Cesium Transfer Factors from Fukushima-Contaminated Soil to Plants

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Abstract

We are interested in whether potassium is effective in suppressing the absorption of cesium when growing vegetables in contaminated soil. Firstly, we collected edible plants growing in soil contaminated with radioactive cesium near the Fukushima Daiichi Nuclear Power Plant. We collected butterbur sprouts growing wild abundantly. By measuring the radioactivity concentration in both the soil and the butterbur sprouts with germanium semiconductor detectors(Ge detectors), we measured the trend of cesium transfer from soil to butterbur sprouts. However, it was difficult to discern clear trends since the transfer factor for plants in nature depends on many factors such as soil type and climate.

Therefore, we cultivated our own vegetables to investigate the transfer factor by controlling environmental conditions to some extent. We grew basil in three planters containing contaminated soil with different potassium fertilizer amounts and another planter with uncontaminated soil. Subsequently, we measured the radioactivity concentration in the soil and basil leaves from each planter. By calculating and comparing the transfer factors, we examined whether changes in potassium levels in the soil affect the plant's absorption of cesium. This poster presents those results and analysis.

Motivation

It is important to understand the potential for agriculture in areas affected by radioactivity contamination from the Fukushima Daiichi Nuclear Power Plant accident. Potassium fertilizer is used as a method to control cesium uptake by plants. We conducted research focusing on the suppression effect of cesium uptake depending on the amount of potassium fertilizer in the soil.

[1] Transfer of Cesium from Soil to Butterbur sprouts

First, by measuring the amount of radioactivity in naturally growing plants and the surface soil near them, we can understand the tendency for cesium to migrate from soil to plants.

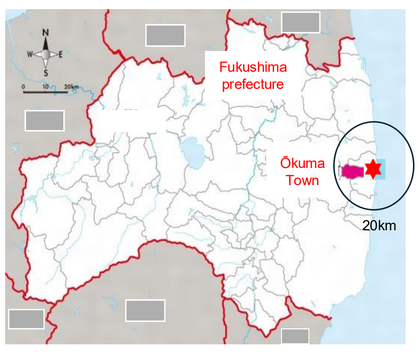
Method

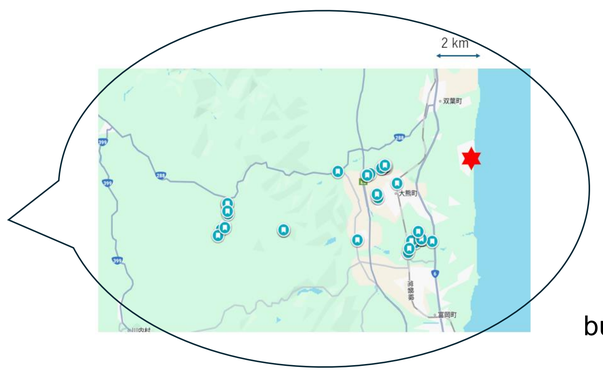
We collected butterbur sprouts at several locations in Okuma Town and measured radioactivity concentration(^{137}Cs) using a germanium semiconductor detector(Ge). We also measured the surface soil at the collection sites.

