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ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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Y. Z.Murtazin, O. L. Miroshnichenko, L. Y. Trushel

"KazNRTU named after K. I. Satpayev" NPJSC – Ahmedsafin Institute of Hydrogeology
and Environmental Geoscience, Kazakhstan.
E-mail: ye_murtazin@list.ru; o_mirosh@mail.ru; lydmila_y_t@mail.ru

STRUCTURE OF GEOINFORMATIONAL AND ANALYTICAL SYSTEM "GROUNDEWATER RESOURCES AND RESERVES OF THE REPUBLIC OF KAZAKHSTAN"

Abstract. In the context of strong man-caused impact on groundwater, the challenges of water resources management become particularly relevant, and they require significant amount of information from different areas of knowledge. Information and analytic systems can be an efficient tool for accumulating, processing and analyzing information.

The informational system "Groundwater resources and reserves of the Republic of Kazakhstan" consists of the document database, the graphic and semantic database, the database of mathematical models, the structure of those is, to a large extent, determined by the used software programs. All information of the system is divided into general and special information according to its intended purpose. The general information contains the information that underlies all hydrogeological investigations. The special information is intended to solve certain tasks of the assessment of groundwater resources and reserves.

The document database is used for accumulating all available materials, including the materials of the related areas of knowledge. The tables with structured texts constitute the semantic database. The graphic database represents a geographic information system, and contains the data, required for investigating groundwater resources and reserves. The database of mathematical models contains hydrodynamic and geomigration models. The geoinformational and analytical system is open, and can be extended by the inclusion of new information, and its structure can be updated in case of the change of the type of hydrogeological investigation.

The structure is perfectly developed to solve the task of the assessment of groundwater resources and reserves, and can be recommended for creation of the geoinformational and analytical system of groundwater resources and reserves of the Republic of Kazakhstan.

Key words: groundwater, informational systems, groundwater resources.

The intensive development of computer equipment and its availability to a wide range of scientists and specialists boosted the development of the informational systems in different fields of activities. Now informational systems are not just a final isolated product, accumulating the results of some development projects. They represent a tool for conducting scientific research, and it explains their link to the subject area.

Earth sciences, including hydrogeology, have a large amount of unsystematized, miscellaneous materials, and also data from the related areas of knowledge. The creation of information and analytic systems for accumulating, processing and analyzing the hydrogeological data has a particular significance for solving the tasks of groundwater management.

The efficiency of usage of informational systems in hydrogeology is proven by the world experience. Our article contains the review of the investigations in this area [1]. One must emphasize that the informational systems with groundwater data operate in many countries, including Russia [2], Kazakhstan [3], the USA [4, 5], Canada [6], Australia [7], Europe [8-11], China [12], Japan [13], India [14], Mongolia [15], the RSA [16], etc.

The informational system is a system that includes an ordered and organized set of data and means to manage it, designed for acquisition of new quality information about the state of an object, a process or an event [17]. The purpose of creation of the geographic geoinformational and analytical system of groundwater resources and reserves of the Republic of Kazakhstan is accumulation of the data about groundwater resources and the natural environments related to them, and its usage as an informational basis for solving the practical hydrogeological tasks. The principles that are presented in [18] form the basis of the system development methodology. It involves collecting and accumulating the data, solving the practical hydrogeological tasks, elaborating the recommendations, and providing the reference and information service [1].

The geoinformational and analytical system "Groundwater resources and reserves of the Republic of Kazakhstan" consists of the document database, the graphic database, the semantic database, and the database of mathematical models. The structure of the databases is, to a large extent, determined by the used software programs. All information of the system can be conventionally divided into general and special information according to its intended purpose. The general information contains the information that underlies all hydrogeological investigations. The close connection of groundwater with different natural environments requires the informational system to contain data from the related knowledge areas, such as geology, hydrology, meteorology, topography, etc.

The special information is intended for solving the certain tasks, in this case, the task of the assessment of groundwater resources and reserves. The special information is formed by the expert on the basis of the general information by the inclusion of additional data, and it reflects the expert's subjective point of view on the certain problem.

