Volume 10 | Issue 11 | Number 8 | Article ID 3718 | Mar 05, 2012

Ocean Contamination in the Wake of Japan's 3.11 Disaster□□日本の3. 11災害の残した海洋汚染

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by Miguel Quintana

Radioactive particles released after the accident at the Fukushima Daiichi nuclear power plant continue to spread along the seashore and rivers of eastern Japan, creating underwater hotspots as far as Tokyo Bay, according to recent scientific studies. But the full magnitude and impact of the contamination, already considered the largest case of unintended[1] marine pollution by radionuclides in history, has yet to be established.

Experts have pointed out four main routes of ocean contamination, namely the initial atmospheric fallout, direct releases from the plant, rivers draining particles that fell over land, and groundwater. Only the first two categories have been quantified so far.

Initial Assessments of Fallout at Sea

Estimates regarding the total amount of cesium-137 (half-life of 30 years) released into the ocean remain subject to debate. France's Radioprotection and Nuclear Safety Institute (IRSN) estimated in October that direct releases into the sea totaled 27 Petabecquerels (PBq)[2] between Mar. 21 and mid-July, representing "the largest release of artificial radionuclides in the marine environment ever observed." The same month, the Norwegian Institute for Air Research said that total releases from the plant amounted to 36 PBq, 80 percent of which were deposited in the water.

Fukushima Daiichi by the sea

Prof. Yoshimura Kei, from the University of Tokyo's Atmosphere and Ocean Research Institute, conducted a simulation of atmospheric releases based on government information. According to his model, of the 16.5 PBq of cesium released in March, some 0.3 PBq fell over land, 2.7 PBq over the ocean in the region, with the rest going further away."

Such calculations are further complicated by the regular influx of cesium that fell over land before draining back into the ocean via contaminated rivers. One survey of Abukumagawa River, which runs through Fukushima Prefecture and into neighboring Miyagi, uncovered an average flow of 50 billion becquerels of cesium per day in late August.[3] When contacted last December, a spokesman for the Japanese Ministry of Science and Technology - which oversees many of the studies conducted by academic institutions - said the river was not subject to regular monitoring.

Project leader Onda Yuichi, from Tsukuba University's Graduate School of Life and Environmental Sciences, said in late February that his team had continued taking measurements "once every other week, and sometimes once a month." Onda said he could not comment on the general evolution of cesium levels since August because the results were "still being processed." An official report on the situation there is to be delivered to the government on March 8th and presented at a press conference on March 13th.

Early monitoring activities at sea depended on samples collected by Tokyo Electric Power Co. (Tepco) near the plant and surveys sponsored by the Japanese Ministry of Science and Technology at eight stations some 30 kilometers offshore. Analysis of this initial data was featured in an article entitled Impact of the Fukushima Nuclear Power Plants on Marine Radioactivity, published in December in the journal *Environmental Science and Technology*.[4]

According to Ken Buesseler from the Woods Hole Oceanographic Institution and two co-authors, ocean discharges of cesium peaked in early April. Higher-than-expected concentrations in May pointed towards a "steady, albeit lower" release at least through the end of July. The authors, who took measurements in the sea off Fukushima, say Fukushima "has become the largest accidental source of radionuclides to the ocean," surpassing the impact of Chernobyl on the Baltic and Black Seas in 1986. But their assessment "does not consider bioaccumulation and consumption of seafood and seaweeds and possible impacts on humans," prompting them to call for "continued monitoring and bans on fishing in Fukushima impacted waters."

Buessler aboard ship. He previously studied the Chernobyl radiation.

"Levels of several isotopes, such as cesium-134 and cesium-137 are more than 1,000 times higher concentrations than existed prior to the accident," says Buesseler. "At these levels, cesium is not directly harmful to humans or marine biota, or to humans via seafood consumption. However, the Fukushima site continues to leak these isotopes at levels that are of concern – about 1,000 to 10,000 times higher offshore than [before the accident] – and there is no sign that this is significantly decreasing."

Tracking the Spread of Radioactive Cesium

In November, researchers from the Tokyo University of Marine Science and Technology conducted the first – and so far only – scientific survey inside the 20-km exclusion zone with the cooperation of local fishermen. Their mission was featured in an investigative documentary aired in January by national broadcaster NHK, entitled *Unknown Radioactive Contamination: an urgent report from the ocean.*

The team led by professors Ishimaru Takashi and Kanda Jota collected mud samples from the seabed near the entrance to the nuclear plant's dock. They collected water, plankton, fish, squid, ocean floor mud, and air samples. According to the NHK documentary, they detected as much as 4,220 becquerels of

radioactive cesium per kilogram (Bq/kg), while more than half of the 30 spots surveyed inside the perimeter topped 500 Bq/kg (publication of these figures is still pending).

