United Nations Scientific Committee on the Effects of Atomic Radiation

ELECTRONIC ATTACHMENT 1

COMPARISON OF THE COMMITTEE'S EARLIER AND CURRENT METHODOLOGIES

UNSCEAR 2016 Report, Annex A,
Methodology for estimating public exposures due to radioactive discharges

Contents

The following tables in this attachment contain a comparison of various features of the Committee’s earlier and current methodologies for estimating exposures from radioactive discharges, and a comparison of estimates of collective doses using the current methodology with those using the previous methodology for various pathways of exposure.

Notes

This publication has not been formally edited.

Table 1. Features of the earlier and current methodologies

Factors	*Earlier methodologies*	*Current methodology*
REGIONAL CONSIDERATIONS		
Site location	Regional factors not considered, except in assessment of impacts from coal-fired power stations in [U3]	Regional variations in population density, consumption rates and fish catch reflected
Population distribution	Average population density for all sites used	Absolute number of people around each nuclear site (electronic attachment 3) and density information for other types of facility
Consumption rates	Global average values used to represent total consumption of foods	Regional consumption rates *(a)* for individual dose calculations from discharges to atmosphere and from aquatic discharges, and *(b)* as intermediates in calculation of collective dose from discharges to atmosphere. For collective doses from aquatic discharges, some regional variations in fish catch and irrigation rates reflected
Occupancy	Global average values used	Comparison of indoor/outdoor occupancy demonstrates little variation and no climatic trend; thus, similar global average values used
Irrigation	Methodology referenced to [C1]; further details not provided	Regional/climatic factors influence both proportion of crops irrigated and irrigation rate. Approach based on FAO data on proportion of water withdrawals for agricultural use and proportion of agricultural land irrigated for different regions
Water treatment	Drinking water treatment removal factors presented in table 27, annex A [U4]; no regional factors considered	Single set of (radionuclide-specific) water treatment factors appropriate for simple water treatment methods applied for all regions
Inhalation and water ingestion rates	No regional factors considered	No regional factors considered
FEATURES OF THE SCENARIO		
Discharges	Radon discharges from operational and remediated tailings from uranium mining and milling assuming different discharges for each phase Discharges from reactors to atmosphere of noble gases (specified separately for PWRs, BWRs and GCRs), tritium, ^{14}C, ^{131}I and particulates (representative composition assumed); aquatic discharges of tritium and particulates Radionuclide-specific information for fuel reprocessing sites (tritium, ^{14}C, ^{85}Kr, ^{131}I and ^{129}I and ^{137}Cs for discharges to atmosphere and tritium, ^{14}C, ^{90}Sr, ^{106}Ru, ^{129}I and ^{137}Cs in aquatic discharges)	Radionuclides contributing most to collective dose are: noble gases, tritium, ^{14}C and some particulates. Naturally occurring radionuclides included for early stages of nuclear fuel cycle and non-nuclear facilities Focus on calculating dose per unit discharge of specific radionuclides; radionuclide grouping assumed depending on application

Factors	*Earlier methodologies*	*Current methodology*
Site description	Characteristics of model sites specified in [U2] for mining and milling, fuel fabrication, reactor operation and reprocessing. Stack height and population density based on data for USA and western Europe	Location-specific factors, include population distribution and location relative to the coast, determines whether freshwater or marine discharges appropriate
REGIONAL FACTORS RELATED TO LOCATION OF SITE		
Population distribution	Population density information representative of early 1980s.[a] For power generation: densities of 400 km^{-2} within 50 km and 20 km^{-2} for 50–2,000 km. For mines: 3 km^{-2} within 100 km and 25 km^{-2} for 100–2,000 km	UNEP analysed population numbers within set distances from each nuclear site. Regional-average data used in deriving dose calculation factors
Stack height	30 m (power generation); 10 m for mine and mill tailings	30 m for all sites (influence of stack height discussed in electronic attachment 4)
Form of aquatic discharge	Application of marine and freshwater modelling unclear, although reference in [U2]	Unless known, application of marine or freshwater models determined from site location relative to coast. Coastal sites assumed to discharge to sea, inland sites assumed to discharge into a river (nuclear facilities assumed to discharge into a large river). Mines and mills and non-nuclear facilities assumed to discharge into a small river
GENERAL CONSIDERATIONS FOR DOSE ASSESSMENT		
Endpoints	Local, regional and global components of collective effective dose. Some per caput and critical group doses	Collective dose information in form of matrix, including characteristic individual doses in local populations (e.g. at 5 km for terrestrial pathways) and local, regional and global components of collective doses integrated to 100 years; characteristic individual doses from terrestrial pathways calculated at 5 km from site; those from freshwater discharges based on activity concentrations in water assuming instantaneous mixing at representative river flow rates; those from marine discharges derived from activity concentrations within local and regional compartments; collective doses from discharges into freshwater bodies derived from *(a)* fraction of volume abstracted for drinking water, *(b)* freshwater fish catch per unit length (related to volume) of river; collective doses from marine discharges derived from *(a)* fish catch data per unit volume for local and regional compartments, *(b)* mollusc and crustacean catch data per unit length of coastline applied
Integration period (for collective dose)	Before 2008, integration period of 10,000 years used, and [U3] used to derive values for 100 years[b] [U2] indicates that future maximum dose rate only be integrated to expected length of practice (500 years assumed for nuclear power)	Local, regional and global components of collective doses integrated to 100 years. Global component estimated for other integration periods—500, 10,000 years and infinity (taken as 10^8 years)—from global dispersion (presented for information)

