Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Journal of Environmental Radioactivity 96 (2007) 144–156
JOURNAL OF ENVIRONMENTAL RADIOACTIVITY
www.elsevier.com/locate/jenvrad

^{137}Cs and ^{40}K in the terrestrial vegetation of the Yenisey Estuary: landscape, soil and plant relationships

Elena M. Korobova [a,*], Justin B. Brown [b], Natalia G. Ukraintseva [c], Vitaly V. Surkov [c]

[a] *V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Ac. of Sci., 119991 Kosygin Str., 19 Moscow, Russia*

[b] *Nowegian Radiation Protection Authority, P.O. Box 55, N-1332 Østerås, Norway*

[c] *M.V. Lomonosov Moscow State University, 119334 Vorobyevy Gory, Moscow, Russia*

Accepted 15 January 2007
Available online 25 April 2007

Abstract

Plant species, forming important components of Arctic food chains and of interest from a monitoring perspective, were studied at 36 plots representing flood plain and terrace landscapes of the Yenisey River and Estuary from its upper delta to the gulf. ^{137}Cs contamination densities at the plots varied from 0.35 kBq/m^2 (central delta, sandy riverside plot) to 88 kBq/m^2 (the upper delta plot) indicating both global and regional sources of anthropogenic pollution.

Cs-137 levels in plants were within the range expected from global fallout inputs and varied from 31 to 140 Bq/kg d.w. increasing in dominant groups in the order: grasses < alder, willow (leaves), lichens < mosses (upper part) < mosses (lower part), litter. Tundra plants exhibited remarkably high ^{137}Cs Tag values (0.03–0.1 m^2/kg) comparable to those found on swampy areas contaminated by Chernobyl fallout. The frontal delta island seems to act as a barrier, contributing to local accumulation of ^{137}Cs as reflected in higher inventories in soil and biomass. Horsetail and willow leaves were noted for

* Corresponding author.
E-mail addresses: korobova@geokhi.ru (E.M. Korobova), justin.brown@nrpa.no (J.B. Brown).

doi:10.1016/j.jenvrad.2007.01.024

higher ^{40}K content and lower ^{137}Cs Tag compared to mosses and alder, respectively. This makes the latter plant types more appropriate indicators of ^{137}Cs contamination.

Keywords: Radioecology; Yenisey; Estuary; Tundra; Landscape; ^{137}Cs; ^{40}K; Aggregated Transfer factor; Mosses; Lichens; Willow; Grasses

1. Introduction

Levels of ^{137}Cs in tundra vegetation have remained a theme for intensive study over recent decades due to the considerable accumulation of this radionuclide in mosses, lichens, reindeer meat and the components of local diets (Strand et al., 1998; Nifontova, 1998; Baranov and Vasin, 2001; and others). In addition to contamination from global fallout, the Yenisey River has received inputs of anthropogenic radionuclides from regional sources, primarily the Krasnoyarsk Chemical and Mining Combine (KMCC) (Sukhorukov et al., 2004). These contaminants are deposited on the flood plains along the course of the river, causing local pollution of soils and ecosystems extending as far as the estuary (Sukhorukov et al., 2004; Vakulovsky et al., 1995; Nossov and Martynova, 1996; Kuznetsov et al., 2000, etc.). However, a detailed study of ^{137}Cs in terrestrial systems of the Yenisey Estuary was not performed until 2000 when a project devoted to the study of biogeochemical interactions within this system was initiated (INCO-Copernicus project "Establish", Brown, 2003; Korobova et al., 2003).

The objective of this terrestrial study as a part of the project was to investigate radionuclide contamination of the soil and vegetation within the Yenisey river flood plain, in its delta area and the nearby watershed areas. It was hoped that such an approach would allow the characteristics of ^{137}Cs global and local contamination to be revealed and explained in the context of landscape structure (geomorphology) and bioaccumulation by different plant groups.

Four factors appear to be of primary importance in the estimation of radionuclide transfer in plants and food chains, these being

(1) Soil and plant contamination level;
(2) Spatial (landscape-dependent) variability in contamination levels;
(3) Radionuclide distributions and mobility in soil profiles; and
(4) Retention by and availability to different plant species, especially those forming significant components of food chains or those that are considered important in the context of environmental monitoring.

Radionuclide transfer is often estimated by deriving an aggregated transfer factor or Tag calculated as a ratio: radionuclide activity in plant sample (Bq/kg)/radionuclide contamination density for the established soil layer (Bq/m^2) (for more details see Howard et al., 1995). The highest radioecaesium Tag values have been found for vegetation covering peaty and sod-podzolic sandy soils (Fesenko et al., 1997). Given higher Tag values on peaty and highly humic, wet soils, it is possible to infer that uptake of certain contaminants by tundra plants is likely to be enhanced. Radionuclide contamination levels are also likely to exhibit a dependence upon complex landscape and soil cover structure as they do at locations further upstream (Linnik et al., 2005). Furthermore, it was considered interesting to compare ^{40}K and ^{137}Cs