_Mon_Rep_10_11_12.pdf
IT	2015	-	Jul-15	MANUALE RETE RESORAD	http://www.arpa.veneto.it/temi-ambientali/agenti-fisici/file-e-allegati/resorad/Manuale%20della%20rete%20RESORAD.pdf/view
	2014-2015	annually	2015	ANNUARIO DEI DATI AMBIENTALI - EDIZIONE 2014-2015	http://www.isprambiente.gov.it/it/pubblicazioni/stato-dellambiente/annuario-dei-dati-ambientali-edizione-2014-2015
	2002		Oct-05	RETI NAZIONALI DI SORVEGLIANZA DELLA RADIOATTIVITÀ AMBIENTALE IN ITALIA 2002	http://www.paa.gov.pl/sites/default/files/2000L191-37.pdf
LT	2014	annually	2015	APLINKOS APSAUGOS AGENTŪROS 2014 METAIS VYKDYTO VALSTYBINIO APLINKOS RADIOLOGINIO MONITORINGO REZULTATAI	http://gamta.lt/files/RM%20duomenys%202014_AAA_tinklalapiui1437985949061.pdf
LU	2016	monthly	2016	SURVEILLANCE DE LA RADIOACTIVITÉ DANS L'ENVIRONNEMENT AU GRAND-DUCHÉ DE LUXEMBOURG	http://www.sante.public.lu/fr/publications/s/surveillance-radioactivite-lux-2016-1
LV	2004-2007		2008	NACIONĀLAIS ZIŅOJUMS PAR VIDES STĀVOKLI 2008	http://meteo.lv/fs/CKFinderJava/userfiles/files/Vide/Stavokla_parskati/Nacionalais_zinojums_vides_stavoklis.pdf
MT				-	

Country	Ref. Year	Pub. Freq.	Print Pub. Year	Report Title	Internet- link
NL	2013	annually	2015	ENVIRONMENTAL RADIOACTIVITY IN THE NETHERLANDS RESULTS IN 2013	http://www.rivm.nl/dsresource?objectid=rivmp:282813&type=org&disposition=inline&ns_nc=1
PL	2014	annually	2015	ANNUAL REPORT ON THE ACTIVITIES OF THE PRESIDENT OF THE NATIONAL ATOMIC ENERGY AGENCY AND ASSESSMENT OF NUCLEAR SAFETY AND RADIOLOGICAL PROTECTION IN POLAND IN 2014	http://paa.gov.pl/strona-180-president_s_annual_report.html
PT	2013	annually	2015	PROGRAMAS DE MONITORIZAÇÃO RADIOLÓGICA AMBIENTAL (ANO 2013)	http://www.itn.pt/docum/relat/radiolog/rel-vig-radiol2015.pdf
RO	2014	annually	2015	RAPORT ANUAL PRIVIND STAREA MEDIULUI ÎN ROMÂNIA, ANUL 2014	http://www.anpm.ro/documents/12220/2209838/RSM.2014.pdf/4dbde2ae-a7a4-43ef-8abc-67511d11715f
SE	1950-2007			SSI RAPPORT 2007:02	http://www.stralsakerhetsmyndigheten.se/Yrkesverksam/Miljoovervakning/Radioaktiva-amnen/Radionuklider-pa-partiklar-i-luft/
SI	2014	annually	Jul-15	ANNUAL REPORT 2014 ON RADIATION AND NUCLEAR SAFETY IN THE REPUBLIC OF SLOVENIA	http://www.ursjv.gov.si/fileadmin/ujv.gov.si/pageuploads/si/Porocila/LetnaPorocila/2014/Annual_report.pdf
	2014	annually	Mar-2015	NADZOR RADIOAKTIVNOSTI V OKOLICI NUKLEARNE ELEKTRARNE KRŠKO	http://www.nek.si/uploads/documents/Porocilo2014.pdf
SK	2014	annually	May-2015	ZÁVEREČNÁ ROČNÁ SPRÁVA ČIASTKOVÉHO MONITOROVACIEHO SYSTÉMU „RÁDIOAKTIVITA ŽIVOTNÉHO PROSTREDIA" 2014	http://www.shmu.sk/File/radioaktivita/Zaverecna_sprava_CMS_Radioaktivita_2014_final.pdf

The reported data could be not exhaustive

National Report

The record keeping system of environmental monitoring results is generally designed to retain all relevant information about :
the collection of individual samples,
the measurements of samples,
the calibration procedures and uncertainties,
the summaries of the results that are reported routinely.

