Comments on TEPCO Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (design stage)

Greenpeace East Asia

Summary of Public Submission

16 December 2021

Introduction

These are comments on the radiological impact assessment (RIA) released by Tokyo Electric Power Company Holdings, Incorporated (TEPCO) on 17 November 2021. The Guidelines to the assessment specify that public comments are due by December 18, 2021.

The Japanese government and TEPCO have created a false premise for plans to discharge radioactive waste water into the Pacific Ocean from 2023. There is sufficient storage space on both the Fukushima Daiichi site and the adjacent localities of Okuma and Futaba to provide long term storage areas for existing and accumulating contaminated water. This was acknowledged by TEPCO in 2018 and also by the Japanese government's own Task Force in their 2020 report.

In terms of the requirement to secure storage space for nuclear fuel debris and other nuclear waste on the Fukushima Daiichi site, TEPCO's Mid-Long Term road map or Strategic Plan, lacks credibility. There are no prospects that nuclear spent fuel debris of any significant amount, and certainly not the estimated 600-1100 tons, will be retrieved from reactors 1-3 within the coming decades, if ever. In the meantime, TEPCO's failure to isolate this material from the environment means groundwater contamination will continue indefinitely until a new approach is applied. There is a uniquely hazardous medium and long term radiological threat to the environment, including the Pacific Ocean, posed by the highly radioactive wastes, in particular the debris reactor fuel, at the Fukushima Daiichi site. This threat will not be resolved with the plans to discharge or with the current decommissioning plan. The fundamental problems continue to be ignored by both TEPCO and the Japanese government. The decommissioning plan for Fukushima Daiichi is not attainable, neither within the timeframe of 2041-2051, or beyond and a return to pre-2011 accident conditions is not possible. The Fukushima Daiichi site is and will remain for the long-term future a permanently contaminated nuclear waste storage site. TEPCO and Japanese government agencies have the wrong priorities and must embark on a comprehensive reassessment of the entire decommissioning plan.

This summary and the full preliminary analysis submitted to TEPCO by Greenpeace East Asia finds major flaws in TEPCO's RIA. The very limited scope of TEPCO's assessment means that many of the wider, but relevant issues and their implications, are ignored. To this end, TEPCO's plans for the discharge of radioactive waste water into the Pacific Ocean should be abandoned.

The report is not an Environmental Impact Assessment

The TEPCO draft RIA is not an environmental impact assessment (EIA) as required by the 1982 Law of the Sea Convention Article 206 of which Japan is a signatory. The RIA is only a limited radiological assessment produced by the proponent of the polluting activity, TEPCO, and it is not a full assessment of the potential effects of the proposed discharge on the marine environment. There is no assessment of effects on ecosystems or cumulative effects over the intended 30-year discharge or over the longer term when many of the radionuclides released will persist. There is no assessment of alternatives to the discharge. The RIA does not evaluate long-term uptake of tritium and other radionuclides on the marine environment, including cumulative effects, trophic effects (effects through the marine food chain), and does not evaluate the effects of organically bound tritium (OBT). It does not properly assess the effects of the radiation on sediments and accumulation in those sediments and in biota living in the sediments.

There are alternatives

The TEPCO RIA does not assess alternatives to the proposed discharge which would minimize radiological releases into the environment. In particular continued storage on land in tanks and the application of the Best Available Technology for processing radionuclides, including in the ALPS and for tritium and carbon 14. TEPCO could acquire more land and build more tanks, and the longer the tritium remains in tanks, the more it decays, with a half-life of 12 years.

The processing or de-nitration of tritium to remove it from the tank water was only superficially considered by the Japanese government, despite multiple offers of technology supply that had the potential to be scaled up to meet the challenge at Fukushima. For example, as Kurion's chief technical officer said in 2015, "Kurion's system could remove the tritium from 800,000 cubic meters of water so that only about a cubic meter of the radioactive material remained."[1]

The dumping of radioactive waste water will be illegal

States have the obligation to protect and preserve the marine environment under article 192 of the Law of the Sea Convention.[2] It is "every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States."[3] It follows that a largescale

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[1] Los Angeles Times, "4 years after Fukushima, Japan considers restarting nuclear facilities", 30 March 2015. See http://www.latimes.com/world/asia/la-fg-japan-nuclear-20150330-story.html.

