

NECESSITY AND OBJECTIVES FOR A COMPUTER BASED GROUNDWATER
QUALITY MANAGEMENT IN THE GDR

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IDENTIFICATION OF THE PROBLEM

Groundwater is the major source for drinking water supply in the GDR. About 70 percent of the total demand for drinking water are covered by this source. By 1990 only 30-40 percent of the resources to be used will be natural ones. Hence, it follows that the usable share of groundwater resources needs to be artificially expanded in order to meet future water demand.

Besides using bank filtered water the decisive increase will be achieved by artificially recharging aquifers. Furthermore, even the use of surface mine drainage water must be taken into account as an alternative for resolving the demand supply conflict. Because of the extraction of ever deeper lying coal seams an ever increasing quantity of water needs to be drained off. At present the total quantity of drainage water amounts to about 1.5 million m³/a which are predominantly discharged to receiving surface water courses.

Despite of the above mentioned facts the methodological problems of groundwater quantity management are largely solved. The computer model system "Subsurface Water", developed by the joint research group "Groundwater" of the Institute of Water Management Berlin and the Technical University Dresden was implemented using a hierarchical model concept (concept of continuously working models). It has proved to be a useful tool for solving practical management problems.

In the future water quality will become the constraining factor of groundwater management. All the above mentioned procedures for artificially expanding the usable resource basis cannot be economically used without solving the related quality problems. Due to the specific hydrogeological conditions of the GDR, and in particular, due to the highly mineralized water in deeper aquifers, predominantly less pollution-protected shallow aquifers have to

be utilized. Since these aquifers are usually directly corresponding with the surface water they are potentially endangered by impacts resulting from intensive industrial and agricultural activities taking place in the surface watersheds. One example for this is the intensive use of chemical fertilizers in agriculture which in the long run may cause the nitrate concentration in groundwater to be exceeding the limit set in the drinking water standard.

In order to preserve groundwater as the main source of drinking water supply, groundwater protection is an urgent task in view of the presently increasing risk of pollution. It necessitates the integration of quality aspects into the existing quantity management concept, that means a comprehensive groundwater quality management needs to be implemented.

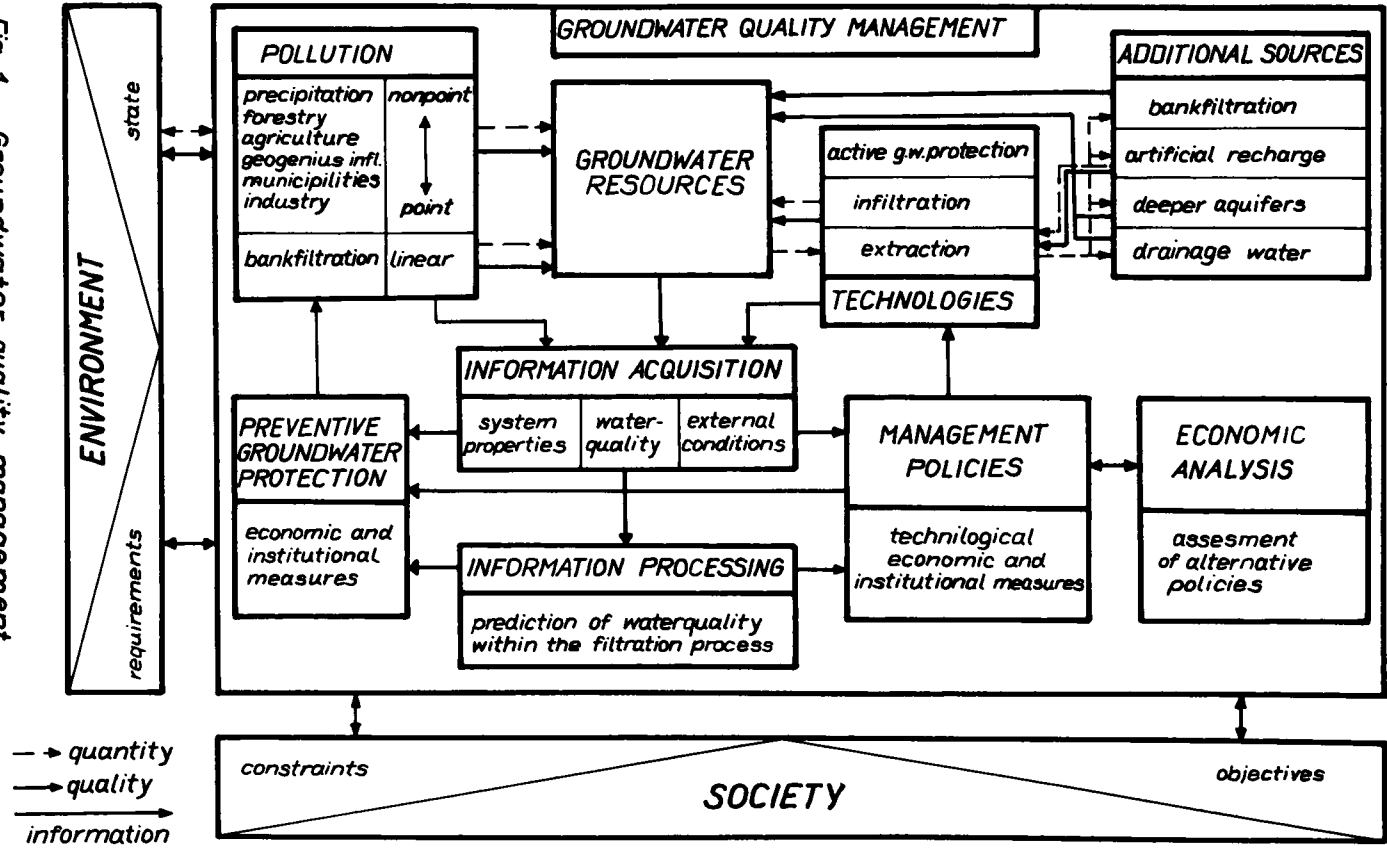
PRINCIPLES OF GROUNDWATER QUALITY MANAGEMENT