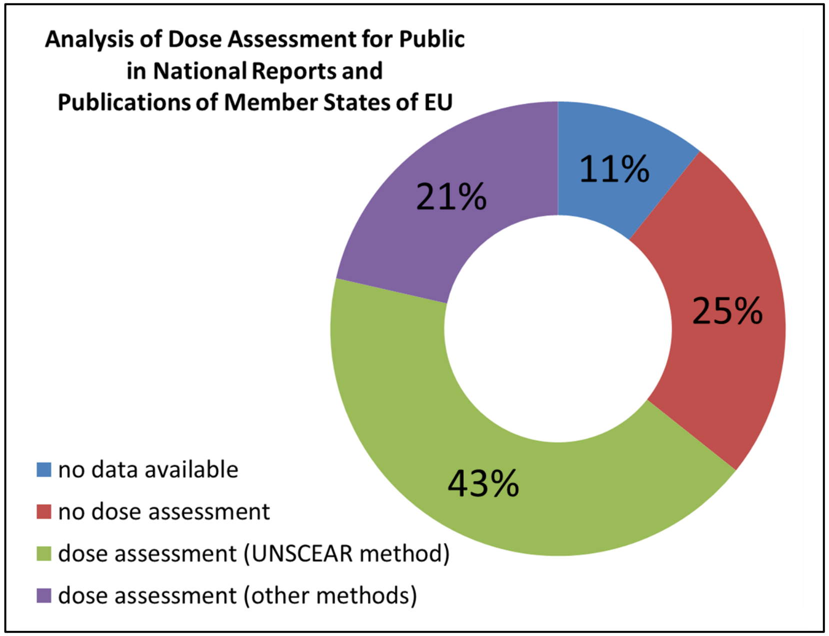
The summary reports are generally published at defined intervals (e.g. monthly, six-monthly, annually).

Specific report on Dose Assessment of the Public are published in some European Country (e.g. United Kingdom, Ireland, France, Sweden, Lithuania), and in other Member States the dose evaluation is part of Environmental Monitoring Report or Yearbook.

National Report

This first study(*) of the National reports shows the inhomogeneity in the presentation of results of dose assessment for the public:

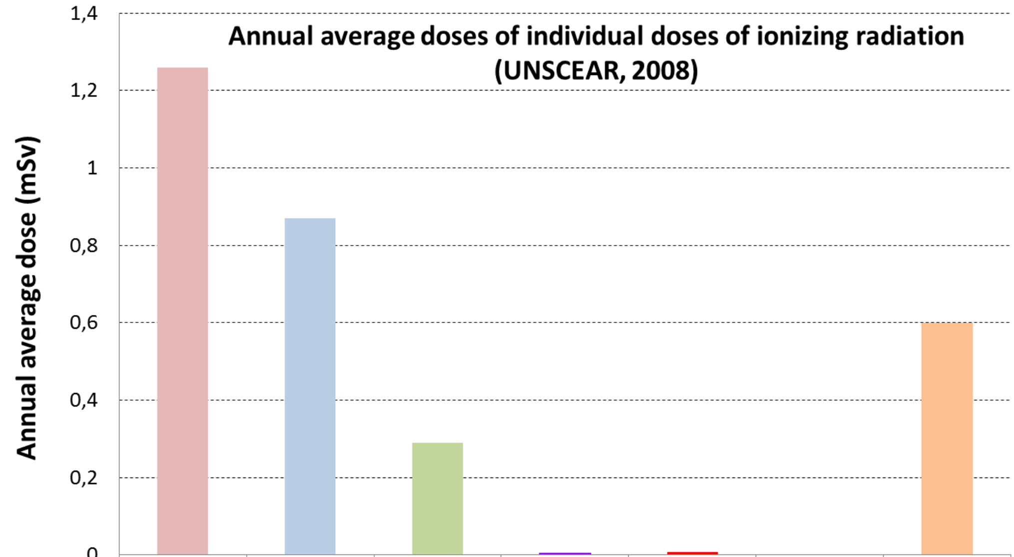
- no data was found for 3 countries,
- in 7 national reports there were not dose evaluations ,
- for 18 Member States there are dose assessments for public in available publications (in 12 cases the dose calculations refer to UNSCEAR methodologies) ,



(*) The study try to collect all public and available information by way of example, without be exhaustive.

- rarely diversification in dose assessments for different population groups (adults, children, and infants),
- in some specific site monitoring reports, the effective collective dose is estimated within 30 km from the site.

Annual average doses worldwide of ionizing radiation - UNSCHEAR



	Inhalaion (radon gas)	External Terrestrial and Cosmic Radiation	Ingestion (natural sources)	Occupational exposure	Chernobyl accident and atmosferic nuclear testing	Nuclear fuel cycle (public exposure)	Medical diagnosis
Annual average dose (mSv)	1,26	0,87	0,29	0,005	0,007	0,0002	0,6

Natural sources (~80%)

Man-made sources (~20%)

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) methodology values the exposure of the public to several different natural and man-made sources of radiation.

Dose Limit

The dose evaluation is an important part of the radiation protection system to verify and ensure the health of the population.

When ionizing radiation passes through matter, including living tissue, it deposits energy that produces ionization and excitation in the matter.
The biological damage caused by radiation is related to the amount of energy deposited.

In radiation protection the quantity called the Effective Dose is used as indicator of the potential biological effects associated with exposure to ionizing radiation in humans.

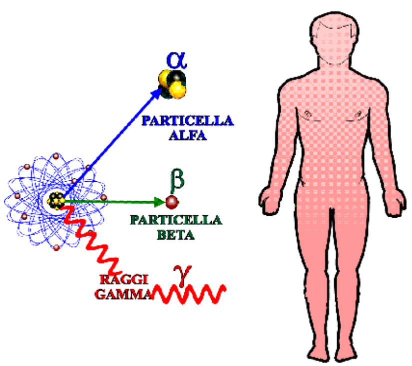
The International Commission on Radiological Protection (ICRP) quantified the risks of stochastic effects of radiation and proposed a system of dose limitation.

Member States shall set the limit on the effective dose for public exposure at 1 mSv in a year.