[2] United Nations Convention on the Law of the Sea, Dec.10, 1982, entered into force Nov. 16, 1994, UN Doc. A/CONF.62/122 (1982), 21 I.L.M. 1261 (1982). At http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htmhttp://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm.

[3] ICJ. Pulp Mills on the River Uruguay (Argentina v. Uruguay) (Pulp Mills), at https://www.icj-cij.org/en/case/135/judgmentshttps://www.icj-cij.org/en/case/135/judgments. Paragraph 101.

and deliberate discharge of radioactive waste waters, if they were to reach international waters, State waters or both, would constitute a breach of Japan's international legal obligations. International law prohibits significant transboundary environmental harm, both with respect to the territory of other States and to areas beyond national jurisdiction.

Article 194(2) of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) requires that Japan as a signatory, "take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights in accordance with this Convention."

Clearly, if TEPCO proceeds with the discharge of radioactive waste water over the coming years, radioactive pollution will spread well beyond the 10km2 area assessed by TEPCO in their RIA. Article 195 of UNCLOS requires that Japan as a signatory, "shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another." TEPCO's RIA fails to address this legal requirement.

The precautionary principle articulated in Principle 15 of the Rio Declaration as follows:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

The UNCLOS ITLOS Seabed Disputes Chamber recognizes the importance of applying the precautionary principle within customary international law.[4] However, TEPCO and the Japanese government have completely ignored this approach. In conclusion, Japan's international legal obligation not to cause damage by pollution to the high seas as well as to the waters of neighbouring States such as the Republic of Korea and the Peoples' Republic of China would be breached by the proposed discharges as detailed in the RIA.

Justification and Optimization – Ignored by TEPCO

TEPCO's draft RIA fails to apply basic principles of radiation protection, as laid out by the ICRP, for the population of Fukushima, neighbouring prefectures, as well as wider Japan and internationally. A principle of **justification** requires that any decision that alters the radiation exposure situation should do more good than harm; in other words, the introduction of a radiation source should result in sufficient individual or societal benefit to offset the detriment it causes. The opposition to any discharge into the environment from Fukushima municipal assemblies, fisheries associations, and citizens reflects the reality that there are no benefits to these communities.

TEPCO and the Japanese government have failed to apply and adopt new technology (storage and processing, including for tritium and carbon-14, as well as advanced ALPS) that would avoid discharge. Yet, the principle of **optimization** requires that the likelihood of incurring exposures, the number of people exposed and the magnitude of their individual exposure should all be kept as low as reasonably achievable, taking into account economic and societal

[4] Case 17. Para 135

factors.[5] To keep radiation exposure to as low as reasonably achievable, would mean TEPCO opting for long term tank storage and processing and no discharge.
TEPCO makes the case that the impact of the discharges will be minimal. But as the European Commission scientific committee explains, "the justification process will require an explicit demonstration of a net benefit…The fact that the doses arising from a practice may be well below the public dose limit **does not** remove the requirement for justification or optimization."[6]
The decision of TEPCO and the Japanese government to deliberately increase the radiation burden to the human population and the environment by discharging radioactive waste water into the Pacific Ocean does not meet the radio-protection principles of justification or optimization, and by doing so, TEPCO is compounding the violation of their human rights.[7]

Failure to consider the discharge plan in the context of overall decommissioning

TEPCO has failed to consider the much wider implications as they relate to the overall decommissioning of the Fukushima Daiichi site. The current TEPCO Strategic Plan/Mid-Long Term Roadmap is unachievable in the timeframe of 2041-2051 as currently proposed. Greenpeace commissioned analysis in 2021 concluded that an alternative path is desperately needed - a new approach that acknowledges the scale of the disaster and the amount of nuclear contaminated material and land.[8] Returning the site to greenfield is unattainable and that instead it is acknowledged what in reality it already is – a nuclear waste storage site.
The draft RIA does not consider the future radiological hazards that will arise from the current approach to decommissioning. These include:

