

Knowledge-based decision support tool for water quality assessment in water distribution systems

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Water supply and distribution companies and governmental regulatory agencies have become more concerned with potential problems associated with contaminants in water distribution systems. The primary objectives of this study were to model key performance indicators which strongly affect drinking water quality in a distribution system by application of a Knowledge-Based Decision Support Systems (KBDSS) approach. The approach is an empirical one which is based on historical data about operating water quality data through routine utility management and performance criteria and regulations.

This research into understanding water quality in distribution systems has been focused on assessment of the key performance indicators of quality of service. Performance Indicators (PI) are a basis for assessing the effectiveness and efficiency of the water distribution system. Effectiveness is measured by the achievement of defined targets set by criteria and regulations. Efficiency is defined by agreed service levels. PI can be used to identify the trend in the performance of a water distribution system over a period of time. An attempt has been made to establish a performance assessment framework by providing decision makers with support to understand, in a given situation, which parameters are critical in affecting water quality, and within which range of variation of these parameters risks for the water distribution system can appear. In the framework, PI are investigated with regard to chlorine decay, coliforms, iron, manganese, pH value, temperature, turbidity, and apparent colour. Time series analysis was selected to identify whether these parameters comply with criteria and regulations based on data collection. Risks of the contaminants in pipe were assessed in order to rank the water quality level in the water distribution system by a rule-based expert system. The possible solutions for the water quality problems were determined and provided by strategic knowledge evaluation. The type of question addressed can be for a problem of water quality degradation which is endangering the water distribution system: How to identify it without much difficulty and which possible solution is the most effective?

Based on defining and specifying the key functions and requirements of a water distribution system, the KBDSS tool was designed and developed. It encompasses database management,

data analysis, risk assessment, knowledge base, and control measure evaluation. This model serves as an information base relating to water quality assessment and reporting, as well as aids water operators in controlling residual chlorine in the water, pH value, temperature, turbidity, and coliforms. The model allows its user to build a database to store monitoring data, identify the trend in the performance of a distribution system over a period of time, analyse the risk of contaminants, and guide the user in evaluating different effective control strategies under various scenarios. The key outputs from the model are to:

- Analyse the past water quality trends;
- Predict the future water quality trends;
- Identify and rank water quality problems by qualitative analysis based on the measured data points;
- Determine effective remedial actions in response to water quality problems.

The KBDSS tool has been tested and validated by using field data provided by Melbourne Water for a water supply system. Different scenarios were developed and alternatives were compared for management of the water supply system. It was shown that the model provides information which is reliable, timely and suitable for the purpose of the maintenance of drinking water quality in accordance with legal requirements.

In conclusion, through development of the KBDSS-based model, several major different points have been identified:

- The KBDSS approach can be adapted to structure a tool for water distribution system management,
- Time series analysis can be used to predict water quality in a distribution system, based on historical data,
- Risk analysis built into a rule-based expert system is an important and innovative tool in determining water quality problems in a distribution system using performance criteria and regulations,
- Decision analysis (Analytical Hierarchy Process) can be used to evaluate the effective control measures under different scenarios as well as to aid the water operators in optimising control of water quality in a distribution system.