

Radiocesium in the Environment

Dr. Ralf Sudowe
Associate Professor of Radiochemistry & Health Physics
Colorado State University



National Analytical Management Program (NAMP)
U.S. Department of Energy Carlsbad Field Office

TRAINING AND EDUCATION SUBCOMMITTEE



Meet the Presenter...

Ralf Sudowe

Dr. Ralf Sudowe currently holds an appointment as Associate Professor for Radiochemistry & Health Physics in the Department of Environmental and Radiological Health Sciences at Colorado State University. He has extensive experience in the area of nuclear and radiochemistry, in particular in the development of radioanalytical separations for actinide and transactinide elements as well as fission products. He received a M.S. in Chemistry from the Philipps-University Marburg in Germany in 1995 and a Ph.D. in Nuclear Chemistry from the same institution in 1999. Dr. Sudowe spent two years as Visiting Postdoctoral Fellow in the Nuclear Science Division at Lawrence Berkeley National Laboratory and then worked for five years as a Staff Scientist in the Nuclear Science and Chemical Sciences Division at LBNL. Before coming to Colorado State University in 2016, Dr. Sudowe spent ten years as a faculty member in the Department of Health Physics & Diagnostic Sciences at University of Nevada Las Vegas, where he held appointments as Assistant Professor (2006 – 2012) and Associate Professor (2012 – 2016).



Dr. Sudowe's research focuses on the development and optimization of advanced separation methods for the emergency response and environmental monitoring, nuclear forensics and safeguards as well as the nuclear fuel cycle. In addition he is involved in the study of the fundamental chemical properties of the heavy actinide and transactinide elements. At CSU he teaches lecture courses in radiochemistry and radiation detection, as well as laboratory courses in radiochemistry and radiation measurements. Dr. Sudowe is a member of the American Chemical Society, the American Nuclear Society, ASTM International and the Health Physics Society.

Contact information:

Phone: +1 (970) 491-0219

Email: ralf.sudowe@colostate.edu



Cesium

- Discovered by Bunsen and Kirchhoff in 1860.
- Atomic mass: 132.90546 amu
- Only one stable isotope: ^{133}Cs
- More than 30 radioisotopes known.

Cesium

- Typically only found in low concentrations.
 - Average concentration in earth crust: 2-3 ppm.
- Stable cesium is also present in natural waters.
 - Average concentration in seawater is 0.3 ppb.

Cesium

- Minerals containing larger amounts of cesium:
 - **Pollucite**
 - Londonite
 - Rhodizite

Radioisotopes of Interest

Isotope	Half-life	Decay Mode	Source
Cs-134	2.0652 y	β^- /EC	Activation product
Cs-135	2.3×10^6 y	β^-	Fission product
Cs-137	30.08 y	β^-	Fission product

Cesium Chemistry

- Electron configuration: $[\text{Xe}] 6s^1$
- Oxidation state: +1

Alkali Metal Series

Element	Boiling Point (°C)	Ionic Radius (pm)	Atomic Radius (pm)	Electronegativity (Pauling)
Lithium	1342	76	130	0.98
Sodium	883	102	160	0.93
Potassium	759	138	200	0.82
Rubidium	688	158	215	0.82
Cesium	671	1.67	238	0.79

Cesium Chemistry

- Due to its electropositivity, cesium mostly form ionic bonds.
 - Similar to other alkali metals.
- Common cesium compounds include the halides, some selenides and tellurides, sulfides, and oxides.
- Most cesium salts are soluble in water and many other solvents.

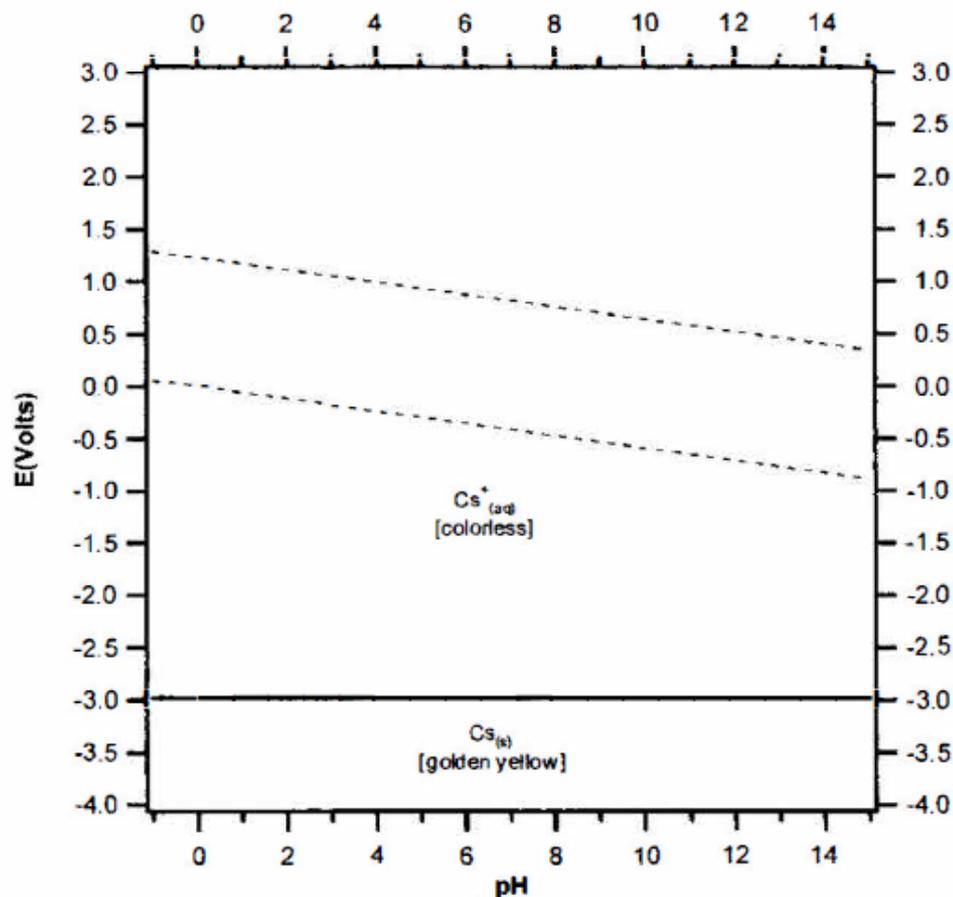
Cesium Chemistry

- Insoluble Cs salts include:
 - Cesium tetrphenylborate ($\text{CsB}(\text{C}_6\text{H}_5)_4$)
 - Cesium hexachloroplatinate (Cs_2PtCl_6)
 - Cesium hexafluorosilicate (Cs_2SiF_6)
 - Cesium hydrogen tartrate ($\text{CsHC}_4\text{H}_5\text{O}_6$)
 - Cesium picrate ($\text{CsC}_6\text{H}_2\text{N}_3\text{O}_7$)
 - Cesium perchlorate (CsClO_4)
 - Cesium periodate (CsIO_4)
 - Dicesium sodium hexanitritocobaltate(III) ($\text{Cs}_2\text{NaCo}(\text{NO}_2)_6$)

Aqueous Chemistry

- The cesium cations is solvated and very stable in water.
- Species in solution: $\text{Cs}(\text{H}_2\text{O})_8^+$
- Displacement of the water molecules by other ligands occurs only with great difficulty.
- Cs^+ therefore forms very few other stable complexes.
- Any complexes formed are very weak.

Aqueous Chemistry



E-pH diagram for Cs species.

Soluble species concentrations (except H⁺) = 10⁻¹ M.

