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Science for Environment Policy

New insight on the spread of contamination from Fukushima

A study on the transport of radioactive isotopes from Fukushima in the two months after the nuclear incident suggests that they were at official levels of contamination for 34,000 km^2 of Japan, and that 2.8% of iodine radionuclides from the event were calculated to have reached the EU.

The 2011 nuclear accident at Fukushima, Japan, caused the release of large amounts of radionuclides (unstable atoms that produce radioactive emissions) to the atmosphere. Caesium and iodine radionuclides can negatively affect human health through the contamination of air, water, soil and agricultural products.

The EU-funded study[1] modelled the global spread of radionuclides of caesium and iodine from Fukushima in the atmosphere and the deposition patterns between March and May 2011 using the ECHAM5/MESSy Atmospheric Chemistry (EMAC) general circulation model. It focused on radionuclides that were emitted as gases and used estimated emissions of radionuclides from the incident. The modelling accounted for processes that affect radionuclide concentrations, such as precipitation, particle sedimentation and radioactive decay.

The prevailing winds after the incident transported most of the radionuclides in an easterly direction, away from Japan and over the Pacific Ocean where about 80% of the caesium was deposited. The rest was deposited mostly in Japan, while a small fraction (less than 1%) deposited in the Arctic.

The situation was different for iodine radionuclides, where meteorological conditions and convection promote more long-distance transport. This is because iodine does not dissolve as easily as caesium so it remains in a gaseous form and is redistributed by convection to the troposphere (lowest part of atmosphere) where the wind speed is greater and transports the iodine greater distances. The model results suggest that 12.7% of iodine radionuclides were deposited over the USA and Canada, 4.5% over Russia and 2.8% over the EU. Approximately 50-60% was deposited locally in Japan.

The International Atomic Energy Agency defines 'contamination' as the presence of a radioactive substance in quantities more than 40 kilobecquerels (kBq - unit of radioactivity) per m^2. The study estimates that the land area affected by radioactivity from both types of radionuclides above this threshold is approximately 34,000 km^2 of Japan, inhabited by around 9.4 million people.

However, the estimate used for the iodine radionuclide emissions from the incident is considered to be an underestimate. A separate calculation which assumed source emissions that were five times greater, suggested that a relatively large and densely populated part of Japan - 56,000 km^2 - would be classified as contaminated. This highlights the uncertainty that is integral to both measuring and modelling emissions (particularly for iodine radionuclides) and the need for more accurate estimates of the emissions.

Finally, the research investigated the exposure to the local population around the Fukushima nuclear accident site in terms of the inhaled dose of radioactivity measured in milliSieverts (mSv). This was estimated to be between 10 and 20 mSv, where one Sv is associated with a 10% chance of eventually developing cancer. It should be emphasised that this refers to two radionuclides only, whereas additional ones are unaccounted for due to a lack of measurements. This estimate was for the general public and not workers who probably received higher doses. There was no assessment of likely health effects of this dose.

Despite the uncertainty surrounding some of the assumptions and estimates used in the model, it provides a valuable indication of the geographic range, affected population and timescale of the contamination problem. This could be useful as a basis for developing mitigation and emergency-response policies for future incidents.