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

Greenpeace East Asia

Public Submission

16 December 2021

Introduction

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

The premise for plans to discharge radioactive waste water into the Pacific Ocean from 2023 is false. 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 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. 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 long term radiological threat to the environment, including the Pacific Ocean, posed by the highly radioactive waste debris reactor fuel at the Fukushima Daiichi site. This threat will not be resolved with the plans to discharge into the Pacific Ocean 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. 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 facility. TEPCO, and Japanese government agencies have the wrong priorities and must embark on a comprehensive reassessment of the entire decommissioning plan.

This preliminary analysis, and submitted by Greenpeace East Asia to TEPCO finds major flaws in TEPCO's RIA. The unduly limited scope and incomplete nature 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 clearly not the environmental impact assessment (EIA) that is required. The 1982 Law of the Sea Convention requires in Article 206 that "When States have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they shall, as far as practicable, assess the potential effects of such activities on the marine environment and shall communicate reports of the results of such assessments in the manner provided in article 205."

There is no doubt that this is not an environmental impact assessment (EIA) as is required by international law. It is even on the face of it only a very 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, including a comparison with their radiological impacts.

The TEPCO RIA has numerous deficiencies. 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.

TEPCO fails to provide justification for its planned discharges. It does not assess alternatives to the proposed discharge, such as the application of removal of tritium and continued storage on land in tanks. 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.

TEPCO's draft RIA has been released before an IAEA Working Group has reported, and as such can be seen as an attempt to influence the IAEA report.

The public comment period is far too short for a 160-page document and overview that contains a number of technical issues that require sufficient analysis. At the same time, it is deliberately vague, describing its plans (announced elsewhere) to discharge radioactive water as a 'process' "spanning the next few decades".

Nor is the scope acceptable. Even on the face of it:

> *"The conclusion of the report is that exposure to radioactivity resulting from the implementation of the planned systems for treatment and discharge of treated water from the FDNPS will fall well within established international safety limits (i.e., dose limit and DCRL), based on internationally recognized technical documents."*

The conclusion shows that the scope of the report is far too narrow. It does not conclude there will not be adverse effects on species, on the marine environment, on biodiversity or on fish or fisheries or tourism.

Likewise, the scope is described in the following terms:

The purpose of this radiation impact assessment shall be as follows.

> *Purpose 1: Assess the impact of radiation resulting from the discharge of ALPS treated water conducted by TEPCO while referring to internationally recognized technical documents (IAEA Safety Standards, ICRP Recommendations, etc.).*
>
> *Purpose 2: Communicate the results of the assessment both domestically and internationally, and based on opinions received from various parties, conduct reviews, etc., as necessary, to consider ways to optimize the risk regarding discharge.*

Purpose 1 is clearly not achieved: the impact of radiation is not adequately analysed.

Purpose 2 assumes that the result of the report will be that the radioactive discharges will go ahead: the only stated goal is to "*consider ways to optimize the risk regarding discharge."*

There are alternatives

The report does not assess alternatives to the proposed discharge, in particular continued and extended storage in tanks and the application of the Best Available Technology for processing radionuclides, including in the ALPS and for tritium and carbon 14 removal. 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.

One main reason for discharge used by TEPCO and the Japanese government is lack of land availability for storage. But as the Japanese government's own committee assessed, "a substantial amount of coordination and time would be needed until implementation to acquire the understanding from local municipalities and others, to decide upon where storage facilities might be built, and to acquire an approval for radioactive waste storage facilities."[1] In other words, finding land is difficult, but possible.

The costs of retaining the water on land and with no discharge to the Pacific were estimated at up to 51 trillion yen or US$480bn.[2] Clearly discharge to the Pacific is the cheaper option for TEPCO. Equally clearly, the full economic costs to Japanese fishermen, foreign fishermen, and to the environment have not been quantified.

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."[3] The estimated cost for the Kurion system was US$1bn to set up, plus several hundred million dollars a year to operate. Ion exchange technology from a United States supplier Purolite showed that it could reduce concentrations of radionuclides in the contaminated water to non-detectable levels.[4]

[1] METI, "The Subcommittee on Handling of the ALPS Treated Water Report" 10 February 2020 (Provisional Translation).

