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USE OF KNOWLEDGE BASED EXPERT SYSTEMS IN WATER MANAGEMENT OF SETTLEMENTS

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Abstract

From the beginning of seventies after the development of tools and techniques in computer sciences significant step could have been observed in the field of planning so called knowledge based expert systems. This paper presents two ways of application of expert system in water management of settlements. One of them is based upon the knowledge of ground-water pollution control, the other concerns of the sewer operation.

Keywords: knowledge based expert system, ground-water pollution, areawide sewer system, sewer system operation.

Introduction

Because of developing electronics, many qualitative changes can be seen in computer technique from the beginning of the seventies. These changes can be divided into two parts, the hardware and the software parts.

Almost everybody has contacts with computers at his working place or at home due to electronical and computer technical researches. From the viewpoint of software part a considerable step can be seen first of all in the area of artificial intelligence researches.

The developed clauses and database based programs as Prolog and LISP gave the users the possibility of producing so-called 'knowledge based expert systems' (KBES), like in (WATERMANN, 1986).

There are two ways of using KBES in civil (hydraulic) engineering written about it in this topic. One of them deals with the problems of ground-water resources protection against several types of pollution. The other gives us solution to problems in sewer operation.

Using the developed clause and database based program languages many expert systems are already under research or developed in several different areas of technical sciences.

We must note the conditions of telling about a computer program 'expert system' in many cases are not satisfied.

What is an Expert System?

Based upon the special literature from abroad and Hungary, we can say the followings:

The expert system is a very special computer program using clause and database in a special field. This clause and database must be filled with case studies, with knowledge of several experts of the chosen field. The expert system can give us solution or solutions after giving the data and the conditions of a problem the user is interested in. These systems can be learnt already.

During the development of an expert system some special problems must be solved. One of the problems is the 'depth' of the knowledge. It is very difficult to create suitable database and clauses from the human knowledge. There are very simple facts which have to be 'put' inside the expert systems at first view, but very difficult to create descriptive knowledge elements.

Other problem in developing expert system is to collect the information, the knowledge from experts. This can be realized by interviews, given by the experts. For example, like in (FENVES–MAHER–SRIRAM, 1984):

question: What are the most important facts to assess the surface runoff?

answer: Geology, vegetation, soil type, etc.

Due to the difficulties written above, the used expert systems deal with only limited parts of problem solving, only with a special field. The complexity of the problems to be solved needs a teamwork of numbers of hardware and software engineers, knowledge engineers and experts of the chosen problem.

It would need a very long period, many ten years to develop a good expert system from a significant part of any speciality. Therefore we can say:

There are so-called expert systems operated and under development all over the world, but these systems only fit to a limited area of a speciality and only a few of them can reach a good expert knowledge level .

A Knowledge Based Expert System to Ground-Water Pollution Problems

The pollution of water resources becames an important problem in the last ten years in Hungary. The evolution of environmental viewpoint, the increase of purification costs needed to develop new applying methods to

solve these kinds of problems first of all based upon the experiences of international and Hungarian research and practice.

This expert system (ES) gives help to engineers, members of councils to know, how a real problem which can have several aftermaths, can be solved, or what the suitable special method is to carry out these kinds of difficult tasks.

The knowledge base of this problem was collected from books e.g. (CANTER and KNOX, 1985) and from experts of this speciality. There are many 'clauses' and 'facts' in this system, which were got by interviews participating experts. One who deals with computer technics, programming and developing so called expert systems knows, the heaviest task here is the database acquisition, and to join the other components of knowledge base like the clause system.

This ES developed by logical programming language 'PROLOG' helps to get information from, or give solution(s) to an observed pollution what needs urgent localization or removal. In addition to this, there is a control of planned place of waste disposals based upon the Hungarian standards. This has the following contact with the other part of this ES: A technically and theoretically good place and isolation system have to be chosen for waste disposals to prevent any possibility of ground-water pollution in the future.

The main part of this ES as it has been mentioned deals with direct pollution of water resources. This means the computer program gives us solutions only to remove or to localize the given pollution without dealing with its origin.

The main directions of the suitable method accumulated in knowledge base are the followings:

a) Pollution removing:
   - soil excavation (with the pollution, certainly);
   - removing with well-systems;
   - removing with drainage systems.

b) Pollution localizing:
   - soil injection;
   - localizing with bentonite slurry walls;
   - localizing with steel piles.

There are some cases, e.g. the soil around the pollution is waterproof clay, when only control-wells have to be drilled to observe whether the pollution moves or not.

