Water Quality Management of a Sub-Watershed of the River Elbe

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Water quality management (WQM) strategies on a river basin scale have to consider political, economical, environmental, social, technological, and informational objectives. To facilitate the analysis of valid management options decision models are needed which represent the different facets of the problems. Such models must be capable of depicting the hydrological, chemical, and biological processes occurring in the river adequately, while incorporating social, economic and political indicators within the decision framework. Applying multi-objective decision making methods for WQM of river basins optimal compromise solutions between ecological and man-made control operations will be obtained. The decision making process itself is characterised by the choice of one objective allowable kind of action related to a subjective valuated compromise on partial satisfaction of the concurrent and conflicting WQM goals. That means, decision making for WQM can be understood as a search for a compromise between contradictory goal functions. Decision support systems (DSS) are necessary in order to screen the array of possible courses of action.

Most of the river water quality problems arise due to interactions between throughflow, discharged soluble and suspended matter, natural and man-made chemical substances and environmental influences from the catchment. Rivers are polluted by various anthropogenic interactions within settlements, by agriculture, and by industries. Polluted water affect the ecosystem behaviour and various water uses, and risk human health. WQM of river basins is usually achieved through legislation, by rules such as specific water quality standards, by effluent conditions, and by conditions of immissions. Therefore, major emphasis is laid on eutrophication and self-purification processes. Extended DO-BOD models and eutrophication models have become widespread for river basin management studies where WQM options are specified either in terms of river water quality or in terms of effluent standards. Management decisions were made by ranking of different scenarios resulting from simulation models. In applying multi-objective decision making methods to water quality management tasks optimal

compromise solutions between ecological and man-made management operations will be obtained.

In Table 1 two general goals of WQM on a river basin scale are given. The first one is to maintain water quality at desired levels corresponding to different anthropogenic water uses. The second one is to achieve the first goal with a minimum cost or maximum benefit for human society. It is focused to obtain a constant operating behaviour of WWTPs.

Table 1. General goals of water quality management

Goal	Indicator	Performance	Example
Optimal control	Extreme values of state variables	Integral criteria	Freshwater ecosystems, aquifers
Constant systems behaviour	Fixed dynamic systems behaviour	Standards, regulations, rules of operation	Waste water treatment plants, water supply networks, sewer networks

WQM is possible through actions that prevent pollution or change the level of pollution. The latter include wastewater treatment, storing of effluents, wastewater disposal on land, artificial in-stream aeration, low flow augmentation or various combinations of them. Controlling of non-point source pollutants is usually achieved indirectly. The alternatives appropriate for a particular situation depend on many factors. More decisions are needed with regard to efficiency, capacity, location, and scheduling of implementation of the selected option. Once assured that the water quality system operates correctly, it is also important that its operating cost are minimal or that it works in optimum time or whatever performance measure is chosen. While functional correctness is taken for granted, the latter quantitative properties will often decide the best operation of the WQM system.

In this paper results of two different DSS for WQM on a river basin scale are presented and discussed. The rivers Spree and Havel form a sub-watershed of the Elbe river. They contribute to the pollution of the Elbe river by dissolved inorganic load and phytoplankton biomass. For the Upper Spree river selfpurification problems play an important role while for the Lower Havel river eutrophication processes ar of main interest.

The DSS REHSPROX was used to compute optimal management decisions regarding to the DO-balance of the Upper Spree river. The variables DO, BOD, the amount of wastewater quantity and costs of enlargement or new construction of WWTPs are taken into consideration. For all river segments and all time steps two management strategies are taken into consideration respectively:

1. Efficient control of waste discharges from point sources.

2. Cost-benefit analysis for reconstruction and/or enlargement of existing or new construction of WWTPs.

Goal functionals for the DSS REHSPROX are formulated by expressions max (min ∑DO(t)), min (max ∑BOD(t)), max ∑QE(t) and min ∑IC valid for all river segments and all time steps. IC means investment costs for reconstruction or enlargement of an existing WWTP or for new construction of a WWTP. In table 2 some results of WQM scenarios for different river stretches are given.

Table 2. WQM scenarios of the Upper Spree river

River segment	Capacity (m^3/d)	Capacity (%)	BOD (mg/l)	BOD (kg/d)	Costs (Mio. DM)
3	0	0	140	3013	0,00
	10750	50	82	1765	16,50
	21500	100	24	516	33,00
7	0	0	580	4009	0,00
	1037	15	561	3878	2,00
	2074	30	542	3746	4,00
	4500	65	426	2945	8,50
	4835	70	348	2405	9,00
	6912	100	310	2143	13,00
9	0	0	94	2282	0,00
	1250	5	83	2015	2,00
	2500	10	78	1894	2,00
	5000	20	66	1600	8,00
	7500	30	59	1491	11,20
	18750	75	45	1122	30,40
	22000	90	28	702	33,60
	23750	95	20	514	39,60
	25200	100	13	333	41,60

To solve WQM problems for the Lower Havel river the DSS HAVEL was developed. For this reason the eutrophication model *HavelMod* was implemented in the ISSOP software tool to get optimised management options. Because a one-dimensional model was used segmentation was done in longitudinal direction by river segments, where segmentation cuts are performed by river stretches close to homogeneous characteristics. All segments have different length' and hydraulic conditions where a segment is considered as a CSTR with complete mixing approximately. According to the model structure the goal functions are formulated as extremal values. Management options are obtained for the water quality indicators phytoplankton-biomass, orthophosphate, ammonia and nitrate.