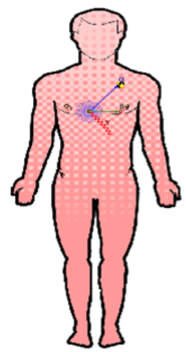
Human exposure pathways and Effective Dose

An exposure pathway defines routes from a source of radionuclides and/or radiation to a target individual or a population through media in the environment.

There are **two main categories of exposure pathway**:



external exposure
(the source of exposure remains outside the body)



internal exposure
(the source of exposure is incorporated into the body by inhalation and ingestion)

The computation of the **annual effective dose E** requires to quantify all the contributions :

$$E = E_{ext} + E_{ing} + E_{inh}$$

The dose is usually not obtained by individual monitoring as for occupational exposure but is mainly determined by environmental measurements, habit data, and modelling.

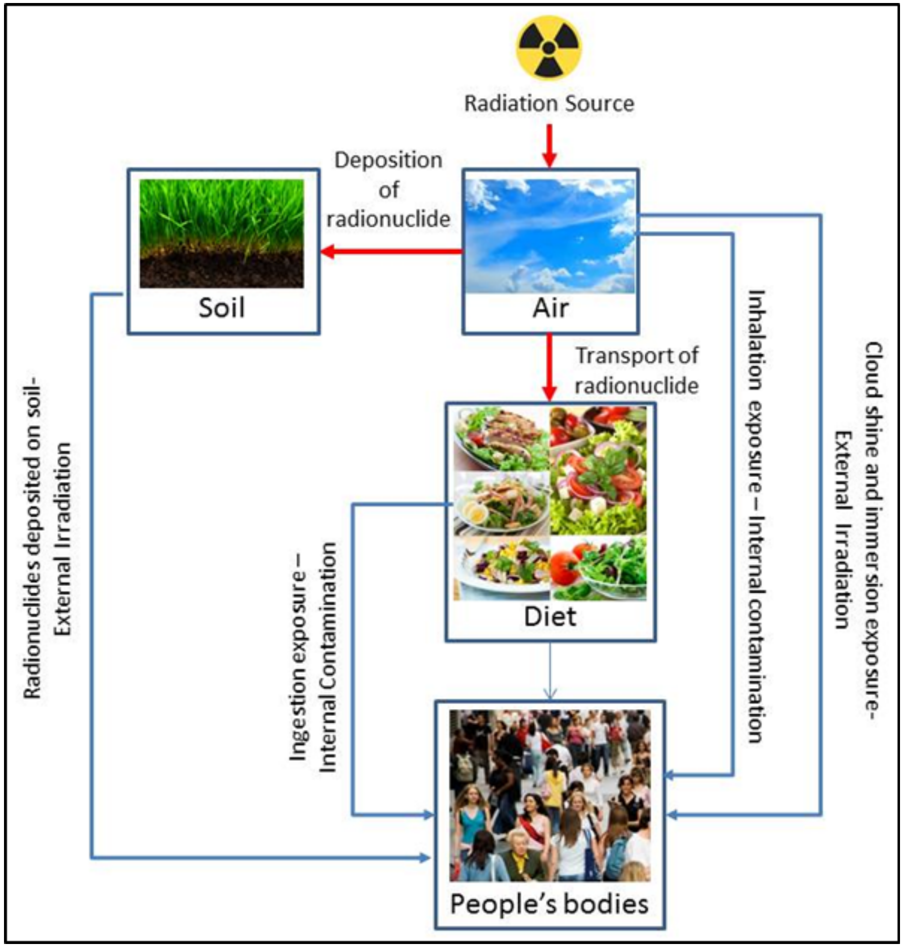
Retrospective Dose Assessment

The **retrospective dose assessment** for the public is based on the identification of a representative person and the use of **measured activity concentrations** in environmental media.

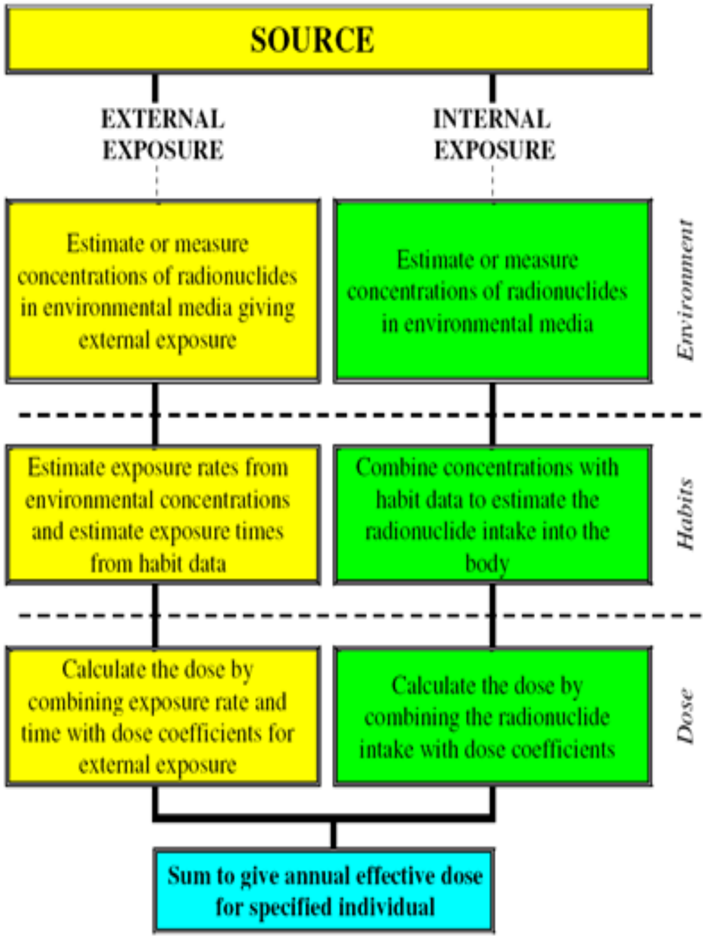
In real condition measurement results are not available at any point in the chain, the calculation of the movement of radioactivity from different compartment are described in **models** which use transfer coefficients to describe environmental behavior and transport of radionuclides.