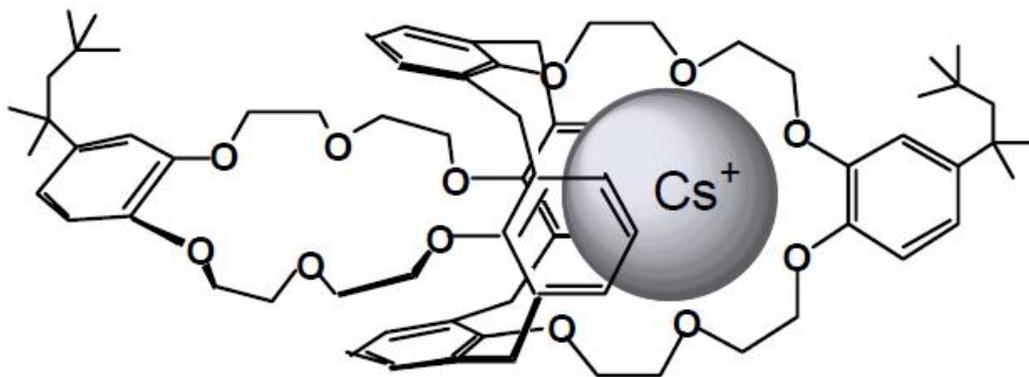
Soluble species and most solids are hydrated.

No agents producing complexes or insoluble compounds are present other than H₂O and OH⁻.

Aqueous Chemistry

- Cesium does not form very many complexes with organic molecules.
- This is important for the transport/retention in aqueous media.
- It also means that it is difficult to separate cesium using solvent extraction techniques.
 - Exception:
calix[4]arene-bis-(tert-octylbenzo-crown-6)
(BOBCalixC6)

Aqueous Chemistry



Calix[4]arene-bis(4- *tert*-octylbenzo-crown-6)
"BOBCalixC6"

(As complexed with Cs^+ ion)

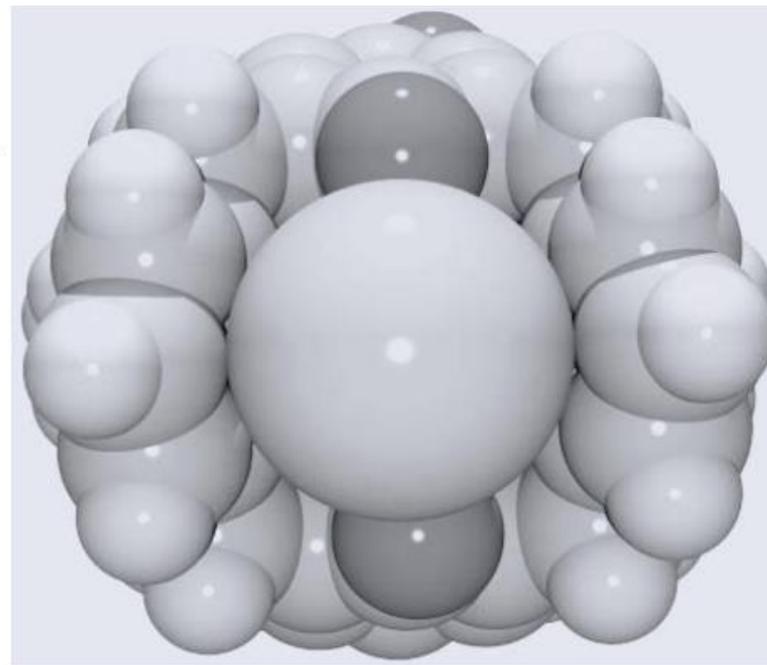


Figure 1. Calixcrown extractant adopted for CSSX, as complexed with Cs^+ ion. Left: chemical drawing of the complex. Right: a space-filling view of part of a crystal structure of the model complex $\text{Cs}_2\text{Calix[4]arene-bis(benzo-crown-6)(NO}_3)_2 \cdot 3\text{CHCl}_3$ [69] showing the good fit of the Cs^+ ion inside the calixarene cavity; the crown ether atoms have been removed for clarity.

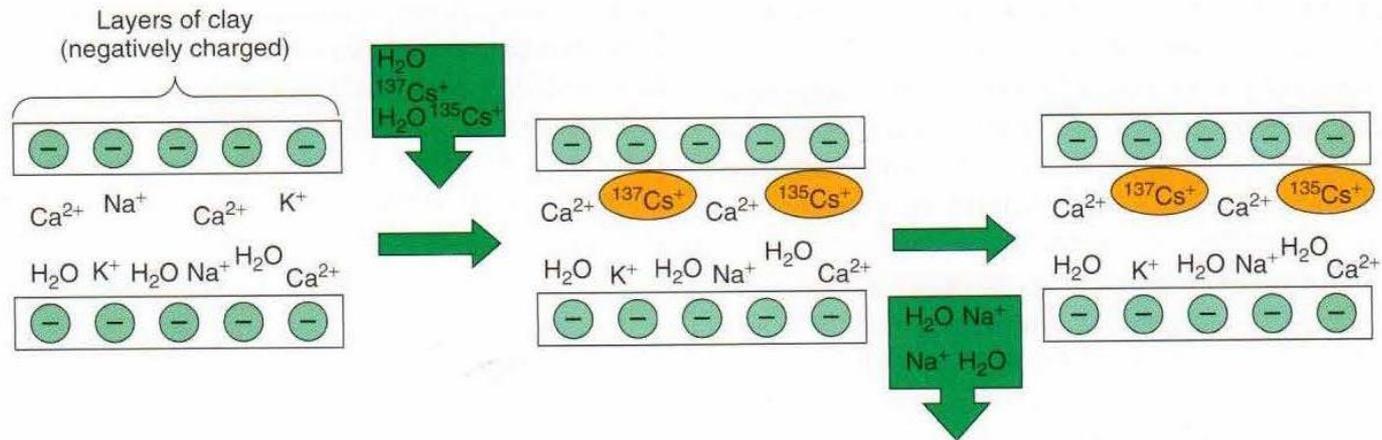
Cesium Chemistry in Soil

- Cesium radionuclides interact with soil by reversible ion exchange,
- However, fixation can also occur.
- Bioavailability of Cs is strongly influenced by:
 - Potassium content
 - pH
 - Clay content
 - Presence of organic matter

Cesium Chemistry in Soil

- The content of clay mineral is important because cesium has an affinity for the interlayer space of these aluminosilicates.
- Several models have related soil clay content with cesium bioavailability.
- Bioavailability of cesium in soil reduces with time due to the processes of fixation by clay minerals and leaching from the root zone.

Cesium Chemistry in Soil



Cesium Chemistry in Soil

- The amount of organic matter present also influences the fixation of cesium in soil.
- Cesium can be retained by organic molecules of low and medium molecular weight.
- The interaction with humic acids is particularly important.
- These are organic acids with many carboxylic and hydroxyl groups attached to aromatic rings.

Reactor Release of Cs

- In the case of a reactor accident, volatile cesium will be released from the overheated reactor core.
- It will be released as CsOH and CsI.
 - 90 % CsOH : 10% CsI
 - Small amounts of elemental Cs could be stable at high T and high hydrogen concentrations.
- Volatile CsOH and CsI will deposit on suspended aerosols and on structural reactor elements.

Reactor Release of Cs

- CsOH is the primary species transported through the reactor systems.
- Decreasing gas temperature will result in deposition of CsOH onto the surface of aerosols.
- Deposition processes depend on the nature of the aerosol:
 - Condensation
 - Physisorption
 - Chemisorption

