Short Paper

Journal of Agricultural Meteorology 73(2): 82-87, 2017

Development of methods for collecting the stemflow on the trunk of trees contaminated with radioactive fallout

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Abstract

Methods have been developed and evaluated to collect ^{137}Cs in stemflow to investigate the possibility of secondary radiocaesium contamination via stemflow in Japanese persimmon (*Diospyros kaki* Thumb.) orchards. Collection pads were made by encapsulating sphagnum or absorbent cotton in a tea pack (polyester-polyethylene composite fiber). In addition, stemflow was collected directly by a plastic zipper bag (collection bag). A significant linear relationship between the amount of ^{137}Cs per 1 g sphagnum collected and the accumulated precipitation over the measurement period was evident, indicating a close relationship between outflow of ^{137}Cs from the bark and precipitation. There was a significant difference between the percentages of dissolved ^{137}Cs to the total ^{137}Cs in stemflow collected by the sphagnum pads and the collection bag (Kruskal-Wallis test, P<0.01), suggesting that organic mediums consisting mainly of cellulose should not be used for the investigation of dissolved ^{137}Cs. The weight of stemflow, the amount of ^{137}Cs in particulate form and the total ^{137}Cs in the stemflow collected with sphagnum were significantly higher than those in the water collected with cotton. Accordingly, it is concluded that collection pads using sphagnum are more appropriate as stemflow collectors to quantify secondary deposition because of enabling to fix anywhere.

Key words: Dissolved ^{137}Cs, Fukushima Daiichi Nuclear Power Station accident, Precipitation, Sphagnum, Stemflow

Introduction

Radioactive fallout from the accident of the Tokyo Electric Power Company, Fukushima Daiichi Nuclear Power Plant (FDNPP), was released from March 12 to 14, 2011 after the Great Eastern Japanese earthquake and tsunami on 11 March 2011. Radioactive deposition was greatest on March 15, 2011 in many areas associated with rainfall and snowfall (Chino *et al*., 2011; Imanaka, 2012). The fallout contaminated all fruit production orchards in Fukushima Prefecture. Fukushima Prefecture, with 7177 ha of orchards, was the sixth most important deciduous orchard areas among 47 prefectures when ranked in 2010, and is, therefore, one of the major deciduous fruit production areas in Japan (Ministry of agriculture, forestry and fisheries, 2016). In Fukushima prefecture, most deciduous fruit trees, except for Japanese apricot [*Prunus mume* (Sieb.) Sieb et Zucc.)], had not developed leaves by the time that the major radiocaesium deposition occurred, because the FDNPP accident (FDA) took place during the dormant phenological stage of deciduous fruit trees (Sato *et al*., 2015).

Rainfall is intercepted by canopy of trees, after which throughfall and water flowing over bark, termed stemflow, occurs. Though the dynamics of throughfall and stemflow in forests has been widely reported (*e.g*. Loustau *et al*., 1992; Carlyle-Moses, 2004; Park and Cameron, 2008; Mattaji *et al*., 2012), there have been few studies of these processes in orchards. Interception of radionuclides by the above-ground part of peach trees results in inward-migration via the bark after the FDA (Takata, 2013). Bark washing with a high pressure washer was conducted in most orchards in Fukushima prefecture from the leaf-fall season in 2011 to the pre-season of budding in 2012 to reduce the radiocaesium content of fruit trees. High pressure bark washing conducted 6 months after the FDA on 30 year old Japanese persimmon (*Diospyros kaki* Thumb.) reduced radiocaesium activity concentrations in fruit by 29.1% (Sato *et al*., 2015). The radiocaesium activity concentrations in the Japanese persimmon fruits have continued to decrease in the following 3 growing seasons (Sato *et al*., 2015). Radiocaesium has been shown to migrate inward from the bark surface via plant organs (Momoshima and Bondietti, 1994). It was therefore estimated that a large amount of radiocaesium inward migration via the bark had already occurred before the washing treatment was conducted (Sato *et al*., 2015). Although the washing treatments in the corresponding stage was already too late to inhibit radiocaesium migration, the decrease in radiocaesium in the leaves and fruits of persimmon in 2012 for the next developing season after bark washing contradicted this hypothesis. Another possibility consistent with the data, which does not conflict with these results, is that secondary contamination from the bark occurred in the growing season directly after the bark washing. Two possible pathways of (i) direct inward migration and (ii) the adhesion of radiocaesium to leaves or fruits originating from the bark were considered as the process leading to the secondary contamination. Stemflow has the potential to be an important

