Possibilities to control environmental flows in case of emission of contaminations

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The work of many industrial enterprises and all Nuclear Power Plants (NPP) technologically is connected to use of a plenty of water and assumes accommodation near to the rivers, lakes and reservoirs. Therefore, for want of possible failures the hit of contaminations in a water medium is represented inevitable. The problem becomes important while expanding population. The possibility of a diminution of consequences of hit of contaminations in water due to changes of a mode of a ejections of contaminations and modification about work hydroelectric power plants (HPP) is of interest. It was taken into account the influence of contaminations to water for normal work of the enterprises and in conditions of emergency ejections to take into account different interests of water users.

For estimation of change of concentration of contamination under action of different factors a new box model (UNDBE) was developed.

Model UNDBE takes account that the transposition flows past in two stages. In the first step each portion of the water and pollution only moves through reservoir till the outflow. There are no dilution, interaction with bottom and suspended sediments, chemical and phisical transformations.

For such assumptions it is possible to note

$$\vec{C}_{out}(t,x) = \vec{C}_{\inf}(t - \frac{A}{Q}x) = \vec{C}_{\inf}(t - \frac{L}{v}) \quad , \qquad (1)$$

where $\vec{C}_{out}$ – vector of concentrations in the outflow;

$\vec{C}_{\inf}$ – vector of concentrations in the inflow;

A – cross-sectional area;

Q – streamflow rate;

Q/A = v – average velocity of flowing;

L – length of streamline;

L/v – time of transportation of water (and of the pollutant) through a reservoir.

In the second step only at the end of transportation each portion of water and pollution mixes up in a certain part (V/n) of compartment volume V and interacts there with sediments and bottom depositions as in usual box model.

Therefore with allowance (1) for volume V/n located near outflow of the box can be noted

$$\frac{d(V\vec{C}^*)}{ndt} = Q_{\inf}\vec{C}_{\inf}(t - \frac{L}{V}) - Q\vec{C}^* + V\vec{R}^*(\vec{C}^*, \vec{P}^*) \quad , \qquad (2)$$

where $\vec{C}^*$ - vector of concentrations average in volume V/n;

Q_{inf} - streamflow rate in the inflow;

Q - streamflow rate in the outflow;

$\vec{R}^*(\vec{C}^*, \vec{P}^*)$ - vector of rates of change of averaged concentrations due to conversion processes;

P* - parameters of transformation of contamination.

Such approach allows taking into account time of transporting of water masses and intermixing of contamination in some part of volume of the camera at the moment of a termination of transporting, and all transformations of contamination during transposition are reduced to equivalent transformations in volume V/n.

The assumptions reduce in a model which is described by a system of the usual differential equations with retardation parameter $T_R = L/v = W/Q$, where W – volume of the box participating in water exchange.

In the equation (2) $\vec{C}^*$ are concentrations averaged, not over the total volume of the compartment, but only over the V/n part found at the outlet. Therefore for separation of a water body on boxes, inflow of boxes it is necessary to arrange so that they coincided with places, necessary for the analysis, of a water body.

The numerical box model with lagging argument (UNDBE) is simple, less requiring for full-scale measurements, short time of computation. Short time of calculation gives the opportunity to solve the task of parameters identification - adapt a model for object. It contributes to increase the accuracy of the model and provides the possibility of its adjustment to a particular water object [1].

The research of passing of ejections tritium (H^3) in 350 kilometers channel Loire River (France) was made in the framework of the IAEA program EMRAS (**E**nvironmental **M**odelling for **RA**diation **S**afety). The data for calculations was prepared by EDF-LNHE (France) [2].

A calculations of tritium dispersion for 11 points along the river on stretch a half-year taking into account water discharges from tributaries and using real hydraulic conditions of the year 1999 with 1 hour time step was conducted with help of the model. The ejections of H^3 take place in an outcome of normal work of five NPP. The outcomes obtained with the help of the model UNDBE in Angers (next to last point) and compared to measurements, are represented on Figure 1. Comparison of results is executed by employees EDF. Figure 1 demonstrates good coincidence of outcomes of modeling and measurements. Computing time for modeling is only 2 minutes.