Boiling Point

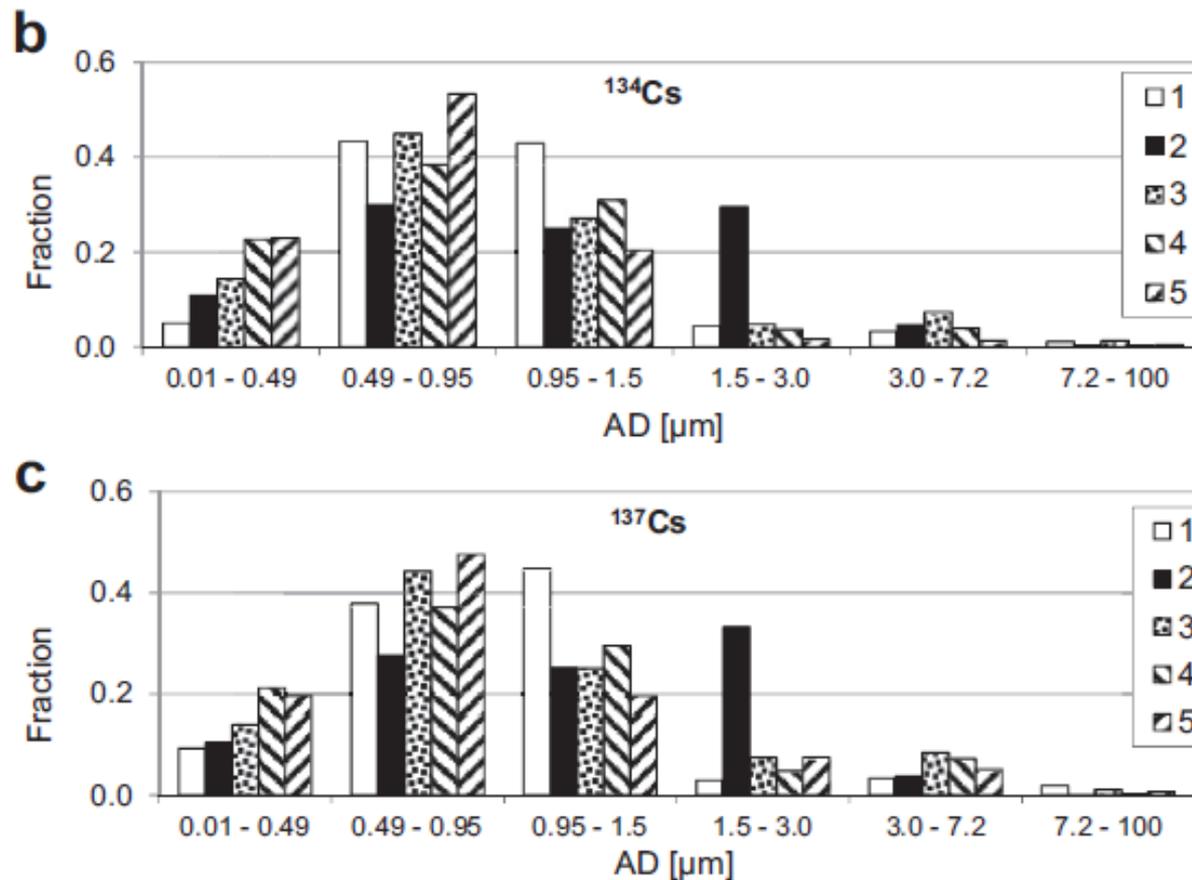
Element	Species	Melting Point (°C)	Boiling Point (°C)
Iodine	I ₂	114	184
Tellurium	Te	450	988
	TeO ₂	733	1245
Cesium	CsOH	343	990
	CsI	632	1280
Strontium	SrO	2531	3249
Uranium	UO ₂	2847	3293

Source: Need, K.H., The Radiochemistry of Nuclear Power Plants with Light Water Reactors, de Gruyter (1997)

Cesium & Aerosols

- The cesium released is typically not associated with large particles.
- It breaks away from larger fragments of fuel during the evaporation.
- Particle size is typically described by the activity median aerodynamic diameters (AMAD).
 - The AMAD of airborne aerosols lies within a five-order range from 0.001 to 100 μm .

Cesium Aerosols - Fukushima



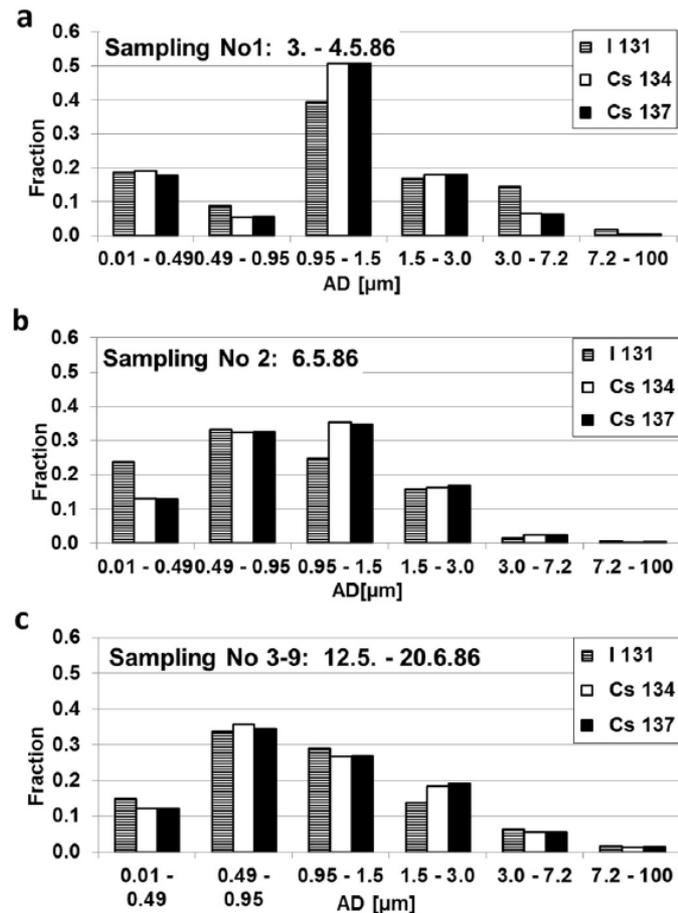
Cesium Aerosols - Fukushima

Table 3

AMAD [μm] and GSD values of 5 sampling sets after the Fukushima accident (AM = arithmetic mean from log-normal distribution).

Sampling		^{131}I	^{134}Cs	^{137}Cs	^7Be
No.1	AMAD	0.38	0.69	0.48	0.53
	GSD	3.6	3.1	4.3	2.6
No.2	AMAD	0.36	0.66	0.71	0.46
	GSD	3.3	2.6	2.3	2.7
No.3	AMAD	0.35	0.36	0.40	0.44
	GSD	3.8	4.6	4.2	3.2
No.4	AMAD	0.47	0.25	0.31	0.34
	GSD	3.4	3.7	3.5	3.3
No.5	AMAD	0.53	0.17	0.27	0.28
	GSD	3.4	4.0	4.3	3.3
AM	AMAD	0.42	0.43	0.43	0.41
	GSD	3.5	3.6	3.7	3.0
AM of AMAD values for ^{131}I , ^{134}Cs and ^{137}Cs				0.43	
AM of GSD values for ^{131}I , ^{134}Cs and ^{137}Cs				3.6	

Cesium Aerosols - Chernobyl



Cesium Aerosols - Chernobyl

Table 4
AMAD [μm] and GSD values of 9 samplings after the Chernobyl accident (AM = arithmetic mean from log-normal distribution).

Sampling		^{141}Ce	^{144}Ce	^{134}Cs	^{137}Cs	^{103}Ru	^{106}Ru	^{131}I	^{132}Te	^{95}Nb	^{95}Zr	Ba–La
No.1	AMAD	2.00	1.87	0.44	0.47	0.35	0.37	0.44	0.54	3.05	4.03	1.06
	GSD	3.2	3.2	3.4	3.2	4.1	4.0	5.1	3.2	3.2	3.6	2.8
No.2	AMAD	1.08	1.08	0.48	0.49	0.58	0.57	0.25	0.69	1.70	1.59	0.81
	GSD	2.7	2.3	3.0	3.1	2.9	2.9	4.0	2.5	1.8	1.7	2.8
No.3	AMAD			0.49	0.48	0.30		0.48	0.30			0.36
	GSD			3.0	2.8	3.7		5.0	4.2			4.0
No.4	AMAD			0.60	0.59	0.43				1.10	1.95	0.76
	GSD			3.3	3.3	4.2				3.9	1.9	3.0
No.5	AMAD			0.51	0.52	0.40	0.42	0.47		0.93	1.27	0.51
	GSD			4.0	4.1	3.6	4.8	3.4		4.3	5.3	3.5
No.6	AMAD			0.96	1.00	0.83	0.91			2.13		1.27
	GSD			3.4	3.4	2.8	2.9			4.5		2.9
No.7	AMAD			0.15	0.16	0.17						
	GSD			8.7	8.1	5.6						
No.8	AMAD			0.60	0.65	0.80	0.55					
	GSD			5.4	5.9	3.7	3.0					
No.9	AMAD			0.24	0.35	0.42	0.56					
	GSD			7.0	8.8	3.8	3.5					
AM of 3–9	AMAD			0.51	0.52	0.40	0.39	0.40	0.30	0.34	1.86	0.52
	GSD			3.9	3.9	3.7	3.9	4.8	4.2	9.2	3.8	3.5

Releases of Radioactive Cs

Isotope	Atmospheric Release Weapons Tests (PBq)	Atmospheric Release Chernobyl (PBq)	Atmospheric Release Fukushima (PBq)	Total Release Fukushima (PBq)
Cs-134	-	54	17.5	168
Cs-136				41
Cs-137	948	86	15.3	156

Releases of Radioactive Cs

Table 2
Summary of ^{137}Cs inventories.