The hydrogeological investigations involve using and processing of a large amount of miscellaneous data from different sources. The usage of different methods of interpretation of primary data results in the subjectivity of information, therefore, all investigation results, obtained by different experts have to be stored. The document database (figure 1) is created to accumulate all available materials, including the materials of the related areas of knowledge. The main components of the document database are unpublished and published materials, and reports on the basis of the data, contained in the information and analytic system.

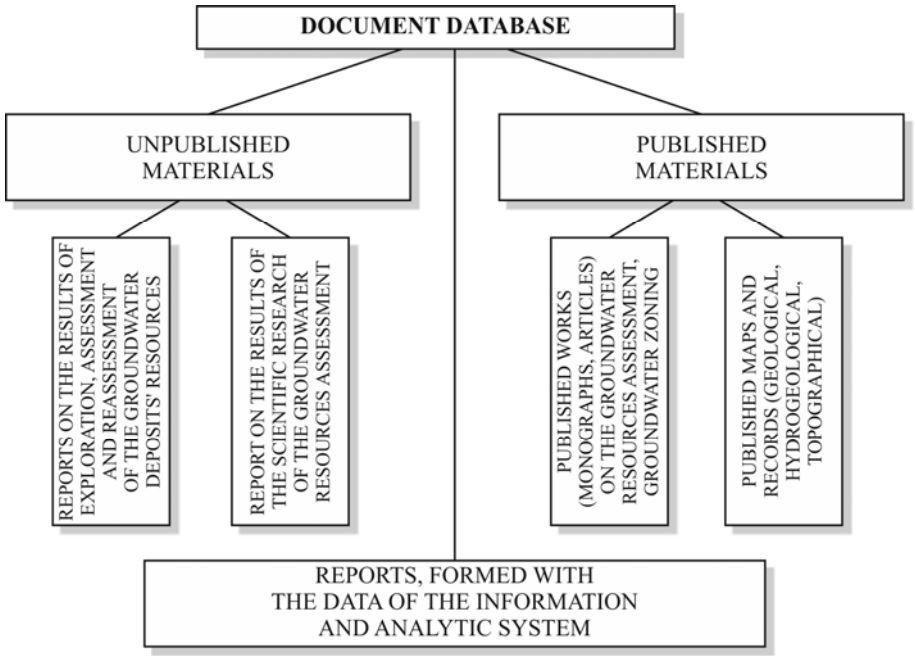


Figure 1 – Structure of the document database

The semantic database consists of a set of tables, and it constitutes the system of collection, storage and analysis of numeric and text data (figure 2). All its information can be conventionally divided into general and special information. The general information includes primary materials, values of geofiltration parameters and descriptions of the facilities used for economic activities.

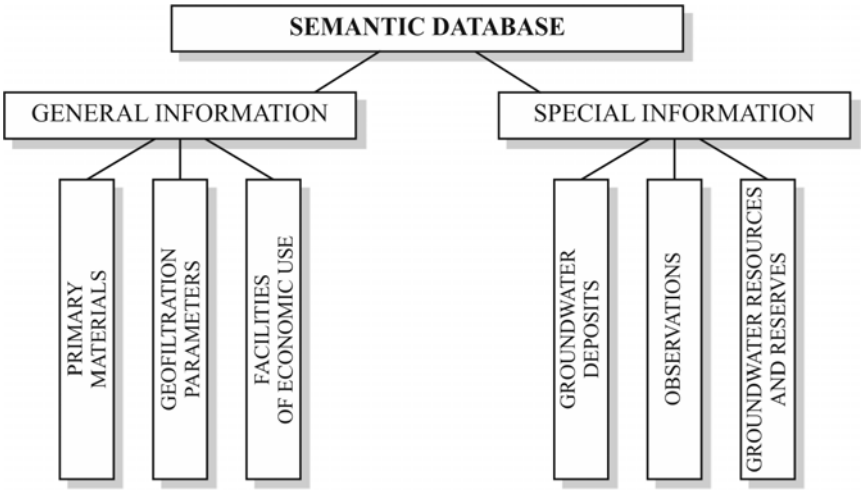


Figure 2 – Structure of the semantic database

Primary materials include descriptions of exploration and observation wells (geological and hydrogeological), results of overdrafts, and geophysical data. Geofiltration parameters are the result of processing the primary materials, and they include the coefficients of transmissibility, filtration, conductivity, piezo conductivity, elastic and gravity water yield, and migration parameters [17]. In the informational system the facilities used for economic activities are defined as man-made objects that have impact or may have impact on groundwater. Water intake structures certainly have the biggest impact on groundwater. Therefore, all data related to the groundwater deposits is allocated in the separate block of the section Special information of the informational system.

