Prachinburi Cs-137 analysis

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RD @ TINT

data of Cs-137 source		value	unit	
energy	gamma	662	keV	
	beta	0.51	keV	
branching ratio	gamma	0.85		
half-life	physical	30	years	
	biological	70	days	
nucleus	p	55		
	n	82		
current activity	A	41.14	mCi	[1]
current dose rate	D (at 30 cm, open shutter)	1.29	mSv/hr	[1]

conversion factors and constants		value	unit	
Ci to Bq		3.70E+10		
Gy to rad		100		
Sv to rem		100		
micro to milli		1.00E-03		
Gy to Sv (gamma)		1.00		
R to rad (gamma, tissue)		0.97		[4]
3-month old	ingestion	0.021	µSv/Bq	[3]
adult	ingestion	0.013	µSv/Bq	[3]
mass energy absorption coef	tissue, soft at ~700 keV gamma	3.20E-02	cm2/g	[8]

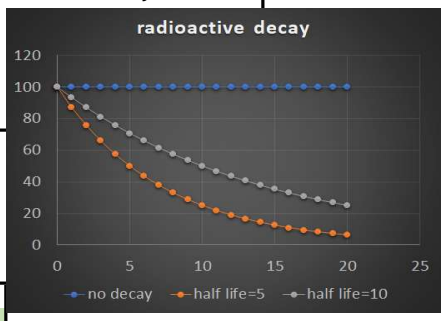
ICRP guideline [2]		value	unit
safe limit	worker (5-year average)	20	mSv/y
	public	1	mSv/y
per working day	worker	0.08	mSv/d
per working hour	worker	0.01	mSv/hr
		9.62	µSv/hr

natural background radiation		value	unit
	per year	3.50	mSv/y
	per hour	0.40	µSv/hr

formulas		
Eq1: D [R/hr] = 0.5CEN	D = exposure rate to gamma point source at 1 m (R/hr)	[6]
	C = Activity (Ci)	
	E = gamma energy (MeV)	
	N = gammas per decay	
	at other distance, dose can be calculated from inverse square law:	
	(dose rate 1)x(distance 1)^2 = (dose rate 2)x(distance 2)^2	
Eq2: D [µSv/hr] = ME/(6*(R^2))	D = dose rate at distance R (µSv/hr)	[7]
	M = Activity (MBq)	
	E = gamma energy (MeV)	
	R = distance (m)	
Eq3: X [R/hr] = AG/(R^2)	X = exposure rate (R/hr)	[4]
	A = Activity (Ci)	
	G = gamma factor = 19.53 E I (µ/rho) (R m^2 h^-1 Ci^-1)	
	R = distance (m)	
	E = gamma energy (MeV)	
	I = gammas per decay	
	µ/rho = mass energy absorption coefficient (cm2/g)	

calculation				
using dose rate:				
	time to receive 20 mSv (annual limit)	15.50	hr	
	time to receive 1 Sv (cancer risk)	32.30	days	
using activity: (more fundamental than dose rate, which depends on shape and orientation of source)				
A (Bq)		1.52E+09	Bq	
ingestion:				
D (3-month old)	ingestion	31.97	Sv	
D (adult)	ingestion	19.79	Sv	
exposure (Eq1):				
	1-m exposure rate	0.01	R/hr	
	1-m dose rate	112.27	µSv/hr	
	30-cm dose rate	1,247.50	µSv/hr	
exposure (Eq2):				
	1-m dose rate	167.95	µSv/hr	

	30-cm dose rate	1,866.08	µSv/hr
exposure (Eq3):			
	1-m exposure rate	1.45E-02	R/hr
	1-m dose rate	140.33	µSv/hr
	30-cm dose rate	1,559.27	µSv/hr
average (3 Eqs):	30-cm dose rate (average)	1,557.62	µSv/hr
	time to receive 20 mSv (annual limit)	12.84	hr
	time to receive 1 Sv (cancer risk)	26.75	days
diffusion effect:	10-m dose rate	1.40	µSv/hr
	time to receive 1 Sv (cancer risk)	81.43	years
decay effect:	the 81 year is a pessimistic estimate, assuming constant radioactivity.		
	It actually would take much longer, due to decay.		
	N = N0 * exp(-lambda*t)		
	A = A0 * exp(-lambda *t)		
	dose rate ∝ activity (exponentially decreasing)		
	dose = integ(dose rate) dt		



risks of acute radiation [5]	
1 Sv	Risk of cancer later in life (5 in 100)
10 Sv	Risk of death within days or weeks

comparison				
Chernobyl (Apr 1986)	Cs-137	2,297,297.30	Ci	[9]
Samut Prakan (Jan 2000)	Co-60	420.00	Ci	[10]
Prachinburi (Mar 2023)	Cs-137	0.04	Ci	
	smaller than Chernobyl (only considering Cs-137) by:	55,840,964.93	times	
	smaller than Samut Prakan by:	10,209.04	times	

Refs

1 https://www.oap.go.th/images/documents/information/news/2023/03/ซีเซียม-137_Cs-137_ปราจีนบุรี/14-03-66/Cs137_lostrevised02.pdf
2 https://hps.org/publicinformation/ate/q8900.html
3 https://www.env.go.jp/en/chemi/rhm/basic-info/1st/pdf/basic-1st-02-04.pdf
4 https://www.nrc.gov/docs/ML1122/ML11229A688.pdf
5 https://www.ccohs.ca/oshanswers/phys_agents/ionizing.html
6 https://www.quora.com/How-do-you-calculate-the-dose-rate-from-a-radioactive-source
7 https://ionactive.co.uk/resource-hub/guidance/formula-for-calculating-dose-rates-from-gamma-emitting-radioactive-materials
8 https://physics.nist.gov/PhysRefData/XrayMassCoef/ComTab/tissue.html
9 https://www.oecd-nea.org/jcms/pl_28292/chernobyl-chapter-ii-the-release-dispersion-deposition-and-behaviour-of-radionuclides
10 https://en.wikipedia.org/wiki/Samut_Prakan_radiation_accident
11 https://www.world-nuclear.org/uploadedFiles/org/Features/Radiation/4_Background_Radiation%281%29.pdf