Factors	*Earlier methodologies*	*Current methodology*
Dispersion in atmosphere	Dispersion factors based on long-term sector-averaged Gaussian-plume model; uncertainty and sensitivity of approach reviewed in [U4]	General approach still appropriate for generic assessment, and results within factor of 10 of those from more complex models. Approach modified to account for radioactive decay of short-lived radionuclides (notably of radon) and supplemented to derive matrix of dose information, using various methods, including [I3, S1]. Approach retained and activity concentration data compared with existing model results
Dispersion in aquatic environment	Factors based on total volume of freshwater bodies; dispersion model for discharges to marine environments was simple single compartment model [U2], and assumed that North Sea exchange rates representative from information in [C1]. Residence times based on data for ^{137}Cs, ^{90}Sr and ^{239}Pu	Simple two-box model defined for dispersion in coastal seas and single box model for deep-sea environments (for discharges from oil and gas platforms) Discharges into freshwater bodies assumed to be instantaneously diluted into a representative river
Dosimetric quantities	Internal dose coefficients [I6, I7]	No change required currently. Update will need to be considered when new ICRP dose coefficients become available
ENVIRONMENTAL BEHAVIOUR OF RADIONUCLIDES		
Terrestrial	Empirical transfer parameters, primarily based on fallout data for ^{137}Cs and ^{90}Sr, supplemented by transfer factors for grain for other radionuclides, except ^{131}I, for which transfer factor for milk used	Activity concentrations based on recent compilation of transfer parameters
Aquatic	Transfer parameters and K_d values derived from [I1, I2]	Transfer parameters from [I4, I5]
Irrigation	No details given, but referenced to [C1]	Simple approach applied that account for regional differences in abstraction of water for irrigation and application. Transfer parameters applied consistent with approach for deposition from atmosphere. FAO data on abstraction for irrigation applied and region-specific cereal yields used in assessing collective dose
EXTERNAL IRRADIATION		
Radionuclides in air: exposure from radionuclides in air	Dose coefficients based on [E1] for semi-infinite cloud model and effective dose equivalent (rather than effective dose). Factors modified to account for skin dose contribution	Approach applied previously still appropriate
Radionuclides deposited on soil (and sediment)	Dose coefficients from [B1]	Dose coefficients for calculating doses from deposited material on soil based on [P1] modified to account for migration of radionuclides down soil column Exposure from occupancy on beaches and river banks included in assessment of individual dose only (see above)