Models need to take account of both **accumulation** in the environment (e.g. Pu-239 has a long half-life and can build up in the local environment) and **progeny ingrowth** (e.g. Pu-241 decays into Am-241, which is more radiologically harmful).

Transfer of radionuclides through the environment



Dose Assessment – Multistage process



Dose assessment can be described as a multistage process (ICRP101a):

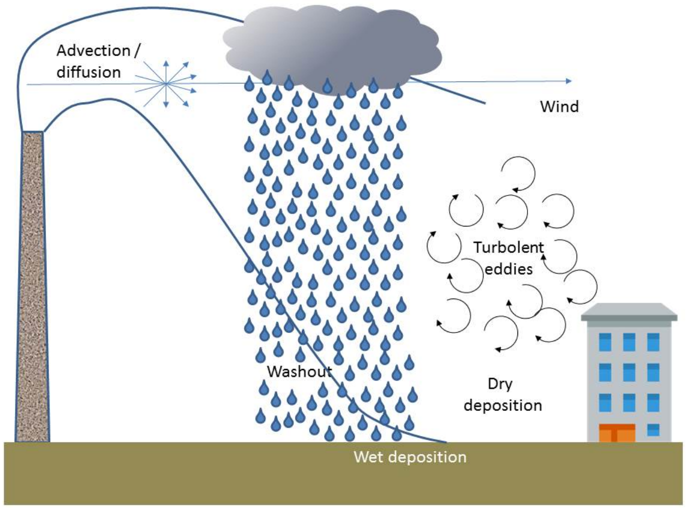
- identification of radiation fields and sources quantification
- estimation of radionuclides concentration under investigation in environmental media
- information about habit data based on exposure scenario of the relevant person or group
- using of dose coefficients to assess effective dose contributions
- summing of all contributions from external and internal exposure as appropriate

First stage: identification of radiation fields

The first stage is to obtain information about the source, including data on the types and quantities of radionuclides and radiations emitted (eg. ^{3}H - ^{137}Cs - ^{90}Sr - ^{131}I - ^{129}I - $^{239/240}Pu$ - ^{241}Am).

The source of the exposure should be characterised.

In the case of discharges to the environment, this characterisation should include discharges for radionuclides of interest, stack heights, proximities of relevant neighbouring buildings, physical and chemical forms of the material, and meteorological conditions.



Models are optimized for estimating radionuclide concentration in water and sediment from routine radionuclide discharge into surface water (river/estuaries/ coastal water/lakes).

Second stage: radionuclides concentration in environmental media

In the second stage, environmental concentrations at various locations are obtained by measurements, by modelling the dispersion, deposition, and transport of radionuclides through environmental media, or by a combination of both.

For doses due to **external exposures**, either the concentrations in air, soil, or water, or the external dose rates are needed.

For doses due to **internal exposures**, it is necessary to know concentrations in food, water, or air that may be taken into the body.

Principal measurement category for environmental media of dense and sparse networks (Recommendation 2000/473/Euratom)

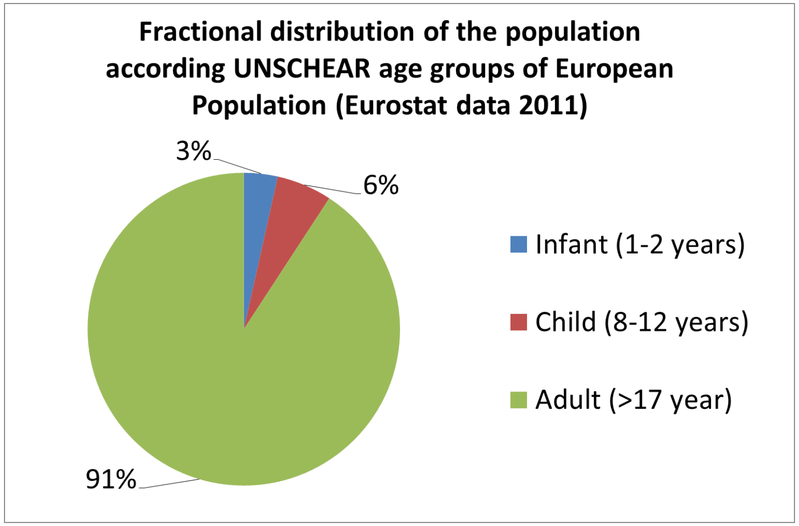
Media	Measurement Category	
	Dense Network	Sparse Network
Airborne particulate	^{137}Cs, gross beta	^{137}Cs-, ^{7}Be
Air	Ambient gamma dose rate	
Surface water	^{137}Cs, residual beta	^{137}Cs
Drinking water(*)	^{3}H, ^{90}Sr, ^{137}Cs	^{3}H, ^{90}Sr, ^{137}Cs
Milk	^{90}Sr, ^{137}Cs	^{90}Sr, ^{137}Cs, ^{40}K
Mixed diet	^{90}Sr, ^{137}Cs	^{90}Sr, ^{137}Cs, ^{14}C

