Comments on Nov. 2021 TEPCO Radiological Impact Assessment (RIA) Report

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Overall, the RIA report and calculated dose assessment suggests a low dose associated with the proposed release of FDNPP tank waters to the ocean. The report documents the discharge scenarios and assumptions made to reach this conclusion, and these dose calculations and assessment appear to be reasonable and similar to the conclusion of other studies, such as in Bezhenar et al. STOTEN 2021.

I will focus my comments therefore mostly on what is missing, or left unsaid about these plans in the hopes of increasing transparency, with a goal of expanding the considerations and changes that would be needed to fully evaluate this release plan from a marine radiochemists perspective with a long history of involvement in this area, but from a scientific and public educational perspective. The hope is to increase trust and public acceptance, or at least improve the understanding of the motivations and rationale for such a plan vs. other alternatives.

To make this assessment I have grouped these under short subsections for easier dissemination, and not necessarily in order of most importance. For each section a set of recommendations is provided.

Scale of problem for tritium alone

With on order 0.86 PBq of tritium (3H) in >1.3 million m3 water stored in over 1000 tanks so far (data from this report and others), and a stated yearly release of 0.022 PBq/yr (22 TBq/yr- this report) it would take on order **39 years** to release the amount of 3H stored today in the tanks. Over this 40 year time frame, even if amount of water collected is reduced by 30% (140 to 100 m3/d), the site would need to store and process another 1.4 million m3, essentially **doubling the amount of tank waste water** being considered here. These time scales and additional water and 3H risk are not mentioned in the RIA.

It should be noted that the total amount of 3He to be released is greater than estimates of 3H released in 2011 (0.1-0.5 BPBq), so by this measure, this is not standard operations but a deliberate release that is already on the same scale or larger for 3H, compared to the release from the 2011 accident.

In several places in the report, it is said that water would be diluted by a factor of 100, or more than 100 times, in order to reduce 3H below 1,500 Bq/L (lower than the 60,000 Bq/L normal operational threshold). 3H levels in over 200 tanks that have been reported, with maximum activities up to 2,500,500 Bq/L, **requiring dilution of 1,700 times** to reach the stated 1,500 Bq/L threshold. The median 3H in the tanks is 381,000 Bq/L (B et al Science, taken from TEPCO tank data), requiring a dilution factor of 254. The point is that dilution will need to be much higher than 100 that is referenced here for tritium essentially all of the tanks. This is feasible, but needs to be emphasized as the scale of tanks/pumps for dilution is much higher than the 1/100 focus.

No mention is made of **organic bound tritium** (OBT), which has a different fate/behavior in the ocean and impact on doses to humans and marine life. See Eyrolle et al., 2018, J. Env. Radioactivity as just one recent discussion of the need to consider this form of tritium and its different behavior in the environment. Other studies as to the health effects of OBT would also need to be considered in any plan.

Recommendation

Be more transparent about scale of the tank issues. Need to be upfront not just about volume, but concentrations, total amount/inventory on site, disposal time frame, continued sources, differences in 3H and OBT.

Other radionuclides beyond 3H in the tanks

It was not until 2018 that values for non-tritium radionuclides in the tanks were reported to the public. At that time, over 70% of the tanks were reported to have non-3H isotopes at levels that are too high to release, and this **high percentage not changed in over 3 years**. The lack of effort thus far, for secondary purification, which is essential to the evaluation of the project, does not build trust in a plan that relies on this as a central feature. And given the same/similar ALPS purification system, there is little confidence there will not be similar issues in treatment moving ahead with secondary treatment with variable success. Building trust is as important, and secondary treatment should have been started and well on its way by now.

Variability the radionuclide concentrations in the tanks is also an issue. The range in radioactivity levels of the non-3H radionuclides in the tanks exceeds in many cases, the variability of 3H in the tanks. For example, the reported levels of 90Sr (so far from only a subset of tanks) differ by more than 6 orders of magnitude, or factor of one million. Given the **extreme variability in contaminant levels**, data from all tanks, and all 62 radionuclides are needed with 3rd party verification.

So far **only 2 tanks have apparently undergone secondary treatment** (J1-C and J1-G) that includes full reporting of 62 radionuclides (TEPCO, 2020). These 2 tanks had high initial "sum of ratios" >100, but are not the highest in terms of contamination levels, and no indication is given how long/difficult is was to reach the levels <1 considered "conservative" in this release model. As just one example, 90Sr remaining in tanks has maximum of 433,300 Bq/L but of these two tanks chosen for secondary treatment, the highest 90Sr was 64,600. Given that the ALPS processing over the last 10 years did not reach these lower levels, it is upon TEPCO to demonstrate in advance, that all tanks can be reduced to these lower levels in an efficient and timely manner.

Recommendation

Data from all tanks, and all 62 radionuclides are needed with 3rd party verification before and after secondary treatment. This should include volumes so that total amount or inventory of each radionuclides can be readily calculated. Tables in digital format, not just pdf, should be provided. The source term and hence final plans that rely on secondary treatment can only be made with confidence after treatment is completed and verified.

Behavior in the ocean & ocean assessments

The model of ocean dispersion here is for 3H and compared/validated with prior 137Cs releases to the ocean in 2011. So the assessment of flow, dilution, physical transport with currents would be correct for a soluble radionuclide in the ocean. However a large number of **the non-3H radionuclides have much higher uptake ratios for marine biota and seafloor sediments, so this model does not represent their behavior after release.** It is important to remember that **radionuclides are dispersed or concentrated by environmental processes** depending upon their geochemical and biologically relevant properties.

Kd's (fraction of individual radionuclide in equilibrium with ocean water and seafloor sediments) are 1 for 3H but range from 8 to 300,000 for just the 9 isotopes discussed in Buesseler, Science, 2020.