Factors	*Earlier methodologies*	*Current methodology*
Occupancy and location factors	[U2] gave overview of occupancy and location factors for different building types. Referred to as “transmission factors”. Occupancy of 0.8 indoors assumed; transmission factors range from 0.5 in office buildings, 0.2 in homes, 0.3 in brick and 0.4 in wooden buildings. A combined transmission and occupancy factor of 0.25 would be appropriate—combined value of 0.3 used in [U1] therefore retained	Available data suggest limited variation in indoor/outdoor occupancy due to climate or region. Indoor occupancies of 0.8–0.9 typical. Most time likely spent in homes or office buildings. Some variation in nature of building materials by region likely Without data to demonstrate significant variation in shielding factors between regions, assumptions in [U2] retained (unlikely to differ by more than factor of 2 or so)
INHALATION		
Nuclear installations/general	Population and age-weighted inhalation rates and dose coefficients applied. Dust-loading approach also applied to resuspension of radionuclides deposited on soils	Adult inhalation rate assumptions applied—similar to age-weighted values; added complexity of age weighting not warranted
Mine and mill tailings/radon	Radon dose factors reviewed in detail in [U4]; radon dose coefficient consistent with that recommended in annex E, 2006 Report [U5]	Approach revised to ensure consistency with other radionuclides and for discharges of radon from non-nuclear facilities. Situation associated with tailings and discharges are different and [U4] approach still appropriate. Dispersion, equilibrium factors, integration periods and deposition of progeny for radionuclides consistent to allow comparison of different energy sources
INGESTION		
Radionuclides discharged to terrestrial environment	Population-weighted average consumption rates derived from [U3]. Aggregated to provide single consumption rate value	Generic consumption rates applied directly for different regions using simple spreadsheet tool
Radionuclides discharged to aquatic environment	Based on generic assumption of relationship between volume of water and number of people receiving exposures from it, validated by global aquatic food-catch data	Dose factors derived using region-specific fish-catch data for collective doses, where available
Freshwater abstraction and fish-catch data	Global values used	Representative abstraction rates based on FAO data on municipal abstraction. Region-specific fish-catch data determined per unit length for two types of river from data for specific rivers
Marine fish-catch data	Global values used	Region-specific fish-catch data per unit area and per unit coastline for shellfish for marine compartments applied

Factors	*Earlier methodologies*	*Current methodology*
GLOBALLY CIRCULATING RADIONUCLIDES		
Tritium	Based on simplified model developed in [K1]. The UNSCEAR 2000 Report [U4] found results within factor of 3 of more complex approaches	No change except for size of global population
Carbon-14	Based on 23-compartment model [T1]. Estimates using different models within factor of 1.5 [U4]	No change except for size of global population
Iodine-129	Based on model in [T1]	No change necessary except size of global population
Krypton-85	Based on simple two-compartment model, originally presented in [C1]	No change other than to update dose factors and size of global population

[a] Local and regional populations defined as 0–100 and 100–1,000 km, respectively [U3].

[b] Inconsistent with approach for radon from mine and mill tailings where integration period of 10,000 years is retained.

Table 2. Comparison of estimates of collective effective doses from external irradiation due to radionuclides deposited following discharges to the atmosphere

Radionuclide	*Collective effective dose (man Sv) from 1 year's discharge at 1 Bq/s*					
	UNSCEAR 2000 Report	*Current methodology*[a]				
		Asia & Pacific	*Europe*	*Latin America*	*North America*	*World-average*
^{60}Co	9.6×10^{-5}	3.6×10^{-4}	1.3×10^{-4}	5.1×10^{-5}	6.3×10^{-5}	1.1×10^{-4}
^{131}I	1.4×10^{-7}	3.5×10^{-7}	1.2×10^{-7}	5.3×10^{-8}	6.1×10^{-8}	1.1×10^{-7}
^{134}Cs	2.5×10^{-5}	1.1×10^{-4}	3.9×10^{-5}	1.6×10^{-5}	1.9×10^{-5}	3.4×10^{-5}
^{137}Cs	1.3×10^{-4}	2.8×10^{-4}	9.9×10^{-5}	3.9×10^{-5}	4.9×10^{-5}	8.5×10^{-5}
^{241}Am	6.0×10^{-5}	1.4×10^{-5}	5.0×10^{-6}	2.0×10^{-6}	2.5×10^{-6}	4.3×10^{-6}

[a] The values for the current methodology are not available directly in the workbooks, but were calculated separately.

Table 3. Comparison of estimated collective effective doses from inhalation following discharges to the atmosphere

Radionuclide	*Collective effective dose (man Sv) from 1 year's discharge at 1 Bq/s*					
	UNSCEAR 2000 Report	*Current methodology*[a]				
		Asia & Pacific	*Europe*	*Latin America*	*North America*	*World-average*
^{60}Co	2.1×10^{-6}	7.4×10^{-6}	2.6×10^{-6}	1.0×10^{-6}	1.3×10^{-6}	2.2×10^{-6}
^{90}S	7.9×10^{-6}	2.7×10^{-5}	9.4×10^{-6}	3.7×10^{-6}	4.6×10^{-6}	8.1×10^{-6}
^{131}I	1.5×10^{-6}	4.6×10^{-6}	1.6×10^{-6}	6.9×10^{-7}	8.0×10^{-7}	1.4×10^{-6}
^{134}Cs	1.4×10^{-6}	4.9×10^{-6}	1.7×10^{-6}	6.8×10^{-7}	8.5×10^{-7}	1.5×10^{-6}
^{137}Cs	9.8×10^{-7}	3.4×10^{-6}	1.2×10^{-6}	4.8×10^{-7}	5.9×10^{-7}	1.0×10^{-6}
^{239}Pu	1.0×10^{-2}	3.7×10^{-2}	1.3×10^{-2}	5.2×10^{-3}	6.4×10^{-3}	1.1×10^{-2}
^{240}Pu	1.0×10^{-2}	3.7×10^{-2}	1.3×10^{-2}	5.2×10^{-3}	6.4×10^{-3}	1.1×10^{-2}
^{241}Am	8.8×10^{-3}	3.1×10^{-2}	1.1×10^{-2}	4.3×10^{-3}	5.4×10^{-3}	9.4×10^{-3}

