NEWS IN FOCUS

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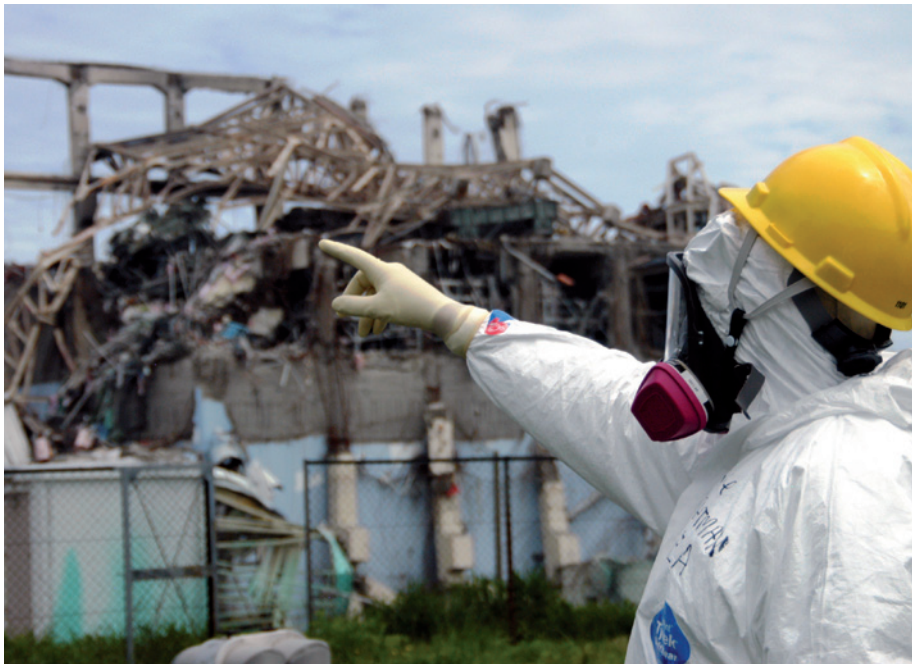

On a visit to Fukushima in late May, safety experts praised Japan's response to the nuclear disaster.

NUCLEAR ENERGY

Fukushima deep in hot water

Rising levels of radioactive liquid hamper clean-up effort.

BY GEOFF BRUMFIEL AND DAVID CYRANOSKI

In the first hours of March's accident at the Fukushima Daiichi nuclear power plant, workers rushed to flood three damaged reactors with sea water to prevent a catastrophic meltdown. Three months later, water is still being pumped into the cores and has become the biggest obstacle to cleaning up the site.

Buildings there are deep in radioactive water, slowing work to a crawl. Storage tanks are rapidly reaching capacity and, if the trend continues, drainage trenches will start overflowing as early as 20 June, according to a report last week from the plant's operator, the Tokyo Electric Power Company (TEPCO).

TEPCO plans to install a decontamination system, which it hopes will remove radioisotopes from the water so that it can be reused to cool the reactors. The system should slow the consumption of water and reduce the danger posed by the wastewater. But even when the system is up and running — expected to be on 15 June — it will generate large amounts of radioactive waste, leading some critics to question whether it is the best solution.

Residual nuclear decay in the three reactors — which all suffered total meltdowns — means that they will need cooling for many months to come. TEPCO switched to using fresh water two weeks after the accident, because the salty sea water they had been using was extremely corrosive to the stainless-steel reactor vessels. The water in the reactors remains salty, even though several thousand litres of fresh water are being poured into the reactors every hour.

More than 100,000 tonnes of water are now swilling around various parts of the site. In early April, TEPCO was forced to dump more than 10,000 tonnes of low-level contaminated water into the Pacific Ocean, and it has since admitted that several hundred tonnes of highly contaminated water also leaked out, exposing marine life to large doses of radiation (see *Nature* doi:10.1038/news.2011.326; 2011). TEPCO says it has now stemmed those leaks.

The radioactive water is hampering work to bring the reactors under control and prepare for their decommissioning, says Jack DeVine, a retired nuclear consultant who led water-decontamination efforts after the 1979 Three Mile Island nuclear meltdown in Pennsylvania. Basements filled with radioactive water also put workers on the site at risk. "It makes even small things nightmarish to do," he says.

Rather than simply pouring ever more water into the hot reactors, TEPCO had planned to establish a closed-loop cooling system that would recirculate water through the cores. But extensive damage to the reactors has made that impossible.

Under a revised plan posted on the company's website on 17 May, the reactors will continue to be filled with a steady flow of fresh water, which will then be pumped out of the basements of the reactor buildings, decontaminated and circulated through the cores again. TEPCO estimates that it will need to decontaminate some 250,000 tonnes of water by mid-January 2012, when it hopes the reactors will finally be cool enough to shut down permanently. But the system will be far less efficient than the original plan, and will ultimately increase the amount of waste to be handled.

The decontamination system is being built by Paris-based nuclear manufacturer Areva and nuclear-remediation company Kurion, headquartered in Irvine, California. The water will pass through Kurion's filters, which contain a zeolite mineral — an extremely porous aluminosilicate that loosely binds metal ions. Through a combination of adsorption and ion exchange, the filters will trap the radioactive elements strontium-90, caesium-134 and caesium-137, reducing their concentration in the water by a thousand times.

