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Tracing Fukushima Radionuclides in the Northern Hemisphere –An Overview

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A massive 9.0 earthquake and ensuing tsunami struck the northern coast of the Honshu-island, Japan on March 11, 2011 and severely damaged the electric system of the Fukushima- Daiichi Nuclear Power Plant (NPP). The structural damage to the plant disabled the reactor's cooling systems. Subsequent fires, a hydrogen explosion and possible partial core meltdowns released radioactive fission products into the atmosphere. The atmospheric release from the crippled Fukushima NPP started on March 12, 2011 with a maximum release phase from March 14 to 17. The radioactivity released was dominated by volatile fission products including isotopes of the noble gases xenon (Xe-133) and krypton (Kr-85); iodine (I-131,I-132); cesium (Cs-134,Cs-136,Cs-137); and tellurium (Te-132). The non-volatile radionuclides such as isotopes of strontium and plutonium are believed to have remained largely inside the reactor, although there is evidence of plutonium release into the environment.
Global air monitoring across the northern hemisphere was increased following the first reports of atmospheric releases. According to the source term, declared by the Nuclear and Industrial Safety Agency (NISA) of Japan), approximately 160 PBq (1 PBq (Peta Becquerel = 10$15$ Bq)) of I-131 and 15 PBq of Cs-137 (or 770 PBq "iodine-131 equivalent"), were released into the atmosphere. The 770 PBq figure is about 15% of the Chernobyl release of 5200 PBq of "iodine-131 equivalent". For the assessment of contamination after the accident and to track the transport time of the contaminated air mass released from the Fukushima NPP across the globe, several model calculations were performed by various research groups. All model calculations suggested long-range transport of radionuclides from the damaged Fukushima NPP towards the North American Continent to Europe and to Central Asia. As a result, an elevated level of Fukushima radionuclides were detected in air, rain, milk, and vegetation samples across the northern hemisphere. Although the releases from the Fukushima NPP were pronounced, due to significant dilution of the radioactivity in the atmosphere as it was transported across the globe, the concentrations of radionuclides measured outside Japan were extremely low. The activities of I-131, Cs-134, and Cs-137 in air were estimated to have diluted by a factor of 10$5$ to 10$8$ during trans-Pacific transport.

This paper will present a compilation of the radionuclide concentrations measured across the northern hemisphere by various national and international monitoring networks. It will focus on the most prevalent cesium and iodine isotopes, but other secondary isotopes will be discussed. Spatial and Temporal patterns and differences will be contrasted. The effects from this global radionuclide dispersal are reported and discussed. The activity ratios of 131I/137Cs and 134Cs/137Cs measured at several locations are evaluated to gain an insight into the fuel burn-up, the inventory of radionuclides in the reactor and thus on the isotopic signature of the accident. It is important to note that all of the radiation levels detected across the northern hemisphere have been very low and are well below any level of public and environmental concern.