# Root Uptake and Distribution of Radionuclides $^{134}$Cs and $^{60}$Co in Sunflower Plants (*Helianthus annuus. L*)

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**Abstract.** Phytoremediation is the most common method to recover polluted environment caused by radionuclides. This study aims to determine the distribution of $^{134}$Cs and $^{60}$Co radionuclides in sunflower plants (*Helianthus annuus. L*). The sunflower plants were cultivated in soil media for 50 days, then transferred into a tube containing hydroponic solution contaminated by $^{134}$Cs and $^{60}$Co with variation of concentration of $^{134}$Cs (0.85 Bq/ml, 1.31 Bq/ml, 1.74 Bq/ml, 2.24 Bq/ml, 2.67 Bq/ml) and $^{60}$Co (4,213 Bq/ml, 8,537 Bq/ml, 12,187 Bq/ml). The distribution of radionuclides in roots, stems, leaves were observed using a gamma spectrometer to determine the accumulation of contaminants in plants. Samples were taken at varying intervals (0-720 hours) to determine the increased accumulation of contaminants in plants. The results showed that $^{134}$Cs and $^{60}$Co accumulated mostly in the leaf section. and the highest accumulation of $^{60}$Co was observed in the root section.

Keywords: **phytoremediation, sunflower, radionuclides**

## 1 Introduction

Radionuclides can be found in the environment naturally or artificially due to the use of nuclear facilities, or the consequences of nuclear accidents [1,2]. One of the fission results that may be released into the environment in nuclear accidents is $^{134}$Cs, $^{137}$Cs and $^{60}$CO [3-8] The radionuclides are potentially harmful to human health and the environment, due to emitted gamma radiation and long half-life (2.05 years for $^{134}$Cs, 30 years for $^{137}$Cs and 5.2 years for $^{60}$Co) [9,10], so that the radionuclides can be in the environment for a long time. Radionuclides released into the soil can be absorbed by plants and end up in humans through the respiration, and the food chain. Radionuclides that enter the human body or other living things can be sources of internal radiation that damage cells and tissues.[11]

recently many scientists are developing cost effective technologies to clean up land from radionuclide contaminants such as the use of microorganisms, biomass, and plants. [1]. One of the most interesting and discussed methods in this study is phytoremediation or remediation of contaminated areas by radionuclides using plants. Selection of plants used are plants that are not included in the category of consumption plants. This is to prevent radionuclides from entering the food chain. Several studies have been conducted using adult plants grown in hydroponics. [12,13].

This study presents the distribution of $^{134}$Cs and $^{60}$Co radionuclides by sunflower plants (*Helianthus annuus L.*) which are cultivated in hydroponic media in tropical region. The distribution and translocation of radionuclides in plants needs to be evaluated because cesium can be absorbed by plants because it has similarities with potassium which is a nutrient for plants, while cobalt is a trace element which is found in almost all plants but is toxic if it accumulates in large quantities [1]. The selection of sunflowers is done because this plant has been tested to clean the contaminated water body $^{137}$Cs in case of Chernobyl accident. [14]

## 2 Material and Methods

### 2.1 Plant Material

The Sunflower were cultivated in soil for 50 days. This process is done to obtain sunflower plants with the same physical condition. 100 plants that have been selected will be transferred into hydroponic media.

Hydroponic media made using 100 pieces of tubes filled with water (each 2300 ml) and mixed with 10 ml of hydroponic solution. The tubes are then grouped into two, 30 tubes were used as control and 70 as tubes of treatment..

The tube of treatment was contaminated using $^{134}$Cs and $^{60}$Co with variation of concentration of $^{134}$Cs (0.85 Bq / ml, 1.31 Bq / ml, 1.74 Bq / ml, 2.24 Bq / ml, 2.67

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Bq / ml) and $^{60}$Co (4,213 Bq / ml, 8,537 Bq / ml, 12,187 Bq / ml).

### 2.2 Sampling Methods (Hydroponic Solutions and Plants)

The sampling of plants and hydroponic solutions was carried out at intervals shortly after hydroponic solution, 1 hour, 2 hours, 4 hours, 6 hours, 8 hours, 24 hours, 5 days, 6 days, 10 days, 15 days, 20 days and 30 days. Each sample is randomly selected 8 plants which have the same relatively physical characteristics. Besides the selection of samples need to be prioritized the withered plants and will die.. The required sample composition is 3 control plants and 5 plants on treatment medium. The hydroponic solution sampling done by entering 100 ml of sample plants hydroponically previously taken into bottles.

