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Electronic classifier of natural water treatment technologies

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Abstract. The choice of methods of water treatment in conditions of increasing requirements for drinking water quality, lack of funding for the commissioning of new water supply capacities and non-decreasing anthropogenic loads on water sources, is dominant in the design of new and reconstruction of existing water treatment stations. The authors developed an electronic classifier of natural water treatment technologies for computer support of selection and feasibility study of optimal design solution of water supply on the basis of classifiers of technological schemes of water treatment, developed by the team of authors under scientific and methodological guidance of M.G. Jurba. Use of this system allows to increase efficiency of design of new water treatment stations and reconstruction of existing ones due to reduction of selection time of technological schemes, to minimize probability of selection error. It provides the best value for money for the project.

1. Introduction

Fresh water reserves suitable for drinking needs constitute no more than two per cent of the total [1]. Due to increasing anthropogenic loads on water supply sources, they are contaminated by insufficiently treated wastewater discharged into the water basin [2]. Many of the \are of considerable toxicological concern, especially when present in complex mixtures [3]. In world practice, standards [4] - [7] have been established to regulate emissions of pollutants into water natural resources.

In order to develop and implement efficient technologies for water purification from surface water sources, careful analysis of source waters, water treatment process schemes, consideration and introduction of new water quality standards is necessary.

For the past 50 years, traditional water purification technologies have consisted in chemical clarification, filtration of granular media and decontamination, mainly by oxidation of water with chlorine. [8] - [9].

However, over the past 20 years, there have been fundamental changes in the approach of the water industry to water treatment, as a result of which the decision-making structures of the water channel have begun to seriously consider alternative treatment technologies compared to traditional ones [10] - [11].

The choice of methods of water treatment in conditions of increasing requirements for drinking water quality, lack of funding for the commissioning of new water supply capacities and non-decreasing anthropogenic loads on water sources, is dominant in the design of new and reconstruction of existing water treatment stations.

However, the scientific and technical literature and practice of water treatment has so far lacked a clear methodology and recommendations for the choice of alternative water treatment technologies depending on the water source classes, especially in view of the temporary or permanent impact on recent anthropogenic (man-made) factors. The recommendations on this issue contained in sanitary norms and regulations, Manuals, Handbooks and Training Publications are insufficient. The widespread disinfection of water with chlorine, with significant organic contamination, often results in the formation of carcinogenic organochlorine compounds.

Improving the sanitary reliability of existing water treatment plants abroad is often achieved by supplementing traditional technologies with new modern technologies, which leads to a significant increase in the cost of construction and maintenance costs (35-50%). Such solutions should be approached with a high degree of technical and economic assessment and taking into account of regional capacity.

The quality of design solutions is largely determined by the results of the initial design stages (technical design and technical proposal stages), at which fundamental decisions are made on the structure and principle of operation of the developed technical system. Initial stages of design are characterized by processing of considerable volumes of information, large number of developed versions of implementation. Designers at the stage of feasibility study of water supply facilities and detailed design can make serious mistakes in choosing the composition of water treatment facilities and methods, including in conditions of increased anthropogenic load on water sources. The solution of the tasks of the initial design stages is largely determined by how the developer will be provided with new information technologies, which strengthen his intellectual capabilities, which allow to automatize the processes of information search and processing by applying a system approach to the development of technical systems [12], [13].

The creation of an effective approach to the analysis and synthesis of technological schemes for water purification and the development of algorithms and software based on it for automation of initial stages of design is a pressing scientific task.

2. Materials and methods

The information basis for computer support of selection and feasibility study of optimal design solution of water supply is a tool in the form of classifiers of technological schemes of water treatment. Most successfully this task is solved by classifiers of technologies of drinking water preparation from surface and underground water sources, developed by the team of authors of laboratories of natural water purification and engineering structures of water treatment and water management under scientific and methodological guidance of M.G. Jurba [14], which are the information base of automation of this process.

They propose and justify 7 classes of surface water sources and 8 subclasses of anthropogenic ingredients for them, 5 classes on major background pollution and mineralization and 8 subclasses on categories of anthropogenic pollutants have been proposed for groundwaters. In contrast to previous classifications, these classifiers do not limit themselves to a list of methods that could be used to remove one or more of the four impurity groups (suspensions, colloidal, molecular and ionic solutions) from water, but to propose up to 3-6 alternative specific water treatment schemes for each water source class under anthropogenic conditions. Using mathematical methods, on the basis of the proposed classifiers, it is possible to choose the optimal technological scheme and composition of the structures taking into account the temporary or constant effects of anthropogenic factors on the background quality of water in a particular water source and the place of water intake from it.

