An Integrated Water Resources Management Approach for the River Spree and its Catchment

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The Integrated Water Resources Management (IWRM) is the contemporary approach for the development and use of all available regional sources of water. The aim of this paper is to illustrate how water resources demands can be met by incorporating the management of all types of water resources under a single umbrella and designing the mechanisms and tools that are needed to achieve an integrated system and its objectives. The reference to the River Spree originates from the current experience of the IWW with the development of various important components of the IWRM approach, which is the appropriate way to solve all water resource problems and issues connected to this river and its catchment.

Brown coal open-cast mining results in several environmental problems, for example serious disturbances of the natural water balance or heavy impacts on water quality. To control the complex relationship between water quantity and water quality in the Lusatian lignite mining district, located in the eastern part of Germany, the joint project „Research into the development of water quality of the River Spree“ has been initiated in 1999. Within this joint project the development of water quantity and water quality of the entire catchment area of the River Spree has to be modeled. Since the multifaceted relations between quantity and quality will persist for decades the model has to perform long-term simulations up to 2035. Beside the IWW another seven institutes are involved in the joint mission. Each institute is researching in a section of the catchment area. Within their subprojects they have to develop water quality modules. Sections are the River Spree itself (subdivided into lower and upper stream) and its tributaries, the reservoirs, the mining lakes, the biosphere reservation Spreewald as well as diffuse and point sources. The aim of the project is to develop a Decision Support System (DSS) which includes a long-term water balance module ArcGRM (developed by WASY), which is coupled to all water quality modules.

The paper concentrates on subproject 3. Within this subproject a water quality module for the most interesting part, the upper River Spree and its tributaries, has to be developed (see figure). Particularly this part of the River Spree has been heavily affected by lignite mining for decades. The parameters, which have to be integrated into this water quality module, are dissolved oxygen, BOD, nutrients (ammonia, nitrate, phosphate), water temperature, phytoplankton as well as iron, sulfate and pH-value. The latter three parameters are typically strongly influenced by pyrite weathering which is caused by mining activity.

The algorithms describing water quality have to be coupled to a stochastic, long-term water balance module by the delivery of simulated discharges and water usage at defined balance profiles as well as lateral non-point discharges and the actual time step (1 month). Flow velocities, water depth, and shear stresses, which are essential for simulating the
transformation processes, are not calculated within the balance model. Because of that simplified algorithms to describe the flow situation have to be coupled to the balance model as well, since the integration of a complex numerical model would be too run-time wasting. For example, a standard simulation of 35 years needs 42,000 single simulations, which means that the water quality module is called this number of times. To develop a user-friendly tool run-time has to be minimized.

The main focus of this subproject (as well as of each subproject) is the development of algorithms describing the transport, mixing, and transformation processes. For long-term simulation the time-derivative can be neglected. This enables to integrate the analytical solution of the residual of the transport equation into the algorithms. Since the simulation of water quality in a long-term balance model is subject to a rougher consideration than in a process model, the elaborated transformation processes have to be simplified. The process of developing the transformation processes will be presented by means of the parameter iron, which is existing as a sensible reacting redox-couple. It is the aim to find an algorithm which simplifies the relevant processes on the one hand but, on the other hand, is still able to describe the essential reactions sufficiently precise.

After constructing an algorithm it has to be calibrated and verified. Since only little data was available extensive field measurements had to be carried out. These measurements included sampling and analyzing water quality in the flowing wave, and of the sediment. Furthermore, erosion processes and their impact on water quality were investigated with the in-situ device EROSIMESS, which was developed at the IWW.

By means of the subproject 3 of the joint task „Research into the development of water quality of the River Spree” this paper gives insight into the development of a DSS as part of an Integrated Water resources Management for the River Spree and its catchment area. The modules which describe the hydraulic situation as well as transport and transformation processes of all implemented parameters are presented. Further on, the process of calibration and verification of the algorithms, basing on extensive field measurements, is presented. Finally, simulation results, carried out with the overall-model are discussed with respect to the particular situation in the Lusatian lignite mining district.