Received; March 31, 2016.
Accepted; November 21, 2016.
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DOI: 10.2480/agrmet.D-16-00007

source of secondary contamination. Sekizawa *et al*. (2016) have shown that ^{137}Cs solution is also absorbed into persimmon fruit via the calyx. Rainfall contaminated with ^{137}Cs intercepted by forest canopies has been shown to transfer to the soil by stemflow (*e.g*. Schimmack *et al*., 1993; Kato *et al*., 2012). These findings suggest that stemflow is likely to be the migration source for secondary contamination of Japanese persimmon fruits. Finally, a number of fine cracks on the outer bark surface of Japanese persimmon retain raindrops and enable moss to settle. Epiphytic moss had been flourishing on the bark before washing (Sato *et al*., 2012; Sato *et al*., 2015). Moss is known to concentrate radiocaesium within its tissues because of efficient interception by its large surface area and slow growth (International Atomic Energy Agency, 2010). The efficient interception means that “Lichens and mosses are suitable bioindicators of the fall-out, given their long life expectancy” (Iurian *et al*., 2011). Moss is concerned to be another source for secondary contamination by supplying ^{137}Cs to stemflow or bark. However, there has been no study of these processes. Nor even efficient equipment for study has been developed.

To investigate these possible mechanisms further we aimed to collect and analyze stemflow flowing down the fruit trees. There are different methods of collecting ^{137}Cs in water. One method, which utilizes the high water-holding capacity of sphagnum, have been developed and evaluated in this study The aim of this experiment was (i) to determine the relationship between the amount of ^{137}Cs captured from the stemflow and precipitation, (ii) to compare the ratio of the dissolved ^{137}Cs to the total ^{137}Cs between the stemflow captured using a sphagnum pad and the stemflow collected directly, and (iii) to compare the ^{137}Cs collection efficiency between sphagnum and cotton. Experiment (i) was conducted on the site growing epiphytic moss where was concerned likely to keep the close relationship between amount of ^{137}Cs in stemflow and participation. But part of experiment (ii) and all of (iii) were conducted on the site out of the epiphytic moss area, because areas growing moss were not enough to apply these examinations.

2. Materials and Methods

2. 1 Relationship between accumulated ^{137}Cs in the stemflow over the trunk and precipitation