Classifiers are four tables of classification characteristics and criteria for the selection of water treatment technologies and two final tables, the data of which allow, on the basis of qualitative indicators of source water on background and anthropogenic contamination, groups of impurities in it, time factor and set of existing reagent and reactive methods of water treatment, to select a technological scheme of water treatment in the first approximation.

On its basis designers at the stage of feasibility study of water supply facilities and detailed design will be able to avoid serious errors in choosing the composition of water treatment facilities and methods, including in conditions of increased anthropogenic load on water sources.

According to the proposed classifier, surface water supply sources are divided into 7 classes. Each class is based on background characteristics of water quality of traditional Russian rivers (turbidity, chrominance, oxidability, pH, phytoplankton content, general mineralization) with values of their quantitative indicators. In addition, each water source class is characterized by a time factor (t) indicative of the duration of presence in the water within a given concentration range of the particular ingredients.

Anthropogenic load on water sources is characterized by 8 subclasses, which record the presence of petroleum products, phenols, surfactants, nitrogen group elements, pesticides, heavy metal salts, organochlorine compounds and radiation pollutants in water.

Phase-dispersion state of impurities in water sources waters is represented by 4 groups according to classification proposed by academician L. A. Kulsky.

All main technological methods of water purification are coded with symbols and evaluated from the point of view of their potential capabilities for extraction of different impurities at water treatment stages.

The main tables of the technology classifier make it possible to select optimal technological processes implemented at water purification plants, depending on the class of the water source, the subclass of the level of its anthropogenic contamination, the phase-dispersed state of impurities in the source water and the temporary factor of their presence.

3. Results and Discussion

During the database design process, 3 stages are identified: conceptual design (creating a conceptual database model); logical design (creating a logical database model for the selected DBMS); and physical design (creating database files on machine media).

The conceptual model represents objects and their relationships without specifying how they are physically stored. It is essentially a model of the subject area. During the conceptual design phase of the database, the information of the natural water treatment classifier was formalized and structured. The database is in the third normal form, ensuring that there is no duplication of data. The data diagram is shown in figure 1.

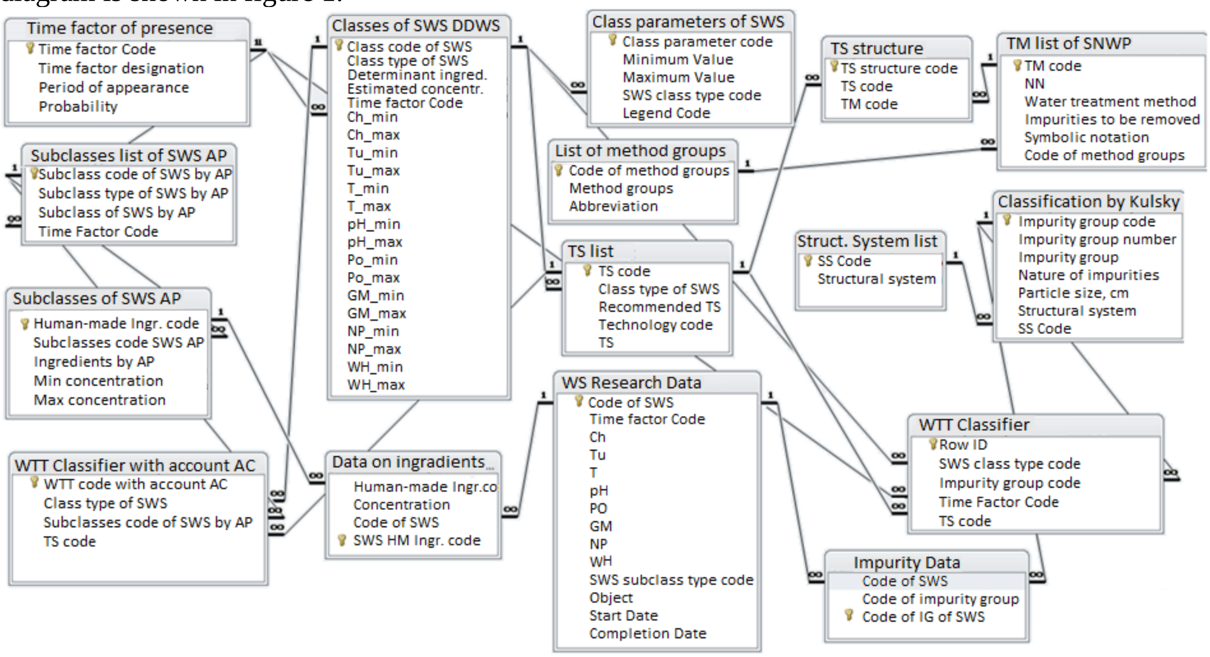

Figure 1. Data scheme

The database is designed to meet performance requirements, ease of updating, data independence, multi-user data sharing, and data security.