- The continued accumulation of contaminated ground water – which during the coming decade are projected to exceed hundreds of thousands of cubic meters;
- The uncertainties in the operation of the frozen ice wall barrier,[9] including the further increase in groundwater entering the site;

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[5] ICRP, 2009. Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas After a Nuclear Accident or a Radiation Emergency. ICRP Publication 111. Ann. ICRP 39 (3). See https://www.icrp.org/publication.asp?id=ICRP%20Publication%20111

[6] What are the current guidelines for radiation protection – see European Commission, 2. The Scientific Committee on Emerging and Newly Identified Health Risks, 2012, see (SCENIHR)https://ec.europa.eu/health/scientific_committees/opinions_layman/security-scanners/en/l-3/2-radiation-protection.htm

[7] Kyodo News, "OPINION: Fukushima nuclear waste decision also a human rights issue", 8 July 2020, see https://english.kyodonews.net/news/2020/07/1145e5b3970f-opinion-fukushima-nuclear-waste-decision-also-a-human-rights-issue.html

[8] Greenpeace East Asia," Decommissioning of the Fukushima Daiichi Nuclear Power Station", Sato Satoshi, March 2021, see https://www.greenpeace.org/static/planet4-japan-stateless/2021/03/20cf92ab-decomrep_final2.pdf

[9] Kenta Onozawa, "Frozen soil wall, unexpected long-term operation Fukushima Daiichi nuclear power plant contaminated water countermeasure "trump card", verification remains insufficient" Tokyo Nippo – 19 July 2021 (in Japanese), see https://www.tokyo-np.co.jp/article/117551; and Tokyo Nippo, "TEPCO Fukushima Daiichi Nuclear Power Plant begins driving steel pipes into the thawed part of the frozen soil wall", 6 December 2021 (in Japanese), see https://www.tokyo-np.co.jp/article/147155?rct=national&fbclid=IwAR30nXaBUALO9eC4RHZkaRsXHg3j01jRmWd0RBkk4oF53UDmROD0Dk3YGNg

- The potential for future releases to the environment due to the failure to isolate nuclear spent fuel debris from the environment, in particular groundwater;

TEPCO also fails to apply recommendations from the IAEA Guideline document, General Safety Guide No. GSG-9, that calls for assessing additional radionuclides in the environment. [10] There is no evidence provided in the TEPCO draft RIA that any of these have been considered, including the enormous risks posed by the nuclear spent fuel debris and their on-going exposure to the environment. The radiological hazards at Fukushima Daiichi are complex and enormous. The Fukushima contaminated water is a symptom not the root cause of the crisis at the site. TEPCO's plans for discharge the water to the Pacific Ocean do not address these underlying issues.

Pre-existing radiological contamination resulting from the Fukushima Daiichi disaster

The planned discharges will take place into an environment already contaminated with many different radionuclides released as a result of the Fukushima Daiichi disaster. The incorporation of long-lived radioactive elements into the cycle of ecosystems, means the impacts of the disaster will last for decades and centuries. In the last decade many scientific assessments have been conducted on the concentrations and behaviour of radioactivity in the environment, including in marine coastal sediments and estuaries,[11] but much remains to be understood. In particular, there is a significant lack of research pertaining to species and ecosystem impacts, as most research has focused on concentrations in specific marine animals or in sediments. These do not, however, provide sufficient insight into the impacts of these concentrations on species fitness nor a comprehensive understanding of how these radionuclides behave in complex marine ecosystems. There is clear evidence of concentrations of radioactive cesium in coastal sediments whose impacts on marine eco-systems and organisms, including benthic species, has yet to be fully explored and is far from understood. TEPCO makes no acknowledgement of this reality, and does not provide any evidence that it has included this in its draft RIA.