Two 46-year-old ‘Hiratanenashi’ Japanese persimmon trees planted at the Fruit Tree Research Center, Fukushima Agricultural Technology Center, (FTRC), approximately 65 km from FDNPP, were used for this experiment. Trees for experiment were trained by modified open center system with two scaffold limbs. One of survey trees has been bark-washed with a high pressure washer in the beginning of April in 2012; the other tree had not been washed. To collect stemflow, collection pads (Sphagnum pad) were made by encapsulating approximate 7 g of sphagnum (Besuguro-Supagumosu, New Zealand (NZ)) into a tea pack (polyester-polyethylene composite fiber). We used sphagnum from NZ because it was expected to contain a negligible amount of ^{137}Cs from past nuclear accidents and weapons tests. The sphagnum pad was fixed on the trunk of an unwashed tree with a polyester band and stopper, on top of patches of epiphytic moss. The sphagnum pads were covered with polyethylene film pinned at each of the four corners to shield the pads from throughfall and raindrops (Fig. 1). The stemflow was captured five times over the following periods in 2015: Jun 27 to 29, Jul 31 to Aug 27, Aug 31 to Sep 2, Nov 2 to 9 and Nov 14 to 20. Trees, which held leaves with full green-color, were kept in almost same shape during Jun.27 to Nov 2, following by yellowing leaves gradually from Nov. 7. Each sphagnum pad was sampled within several hours from the end of every rainfall event. Precipitation was measured using a tipping bucket type rain gauge (RH-5E, Koshin Denki Kogyo. Co., Ltd, Tokyo) placed at the FTRC. The accumulated rainfall during each of the five collecting period was recorded. The weight of the collected water was estimated by subtracting the weight of an empty tea pack and sphagnum before collecting water from the weight of the sample sphagnum pads removed after the collection period. The ^{137}Cs concentration (C, in Bq kg^{-1}) in stemflow was calculated the following formula as $C = 1000A\ w^{-1}$ (1), where w is the weight of stemflow (g) and A is the ^{137}Cs amount (Bq).

Regression analysis between the ^{137}Cs amount captured with 1 g of the sphagnum and the accumulated precipitation values was conducted. KyPlpot 5.0 (KyensLab Incorporated, Tokyo, Japan) was used for the statistical analysis.

2. 2 Comparison between the ratios of dissolved ^{137}Cs to total ^{137}Cs in the stemflow collected with the sphagnum pad and the plastic zipper bag

Same trees in the examination 2.1 were used. The stemflow was collected directly by fixing a 17 by 24 cm plastic zipper bag,

Fig. 1. Preparation of a sphagnum pad for collecting ^{137}Cs in the stemflow.
Trapping pad (A: Sphagnum pad) was made by encapsulating approximate 7 g of sphagnum (B: Besuguro-Supagumosu, New Zealand) in a tea pack (C: polyester-polyethylene composite fiber). The sphagnum pad was covered with polyethylene film and was attached on the epiphytic moss on the trunk with polyester band and stopper (D).

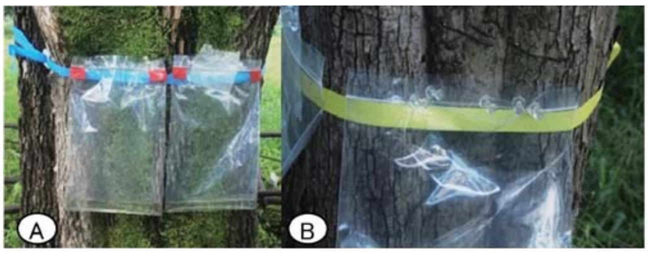

Fig. 2. Fixing of a bag for collecting the stemflow.
The stemflow was collected directly by fixing a 17 by 24 cm plastic zipper bag on two areas of the epiphytic moss on the trunk (A). The inlet side of the stemflow was pinned (B).