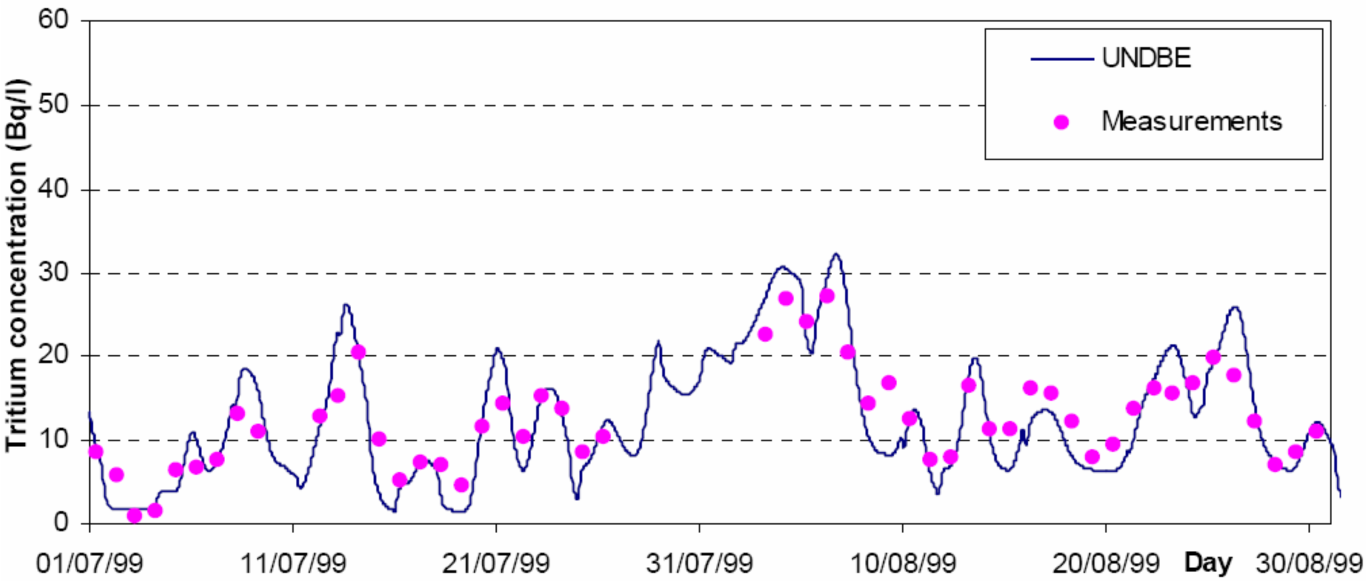
Sharp growths of concentration of tritium are investigation of interference of the ejections H^3 from different stations. Thus there is of principle possibility to decrease the maximal concentrations H^3 by the change of time of the ejections of the separate stations. The amplitude and duration of separate ejections remains without modifications. The search of favourable combinations of moments of the ejections can be certain with the help by the modeling.