Kbio's (fraction in equilibrium with ocean water and marine fish) are 1 for 3H but range from 3 to 50,000 for those same 8 non-H isotopes in Buesseler, Science 2020.

As such the models here do not apply equally well to all radionuclides. In particular, the Kd for "sand" uptake used in this RIA was 1,000 for all radionuclides (pg 19), which is incorrect, and not "conservative". Again accumulation on the seafloor would increase radioactive contaminant levels over time as disposal continues, thus increasing the chances to impact the benthic food web (shell fish & seafloor/benthic fish) and species that consume them. Note some of the highest values of Cs post 2011 were in these benthic fish (e.g. Wang et al., 2018, Env. Sci and Tech.).

No provision is made for seafloor sampling in the proposed ocean assessments, **nor are there plans for measurements of non-3H isotopes** other than 137Cs. Sampling is needed of ocean water, biota and seafloor. While it has been said that the non-3H isotopes will be removed to levels below concern, given their higher health and dose impacts, higher uptake by marine biota and their higher propensity to become localized near the outfall pipe, this assessment and monitoring plan is lacking in its ability to assess consequences of tank releases on the ocean, and this is a **major flaw in this RIA**.

Discussion is lacking why the outfall pipe is located 1 km off shore? What is the water depth? Why subseabed, vs pipe above seafloor? There is no evidence of the selection criteria used. To minimize exposure for example, a release further offshore and deeper would be advantageous. Also, with waste water coming from land/tanks, the temperature difference of water on land vs ocean would lead to changes in buoyancy, as would differences in salt contents, hence impact transport at release point. Was this considered?

What are specific criteria for stopping discharge after discovery of "abnormal" values?

Recommendation

Tables and information on Kd and Kb for each of 62 radionuclides needed and should be considered in planning. Enhanced ocean monitoring of not just 137Cs and 3H, but key target radionuclides with differing affinities for biota and sediment are needed (such as 90Sr, 60Co, 14C, etc) with samples from seawater, filtered seawater particles, biota (nets, seafloor) and seafloor sediments (multi-coring) collected over a regular sampling grid and sustained for the decades of release. This should start at least one year prior to releases. Independent 3rd parties should be engaged. Local communities and stake holders could help collect samples to build confidence and trust.

3rd party involvement

While it is said that 3rd party verification will be used (of tanks, in ocean), who are these 3rd parties? And why hasn't 3rd party verification been reported for example already on for example all of the water in the 1000 tanks, and for the 2 tanks that have undergone secondary processing?

IAEA is mentioned several times being in support of this plan, but with an organization centered around the themes of "Atoms for Peace" and the "promotion of safe, secure and peaceful use of nuclear technologies" at the core of their mission, this is not a neutral 3rd party, nor is it considered one by many in the public.

Recommendation

Define more clearly 3rd party groups that might participate, from academic institutions, NGO's, fisheries, etc and their roles, with some sampling organize alongside and with deliberate intercomparisons with government and nuclear power company agencies.

Normal operations vs. ocean dumping of radioactive waste

This plan is not related to normal NPP operations for which release levels have been established. This brings up several issues:

1) are these "legally required concentrations" established for normal NPP operations applicable, or would they differ for deliberate ocean waste disposal?

2) does the "sum of ratios" capture the impacts of different radionuclide behaviors in the ocean, such that at the release point the sum of ratios may be <1, but over time accumulation in oceans will alter these ratios as some bioaccumulate or become associated with sediments while others disperse?

3) what are the consequences for setting a precedent of disposal of nuclear waste via ocean pipes? With many hundreds of aging NPP's along rivers and ocean coasts, is ocean release an acceptable option? Even low level dumping of nuclear waste has been halted globally. While comparisons to deliberate releases at Sellafied, UK and Cape de La Hague, France can be made, no new ocean waste disposal has been approved for many decades, or if so, can examples be given and considerations discussed for such new releases.

3) **transboundary effects need to be considered** which requires consultation with neighboring countries in the Pacific. Radionuclides released to the Japan coast at FDNPP will travel largely to the east across the Pacific, but return flows around Japan have been noted and now verified after 2011 (e.g. Inoue et al., Marine Chemistry, 2019). This is a major issue for neighboring countries and given #3 above and for example plans by China, Russia, US, Korea and many others for decommissioning their own NPPs and few on land permanent disposal options for nuclear wastes. Customary international law requires notifying and consulting with potentially affected states.

Recommendation

Open up discussions with international states and agencies to consider transboundary issues and precedent of approval of ocean nuclear waste disposal, even if the levels are not expected to be harmful

Release plan vs alternatives, such as storage

The premise is that discharge to the sea is "necessary" however that is a choice based upon an earlier selection process (pg ii- started 2013), and summarized here to conclude that between the options of 3H disposal using vapor release and ocean discharge, ocean discharge was preferred. Consideration of storage and decay does not appear to have been evaluated. This is especially significant when considering tritium, 97% of the tritium would decay if waters were held for 60 years due to natural decay (see above for an estimated release time needed). Storage on site or outside the boundaries should be considered and the "urgency" (pg ii) does not seem to balance the ability to expand storage on site within and outside of current FDNPP boundaries. The ability for safe and long term storage of other hazardous materials in Japan, such as LNG and other petrochemicals suggests that this option is viable and would allow for consideration of costs and siting issues.

Recommendation

Reconsider on site storage plans. Urgency and space limitations in wider FDNPP area are not well justified. Even a 10 year delay would reduce current tritium levels by almost 50% (and more for some of the other short lived radionuclides). Consideration of costs, storage safety etc. need to be weighed against reputational damage to local fisheries and public concern with nuclear waste dumping.

References

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