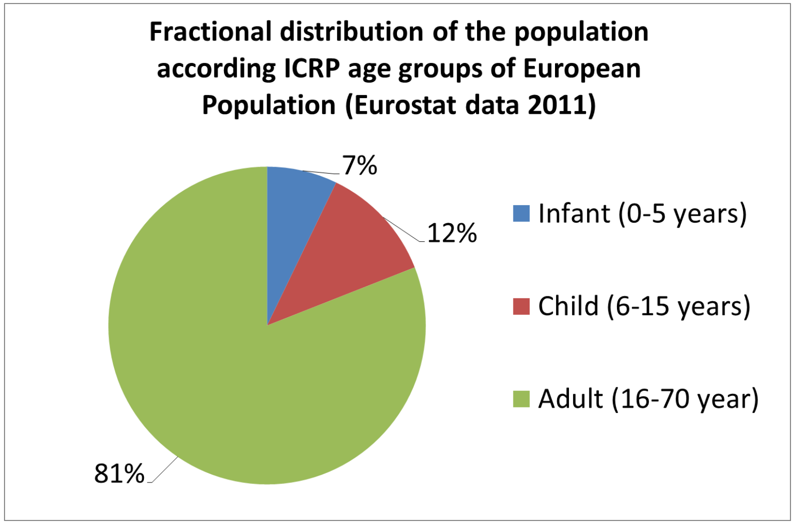
Third stage: habit data (1)

The third stage of the process is to combine concentrations with habit data that are selected based on exposure scenarios of the relevant person or group.

For external exposures, the amount of time spent in different radiation fields is needed, while for internal exposures, information on the amount of food and water consumed or air breathed is required to estimate activity intakes.

Information to be considered includes: location, diet, lifestyle activities leading to radiation exposure, age-dependent physiological factors.





Third stage: habit data (2)

It is recommended to use the more appropriate database for a more realistic dose assessment really referred to local habit.

Three age categories (ICRP 101a)	Milk consumption (kg/year)	Green vegetable consumption (kg/year)	Beef consumption (kg/year)	Inhalation Rate (m^3/h)
Infant (1-year old)	320	30	20	0.22
Child (10-year-old)	240	35	30	0.64
Adult	240	80	45	0.94

World Region (IAEA SRS n°19,2001)	Milk consumption (kg/year)	Grain, root crops, vegetables and fruits consumption (kg/year)	Beef consumption (kg/year)	Water (L/year)
Europe	250	410	100	600

Three age categories	Inhalation Rate(m^3/year)		
	UNSCEAR 2000	IAEA,SRS n°19 (2001)	ICRP 101a (2006)
Infant	1927 (0.22 m^3/h)	1400 (0.16 m^3/h)	1927 (0.22 m^3/h)
Child	5606 (0.64 m^3/h)	-	5606 (0.64 m^3/h)
Adult	8234 (0.94 m^3/h)	8400 (0.96 m^3/h)	8234 (0.94 m^3/h)

Third stage: habit data (3)

Member States should measure foodstuffs and complete meals to report the average level of radioactivity in mixed diet (Recommendation 2000/473/Euratom).

Data: average level of radioactivity in ingredients and composition of the diet

Data: average level of radioactivity from canteens/ restaurants

The losses in food preparation and the variation in intakes of radionuclides can be used to ensure that doses are not systematically overestimated.

Drying foods increases the concentrations in the dried products, typically by a factor of 5 compared with the fresh foods. Boiling meat considerably reduces the radionuclide content. Radionuclide contents in vegetables and fruits are affected by washing, peeling, and cooking.

Fourth stage: external exposure

The fourth stage of the dose-assessment process is the computation of separate quantities : external exposure and internal exposure.

The external exposure could be computed applying the following formula:

$$E_{ext} = H^{*}(10)_{indoor} + H^{*}(10)_{outdoor} = H^{*}(10)_{detect.} \times (1 - F_{0}) + H^{*}(10)_{detect.} \times F_{0} \times F_{S}$$

Where:

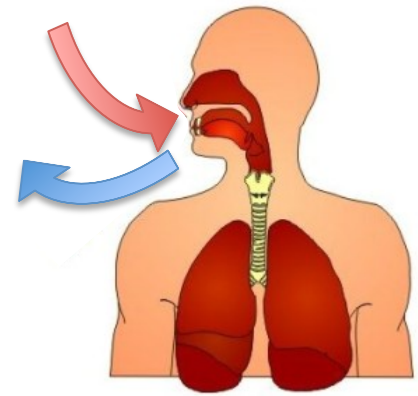
- E_{ext} is effective dose due to external exposure
- H*(10)detect. is the result of measured data (ambient dose equivalent rate) without the contribution of natural radiation background,
- F_0 is the indoor occupancy factor (generally 0.8),
- F_S is the general building shielding factor, it is the ratio of indoor to outdoor dose rate and its value could be equal to 0.2.

The releases from nuclear installations of radionuclides that contribute to external exposure are, in general, too low to be measured in air or deposition at distance beyond the installation site and point of release.