### 2.3 Sample Preparation

Plant samples were washed to remove molded moss and then cut to separate the three main components. Each part of the plant is cut thin and inserted into aluminum foil. The wet weight of each part of the plant is measured before it is dried. The drying process is carried out using an oven at 100 ° C until the sample mass is stable. This step is carried out in order to obtain sample dry weight and the absorption of radionuclides by plants only. Samples that have been dried and then inserted into a plastic clip.

Plants from experiments were evaluated using a High Purity Germanium (HPGe) detector equipped with Multi Channel Analyzer (MCA) [14] for 600 seconds for each sample. Enumeration is only done once without repetition.

## 3 Results and Discussion

### 3.1 Green House Temperature

sunflowers can grow in environments with low or high temperature conditions. Sunflowers can usually grow optimally at temperatures between 23-28°C, the wider range can reach 34°C but little effect on productivity[15]. **Table 1** displayed temperature in the green house during sampling. Condition of the room is in the temperature between 25°C to 33°C with an average temperature of 27.3°C, this shows the plant is still at its optimum temperature to grow.

### 3.2 Distribution and Translocation of $^{134}$Cs and $^{60}$Co in Sunflower Plants

In this study sunflowers have been tested for their ability to absorb radionuclides $^{134}$Cs and $^{60}$Co from hydroponic media with varying initial concentrations. Variation of concentration of $^{134}$Cs 0.85 Bq / ml (tube 1), 1.31 Bq / ml (tube 2), 1.74 Bq / ml (tube 3), 2.24 Bq / ml (tube 4), 2.67 Bq / ml (tube 5) and $^{60}$Co 4,213 Bq / ml (tube1), 8,537 Bq / ml (tube 2), 12,187 Bq / ml (tube 3).

**Tabel 1.** Green house temperature at the time of sampling

| Sampling | Temperature (°C) |
|---|---|
| I (0 hours) | 26 |
| II (1 hours) | 26 |
| III (2 hours) | 28 |
| IV (4 hours) | 30 |
| V (6 hours) | 28 |
| VI (8 hours) | 27 |
| VII (24 hours) | 28 |
| VIII (5 days) | 27 |
| IX (6 days) | 27 |
| X (10 days) | 25 |
| XI (15 days) | 26 |
| XII (20 days) | 26 |
| XIII (25 days) | 26 |
| XIV (30 days) | 33 |

In sampling, dry mass was measured to determine the effect of contaminants on plant growth rates. The result of plant growth observation is shown in graph of mass and time comparison. In **Figure 1** it can be seen that the presence of contaminants in the hydroponic solution does not affect the growth rate in general. The dry mass value of the plant continues to increased, but when compared with the growth of the control plants, the plants in the treatment medium showed growth delay. This occured because parts of the plant that are in direct contact with the contaminant will received greater radiation exposure. Exposure to radiation causes death of the cells that triggered growth delay of the plant organs, especially roots. This process arised from the inhibition of the synthesis of root-growth stimulants (auxin) and the division of the root meristem tissue. From these results it can be seen that sunflower plants can still grow normally in contaminated hydroponics media $^{134}$Cs and $^{60}$Co despite experienced growth delay[14,16]

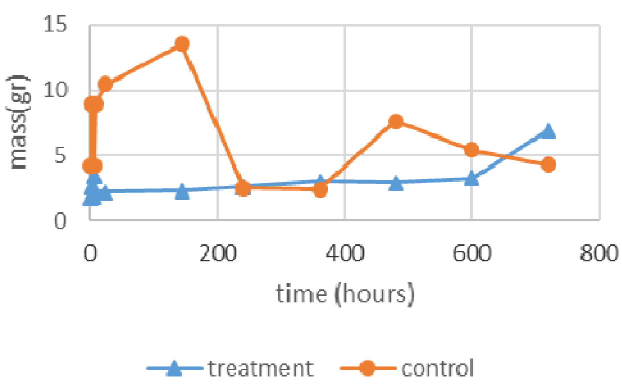
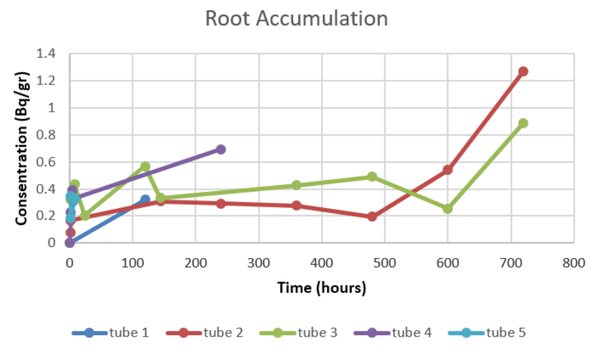