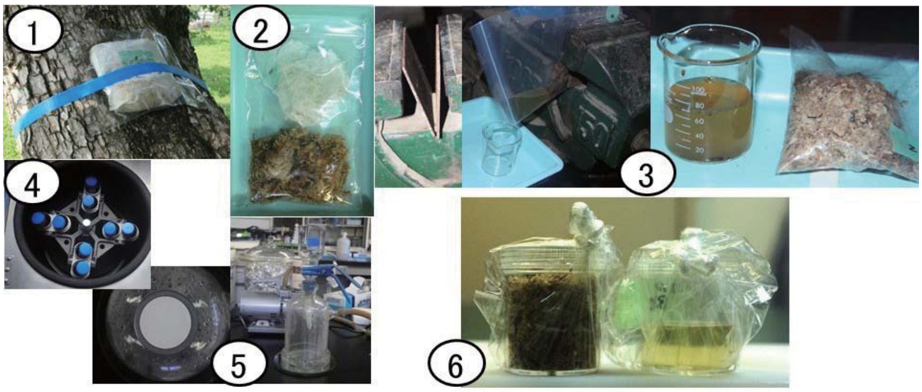

Fig. 3. Procedure to prepare the dissolved ^{137}Cs from a sphagnum pad after collecting the stemflow.
After collecting the stemflow, collection pad (1) was separated into sphagnum and tea pack (2). Sphagnum was put in a plastic zipper bag and was squeezed with a parallel bench vice (3). After centrifuging at 3500 rpm for 20 min (4), supernatant solution was filtered with suction by passing through a 0.45μm membrane filter (5: Cellulose-ester mixed type) to prepare the dissolved ^{137}Cs (6). The stemflow collected directly was filtered with the 0.45μm membrane filter using a suction pump to prepare the dissolved ^{137}Cs.

termed collection bag, on the trunk of the unwashed tree at twice in 2015: Oct 1 to 2 and Oct 29 to Nov 4 (Fig. 2). One of bags was placed on the site out of moss area; the others were placed on the epiphytic moss. The upper edge of the plastic zipper bag was pinned at four places. To collect the stemflow, sphagnum pads were fixed on the scaffold limbs at 4 place of an unwashed tree and 3 place of a bark-washed tree from July 1 to 20. One of pads on each tree was placed on the epiphytic moss; the others were placed on the site out of moss area. After collecting the stemflow, the tea pack and sphagnum in the pads were separated. The sphagnum containing the stemflow was put in a plastic zipper bag with a chuck and was squeezed with a parallel bench vice. The sphagnum after squeezing, filtration residue and the 0.45μm pore size membrane filter used were combined to one sample for measuring the ^{137}Cs concentration. The stemflow collected with the plastic zipper bag and the solution squeezed from the sphagnum pad were filtrated with the 0.45μm pore size membrane filter (Mixed cellulose ester, Toyo Roshi Kaisha, Ltd, Tokyo) using a suction pump (Fig. 3). According to Schimmack *et al*. (1993), the ^{137}Cs in the water after filtrating was defined as the dissolved ^{137}Cs (< 0.45μm), and the ^{137}Cs in the remainder (the sphagnum moss after squeezing, the filtration residue and the 0.45μm pore size membrane filter used) was defined as the particulate form.

2. 3 Comparison of ^{137}Cs collection efficiency between Sphagnum and absorbent cotton for the collection medium

For this experiment, three approximately 35-year-old Japanese persimmon 'Hachiya' trees, which had not been bark-washed, planted at an orchard in Date City, approximately 60 km from FDNPP, were used. Collection pads were made by encapsulating approximate 7 g of sphagnum or absorbent cotton (Hakujuji. Co. Ltd, Tokyo) in a tea pack same as the experiment 2.1. The weight of every tea pack was measured before putting the collecting media. Collection pads made with sphagnum or cotton were fixed at the same location where no epiphytic moss grew on the trunk or scaffold limb of each tree with polyester band and stopper from July 23 to Aug 26 in 2015 (Fig. 4). After collecting stemflow, each collection pad was measured the weight and was separated into the tea pack and the collection medium (sphagnum or cotton). The weight of the collected water was estimated same as the experiment 2.1. Samples to measure the dissolved ^{137}Cs and the particulate ^{137}Cs were prepared according to the same procedure as the experiment 2.2. The ^{137}Cs activity concentrations of the dissolved ^{137}Cs, the particulate ^{137}Cs and the empty tea bag sampled after the collection of stemflow were measured respectively.