[2] CER, "Contaminated water strategy of critical importance", Japan Center for Economic Research, March 7, 2019, (in Japanese).

[3] 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.

[4] John Large, "Preliminary analysis of TEPCO processed water data sheets", June 21st 2018, Large & Associates, London for Shaun Burnie, Greenpeace Germany.

The dumping of radioactive 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.[5] States are responsible for the fulfilment of their international obligations concerning the protection and preservation of the marine environment and they shall be liable in accordance with international law.[6] International law prohibits significant transboundary environmental harm, both with respect to the territory of other States and to areas beyond national jurisdiction. Environmental impact assessments are required as a preventive measure to ensure that States have assessed proposals so they can ensure that significant transboundary harm does not occur.

Article 194(2) of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) provides that:

> "States shall 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."

Another prohibition is in Article 195 of UNCLOS "In taking measures to prevent, reduce and control pollution of the marine environment, States 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."

The ICJ has said in the *Gabčíkovo–Nagymaros* case[7] that "[t]he existence of the general obligation of States to ensure that activities within their jurisdiction and control respect the environment of other States or of areas beyond national control is now part of the corpus of international law relating to the environment."

Likewise, States must ensure that activities within their jurisdiction and control respect the environment of other States or of areas beyond national control'.[8] In its advisory opinion on deep seabed mining, the Seabed Disputes Chamber of the International Law of the Sea (ITLOS), applied the *Pulp Mills* principle to areas beyond national jurisdiction, stating that

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[5] 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.

[6] Law of the Sea Convention, Article 235(1).

[7] Gabčíkovo-Nagymaros Project (Hungary/Slovakia) [1997] ICJ Rep 7, para. 53. At https://www.icj-cij.org/en/case/92/judgments. Citing Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion) [1996] ICJ Rep 1996 226, 241 -242.

[8] *Nuclear Weapons* Advisory Opinion [1996] ICJ 2. At https://www.icj-cij.org/files/case-related/95/095-19960708-ADV-01-00-EN.pdf. Paragraph 29.

“[t]he Court’s reasoning in a transboundary context may also apply to activities with an impact on the environment in an area beyond the limits of national jurisdiction.”[9]

It is “every State’s obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States.”[10] It follows that a discharge of radioactive waters, if they were to reach international waters, State waters or both, would constitute a breach of Japan’s obligations to ensure that activities within its jurisdiction and control respect the environment of other States or of areas beyond national control, and of Japan’s obligation to ensure that it take all measures necessary to ensure that activities under its 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 the Convention.

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 ITLOS Seabed Disputes Chamber[11] said that:

> “The Chamber observes that the precautionary approach has been incorporated into a growing number of international treaties and other instruments, many of which reflect the formulation of Principle 15 of the Rio Declaration. In the view of the Chamber, this has initiated a trend towards making this approach part of customary international law.”

The application of the precautionary principle requires scientific uncertainty about the effects of releasing tritium to the marine environment not to be used as a reason for postponing a decision to protect the environment by not releasing the radioactive water.

In conclusion, Japan’s obligation not to cause damage by pollution to the high seas as well as to the waters of the Asia/Pacific region, including neighbouring States such as the Republic of Korea and the Peoples’ Republic of China, and small island Pacific nations, would be breached by the proposed radioactive waste water discharges.

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[9] International Tribunal for the Law of the Sea. Case No. 17. Advisory Opinion. Responsibilities and obligations of States sponsoring persons and entities with respect to activities in the Area (Request for Advisory Opinion submitted to the Seabed Disputes Chamber). 1 February 2011 At https://www.itlos.org/fileadmin/itlos/documents/cases/case_no_17/adv_op_010211.pd. Para. 142.

[10] 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.

[11] Case 17. Para 135

Principles of radiation protection – ignored by TEPCO

TEPCO's draft RIA fails to apply basic principles of radiation protection for the population of Fukushima (as well as wider Japan and internationally) as recommended by the International Commission for Radiological Protection (ICRP), especially ICRP 103.

The 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.

Application of the justification principle to this new practice of deliberately releasing radioactive waste water resulting from a nuclear accident requires that no practice should be introduced unless it produces sufficient net benefit to the exposed individual or to society to offset the radiation detriment it causes. The justification may need to be re-examined as new information or technology becomes available.

