Transfer of Chernobyl ^{137}Cs and ^{90}Sr by surface run-off

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Abstract. Presented are results of Subproject 3c of the Project 2 "Radioecology" of Franco-German Initiative on Chernobyl aiming at creating of database on radionuclide transfer by surface runoff in heavily contaminated areas of Belarus, Russia and Ukraine after the Chernobyl accident. Detailed information about 65 experiments on runoff plots in 30-km zone is collected. Data on general characteristics of contaminated watersheds and characteristics of their contamination, data on radionuclide concentrations in 17 small rivers and 5 large rivers together with hydrochemical characteristics are included in database. The database provides an opportunity for development of specific scenarios for model testing and validation, calculation of key characteristics of radionuclide wash-off from contaminated watersheds, increased understanding of contaminant transport at the process level, and development and use of methods for estimation of key parameters.

1. INTRODUCTION

Surface run-off from contaminated land is one of the major processes responsible for the contamination of water bodies. The large area of land contaminated after the Chernobyl accident becomes a continuing source of radionuclide contamination for natural waters and aquatic ecosystem. Data from the Chernobyl accident provide an excellent opportunity to test models concerned with the movement of trace contaminants from terrestrial sources to water bodies as well as redistribution of contamination within the catchment [1,2]. Information in the database pertains to interrelated objects of significantly different scale and complexity. These are, first, experimental plots; second, tributaries of the main rivers; and third, the main rivers themselves. The information for an experimental runoff plot located on a tributary watershed accounts for the tributary and the main river into which it flows. The database is organised in such a way that when considering an object of higher complexity level all available information about it is possible to be used, irrespective whether it applies to the object directly or indirectly through the related objects of lower levels.

The principal goal of developing the DATABASE "RUNOFF" is creating a common storage of data on radioactive contamination of rivers and experimental results from the studies of mechanisms underlying formation of such contamination which were obtained by researchers of Belarus, Russia and Ukraine within national programs of surface water monitoring and special-purpose experiments in the territory contaminated after the Chernobyl accident [3].

Using the database the following tasks can be addressed:

- Testing and validation of models of radionuclides wash-off to rivers from contaminated watersheds; models of radionuclides transport to river systems; models of vertical migration and transformation of radionuclides species in soils; hydrological models; methods for estimating parameters of the above models;
- Study of features of formation of radioactive contamination in rivers;
- Estimation of model parameters by their calibration using experimental data;
- Reconstruction of radiation doses received by the population of contaminated areas through the aquatic pathway.

It was decided not to orient the database at certain class of models, but rather develop it as universal as possible.

2. DATA BASE DESCRIPTION

The database includes the following information arrays:

2.1. Radionuclide concentrations in river water

Data on the concentration of ^{137}Cs and ^{90}Sr in solution and on suspended matter in 20 rivers flowing through the territory contaminated after the Chernobyl accident are available. These data were obtained in the period from 1986 to 1999 within national monitoring programs and special experiments by organizations of Belarus, Russia and Ukraine [4].

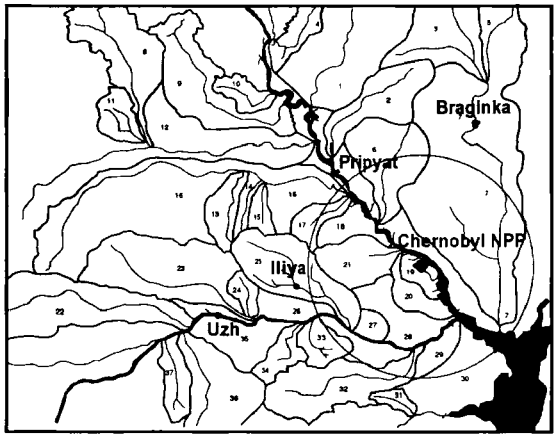

Figure 1: Map of main watersheds in surrounding area close to the Chernobyl nuclear power plant

Table 1: List of small rivers, for which data on ^{137}Cs and ^{90}Sr concentration are included in DB "RUNOFF"

No	River	Period of observations
1	Uzh	1986-1999
2	Braginka	1987-1999
3	Iliya	1987-1999
4	Sakhan	1987-1999
5	Stream Rodvino	1987-1999
6	Stream Borschi	1987-1999
7	Grezlya	1987-1999
8	Right tributary of Braginka	1987-1999
9	Rozhava	1987-1999
10	Glinitza	1987-1999
11	Veresnya	1986-1999
12	Pogonianskiy canal	1988-1999
13	Vyaltcha	Flood of 1988
14	Iltcha	Flood of 1988
15	Rudava	Flood of 1988
16	Nesvitch	1991-1998
17	Slovechno	1991-1998
18	Small streams on Prityat watershed	1987-1999

Table 2: List of large rivers, for which data on ^{137}Cs and ^{90}Sr concentration are included in DB "RUNOFF" (in brackets a number of cross-sections are presented).

