Tritium Detected at Fukushima Daiichi Nuclear Power Station

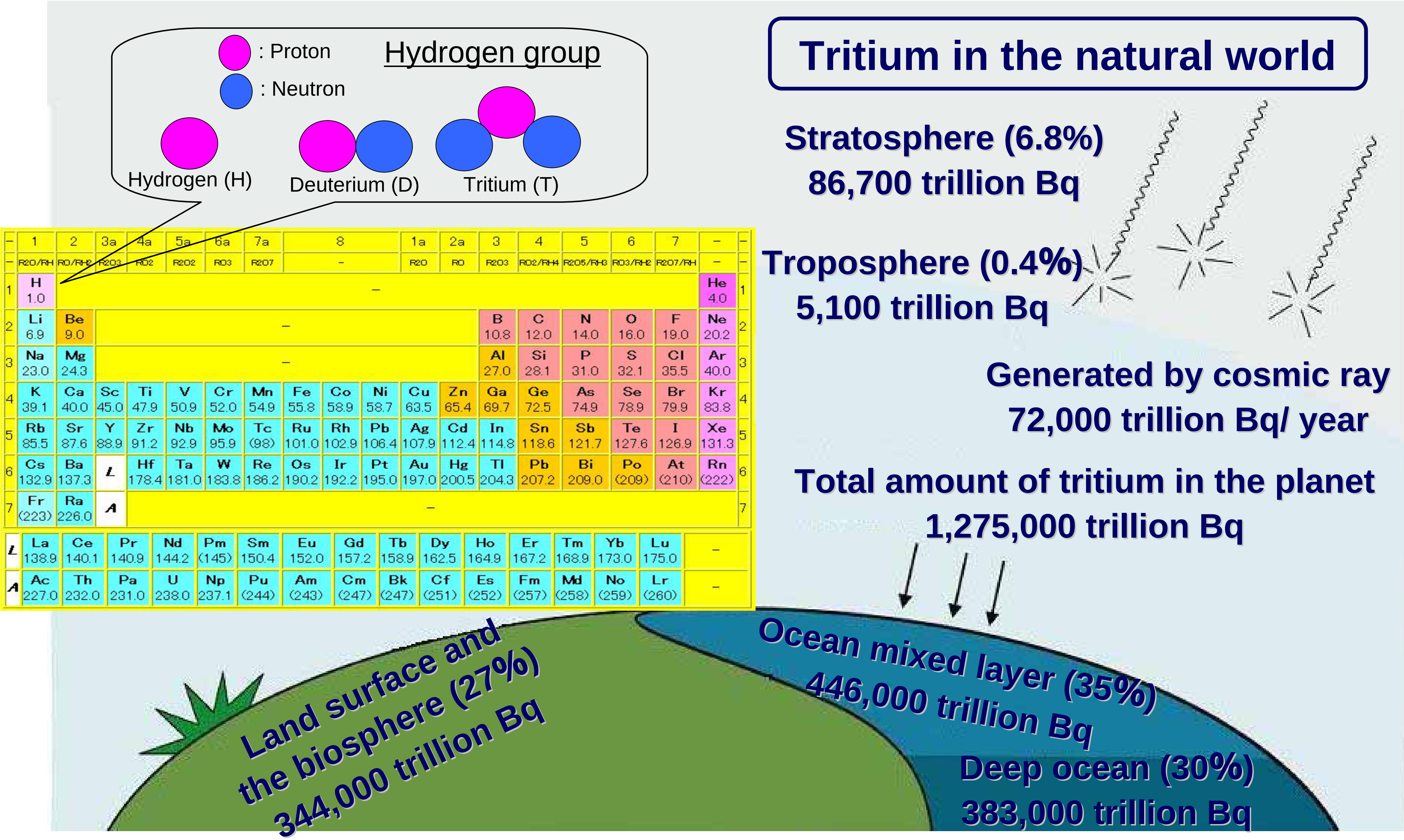
February 28, 2013

Tokyo Electric Power Company

東京電力

TEPCO

1. Natural World and Tritium



–	1	2	3a	4a	5a	6a	7a	8			1a	2a	3	4	5	6	7	–	–
–	R2O/RH	RO/RH2	R2O3	RO2	R2O5	RO3	R2O7	–			R2O	RO	R2O3	RO2/RH4	R2O5/RH3	RO3/RH2	R2O7/RH	–	–
1	H 1.0	–																He 4.0	1
2	Li 6.9	Be 9.0	–										B 10.8	C 12.0	N 14.0	O 16.0	F 19.0	Ne 20.2	2
3	Na 23.0	Mg 24.3	–										Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5	Ar 40.0	3
4	K 39.1	Ca 40.0	Sc 45.0	Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.8	Co 58.9	Ni 58.7	Cu 63.5	Zn 65.4	Ga 69.7	Ge 72.5	As 74.9	Se 78.9	Br 79.9	Kr 83.8	4
5	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9	Tc (98)	Ru 101.0	Rh 102.9	Pb 106.4	Ag 107.9	Cd 112.4	In 114.8	Sn 118.6	Sb 121.7	Te 127.6	I 126.9	Xe 131.3	5
6	Cs 132.9	Ba 137.3	L	Hf 178.4	Ta 181.0	W 183.8	Re 186.2	Os 190.2	Ir 192.2	Pt 195.0	Au 197.0	Hg 200.5	Tl 204.3	Pb 207.2	Bi 209.0	Po (209)	At (210)	Rn (222)	6
7	Fr (223)	Ra 226.0	A	–															7

L	La 138.9	Ce 140.1	Pr 140.9	Nd 144.2	Pm (145)	Sm 150.4	Eu 152.0	Gd 157.2	Tb 158.9	Dy 162.5	Ho 164.9	Er 167.2	Tm 168.9	Yb 173.0	Lu 175.0	–
A	Ac 227.0	Th 232.0	Pa 231.0	U 238.0	Np 237.1	Pu (244)	Am (243)	Cm (247)	Bk (247)	Cf (251)	Es (252)	Fm (257)	Md (258)	No (259)	Lr (260)	–

Source: UNSCEAR Report 2000 and 1977

2. Properties of Tritium

General properties of tritium are as follows.

- The chemical form of tritium is mainly water (Tritium is contained in tap water we drink).
- It is difficult to separate tritium from regular hydrogen even through filtration, desalination and distillation.
- The half life of tritium is 12.3 years and the β ray released from it can be blocked by cling wrap (0.0186MeV).
- In the case that tritium is taken into human body or fish/shellfish, it does not remain inside the system and gets discharged as its chemical form is water.
- The radiation exposure dose (mSv) per Bq is approx. one-thousandth of that of cesium 134 and 137.

Radioactive nuclides	Intake of 1Bq of radioactive material (Oral intake)	
	Radiation dose factor (mSv/Bq)	Comparison with potassium-40 (Natural nuclide)
