The Model of Mineral Water Deposits Sustainable Management Using the Decision Support System

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Abstract: The decision support system "Hydromineral resources" can organize the management of the mineral water deposits and ensure the safety of underground water reserves. The system consists of three components: information system "Deposit", management information system (MIS) "Production rate control", decision support system (DSS) "Exploitation strategy". Information system "Deposit" stored the water wells initial hydrogeological information. Besides a distributed controller model mathware of the management information system "Production rate control" includes the standard methods of the wells operating parameters calculating. The system "Exploitation strategy" mathware uses Bayesian networks for the implementation of the deposits parameters control algorithm. The consolidated data of the hydromineral investigative management results is necessary for the strategy development construction and deposit exploitation.

Key words: Decision support system · Bayesian networks · Intelligent algorithm · Hydromineral resources · Deposits production rate control · Distributed controller

INTRODUCTION

The development of the management system that controls hydrolithosphere processes in relation to the mineral waters deposits is a difficult task. Solution of this problem will ensure the safety of hydromineral base of a region. Specialty of geologic feature in relation to the technical objects is their weak scrutiny. In such circumstances, the construction of mathematical models is not always possible or they will not have high accuracy [1]. The building of the management systems based on the feedback allows the using of approximate models for the effective production process organization. The use of information systems for monitoring the state of the field, as well as for the implementation of process control flow rate can monitor production parameters and monitor the stability of the parameters of the object [2]. On the basis of the accounting information system and the information system of control can be implemented in a decision support system. The implementation of the DSS will apply modern mathematical techniques such as Bayesian network, for the process of reservoir management at the strategic level [3]. This approach will increase the efficiency of production process control of mineral water.

Modeling Methods: The model of decision support system "Íydromineral resources": The development and implementation of the DSS "Hydromineral resources" is proposed in response to the hydromineral potential safety problem. This system includes three components: information system "Deposit", management information system "Production rate control", decision support system "Exploitation strategy".

Information system "Deposit" performs the investigate record of the fields of mineral water exploring results. Information system "Production rate control" can organize the management of the hydromineral resources production parameters. decision support system "Exploitation strategy" is meant to make the management parameters analysis and to construct the deposits long term planning [2, 3].
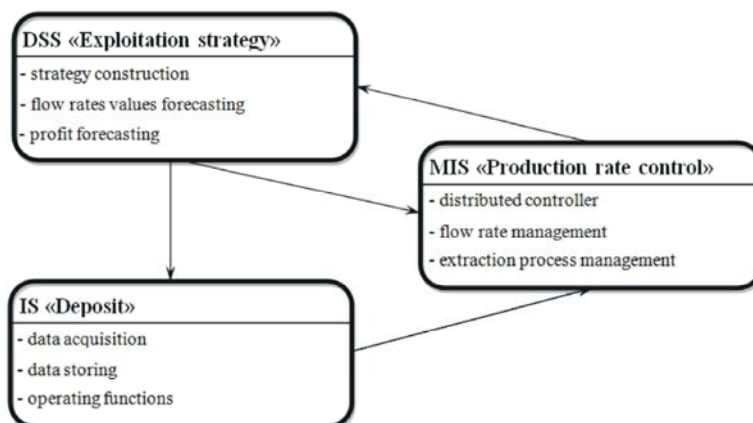
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Fig. 1: Decision support system "Hydromineral resources"

DISCUSSION

Development of the decision support system "Hydromineral resources" involves the building of the condition deposit exploitation model. Numerous hydrological models have been developed for various applications. Computer simulation using such models is nowadays an essential tool for studying hydrological catchment dynamics [4].

Possible solution of hydrogeological model building that provides the flow rate control is a design of a distributed controller. The management problem is to support the optimal hydrodynamic modes of the wells exploring that provides a minimal depletion of the groundwater storage. Mathematical calculations such processes were held in the works of Pershin I.M., where the synthesis of distributed control was implemented on a number of fields. The result of the synthesis of distributed control is the guidelines for choosing the point of mineral water extraction, as well as water intake recommended settings [5].

In the present exploring, a general model of the control system was built. This system includes two control exposure: estimates developed by well exploring specialists and evidence-based calculations based on the distributed control model. At the output the rapid accounting of the wells exploring parameters is carried.

At the initial stage the system receives the management of two components: the distributed controllers management method and the fields operation control. Control of the engineering object is determined by the company, which produces mineral water, in accordance with this, the mining process will be organized in order to maximize profits. Extremely high values of flow rate can lead to the mineral waters depletion.

The calculation the distributed controllers management method parameters allows to organize the rational use of the resource. Thus, a distributed controller makes the necessary adjustments to the wells exploring technology. Restriction of the output assures the sustainability indicators of mineral waters quality [5].

The input system receives the boreholes geophysical data, including the predicted production. A set of parameters that describe the aquifer and the well itself is quite extensive.