No.	River	Period
1	Dneper (12)	1986-2000
2	Pripyat (2)	1986-2000
3	Iput' (4)	1986-2000
4	Besed' (4)	1986-2000
5	Sozh (2)	1987-1994

Potential use:

- Reconstruction of radiation doses received by the population of contaminated areas through the aquatic pathways.
- Formation of test data files for validation of the models accounting for wash-off from watersheds and radionuclides transport in river systems.
- Study of the relationship of radionuclides concentrations in river water and its change in time as a function of watershed characteristics (structure of contamination, soil properties, presence of forests and swamps etc.), hydrological, meteorological and other parameters.
- Estimation of input model parameters by calibration using experimental data.

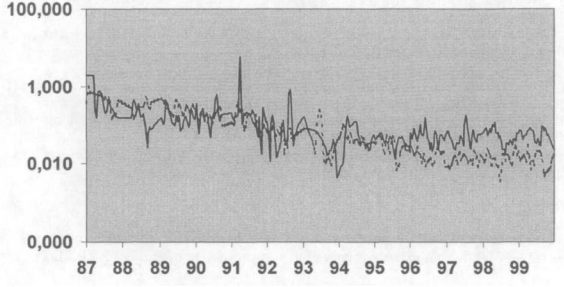

Figure 2: Long-term dynamics of dissolved ^{90}Sr (solid line) and ^{137}Cs (dash line) in Dneper river (cross-section Nedanchichi) designed on the basis of data of DB "RUNOFF"

2.2. Experiments on runoff plots

Overall, 65 experiments were conducted on experimental plots from 1986 to 1999, of them 6 sprinkling and 7 snowmelt experiments on large plots and 45 sprinkling and 7 snowmelt experiments on small plots. The data obtained for all plots include [5,6]:

- deposition and vertical distribution of ^{137}Cs and ^{90}Sr down the soil profile;
- content of ^{137}Cs and ^{90}Sr in the run-off as a function of time;
- general description of soil and vegetation;
- plot topography;
- soil water content before and after sprinkling in 1 m layer at 10 cm steps,
- run-off hydrograph (for sprinkling experiments);
- thickness of snow cover, water equivalent of snow pack, air temperature (for snowmelt experiments).

For some plots the following indicators were additionally determined [7]:

- turbidity and ^{137}Cs and ^{90}Sr in suspension as a function of time (for most plots);
- ^{137}Cs and ^{90}Sr speciations in soil;
- Ca, Mg, K and Na content in run-off;

- exchangeable Ca, Mg, K and Na in the surface soil layer;
- soil temperature as a function of time.

Potential use:
- Testing of models of radionuclides wash-off by surface run-off.
- Study of the relationship of parameters of water run-off and radionuclides wash-off with run-off plot characteristics, properties of soil, rain and snow cover etc.
- Determination of the soil hydraulic conductivity coefficient, runoff and wash-off coefficients.

2.3. Hydrological and meteorological data

Available are results of hydrological and meteorological observations conducted in the contaminated areas by hydrometeorological services of Belarus, Russia and Ukraine. Both mean many-years characteristics and daily measurements at meteorological and hydrological stations in the Chernobyl contaminated territories are entered in the database.
Potential use:
- Formation of input data files for validation of models accounting for wash-off from watersheds and radionuclides transport in river systems.
- Formation of files of text data for validation of hydrological blocks of the model.
- Study of the relationship of radionuclides concentrations in river water and its change in time as a function of hydrological and meteorological parameters.

Data on content, species and vertical distribution of radionuclides in soils and soil properties on river watersheds flowing through contaminated territories [8].
Potential use:
- Formation of input data files for validation of the models accounting for wash-off from watersheds and radionuclides transport in river systems.
- Formation of test data files for validation of the models accounting for vertical migration and transformation of radionuclides species in soils.
- Study of the relationship of vertical migration and transformation of radionuclides species in soil with soil properties.

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