TEPCO and the Japanese government have failed to apply and adopt new technology (storage and processing, including for H3 and C-14, as well as advanced ALPS) that would avoid discharge. The TEPCO draft RIA, fails to show that there is a net benefit to society, (within Japan or internationally) from discharging radioactive waste water into the Pacific Ocean.

And finally, "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."[12]

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 factors. In addition, as part of the optimization procedure, the ICRP recommends that there should be restriction on the doses to individuals from a particular source and this leads to the concept of dose constraints. Japan does not apply dose constraints.

For a planned situation such as the discharge of radioactive water by TEPCO, ICRP-103[13] highlights the problem of inequality of costs and benefits, with "little or no individual benefit". In this case, that the local population could be most affected by the discharges from the FDNPS but would have no individual benefit, while the benefits are for the company. For that reason, a dose constraint as part of the optimisation process is needed to protect the individual.

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[12] 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

[13] ICRP, "ICRP-103", Chapter 5 paragraph 232, 2007, see https://www.icrp.org/publication.asp?id=ICRP%20Publication%20103

"In Publication 82 (ICRP, 1999a), the Commission issued guidance that in circumstances where there are planned discharges of long-lived radionuclides to the environment, planning assessments should consider whether build-up in the environment would result in the constraint being exceeded, taking account of any reasonable combination and build-up of exposures."[14]

To keep radiation exposure to as low as reasonably achievable, would mean that TEPCO should opt for long term tank storage and processing and no discharge. Japan does not apply dose constraints.

The ICRP 111 recommends that the radiation reference levels should be reduced over time:

"The optimization of protection is a forward-looking iterative process aimed at preventing or reducing future exposures".[15]

Potential exposures are not included in the evaluation by TEPCO. In ICRP-103 a potential exposure is described as "higher exposures may arise following deviations from planned operating procedures, accidents including the loss of control of radiation sources, and malevolent events". And furthermore: "Potential exposures should be considered at the planning stage of the introduction of a planned exposure situation. (...) Due consideration should be afforded to potential exposures during application of the principles of justification and optimisation." This means that an evaluation of potential exposures such as an accidental release of contaminated water into the ocean or future leakage of contaminated groundwater from the FDNPS should be considered in the evaluation of the different water treatment options in the justification process.

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.

By ignoring justification and optimization principles, TEPCO is compounding the violation of human rights. There is strong local opposition to any discharge into the environment, including from municipal assemblies, fisheries associations, and citizens.

The former UN Special Rapporteur on disposal of hazardous substances and wastes, Baskut Tuncak, stated: "It is their human right to an environment that allows for living a life in dignity, to enjoy their culture, and to not be exposed deliberately to additional radioactive

[14] ICRP-103 paragraph 261

[15] 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

contamination. Those rights should be fully respected and not be disregarded by the government in Tokyo."[16]

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

There is no evidence that TEPCO in its consideration of the environmental impact of its planned discharges has considered the much wider implications as they relate to the overall decommissioning of the Fukushima Daiichi site. As we note below, the radiological hazards on the Fukushima Daiichi site are globally unprecedented for a nuclear power plant. As we note below there are major uncertainties in the current decommissioning plant of TEPCO. Greenpeace commissioned analysis released in March 2021 recommended a complete re-assessment of the current Mid-Long Term Roadmap.[17]

The current TEPCO Strategic Plan Mid-Long Term Roadmap is unachievable in the timeframe proposed. In Greenpeace commissioned analysis it concludes 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.[18] Returning the site to greenfield is unattainable and that instead it is acknowledged what in reality it already is – a nuclear waste storage site. Rather than desperately trying to keep to an unrealistic and unattainable timetable, Greenpeace has called for a new long term strategic approach.

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;
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> The uncertainties in the operation of the frozen ice wall barrier,[19] including the further increase in groundwater entering the site;
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> The potential for future releases to the environment due to the failure to isolate nuclear spent fuel debris from the environment, in particular groundwater;

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[16] 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

[17] 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

[18] Ibiden.

[19] 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 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 discharging the water to the Pacific Ocean do not address these underlying issues.