Tritium	0.000000018	0.003
Cesium-134	0.000019	3
Cesium-137	0.000013	2
Potassium-40 (Natural nuclide)	0.0000062	1

*The radiation dose factor is stipulated by Appendix 2 (Section 3) of the "Public notice to determine radiation dose limit, etc. in accordance with the provisions of the Rule for the Installation, Operation, etc. of Commercial Nuclear Power Reactors (Public notice of the Ministry of Economy, Trade and Industry)".

*The residual period is excerpted from "ICRP Publication 30".

3. Tritium Generation at Nuclear Power Station and Concentration Limit

Source of tritium generation at nuclear power station

1. Ternary fission of fuel (Uranium breaking into 3 products through fission)
2. Irradiation of boron-10 contained in the boron carbide control rods
3. Radioactivation of reactor water (Irradiation of impurities such as lithium-6)

*1 is the main source of tritium generation.

Tritium concentration of the accumulated water at Fukushima Daiichi Nuclear Power Station

Based on the sampling results, the tritium concentration of the accumulated water is considered to be 1 to 5 million Bq/L. (The equivalent concentration of tritium is contained in the treated water and the water contained in the waste considering that tritium cannot be removed by the multi-nuclide removal equipment (ALPS).)

Concentration limit of liquid tritium, etc. at nuclear power station

Concentration limit specified by laws and regulations (Public notice to determine radiation dose limit, etc. in accordance with the provisions of the Rule for the Installation, Operation, etc. of Commercial Nuclear Power Reactors)

- Concentration limit in the water outside the surrounding monitored areas: 60,000Bq/L
  - *Cesium-137 concentration limit: 90Bq/L
  - *Cesium-134 concentration limit: 60Bq/L

Release standard value specified by the technical specification of Fukushima Daiichi Nuclear Power Station (before the nuclear accident)

- 22 trillion Bq/ year 0.024mSv/year* including other nuclides.

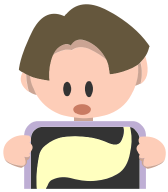
*The radiation exposure dose is the effective dose due to gaseous waste and liquid waste.