Areva's process will then take over. The ▶

water will pass into a series of tanks, where it will mix with reagents such as nickel ferrocyanide and barium sulphate, along with polymers and sand. The dissolved radioactive metals will form precipitates and colloids, which can be trapped as a radioactive sludge, allowing the water to be desalinated and fed back into the reactors. The two processes should reduce the concentration of caesium — the major element of concern from the reactors — in the water by up to a million times. TEPCO estimates that the process will cost ¥53.1 billion (US$660 million). Areva says it has successfully tested its system with sea water containing radioisotopes and borates — a simulation of the chemical brew in the reactors, where boric acid was added to halt nuclear reactions.

But some experts in Japan have expressed reservations about the decontamination process. Radioactive water will continue to flow from the cores into basements and trenches, and damage to the site means there will probably be further leaks. Ming Zhang, who studies environmental pollution risks at the National Institute of Advanced Industrial Science and Technology in Tsukuba, fears that contaminated water will end up in the ocean.

Kenji Takeshita, a specialist in water treatment at the Tokyo Institute of Technology, says that although a zeolite filtration system worked at Three Mile Island, the water pumped through it was fresh. "This time the water is full of salt," he says. The chemical similarity between sodium and caesium ions may make the zeolite extraction process far less efficient, he says.

Areva's system will also generate up to 2,000 cubic metres of hot, radioactive sludge by next January. Compared with solid waste, which can be encased in cement for long-term storage, the sludge will need more elaborate containment to prevent it from leaking out into the environment. TEPCO says that the Areva system was added to "ensure the success of the extraction system", and is now drafting plans for dealing with the zeolite and sludge waste.

Even when the water is dealt with, Japan will face a bigger contamination problem. Radioactive soil has been removed from around schools and other institutions near Fukushima, but it currently sits in large mounds or has been buried at shallow depths. Chihiro Inoue, an expert in soil and groundwater remediation at Tohoku University, estimates that hundreds of thousands of tonnes of radioactive soil will have to be dealt with. "They're not even thinking about what to do with that yet," he says. ■ SEE EDITORIAL P.128

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Q&A Yusuke Nakamura
A healthier Japan

Yusuke Nakamura, a geneticist at the University of Tokyo, has long argued that the country should reform its health-care system and work harder to cash in on its biological discoveries. His mission was given fresh urgency by the Tohoku earthquake and tsunami in March — and now he has a pulpit. In January, Nakamura launched the Office of Medical Innovation, a cabinet-level advisory organization, and he will make his case at a high-level government meeting next week.

MARIKO IKEDA

How did the disaster expose weaknesses in Japan's medical system?

Many people lost their medical records, so the government in Tokyo didn't know the volume of drugs needed in different places. And medical support is terrible. If you have a stroke in Soma, you'll have to drive an hour and a half or two hours to the hospital in Sendai or elsewhere. It's an urgent situation.

Victim identification has been delayed because the government is trying to do it on the basis of dental records, which often aren't available. Two thousand recovered bodies remain unidentified. I argue that they should use single-nucleotide-polymorphism testing, which is faster and more accurate. I estimate it would cost ¥800 million (US$10 million) — nothing compared with the recovery costs.

How could these problems be avoided?

In Japan, each hospital has its own medical-record system. We need instead to have a national 'cloud' system to store records, and patients could carry their own records on a data card or a phone. We should start with Tohoku, where the system needs reconstructing anyway, and then extend to the rest of the country. More destructive quakes will occur. With a good system in place, we could save a large number of lives.

What health studies are you advocating to monitor tsunami survivors?

We have proposed three kinds of cohort study that would cover a total of about 500,000 people. The first would monitor the psychological condition of survivors. A study in Thailand [after the 2004 Indian Ocean tsunami] found that one-fifth of people had post-traumatic stress syndrome. That would mean a huge number in Japan. We need to start monitoring, so that we can treat it at an earlier stage.

The second study would look at health impacts and chronic disease in those who lived through the disaster and were evacuated for extended periods. We would also have to consider the effects of persistent low-level radiation [from the damaged Fukushima nuclear plant]. The third cohort would be for workers and residents exposed to high doses of radiation. That would have to go on for 20–30 years.

How good is medical innovation in Japan?

It's terrible. We import over $10 billion more than we export in drugs (see 'Drug imbalance'). Japanese scientists have papers in *Nature*, *Science* and *Cell*, but few publish in *The Lancet* or *The New England Journal of Medicine*, and some say that we need more support for clinical trials. That's true, but the drugs in the trials would still come mainly from the United States or Europe. What we need is support for applied research. We are going to propose a super-high-throughput screening and drug-optimization facility. There is one in Taiwan that can screen a million compounds per month. We are proposing something on that scale, with an operating cost of $30 million–40 million a year.

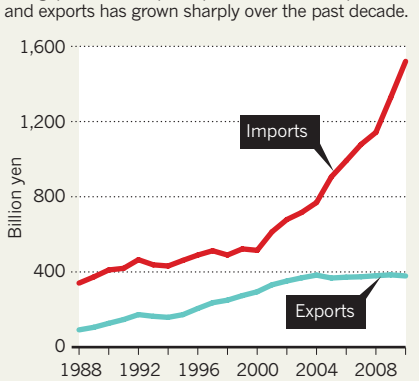
We have also proposed a bioinformatics centre that could help to manage the steep increase in genetic and epigenetic data. Integrating them with clinical records could create a personalized medical system within the next ten years.

The government has put a lot of money into life sciences over the past decade, but the ultimate goal was medical innovation. We need to learn why we have failed to achieve that. ■

INTERVIEW BY DAVID CYRANOSKI

DRUG IMBALANCE

The gap between Japan's pharmaceutical imports and exports has grown sharply over the past decade.



SOURCE: MINISTRY OF FINANCE, JAPAN