Fourth stage: internal exposure - inhalation

The annual effective dose from inhalation E_{inh} (Sv/year) could be computed applying the following formula:

$$E_{inh} = \sum_{i} E_{inh,i} = \sum_{p} C_{air,i} \times R_{inh} \times D_{inh,i} \times (1-F_{0})$$
$$+ \sum_{i} C_{air,i} \times R_{inh} \times D_{inh,i} \times F_{0} \times F_{R}$$



Where:

- $C_{air,i}$ is the radionuclide concentration in air (Bq/m^3),
- R_{inh} is the inhalation rate (m^3/year),
- $D_{inh,i}$ is the inhalation dose coefficient for the i radionuclide (Sv/Bq),
- F_0 is the indoor occupancy factor,
- F_R is the ratio of indoor to outdoor air concentration. This parameter should be assigned a value of 0,3 during a specific release.

Estimates of inhalation exposure from releases of radionuclides from nuclear installations may be made using dispersion model.

Fourth stage: internal exposure - ingestion

The internal exposure contribution due to the ingestion of contaminated food and/or drinking water could be estimated on the basis of environmental monitoring data by the use of a simple calculation model:

$$E_{ing} = \sum_{p} \sum_{i} E_{ing,p,i} = \sum_{p} \sum_{i} C_{p,i} \times R_{ing,p} \times D_{ing,i}$$

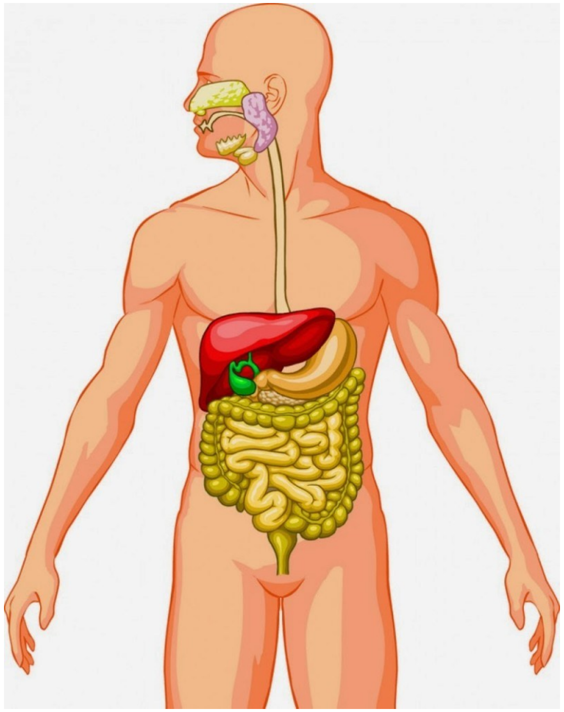
Where:

$E_{ing,p}$ (Sv/year) is the annual effective dose from consumption of nuclide i in foodstuff subset p/ water,

$C_{p,i}$ is the concentration of radionuclide i in foodstuff p/water at the time of consumption (Bq/kg),

$R_{ing,p}$ is the consumption rate for foodstuff p/ water (kg/year),

$D_{ing,i}$ is the dose coefficient for ingestion of radionuclide i (Sv/Bq).



Fifth stage: total annual dose

The final stage is to sum all contributions from external and internal exposure in a total annual dose.

$$E = E_{ext} + E_{ing} + E_{inh}$$

- For dose assessments the dose coefficients published in the EURATOM Directive should be used.

Radionuclide	Absorption Type for particulate	Dose Coefficient for INFANT (Sv/Bq) (1-2 years)		Dose Coefficient for CHILD (Sv/Bq) (7-12 years)		Dose Coefficient for ADULTS(Sv/Bq) (> 17 years)	
		Inhalation	Ingestion	Inhalation	Ingestion	Inhalation	Ingestion
Sr-90	M	$1.0\ 10^{-7}$	$7.3\ 10^{-8}$	$5.1\ 10^{-8}$	$6.0\ 10^{-8}$	$3.6\ 10^{-8}$	$2.8\ 10^{-8}$
Cs-137	F	$5.4\ 10^{-9}$	$1.2\ 10^{-8}$	$3.7\ 10^{-9}$	$1.0\ 10^{-8}$	$4.6\ 10^{-9}$	$1.3\ 10^{-8}$
Pu-239/Pu-240	M	$7.7\ 10^{-5}$	$4.2\ 10^{-7}$	$4.8\ 10^{-5}$	$2.4\ 10^{-7}$	$5.0\ 10^{-5}$	$2.5\ 10^{-7}$

- Expert judgement could be used to determine the most appropriate chemical form for use in the assessment, rather than assuming the chemical form that leads to the highest dose coefficient.

- It is recognised that the use of three age categories is recommended for estimating the annual dose to the representative person dose assessments.

I wish to thank:

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Thank you for attention!