To choose the suitable method and submethods after the main method was concluded (e.g. method: injection, submethod: bitumen injection) data have to be given in connection with the circumstances of the observed pollution. This means that the computer program needs the features of

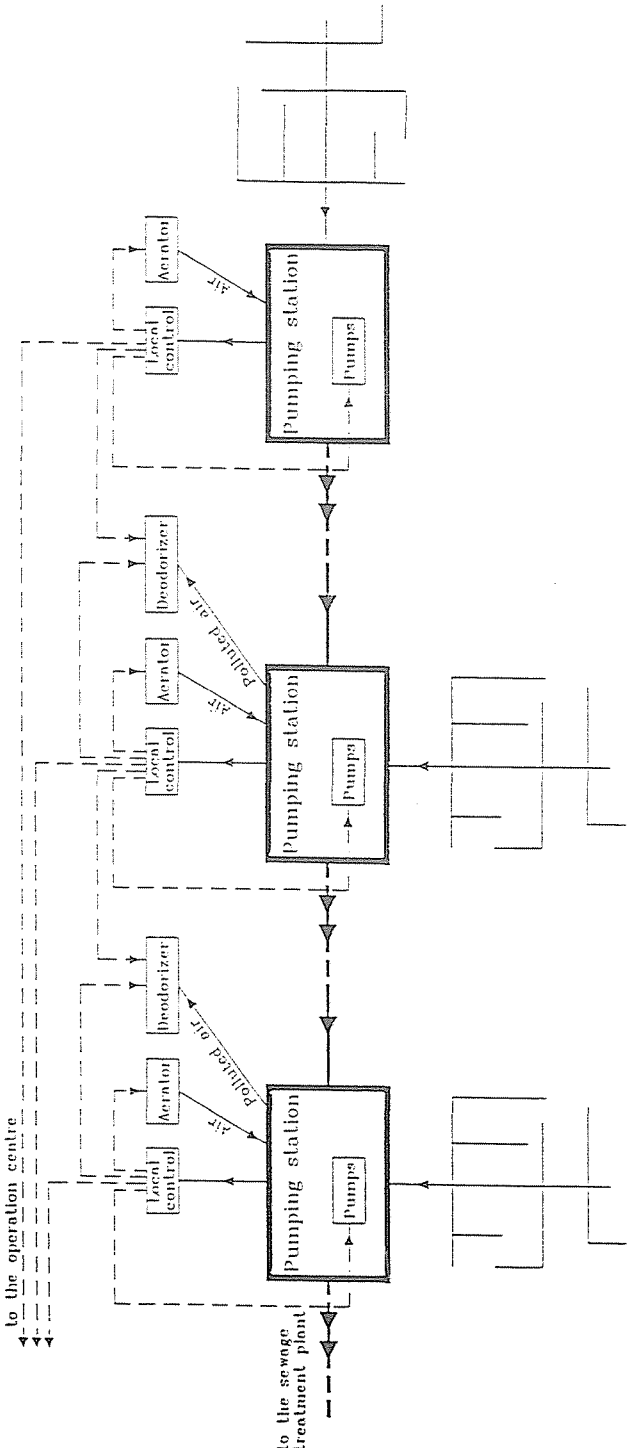


Fig. 1. Quality and quantity control system of acrawide sewage system

soiltype, the vertical and horizontal siting, the chemical components of pollution, etc.. These data have to be collected after thorough examination.

During the use of this system the users (probably engineers and members of councils) can find solution or solutions to a living pollution problem. They will get information about the most suitable method to their special case. Based upon this, firms can be chosen, which have adequate profile to avert the dangerous pollution problems urgently.

Expert System for Operating Areawide Sewer Systems

Operation of integrated urban sewer systems that is the areawide sewer systems becomes quite difficult in case of large regions. The inputs of those systems are the individual urban sewer systems. Getting into the areawide system, the waste water flows toward the sewage treatment plant due to the gravity or under pressure. The needed pressure is produced by pumping stations, of which connection is usually sequential. In case of a breakdown due to the stop of a pumping station the system breaks into two or more parts. Then the direction of the waste flow also can change.