Nuclear fuel debris uncertainties, including future releases

The precise location, condition and amount of nuclear fuel debris in units 1-3 of the Fukushima Daiichi reactors remains uncertain. The Fukushima Daiichi nuclear fuel debris has its own instabilities in terms of criticality, radioactivity, decay heat, shape.[20] The Nuclear Damage Compensation and Decommissioning Facilitation Corporation has acknowledged that in the mid-to-long-term, "the state of fuel debris may change over time, such as radioactive materials leaching from fuel debris as colloid or ions, and becoming granular or fragmented due to 4-29 oxidation or collapsing. If the volume of fuel debris in highly mobile forms increases due to leaching and/or granulation, the risk may rise for such form of fuel debris to flow into a circulated cooling system along with coolants, **or even released into the environment along with the flow of gas or coolant if a major loss of containment functions occurs.** Additionally, if granular and fragmented fuel debris with high mobility had high concentration of nuclear fuel materials, there will be an undeniable possibility of it accumulated at one place and causing local criticality."

The IAEA Guideline document, General Safety Guide No. GSG-9, and cited by TEPCO in its draft RIA, requires that,

"7.5. ...consideration should be given to the following aspects:

(a) The possibility of additional radionuclides being discharged that were not present in routine discharges during normal operation. For example, alpha emitters, which might not have been present in the discharge during operation, might be discharged when a nuclear installation is dismantled.

(b) The need for a survey of these additional radionuclides in the environment to determine pre-existing levels.

(c) The possibility that any contamination on the site that resulted from incidents

during operation may affect the discharges during decommissioning."

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.

Of particular importance is the fact that radioactive contamination of the Pacific Ocean, and mainland Japan, including Fukushima prefecture has already occurred as a result of the March 2011 disaster.

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[20] Technical Strategic Plan 2017 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.,, August 31, 2017 Nuclear Damage Compensation and Decommissioning Facilitation Corporation, see https://www.dd.ndf.go.jp/files/topics/448_ext_02_0.pdf

Pre-existing radiological contamination resulting from the Fukushima Daiichi disaster

The planned discharges will take place into an environment already contaminated with radionuclides due to the Fukushima Daiichi disaster. Due to the radionuclides released by the Fukushima nuclear accident, and their incorporation into the materials cycle of the ecosystem, the impacts of the disaster will last for decades and centuries. The widespread contamination of the marine environment has been extensively investigated over the past 10 years, 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 radio-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 its assessment of the radiological impact of its discharges, TEPCO does not take into account that the environment of Fukushima prefecture, wider Japan, and the Asia Pacific region that has been contaminated with radiation as a result of the 11 March 2011 earthquake, tsunami and resultant meltdown of Fukushima Daiichi reactors 1-3. There are many assessments on the radiation releases to the environment from March 2011 and the concentrations and behavior of radioactivity in the environment, including in marine coastal sediments and estuaries.[21] Many scientific assessments have been conducted since 2011, but there is a near universal recognition that there remains much to be investigated and with many uncertainties, including long term behavior of radionuclides and future pathways for exposure. None of this is included in TEPCO's RIA.

Evidence of the increased radiation levels in Fukushima prefecture, including on-going releases to the environment, are not included in TEPCO 's RIA.

As a result of the March 2011 disaster, the Japanese government 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

[21] 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#!

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 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."[22] The fact that the citizens of Fukushima prefecture are already exposed to a higher radiation burden than prior to 2011, and that the permissible levels of 20mSv/y are twenty times the international norm, has been ignored by TEPCO in its draft RIA. There is no reference by TEPCO of the cumulative radiation exposure the people of Fukushima are subject to, including, and in particular, those representative groups living in relative proximity to the Fukushima Daiichi plant.