The data of the Special information section of the semantic database is used for solving the tasks of the assessment of groundwater resources. It contains the block "Groundwater deposits", the block "Observations", the block "Groundwater resources and reserves".

The block "Groundwater deposits" includes the descriptions of deposits and water intakes, as well as real and expected water intake. The block "Observations" contains the results of permanent observation of groundwater resources and the natural environments related to them, and the results of one-time observations. Groundwater, surface water and the air are monitored to assess the state of groundwater and to

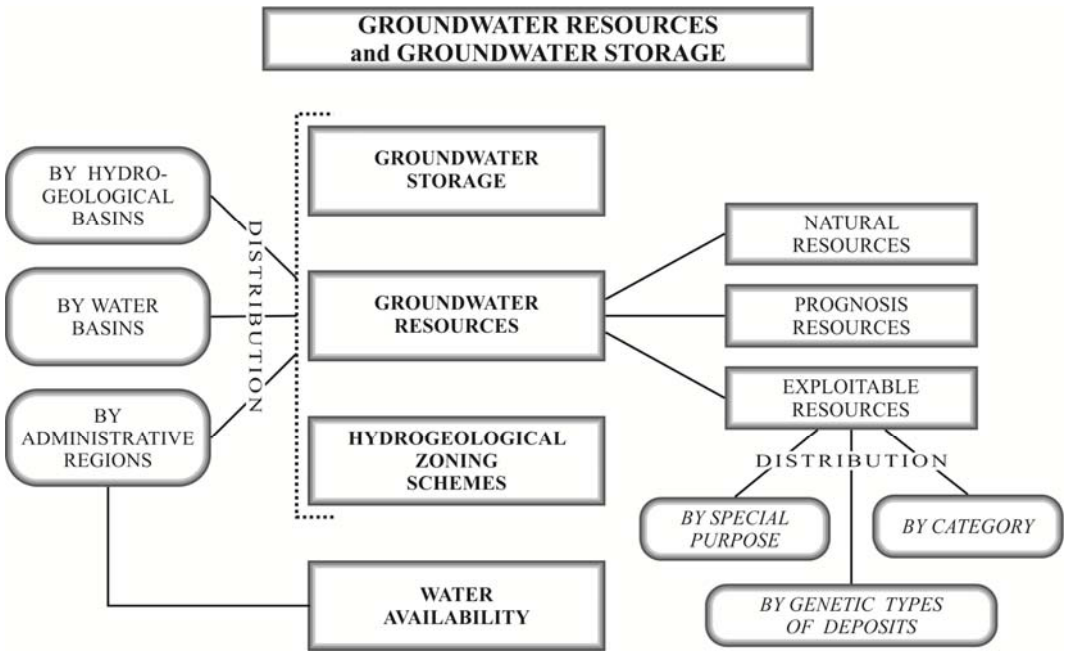


Figure 3 – Structure of the block "Groundwater resources and groundwater storage"

make forecast of its changing under anthropogenic impact. The information about groundwater resources, hydrogeological zoning plans, and groundwater resources endowment constitutes the block "Groundwater resources and reserves". The resources are estimated within the hydrogeological basins, water basins and administrative districts (figure 3).

Hydrogeological investigations are followed by the estimation of natural, expected and operational groundwater resources. The operational resources in turn can be divided according to the intended purpose, category and genetic type of the deposit [19, 20]. The estimation results are presented in the tables of the semantic database (figure 4).