Usually many different geologic processes combine to produce the distribution of geologic materials in a region. Patterns of groundwater flow vary widely from one geologic setting to another, since the distribution of porosity and permeability vary so greatly in geologic materials [6].

The initial data for the deposit includes a large number of parameters. The information about them is needed for the calculations. For example, hydrogeological section allows you to visually see the field location of aquifers.

Note that the coefficients for the different deposits that characterize the geophysical properties of the aquifer are different. For the data structuring the information system "Deposit" is provided to use. Deposits parameters will be stored in the database of the system. Thus, the information about hydromineral resources, that is necessary for DSS "Exploitation strategy", will be collected and structured.

The well data should be supplemented by a number of parameters that allow the performing of the distributed controller model coefficients computation. This is an important step for a comprehensive study of mineral waters geophysical parameters. Thos approach is being used for another problem domain [7, 8].

Structuring of the deposits data will perform the parameters exporting to the MIS "Production rate control". The system "Production rate control" will be carried out the necessary engineering calculations for the deposits exploitation and the synthesis of distributed controller will be implemented.

Let us consider the components of the "Exploitation strategy", which is represented as a decision support system. In the decision support systems algorithms are used such tasks that required the application of the probabilistic graphical analysis methods. To the point of this there are a lot of research papers. The paper "Probabilistic graphical models" by Daphne Koller (Stanford University) and Nir Friedman (Hebrew University of Jerusalem) provides the most complete description of the graphical model and there using process.

A special-purpose computer program for any questions could be written. The resulting system, although possibly quite successful at its particular task, is often very brittle: if application changes, significant changes may be required to the program. Because of this ubiquitous and fundamental uncertainty about the true state of subject area, we need to allow our reasoning system to consider different possibilities. One approach is simply to consider the any state of the subject area that is possible [9].

Typically, there is a huge number of given parameters and convents for the deposit that are possible given an effective rate of flow. The development of the DSS "Strategy of exploitation" algorithm is necessary to construct a graph model of the determining the effective flow rate values algorithm. Flow rate is determined by the following factors: hydrogeological parameters, the results of the deposits engineering calculations, natural factors (season, precipitation).

Deposit development strategy must ensure not only the safety the mineral waters quality, but stable profit performance. In this case the negative scenario is a quick return at the expense of production rate overvaluation. Such scenario would lead to the depletion of reserves and to a sharp decrease of economic benefits in the long term.

Accordingly, the correct strategy is to enable long-term life of the deposit, herewith the stable rates of economic benefits must be accompanied by a strong performance of the deposits hydrogeological parameters (quality, renewability of stocks, the environment of the mining process).

The task of the system "Exploitation strategy" is the following: it is necessary to determine the effective values of the flow rate, taking into account the main factors determining the process of hydro resources exploring. Figure 2 depicts the graph that illustrates the operating algorithm of the DSS "Exploitation strategy". The following elements that must enter the graph are: deposits initial data, operating parameters, external factors (natural and economic).
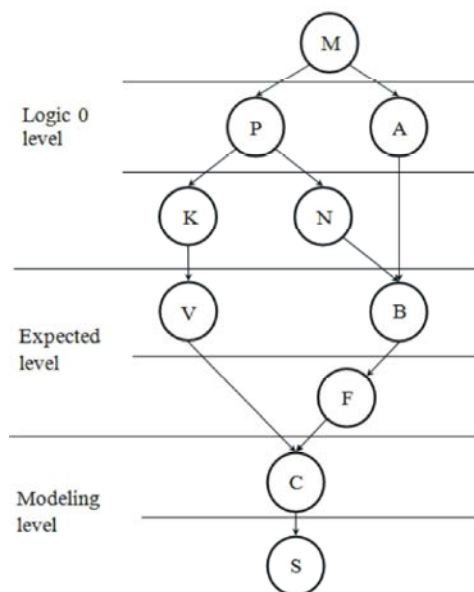

Fig. 2: Operation algorithm of DSS "Exploration strategy"

Figure 2 shows the following notation:

M - field of mineral water;

A - deposits initial hydrogeological data;

P - external factors that influencing over the exploring process and its economical benefits;

K - economic factors (seasonal demand for mineral water, the conjuncture of the market);

N - external factors (season, precipitation);

V - current estimate of market capacity;

B - engineering exploitation parameters of the deposit;

F - distributed controller management;

C - flow rate of the deposit;

S - the strategy of the mineral water deposit management.

In the Bayesian network the object parameters are represented as nodes of the graph. Location peaks suggests that they have different levels of importance for the user. Cause-effect relationships that are available between the tops are in according with the next set of knowledge:

- deposits initial hydrogeological parameters data (set A) and the external factors (the set P);
- external factors P includes economic parameters (the set P) and environmental factors (the set N);
- economic parameters of P determine the capacity of the mineral water market capacity (the set V);
- deposits hydrogeological parameters A and environmental factors N determines the deposits exploration engineering parameters (the set B);
- deposits exploration engineering parameters B are the basis of the distributed controller synthesis F;
- market capacity V and management based on distributed controller F define the effective values of the flow rate C;
- forecast of the effective low of rate values C for a long period is the basis for building of the deposit exploring strategy.

