The tracer study on pollutants dispersion in unregulated rivers

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Surface waters are primary receiver for wastes discharged in liquid form. Continuous expansion of industrial activities and urban agglomerations results in still increasing amount of pollutants discharged into rivers, lakes and coastal sea areas. This results in harmful effects on environment equilibrium in natural water reservoirs affected with discharged pollutants leading in extreme cases, to complete disappearance of biological life in water regions highly loaded with pollutants. On the other hand, the surface waters constitute one of most important water sources for municipal and industrial use. High degree of their pollution, beside of technical difficulties associated with treatment of water in order to make it suitable for both household and process purposes, creates numerous hazards of secondary nature through various kinds of potable water, fish and industrial water contamination.

The proper understanding the effluent transport process mechanism and influence of hydrological and morphological conditions on it will approach us to more precise assessment of ecological hazards.

All previous experience (1,2) have based on the solutions of dispersion equation for straight channel approximation. Such solution do not take into account the river bed morphology which suspected to play a significant role for pollution transport in unregulated rivers. There are a few publications in which the authors introduce the factors depending on river morphology to the model equation, such approach complicate very much the analytical solutions of model equations even for single dimension. One of more promising approaches seems to be the dead volume model (3-5).

\[
\frac{\partial c}{\partial t} + v \frac{\partial c}{\partial x} - D \frac{\partial^2 c}{\partial x^2} = \varepsilon T^{-1} (c_d - c)
\]

where:
- \( c_d \) - effluent concentration in dead zone
- \( c \) - effluent concentration in the stream
- \( v \) - mean stream velocity
- \( \varepsilon \) - ratio of the dead zone volume
- \( T \) - kinetical consonant of exchange process between stream and dead zone.

The dead volumes are generated by river bed irregularities. Validation of such approach can be checked in natural conditions.

That was the main topic of our work in 1998. We carried out a series of field experiments at the river being carefully selected from the view point of experimental conditions. The 5 km section of Wkra River have been selected after hydrological analysis. Wkra River is a small unregulated right tributary of Vistula River (average depth 1.5 m and width 30 m). The five measuring cross section was localized practically in every 1 km of river course.

The tracer injection was performed at a weir (~ 130 km of Wkra course), which should limit the complete mixing length in transverse cross-sections. After instantaneous injection of the tracer their distribution in all 5 cross-sections was measured.

The obtained measuring curves \( c(t) \) enable the determination of the searched values describing the transport dynamics of the tracer from the inlet to a given measuring profile. The first, second and third statistical moments of the \( c(t) \) curves are calculated in order to define the model parameters.

It seems to be a good agreement of experimental data with dead-volume model. The dead volumes for Wkra River are about 10%, what is typical value for the slightly meandered lowland rivers. We believe that proposed model can also well approximate the effluent transport in rivers of different morphology (strongly meandered, with dead volume exceed 10%). However, to be sure of it the next experiment should be carried out in the river of different character than Wkra. We are going to run such experiment in 1999.
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