Available online at www.sciencedirect.com
ScienceDirect
Science of the Total Environment 372 (2007) 595–604
Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind
www.elsevier.com/locate/scitotenv

Long-term mobility of fallout ^{90}Sr in ploughed soil, and ^{90}Sr uptake by wheat grain

N. Yamaguchi [a,*], K. Seki [b], M. Komamura [a], K. Kurishima [c]

[a] Soil Environment Division, National Institute for Agro-environmental Sciences, 3-1-3, Kan-non-dai, Tsukuba, Ibaraki, 305-8604, Japan
[b] Faculty of Agriculture, The University of Tokyo, 1-1-1, Yayoi, Bunkyo, Tokyo, 113-8657, Japan
[c] WDB Co., Ltd., 1-6-1 Takezono, Tsukuba, Ibaraki, 305-0032, Japan

Received 18 May 2006; received in revised form 5 October 2006; accepted 10 October 2006
Available online 21 November 2006

Abstract

In this study, we evaluated the mobility of ^{90}Sr in ploughed upland soil, which affects the residual amount in the soil and plant uptake on the basis of long-term monitoring data. Paired samples of soil and wheat grain were taken annually from 1961 to 1995 from 8 agricultural fields in Japan, and the concentrations of exchangeable ^{90}Sr in soil and total ^{90}Sr in wheat grain were determined. The concentration of exchangeable ^{90}Sr in ploughed soil decreased exponentially with time. The environmental factor responsible for the decrease of exchangeable ^{90}Sr in the ploughed layer, λ_e, was determined from the monitoring data of exchangeable ^{90}Sr in the ploughed soil and the amount of fallout-derived deposition. The λ_e was larger from 1970 to 1980 than it was from 1980 to 1995, suggesting that an easily removable fraction of ^{90}Sr in soil was preferentially lost from ploughed soil. Among various soil properties that we investigated, the main factor controlling the long-term mobility of ^{90}Sr from ploughed upland soil and ^{90}Sr uptake by wheat grain was the cation-exchange capacity (CEC) of soil. Our experimental results indicate that the entrapment of ^{90}Sr on a cation-exchange site retards the downward migration and wheat uptake of ^{90}Sr from ploughed soil. The empirical parameters that we obtained based on the long-term observation of a wheat-cultivated upland field in Japan could be used as reference data in order to roughly estimate the mobility of ^{90}Sr in ploughed soil and soil-borne ^{90}Sr transfer to wheat grain in the humid Japanese climate.

Keywords: Radiostrontium; Ploughed soil; Mobility; Decreasing trend; Wheat; Concentration ratio

1. Introduction

Though more than 25 years have elapsed since the latest atmospheric nuclear test in 1980, long-lived artificial radionuclides, such as ^{137}Cs and ^{90}Sr, remain in the soil, and those trace amounts are still being absorbed by agricultural products (Komamura et al., 2005; Tsukada et al., 2005), resulting in a potential pathway of radiation to humans. The major source of ^{137}Cs and ^{90}Sr in soils in Japan is the global fallout derived from the testing of nuclear weapons. Once deposited on soil surface, the fallout-derived radionuclides tend to migrate down to subsurface layers. The migration characteristics of radionuclides in soil have been shown to vary depending on the soil properties, climatic conditions, land use, and management practices (Baes and Sharp, 1983; Fernandez et al., 2006; Ivanov et al., 1997). A notable characteristic of the Japanese climate is high annual precipitation, which enhances the downward

* Corresponding author. Tel./fax: +81 29 838 8433.
E-mail address: nyamag@affrc.go.jp (N. Yamaguchi).

0048-9697/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.scitotenv.2006.10.011