DISTRIBUTION OF PROVEN EXPLOITABLE GROUNDWATER RESOURCES WITHIN THE WATER BASINS

BY SPECIAL PURPOSE						
WATER BASIN	EXPLOITABLE RESOURCES, THOUSAND CUBIC METERS/DAY					
	HOUSEHOLD and DRINKING WATER	DRINKING WATER	IRRIGATION	MINERALIZATION	TOTAL	INCLUDING WITH MINERALIZATION UP TO 1 G/L

BY GENETIC TYPES	
WATER BASIN / GENETIC TYPE OF GROUNDWATER DEPOSIT	EXPLOITABLE RESOURCES, THOUSAND CUBIC METERS/DAY
BASIN	
IN RIVER VALLEYS	
IN ARTESIAN BASINS	
IN DETRITAL CONES	
IN SANDY MASSIFS	
IN FISSURED ROCKS	

BY CATEGORY						
WATER BASIN	SPECIAL PURPOSE OF GROUNDWATER DEPOSIT	EXPLOITABLE RESOURCES, THOUSAND CUBIC METERS/DAY				
		A	B	C1	C2	TOTAL

Figure 4 – Structure of the data that demonstrates the allocation of operational reserves within the water basins

The graphic database, as a geographic information system, represents the system of collection, storage, processing, access, analysis, interpretation and graphical visualization of the spatial data. The information and analytic system "Groundwater resources and reserves of the Republic of Kazakhstan" contains the data that is necessary for studying groundwater resources, and the results of their assessment. The forms of materials presentation allow using them for solving the practical hydrogeological tasks.

The characteristics of hydrogeological information, such as a large amount of data, the necessity to consider the connection of groundwater with natural environments and man-made objects, low formalizability of the subject domain, high differentiation of the territorial data, subjectivity of the materials assessment, etc, were considered in formation of the graphic database.

The graphic database includes general and special information (figure 5). The general information shows the connection of groundwater with the environment. The general information contains hydrogeological, geological, hydrographical, meteorological information, topographical data, the facilities used for economic activities, administrative-territorial units, and the data of Earth remote probing.

The special information includes the data associated with the certain hydrogeological task of the assessment of groundwater resources. It is the results of the assessment of groundwater resources and reserves, obtained by different experts in different territories, using different methods. The names of the special information sections of the semantic database and the graphic database are the same, it is explained

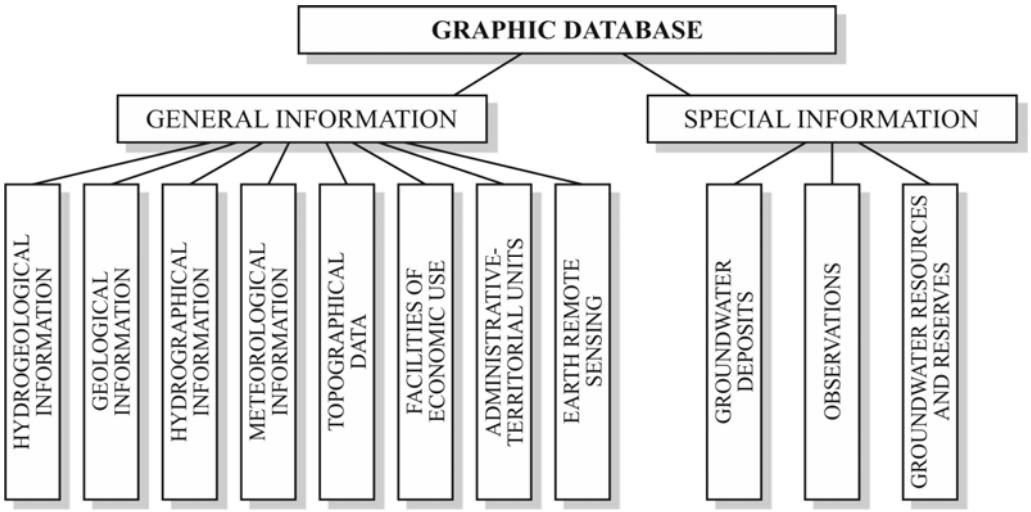


Figure 5 – Structure of the graphic database

by the specific character of the task of the assessment of groundwater resources, and the possibility to use the tables of the semantic database as attributes of graphic objects.

The unique attribute information is connected with each graphic object. It is used for data sampling, designing the thematic maps, creating the links of the spatial objects with the tables of semantic database, constructing the array of initial data for the mathematical model, etc.

The groundwater deposits are presented as point objects with the code and name of the deposit, etc. The observations in the graphic database are presented as layers of point objects of hydrogeological observation wells, hydrometeorological and hydrogeological stations, meteorological stations. The block "Groundwater resources" has the same structure as the one in the semantic database.

