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Estimated environmental radionuclide transfer and deposition into outdoor swimming pools

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ABSTRACT

In 2011, a large radioactive discharge occurred at the Fukushima Daiichi nuclear power plant. This plant is located within a climatically temperate region where outdoor swimming pools are popular. Although it is relatively easy to decontaminate pools by refilling them with fresh water, it is difficult to maintain safe conditions given highly contaminated diurnal dust falls from the surrounding contaminated ground. Our objectives in this paper were to conduct daily radioactivity measurements, to determine the quantity of radioactive contaminants from the surrounding environment that invade outdoor pools, and to investigate the efficacy of traditional pool cleaners in removing radioactive contaminants. The depositions in the paper filterable particulates ranged from 0 to 62,5 Bq/m^2/day, with the highest levels found in the southern Tohoku District containing Fukushima Prefecture and in the Kanto District containing Tokyo Metro. They were approximately correlated with the ground contamination. Traditional pool cleaners eliminated 99% of contaminants at the bottom of the pool, reducing the concentration to 41 Bq/m^2 after cleaning. Authors recommended the deposition or the blown radionuclides into outdoor swimming pools must be considered into pool regulations when the environments exactly polluted with radionuclides.

1. Introduction

Swimming pools in elementary, junior-high, and high schools throughout Japan are important facilities for physical education. Studies by the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) indicate that 28,171 outdoor pools affiliated with schools were active in the summer of 2008 (School Health Education Division, Sports and Youth Bureau, MEXT, July 16. 2011). Following the 2011 Fukushima Daiichi nuclear power plant (FDNPP) accident, MEXT outlined a national guideline whereby radiation levels (total Cesium) were provisionally required to be below 200 Bq/l in school pools in Fukushima Prefecture (School Health Education Division, Sports and Youth Bureau, MEXT, June 16 2011; School Health Education Division, Sports and Youth Bureau and Nuclear Safety Division, Science and Technology Policy Bureau, MEXT, June 16 2011). This guideline was set based on the advice of the Food Safety Commission (27. October 2011). Food Sanitation Low in Japan (1947) and the Ministry of Health, Labor, and Welfare (23. June 2011), Water Environmental Division, Environmental Management Bureau, the Ministry of Environment of Japan (24. June 2012). In response, the Nuclear Emergency Response Headquarters and the Board of Education (School Life Health Division) in Fukushima Prefecture began monitoring 144 outdoor pools not far from the site of the nuclear accident (Fukushima Prefecture, 4. July 2011). Thus, water quality in these pools remained at safe levels, and no specific health problems were reported.

Authors could not find actual radionuclide contamination of swimming pools preceding the accident. No radioactivity was detected from drinking water in Shizuoka Prefecture, the usual source of swimming pools, throughout 2006–2011 (Environmental Radioactivity Database). The government ^{137}Cs monitoring of ground surface soils in grass land or uncultivated places, showed less than 10 Bq/kg in all Japan prefectures in 2010. However, in 2011 when the FDNPP failed, the values of three prefectures in Tohoku District, and all seven prefectures in Kanto District grew 3.0 to 98 times more ^{137}Cs (Environmental Radioactivity Database).

One year later, the tentative radioactivity guidelines were revised and restored to the drinking water standard preceding the accident (School Health Education Division, Sports and Youth Bureau, MEXT, 10. April 2012, Water Environmental Division,

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Environmental Management Bureau, the Ministry of Environment, 8. June 2012, and WHO, 2006). Fresh water supplied to pools by authorized plants was not contaminated after filtration; however, pool water must be partially filtered. Moreover, circular filter apparatuses typically installed in swimming pools are relatively ineffective at eliminating sediment (e.g., soils). Because school swimming pools are open, it is possible that radioactive dust blown from surrounding environments could settle into these pools. It is thus critical to investigate the quantities of radionuclide that accumulate in swimming pools located in highly contaminated areas. There are no recommendations how to treat or prevent radionuclides contaminations of bathing water (WHO, 2006).

Although MEXT began monitoring pool water and water source contamination immediately following the nuclear accident, additional counter-measures may be required to avoid further pool contamination from pollutants introduced through human activities, wind, and rain. Previous studies of historical radioactive discharges (e.g., Hiroshima, Nagasaki, Nevada, Chernobyl, and Three-mile Island) did not examine the levels of radioactive contamination in swimming pools, and data on this subject will be of practical importance for the safe use of many outdoor school pools located in Fukushima Prefecture.