Collection site

=Fukushima Daiichi Nuclear Power Plant

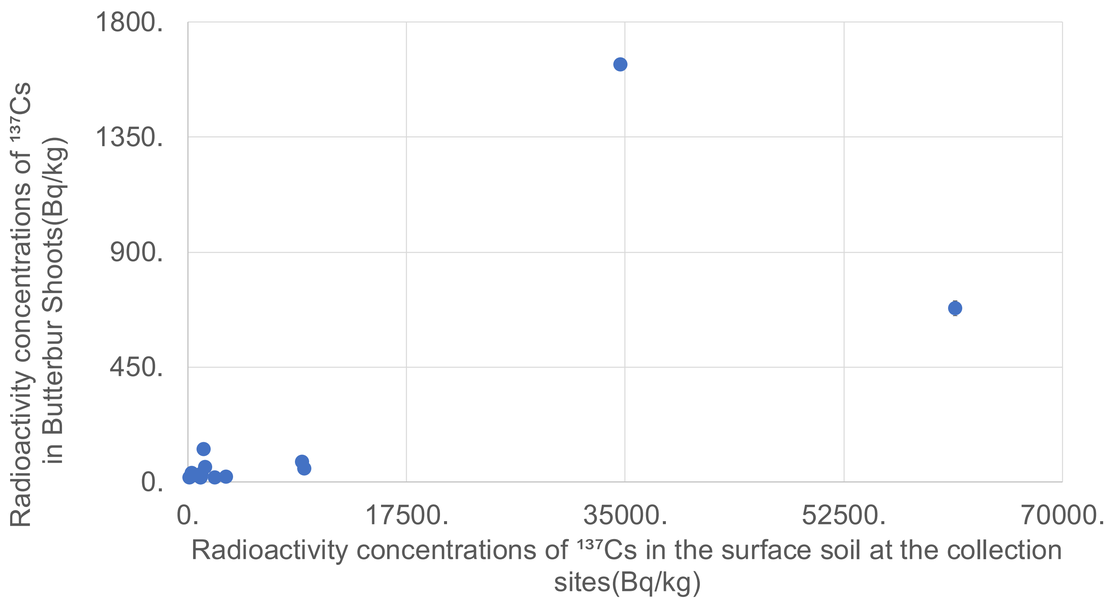
= The place where we collected butterbur sprouts(both within and outside the restricted access zone).





butterbur sprouts

Result



(The error is contained within the data points on the scatter plot.)

Analysis

・The radioactivity concentration of butterbur sprouts collected from soils with more than 10,000 Bq/kg was higher than that of those collected from soils with less than 10,000 Bq/kg. This suggests that the higher the radioactivity concentration in the soil, the higher the radioactivity concentration in the butterbur sprouts tends to be. However, no clear correlation was concluded, since the butterbur sprouts grown in soil with a radioactivity concentration of approximately 35,000 Bq/kg exhibited higher radioactivity concentrations than sprouts grown in soil with approximately 60,000 Bq/kg

.→ In natural environments, numerous additional factors such as soil type, climate, and radioactive distribution exist, and the transfer factor is thought to depend on these factors.

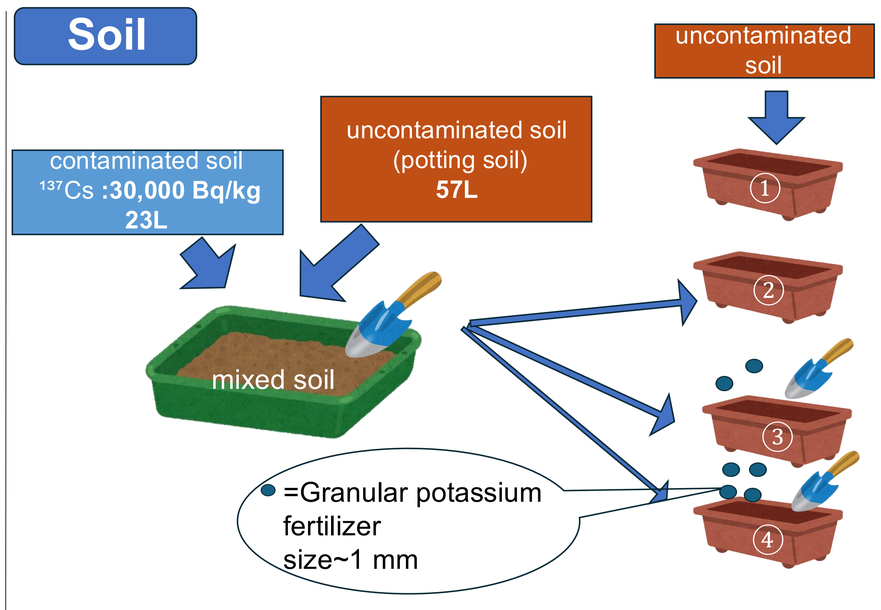
・The majority of collected soil samples had radioactivity concentrations mostly below 10,000 Bq/kg, and only two samples exceeded 10,000 Bq/kg. This makes it difficult to observe a clear trend between the amount of cesium in the soil and the amount absorbed by plants.