2.4 Sample treatments and radiocaesium measurements

The epiphytic moss, the collection pad, sphagnum, stemflow and the filtrated water were placed in a 100-mL capacity polypropylene container (U-8 pots). ^{137}Cs activity concentrations were measured using a germanium detector in Fukushima University. Gamma-ray emission at energies of 662 keV was measured for 3600 to 80,000 sec. Since ^{137}Cs measurement was conducted within 2 weeks from sampling, decay correction was not applied. For the blank, 7 g sphagnum before applying examinations with 70-mL distilled water placed in a U-8 pot was prepared. ^{137}Cs activity (A, in Bq) was calculated using the following formula: $A = wC/1000$ (2), where w is the weight of sample (g) and C is the ^{137}Cs activity concentration (Bq kg^{-1}).

Fig. 4. Fixing of a sphagnum pad and an absorbent cotton pad to collect the stemflow.
Both collection pads made with sphagnum moss and cotton were fixed at the same location on the trunk or scaffold limb of three trees with polyester band and stopper from July 23 to Aug 26 in 2015.

3. Results and Discussions

3.1 Relationship between accumulated ^{137}Cs activity in the stemflow over the trunk and precipitation

A significant linear relationship between the collected ^{137}Cs activity per 1 g sphagnum and the accumulated precipitation is observed, with an R^2 value of 0.99 (Fig. 5). In addition, a similar relationship between ^{137}Cs concentration in the stemflow and the accumulated precipitation is also observed (Fig. 6), indicating that water lost due to exceeding the water holding capacity of the sphagnum contained only a small amount of ^{137}Cs. Since the sphagnum had been shown to have ^{137}Cs below detection limits prior to the experiment, these results showed sphagnum has captured ^{137}Cs in the stemflow and accumulated ^{137}Cs in proportion to the volume of precipitation. Rainfall event affects throughfall and stemflow (Steinbuck, 2002; Carlyle-Moses, 2004; Park *et al*., 2008; Mattaji, 2012). Mattaji *et al*. (2012) reported that there was significant correlation between the increase of gross precipitation height and the share of stemflow, throughfall and interception by oriental beech trees in North Forests of Iran. Though Schimmack *et al*. (1993) found that the ^{137}Cs concentration decreased significantly with increasing stemflow intensity (L week^{-1}) on the beech trees in the Höglwarld forest of Germany, regression analysis between the ^{137}Cs amount in stemflow and the accumulated precipitation was not conducted. This investigation has confirmed that there is the close relationship between the volume of above-ground ^{137}Cs depositing to the soil and rainfall in the Japanese persimmon orchards. This result was concerned to show the fundamental relationship between amount of the ^{137}Cs exuded from moss and the accumulated precipitation because of being confirmed by the examination conducted on the epiphytic moss at the same position. Though same relationship would be expected on the site out of moss area on the trunk, no experiment conducted on those site. More investigations, therefore, would be necessary to clarify the difference of the relationship between amount of ^{137}Cs in stemflow and participation by the presence of epiphytic moss.

3. 2 Comparison between percentages of dissolved ^{137}Cs to total ^{137}Cs in the water collected with the sphagnum pad and the plastic zipper bag