In terms of public exposure, and in response to the March 2011 disaster, the Japanese government has increased the maximum permitted dose to the general public in Fukushima prefecture to 20mSv/y. This increase from the global recommended maximum of 1mSv/y, has been widely condemned within Japan and internationally, including from United Nations human rights Special Rapporteurs, and the UN Human Rights Council. The most recent Universal Periodic Review (UPR) of Japan's human rights in 2018 concluded that the

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[10] IAEA, "Regulatory Control of Radioactive Discharges to the EnvironmentGuideline document", General Safety Guide No. GSG-9, 7.5, General Safety Guide Jointly Sponsored by the International Atomic Energy Agency and United Nations Environment Programme, 2018, https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1818_web.pdf

[11] Eds. K. Buesseler, H. Nies, M. Aoyama, P. Povinec, and M. Dai, "Impacts of the Fukushima nuclear power plant discharges on the ocean", 2014, European Geo Sciences Union, https://bg.copernicus.org/articles/special_issue126.html; Greenpeace, "Atomic Depths : An assessment of freshwater and marine sediment contamination The Fukushima Daiichi nuclear disaster- Five years later", July 2016, http://archivo-es.greenpeace.org/espana/Global/espana/2016/report/Nuclear/20160721_AtomicDepths_ENG.pdf , Yonglong Lu, Jingjing Yuan, Di Du, Bin Sun Xiaojie Yi, "Monitoring long-term ecological impacts from release of Fukushima radiation water into ocean", 27 April 2021, see https://www.sciencedirect.com/science/article/pii/S2666683921000183#!

government should, “Respect the rights of persons living in the area of Fukushima, in particular of pregnant women and children, to the highest level of physical and mental health, notably by restoring the allowable dose of radiation to the 1 mSv/year limit, and by a continuing support to the evacuees and residents.”[12] TEPCO has not even acknowledged these higher levels of radiation exposure, including cumulative, that the people of Fukushima are subjected to, including and in particular, those representative groups living in relative proximity to the Fukushima Daiichi plant and referenced by TEPCO in the RIA.

Among the many uncertainties and for which there is currently no assessment as to their long-term health impacts is public exposure to Cesium-rich Microparticles including through respiration. There are currently no epidemiological studies of the health effects caused by these particles and the number and distribution of CsMPs in the environment is not precisely known.[13]

Evidence of the presence of CsMPs in the coastal marine environment of Fukushima and other prefectures is also emerging, most recently in 2021.[14] Again, TEPCO fail to acknowledge these existing radiological hazards to the human population, including fishing communities, or the wider ecosystem. The IAEA guideline also recommends a revision of the RIA “if new exposure pathways need to be included.”[15] There is no indication that TEPCO has considered these and other issues in its draft RIA.

On-going contamination of the Pacific Ocean

TEPCO does not include any assessment of the radiological releases to the Pacific Ocean that have already occurred in 2011, during the past decade, or those on-going. The large-scale inventory of radio-cesium in the upland forests and lakes of Fukushima prefecture, are, and

[12] [3] United Nations Human Rights Council, “Universal Periodic Review of Japan, Human Rights Council, Decision of Working Group”, 26 February to 23 March 2018, see https://www.ohchr.org/en/hrbodies/upr/pages/jpindex.aspx

[13] Chemosphere, “Abundance and distribution of radioactive cesium-rich microparticles released from the Fukushima Daiichi Nuclear Power Plant into the environment”, Ryohei Ikehara a, 1, Kazuya Morooka a, 1, Mizuki Suetake a, Tatsuki Komiya a, Eitaro Kurihara a, Masato Takehara a, Ryu Takami a, Chiaki Kino b, Kenji Horie c, d, Mami Takehara c, Shinya Yamasaki e, Toshihiko Ohnuki f, Gareth T.W. Law g, William Bower g, Bernd Grambow h, Rodney C. Ewing i, Satoshi Utsunomiya a, *a Department of Chemistry, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka, 819-0395, Japan b The Institute of Applied Energy, 1-14-2 Nishi-shimbashi, Minato-ku, Tokyo, 105-0003, Japan c National Institute of Polar Research, 10-3 Midori-cho, Tachikawa-shi, Tokyo, 190-8518, Japan d Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Shonan Village, Hayama, Kanagawa, 240-0193, Japan e Faculty of Pure and Applied Sciences and Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, 305-8577, Japan f Laboratory for Advanced Nuclear Energy, Institute of Innovative Research, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo, 152-8550, Japan g Radiochemistry Unit, Department of Chemistry, The University of Helsinki, Helsinki, 00014, Finland h SUBATECH, IMT Atlantique, CNRS-IN2P3, the University of Nantes, Nantes, 44307, France i Department of Geological Sciences and Center for International Security and Cooperation, Stanford University, October 2019, see https://doi.org/10.1016/j.chemosphere.2019.125019