→We needed data of soils exceeding 10,000 Bq/kg, but radioactivity concentration can only be determined after collection and measurement. Furthermore, we must search for locations where butterbur sprouts are growing, severely limiting potential sites. Consequently, collecting data at the desired radioactivity concentration levels in the natural environment is difficult.

→ Based on these two facts, we concluded that it is difficult to investigate the actual transfer of cesium from soil to plants under natural conditions in detail. To overcome these difficulties, we cultivated basil ourselves with radioactivity controlled soil.

[2] Grow vegetables and investigate the transfer of radioactive cesium

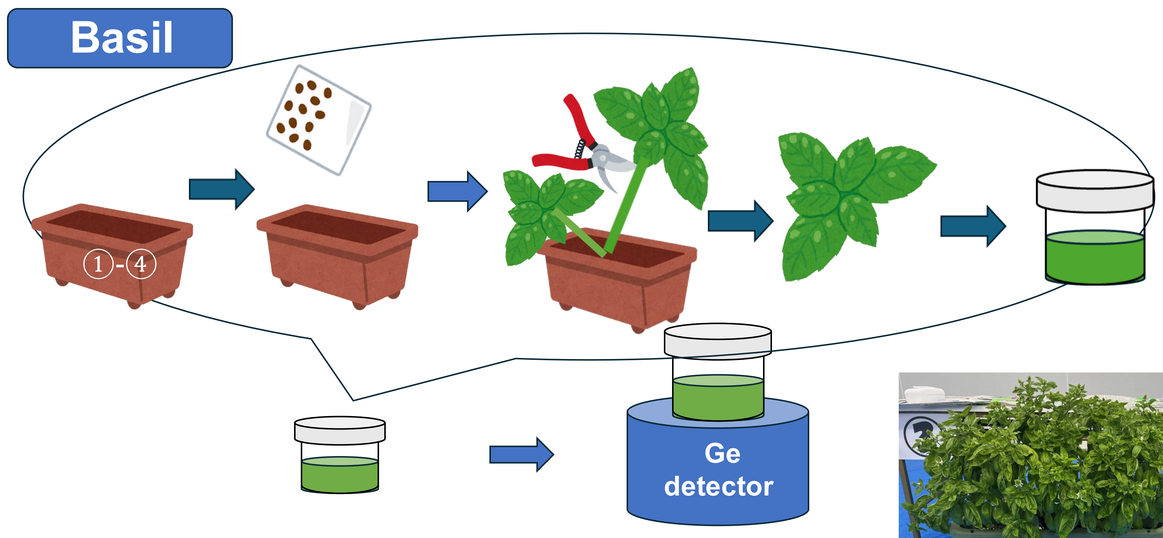
Soil



	Soil type	Potassium fertilizer
①	potting soil	0 g
②	mixed soil	0 g
③	mixed soil	5 g
④	mixed soil	10 g

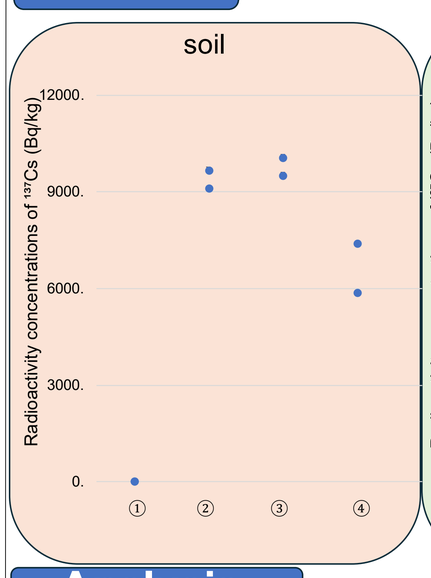
We used contaminated soil from a former pear orchard located about 8 km from the Fukushima Daiichi Nuclear Power Plant. We mixed the contaminated soil and potting soil (uncontaminated soil) in approximately 1:2 ratio in a large bucket with a shovel, because we thought contaminated soil alone may not contain enough nutrients. We filled three planters with the mixed soil adding 0 , 5 , and 10 grams of potassium fertilizer and then mixed the soil again with a shovel.

