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SOIL TO PLANT TRANSFER FACTOR OF RADIOCESIUM BY POT EXPERIMENT*

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Abstract.

This paper deals with the soil to plant transfer factor (TF) of radiocesium (Cs^{137}) considered to be an important parameter while calculating radiological doses due to the potential release of radionuclides into the environment. In the present work, TF values were measured for the main foodstuffs in Bangladesh such as leafy vegetables (Lalshak, Palangshak), Ladyfinger, Radish, Potato, Potato Plant, Paddy, Paddy plant, Grass, Ginger, Ginger plant, Turmeric, and Turmeric plant by pot experiments grown in the AERE soil. Soil characteristics have also been investigated to assist the measured values of the corresponding radionuclide. TF values of the leafy parts and products of the corresponding plants were found in the range of 2.02×10^{-1} to 1.8×10^{-2}, which are reasonably comparable with the value found in the literature. It has been observed that the TF values in the leafy part of the plants are higher than the products.

1. Introduction

In the recent years, there has been growing concern about the potential impact of released radioactive contaminants into the environment from nuclear activities after the Chernobyl nuclear accident in the former USSR in 1986. During detonation of a nuclear device, fission products are released into the environment. Among them, Cs^{137} is highly radiotoxic, long-lived and may inter into the human body through various metabolic pathways [1]. It is therefore, necessary to assess the radiological impact to the environment due to potential release of Cs^{137} by means of global fallout as well as nuclear accident for regulatory requirement. Site-specific parameters need to be measured experimentally in order to assess the radiological impact into the environment. Soil to plant transfer factor (TF) is an important affecting parameter that might cause significant dose to the population through ingestion [2, 3]. There are many studies regarding the TF values for Cs^{137} performed for a specific site [4-8]. However, no data is currently available in Bangladesh especially in the vicinity of AERE campus where major nuclear facilities in the country have been established. In the present work, TF values of Cs^{137} for the main and daily intake of vegetable/product such as Lalshak, Palangshak, Ladyfinger, Radish, Potato, Potato Plant, Paddy, Paddy plant, Grass, Ginger, Ginger plant, Turmeric, and Turmeric plant in Bangladesh have been investigated by pot experiment in the AERE soil. It is well known that TF value for a particular radionuclide mainly depends on the climate, plant species, and soil properties. To assess the TF values, soil properties have also been investigated in the present work.

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The aim of the present work is to investigate soil to plant TF for leafy part and product of the plant by pot experiments. The results obtained can be used as a reference data while predicting the radiological assessment around 3 MW TRIGA Mark II research reactor, a radioactive waste disposal facility likely to be established and a central radioactive waste processing and storage facility (near completion) in the AERE campus, Savar, Dhaka.

2. Materials and methods

2.1. Transfer factor (TF)

The term soil to plant TF measures the transfer of radionuclides from soil to plant when uptake by plant roots is the only process affecting the transfer. From the observed activity concentrations of the radionuclide in the plant and in the corresponding soil, the TF can be calculated according to

$$TF = \frac{\text{Activity in plant (Bq/kg fresh mass weight)}}{\text{Activity in soil (Bq/kg dry mass weight)}} \qquad (1)$$

The TF is expressed in this experiment in fresh mass basis because fresh mass is required in the radiological assessment. Soil samples were collected from the alluvium of AERE campus, transported to the laboratory and air-dried. Each pot was filled with 10 kg of air dry soil in which appropriate amounts of Cs^{137} was added in the following manner: in a graduated plastic bottle 10^4 Bq of Cs^{137} was diluted to 300 ml with tap water. From this standard solution, a known activity was mixed with the soil uniformly. The soils in pots were stored for three weeks. The pots were then appropriately sown and irrigated.

Nine different plants (Lalshak, Palanshak, Ladyfinger, Radish, Potato, Rice, Grass, Ginger and Turmeric) were grown on the soil of the pots. Irrigation, thinning of plants and insect control measures were taken as an additional care according to the needs of each species for three month. The plants were harvested at maturity, separated, when appropriate, into edible and other parts, sliced into small pieces and counted for Cs^{137} employing HPGe detector with associated accessories.