Location	Contamination type	Date	^{137}Cs released	Reference
Global weapons testing	Atmospheric fallout	1950's–1960's	545–765 PBq	[117–121]
Sellafield, UK	Aqueous discharges	1952–2011	41.3 PBq	[25,27,28]
La Hague, France	Aqueous discharges	1966–2011	1.0 PBq	[26]
Chernobyl, Ukraine	Atmospheric	1986	42.5 TBq	[37]
Fukushima, Japan	Atmospheric	2011	13–53 PBq	[38,42]
	Aqueous discharges	2011	3.5–27 PBq	[21]
	Inventory in damaged reactor cores	2011	77.5 kg	[21]
Dounreay, UK	Hot particles	1960's–1970's	1.4–5.5 MBq ($^{137}\text{Cs}+^{90}\text{Sr}$)	[30,31]
Hanford, USA	Tank waste inventory summation	1994	2.0×10^3 PBq	[123]
	Waste capsules	2013	37 PBq ($^{137}\text{Cs}+^{90}\text{Sr}$)	[34]
	Vitrified glass	2013	296 PBq ($^{137}\text{Cs}+^{90}\text{Sr}$)	[34]

Releases of Radioactive Cs

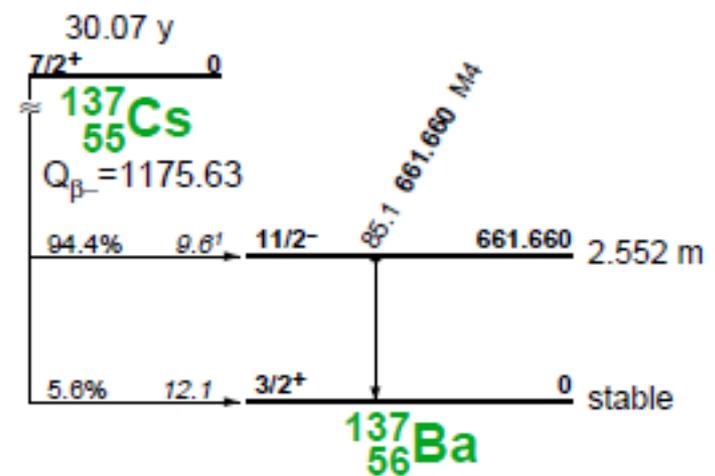
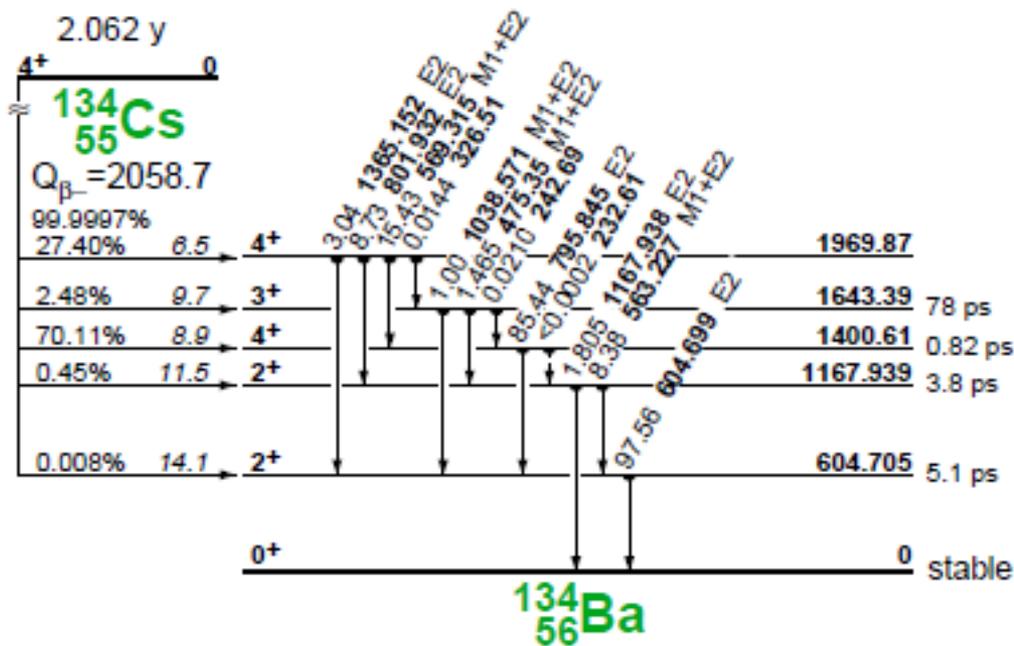
Table 3
Summary of ^{137}Cs activities in multiple locations and sample types.

Location	Sample type	Source of contamination	Date	^{137}Cs concentration	Reference
Northern hemisphere	Global fallout	Weapons test fallout	1970	3830–5090 Bq m^{-2} (55°N) – 280–900 Bq m^{-2} (85°N)	[117–121]
Southern hemisphere	Global fallout	Weapons test fallout	1970	440–530 Bq m^{-2} (15°S) – 580–810 Bq m^{-2} (35°S)	[117–121]
Northern hemisphere oceans	Seawater	Weapons test fallout, reprocessing facilities, Chernobyl	2012	3–5 Bq m^{-3}	[46–51]
Southern hemisphere oceans	Seawater	Weapons test fallout	2012	<1 Bq m^{-3}	[46,47]
Cumbria, UK	Coastal sands and muds	Sellafield	2011	39–450 Bq kg^{-1}	[27]
Northern Ireland coast	Coastal sands and muds	Sellafield	2011	1–35 Bq kg^{-1}	[27]
Irish Sea	Seawater	Sellafield	2011	$<3 \times 10^{-5}$ – 1.2×10^{-4} Bq kg^{-1}	[27]
Japan seawater	Seawater	Weapons test fallout	1960	~30 Bq m^{-3}	[38,39]
			2010	1–4 Bq m^{-3}	
Discharge channels from Fukushima NPP	Water	Fukushima	2011	4×10^7 Bq m^{-3} (at time of accident) 25,000 Bq m^{-3} (4 months after accident)	[38,44,115]
Baltic and Black Seas	Seawater	Chernobyl	1986	10–10,000 Bq m^{-3}	[38]
			2012	<10–100 Bq m^{-3}	
Chalk River	River water	Chalk River Laboratories		85 Bq kg^{-1} (upstream) 198 Bq kg^{-1} (downstream)	[52]
Columbia and Snake River	Sediments	Hanford	1988–1994	2 – 7×10^{-6} Bq kg^{-1} (dry weight)	[122]

Isotopes of Interest

Isotope	Half-life	Gamma-ray Energies
Cs-134	2.0652 y	604.721 (97.62%) 795.864 (85.46%) 569.331 (15.37%) 801.953 (8.688%) 563.246 (8.338%) 1365.185 (3.017%) 1167.968 (1.790%) 475.365 (1.477%)
Cs-135	2.3×10^6 y	None
Cs-137	30.08 y	661.657 (85.1%) Ba-137m

Isotopes of Interest



Preconcentration of Cs

- Cs-137 is sometimes present in the environment in such small amounts that enrichment is required prior to measurement.
- This is especially the case for water samples.
- Lake and stream water can be evaporated to reduce the volume and increase Cs concentration.

Preconcentration of Cs

- Alternatively, Cs^+ can be separated together with other cations from the water onto a strong organic cation exchange resin.
- An ion exchange capacity of a few hundred milliliters is sufficient for the separation of all cations from a few tens of liters of fresh water.

Preconcentration of Cs

- Seawater presents however a problem.
- It contains such large concentrations of salts that the capacity of a cation exchanger is rapidly exceeded, rendering the method ineffective.