[14] Miura, H., Ishimaru, T., Ito, Y. et al. “First isolation and analysis of caesium-bearing microparticles from marine samples in the Pacific coastal area near Fukushima Prefecture.” Sci Rep 11, 5664 (2021). https://doi.org/10.1038/s41598-021-85085-w

[15] Op.Cit. IAEA, 2018.

will remain, an ongoing and long-term source of radio-cesium inputs into the Pacific Ocean.[16] This persistent, slow-moving, vast stock of radioactivity in terrestrial and freshwater systems presents a major hazard to both communities and non-human biota for the foreseeable future. One consequence of down-stream migration of radionuclides is the contamination of estuaries along the Fukushima coast. Due to the high nutrient inputs from rivers, and the fact that estuaries are often sheltered from strong coastal currents, shellfish, and marine animals use estuaries for food and as breeding grounds. Although some of the suspended cesium-bearing particulates are deposited along riverbanks,[17] a large portion of the mineral-bound radio-cesium is discharged into marine estuaries[18] and can then "easily accumulate in marine biota".[19] TEPCO fails to explain or take account of any of these issues in its draft RIA. The very narrow scope of the draft RIA selected by TEPCO and which only considers impacts within a 10km2 area around the end of the proposed discharge point, is clearly not justified.

Matters missing in the report

Secondary ALPs operation - The TEPCO RIA and discharge plans are based on the successful operation of the ALPS in secondary processing of contaminated water. However, the TEPCO RIA fails to explain the complexity and uncertainties in the secondary processing and the implications if it is not successful, including for future arisings and storage of contaminated water on the site.There are major uncertainties in the ultimate performance of the ALPS during the coming years;[20] to this must be added TEPCO's failure to stop groundwater contamination. In addition to the 1.284 million cubic meters that currently is stored in tanks, estimates of up to an additional 456,250 cubic meters could accumulate by 2030.[21] All of this will need to be processed in ALPS. TEPCO's RIA makes no mention of this.

Tritium - The TEPCO RIA is significantly lacking in any analysis of tritium effects, including the behaviour of Organically Bound Tritium (OBT). Tritium released from nuclear power plants is almost entirely in the form of HTO, or tritiated water: a radioactive form of

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[16] Greenpeace Japan, "Radiation Reloaded: Ecological Impacts of the Fukushima Daiichi Nuclear Accident 5 years later", February 2016, see https://www.greenpeace.org/archive-japan/Global/japan/pdf/GPJ-Fukushima-Radiation- Reloaded-Report.pdf.
[17] For example, see Kakehi, S., et al. "Radioactive cesium dynamics derived from hydrographic observations in the Abukuma River Estuary, Japan." (2016). Journal of Environmental Radioactivity. Vol. 153: 1–9. see http://www.science direct.com/science/article/pii/S0265931X15301600.
[18] Iwasaki, T., et al. "Computational modeling of Cs-137 contaminant transfer associated with sediment transport in Abukuma River." (2014). Journal of Environmental Radioactivity. Vol.139: 416–426, see http://www.sciencedirect.com/ science/article/pii/ S0265931X14001520.
[19] Ibid.
[20] Greenpeace, "Stemming the tide 2020: The reality of the Fukushima radioactive water crisis", October 2020, see https://www.greenpeace.org/static/planet4-japan-stateless/2020/10/5e303093-greenpeace_stemmingthetide2020_fukushima_radioactive_water_crisis_en_final.pdf; NRA, "The 93rd Specified Nuclear Facility Monitoring and Evaluation Study Group", 13 September 2021 (in Japanese), see https://www.nsr.go.jp/disclosure/committee/yuushikisya/tokutei_kanshi/140000128.html
[21] The current TEPCO plan is for the additional groundwater contamination to be reduced from an average of 150 cubic meter / tons per day by the end of 2020, and to 100 cubic meters / tons by 2025. If this is achieved, between 2020 and 2025 an additional 273,750 cubic meters of water will be generated, and in the period 2025-2030, a further 182,500 cubic meters/tons – for a total of 456,250 cubic meters.