The results of the assessment of groundwater resources and reserves reflect the original view of the researcher; therefore, there is a variety of graphic representations of these parameters. The estimations are based on the data of lithologic age composition of hydrophilic formations, mineralization of groundwater, limits of aquiferous formations, stratification depth of groundwater, groundwater accumulation and discharge areas, tectonic faults, etc. Therefore, the maps of groundwater resources and reserves are highly important.

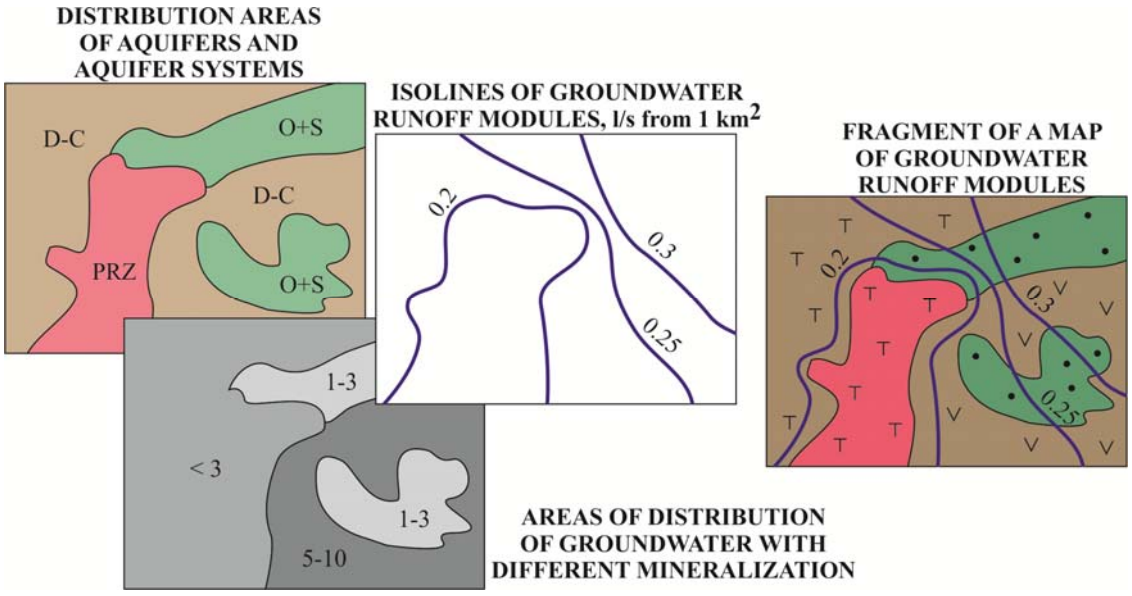


Figure 6 – Design of the map of groundwater natural resources

The maps, containing the data about groundwater resources and reserves are designed with isolines or zones. A code is connected with each graphic object. As well as this, the reserves volume or the resources flow dimension can constitute attribute information. One should note that module maps are the most demonstrative (figure 6). Module maps of groundwater resources demonstrate the flow discharge from the area unit. Resources and reserves volumes are presented in diagrams on the maps.