The percentage of dissolved ^{137}Cs to total ^{137}Cs amount in the water collected with sphagnum pads on 2 trees was 6.6% in an unwashed tree and 3.9 % in a washed tree on the site out of moss, and 3.0% in an unwashed tree and 1.3 % in a washed tree on the epiphytic moss (Table 1). On the other hand, the percentage of dissolved ^{137}Cs concentration in the stemflow collected directly on the epiphytic moss with 61700 Bq kg^{-1} was 47.9% and the total ^{137}Cs activity concentration was 21.8 Bq kg^{-1} (Table 2). The ratio of dissolved ^{137}Cs to particulate ^{137}Cs which was valid by subtracting the amount of ^{137}Cs collected water from filtrated water was 0.80 in the stemflow on the epiphytic moss. No differences of the percentage of dissolved ^{137}Cs concentration were found by the presence of the epiphytic moss in both collection methods (Table 1 and Table 2). There was a significant difference between the percentages of the dissolved ^{137}Cs to the total ^{137}Cs amount in the stemflow collected by sphagnum pads and by collection bag by Kruskal-Wallis test (P<0.01) using the whole data. In the present examination, it was demonstrated that sphagnum has an ability to retain dissolved ^{137}Cs. An ability to retain the dissolved ^{137}Cs is likely due to these characteristics of moss. Mosses do not have an epidermis or a cuticle, but have a high absorbing power (Iurian *et al*., 2011). Dragovića *et al*. (2004) found that membranes of moss are the primary ^{137}Cs-binding sites at the cellular level. Schimmack *et al*. (1993) reported the ratio of dissolved ^{137}Cs to particulate ^{137}Cs in the stemflow collected from beech trees in the Höglwarld forest of Germany was approximately 10. There was a magnitude of difference compared with the present study. In this study, stemflow on the epiphytic moss was collected. The epiphytic moss may be related to low dissolved ^{137}Cs in stemflow. For another possible reason, Schimmack *et al*. (1993) have prepared the sample for measuring ^{137}Cs in stemflow concentrated to approximately 10 times by evaporating. The possibility that particulate ^{137}Cs has been

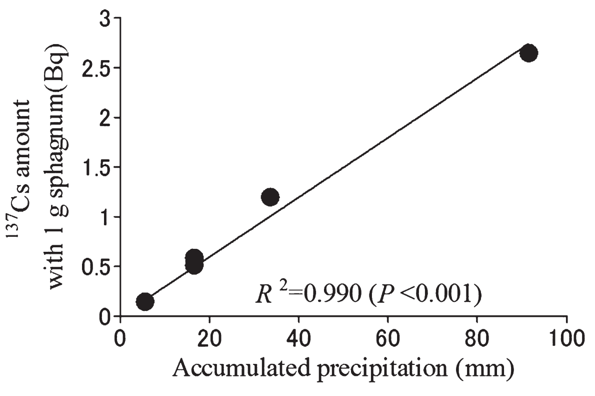

Fig. 5. Relationship between the accumulated precipitation and the collected ^{137}Cs activity per 1g sphagnum.
To collect the stemflow, a sphagnum pad was fixed on top of patches of the epiphytic moss on the trunk of an unwashed tree with polyester band and stopper. The stemflow was captured at five times for following period in 2015: Jun 27 to 29, Jul 31 to Aug 27, Aug 31 to Sep 2, Nov 2 to 9 and Nov 14 to 20. Accumulated precipitation means the sum of rainfall during each collecting period. ^{137}Cs amount trapped means the ^{137}Cs budget in the stemflow collected with 1 g sphagnum.

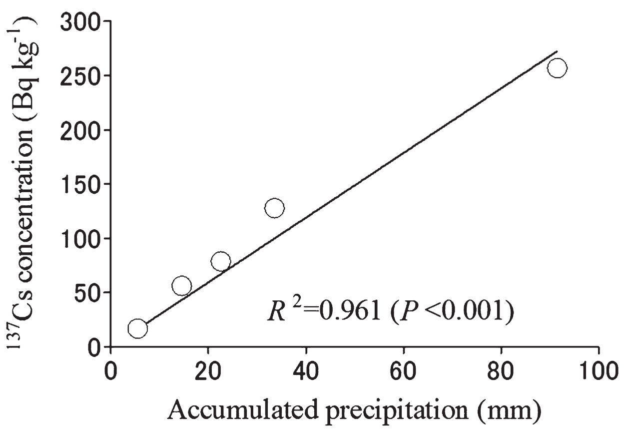

Fig. 6. Relationship between the accumulated precipitation and the ^{137}Cs activity concentration in stemflow collected with a sphagnum pad.
The weight of the collected water was estimated by subtracting the weight of an empty tea pack and sphagnum before collecting water from the weight of the sample sphagnum pads removed after the collection period. ^{137}Cs concentration (C, Bq kg^{-1}) in stemflow was calculated the following fomula as C=1000A/w, where w is the weight of stemflow (g) and A is the ^{137}Cs amount (Bq).

re-dissolved cannot be excluded. Furthermore, beech tree does not form rough bark, but persimmon tree forms rough bark, which is removed easily. Dissolved ^{137}Cs is likely held in the fragment of rough bark. More investigations would be necessary to clarify the ratio of dissolved ^{137}Cs to particulate ^{137}Cs in stemflow.

