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MODELLING OF FLOW DYNAMICS IN LAYERED GROUNDWATER SYSTEM - COMPARATIVE EVALUATION OF BLACK BOX AND NUMERICAL APPROACHES

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To evaluate the short- and long-term spatial effects of pollutants in underground water, mean transit times and balance calculations of the pollutant input and output are needed. These are determined with the help of mathematical models.

Among the mathematical models, the discretising models based on the Finite-Element- or the Finite-Difference-Methods and the stochastic models are the best known. To apply them in actual cases, an extensive data base is required. These data are very often not available, and when available, usually not at the beginning of most investigations.

Black-Box-Models are mathematical models that require only a minimum of information concerning the turnover zone of the underground water and that need for the calibration the record of non-reactive tracer concentrations within the time measure in the input and the output from the system. They can be simply validated with hydrogeological data available.

Black Box Models are based on the assumption that the forms of continuous distribution of the individual flow times of the water particle represented by the flow times of non-reactive tracers in groundwater between input and output of the system are known or can be predicted. The mean transit time represents the average of the large number of individual flow times in the aquifer, weighted with the amount of water flowing through the system. In doing this, it is presumed that the groundwater is a closed system, sufficiently homogeneous, anisotropic, and stationary; there is a defined input and a corresponding output in form of pumping wells, springs or streams drainage the system.

To judge the application possibilities and limits of the different Black Box Models to determine aquifer data and pollutant expositions, transit time distributions and mean transit times were calculated for an assumed, layered groundwater reservoir with defined boundary conditions and permeability distributions. Black Box, numerical, and transport models were used for this and the results compared. The boundary

conditions used in the models are oriented on commonly occurring sequences of aquifers, as described in DVWK (1987, 1994).

In the first step, using a numerical model of water flow in a vertical plane (x=5000m, z=200m, recharge: q= 150mm/a equally distributed of the whole length of aquifer, two no-flow boundaries and a constant head: h=200m by x=5000m), the streamline distribution and thus the flow times of the water in a narrow flow paths between neighbour streamlines were calculated for the whole aquifer. Then the flow time distribution was determined from the flow times and flow rates in these different flow paths. Using these results, the art of the distribution and the mean transit times were determined using an exponential, exponential-piston-flow or a dispersion distribution functions.

In the second step, numerical transport modeling is carried out for non-reactive tracers, i.e. the weighted concentration-time-distributions in the system output (e.g. receiving stream) for different, assumed longitudinal and transversal dispersivities were calculated. In all cases, it is assumed that the tracer enters the system continuously and with a constant concentration. Finally was examined which of known Black-Box Models is applicable to describe the output concentrations calculated numerically and which is the value of mean transit time. From the large number of calculated cases of layered heterogeneous aquifers, three representative examples were selected and presented.

The results give the possibility to better understanding of the Black Box Model approaches and their applicability and show the hydrogeological meaning of the mean transit time of water interpreted based on environmental tracer data in the case of strongly heterogeneous aquifer.

Literature

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