3. Soil characteristics

A wide range of physical and chemical characteristics of soil can affect the transfer of radiocesium to crops, both directly and indirectly. Since the activity concentration of radionuclides in crops is based on soil properties, a comprehensive set of soil parameters (soil type, physical and chemical properties of the soil) were measured using standard procedure as shown in Table 1.

Table 1: Soil type, physical and chemical properties of the soil.

Components	Measured values
P^H	5.80
Organic Matter (%)	0.78
Clay (%)	46.50
Silt (%)	43.30
Sand (%)	11.20
Porosity (%)	39-43
Bulk density (gm/cm^3)	1.53
Cation Exchange Capacity (CEC) (meq/100gm)	13.20

Table 2: TF values for Cs^{137} by pot experiment in the AERE soil

Name of the Plant	TF of Cs^{137}
Lalshak	4.40×10^{-2}
Palangshak	2.72×10^{-2}
Ladyfinger	3.69×10^{-2}
Radish	4.92×10^{-2}
Potato	3.38×10^{-2}
Potato Plant	2.02×10^{-1}
Paddy	3.36×10^{-2}
Paddy plant	4.85×10^{-2}
Grass	2.05×10^{-2}
Ginger	3.37×10^{-2}
Ginger plant	6.61×10^{-2}
Turmeric	1.8×10^{-2}
Turmeric plant	3.96×10^{-2}

4. Results and discussion

The soil characteristics and physical and chemical properties of the soil are shown in Table 1. The pH of the soil was found acidic. The selected soil lies in silty clay soil based on Marshal textural classification. The TF values for Cs^{137} for the selected leafy parts and products of the plants are shown in Table 2. It can be seen in this Table that the TF values were 4.40×10^{-2}, 2.72×10^{-2}, 3.69×10^{-2}, 4.92×10^{-2}, 3.38×10^{-2}, 2.02×10^{-1}, 3.36×10^{-2}, 4.85×10^{-2}, 2.05×10^{-2}, 3.37×10^{-2}, 6.61×10^{-2}, 1.8×10^{-2} and 3.96×10^{-2} for Lalshak, Palangshak, Ladyfinger, Radish, Potato, Potato Plant, Paddy, Paddy plant, Grass, Ginger, Ginger plant, Turmeric, and Turmeric plant, respectively. These values are found to be comparable with the values found in the literature [4-8]. The highest TF value was found to be 2.02×10^{-1} for potato plant while the lowest TF value was found to be 1.8×10^{-2} for Turmeric. The TF values for Ladyfinger, Potato, Paddy, Ginger and Turmeric plant were nearly equal while the TF values for Lalshak, Radish and Paddy plant were nearly the same. The TF values for Potato, Paddy, Ginger and Turmeric plants were observed to be higher than the products of for Potato, Paddy, Ginger and Turmeric, respectively. This observation indicates that there is a considerable variation between leafy part and product of the plant, which attributes to a variation while calculating radiological dose to the population considering ingestion. Therefore, TF values for the most essential consumable vegetable/food could be applied considering both leafy and product parts of the plant in order to predict more reliable dose assessment for ingestion.

5. Conclusion

Soil to plant TF values for the main foodstuffs in Bangladesh such as leafy vegetables (Lalshak, Palangshak), Ladyfinger, Radish, Potato, Potato Plant, Paddy, Paddy plant, Grass, Ginger, Ginger plant, Turmeric, and Turmeric plant have been investigated by pot experiments grown in the AERE soil. Based on Marshal textural classification, it is found that the selected soil is silty clay. TF values of the leafy parts and products of the corresponding plants were found in the range of 2.02×10^{-1} to 1.8×10^{-2}, which are reasonably comparable with the value found in the literature. It has been observed that the TF value in the leafy part is higher than the products of the plant. This may attribute to a variation of dose considering a single TF value of a plant while calculating radiological dose to the population for ingestion pathways. Therefore, TF values for the most essential consumable vegetable/food could be applied considering both leafy and product parts of the plant in order to predict more reliable

dose assessment for ingestion. The results obtained in the present study could provide a reference data for soil to plant TF of Cs^{137} while calculating the probabilistic dose to human and the environment for the regulatory requirements.

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