Application of GIS-technologies in studying the hydrogeochemical zonation of groundwater (on the example of the Navoi region)

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Abstract. One of the most principal issues in regional hydrogeochemistry is the study of hydrogeochemical zonality of groundwater. This phenomenon is manifested in regular and systematic changes in the chemical composition and mineralization of groundwater, varying by geographic area and depth. Understanding these regularities is not just academically significant; it enables critical applications in resource management and environmental protection. By studying the alterations in the chemical composition of groundwater, researchers can elucidate the origins and formation processes of various groundwater systems. Additionally, this knowledge provides valuable insights for the targeted exploration of groundwater sources with diverse compositions. It also aids in predicting potential changes in both chemical composition and mineralization within different geological structures over time. This project encompasses the development of a Geographic Information System (GIS), where selected observation points are mapped, thereby facilitating the construction of detailed layer-by-layer geochemical maps. Such tools are essential for visualizing and interpreting the complexities of groundwater chemistry across the region [1].

1 Introduction

Geoinformation system (GIS) technologies are used almost everywhere today - in forestry, construction, cartography, ecology, seismology and so on. They are studied in universities and scientific institutes. GIS-technologies are a whole industry that affects almost all aspects of human life.

What is GIS - it is a geographical information system. It allows you to map the objects of the world around you and then analyse them according to a huge number of parameters, visualise them and, based on this data, predict a variety of events and phenomena. Such a powerful technology allows to solve with the help of GIS a huge number of tasks, both global

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and private. GIS technology can serve the whole of humanity, preventing ecological disasters or helping to solve the problems of overpopulation in certain regions.

How does a GIS work? An information system is a huge database of digital data converted into a digital format. They are detailed layers that are geographically organised and linked to a specific coordinate system. Any event that occurs can be successfully tracked through such a database. In addition, it can be used to find almost any point on the globe and track the movement of almost any object. GIS databases are capable of performing five different tasks. You can enter actual data into the database, and in most cases this is done automatically with a scanner. You can manipulate the data, scale it as you see fit, and gather the information you need to solve a particular problem. Like conventional databases, a GIS system can be managed. This is done through a range of integrated applications. The large amount of data contained in the database provides a wide range of possibilities for analysing various parameters. You can find vacant plots for building a house, optimally shape traffic flows, analyse the proximity of different objects (for example, determine the number of people living within walking distance of your shop), overlay various indicators on each other and analyse the resulting picture. The last task that GIS allows you to perform is data visualisation. You can get maps, graphs, tables and even photographs of the area of interest. This data is of great importance both for scientific research and for the work of individual companies and organisations. Where are GIS technologies used? From the descriptions offered above, it is clear that GIS technology has a wide range of applications in many different fields of activity [2].

2 Materials and methods

In accordance with the set tasks the main research methods and their solutions were carried out in three stages: 1) consideration of the world opit) 1) Collection of stock materials of field studies (on water samples) on the territory of the Republic; 2) field studies at the site and 3) processing of the obtained data.

Material was collected from stock sources regarding chemical analysis of groundwater at different wells and observation points [3].

The collected data of chemical analyses were used to identify the spatial zonality of changes in the chemical composition of groundwater. This work includes preparation of a GIS-project with placement of selected observation points over the whole territory and construction of layer-by-layer geochemical maps.

Hydrogeological maps are also produced using ArcGIS software. ArcGIS software in brief.

ArcGIS allows you to do the following:

Create, share and use digital maps

Compilation of geographical information

Create and manage geographic databases

Problem solving using spatial analysis

Creating applications based on maps

Communication and information sharing using the power of geography and visualisation

ArcGIS is an infrastructure for creating maps.

ArcGIS is a complete system that allows you to collect, organise, manage, analyse, share and distribute geographic information.

ArcGIS allows you to create large-format printed maps, maps in reports and presentations, atlases, collections, maps used in applications, etc.

Maps produced with ArcGIS display information and use it to support querying, analysing, planning and management. This is a key point about ArcGIS: maps are both the end product of GIS work and the tool for that work. ArcGIS maps provide an interactive

window through which geographic information can be visualised, explored, analysed and updated. With ArcGIS, maps are created not only to display information, but also to find and understand trends and relationships, perform analysis and modelling to solve special problems, visualise and track status, provide data entry and compilation, and share ideas, plans and developments [4].

3 Results and discussion

An ArcGIS map starts with a good base map. ArcGIS contains an excellent set of built-in base maps that include topography, image, street, elevation, ocean, and more. Other specialised base maps such as hydrology, land use and geology are available. You can also create your own custom base maps. For example, a city government can create a standardised base map that highlights land and infrastructure. Once a base map is selected, you can add rich layers of working data, select symbols, apply lettering, and define map scales, as well as customise pop-up windows that represent key attributes of map objects. You can customise additional tools based on the intended purpose of the map, such as editing tools, access to analytical models, time sliders, and so on. Map templates simplify map creation and production [5].