TEPCO does not provide any reference to the elevated background radiation levels in Fukushima and the increased radiation exposure that the people of Fukushima, and other prefectures are exposed to. These radiological hazards include many uncertainties in terms of their actual dose to the human population and wider ecosystem. In addition to generally higher radiation levels in large areas of Fukushima prefecture, including the coastal communities, there are issues where there is currently no assessment as to their long-term health impacts. For example, exposure to cesium rich microparticles, including through respiration. As reported by scientific literature, including most recently in 2019, "Due to the small size and high Cs specific activity, CsMPs have the potential to penetrate deep into the human respiratory system and remain for decades, which may lead to high localized radiation doses. Nevertheless, there are currently no epidemiological studies of the health effects caused by these particles. Furthermore, the number and distribution of CsMPs in the environment is not precisely known... CsMPs in residential areas at present have experienced varying environmental conditions, such as being surrounded by vegetation, concrete, and buildings, and this may profoundly increase CsMP mobility by being washed out from the surfaces."[23]

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[22] [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

[23] 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

Evidence of the presence of CsMPs in the coastal marine environment of Fukushima and other prefectures is also emerging, most recently in 2021.[24] The mechanisms for their presence in the Pacific Ocean include atmospheric and direct liquid releases in 2011; river-to-ocean transfer; and on-going releases via contaminated groundwater from the Fukushima Daiichi site. Again, TEPCO fails to acknowledge these existing radiological hazards to the human population, including fishing communities, or the wider ecosystem.

TEPCO references the IAEA General Safety Guide No. GSG-9 as central to their draft RIA, but are also highly selective. For example, the GSG-9 calls for,

"(b) The need for a survey of these additional radionuclides in the environment to determine pre-existing levels."[25]

Such a comprehensive assessment of the pre-existing situation has not been conducted by TEPCO and is not included in its draft RIA.

The Guideline also recommends a revision of the RIA "if new exposure pathways need to be included."[26] There is no indication that TEPCO has considered these and other issues in its draft RIA.

The IAEA Guidelines recommend that, "5.23. Pre-operational studies should also be carried out to determine the existing levels of background radiation in the area surrounding the facility prior to its operation and should include a determination of the external radiation levels as well as the concentrations of radionuclides in the environment (e.g. water, soil, plants, crops, food). These studies should be used to establish a baseline above which the actual impact of the discharges can be determined. This baseline can vary from site to site because of variations in natural background radiation and possible residual contamination from past practices, accidents or global fallout after nuclear weapon tests."

TEPCO makes no reference to these 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.

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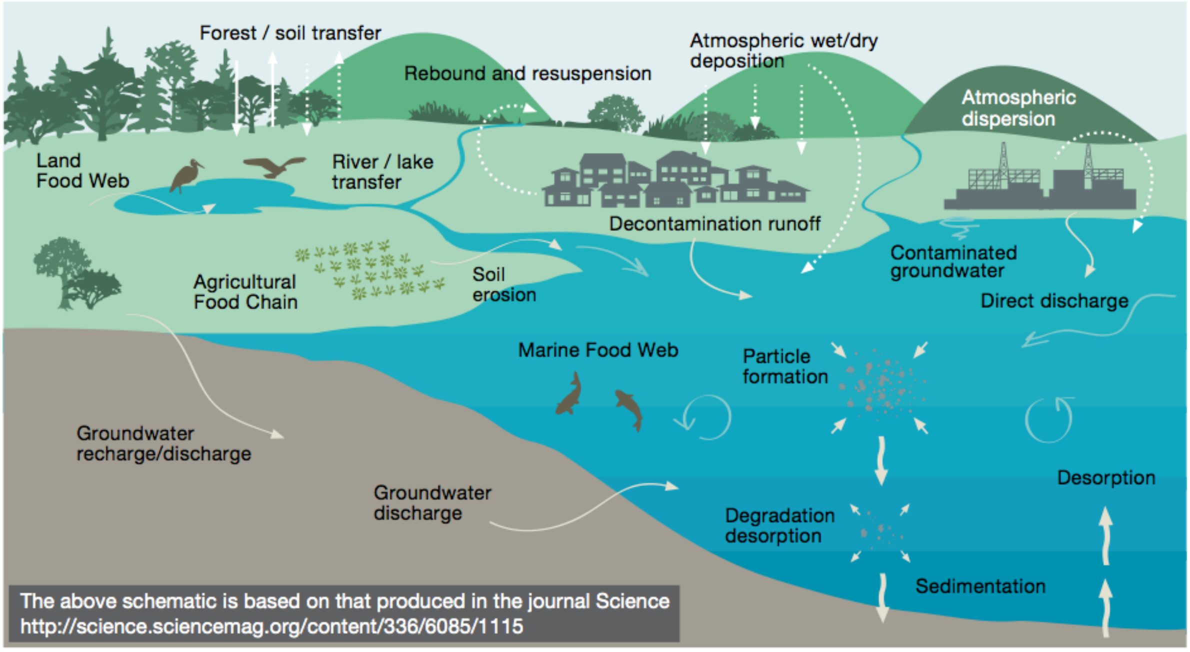
for International Security and Cooperation, Stanford University, October 2019, see https://doi.org/10.1016/j.chemosphere.2019.125019

[24] 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

[25] Ibiden.

