Impact of Wastewater from Fukushima Nuclear Power Station

On the Oceanographic Environment

The Great East Japan Earthquake and Tsunami of 11 March 2011 measuring 9.0 on the Richter scale caused the meltdown and melt through of three reactors at Fukushima No.1 Nuclear Power Station (NPS). This resulted in a hydrogen gas explosion followed by the serious contamination of air, land and water over a 100-kilometre radius of NPS, including the Tokyo area. Air contamination is decreasing and is concentrated in a limited area. Land contamination has also decreased through decontamination processes. However, despite all the efforts by Tokyo Electric Power Company (TEPCO) and the Japanese government, water contamination in surface and ground water is getting worse, simply because there are no effective countermeasures.. This paper summarises the current status of the wastewater problems of Fukushima NPS and future views.

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EVEN THOUGH THE wastewater issue is taken seriously by Japanese people as well as people worldwide, the real status of the effect of the contamination is still unknown because neutral third party organisations have no access to within a 20-km radius of Fukushima NPS. The author has tried to make clear what the status of the wastewater issue is by using various sources including a Fishermen Union's report, which appears to be more reliable than the government report or the report by TEPCO.

Most of the Japanese do not trust official reports. Therefore, radiation levels in foods, including 'Sashimi Fish', are measured by individual sellers and buyers in cooperation with the local fish market unions. These inspections are so strict that all certified foods are safe.

Present Status of Reactors

Of the six reactors, the four reactors No. 1 to No. 4 were affected by the Tsunami while the other two reactors, No. 5 and No. 6, were not damaged because they were on slightly higher ground. The reactors No. 1 to No. 3 were in operation at the time of the Great East Japan Earthquake and Tsunami on 11 March 2011. Reactor No. 4 was under inspection, but 1533 bars of spent nuclear fuels were being cooled in a water pool within the generator's building.

As the underground emergency electric power generators stopped due to the 15-metre-high Tsunami, the temperature of the nuclear fuels, including spent nuclear fuels, increased to more than 2000 degrees Celsius. This resulted in a meltdown in reactors No. 1, No. 2 and No. 3 while a hydrogen gas explosion occurred at reactors No. 1, No. 3 and No. 4. It was estimated that the total amount of accumulated radiation was equivalent to 30 Hiroshima bombs.

The situation was critical before seawater was used cool down the nuclear fuels in the meltdown reactors. Initially, 500 tons of water were pumped and provided to the reactors daily. Not much attention was paid to the wastewater used for cooling the reactors as the main priority was avoiding the nuclear fusion. Air and land contamination was the main topic of discussion by people because it was essential for daily life. After TEPCO had succeeded in lowering the temperature of affected reactors, the wastewater issue became an urgent matter as the capacity of the water tanks was not enough to store 400 tons per day until the shutdown of the three reactors No. 1, No. 2 and No. 3.

No one can tell how and when the meltdown fuels at the bottom of the reactor can be carried out safely. Until then, the amount of wastewater to be stored increases day by day as shown by Google Earth in Figure 1. As TEPCO constructed these water tanks in haste with folded iron steel panels to meet the required volume, about

Figure 1: Fukushima No. 1 NPS. (Image courtesy: Google, DigitalGlobe, TerraMetrics, Zenrin).

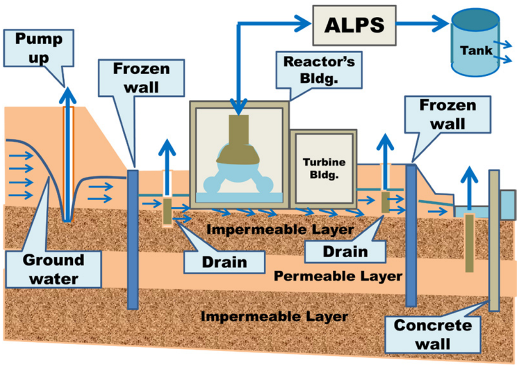


Figure 2: Wastewater issue visualisation.

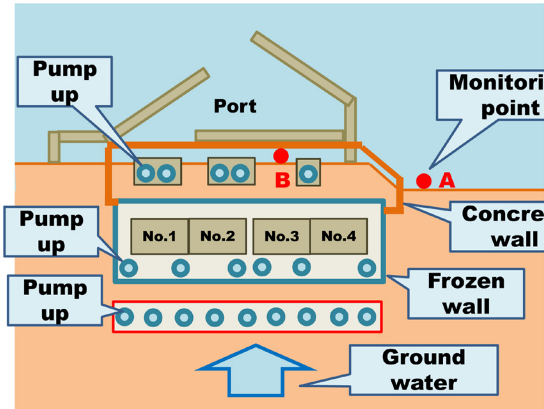


Figure 3: Location of counter measures.

Radiation levels in foods are measured by individual sellers and buyers

300 tons of highly contaminated wastewater leaked out from the water tanks. There are 350 similar tanks at risk of leakage. Although the leaked water is kept in a weir, it was reported that highly contaminated wastewater spilled out. The water leakage was also found at several reactor buildings. In addition, 400 tons of ground water flows into the campus as the flat land was constructed by excavating a rock hill behind the campus. This wastewater flows on the surface and into several underground drains. TEPCO tried to pump up the water but was not entirely successful because the water had spread widely, as shown in Figure 2.