[a] The values for the current methodology are not available directly from the workbooks, but were calculated separately.

Table 4. Comparison of estimated collective effective doses from ingestion of terrestrial foods following discharges to the atmosphere

Radionuclide	*Collective effective dose (man Sv) from 1 year's discharge at 1 Bq/s*					
	UNSCEAR 2000 Report	*Current methodology*[a]				
		Asia & Pacific	*Europe*	*Latin America*	*North America*	*World-average*
^{3}H	6.6×10^{-8}	3.4×10^{-7}	1.5×10^{-7}	3.9×10^{-8}	6.9×10^{-8}	1.1×10^{-7}
^{14}C	8.5×10^{-6}	2.3×10^{-5}	8.4×10^{-6}	2.9×10^{-6}	4.0×10^{-6}	6.9×10^{-6}
^{60}Co	1.8×10^{-5}	3.7×10^{-4}	2.9×10^{-4}	1.0×10^{-4}	2.0×10^{-4}	1.6×10^{-4}
^{90}Sr	9.7×10^{-5}	2.0×10^{-3}	9.8×10^{-4}	2.9×10^{-4}	4.7×10^{-4}	6.4×10^{-4}
^{131}I	7.9×10^{-6}	7.2×10^{-5}	3.2×10^{-5}	1.1×10^{-5}	1.5×10^{-5}	2.2×10^{-5}
^{134}Cs	6.9×10^{-5}	5.8×10^{-4}	2.7×10^{-4}	9.5×10^{-5}	1.6×10^{-4}	1.9×10^{-4}
^{137}Cs	9.9×10^{-5}	5.1×10^{-4}	2.4×10^{-4}	8.4×10^{-5}	1.4×10^{-4}	1.7×10^{-4}
^{239}Pu	3.2×10^{-4}	1.4×10^{-3}	5.8×10^{-4}	1.7×10^{-4}	2.6×10^{-4}	4.2×10^{-4}
^{240}Pu	3.2×10^{-4}	1.4×10^{-3}	5.8×10^{-4}	1.7×10^{-4}	2.6×10^{-4}	4.2×10^{-4}
^{241}Am	7.3×10^{-5}	1.2×10^{-3}	4.9×10^{-4}	1.4×10^{-4}	2.2×10^{-4}	3.5×10^{-4}

[a] The values for the current methodology are not available directly from the workbooks, but were calculated separately.

Table 5. Comparison of estimated collective effective doses from freshwater pathways following aquatic discharges

Radionuclide	*Collective effective dose (man Sv) from 1 year's discharge at 1 Bq/s*					
	Drinking water			*Fish*		
	UNSCEAR 2000 Report	*Current methodology*[a]		*UNSCEAR 2000 Report*	*Current methodology*[a]	
		Small river	*Large river*		*Small river*	*Large river*
^{3}H	4.1×10^{-8}	1.9×10^{-7}	1.9×10^{-7}	9.5×10^{-11}	1.4×10^{-10}	7.0×10^{-11}
^{14}C	1.7×10^{-6}	1.8×10^{-6}	1.8×10^{-6}	2.1×10^{-4}	2.3×10^{-3}	1.2×10^{-3}
^{60}Co	3.0×10^{-6}	5.8×10^{-6}	5.8×10^{-6}	4.4×10^{-6}	1.4×10^{-6}	5.6×10^{-8}
^{106}Ru	2.3×10^{-6}	1.2×10^{-5}	1.2×10^{-5}	1.2×10^{-7}	2.3×10^{-6}	1.1×10^{-7}
^{129}I	2.6×10^{-4}	2.8×10^{-4}	2.8×10^{-4}	3.2×10^{-5}	3.0×10^{-5}	5.2×10^{-6}
^{137}Cs	4.1×10^{-6}	3.3×10^{-5}	3.3×10^{-5}	1.1×10^{-4}	2.1×10^{-4}	1.0×10^{-5}
^{241}Am	4.4×10^{-5}	2.1×10^{-4}	2.1×10^{-4}	3.3×10^{-5}	1.3×10^{-5}	3.1×10^{-7}

[a] The values for the current methodology are not available directly from the workbooks, but were calculated separately.