Groundwater quality management is aimed at resolving conflict situations caused by the competing interests of society. On the one hand, there is the objective of protecting the environment, on the other hand there is the need for more intensively utilizing its resources. The scheme shown in Figure 1 illustrates the complex problem setting. The protection of groundwater from pollution as well as all methods for artificially recharging the usable groundwater resources can only be comprehensively achieved if the related changes of water quality in the underground can be monitored, predicted and controlled.

Based on coordinated methods of collecting, storing and processing data on groundwater quality management policies must be aimed at an integrated implementation of technological, economic and institutional measures. In deriving such policies the technologically feasible control alternatives have to be traded off and assessed within a socio-economic planning process.

A decisive precondition of computer based groundwater quality management is the data processing for analyzing and predicting quality changes in the filtration process. The use of integrated quality models of the soil and groundwater zone, as well as the appropriate consideration of external boundary conditions like precipitation and connection with surface water systems play a central part in this process. The necessary combination with quantity models must be ensured in all phases of modeling.

Fig. 1 Groundwater quality management



A complete survey about the level of simulating coupled transport, exchange and transformation processes in soil and groundwater, achieved in the GDR and some of the CMEA countries during the last ten years, was given by a conference carried out by the Technical University Dresden late in 1979. This conference revealed that only first partial solutions of the whole problem are available for selected substances, or can be expected in the next few years. To model multicomponent systems for practical purposes thereby considering the coupling of all elements of the terrestrial water resource system was regarded an unrealistic objective for the time being.

Information processing, i.e. the modeling of water quality in the filtration process, is one element of groundwater quality management and can only be effective when dealing with practical problems is organized in a coordinated and cooperative manner as shown in Fig. 1. Especially the fundamental significance of data acquisition must be considered. Groundwater quality management cannot be implemented in practice without the setting up and operation of suitable quality monitoring networks. In the GDR, a necessary precondition for this activity was fulfilled by the adoption of guidelines on "Groundwater Monitoring" which define the categories of monitoring networks like basic network, regional monitoring and control networks, plant related monitoring and control networks and special-survey networks.

CONCEPT OF A HIERARCHICAL MODEL SYSTEM

The coverage of all the manifold tasks of groundwater quality management can only be ensured by the use of an hierarchical model system the elements of which produce sufficiently exact results for subproblems with practically justifiable simulation effort. In designing this model system it is advisable and necessary to consider its dependence upon data acquisition. Under this aspect a model system, divided in process models, plant-related models, regional and basis models was devised. Essential features of these model types are listed in Table 1.

The process models provide the scientific basis for the analysis and simulation of transport, exchange and transformation processes in underground water within the framework of basic research carried out at the academies, universities and colleges in the GDR. In the long run, these process models have to serve as a basis for the

TABLE 1 Hierarchical model system

aspect	basic models	regional models	plant related models	process models
objective	prophylactic protection	prophylactic g.w. protection, artificial recharge of g.w. resources	prophylactic and active g.w. protection, artificial recharge of g.w. resources	developing and testing of simulation methods for g.w. quality management
space-division	G.D.R. with sub-division	large scale regions with superimposing pollution effects	locally limited districts with single pollution effects	Laboratory equipments, experimental plants, experimental fields
prediction period	decades	years	years, year, months	according to the objective
time step	year	year until month	month until day	according to the objective
quality parameters	- nitrogen (priority) - biozides	- nitrogen and other nutrients - biozides - geogenous pollution - organic substances	- nitrogen and other nutrients - biozides - geogenous pollution - organic substances - temperature - oxygen	according to the objective
application	central government decisions	regional management policies	local management policies, design and control of plants	basic research
model concept	simplified trend models, stochastic block models	System descriptive models, deterministic block models	system descriptive models, deterministic and stochastic block models	system descriptive models; block models

development and implementation of the other model types for analysing local, regional and national problems in groundwater quality management. Significant fields of such practical applications are predictions of quality changes in artificial groundwater recharge systems as well as the design and control of the latter predictions, on the regional distribution of pollutants in the underground as part of groundwater protection, predictions on the quality development in the drainage water of open-cast mines (as a consequence of pyrite and marcasite weathering) and predictions of pollution load in the groundwater.

From a computer point of view the hierarchical model system is formed by a modular programme system. Since this programme system will make use of an unified problem-oriented programming language the user need not have any specific knowledge about the simulation methods applied and the programme system itself is open for any necessary extensions. Another objective is to make components of the system also usable for mini and micro computers and to create thus more effective conditions for its practical use.

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