TEPCO set up two monitoring points to measure the radiation of the seawater; one within the port (B) and another outside the port (A) as shown in Figure 3. In my opinion, the number of monitoring points is insufficient.

TEPCO and the government decided to construct frozen walls around the four reactors and concrete walls to stop the outflow of wastewater into the sea as also shown in Figure 3. This is better than doing nothing, but the cost will be very high and the effects unknown.

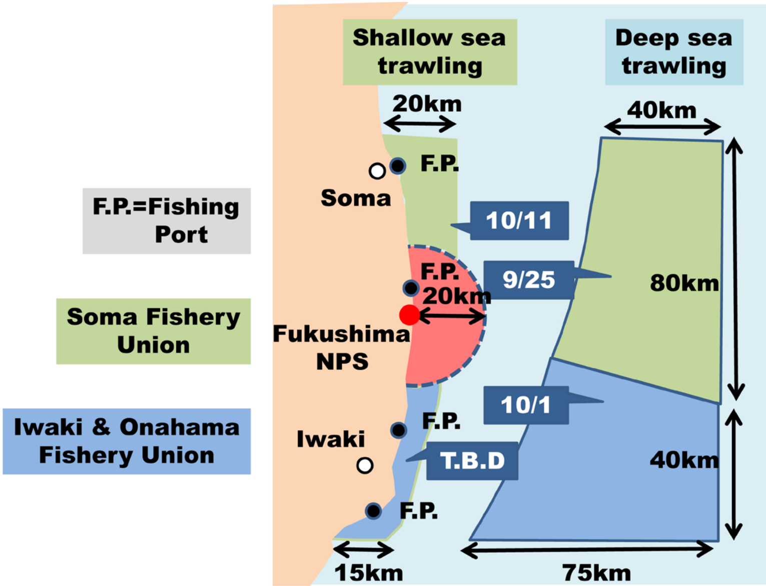
TEPCO has tried to use so-called ALPS to decontaminate the wastewater before sending it on to the water tanks. However, the problem is that not all nuclear particles can be decontaminated. Strontium cannot be removed, even after the ALPS process. We need to find a location to store the used decontaminated materials after decontamination. But most Japanese are against such deposits being based near their homes. All the above mentioned activities need to be carried out under highly contaminated conditions, which makes it difficult to check the efficiency.

Wastewater Problems

The three main wastewater problems are:

1. Daily increase of 400 tons of contaminated water. 400 tons of water is supplied daily into the reactor buildings to cool the meltdown nuclear fuels. 400 tons of ground water flows daily into the turbine buildings and other buildings, which are contaminated after the inflow. Therefore, 800 tons of contaminated wastewater should be pumped up to decontamination vessels but only half can be stored in storage tanks. This means that about 400 tons of contaminated

Figure 4: Test fishing areas and fishing ports.



water appears to flow into the inner port. To date, a total of about 500,000 tons of the wastewater has flowed into the sea. The government announced that the level of contamination is very low at the outer part of the port. But no one can validate the report as no one except the government and TEPCO is permitted to enter the area to measure the radiation. In any case, 400 tons of contaminated water are added every day, which cannot be stored as the capacity and land space of water tanks cannot meet such large volumes.

2. Leakage of contaminated water from tanks. The storage tanks are made of flexible iron steel panels from which the contaminated water leaked on a daily basis. The water spilled onto the surface and the flowed into the sea. No one knows how much wastewater is spilling and contaminating land and sea.
3. Unpumped contaminated water in drains. Several drains for cables and pipes connecting the turbine building and the intake are filled with contaminated water. Part of the wastewater spilled into the inner port through the cracked breakwater.

The most serious problem is not knowing where and how much contaminated water is leaking into the sea.

Contamination of Seawater

The question of how much the sea is being contaminated now arises. TEPCO announced that at measuring point A, outside of the port, the contamination was 100,000Bq/l at the time of the accident and the value is now down to less than 10Bq/l. This is why Prime Minister Shinzo Abe said at the bidding for the Tokyo Olympic Games 2020 that the Fukushima NPS is under control. At measuring point B, inside the port, contamination was more than one million Bq/l at the time of the accident and the value is now down to 10 to 100 Bq/l. The allowable upper limit of Cesium should be below 90 Bq/l. Therefore, the situation at the inner port has not yet been solved. It was reported that the value of the leaked water would be about 100 Bq/l. However, fish caught in the port showed 100,000Bq/l (Cesium) which is 2540 times larger than the allowable value.

