Modeling of major environmental risks for the Kyiv city, Ukraine from the Dnieper river waters - inundation of coastal areas and contamination by the radionuclides deposited in bottom sediments after the Chornobyl accident

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There are two partially linked risks to the Kyiv city associated with the Dnieper river: (A) risk of the inundation of the urban coastal areas during the extremely high floods or due to the break of the Hydropower Plant dam located upstream Kyiv, and, (B) risk of the secondary radioactive contamination of the Dnieper waters due to the intensification of the dynamics of “Chornobyl” radionuclides during high floods and man-made impacts - dredging in Kyiv Reservoirs for navigation routes and other purposes.

The Chornobyl Nuclear Power Plant has located 130 km from Kyiv at the bank of Pripyat river, which is 20 km downstream from ChNPP inflows into the Kyiv reservoir of the Dnieper River. After the Chornobyl accident, about 5.4×10\(^{13}\) Bq of \(^{137}\)Cs and 10\(^{13}\) Bq of \(^{90}\)Sr were deposited in the bottom sediments of the Kyiv Reservoir. Nowadays, 35 years after the Chornobyl accident, the population of Kyiv still is very sensitive to the risks of secondary environmental contaminations by the “Chornobyl radionuclides”. Therefore even low levels of such risks should be carefully assessed by well-grounded methods.

The main goals of our multidisciplinary study are:

- to develop a model/data based Decision Support System (DSS) for the assessment of both kind of the described above risks A) and B),
- to analyze the influence of the natural hazard – extremely high river floods on the resuspension of contaminated sediments and environmental risks due to the man-made impacts – dredging, dam breaks, and others.

The components of these research and development activities are following:
- field and laboratory studies of the contemporary contamination of the bottom sediments and biota in the Kyiv reservoir to receive the input data for the model calibration and improvement of the model structure;
- customization for the Kyiv Reservoir and the Dnieper river at Kyiv of the 2D COASTOX model which the hydrodynamic module is based on the nonlinear shallow water equations, and the sediment/radionuclide transport model using the advection-diffusion equations with specific sink/source terms for radionuclides;
- customization for the Kyiv Reservoir of the hydro-ecological POSEIDON model that simulates the influence of resuspension of radioactive sediments on the contamination of fishes and other hydrobionts;
- improvement of methods for the numerical solution of model equations and algorithms based on finite volume methods for their parallelization using multiprocessor systems and graphics cards to speed up computations;
- to create high-performance DSS with a user-friendly interface that can use GPUs to quickly predict the radiation status of surface waters and inundation of river banks in emergencies.

The DSS is installed in the Department of Hydrological Forecasting of the Ukrainian Hydrometeorological Center and is used for the quantification of the risk scenarios and analyses of the links of both risks. Due to the high computational performance, the DSS can be used for the real-time numerical predictions with the zoning of the flood risks in a case of emergency.