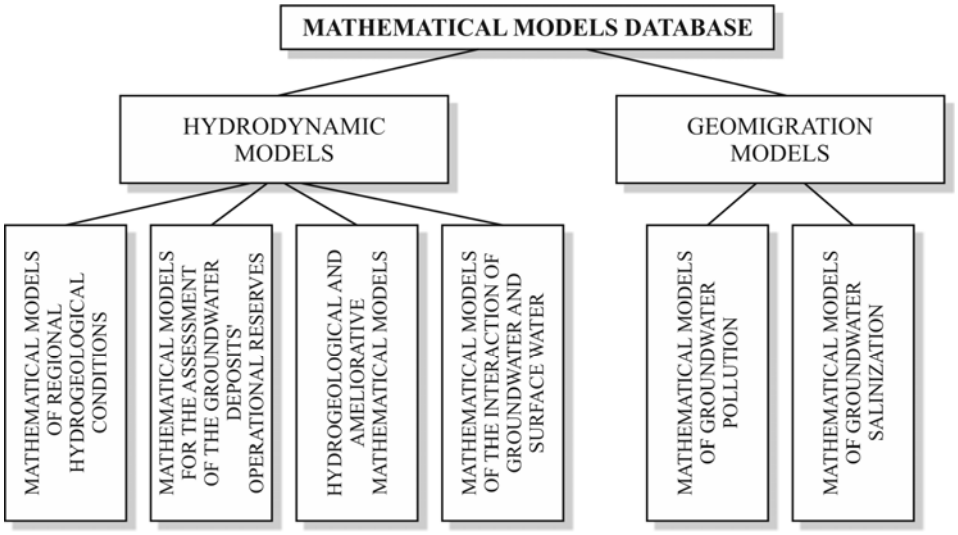
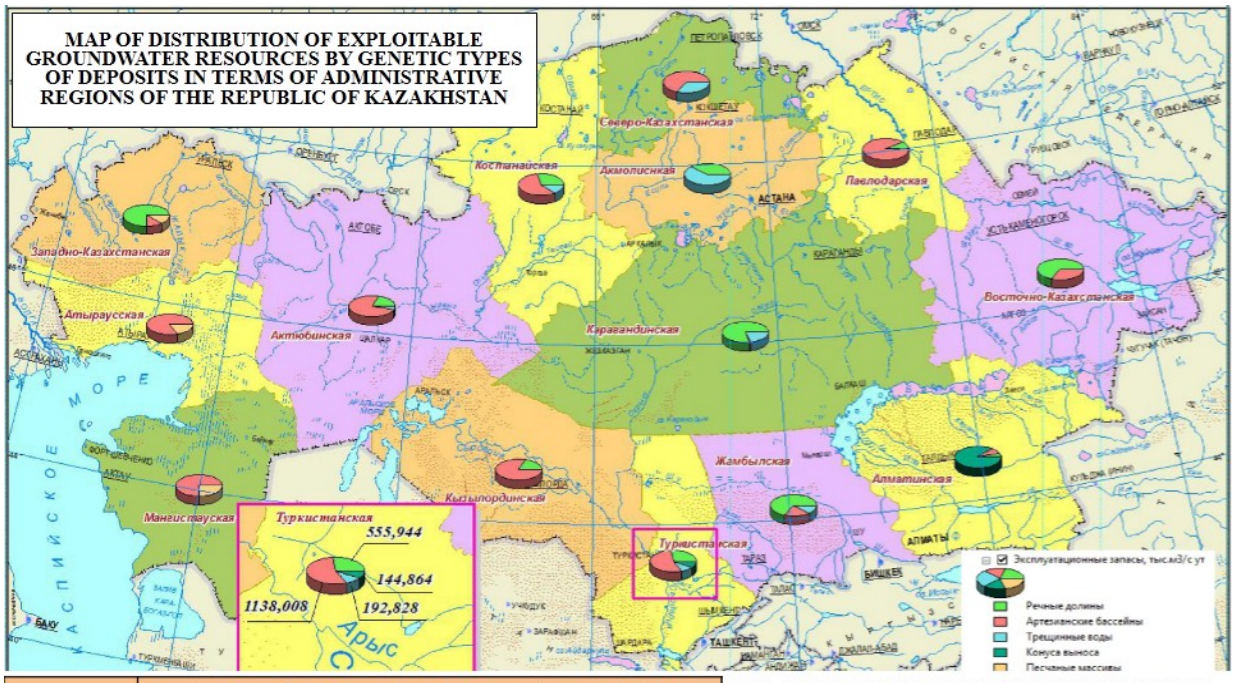


Figure 7– Structure of the mathematical models database



Administrative regions	*Usable groundwater reserves for total categories, thousand cub. m/day*					
	Genetic type of groundwater deposit					*Total*
	In river valleys	*In artesian basins*	*In the massifs of fractured rocks*	*In alluvial cones*	*In sandy*	
Akmola	166,896	0,385	249,965			
Aktobe	349,74	1451,367	79,935			
Almaty	666,797					
Atyrau	0,514					
East Kazakhstan	2211,156					
Zhambyl	1558,214					