The TUMSAT team preparing to collect samples aboard the Umitaka Maru during a survey mission outside the exclusion zone in July 2011 (Miguel Quintana)

Specimens of fish showed levels of cesium comparable with values found in the mud, indicating that contamination is progressing through the food chain. The highest figure so far, 4,500 Bq/kg in a specimen of Japanese flounder, was recorded by Fukushima authorities near the port of Iwaki in November.

Other surveys indicate that contamination is spreading southward along the coasts of Ibaraki and Chiba prefectures, where fishing is still allowed because no specimen containing more than 500 Bq/kg of cesium – the provisional regulatory value for fish – has been caught so far.

Okano Masaharu, a local researcher featured in the NHK documentary, uncovered several hotspots of cesium in the seabed ranging between 300 Bq/kg 30 kilometers south of Fukushima Daiichi to 380 Bq/kg off the coast of Ibaraki Prefecture, 120 km away. One location off Chiba prefecture (180 km to the south), showed levels trebling from 38 Bq/kg to 112 Bq/kg between October and December.

“There is no doubt that cesium is spreading,” says Prof. Kanda from the Tokyo University of Marine Science and Technology, “but the important factor is the actual level of radioactivity in [fish] meat.” According to him, even chronic consumption of the most contaminated specimen caught so far – at 4,500 Bq/kg – would translate into a “statistically insignificant” health risk for consumers. Kanda says that the government’s plan to revise the regulatory threshold for cesium in fish to 100 Bq/kg starting in April could be problematic because ordinary fish already contain some 100 Bq/kg of potassium-40, a radioactive isotope naturally present in seawater.

Environmental protection organization Greenpeace, which has been carrying out its own monitoring of fish and seafood in Ibaraki and other prefectures, stands by the principle of "optimisation in radiation protection" and disagrees with the idea that the risk of contaminated food is statistically acceptable. "Exposure easily removable from the market should be removed," says Jan Vande Putte, a radiation expert dispatched on a temporary mission from Europe. "Food should be safe for everyone, including pregnant women or the fraction of the population that is highly sensitive to radiation." On the natural presence of potassium-40 in fish meat, he says that the isotope can be easily filtered out using gamma spectrometry and should not impact measurements of cesium-137 and 134.

Waterborne Contamination Near Tokyo

A similar phenomenon was observed in Tokyo Bay, where cesium carried by rain drained into the Edogawa and Arakawa rivers. Surveys conducted by Associate Professor Koibuchi Yukio from the University of Tokyo's Water Environment Science and Technology Laboratory showed that as much as 872 Bq/kg had collected in the river bed at the mouth of the Edogawa river. Several hotspots were

detected along the river, including 1,623 Bq/kg some 8 km upstream due to sedimentation caused by the convergence of saltwater from the bay.

Koibuchi blames the accumulation on the pollution of the river's basin, particularly the area around the city of Kashiwa (Chiba prefecture.), some 30 km northeast of Tokyo. "Once the cesium flows into Tokyo Bay, fishermen won't be able to sell their catch due to consumer concerns," says Koibuchi. "All the efforts made to restore the bay's ecosystem over the past 50 years, which included improving the sewage system and quality of the water, could be lost."

According to a simulation carried out by a team from Kyoto University, also presented in the NHK documentary, cesium will continue accumulating and spreading across Tokyo Bay at a speed of 5 km per year, peaking in two years. Experts say the particles are likely to remain for over a decade because of the enclosed characteristics of Tokyo Bay.

In the meantime, some Japanese researchers say they are frustrated by what they call the government's piecemeal approach towards ocean contamination. "The government is neglecting us," says one established expert. "The authorities' commitment to a 'scientific approach' without commissioning a nationwide effort was just a way of shifting responsibility for data gathering and analysis on the researchers. What the public needs is a comprehensive survey backed by the government – and with appropriate funding."

These comments echo a similar plea for comprehensive marine monitoring by Professor Matsuyama Masaji, President of Tokyo University of Marine Science and Technology, in an opinion paper published last May in Nuclear Intelligence Weekly. - Miguel Quintana

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This is an expanded version of an article published in the March 2, 2012 edition of Nuclear Intelligence Weekly.

Recommended citation: Miguel Quintana, 'Ocean Contamination in the Wake of Japan's 3.11 Disaster,' The Asia-Pacific Journal, Vol 10, Issue 11, No 8, March 12, 2012.

See the complete list of APJ resources on the 3.11 earthquake, tsunami and nuclear power meltdown, and the state and societal responses to it here.

[1] Nuclear tests are believed to have released more radioactive particles into the ocean.

[2] 1 PBq = $1x10^{15}$ Bq

[3] For some perspective, a constant flow at this level would translate annually into 18.25 terabecquerels of cesium - an order of magnitude 1,000 times below estimates for total fallout at sea.

[4] Available here.