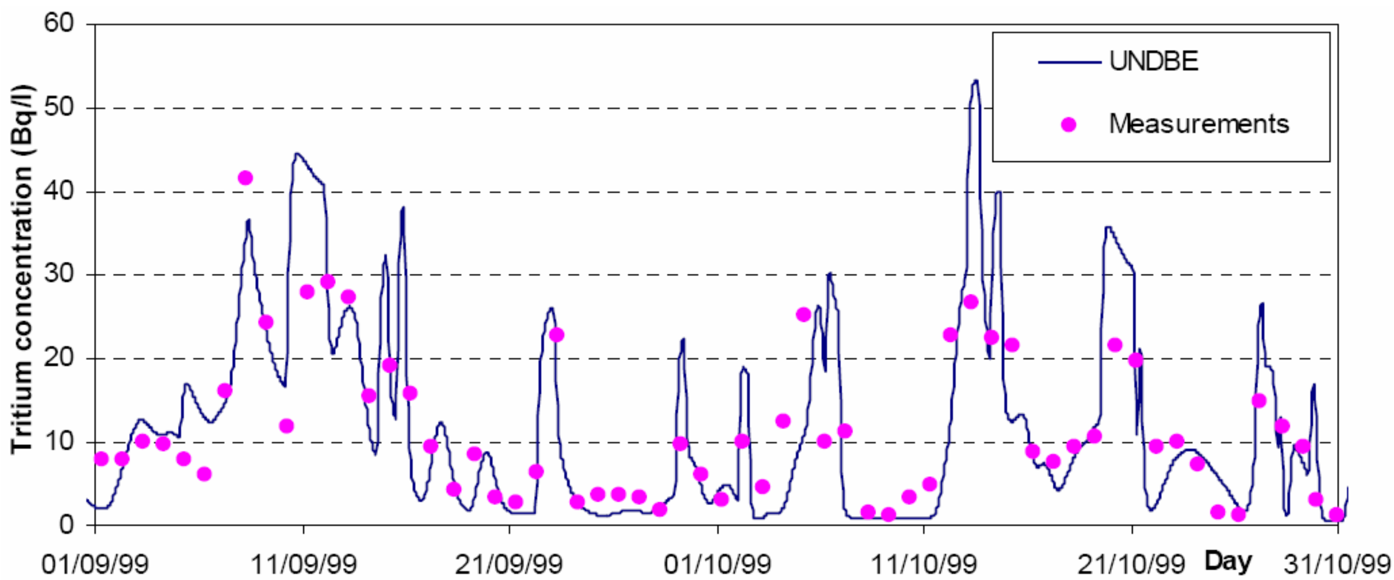
Transportation Sr^{90} (emergency ejections) was learned for the system of reservoirs of the Dnepr River (Ukraine) (six reservoirs of total volume 32 km^3, with six power stations of total installed power capacity of 3 500 MW maximum capacity). Ejections of Sr^{90} take place as a result of washout with polluted in an outcome of Chernobyl accident of territories during high spring floods. The radiological and hydrological data for calculations was prepared by Ukrainian Hydro meteorological Institute and the Ukrainian Hydrological Forecasting Department of the Hydro Met Center.

The operation HPP makes influence on a water level, volume of the reservoir, flow velocity, time of water transportation and, as a result on changes of concentrations of pollution. So the possibilities of influence of a mode of operation HPP on time of passing and magnitude of concentration of radioactive contamination with the help of Decision Support System were analyzed. The interests of different users (hydropower, industrial, agricultural, municipal, fishery, ship transport, recreation) of water from the Dnepr were taken into account. It is important that in an emergency situation the HPP is possible immediately to affect magnitude of concentration of contamination adjusting a mode of operation without the significant financial costs and technical gains.

The calibration of the model was executed on the data set of field measurements 1994. Measured concentrations of Sr^{90} for the Kiev reservoir (upper the most polluted reservoir) and results of modeling with 1 day time step are represented on Figure 2. Computing time for modeling is 1 second.

The water supply point of Kiev (capital of Ukraine, 3 million citizens) is located near the outflow of the Kiev reservoir. For an estimation of possible influence of a mode of operation the Kiev HPP on concentration Sr^{90} in the outflow of the reservoir was carried out modeling