Preconcentration of Cs

- As an alternative, coprecipitation can be used to preconcentrate ^{137}Cs from seawater.
- Coprecipitation can be achieved with:
 - Ammonium phosphomolybdate (AMP)
($(\text{NH}_4)_3\text{PMo}_{12}\text{O}_{40} \cdot 3\text{H}_2\text{O}$)
 - Potassium cobalt hexacyanoferrate
($\text{K}_2\text{CoFe}(\text{CN})_6 \cdot \text{H}_2\text{O}$)

Preconcentration of Cs

1. Measure the seawater volume (5–100 L) and put into a tank of appropriate size.
2. pH should be adjusted to 1.6–2.0 by adding concentrated HNO_3 (addition of 40 mL conc. HNO_3 for 20 L seawater sample makes pH of sample seawater about 1.6).
3. Add 0.26 g of CsCl to form an insoluble compound and stir at a rate of 25 L per minute for several minutes.
4. Weigh 4 g of AMP and pour it into a tank to disperse the AMP with seawater.
5. 1 h stirring at a rate of 25 L air per minute.

Preconcentration of Cs

6. Settle until the supernate becomes clear. The settling time is usually 6 h to overnight, but no longer than 24 h.
7. Take an aliquot of 50 mL supernate to calculate the amount of the residual cesium in the supernate.
8. Loosen the AMP/Cs compound from the bottom of the tank and transfer into a 1–2 L beaker; if necessary, do additional step of decantation.
9. Collect the AMP/Cs compound onto 5B filter by filtration and wash the compound with 1 M HNO₃.

Preconcentration of Cs

10. Dry up the AMP/Cs compound for several days at room temperature.
11. Weigh the AMP/Cs compound and determine weight yield.
12. Transfer the AMP/Cs compound into a Teflon tube of 4 mL volume and subject to γ –ray spectrometry.

Isotope Ratios

- Comparing the ratios of the different Cs isotopes can provide important information about the source of radioactive contamination.
- The $^{135}\text{Cs}/^{137}\text{Cs}$ ratio varies with reactor, weapon and fuel type.
- It can therefore can be used as a forensic tool.

Isotope Ratios

- Cs-134 is produced as an activation product in nuclear reactors.
- It accumulates during the long-term irradiation of fuel and construction materials.
- It was therefore not present in fallout from atmospheric nuclear weapons testing.
- It did however make up a significant portion of the fallout from the Chernobyl accident.

Isotope Ratios

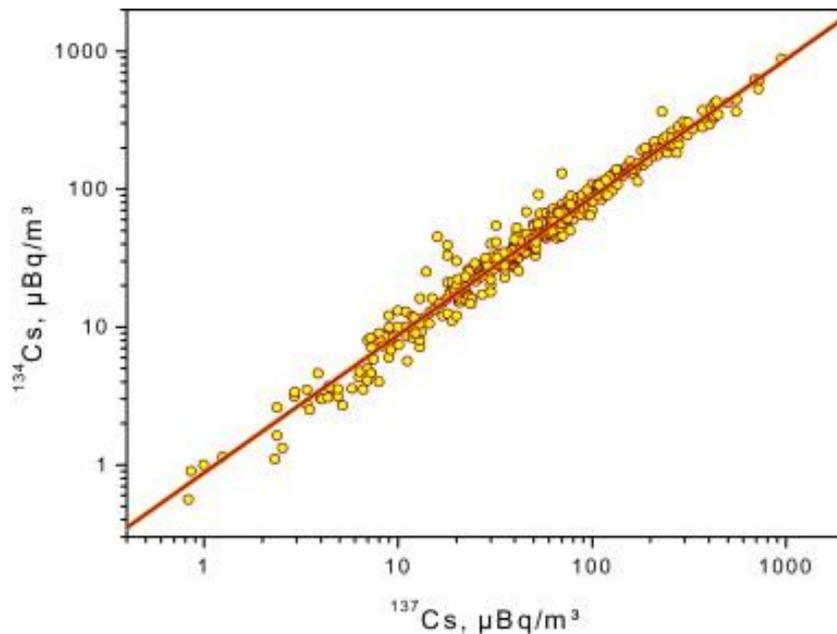


Table 2

Radionuclide ratios in air samples over Europe, referenced to 20 March 2011; the statistics are for 800 simulations of the ratio median (see text); 5% and 95%: estimated confidence limits, 'med(ratio), raw': median of the individual sample ratios, p level: Significance with $p < 0.05$ (1-sided) labelled with an asterisk.

	Number of samples	Median	5%	95%	p level	Med (ratio), raw
^{131}I (part): ^{131}I (gas)	136	3.71	3.19	4.36	<0.001*	3.94
^{131}I (part): ^{137}Cs	862	28.6	27.3	29.8	<0.001*	28.5
^{134}Cs : ^{137}Cs	393	0.874	0.840	0.907	<0.001*	0.857
^{136}Cs : ^{137}Cs	38	0.132	0.099	0.164	<0.001*	0.120
^{132}Te : ^{137}Cs	121	2.45	2.21	2.75	<0.001*	2.55
$^{129\text{m}}\text{Te}$: ^{132}Te	14	0.46	0.30	0.73	0.002*	0.460
^{95}Nb : ^{137}Cs	10	0.9	0.5	2.3	0.37	0.69
^{140}La : ^{137}Cs	8	0.2	0.04	0.4	0.91	0.09
^{89}Sr : ^{90}Sr	34	11.2	8.9	12.2	<0.001*	10.1
^{238}Pu : $^{239+240}\text{Pu}$	20	2.28	1.98	2.58	<0.001*	2.14

Isotope Ratios

Table 6. Ratio of ^{134}Cs to ^{137}Cs in the Chernobyl release plume calculated from fission yield and measured in the plume decay corrected to 26 April 1986, 2:00 a.m.

Evaluation/measurement site	Ratio $^{134}\text{Cs}:^{137}\text{Cs}$ at 26.04.1986	Reference
Calculated values (in core)		
official USSR calculation shortly after the accident	0.64	data given at IAEA conference 1986 (USSR 1986)
Code unknown	0.59	Begichev et al. (1990)
— ^a	0.60	Borovoi et al. (1991)
FISPIN code	0.51	Clough (1987)
ORIGEN code	0.51	Kirchner and Noack (1988)
ORIGEN code	0.65	Gudiksen et al. (1989)
WIMS/CACH2	0.65	Sich (1994)
	0.66	Buzulukov and Dobrynin (1993)
Russian code	0.54	Kutkov et al. (1996a)
revised calculations 1996	0.59	IAEA (1996)
Mean	0.59 ± 0.06	
Measured values		
13 sites in Russia (Briansk, Kaluga, Tula Oblast)	0.54 ± 0.05	Orlov et al. (1992)
1802 samples in a zone 0–430 km around the NPP	0.54 ± 0.03	Pitkevich et al. (1993)
fallout in Ukraine, arithm. mean over 3 sites	0.55 ± 0.12	— ^a
world wide survey	0.54	Gudiksen et al. (1989)
air, Vienna, Seibersdorf	0.57 ± 0.02	Mück (1988)
air, Göteborg	0.55 ± 0.04	De Geer et al. (1986)
air, Nurmijärvi	0.59 ± 0.02	Sinkko et al. (1987)
deposition, Finland	0.53	Jantunen et al. (1991)
deposition, Munich	0.55 ± 0.03	Winkelmann et al. (1988)
deposition, Munich	0.57 ± 0.02	Hötzl et al. (1987)
Mean	0.55 ± 0.02	

^a Unpublished data, I. Likhtarev, Institute of Radiation Protection, Kiev, 1998.

Cs-137 vs. Cs-135

- Cesium-137 is an important radionuclide in radiation protection, environmental monitoring, sediment dating, land erosion and waste disposal.
- Cs-135 is a long-lived radioisotope with a comparatively low radiation risk;
- It is however a significant contributor to the long term radiological risk associated with deep geological disposal.