Table 6. Comparison of estimated collective effective doses from marine fish following aquatic discharges

Radio-nuclide	*Collective effective dose (man Sv from 1 year's discharge at 1 Bq/s)*														
	UNSCEAR 2000 Report	*Current methodology*[a]													
		Africa		*Asia/Pacific*		*Europe*		*Latin America*		*North America*		*West Asia*		*World-average*	
		Local	*Regional*	*Local*	*Regional*	*Local*	*Regional*	*Local*	*Regional*	*Local*	*Regional*	*Local*	*Regional*	*Local*	*Regional*
^{3}H	3.8×10^{-11}	2.5×10^{-13}	4.7×10^{-14}	2.8×10^{-13}	5.2×10^{-14}	2.5×10^{-13}	4.7×10^{-14}	1.3×10^{-13}	2.5×10^{-14}	8.6×10^{-14}	1.6×10^{-14}	2.9×10^{-13}	5.6×10^{-14}	1.4×10^{-13}	2.7×10^{-14}
^{14}C	2.8×10^{-5}	1.6×10^{-7}	3.2×10^{-8}	1.8×10^{-7}	3.6×10^{-8}	1.6×10^{-7}	3.2×10^{-8}	8.6×10^{-8}	1.7×10^{-8}	5.5×10^{-8}	1.1×10^{-8}	1.9×10^{-7}	3.8×10^{-8}	9.1×10^{-8}	1.8×10^{-8}
^{60}Co	6.0×10^{-6}	3.3×10^{-8}	5.4×10^{-9}	3.6×10^{-8}	6.0×10^{-9}	3.2×10^{-8}	5.3×10^{-9}	1.8×10^{-8}	2.9×10^{-9}	1.1×10^{-8}	1.9×10^{-9}	3.9×10^{-8}	6.3×10^{-9}	1.9×10^{-8}	3.1×10^{-9}
^{90}Sr	1.3×10^{-7}	1.2×10^{-9}	2.3×10^{-10}	1.3×10^{-9}	2.5×10^{-10}	1.2×10^{-9}	2.2×10^{-10}	6.3×10^{-10}	1.2×10^{-10}	4.0×10^{-10}	7.8×10^{-11}	1.4×10^{-9}	2.7×10^{-10}	6.6×10^{-10}	1.3×10^{-10}
^{106}Ru	1.1×10^{-8}	1.9×10^{-10}	2.2×10^{-11}	2.1×10^{-10}	2.5×10^{-11}	1.9×10^{-10}	2.2×10^{-11}	1.0×10^{-10}	1.2×10^{-11}	6.4×10^{-11}	7.6×10^{-12}	2.2×10^{-10}	2.6×10^{-11}	1.1×10^{-10}	1.3×10^{-11}
^{129}I	2.7×10^{-6}	1.4×10^{-8}	2.8×10^{-9}	1.5×10^{-8}	3.0×10^{-9}	1.4×10^{-8}	2.7×10^{-9}	7.4×10^{-9}	1.5×10^{-9}	4.7×10^{-9}	9.4×10^{-10}	1.6×10^{-8}	3.2×10^{-9}	7.8×10^{-9}	1.6×10^{-9}
^{137}Cs	3.0×10^{-6}	1.8×10^{-8}	3.5×10^{-9}	2.0×10^{-8}	3.9×10^{-9}	1.8×10^{-8}	3.5×10^{-9}	9.7×10^{-9}	1.9×10^{-9}	6.2×10^{-9}	1.2×10^{-9}	2.1×10^{-8}	4.1×10^{-9}	1.0×10^{-8}	2.0×10^{-9}
^{239}Pu	2.8×10^{-5}	3.5×10^{-7}	6.9×10^{-8}	3.8×10^{-7}	7.6×10^{-8}	3.4×10^{-7}	6.8×10^{-8}	1.9×10^{-7}	3.7×10^{-8}	1.2×10^{-7}	2.4×10^{-8}	4.1×10^{-7}	8.1×10^{-8}	2.0×10^{-7}	3.9×10^{-8}

[a] The values for the current methodology are not available directly from the workbooks, but were calculated separately.

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