The radionuclide resuspensions of deposited ground surfaces from contaminated nuclear test or inhabiting areas have documented or studied relatively well (Sehmel, 1977; Garland and Nicholson, 1991; Nicholson, 2009; IAEA, 2010), however, the most of them were model or mathematical simulation study. Actual field data obtained from a pond showed that a huge volume of radioactivity flown or brown into the pond from the surrounding environment (e.g., by fast-moving streams, creeks, or wind) accumulated in sediments and decayed more slowly (Kryshev, 1995). Outdoor swimming pools are artificial ponds in inhabiting areas, so, the volume of deposited radionuclides blown into must be realized whether the value exceeds more or not the WHO's drinking water guideline (10 Bq/l) when the sediments are resuspended, in the pool water.

Although the monitored outdoor swimming pool (25 m long × 25 m width × 5 m depth) has not been used after the FDNPP

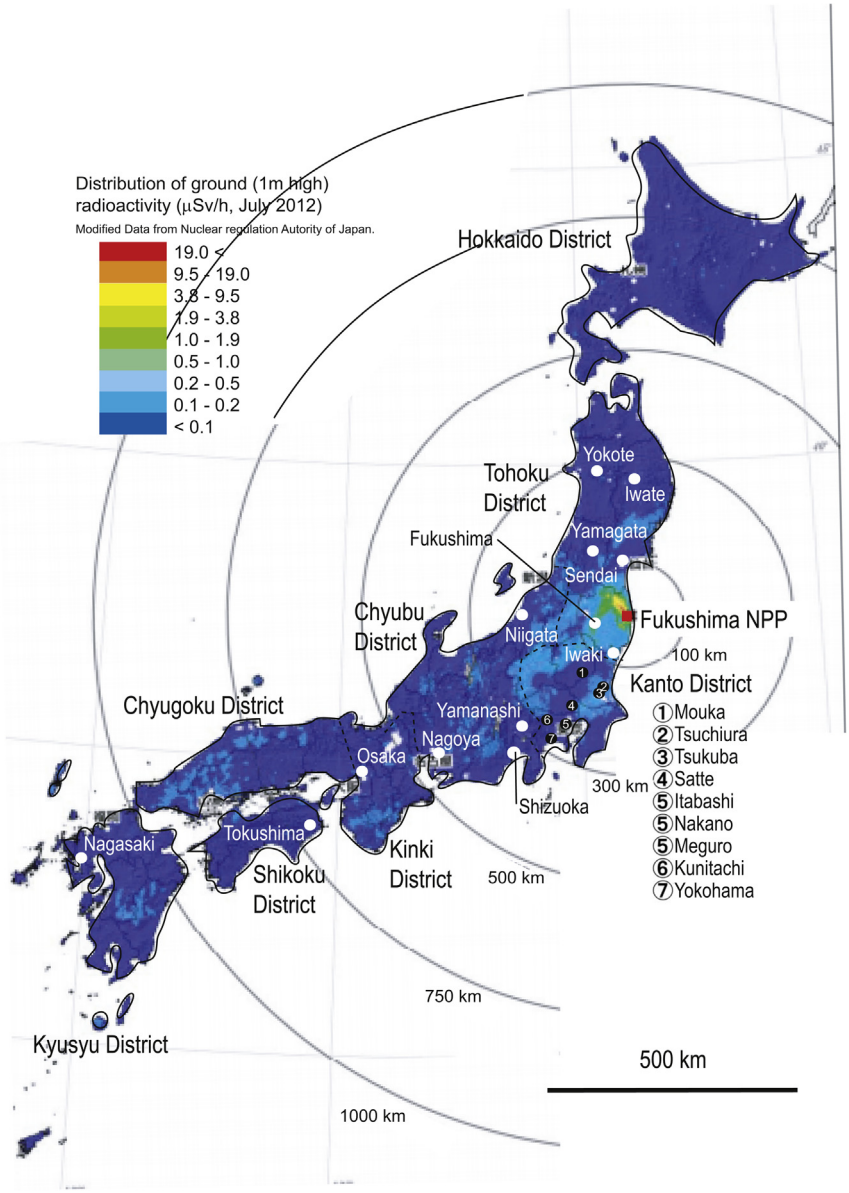

Fig. 1. Geographic locations of sampling sites and FDNPP location on a Japanese map.