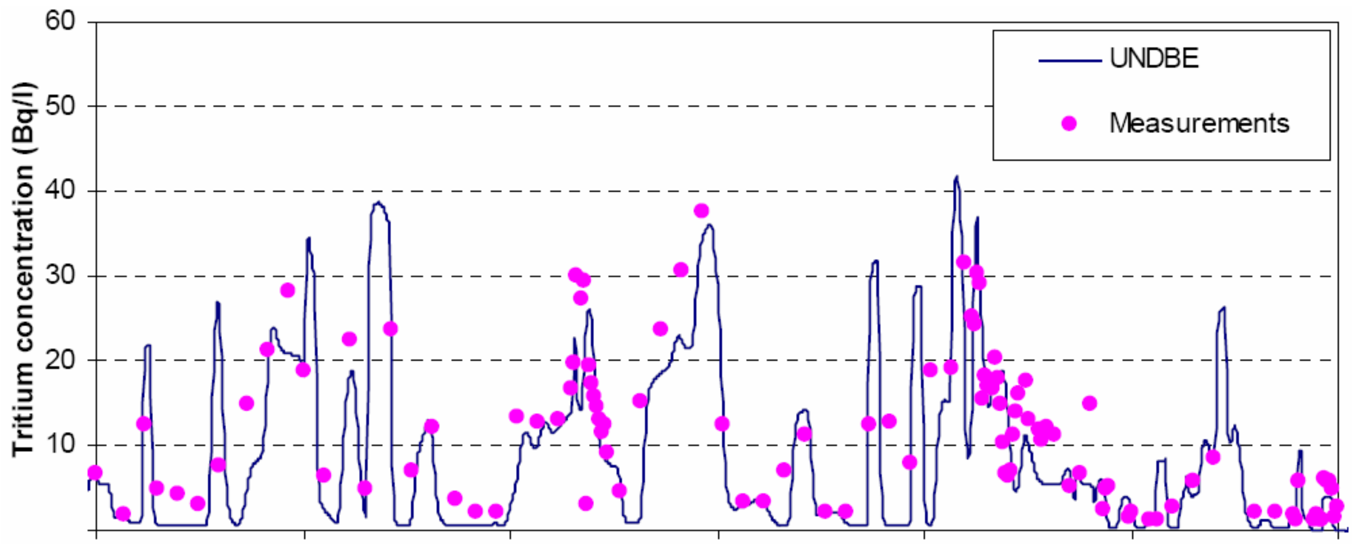


Figure 1. Comparison between calculated and measured tritium concentration at Angers for Undbe.