During this work, more detailed work was carried out within the Pritashkent artesian basin. For detailed interpretation route surveys were conducted, water was sampled, the number of accompanying with laboratory works was increased. Further laboratory studies were carried out [6].

Analysing the obtained results, geochemical types of water in the Pritashkent artesian basin were identified and geochemical maps were constructed. All observation points are divided according to their landscape zones and the composition of water of different geochemical types is compared. As a result, the form of migration of main macro and microelements within several types of relief of Pritashkent artesian basin, including under the influence of anthropogenic factors, was revealed [7].

Based on all the obtained data, the dynamics of changes in the component composition of groundwater was assessed by analysing the results of previous and modern geochemical data. To establish the forms of migration of macro- and micro-components, the data of chemical analyses using OriginPro software were used [8].

Today, maps of cities and localities are rapidly becoming outdated as new construction and roads are being designed. GIS allows tracking these changes and entering them into the database almost lightning fast. Run in a virtual network, such a map will always have up-to-date data at hand. GIS technology is not just a computer database. It is a huge opportunity to analyse, plan and regularly update information. GIS-technologies today find application in almost all spheres of life, and it helps to solve many tasks really effectively [9].

Drawing of the main and auxiliary maps is one of the representations of the results of the works, which will be built for the whole territory refined on the basis of the sampled wells [10].

Hydrogeochemical zonality maps are prepared on the basis of collection, analysis and systematisation of research data aimed at studying the geochemical state of groundwater. Spatial geo-referencing is made (Fig. 1.).

Application of the tool "topo to raster" interpolating, hydrological correct raster surface by point, linear and polygonal data. Here are introduced objects and its input parameters, showing the result of hydrochemical values of mineralisation [11].

For the predominance of anionic and cationic water ions, the same methodology and data interpolation tools in ArcGis are applied as in the detection of mineralisation [22].

The created database of hydrogeochemical data allows to construct digital maps for each prevailing ions of anionic and cationic composition of waters, so in regional and republican scale [12].

We can say the issue of practical use of groundwater, the number one issue is drinking water supply. This issue has two aspects. The first one is provision of necessary volumes of water. The second aspect is water quality and its' monitoring - the task of hydrogeochemistry.

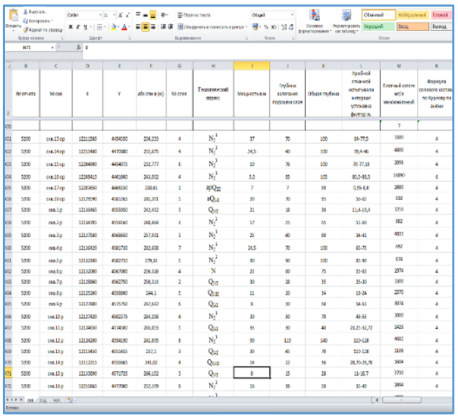

Fig 1. Hydrogeochemical databases

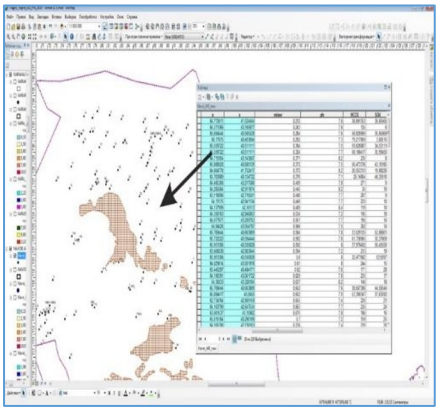

Fig. 2. Spatial georeferencing of data with coordinates and geochemical parameters**.**

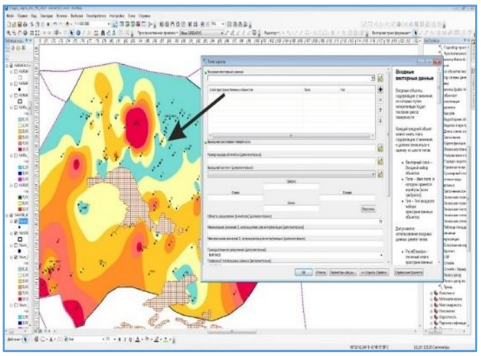

Fig. 3. Interpolation based on the collected database of chemical analyses of groundwater in the Republic of Uzbekistan

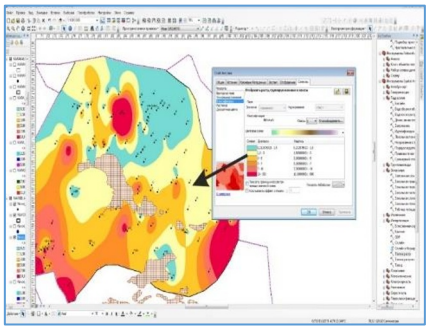

Fig. 4. Using the layers property, it is possible to adjust the value gradation and colour palette of the water salinity halos, as shown in this slide.

