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Calculation of Longitudinal Dispersion Coefficient and Modeling the Pollution Transmission in Rivers (Case studies: Severn and Narew Rivers)

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Introduction: The study of rivers' water quality is extremely important. This issue is more important when the rivers are one of the main sources of water supply for drinking, agriculture and industry. Unfortunately, river pollution has become one of the most important problems in the environment. When a source of pollution is transfused into the river, due to molecular motion, turbulence, and non-uniform velocity in cross-section of flow, it quickly spreads and covers all around the cross section and moves along the river with the flow. The governing equation of pollutant transmission in river is Advection Dispersion Equation (ADE). Computer simulation of pollution transmission in rives needs to solve the ADE by analytical or numerical approaches. The ADE has analytical solution under simple boundary and initial conditions but when the flow geometry and hydraulic conditions becomes more complex such as practical engineering problems, the analytical solutions are not applicable. Therefore, to solve this equation several numerical methods have been proposed. In this paper by getting the pollution transmission in the Severn River and Narew River was simulated.

Materials and Methods: The longitudinal dispersion coefficient is proportional of properties of Fluid, hydraulic condition and the river geometry characteristics. For fluid properties the density and dynamic viscosity and for hydraulic condition, the velocity, flow depth, velocity and energy gradient slope and for river geometry the width of cross section and longitudinal slope can be mentioned. Several other parameters are influencive, but cannot be clearly measured such as sinuosity path and bed form of river. To derive the governed equation of pollution transmission in river, it is enough to consider an element of river and by using the continuity equation and Fick laws to balancing the inputs and outputs the pollution discharge. To calculate the dispersion coefficient several ways as empirical formulas and artificial intelligent techniques have been proposed. In this study LDC is calculated for the Severn River and Narew River and some selected empirical formulas have been assessed to calculate the LDC.

Dispersion Routing Method: As mentioned previously, calculating the LDC is more important, so firstly, the longitudinal dispersion was calculated from the concentration profile by Dispersion Routing Method (DRM). Using the DRM included the four stage.1-considering of initial value for LDC .2-calculating the concentration profile at the downstream station by using the upstream concentration profile and LDC.3- Performing a comparison between the calculated profile and measured profile.4- if the calculating profile is not a suitable cover, the measured profile of the process will be repeated until the calculated profile shows a good covering on the measured profile.

Numerical Method: The ADE includes two different parts advection and dispersion. The pure advection term is related to transmission modeling without any dispersing and the dispersion term is related to the dispersion without any transmission. To discrete the ADE the finite volume method was used. According to physical properties of these two terms and the recommendation of researchers a suitable scheme should be considered for numerical solution of ADE terms. Among the finite volume schemes, the quickest scheme was selected to discrete the advection term, because of this scheme has suitable ability to model the pure advection term. The quickest scheme is an explicit scheme and the stability condition should be considered. To discrete the dispersion term, the central implicit scheme was selected. This scheme is unconditionally stable.

Results and Discussion: The results of longitudinal dispersion coefficient for the Severn River and Narew River were calculated using the DRM method and empirical formulas. The results of LDC calculation showed that the minimum and maximum values for the Severn River was equal to the 12.5 and 41.5 respectively and for the Narew River were reported as 18.0 and 56.0 respectively. The value of the LDC derived using the DRM was used as one of the input parameters for developing the computer program. For validation of numerical model, a comparison was conducted with results of analytical solution. This comparison showed that the performance of numerical method is quite suitable. For assessing the performance of numerical model the pollution transmission

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in the both mentioned rivers was simulated. The calculated LDC and time steps and distance steps was considered as 4m and 2s. The results of simulation showed that the performance of developed computer model is suitable for practical purposes.

Conclusion: In this paper the Finite volume method such as numerical model for Discretization the ADE and also estimating the LDS the Dispersion routing method has been used. To primary evaluating of the model the compression between the model result and analytical solution of ADE has been done. To assess the accuracy of the model in engineering work the results of the model compared with two rivers data observations (Severn and Narew). Final result showed that the performance of model is suitable.

Keywords: Transmission of Pollutant, Finite Volume Method, Severn River, Narew River, Dispersion Routing