water.[22] Only a few reports document the distribution of tritium in aquatic biota following tritium releases from nuclear power plants and even less data are available on tritium that is incorporated into organic matter. There are questions regarding the current uncertainty in the relative effectiveness of a given radiation dose from tritium in the organic form compared to tritium in the water form. If tritium is monitored in the organic form (OBT) as opposed to water form (HTO) the biological effect of radiation doses from OBT may be underestimated.[23] With accumulation in sediments of the Hudson River in New York, bound tritium and tritium in sediment water were significantly greater than the ambient water.[24] This finding could have implications for tritium from Fukushima water in marine sediments: tritium could be organically bound, thus accumulating in sediment. Fish and invertebrates convert HTO to OBT but they can also incorporate OBT taken up through ingestion.[25] This is compounded by the hypothesis that the mussels can appear to bioaccumulate tritium due to its feeding mechanisms.

Evidence from an environmental review has suggested that current estimates for the radio-sensitivities of animals (and perhaps humans) to tritium are too low. This review showed that radiosensitivities in free-living animals were an order of magnitude higher than those predicted by conventional models which used laboratory animals:[26] At higher levels of exposure, tritium has been shown to cause reproductive and developmental problems and genetic abnormalities in laboratory animals.[27] A study of the impact of low doses of tritium on the marine mussel[28] found a dose-dependent increase in the response and HTO was shown to be capable of inducing genetic damage in the haemocytes of these bivalves. The study also showed that inorganic tritium accumulated differentially in mussel tissues in a dose-dependent manner, with the gut accumulating the highest amount of radioactivity, followed by the gill, mantle, muscle, foot and byssus thread.[29] Levels of tritium measured in fish and other aquatic life in areas receiving tritium inputs are often higher than predicted by standard models.[30]

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[22] Svetlik, I., Fejgl, M., Malátová, I., Tomaskova, L., 2014. Enhanced activities of organically bound tritium in biota samples. Appl. Radiat. Isot. 93, 82–86.
[23] Kim, S.B., Bredlaw, M.,Rousselle H., Stuart, M. Distribution of organically bound tritium (OBT) activity concentrations in aquatic biota from eastern Canada. 208-209 Journal of Environmental Radioactivity. At https://doi.org/10.1016/j.jenvrad.2019.105997. (Kim (2019).)
[24] Kim (2019) citing Cohen, L.K., Kneip, T.J., 1973. Environmental tritium studies at a PWR (pressurized water reactor) power plant. In: Tritium. Messenger Graphics Publ, pp. 623–639.
[25] Kim (2019)
[26] Fairlie (2014), citing Martin J. Gardner. Father's Occupational Exposure to Radiation and the Raised Level of Childhood Leukemia near the Sellafield Nuclear Plant. Environmental Health Perspectives. Vol. 94 (Aug. 1991), pp. 5-7.
[27] Kim (2019). Citing Grosche, B., Lackland, D., Mohr, L., Dunbar, J., Nicholas, J., Burkart, W., Hoel, D., 1999.Leukaemia in the vicinity of two tritium-releasing nuclear facilities: a comparison of the Kruemmel Site, Germany, and the Savannah River Site, South Carolina, USA. J. Radiol. Prot. 19, 243–252.
[28] Jha, A.N., Dogra, Y., Turner, A., Millward, G.E., 2005. Impact of low doses of tritium on the marine mussel, Mytilus edulis: genotoxic effects and tissue-specific bioconcentration. Mutat. Res. 586, 47–57.
[29] Awadesh N. Jha et al. "Impact of low doses of tritium on the marine mussel, Mytilus edulis: genotoxic effects and tissue-specific bioconcentration." 2005. DOI: 10.1016/j.mrgentox.2005.05.008.
[30] Kim (2019), citing Williams, J.L., Russ, R.M., McCubbin, D., Knowles, J.F., 2001. An overview of tritium behaviour in the Severn Estuary (UK). J. Radiol. Prot. 21, 337–344 and Yankovich, T.L., Kim, S.B., Baumgärtner, F., Galeriu, D., Melintescu, A., Miyamoto, K.,
Saito, M., Siclet, F., Davis, P., 2011. Measured and modelled tritium concentrations in freshwater Barnes mussels (Elliptio complanata) exposed to an abrupt increase in ambient tritium levels. J. Environ. Radioact. 102, 26–34.