4. Examples of Tritium Exposure Evaluation

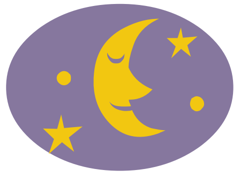
Radiation exposure dose in the case that 2 liters of tritium of the concentration limit is taken into body every day

60,000Bq/L x 2 liters x 365 days x 0.000000018* = 0.79mSv (annual) ≪ 1mSv

*Radiation dose factor in the case of oral intake of tritium (mSv/Bq) (See page 2)



X-ray mass examination of the stomach: 0.6mSv (Once)



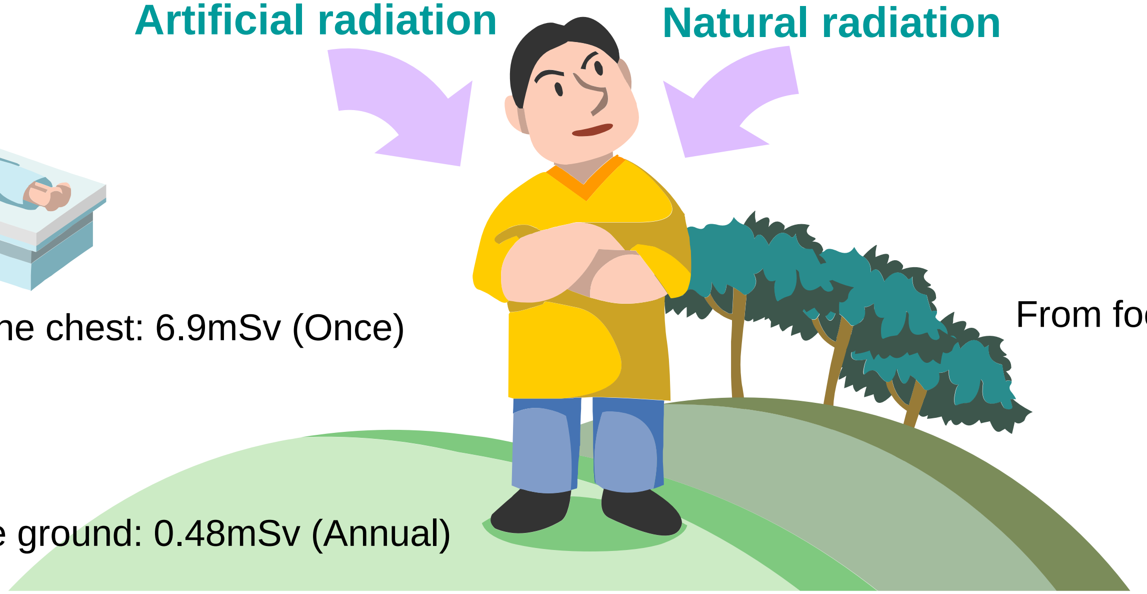
From space: 0.39mSv (Annual)

Artificial radiation

Natural radiation

X-ray CT scan of the chest: 6.9mSv (Once)

From food intake: 0.29mSv (Annual)



From the ground: 0.48mSv (Annual)

Source: UNSCEAR 2000 Report, "Sources and Effects of Ionizing Radiation" and others

5. Tritium Removal Technologies

Tritium removal technologies (Examples)

- In CANDU reactors (Canadian deuterium uranium reactor) and domestic “Fugen” reactors (advanced converter: decommissioned), a large amount of tritium is generated. In Korea, where CANDU reactors are used, tritium removal equipment was developed and put in operation since 2007. The concentration of tritium processed in the removal equipment is approx. a million times more than that at Fukushima Daiichi Nuclear Power Station, and the processing speed of the equipment is low.

- As for “Fugen” reactors, distillation of moderator containing tritium was being performed. However, the concentration of tritium being handled is approx. a million times more than that at Fukushima Daiichi Nuclear Power Station similarly to CANDU reactors, and the processing speed is even lower. The tritium which was separated was discharged into the environment in a form of gas after confirming safety.

< Reference > Tritium in the Environment (Concentration of Tritium in Seawater, etc.)

< Data obtained before the accident >

Category	Number of sampling locations	Timing of measurement, etc.	Concentration (Bq/L) (Ave.)	Source
Seawater River water Lake water	31 20 5 7 19	1982 1983 1982 1982 1983	0.74 0.71 1.91 3.67 2.35	Special research on nuclear fusion: Environmental tritium Current measurement methodology and tritium behavior (Takashima, Kyushu University)
Spring water River water Groundwater	The 100 best waters in Japan (100)	(Hokkaido) (Tohoku) (Kanto) (Chubu) (Kinki) (Chugoku/Shikoku) (Kyushu)	< 0.4 - 6.3 3.7 - 6.3 0.7 - 4.8 0.7 - 3.7 0.7 - 3.3 < 0.4 - 2.6 < 0.4 - 2.2 < 0.4 - 3.3	Special research on nuclear fusion: Environmental tritium behavior and analysis (Kanazawa University)

< Recent data >

Period (June to December 2012)	Bq/L (ND: Approx. 3Bq/L)
3km and 15km offshore of Fukushima Daiichi Nuclear Power Station	ND
North discharge channel at Fukushima Daiichi Nuclear Power Station	ND - 6.4
South discharge channel at Fukushima Daiichi Nuclear Power Station	ND