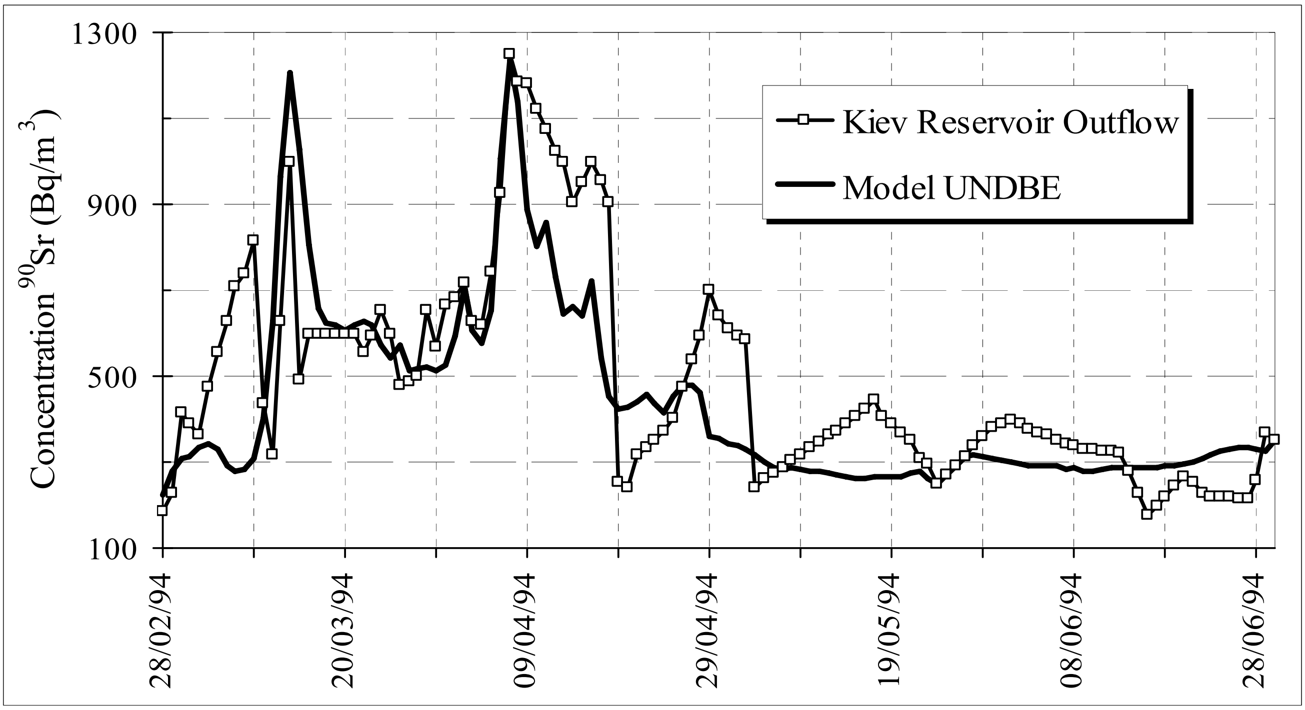


Figure 2. Dynamics of Sr^{90} concentration in outflow of the Kiev reservoir in 1994 and UNDBE model predictions.

situations 1994, 1991 under two scenarios. First (the best) provided gradual filling of Kiev reservoir during passage of peak of pollution from a minimum level of water in reservoir up to maximal. Second (the worst) was assumed work with Kiev HPP on supply waters with maintenance of the minimal constant level of water in reservoir. With the first scenario turns out maximal dilution of the polluted waters to the moment of the termination of transportation with the maximal time of passage of peak of pollution on reservoir, and in the second, minimal dilution with smaller time of passage. The results of modeling are submitted in the Figures 3, 4.

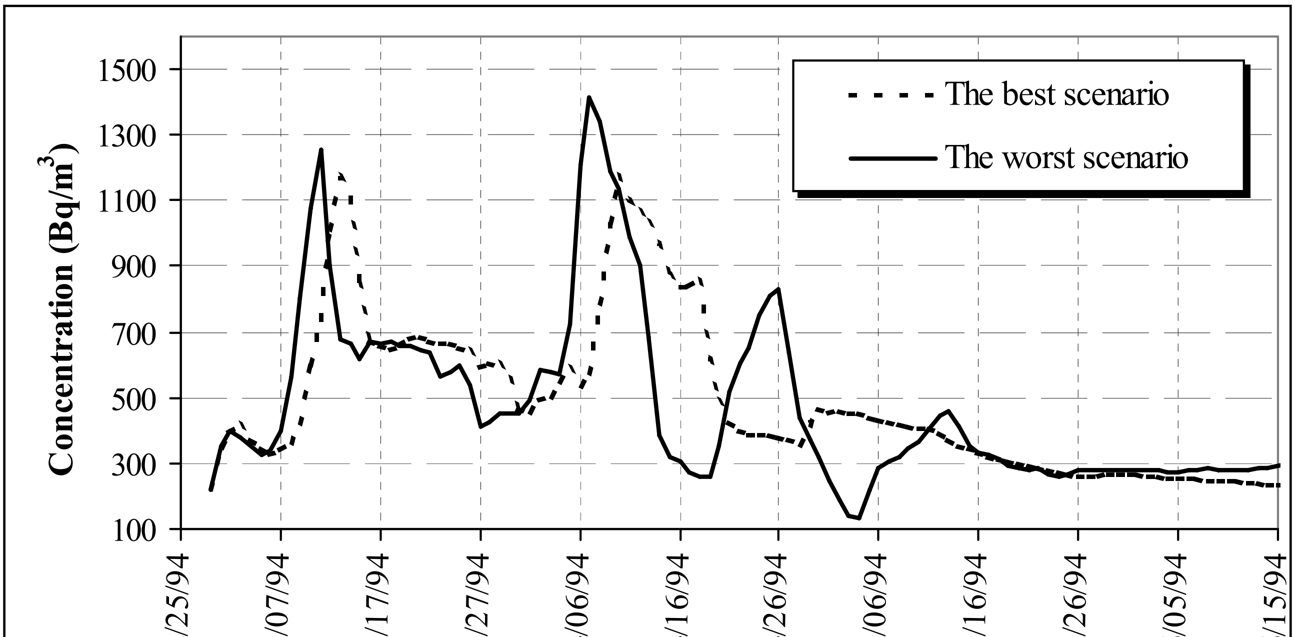


Figure 3. Range of influence of the modes operation of the Kiev HPP in 1994.