Determination of Cs-135



- Low specific activity ($T_{1/2} = 2.3 \times 10^6$ y).
 - Lower health hazard
 - Useful for long-term studies

Cs-135 Measurement - Radiometric

- Beta spectroscopy
 - Requires chemical separation
 - Cs-135 β_{\max} : 269 keV
 - Beta counting is prevented by ^{137}Cs also present.
 - Activity ratio $^{135}\text{Cs}/^{137}\text{Cs}$: 1 : 80,000.

Cs-135 Measurement - Radiometric

- Gamma spectroscopy
 - Ba-135m decays to the Ba-135 ground state.
 - $T_{1/2}$: 28.7 h
 - Gamma-ray energy: 268 keV
 - Gamma counting is prevented by ^{137}Cs also present.

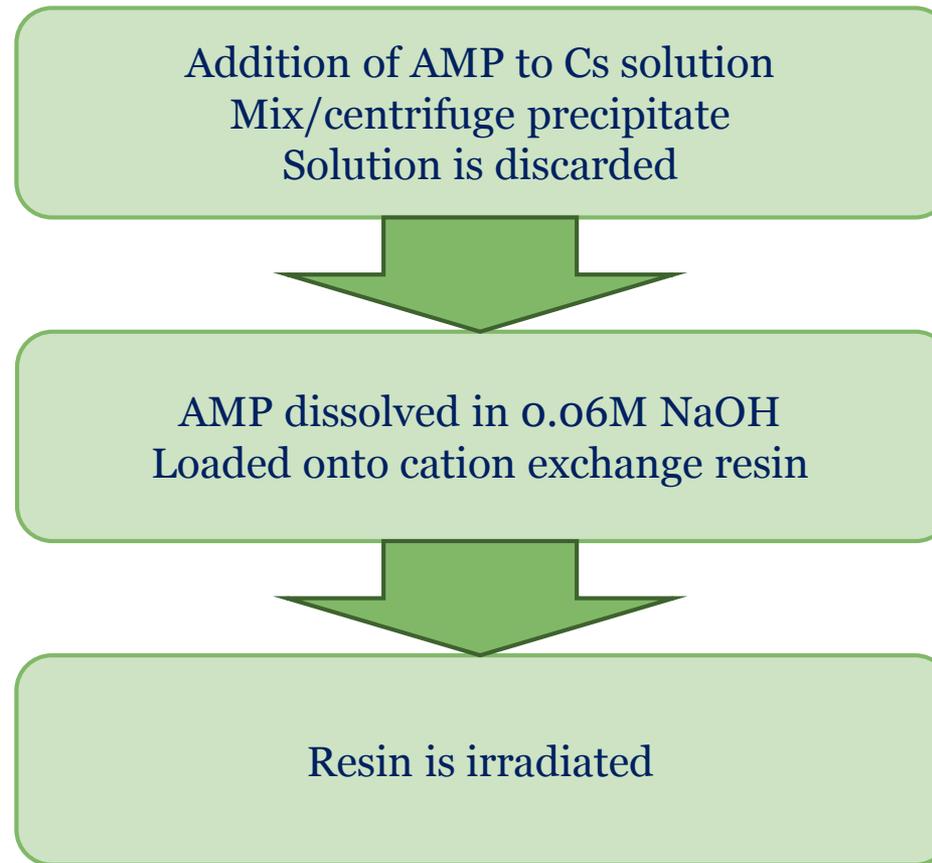
Cs-135 Measurement - NAA

- Cesium is chemically separated and the resulting sample is irradiated with neutrons.

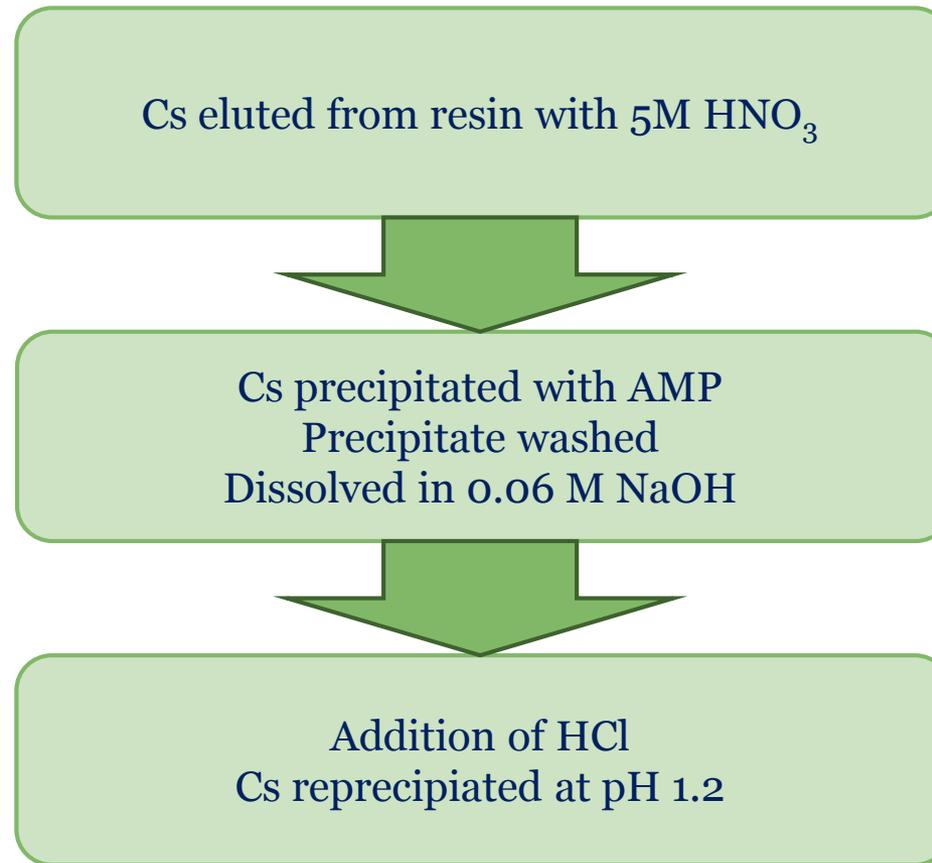


- Thermal neutron cross section: 9 barn.
- Cs-136 $T_{1/2}$: 13.16 d

Cs-135 Measurement - NAA



Cs-135 Measurement - NAA



Cs-135 Measurement - NAA

Isotope	Half-life	Gamma-ray Energies
Cs-136	13.16 d	818.514 (99.70%) 1048.073 (80%) 340.574 (42.2%)

Cs-135 Measurement - NAA

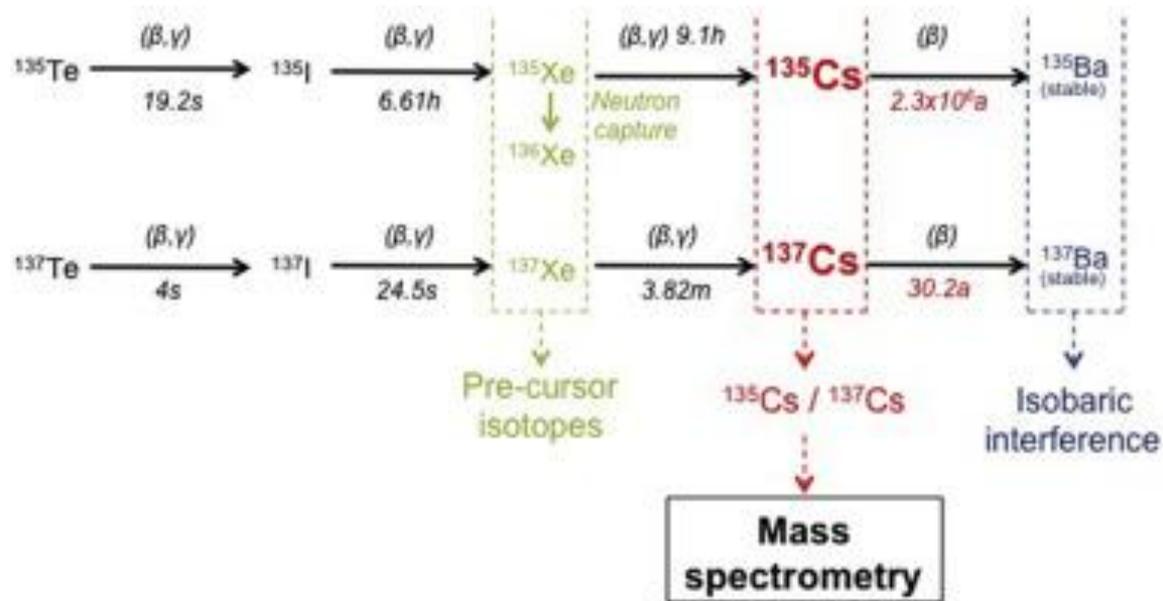
Isotope	Half-life	Gamma-ray Energies
Cs-136	13.16 d	818.514 (99.70%) 1048.073 (80%) 340.574 (42.2%)
Cs-134	2.0652 y	604.721 (97.62%) 795.864 (85.46%) 569.331 (15.37%)

- The presence of stable ^{133}Cs in the sample will lead to production of ^{134}Cs during irradiation.
- The resulting Compton background complicates detection of ^{136}Cs .