To use the database, a user interface has been developed to meet the current requirements for appearance and access to the internal functionality of the system. Some of the form developed are given on figures 2-4.

The program is intended for computer support of research and engineering design of surface natural water treatment facilities.

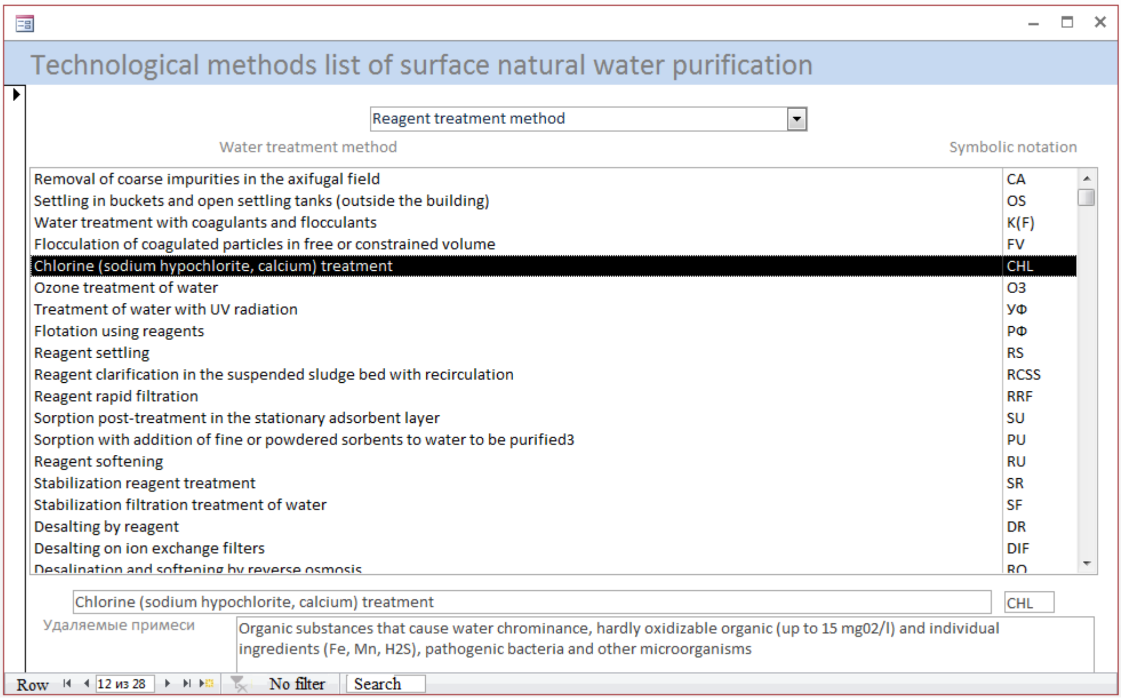

Figure 2. Form of Technological methods list of surface natural water purification