Health effects to exposure to ionizing radiation

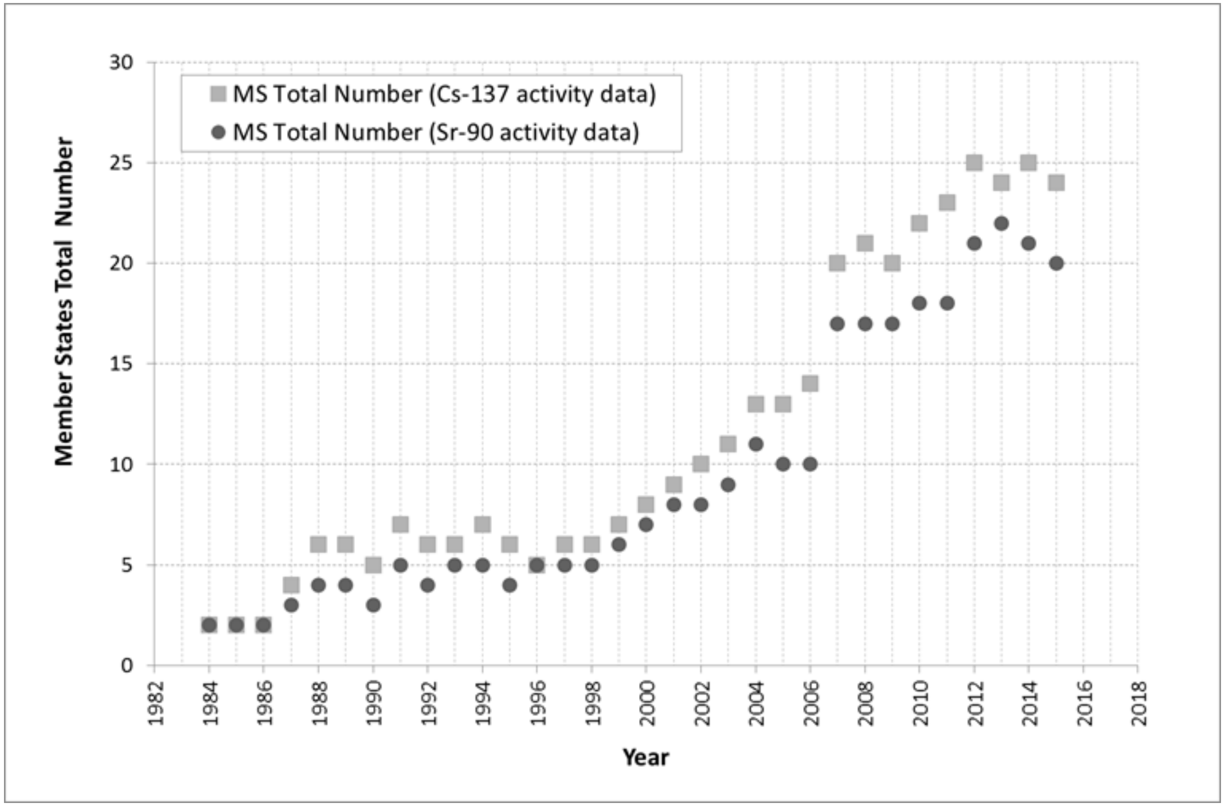
For the induction of cancer and heritable disease at low doses/low dose rates the use of a simple proportionate relationship between increments of dose and increased risk is a scientifically plausible assumption; uncertainties on this judgement are recognised.

International radiation safety standards have taken the UNSCEAR estimates and ICRP recommendations into account, with a rounded overall **nominal risk coefficient** of **~5% Sv^{-1}**. This approach forms the basis of the international requirements for protecting people against radiation in planned exposure situations (IAEA, 1996; IAEA, 2011) but not for assessing dead bodies.

Stochastic effects of radiation-induced cancers are collectively (not individually) attributable, and only in the case that radiation doses are sufficiently high as to permit epidemiological discernment.

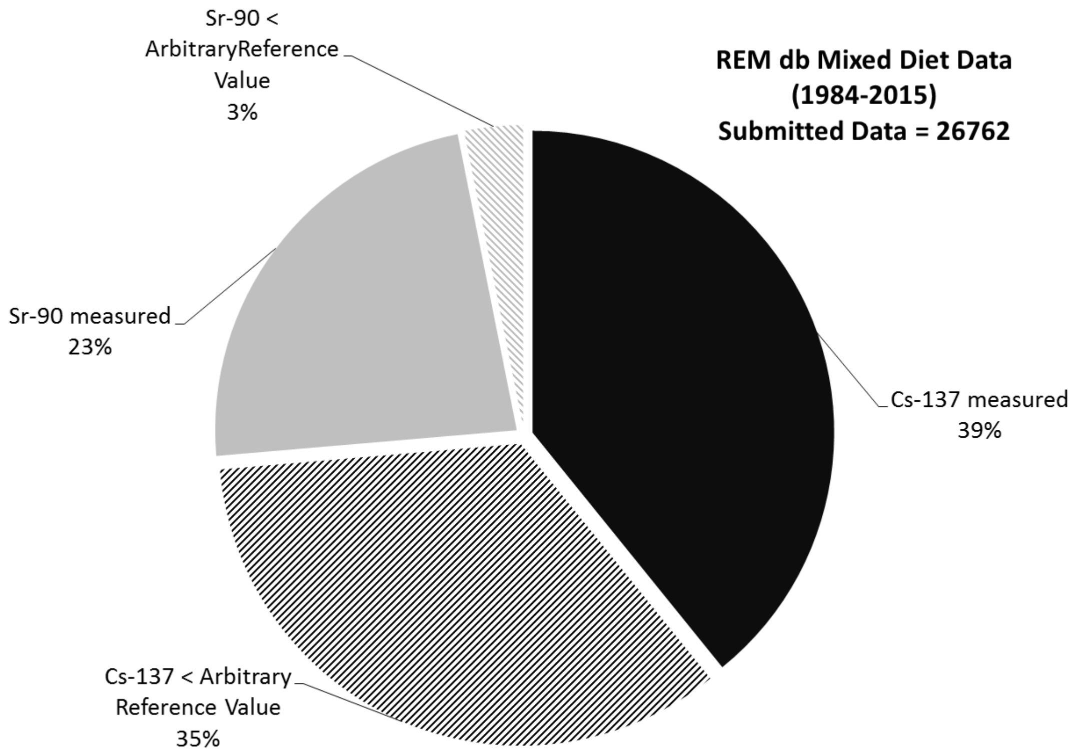
Preliminary Analysis of REM data of Mixed Diet

