PHITS Models for Ambient Dose Equivalent Rates in Fukushima's Radiocesium Contaminated Forests

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Abstract (approx. 55words)

PHITS Monte Carlo models were used to assess factors affecting ambient dose equivalent rates ($\dot{H}$*(10)) in forests of Fukushima Prefecture. Models with different levels of detail were used to understand how the distribution of radioactive cesium within forests, shielding by trees, soil composition and moisture rates affect $\dot{H}$*(10). The models were parametrized using measurements from deciduous and evergreen coniferous forests in Fukushima Prefecture.

Keywords: forest, ambient dose equivalent, radiocesium, modeling, simulation, PHITS, Monte Carlo

1. Introduction

Large areas of forest within Fukushima Prefecture were contaminated with ^{134}Cs and ^{137}Cs by the TEPCO Fukushima Dai-ichi nuclear accident in 2011. In this study factors affecting ambient dose equivalent rates ($\dot{H}$*(10)) at 1 m height in forests were investigated using Particle and Heavy Ion Transport code System (PHITS) simulations [1].

2. Methods

PHITS models were created based on measured densities, dimensions, and ^{134}Cs and ^{137}Cs radioactivities of tree, litter and soil compartments in Fukushima [2]. Soil and litter compartments were modeled as homogeneous layers of material. Tree trunks and the canopy were either modeled as homogeneous layers, or by representing trees individually using cylindrical, conical and ellipsoidal volumes. The simulations calculated the contributions from both direct and scattered radiocesium gamma rays to $\dot{H}$*(10). History numbers were sufficiently large so that Monte Carlo statistical uncertainties could not have caused the differences seen between the results of the different models.

3. Results

$\dot{H}$*(10) was not affected by changing the elemental composition of the soil. $\dot{H}$*(10) was only negligibly different between the cases with simple or detailed geometrical representations of the forest, e.g. homogeneous layers only or with individual trees modeled separately. In the more detailed models, $\dot{H}$*(10) varied only by a small amount with position. $\dot{H}$*(10) was up to 2% lower than the calculated forest average when close to a tree trunk.

The factors found to have the largest bearing on $\dot{H}$*(10) were the moisture contents of the soil, litter and tree compartments. $\dot{H}$*(10) varied by between 5-20% depending on the assumptions used for the moisture rates.

4. Conclusion

The results suggest that moisture rates of trees, litter and soil have a significant effect on $\dot{H}$*(10) within forests. Measurement studies clarifying the average values and fluctuations of moisture rates in forest compartments would help improve the models and our understanding of the dynamics of $\dot{H}$*(10) in forests in Fukushima Prefecture.

References

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