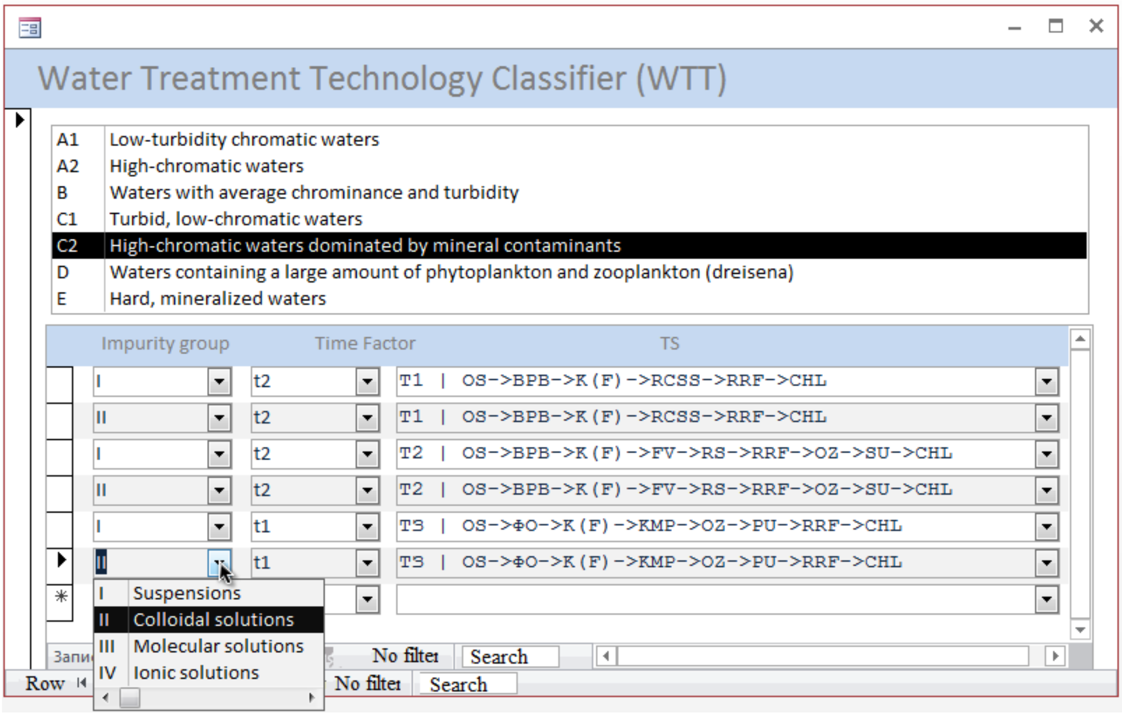

Figure 3. Form of Water treatment technology classifier

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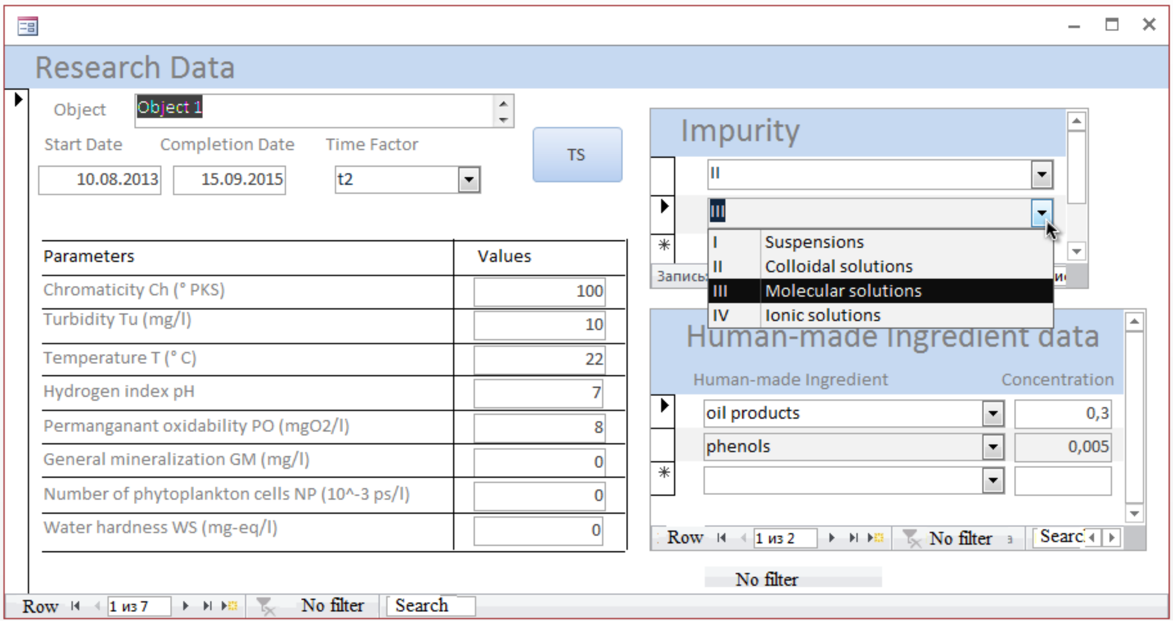

Figure 4. Project information entry form

The use of the system begins with the formation of directories: temporary factor of impurities presence, groups of methods, subclasses of surface water sources by the nature of their anthropogenic pollution, structural systems, symbols. Once the reference books have been completed using the appropriate interfaces, process methods and flow charts are entered. Then classifiers are filled: surface water sources of household and drinking water supply, classifier on Kulsky, classifier of surface water sources by the nature of their anthropogenic pollution, classifier of water treatment technologies by group of impurities, classifier of water treatment technologies taking into account anthropogenic impact.

Once complete information has been entered, the system is ready for use in supporting the decision to select the optimal process schema for each particular design case. A special interface has also been developed for this purpose (figure 3). All necessary information about the water source is inputed: temporary factor of exposure to harmful impurities (up to three months a year, throughout the year), water parameters (chrominance, turbidity, temperature, hydrogen index of pH, permanganate oxidability, total mineralization, number of phytoplankton cells, stiffness). The types of impurities and information on the ingredients of anthropogenic pollution are selected from the relevant lists. Then, at the user's request, the system presents possible versions of the water basin purification process schemes. The final choice remains with the designer.

4. Conclusion

The developed system was successfully tested. Its use allows to increase fficiency of design of new water treatment stations and reconstruction of existing ones due to reduction of selection time of technological schemes, to minimize probability of selection error. It provides the best value for money for the project.

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