3.3 Comparison of ^{137}Cs collection efficiency between Sphagnum moss and absorbent cotton

Weight of water, ^{137}Cs activity of the combined squeezed collection medium and membrane filter and the total ^{137}Cs activity in the water are given in Table 3. The activities collected with sphagnum were significantly higher than those collected with cotton. The percentages of dissolved ^{137}Cs were not significantly different. Cellulose is the main component of both cotton and membranes of moss. Since cellulose may prefer the dissolved ^{137}Cs to particulate ^{137}Cs for trapping, there was insignificant difference between dissolved ^{137}Cs collected with sphagnum and cotton. Leaves

Table 1. Percentages of dissolved ^{137}Cs to total ^{137}Cs activityin the water captured by sphagnum pads.

Bark-washing treatment	Collecting site	Replicate	Sample	^{137}Cs activity				Percentages of dissolved ^{137}Cs	
				Concentration		Amount			
				Mean	SD	Mean	SD	Mean	SD
				(Bq kg^{-1})		(Bq)		(%)	
Unwashed	Out of moss	3	Filtrated water	10.8	10.7	0.6	0.6	6.6	6.5
			Squeezed residue	243	105	7.1	3.3		
	On moss	1	Filtrated water	1.6	-	0.1	-	3.0	-
			Squeezed residue	74.2	-	2.0	-		
	Total	4						5.7	5.6
Washed	Out of moss	2	Filtrated water	1.8	1.1	0.1	0.1	3.9	2.9
			Squeezed residue	127	33.8	3.9	1.1		
	On moss	1	Filtrated water	1.3	-	0.1	-	1.3	-
			Squeezed residue	162	-	5.1	-		
	Total	3						3.0	2.4

Note: One tree bark-washed in 2012 and another tree unwashed were used. To collect the stemflow, sphagnum pads (a tea pack inputted sphagnum moss) were fixed on the trunk or scaffold limbs at 4 place of an unwashed tree and 3 place of a bark-washed tree from July 1 to 20 in 2015. The water squeezed from the sphagnum was filtrated with the 0.45 μm pore size membrane filter using a suction pump. The measured value in the fraction filtrated (< 0.45μm) means the dissolved ^{137}Cs. Squeezed residue contains the membrane filter used. Percentages of dissolved ^{137}Cs were calculated using the data of ^{137}Cs amount in each replicate.

Table 2. Percentage of dissolved ^{137}Cs to total ^{137}Cs amount in the stemflow water.

Bark-washing treatment	Collecting site	Replicate	Sample	^{137}Cs activity				Percentages of dissolved ^{137}Cs	
				Concentration		Amount			
				Mean	SD	Mean	SD	Mean	SD
				(Bq kg^{-1})		(Bq)		(%)	
Unwashed	Out of moss	1	Collected water	18.4	-	0.6	-	30.1	-
			Filtrated water	8.5	-	0.2	-		
	On moss	3	Collected water	21.8	11.1	0.8	0.4	47.9	35.9
			Filtrated water	9.7	2.8	0.3	0.1		
	Total	4						43.4	30.6

Note: The stemflow was collected directly by fixing a 17 by 24 cm plastic zipper bag on the trunk of the unwashed tree at twice in 2015: Oct 1 to 2 and Oct 29 to Nov 4. One of bags was placed on the site out of moss area, the others were placed on the epiphytic moss. The stemflow was filtrated with the 0.45μm pore size membrane filter using a suction pump. The measured value in the fraction filtrated (< 0.45μm) means the dissolved ^{137}Cs. Percentages of dissolved ^{137}Cs were calculated using the data of ^{137}C samount in each replicate.