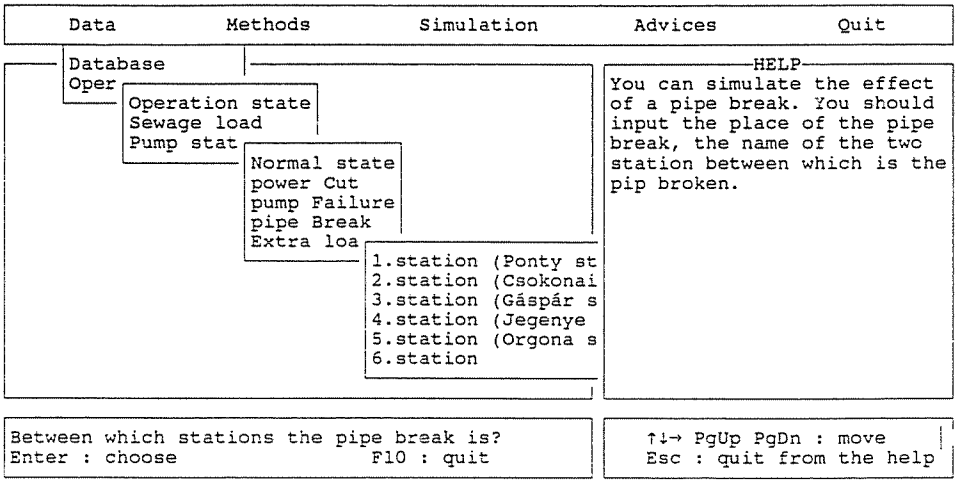
The purposes of the operation:

- the quantitative feature of the flood wave (discharge) does not exceed under normal operating conditions the capacity of the pumping stations and the sewers;
- prevention of the connected gravity systems from backwater in case of breakdown;
- preserving the original quality of the waste water avoiding the anaerobic processes.

The control of the pumping stations means the main operation measure. This can be the usual individual automatic level control at the pumping stations. The connected, feedback based control devices, the remote controlled operation provide the higher level solution of that problem. The *Fig. 1* shows the structure of the quality and quantity control system. An expert system can help the operator to find the optimal intervention-strategy in case of different loads and operation states.

The main functions of the developed expert system:

- It is capable to store and manage all the data needed to operate the areawide system using its internal well-retrievable database. This database works as an inventory system, modifications and enlargement are highly supported.
- It can analyze the outcome of the areawide sewer system due to the change in the connected parts (extra load) and inside the system



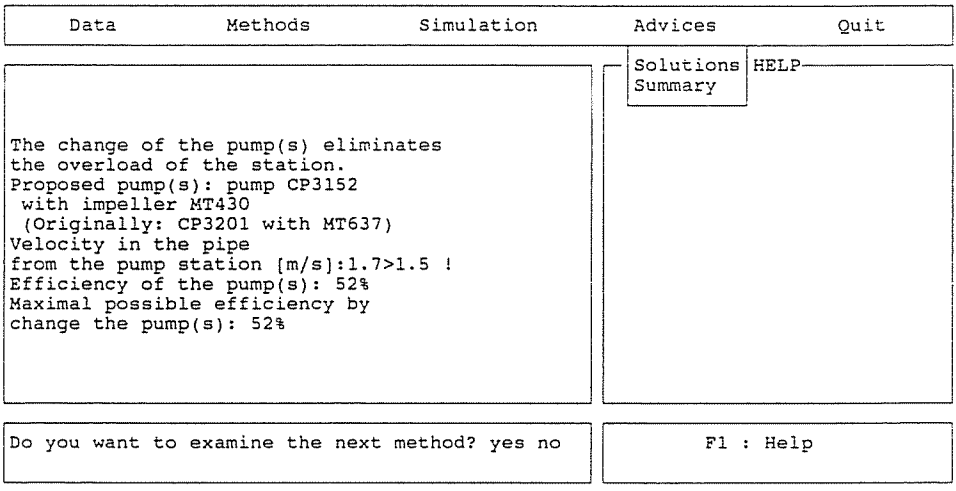


Fig. 2. Typycal program states of the sewer-operation expect system

(power cut, pump failure, pipe break). This process is based on a hydrologic – hydraulic computational simulation model.

- Its main goal is to determine the optimal intervention strategy by eliminating the problems after interactive discussion with the operator. This function is based on the knowledge base of the expert system and the Prolog's internal inference engine. *Fig. 2* shows typical program states. The knowledge base includes the collected experimental data, the simulation results the given facts and the inference rules. These were built on the strength of the experts, the expertise that field like (BUZÁS– CSITI, 1987) and (BUZÁS,1988).

The developed expert system can give help not only in case of existing areawide sewer system, but also during the design process of that ones. In that case this expert system can previously analyze the behaviour of the designed sewer system to help improving its future operation.

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