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

Diagram 1: Land to ocean transfer of radionuclides



Contaminated estuaries

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,[27] a large portion of the mineral-bound radio-cesium is discharged into marine estuaries.[28] As demonstrated by C. Chartin, et al. (2013), the river catchments will be a long-term, ongoing source of radiocesium to estuaries and coastal areas. A small percentage of the particulate-bound cesium experiences desorption with rising salinity, when rivers empty to the ocean. Although the percent- age of the total inventory is very small, the total amount of newly liberated, dissolved radio-cesium can be quite high due to the large total loads of radioactivity water systems can carry. This can then "easily accumulate in marine biota".[29]

TEPCO fails to explain any of these issues in its draft RIA, not least the contamination of estuaries in Fukushima prefecture and other prefectures. 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.

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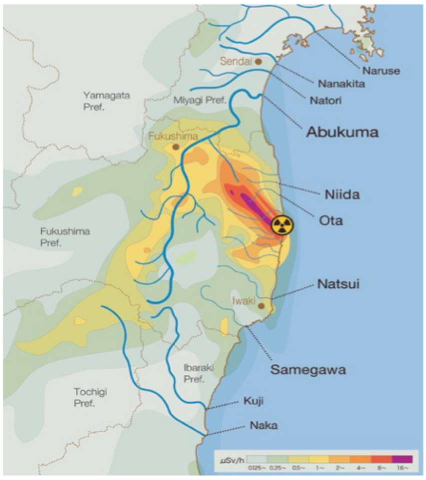
[27] For example, see Kakehi, S., et al. "Radioactive cesium dynamics derived from hydrographic observations in the Abukuma River Estuary, Japan." (2016). Journal of Environmental Radioactivity. Vol. 153: 1–9. see http://www.science direct.com/science/article/pii/S0265931X15301600.

[28] 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.

[29] Ibid.

The large-scale inventory of radio-cesium in the upland forests and lakes of Fukushima prefecture, are, and will remain, an ongoing and long-term source of radio-cesium inputs into the Pacific Ocean.[30] 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.

Map 1: River systems along Fukushima and neighbouring prefecture coastline discharging radioactivity into Pacific Ocean



This map is based on the radiation contour map of the Fukushima Daiichi accident, by Prof. Yukio Hayakawa. (also Map 3 on the page 12)

The TEPCO draft RIA is wholly inadequate in explaining to Japanese citizens and the wider international community in the Asia Pacific region the radiological conditions and consequences of the 2011 disaster, it's on-gong legacies and that its plans for radioactive waste water discharges must be considered in this wider context.

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.

[30] 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.

However, the TEPCO RIA fails to explain the complexity and uncertainties in the secondary processing and the implications if it is not successful,[31] including for future arisings and storage of contaminated water on the site.

As of 25 November 2021, according to TEPCO – 1,284,284 cubic meters of contaminated ALPS water is in storage tanks. Of this, 832,900m3 (67%) needs to undergo secondary processing in ALPS to reduce concentrations of radionuclides such as Sr-90, I-129, Ru-105 – this will take years, yet no details are given on timeframes.

Consequently, at this stage it is not possible to accurately state the total radioactive inventory of the contaminated water after secondary processing has been completed – each tank has a different inventory and batch of ALPS will perform differently, therefore the final concentration will vary.

Failure to stop groundwater contamination. The current TEPCO plan is for 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.

Thus, in addition to the 1.284 million cubic meters that currently is stored in tanks, almost half a million cubic meters of contaminated water will be required to be processed in ALPS. TEPCO's RIA makes no mention of this.