Cs-135 Measurement - Mass Spec

- Mass spectroscopy can provide an important alternative for the determination of ^{135}Cs .
 - Advantage: Low detection limit
 - Disadvantage: Mass interferences
- Chemical separation of cesium is required to remove isobaric interferences.
 - Cs separated using AMP

Cs-135 Measurement - Mass Spec



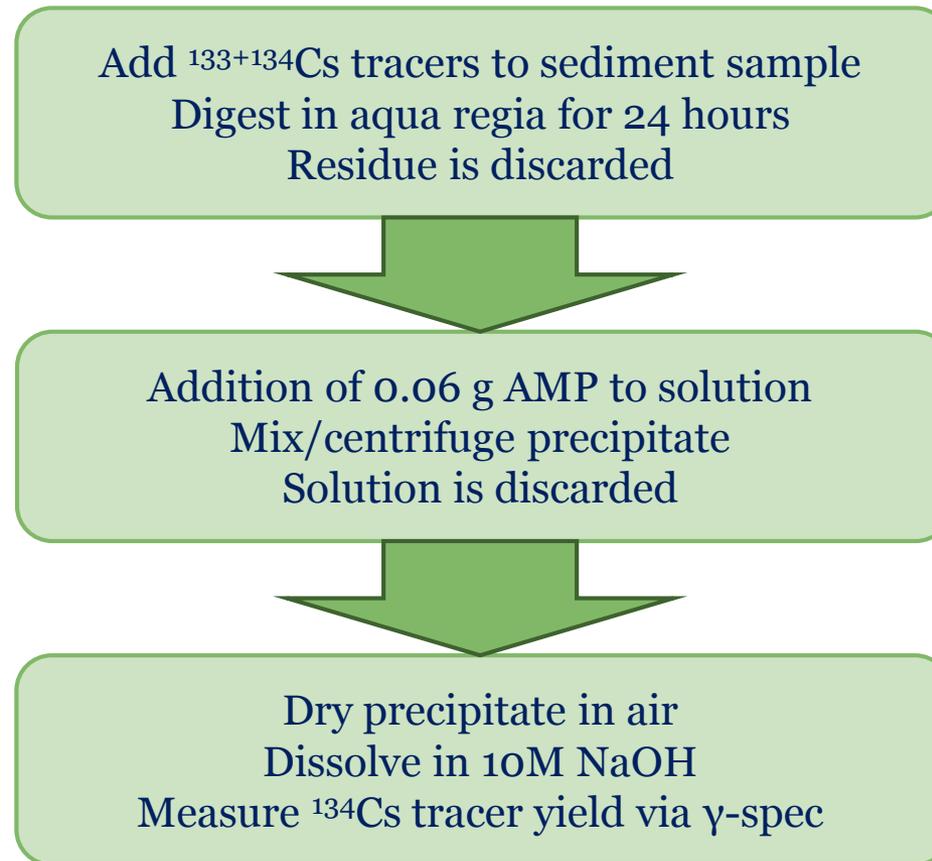
Cs-135 Measurement - Mass Spec

- Tailings due to the presence of stable ^{133}Cs can also interfere with the measurement.
- A very high mass separation efficiency is therefore needed.

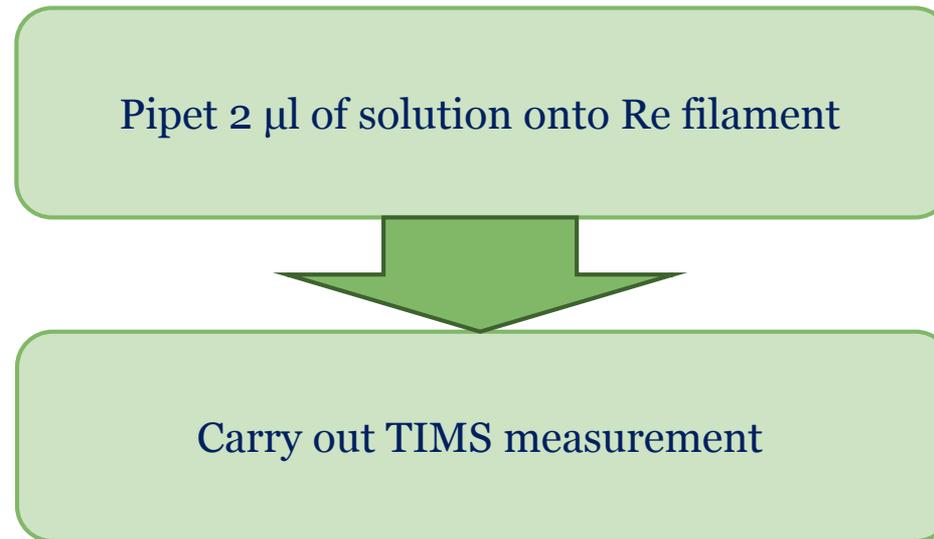
Cs-135 Measurement - Mass Spec

- Mass spectroscopy techniques utilized:
 - Thermal ionization mass spectrometry (TIMS)
 - Inductively coupled plasma mass spectrometry (ICP-MS)
 - Resonance ionization mass spectrometry (RIMS)