Historical increment of the submission data in REMdb, starting from 1984 to 2015 for ^{137}Cs and ^{90}Sr (other radionuclide such as ^{40}K and ^{134}Cs were been measured in less than 0.1% of submitted data).



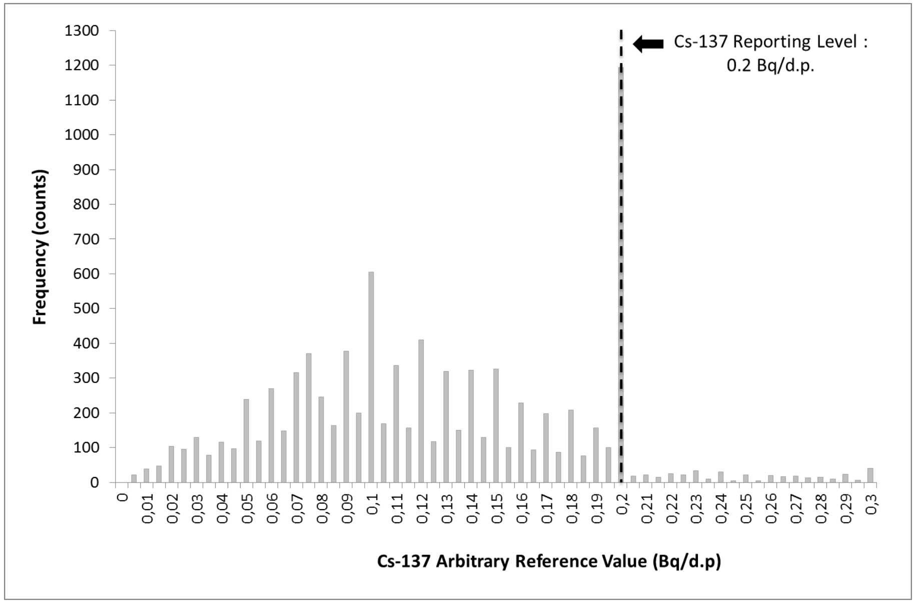
Preliminary Analysis of REM data of Mixed Diet

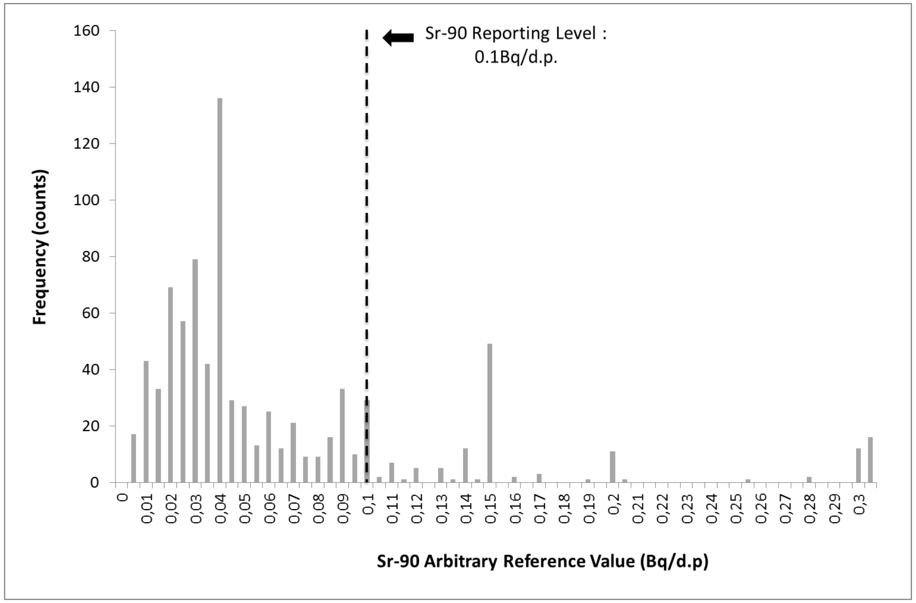
Total number of REMdb measurements of mixed diet divided for radionuclide (Sr-90 measurements are in grey and Cs-137 measurements are in black) and type of values declared



Preliminary Analysis of REM data of Mixed Diet

The distribution of arbitrary reference value for Cs-137 (on the left) and Sr-90 (on the right) present in REMdb and reporting level required by Commission Recommendation 2000/473/Euratom for these measurements.





Bq/d.p.=Becquerel per person per day.

Preliminary Analysis of REM data of Mixed Diet

Median of measured values for the annual distributions of Cs-137 (in black) and Sr-90 (in grey) in mixed diet of REMdb.