The probability is that accumulation of additional contaminated water will continue so long as groundwater enters the site and the reactor buildings and comes into contact with contamination associated with nuclear spent fuel debris. If the fuel debris is not removed or sealed from the environment contaminated water will continue to accumulate.

Ultimately, this will mean the construction of additional storage capacity. The TEPCO RIA makes no reference to this reality.

The major uncertainties in the ultimate performance of the ALPS during the coming years and presence of high concentrations of tritium (as well as carbon-14) –means the only option that minimizes the environmental and human health hazards from the contaminated water is securing additional storage space, either on the Fukushima Daiichi site or offsite in neighbouring municipalities of Futaba and Okuma; and continued water processing with the best available technology.

Tritium

The TEPCO RIA is significantly lacking in any analysis of tritium effects, including the behaviour of Organically Bound Tritium (OBT).

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[31] Greenpeace Germany, "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

Tritium released from nuclear power plants is almost entirely in the form of HTO, or tritiated water: a radioactive form of water.[32] Only a few reports document the distribution of tritium in aquatic biota following tritium releases from nuclear power plants and even less data is 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.[33] 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.[34] 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.[35] This is compounded by the hypothesis that the mussels can appear to bioaccumulate tritium due to its feeding mechanisms. In contrast, fish are more mobile and can spend a significant portion of their time in other areas where the tritium levels may be quite different. Tritium accumulation through the food chain is expected to cause higher OBT values in predator organisms than if they were feeding on non-tritiated foods because heterotrophic organisms can metabolize hydrogen from organic components from their diet as well as from their water intake.[36] A study of tritium concentrations in marine biota near Canadian nuclear power stations found that algae, mussels and fish have different tritium (as OBT) concentration factors (based on the water tritium content). Mussels showed the highest concentration factor compared to algae and fish.[37] Different TFWT (tissue free water tritium) and OBT activity concentrations were found to exhibit intra-species variability within the same aquatic ecosystems. The study found that it follows that past released tritium can produce a persistent effect on OBT content in biota.

The half-life of tritium (H-3) is 12.3 years.[38] With a 12.3-year half-life, in 60 years, 97% of all of the tritium would decay.[39] Also important is that the non-tritium isotopes in the tanks have vastly different toxicities and fates in the ocean.[40] While tritium is present in seawater, tritium can become incorporated in organic compounds, such as monosaccharides and amino

[32] Svetlik, I., Fejgl, M., Malátová, I., Tomaskova, L., 2014. Enhanced activities of organically bound tritium in biota samples. Appl. Radiat. Isot. 93, 82–86.

[33] 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).)

[34] 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.

[35] Op.Cit. Kim (2019)

[36] Kim (2019), citing Komatsu, K., Higuchi, M., Sakka, M., 1981. Accumulation of tritium in aquatic organisms through a food chain with three trophic levels. J. Radiat. Res. 22, 226–241, Kim, S.B., Shultz, C., Stuart, M., Festarini, A., 2015. Tritium uptake in rainbow trout (Oncorhynchus mykiss): HTO and OBT-spiked food exposure simultaneously. Appl. Radiat. Isot. 98, 96–102.

[37] Op.Cit. Kim (2019)

[38] I. Fairlie A hypothesis to explain childhood cancers near nuclear power plants.

J. Environ. Radioact., 133 (2014), pp. 10-17 (Fairlie (2014)).

[39] Ken O. Buesseler. "Opening the floodgates at Fukushima", Science 7 Aug 2020: Vol. 369, Issue 6504, pp. 621-622 DOI: 10.1126/science.abc1507. At https://science.sciencemag.org/content/369/6504/621. (Buesseler 2020).

[40] Ibiden

acids.[41] Living organisms integrate the tritium present in the water into their organic molecules. [42] The effects of tritiated water and organically bound tritium on humans have not yet been thoroughly studied. Some evidence suggests that exposure to elevated levels of tritium can pose a risk of cancer or genetic defects.[43]

There is evidence that current estimates for the radio-sensitivities of animals (and perhaps humans) are too low. At higher levels of exposure, tritium has been shown to cause reproductive and developmental problems and genetic abnormalities in laboratory animals.[44] A study of the impact of low doses of tritium on the marine mussel[45] 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. [46] Levels of tritium measured in fish and other aquatic life in areas receiving tritium inputs are often higher than predicted by standard models.[47]

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

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[41] McCubbin, D., Leonard, K.S., Bailey, T.A., Williams, J., Tossell, P., 2001. Incorporation of organic tritiagirum (3H) by marine organisms and sediment in the Severn Estuary/Bristol Channel (UK). Mar. Pollut. Bull. 42, 852–863.