Table 3. Comparison of the ^{137}Cs collection efficiency between Sphagnum moss and absorbent cotton.

Material for collection medium	Weight				^{137}Cs amount in water collected								^{137}Cs amount attached to a tea pack	
	medium		Water collected		Dissolved form		Particulate form		Total		Percentage of dissolved ^{137}Cs			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	(g)		(g)		(Bq)		(Bq)		(Bq)		(%)		(Bq)	
Sphagnum moss	7.2	0.1	83.4	14.6	0.5	0.4	5.1	3.1	5.6	3.5	7.7	2.4	3.6	3.2
Cotton	7.5	0.6	57.8	8.5	0.2	0.1	1.3	0.8	1.6	0.9	15.1	7.4	3.6	2.1
t-test	NS		*		NS		*		*		NS		NS	

Note: Collection pads were made by encapsulating approximate 7 g of sphagnum or absorbent cotton in a tea pack. Both sphagnum moss and cotton were fixed on a same place on the trunk or scaffold limb from July 23 to Aug 26 in 2015. The weight of the collected water was estimated by subtracting the weight of an empty tea pack and sphagnum or absorbent cotton before collecting water from the weight of the sample sphagnum pads removed after the collection period. The dissolved ^{137}Cs was prepared according to Fig.3. The ^{137}Cs amount in the water after filtrating is defined as the dissolved ^{137}Cs (< 0.45μm), and the ^{137}Cs amount in others (the sphagnum moss or cotton after squeezing, the filtration residue and the 0.45μm pore size membrane filter used) are as the particulate form (> 0.45μm).

of sphagnum have hyaline and chlorophyllose cells. Large hyaline cells and small chlorophyllose cells are arranged alternatively in a line. Hyaline cells become hollow with holes on the surface which is adapted to store a large amount of water (Bold *et al*., 1986). These characteristic of sphagnum likely have the advantage to retain stemflow water and capture particulate ^{137}Cs.

4. Conclusion

The outflow of ^{137}Cs from bark is closely correlated with rainfall. Sphagnum pads have been shown to be useful for trapping ^{137}Cs in the stemflow following rainfall. Both sphagnum and cotton capture dissolved ^{137}Cs easily because of having abundant cellulose. These findings suggested that organic mediums should not be used for the investigation of the dissolved ^{137}Cs in the stemflow. However, it is concluded that collection pads with sphagnum are useful for stemflow collectors to research the secondary deposition source because of having the high ability of water-absorbing and retaining total ^{137}Cs. To collect the stemflow water directly, the equipment using a plastic zipper bag with a chuck was practical because of being easy to prepare the parts and to set to the tree. Since sphagnum pads can be made easily and are flexible to handle, they could be attach to any place where the presence of secondary contamination should be confirmed. It is concerned that sphagnum pads would enable to quantify the secondary deposition of radiocaesium in canopy of tree, *e.g*. leaf, calyx, fruit or anywhere else. In fact, the experiment to compare the amount of ^{137}Cs in stemflow on the trunk by presence of moss has been practiced using sphagnum pads successfully (unpublished). It was found that some of ^{137}Cs captured by sphagnum pads escape through by repeating sunshine and rainfall during a long time. It will be better to clarify its escaping characteristics and to enhance the ^{137}Cs-holding capacity for increasing in its utility. Sphagnum pads would have a high prevalence for the equipment to investigate the ecological radioactivity, if those improvements are performed.

Acknowledgement

The authors thank Dr. Brenda J Howard (Centre for Ecology & Hydrology Lancaster Environment Centre) and Dr. Alan Cresswell (Scottish Universities Environmental Research Centre) for their useful comments and for improving English in the manuscript.

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