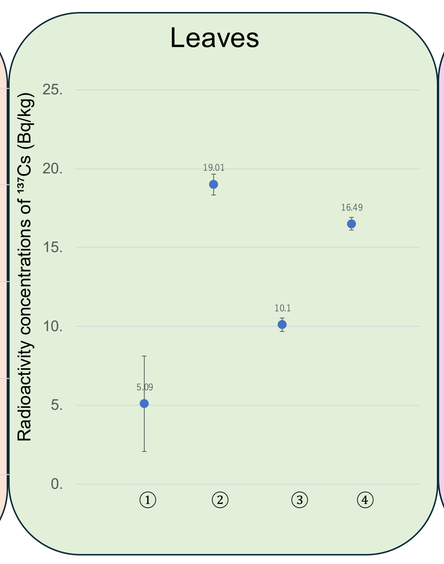
Basil

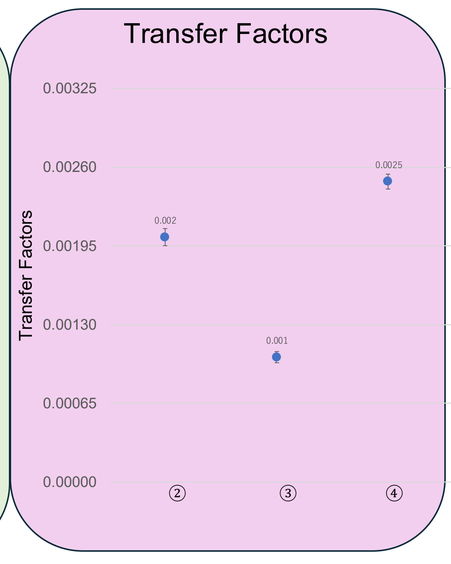


We grew basil from seeds in these four planters and harvested the leaves five months later. Each planter had 4-5 basil plants. We packed them into two U8 containers for each planter. Their radioactivity concentrations of ^{137}Cs were measured with Ge detector.

Results







Analysis

・soil

We measured the radioactivity concentrations of ^{137}Cs of two soil samples for each planter. The left plot shows the results. The concentrations of the mixed soil were not uniform.

・leaves

The radioactivity concentrations of ^{137}Cs in basil are below the standard limit for food(100 Bq/kg).

・transfer factor

The transfer factor of radioactive cesium from mixed soil to basil is roughly 1-2.5%.

Compared to not adding potassium fertilizer, adding 5 g decreased the transfer factor, but adding 10 g increased it.

In this experiment, we were unable to thoroughly mix the contaminated soil with the uncontaminated soil, so the radioactivity concentrations of ^{137}Cs of the mixed soil was not uniform. Furthermore, later we found that the uncontaminated soil (potting soil) originally contained a high amount of potassium (equivalent to approximately 35 g of potassium fertilizer), the mixed soil had sufficient potassium even without adding potassium fertilizer. This suggests that the transfer factor from the mixed soil without potassium fertilizer to the basil may also have been influenced by potassium. Considering these factors, the reliability of these results requires further examination.

Future Research Goals

In this experiment, basil grew better in mixed soil than in uncontaminated soil, indicating that contaminated soil (soil from a former pear orchard located about 8 km from the Fukushima Daiichi Nuclear Power Plant) contains a sufficient amount of exchangeable potassium. Therefore, in future research, we aim to verify the reliability of this experiment by conducting tests with a wide range of potassium fertilizer additions to contaminated soil, without mixing in uncontaminated soil.

Reference

N. Yamaguchi, Y. Takata, K. Hayashi, S. Ishikawa, M. Kuramata, S. Eguchi, S. Yoshikawa, A. Sakaguchi, K. Asada, R. Watanabe, T. Makino, I. Akahane, and S. Hiradate, “Behavior of radiocaesium in soil–plant systems and its controlling factors,” Bull. Natl. Inst. Agro-Environ. Sci., 31, 75–129 (2012).

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