DISTRIBUTION OF PROGNOSIS GROUNDWATER RESOURCES AND EXPLOITABLE GROUNDWATER RESOURCES BY ADMINISTRATIVE REGIONS

Administrative regions	*Undiscovered potential groundwater resources, thousand cub. m/day*			
	Total	*Mineralization, g/dm³*		
		Up to 1	*1-3*	*3-10*
				127
				3837,1
				2307,7
				3415

Administrative regions	*Usable groundwater reserves for designated purpose, thousand cub. m/day*				
	Utility and drinking water supply	*Technical and industrial water supply*	*Land irrigation*	*Mineral waters*	*Total*
Akmola	347,646	69,28		0,35	443,3

Figure 8 – Allocation of groundwater expected resources and reserves resources within the administrative regions of the Republic of Kazakhstan in the graphic and semantic databases

The informational system allows designing the maps of groundwater reserves and resources (natural, expected, operational), and hydrogeological zoning plans within administrative districts, hydrogeological and water basins. The maps of groundwater resources endowment are designed within administrative districts.

The database of mathematical models of geofiltration can be divided into two blocks, the block of hydrodynamic models and the block of geomigration models (figure 7). Hydrodynamic models include mathematical models of regional hydrogeological conditions, mathematical models for the assessment of operational resources of the groundwater deposits, hydrogeological and ameliorative mathematical models, and mathematical models of the interaction of groundwater and surface water. Geomigration models include mathematical models of the groundwater pollution and salinization.

The document database should be created in Microsoft Access, the semantic database in Microsoft Excel, the graphic database in geographic information systems ArcGIS and MapInfo, the database of mathematical models in groundwater mathematical modeling system (GMS).

The maps of expected groundwater resources and operational groundwater reserves (the block Groundwater resources and reserves of the graphic database), and associated tables (the block Groundwater resources and reserves of the semantic database) were included as an example in the geographic information and analytic system Groundwater resources and reserves of the Republic of Kazakhstan [19-21] (figure 8).

Therefore, the structure of the geographic information and analytic system “Groundwater resources and reserves of the Republic of Kazakhstan” is perfectly developed for solving the practical hydrogeological tasks that require a large amount of data. One should note that the system is open, and its structure can be updated in case of the change of the type of hydrogeological investigations.

The investigations are carried out within the framework of the project BR05236664 “Scientific-methodological, geographic information and analytical support of the rational usage and protection of groundwater of the Republic of Kazakhstan in the context of climate and anthropogenic changes”, and using the special purpose funding of the scientific-technical programs of the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan.

Е. Ж. Муртазин, О. Л. Мирошниченко, Л. Ю. Трушель

«Қ.И. Сәтбаев атындағы ҚазҰТЗУ» КЕАҚ –
У. М. Ахмедсафин атындағы гидрогеология және геоэкология институты, Алматы, Қазақстан

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ ЖЕР АСТЫ СУЛАРЫНЫҢ РЕСУРСТАРЫ МЕН ҚОРЛАРЫ» ГЕОАҚПАРАТТЫҚ-АНАЛИТИКАЛЫҚ ЖҮЙЕСІНІҢ ҚҰРЫЛЫМЫ

Аннотация. Жер асты суларына жоғары техногендік әсер ету шарттарында түрлі білім салаларынан алынатын мәліметтердің едәуір көлемін тарту арқылы өз есептерін шешуді талап ететін су ресурстарын басқару міндеті ерекше өзектілікке ие болуда. Деректерді жинақтау, өңдеу және талдау үшін тиімді аспап ретінде ақпараттық-аналитикалық жүйелер қолданылуы мүмкін.

«Қазақстан Республикасының жер асты суларының ресурстары мен қорлары» ақпараттық жүйесі құжаттар базасынан, графикалық және семантикалық деректер базасынан және математикалық үлгілер базасынан тұрады, олардың құрылымы, көбінесе, пайдаланылатын бағдарламалық өнімдермен анықталады. Жүйедегі бар ақпарат арналуы бойынша жалпы және арнайы болып бөлінеді. Жалпы тобына барлық гидрогеологиялық зерттеулердің негізі болып табылатын мәліметтер кіреді. Арнайы топ жер асты суларының ресурстары мен қорларын бағалау бойынша нақты есепті шешу үшін арналған.

