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Spatial heterogeneity of radiocesium concentration on a forest floor soil in a broadleaf and mixed forest in Fukushima, Japan

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Radiocesium in Fukushima forests derived from the nuclear power plant accident still remains in the surface of forest floors. Its distribution is known to show spatial heterogeneity, but little is reported about causes generating it. Horizontal distribution of radiocesium within a forest community needs to be clarified for understanding spatio-temporal dynamics of radiocesium within a forest community and its outflow from the ecosystem to others (e.g. downstream).
Here, we hypothesized as follows; environmental spatial heterogeneity of a forest floor within a forest community generated by vegetation creates the spatial variation of distribution of radiocesium. We examined whether the radiocesium accumulates at the bases of trees, and the amount of the radiocesium is related to tree size and morphological characteristics of the tree such as tree species and bark properties.
The field surveys were conducted in a broadleaf and mixed forest dominated by Japanese oak (Quercus crispula) and Japanese fir (Abies firma) in Soma city in Fukushima Prefecture in August and November, 2014. A 20 m $\times$ 20 m plot was established in the study site. Top soils (0 – 5 cm) were collected from 121 points in a grid system of every 2 m interval within the plot and additional 136 points from south and north sides at bases of all trees ($\geq$ 5 cm of diameters at breast height) in the plot. Diameters at breast height of all the trees were measured, and the tree species were identified. The soil samples were dried and measured by a germanium detector. Activity concentrations of Cs-137 were decay-correlated to the data of the first field survey.
Average concentration of Cs-137 radioactivity in the plot was 14,007 Bq/kg and its coefficient of variance was 74 %, showing large spatial variation of radiocesium distribution on the forest floor. Average concentration collected in the grid points 2 m apart each other was 10,826 Bq/kg, while average concentration from the bases of all trees was 16,836 Bq/kg. Concentrations at the tree bases were significantly higher than that those collected in the grid points (Student's t-test $P < 0.001$). We found very high radioactive concentration points (defined as statistical outlier in the present study; $\geq$ median value + 1.5 times the interquartile range, $\geq$ 26,716 Bq/kg). Out of the total 25 high radioactive concentration points, 20 points (80 %) were observed at tree bases in the plot. Concentration of Cs-137 accumulated at the tree bases did not show significant correlation with tree size (Pearson's product-moment correlation, $P = 0.53$). Tree species and bark characteristics also did not show statistical difference about Cs-137 accumulation (one-way ANOVA, $P = 0.966$).
Spatial heterogeneity of radiocesium distribution can be explained to some extent by tree distribution. High concentration of radiocesium activity at tree bases is probably due to stemflow water containing radiocesium caught by canopies of trees. Since neither size-dependent nor species-specific changes radiocesium accumulation at the tree bases, this process may occur by chance. Radiocesium accumulated at tree bases indicates possibility to up take radiocesium by the tree roots.