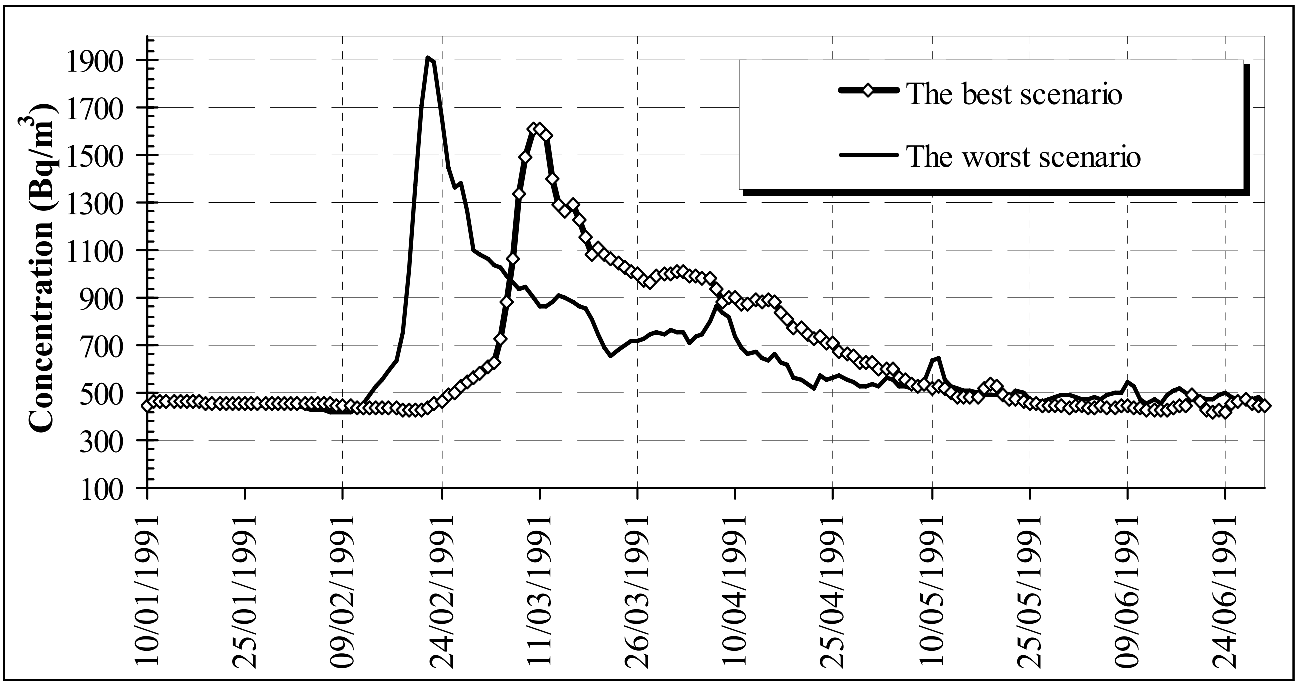


Figure 4. Range of influence of the modes operation of the Kiev HPP in 1991.

The modeling shows an opportunity of change of the maximal meanings of concentration on 20% and temporary shift for 18 day (for the Kiev HPP). An opportunity to influence by a mode of operation HPP size of concentration of pollution allows in some extreme situations to lower a level of concentration below temporarily of allowable level. The opportunity of temporary shift allows to detain or to speed up passage of peak of pollution so that it has coincided with peak of a spring high water on the Desna River (the tributary of the Dnepr below the Kiev HPP) and was diluted by its clean water. The realization of this opportunity will ensure decrease of peak concentration Sr^{90} in underlying reservoirs of the cascade.

References

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