The readers probably do not know that all coastlines and the coastal areas of Japan are divided into territories that are owned by fishermen's unions. This means that Fukushima NPS areas are owned by certain fishermen's unions who can only operate fisheries within a limited territory. Catching safe fish is currently a serious problem for the fishermen's unions. To date, TEPCO compensates the fishermen's unions, but the fishermen really wish to restart fishing. Therefore, the fishermen's unions are trying to test catching and measuring the radiation. As shown in Figure 4, the vicinity of Fukushima NPS is owned by Soma, Iwaki and Onahama fishery unions, which are allowing test fishing in the designated areas. Shallow-sea trawling for testing is permitted as of 11 October 2013 for Soma Fishery Union north of Fukushima NPS while deep-sea trawling for testing is permitted offshore as of 25 September 2013. The two unions of Iwaki and Onahama have only been permitted deep-sea trawling offshore as of 17 October 2013. But shallow trawling has not yet been allowed. 41 species of fish are restricted in the area due to high radiation. The fishery unions are trying to find specific safe fish with radiation levels below the allowable level. The safe fish certified as being within the safety level is on the fish

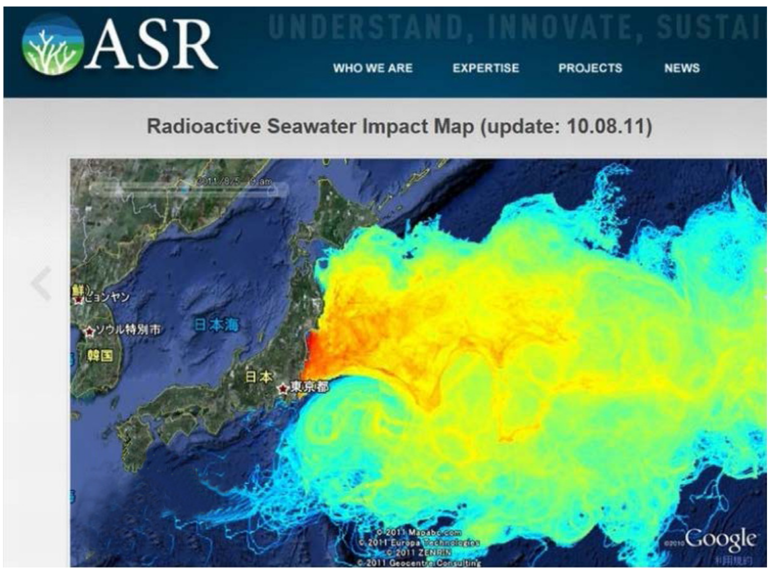


Figure 5: Simulation of water contamination.

market. Only local people purchased the fish as the reputation has been seriously damaged. Whitebait caught by shallow trawling was certified as being safe and was sold on the market.

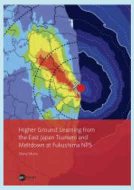
The Fukushima Prefecture also checks the safety level of the coastline and offshore areas outside the 20-km radius of Fukushima NPS every month. 180 species were examined in November 2013 of which about 15% exceeded the allowable limit of 100 Bq/l. Fukushima Prefecture also checked the fish in rivers. Some of these fish were also contaminated.

Figure 5 shows the results of the simulation of water contamination globally as published by ASR. It was reported that black tuna caught in California, USA was contaminated. There is a possibility that the tuna was contaminated as a result of the Fukushima NPS accident.

Conclusions

Despite reports by the Japanese government, including the report by the Ministry of Economy, Trade and Industry (METI), the Japanese are trying to establish their own safety net because it appears that there is nothing absolutely safe when it comes to nuclear power generation. Unfortunately, the truth is still uncertain and we do not know how to solve such extremely difficult issues with the continued contamination of increasing wastewater. We, the Japanese nation, certainly wish to enjoy fresh and safe 'Sashimi' and 'Sushi'.

Higher Ground - Learning from the East Japan Tsunami and Meltdown at Fukushima NPS



The author of this paper has also written a book describing the disaster that struck Japan on 11 March 2011. He portrays individual and group heroism and survival, the suffering, terror and death, based on eye-witness accounts. He distills lessons learned from the cardinal mistakes made and shows ways to correct them in the future. See *http://bit.ly/murai* for details. When ordering using the code HGR20 before 1 June 2014, you receive 20% discount.

Further Reading

(Links are leading to Japanese websites)

www.asahi.com/articles/ASF0TKY201312220121.html

matome.naver.jp/odai/2131829810240813801

www.meti.go.jp/earthquake/nuclear/pdf/osensuitaisaku_houshin_01.pdf

www.asrltd.com/japan/plume.php

headlines.yahoo.co.jp/hl?a=20131224-00000036-asahi-soci

www.asyura2.com/13/genpatu34/msg/880.html

www.meti.go.jp/earthquake/nuclear/osensuitaisaku.html

The Author

Shunji Murai was born in Tokyo in 1939 and graduated from the Civil Engineering Department in 1963. He was awarded a Doctor of Engineering in 1970. He was promoted to Professor at the Institute of Industrial Science of the University of Tokyo in 1983. He was president of ISPRS from 1992 to1996. He retired as Professor in 2000 and was appointed Professor Emeritus at the University of Tokyo. He has been president of the Japan Association of Surveyors since 2007. He is specialised in geospatial technologies, including remote sensing, GIS, GNSS and digital photogrammetry.