Note that the external factors can significantly change the value of the flow rate. The distributed controller's model also takes into account the seasonal water level changes associated with the rainfall and snowbreak.

Ground water contributes to streams in most physiographic and climatic settings. Even in settings where streams are primarily losing water to ground water, certain reaches may receive ground-water inflow during some seasons. The proportion of stream water that is derived from ground-water inflow varies across physiographic and climatic settings. The amount of water that ground water contributes to streams can be estimated by analyzing streamflow hydrographs to determine the ground-water component, which is termed base flow [10].

With the simplification of the problem solution the algorithm gives a comprehend answer. Building the finding effective rate of flow values for a long time process in such way gives an opportunity to formalize the deposits exploitation strategy.

There is a necessity to comply with vast numbers of rules and regulations that are related to water resources planning and management but often are not provided in an integrated, harmonised and rational framework. Also there was a reason to increase the claim for community participation in decision-making processes. The most fruitful approach is to use decision support system to predict and assess the effects of any actions by performing an integrated analysis of multiply aspects [11].

The using of the decision support system for this problem domain is shown on the Figure 3. As a result, the development of DSS "Hydromineral resources" makes possible to implement the feedback control. Operational data of the deposits technological exploitation process accumulated in the IS "Deposit". These data are transmitted to the MIS "Production rate control", which processes the information. The result of the work is the adjustment of the deposits exploring parameters that allows support the effective flow rate values.
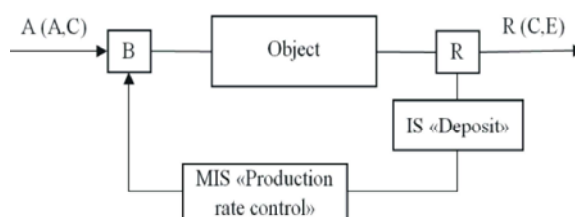

Fig. 3: The model of production rate control with a using of information system

Figure 3 shows the following notation:

A - deposits initial data (hydrogeological parameters, projected flow rate);

C - rate of flow;

B - deposits technological exploitation parameters;

R - exploitation investigative information (deposits production rate, the economic effect of the mineral water extraction);

E - saving rate of the well (the deposits exploitation economical effect).

The circuit is toped up by the feedback control, that organized by the interaction of the information system components. Thus, acting on the circuit shown in Figure 3 makes possible to account the management system with distributed parameters, or ensure the system acceptable quality management. The output also should be compared with hydromineral recourse initial engineering calculations. The proposed on the picture management model will make this confrontation more effective.

CONCLUSION

Capsule the discussion of the DSS modeling. When operating hydromineral base the deposits organization-developer tries to maximize profits, which leads to exceeding the water intakes permissible parameters. On the other hand, making the exploration economically unsound is impossible. Thus, modes of exploring should be such that it may fulfill two conditions: to provide a profit not below estimates; maintain the deposits exploration at a mode that allows to support the safety of the source, by determining the water intake parameters not be higher than the calculated (parameter group defined by MIS "Production rate control").

The fulfillment of these conditions is shown by the output parameters. These data are the basis for IS "Deposit" and MIS "Production rate control". The deposits exploring process sustainable is provided by the work of the MIS "Production rate control".It works on the basis of the analysis obtained from the IS "Deposit" operational water intake data. In the next iteration step (the next time range or a wider time range), this scheme is repeated, allowing to establish the optimum operating conditions reliably.

Further the work process is included by the third component of DSS "Hydromineral resources". Once in MIS "Production rate control" is accumulated sufficient number of the water intake progress corrective action, it would be possible to summarize information over a long period and the providing of analytical studies using intelligent algorithms.

DSS "Exploitation strategy" will make possible to calculate the effective values of the flow rate, to build a deposits exploitation predictive model and to work out an acceptable strategy to ensure the sustainability of the objects basic parameters. Three components that make up the DSS "Hydromineral resources", corresponding to the three levels of government.

Summary: The implementation of the DSS "Hydromineral resources" is the basis for the water resources securing. Levels of management define the functions of the DSS "Hydromineral resources" components. At first - the operational level is the information system "Deposit". It's a simple system that implements the function of collecting, recording and data storing. The purpose of the IS "Deposit" is the accumulation and transferring of deposits information to the next level of tactical control. At the tactical level is a MIS "Production rate control", performing the functions of process control. This system works on the principle of feedback, adjusting of the exploitation process parameters in accordance with the distributed controller model.

Result data of the flow rate control is accumulated in the IS "Deposit" and passed on cemented to a strategic management level - DSS "Exploitation strategy". This system is responsible for building a deposits development strategy. The system is set to reach a steady state of the natural complex, the flow rate effective values and an acceptable level of the deposits economic benefit.

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