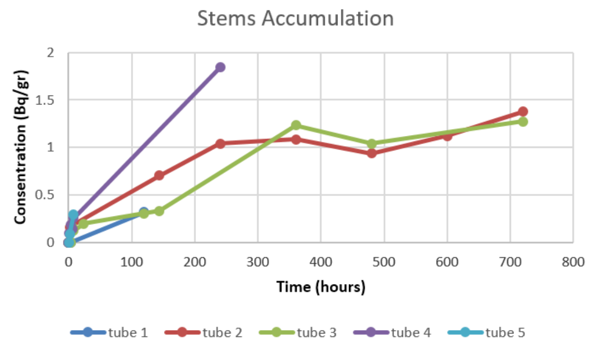

**Fig. 1.** Graph of dry mass increased between treatment and control plants.

The ability of sunflower plants to absorb $^{134}$Cs with some concentration variation was proved by the increase of contaminant concentration in plants obtained from the sampling. Figure 1 shows that the absorption of $^{134}$cs has occurred since the beginning of the plant was moved to the hydroponics medium.

Sunflower plants absorb $^{134}$Cs through the roots, then distributed throughout the plant. The distribution $^{134}$Cs by sunflower in **figure 2** shows that all parts of the plant both root, stem and leaf in all variation of concentration have a same relative absorption pattern..




**(a)**

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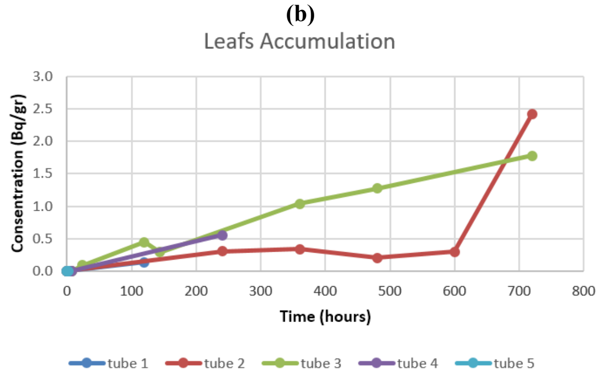
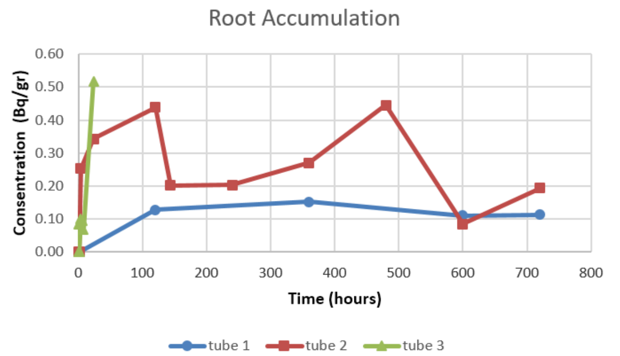



**(c)**

**Fig. 2.** (a) $^{134}$Cs accumulation by roots , (b) $^{134}$Cs accumulation by stems, (c) $^{134}$Cs accumulation by leafs, tube 1 ( 0,85 Bq/ml), tube 2 ( 1,31 Bq/ml), tube 3 ( 1,74 Bq/ml), tube 4 ( 2,24 Bq/ml), tube 5 (2,67 Bq/ml).