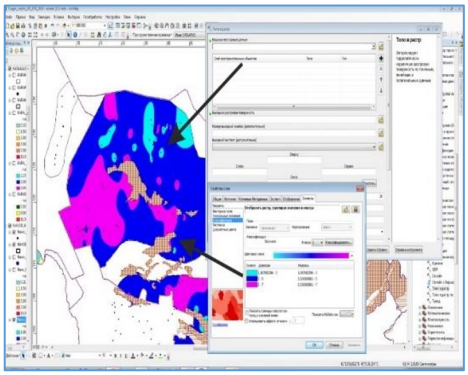

Fig. 5. Anionic composition of groundwater

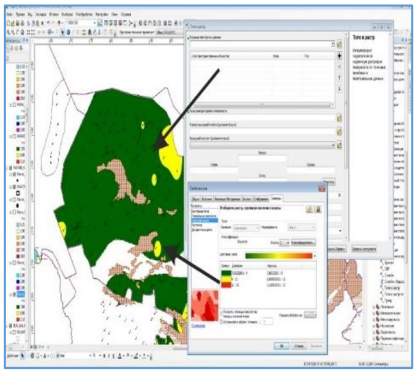

Fig. 6. Cationic composition of groundwater

The term "Hydrogeochemistry" should be understood as the science that deals with the study of the Earth's underground hydrosphere.

Hydrochemistry - science, section of hydrology, studying the chemical composition of natural waters and patterns of its change under the influence of physical, chemical and biological influences. [13].

Therefore, "hydrogeochemistry" is a science that emerged at the junction of hydrogeology and geochemistry and deals with the study of the material (ionic, gas, isotopic) composition of groundwater, the processes of its formation, history and migration of chemical elements in the underground hydrosphere [14].

Hydrogeochemistry objectives - mastering methods of analysing the chemical composition of groundwater, assessing the influence of various natural processes on the formation of the chemical composition of groundwater, solving balance equations of dissolution and precipitation of mineral substances and dissolution of gases [15,21,22,26].

Everywhere in nature, we meet with the phenomena of zonality. Climate zonality, vegetation zonality, etc. are widely known. Zonal phenomena are also widespread in hydrogeology. Hydrogeochemical zonality is most studied on the example of groundwater, as well as deep groundwater within platforms [16,20,22,25,26].

To investigate the hydrochemical rezoning and groundwater conditions, the stock materials of well passport parameters were reviewed, part of which is entered into GIS-system and all intermediate hydrogeochemical databases of the sites in the territory are studied, and maps on chemical composition are made separately for each area [17,25].

After reviewing the stock hydrogeological map materials, the maps were recorded using GIS software

Based on our data, we can conclude that the higher the degree of groundwater salinity, the higher the level of sodium and chloride, and accordingly, the weak manifestation of hydrogen in the water content can be related to the features of the geological structure of the earth, the level of groundwater, its lithological composition, filtration coefficient - permeability of rocks [18].

Map of groundwater mineralisation quaternary sediments of Navoiy region	*Map of anion composition of groundwater quaternary sediments of Navaiy region*	*Map of cation composition of quaternary sediments of Navaiy region*

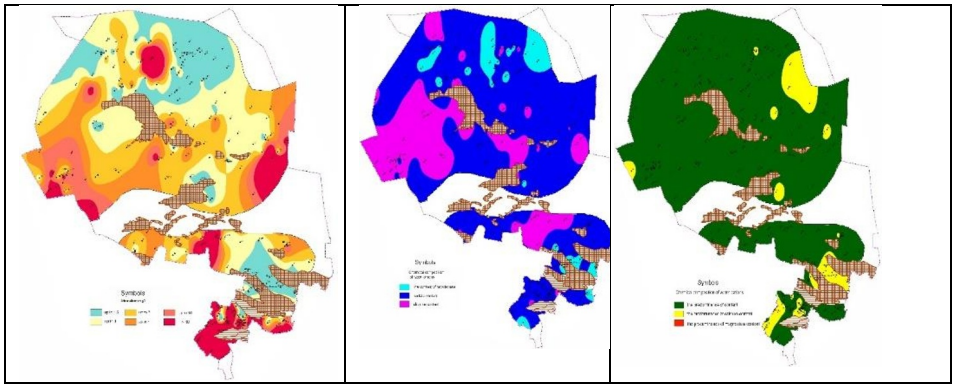

Fig. 7. Mineralisation content, prevalence of chemical composition by anions and cations of Quaternary sediments of Navoi region

4 Conclusion

1. The review of world and domestic experience of geochemical studies in the system "water - rock" showed that, despite the complexity of the problem, there are its private solutions. However, if it is physico-chemical modelling, it is mainly carried out on - objectively on large scales [19].
2. Variability of groundwater chemical composition was revealed using GIS-technology. Medium-scale maps of mineralisation and chemical composition of groundwater were constructed, separately for anions and cations, etc [20].
3. The presence of a large source of subirrigation in principle requires modernisation of irrigated farming techniques and technology in the catchment area of the basin [21].

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