The TEPCO RIA does not reflect the level of uncertainty within the scientific community over the behavior of tritium in the environment, including dose factors. For example, the Tritium Working Group of the IAEA program MODARIA (Modelling and Data for Radiological Impact Assessment) noted in 2011 that there is insufficient data to test dynamic or chronic tritium models for aquatic ecosystems and no experimental data on the dynamics of OBT in fish with body weights larger than 100 grams (Melintescu et al., 2011). "The results implied that increases in fish OBT were largely controlled by the specific activity of the diet rather than the water. Kim et al. (2013) also found that the rate of OBT uptake by fish tissues was faster when fish were exposed to OBT-spiked feed compared to HTO. In addition, Jaeschke et al. (2011) reported that tritium from tritiated glycine demonstrated greater accumulation and persistence in tissue of marine mussels compared to tritium from tritiated water. In this particular case, all tissues demonstrated bio-accumulation of tritium from both HTO and OBT."[31] TEPCO relies upon and cites ICRP in its dose assessments, including for fish, when exposed to tritium. However, the reliability of ICRP models has been questioned. "The final results, in terms of effective dose, assess the potential dose increase from past deterministic recommendations of ICRP with an upper, conservative, safe limit of 5 and a best estimate of 3. In practice, considering the low doses encountered and lower RBE for carcinogenic effects, an increase in dose with a factor about 2 –3 from actual ICRP recommendation, suffices for prospective dose assessment."[32] TEPCO does not even reference the latest ICRP report on this issue – from November 2018.[33]

Carbon-14

If the contaminated water is discharged to the Pacific Ocean, all the C-14 will be released to the environment, with a half-life of 5,730 years. Carbon-14 is a major contributor to the global human collective dose.[34,35] The relatively short half-lives of some of the isotopes point to a possible alternative to discharge: continued storage. As an IAEA report notes, the metabolism and kinetics of 14C in the human body follow those of ordinary carbon. It has been found that accumulation of 14C in the human body via respiration is insignificant compared with that from ingestion of contaminated food. In addition, 14C can be easily concentrated in the food chain. Studies have shown concentration factors of 5000 for fish and molluscs and 2000 for soil sediments.[36] As the French Radio-protection and Nuclear Safety

[31] Canadian Nuclear Laboratories, "Tritium Uptake In Rainbow Trout (Oncorhynchus Mykiss): HTO And OBT-Spiked Feed Exposures Simultaneously", Company Wide CW-121262-CONF-009 Revision 0, 2014, see https://inis.iaea.org/collection/NCLCollectionStore/_Public/49/101/49101389.pdf

[32] Reassessment of tritium dose coefficients for the general public A. Melintescu, D. Galeriu, H. Takeda Radiation Protection Dosimetry, Volume 127, Issue 1-4, November 2007, Pages 153–157, https://doi.org/10.1093/rpd/ncm267

[33] Radiation Weighting for Reference Animals and 14 Plants - 'ICRP, 20YY. Radiation Weighting Factors for Reference 37 Animals and Plants. ICRP Publication 1XX, Ann. ICRP 00(0).' https://www.icrp.org/docs/TG72%20Draft%20Report%20for%20Consultation%202018-11-19.pdf

[34] European Parliament, "Possible Toxic Effects From The Nuclear Reprocessing Plants At Sellafield (UK) and Cap de la Hague (France)", A first contribution to the scientific debate, Schneider, M., Study team: Coeytaux, X., Faïd, Y.B., Marignac, Y., Rouy, E., Thompson, G. (IRSS, Cambridge, USA) Fairlie, I., Lowry, D., Sumner, D. (Independent consultants), European Parliament Directorate General for Research Directorate A The STOA Programme, November 2001. At http://www.wise-paris.org/index.html?/english/stoa_en.html&/english/frame/menu.html&/english/frame/band.html.