Absorption at the root has increased and decreased. Translocation of contaminant from the root to all parts of the plant leads to reduced accumulation of $^{134}$Cs at the root. the highest contaminant absorption rate at the root occurs in tube 2 (initial concentration 1.31 Bq / g) then tube 3 (1.74 Bq / g), tube 4 (2.24 Bq / g), tube 5 (2.07 Bq / g), tube 1 (0.85 Bq / g). the highest absorption on the stem occurs in tube 4, then tube 3, tube 2, tube 1, tube 5. While the highest accumulated leaves occur in the tube tube 2, then tube 3, tube 3, tube 1, tube 5. From the results above obtained the concentration of $^{134}$Cs accumulated at most on the leaves, then inside the stem and the lowest at the root.

The reason leaves have the highest accumulated value of $^{134}$Cs is the result of the process of carbohydrate formation in the process of photosynthesis. The accumulation of $^{134}$Cs in leaves is related to the role of K elements in the photosynthesis process, since K and Cs are in the same class.[14]

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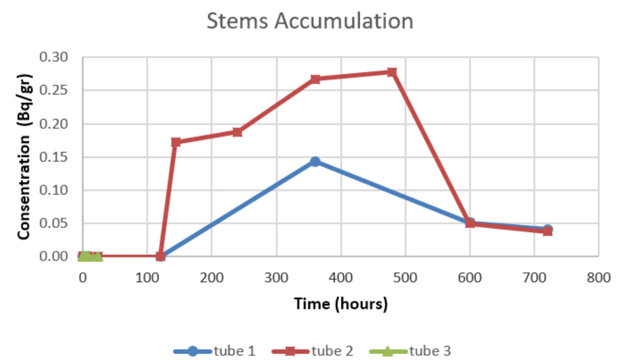


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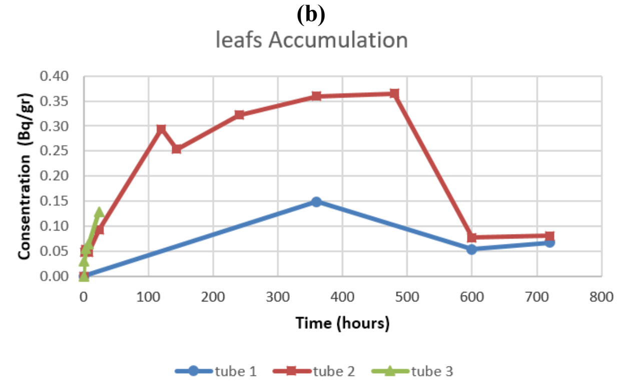


**(c)**

**Fig. 3.** (a) $^{60}$Co accumulation by roots , (b) $^{60}$Co accumulation by stems, (c) $^{60}$Co accumulation by leafs, tube 1 ( 4,21 Bq/ml), tube 2 ( 8,54 Bq/ml), tube 3 ( 12,19 Bq/ml).

The ability of sunflower to absorb $^{60}$Co contaminants can be seen in **figure 3**. $^{60}$Co absorption pattern by roots is relatively similar when compared with absorption of 134Cs by roots. The absorption rate shows an increase and decrease due to the contaminant translocation from the roots to all parts of the plant. While on the stem and leaves have the same absorption pattern. Accumulation of contaminants by the highest roots occurs in tube 3 (12.19 Bq / g) and then tube 2 (8.54 Bq / g), tube 1 (4.21 Bq / g). In the highest accumulation rod occurred on tube 2, then tube 1, tube 3. While on the highest accumulated leaves occurred in the tube tube 2, then tube 1, tube 3. From the above results obtained the concentration of 60Cs accumulated at most roots, then inside the leaves and lowest on the stem. cobalt accumulation in plants occurs because Cobalt is necessary as a trace element for all cells but is toxic at higher concentrations.[1]

## 4 Conclusions

In this study the ability of sunflowers to absorb radionuclides $^{134}$Cs and $^{60}$Co from hydroponic media with varying initial concentrations has proven. Variation of concentration of $^{134}$Cs 0.85 Bq / ml (tube 1), 1.31 Bq / ml (tube 2), 1.74 Bq / ml (tube 3), 2.24 Bq / ml (tube 4), 2.67 Bq / ml (tube 5) and $^{60}$Co 4,213 Bq / ml (tube1), 8,537 Bq / ml (tube 2), 12,187 Bq / ml (tube 3). The results showed that 134Cs and 60Co accumulated mostly in the leaf section. and the highest accumulation of 60Co was observed in the root section.

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