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The long shadow over Fukushima

One impact of Japan's nuclear crisis is a dim but definite echo of Chernobyl — decades of caesium-137.

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Three weeks after the Fukushima accident, a clearer picture is beginning to emerge of possible long-term environmental consequences. The US Department of Energy (DoE) aerial survey of radiation doses was a crucial development. A clear trace reaching out 30-40 kilometres northwest of the plant marked a zone of dose rate above 125 µSv h^{-1}, a level at which immediate evacuation is often advised [can we get an idea of what that means in terms of risk?] Already, external doses are rapidly declining due to the decay of short-lived isotopes (Figure 1).[where is this?] But as with Chernobyl, it is caesium-137 (^{137}Cs), with a half-life of 30.2 years, that will determine the long-term consequences for the contaminated region and its residents.

The extent of ^{137}Cs contamination at Fukushima is not yet clear, but available data indicate very high levels in some areas. The 30 March IAEA press release reports ^{137}Cs from 0.02–3.7 megabecquerels per square metre (MBq m^{-2}) at sites 25-58 kilometres from the Fukushima NPP. The higher values are consistent with Japanese soil data from Iitate village, 40 km northwest of the plant. Perhaps surprisingly, there is still no clear information on ^{137}Cs contamination within 20 km, though the DoE map implies that this could be of the order of MBq m^{-2} if the isotopic composition of deposits near the plant is similar to that in the area further to the northwest.

The implications of these data are far-reaching. If large areas are contaminated with 0.5 MBq m^{-2} or more, evacuation could be long-term. After Chernobyl, long-term resettlement often occurred above about O.5 MBq m^{-2} (see Table 1). Food-chain contamination will depend on soil type: soils rich in clay, particularly illite clays, strongly bind radiocaesium. Bioavailability in mineral-poor upland and forest soils is generally significantly higher than in mineral soils. Based on the data seen so far from Fukushima, it appears likely that in some areas, food restrictions could hold for decades, particularly for wild foodstuffs such as berries and freshwater fish.

As at Chernobyl, 'liquidators' could be brought in to decontaminate towns and villages in evacuated zones and to reclaim agricultural lands. This approach met with varying success in Russia. The UK Health Protection Agency *Recovery Handbook* details a range of measures for residential areas, including top-soil removal and and resurfacing roads. On farms, approaches include applying potassium fertilizers to compete with radiocaesium for uptake to crops, and administration of 'Prussian Blue' boluses to reduce absorption by grazing animals.

Remediation has some drawbacks: huge economic cost, for example, and the potential generation of huge quantities of contaminated waste. Consumers may refuse products grown in contaminated areas even when they meet regulations. Chernobyl has taught us that the social and psychological responses to radiation are of great, perhaps paramount, importance.

'Headline' estimates of Chernobyl's public health impact are dramatic: one 2006 estimate of expected cases led by the International Agency for Research on Cancer came to 16,000 for thyroid cancer and 25,000 for other cancers resulting from the radiation, and "several hundred million cancer cases...from other causes". But risks to the individual are low. As early as 1991, an IAEA study found psychological effects to be "wholly disproportionate to the biological significance of the radiation". This study prioritised the provision of accurate information on radiation health risks to the affected populations. But 15 years later, the WHO Chernobyl Forum Report still concluded that Chernobyl's impact on mental health is “the largest public health problem caused by the accident to date”. Misperceptions, and inefficient compensation, have led to widespread fatalism and feelings of victimisation among people in the region. Increases in harmful lifestyle choices such as alcohol consumption and smoking may well have done more damage than radiation exposures. The failure to solve the social and psychological problems relates not only to a lack of effort (at Chernobyl, vastly more has been spent on physical remediation than on public engagement), but also to the intractability of the problem.

The long-term response to Fukushima will have to be pragmatic. The Japanese authorities may have to rewrite the radiation protection rulebook, as they have begun to do in allowing doses of 250 mSv to radiation workers. In a post-accident situation, it may well be appropriate to set exposure limits higher than the typical 1 mSv y^{-1} maximum for members of the public. A limit of 5-10 mSv y^{-1} (below which resettlement would be voluntary) may be appropriate, bearing in mind that millions of people in areas of high natural radioactivity worldwide are exposed to radiation over 10 mSv y^{-1}, and that occupational exposures (for example, to long-haul air crew) can be of order 5 mSv y^{-1}.

A turning point in my understanding of Chernobyl’s impacts came while studying lakes in Belarus during the mid-1990s. In an evacuated area (about 1.7 MBq m^{-2} ^{137}Cs), lake fish contained tens of thousands of Bq/kg. A couple in their early seventies lived near the lake, eating the fish, growing vegetables. They were living off contaminated land, but leading the life they had chosen to lead. This wouldn’t by any means be the right choice for everybody, but I am convinced they had made the right decision for them: they were Chernobyl survivors, not victims.

Table 1 Criteria for radiation control applied in Ukraine and Russia[*] after Chernobyl (from the 2002 UNDP/UNICEF study). These were developed for local conditions and are not directly applicable to Fukushima. They are not criteria for short-term evacuation.

^{137}Cs in 1986	**Demarcation of contaminated areas by ^{137}Cs contamination density**
< 37 kBq m^{-2}	Area designated as not significantly contaminated by Chernobyl
37 – 185 kBq m^{-2}	*Zone of enhanced radiation control*. Monitoring, food restrictions, compensation
185 – 555 kBq m^{-2}	*Zone with the right to resettle*. Resettlement was voluntary.
555 – 1480 kBq m^{-2}	*Zone of strict radiation control.* Resettlement obligatory in Ukraine; in Russia it was voluntary if the dose was < 5 mSv yr^{-1}
> 1480 kBq m^{-2}	*Zone of obligatory resettlement*
Dose in 1991	**Dose limits based on the “Chernobyl 1991 Concept”**
< 1 mSv y^{-1}	No restrictions or countermeasures need be applied
> 1 mSv y^{-1}	Measures put in place to ensure individual effective dose < 5 mSv y^{-1}

* Criteria in Belarus were similar to those in Ukraine