Құжаттар базасы барлық қолда бар материалдарды, оның ішінде іргелес білім салаларына тиесілі материалдарды жинақтау үшін жұмыс жасайды. Құрамында құрылымдалған мәтіндік деректері бар кестелер семантикалық деректер базасын құрайды. Графикалық деректер базасы геоақпараттық жүйе түрінде жасалған және оның құрамына жер асты суларының ресурстары мен қорларын зерттеу үшін қажетті мәліметтер кіреді. Математикалық үлгілер базасының құрамына гидродинамикалық және геомиграциялық үлгілер кіреді. Геоақпараттық-аналитикалық жүйе ашық болып табылады және жаңа деректерді енгізу арқылы кеңейтілуі мүмкін, ал оның құрылымы гидрогеологиялық зерттеулердің түрі өзгергенде жаңартылуы мүмкін.

Жасалған осы құрылым жер асты суларының ресурстары мен қорларын бағалау есебін шешу үшін оңтайлы болып табылады және Қазақстанның жер асты суларының ресурстары мен қорларының геоақпараттық-аналитикалық жүйесін құру үшін ұсынылуы мүмкін.

Түйін сөздер: жерасты суы, ақпараттық жүйе, жерасты суы ресурстары.

Е. Ж. Муртазин, О. Л. Мирошниченко, Л. Ю. Трушель

НАО «КазНИТУ им. К. И. Сатпаева» –
ТОО «Институт гидрогеологии и геоэкологии им. У. М. Ахмедсафина», Алматы, Казахстан

СТРУКТУРА ГЕОИНФОРМАЦИОННО-АНАЛИТИЧЕСКОЙ СИСТЕМЫ «РЕСУРСЫ И ЗАПАСЫ ПОДЗЕМНЫХ ВОД РЕСПУБЛИКИ КАЗАХСТАН»

Аннотация. В условиях высокого техногенного воздействия на подземные воды особую актуальность приобретают задачи управления водными ресурсами, требующие для своего решения привлечения значительного количества сведений из разный областей знаний. В качестве эффективного инструмента накопления, обработки и анализа данных могут выступать информационно-аналитические системы.

Информационная система «Ресурсы и запасы подземных вод Республики Казахстан» состоит из базы документов, баз графических и семантических данных и базы математических моделей, структура которых в значительной степени определяется используемыми программными продуктами. Вся информация, содержащаяся в системе, по назначению разделяется на общую и специальную. Общая содержит сведения, которые лежат в основе всех гидрогеологических исследований. Специальная предназначена для решения конкретной задачи оценки ресурсов и запасов подземных вод.

База документов служит для накопления всех имеющихся материалов, в том числе относящихся к смежным областям знаний. Таблицы, содержащие структурированные текстовые данные, составляют базу семантических данных. База графических данных реализована в виде геоинформационной системы и включает сведения, необходимые для изучения ресурсов и запасов подземных вод. Наполнением базы математических моделей являются гидродинамические и геомиграционные модели. Геоинформационно-аналитическая система является открытой и может быть расширена путем включения новых данных, а ее структура модернизирована при изменении типа гидрогеологических исследований.

Разработанная структура является оптимальной для решения задач оценки ресурсов и запасов подземных вод и может быть рекомендована для создания геонформационно-аналитической системы ресурсов и запасов подземных вод Казахстана.

Ключевые слова: подземные воды, информационные системы, ресурсы подземных вод.

Information about authors:

Murtazin Yermek, Deputy Director of "KazNRTU named after K. I. Satpayev" NPJSC – Ahmedsafin Institute of Hydrogeology and Environmental Geoscience, PhD; ye_murtazin@list.ru; https://orcid.org/0000-0002-7404-4298

Miroshnichenko Oxana, Leading Researcher of "KazNRTU named after K. I. Satpayev" NPJSC – Ahmedsafin Institute of Hydrogeology and Environmental Geoscience, PhD; o_mirosh@mail.ru; https://orcid.org/0000-0002-0057-6734

Trushel Lyudmila, Senior Researcher of "KazNRTU named after K. I. Satpayev" NPJSC – Ahmedsafin Institute of Hydrogeology and Environmental Geoscience, PhD; lydmila_y_t@mail.ru; https://orcid.org/0000-0002-9171-2761

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