[42] 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.

[43] Kim (2019). Citing I. Fairlie A hypothesis to explain childhood cancers near nuclear power plants. J. Environ. Radioact., 133 (2014), pp. 10-17.

[44] 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.

[45] 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.

[46] 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.

[47] 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.

tritium from tritiated water. In this particular case, all tissues demonstrated bio-accumulation of tritium from both HTO and OBT."[48]

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 (4) 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."[49]

TEPCO does not even reference the latest ICRP report on this issue – from November 2018.[50] During its draft stage, the French Radio-protection and Nuclear Safety Institute (IRSN) questioned the ICRP and recommended that they include in their assessment recent science that shows a higher RBE for tritium.[51]

Carbon-14

If the contaminated water is discharged to the Pacific Ocean, all the carbon 14 (C-14) with a half-life of 5,730 years, will be released to the environment, C-14 is a major contributor to the global human collective dose.[52,53] As an IAEA report notes, the metabolism and kinetics of C-14 in the human body follow those of ordinary carbon.[54] It has been found that accumulation of C-14 in the human body via respiration is insignificant compared with that from ingestion of contaminated food. In addition, C-14 can be easily concentrated in the food chain. Studies have shown concentration factors of 5000 for fish and molluscs and 2000 for soil sediments.[55] As the French Radio-protection and Nuclear Safety Institute, IRSN explains,

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[48] 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

[49] 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.

[50] 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

[51] ICRP, "IRSN comments on TG-72 Draft report : Radiation weighting for Reference Animals and Plants" https://www.icrp.org/consultation_viewitem.asp?guid=%7B60A9326A-F2E4-41C3-BF82-619DF6DCDF66%7D

[52]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.

[53] Op.Cit. Buesseler 2020.

[54] 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.

[55] 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.

"Carbon-14 is interesting from a radiobiological standpoint because it is integrated in cellular components (proteins, nucleic acids), particularly cellular DNA.[56] The resulting DNA damage, involving molecular breaks, may lead to cell death or induce potentially inheritable mutations.[57] In November 2019, METI, when seeking to represent the low risk from tritium releases, cited C-14 as one of the radioactive isotopes that has a greater impact on "living organisms".[58] Though not exactly clear on what they meant, in the table entitled "Comparison of impact of tritium and well-known radioactive nuclides on living organisms, METI gave tritium a value of 1, compared with C-14 at 32. This appears to suggest that for METI, C-14 is 32 times more hazardous to life than tritium. It is possible to apply and operate C-14 removal technology but TEPCO has decided not.

The TEPCO RIA fails to assess and therefore explain to the public the long-term implications of releasing C-14 (or the many other radionuclides) to the environment.

Strontium-90

Representative of TEPCO's RIA lack of credible analysis on the risks from radionuclides they plan to release to the Pacific Ocean, is their failure to explain Strontium-90 (Sr-90),one of the most hazardous of radionuclides. Sr-90's chemical behaviour is similar to that of calcium, and it can accumulate in organisms, particularly in bones.[59] The Fukushima accident has been found to have raised levels of radioactive strontium off the east coast of Japan by up to 100 times. Strontium-90 levels were estimated to be between 90 and 900 TBq (terabecquerels), raising levels by up to two orders of magnitude. The highest concentrations were found to the north of the Kuroshio current.[60] Strontium-90 has been detected in waters near the Korean peninsula.[61] The TEPCO RIA barely references Sr-90 and does not explain the hazards that will result from releasing this radionuclide into the environment.

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[56] IRSN "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, citing 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.)

[57] Ibiden..

[58] METI, "The Outline of the Handling of ALPS Treated Water at Fukushima Daiichi NPS (FDNPS)", Agency for Natural Resources and Energy METI, 21 November, 2019. See https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/20191121_current_status.pdf.

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

[60] 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.

[61] 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.