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Journal of Environmental Radioactivity 79 (2005) 273–296
JOURNAL OF ENVIRONMENTAL RADIOACTIVITY
www.elsevier.com/locate/jenvrad

Review and assessment of models for predicting the migration of radionuclides through rivers

Luigi Monte[a,*], Patrick Boyer[b], John E. Brittain[c], Lars Håkanson[d], Samuel Lepicard[e], Jim T. Smith[f]

[a]*ENEA CR Casaccia, via P. Anguillarese, 301, 00100 Rome, Italy*
[b]*IRSN, St. Paul lez Durance, France*
[c]*LFI, Natural History Museums & Botanical Garden, University of Oslo, Norway*
[d]*Institute of Earth Sciences, Uppsala University, Sweden*
[e]*CEPN, Fontenay-aux-Roses, France*
[f]*CEH Dorset, United Kingdom*

Received 1 December 2003; received in revised form 1 August 2004; accepted 10 August 2004

Abstract

The present paper summarises the results of the review and assessment of state-of-the-art models developed for predicting the migration of radionuclides through rivers. The different approaches of the models to predict the behaviour of radionuclides in lotic ecosystems are presented and compared. The models were classified and evaluated according to their main methodological approaches. The results of an exercise of model application to specific contamination scenarios aimed at assessing and comparing the model performances were described. A critical evaluation and analysis of the uncertainty of the models was carried out. The main factors influencing the inherent uncertainty of the models, such as the incompleteness of the actual knowledge and the intrinsic environmental and biological

* Corresponding author. Tel.: +39 06 30484645; fax: +39 06 30486716.
E-mail address: monte@casaccia.enea.it (L. Monte).

0265-931X/$ - see front matter
doi:10.1016/j.jenvrad.2004.08.002

variability of the processes controlling the behaviour of radionuclides in rivers, are analysed.

Keywords: Model; River; Contaminant; Decision making

1. Introduction

Rivers are complex ecosystems of significant economic, social and environmental values. Models for predicting the behaviour of pollutants in rivers are of paramount importance for the management, in a suitable environmental perspective, of such water bodies and in view of a proper decision-making process. On the other hand, the development of these models is a challenge for the modellers owing to the complicated web of interacting processes that control the migration of toxic substances in lotic ecosystems.

Modelling the behaviour, the consequences and the effects of contaminants in rivers requires, in principle, the quantitative assessment of phenomena of hydraulic, geo-chemical, sedimentological, ecological and anthropogenic nature.

The overall structure of such models comprises the following sub-models:

(a) modules for predicting the hydrological, the hydraulic and the biotic factors that influence the contaminant migration processes occuring in the river ecosystem (such as water fluxes and current velocities, erosion–sedimentation processes and suspended matter in the water column, growth rate of organisms and species, etc.);
(b) modules for predicting the radionuclide transfer:
    a. to the river from its catchment;
    b. through the abiotic components of the river;
    c. from the abiotic components to the biota.
(c) modules for predicting the doses to man and the effects of countermeasures aimed at reducing these doses.

Hydraulic processes are mainly responsible of the transport and the diffusion of toxic substance through the water, whereas geo-chemical processes influence the interaction of dissolved radionuclide with suspended matter and bottom sediments. Sedimentation and resuspension are of importance for controlling the two-way migration of radionuclide from the water column to the bottom sediments and vice-versa. Processes controlling the migration of radionuclides from the abiotic to the biotic components of river systems are, basically, similar to the ones occurring in lakes (Monte et al., 2003).

The aim of the present paper is the assessment of models aimed at evaluating the contamination levels of river ecosystem components. The assessed models, AQUASCOPE (Smith et al., 2002), MOIRA-MARTE (Monte, 2001), RIVTOX