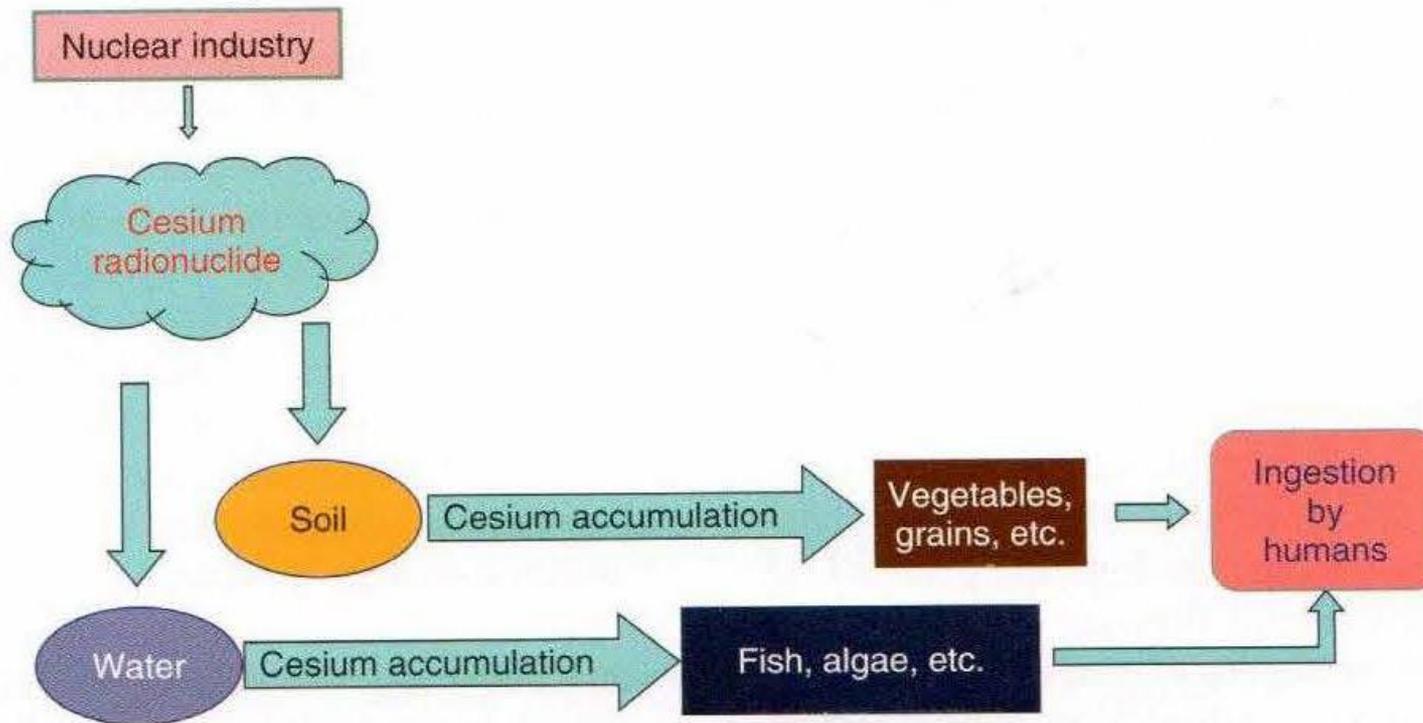
Cs-135 Measurement - Mass Spec



Cs-135 Measurement - Mass Spec



Cesium Transfer



Cesium in the Body

- The common chemical forms of cesium are all soluble in water.
- They are therefore rapidly and completely absorbed across the gastrointestinal tract.
- The element tends to behave in the body as if it were potassium.

Cesium in the Body

- It is localized intercellularly and is deposited predominantly in muscle tissue.
- This is due to the fact that muscle represents the largest portion of body intercellular space.
- Since cesium distributes effectively in all soft tissue of the body, it is also present in meat animals.
- As a result the radionuclide may enter the human body via the food chain in a complicated way.

Cesium in the Body

- The biological half-life of cesium varies widely among individuals.
- It ranges generally between 50 and 150 days.
- It's excretion is characterized by a two component model.

Cesium in the Body

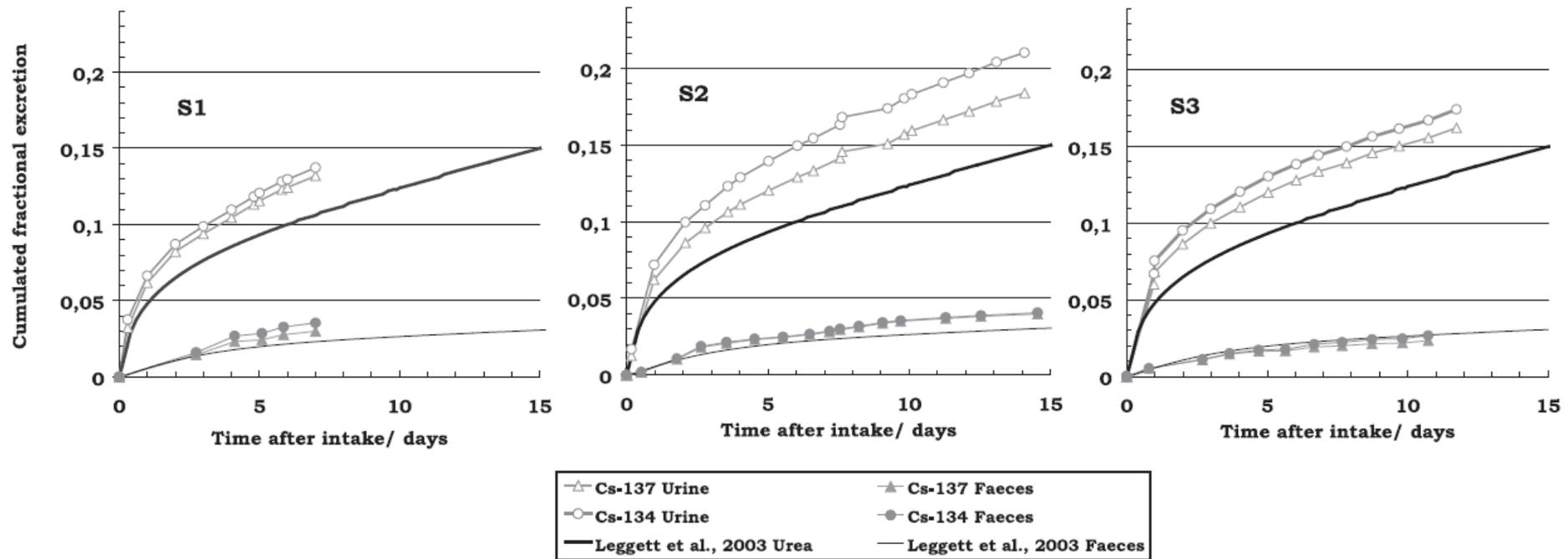


Figure 1. Accumulated excretion of radiocaesium through urine and faeces in fractions of ingested activity. Solid curves indicate the excreted fractions through urine and faeces as calculated from the model suggested by Leggett *et al.*⁽³⁾.

Cesium in the Body

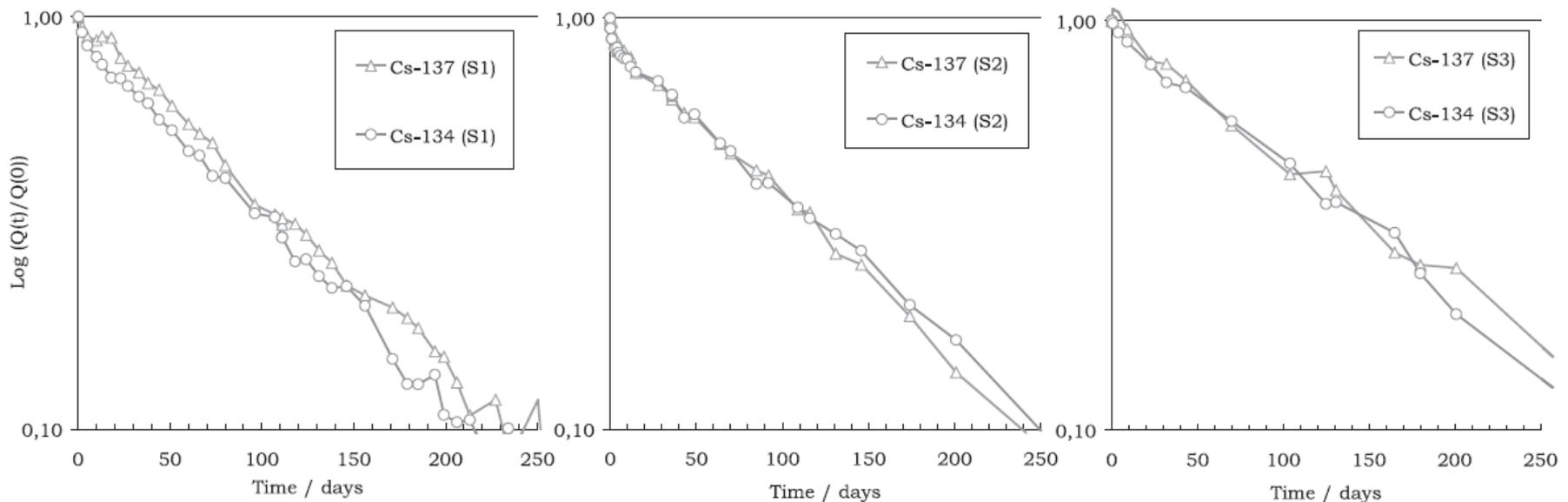


Figure 2. Retention curves of radiocaesium in the individuals S1, S2 and S3. The ratio between the body burden at time, t , and the initial intake has been corrected for physical decay.

References

1. Atwood, D. (Editor)
Radionuclides in the Environment
Wiley (2010)
2. Lehto, J., Hou X.
Chemistry and Analysis of Radionuclides
Wiley-VCH (2010)
3. National Academies of Sciences Nuclear Science Series
The Radiochemistry of Cesium
NAS-NS-3035 (1961)

Upcoming Webinars

- I-129
- Laboratory Subsampling
- Laboratory Sample Preparation

NAMP website <http://www.wipp.energy.gov/namp/>