[35] Buesseler 2020.

[36] IAEA, Management of Waste Containing Tritium and Carbon-14, Technical Report Series 421, International Atomic Energy Agency Vienna, 2004. See https://www-pub.iaea.org/MTCD/publications/PDF/TRS421_web.pdf.

Institute, (IRSN) explains, “Carbon-14 is interesting from a radiobiological standpoint because it is integrated in cellular components (proteins, nucleic acids), particularly cellular DNA.[37] The resulting DNA damage, involving molecular breaks, may lead to cell death or induce potentially inheritable mutations.[38] It is possible to treat water to remove carbon-14, but this is not contemplated by TEPCO. The TEPCO RIA fails to assess and therefore explain to the public the long term implications of releasing C-14 (or the other radionuclides) to the environment.

Strontium-90

The contaminated tank water planned for discharge into the Pacific Ocean contains strontium-90 (Sr-90), one of the most hazardous of radionuclides. Strontium's chemical behaviour is similar to that of calcium, and it can accumulate in organisms, particularly in bones.[39] The Fukushima accident has been found to have raised levels of radioactive strontium off the east coast of Japan by up to 100 times, with estimats ranging between 90 and 900 TBq (terabecquerels), raising levels by up to two orders of magnitude.[40] The highest concentrations were found to the north of the Kuroshio current, which acts as a barrier preventing radioactive material from being carried to lower latitudes.[41] Other studies have shown that levels did not cause Sr-90 levels in fish dangerous to humans.[42] Sr-90 has been detected in waters near the Korean peninsula.[43] The TEPCO RIA barely references Sr-90 and does not explain the hazards releasing this radionuclide into the environment.

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[37] As cited by IRSN (see reference below, Le Dizès-Maurel S, Maro D, Lebaron-Jacobs L, Masson M (2009). « Carbone 14 », in Chapitre 31, Toxicologie nucléaire environnementale et humaine. Ménager M.T., Garnier-Laplace J., Goyffon M. (Coord). 603-618.

[38] “Radionuclide fact sheet Carbon-14 and the environment”. August 2012. See https://www.irsn.fr/EN/Research/publications-documentation/radionuclides-sheets/environment/Pages/carbon14-environment.aspx.

[39] See M. Fukuoto, ed. Low-Dose Radiation Effects on Animals and Ecosystems Long-Term Study on the Fukushima Nuclear Accident. 2020.

[40] Casacuberta, N; Masqué, P; Garcia-Orellana, J; Garcia-Tenorio, R; Buesseler, K.O.. 90Sr and 89Sr in seawater off Japan as a consequence of the Fukushima Dai-ichi nuclear accident. 2013. Biogeosciences; Katlenburg-Lindau Vol. 10, Iss. 6, (2013): 3649.

[41] Ibiden.

[42] Pavel P. Povinec & Katsumi Hirose. Fukushima radionuclides in the NW Pacific and assessment of doses for Japanese and world population from ingestion of seafood

[43] Kim C-K, Byun J-I, Chae J-S, Choi H-Y, Choi S-W, et al. (2012) Radiological impact in Korea following the Fukushima nuclear accident. J Environ Radioact 111: 70–82. See Steinhauser G, Schauer V, Shozugawa K (2013) Concentration of Strontium-90 at Selected Hot Spots in Japan. PLoS ONE 8(3): e57760. doi:10.1371/journal.pone.0057760. At https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0057760&type=printable. See also Tazoe, H., Yamagata, T., Tsujita, K., Nagai, H., Obata, H., Tsumune, D., Yamada, M. (2019). Observation of dispersion in the japanese coastal area of released 90Sr, 134Cs and 137Cs from the Fukushima Daiichi nuclear power plant to the sea in 2013. International Journal of Environmental Research and Public Health, 16(21) doi:http://dx.doi.org.ezproxy.otago.ac.nz/10.3390/ijerph16214094.