PAPER • **OPEN ACCESS**

Geoecological Maps of Surface Water Pollution Akmola Region of Kazakhstan Based on Hydrochemical Analyzes

To cite this article: Beisenova Raikhan *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **901** 012017

Geoecological Maps of Surface Water Pollution Akmola Region of Kazakhstan Based on Hydrochemical Analyzes

Beisenova Raikhan[1,a], Saspugayeva Gulnur[1,b], Zhamangara Aizhan[1,c*], Ramazanova Makhabbat[2,d], Tulebekova Assel[1,e]

[1]L.N. Gumilyov Eurasian National University, Kazakhstan
[2]Universidade Portucalense, Portugal
[a]raihan_b_r@mail.ru, [b]gulnur_erzhanovna@mail.ru, [c]kashagankizi@mail.ru, [d]ramazanova@upt.pt, [e]krasavka5@mail.ru

Abstract. Ecological and geographical map that characterizes the introduction and storage in the natural or built environment of physical, chemical, and biological substances in concentrations exceeding the natural (background) values and adversely affecting human health, fauna, flora, and other components of the environment. Maps may reflect contamination of the earth, atmosphere, surface water and groundwater, soils, vegetation, wildlife, and others. They show the sources of pollution (solid waste, air emissions of gases and aerosols, drains and diversion of utilities and others), pollution factors (impact of power plants, transportation, industrial production, animal husbandry, and so on), distribution of natural and man-made pollutants (mechanical, physical, chemical, biological), and others. The levels of pollution often characterize the performance of exceeding the maximum permissible concentration (MPC), the maximum permissible emissions (MPE), and other regulations.

Keywords: maximum permissible concentration (MPC), the maximum permissible emissions (MPE), phosphates, nitrates, nitrites, ammonium nitrogen.

1. Introduction

Water pollution, as well as air pollution, is a complex and highly dynamic process. The concentrations of the various pollutants present in the water, characterized by a complex and time depend on the dynamics:

- Intensity of the ponds;
- Rate of self-purification and precipitation;
- The volume of water mass, the nature and speed of its movement;

Each of these factors is relatively independent of contamination from the other and has its dynamics. These contaminants have been deposited into water bodies with wastewater from industrial and agricultural enterprises, municipal areas with surface runoff due to runoff from contaminated areas during the deposition from the atmosphere, from the secondary chemical transformation processes of pollutants from natural sources. Information sources and methods of mapping surface water contamination are different for different card sizes. For the creating a survey of small-scale maps are enough published in yearbooks information about the long-term average levels of contamination at gauging stations, as well as the volume and structure of discharges by city. In this case, linear marks (rivers) and ranges (for lakes and reservoirs, expressed on a scale map) classes are characterized by the quality of water for stretches of major rivers and lakes, the levels and composition of pollution, the volume and composition of the discharges, technogenic load on water objects.

In the study of diffuse pollution sources in rural areas, the mapping area was divided into watersheds particular order depending on the scope of the research. Mapping of surface water pollution based on field measurements expeditionary research is less common due to the high mobility of the water environment and, accordingly, the rapid variability in pollution. Pollution of various components of the natural environment is one of the most obvious manifestations of the impact of society on nature. In its structure and dynamics, pollution has global trends, but it is manifested uniquely for each section of the territory; occurs under the influence of both technogenic and natural factors in almost all components of the geosystem. Therefore, it is extremely urgent to develop methods for cartographic support of a scientifically based assessment of the state of territories by identifying the pollution structure of various components of the environment. Cartographic approaches are most effective at the local level. This scale of the study allows us to combine the detail of the displayed information with the clarity of the transfer of the general laws of development of pollution processes, and when using modern geoinformatics, it significantly increases the efficiency and effectiveness of the analysis of environmental and geographical information.

The purpose of our study is the practical implementation of integrated mapping of pollution of the territory of Lake Burabay and Ulken Shabakty for its environmental and geographical assessment using modern geographic information technologies. Following the purpose of the work, the following tasks were set:

- give a general description of geographic information systems;
- identify the level of pollution of the Lake Burabay and Ulken Shabakty;
- develop a map-scheme of pollution of Lake Burabay and Ulken Shabakty using the ArcView 9 geographic information system.

2. Materials and Methods

Ecological mapping is the science of methods for collecting, analyzing, and mapping the information on the state of the human environment and other biological species on the environmental situation [1]. Accurate and reliable data play a crucial role in monitoring the environmental situation. The source of information for environmental mapping is remote sensing data, qualitative and quantitative data, expeditionary and stationary studies of the state of the components of the environment, and the state of bio-indicators. The relevance of the use and the distinctive role of modern cartography in the study of environmental and geographical problems is that it allows using maps based on the principles of spatial-temporal modeling to study the properties of natural complexes, their changes in time, communication and spatial relationships [2, 3].

Today, surface water pollution caused by the intensive development of industrial production and population growth has become a global problem. Industrial and agricultural enterprises, as well as public utilities, consume large amounts of water, which after use re-enters the environment, contaminated with chemical, mechanical, biological substances. Depending on the source of pollution, such waters are called industrial wastewater or domestic wastewater. To display surface water pollution on an environmental map, it is advisable to use the method of localized diagrams. Chart icons in the form of multi-colored and different-sized columns convey the chemical composition and amount of pollutants present at the sampling site [2-6]. With the expansion and deepening of environmental measures, one of the main areas of GIS application is monitoring the consequences of actions taken at the local and regional levels. Sources of updated information may be the results of ground-based surveys or remote observations from air transport and space. The use of GIS is also effective for monitoring the living conditions of local and introduced species, identifying cause-effect chains and relationships, assessing the favorable and adverse effects of environmental protection measures on the ecosystem as a whole and its components, making operational decisions on their adjustment depending on changing external conditions [3,4].

GIS greatly simplifies the publication of any kind of cartographic products. Using the built-in software language (for example, ARC / INFO ARC Macro Language (AML)), one can write programs to automatically create any type of printed card, graph, chart, and table. Also, simple software products (such as ArcView GIS) allow anyone, even inexperienced users, to view and directly operate on the data contained in the GIS database. Using such simple and easily accessible programs, any user can read and print maps (recorded, for example, on CD-ROM in GIS format ARC / INFO) [5-6]. GIS has certain characteristics, which rightly allow us to consider this technology as fundamental for processing and managing information. GIS tools far exceed the capabilities of conventional mapping systems, although naturally, they include all the basic functions of obtaining high-quality maps and plans. The GIS concept itself contains comprehensive capabilities for collecting, integrating, and analyzing any data distributed in space or tied to a specific place. If it were necessary to visualize the available information in the form of a map, graph or diagram, supplement or modify the database, integrate it with other databases - the only right way would be to access the GIS. In the traditional view, the possible limits of integrating heterogeneous data are artificially limited [7-9].

GIS allows researchers to go much further. Demographic information, information on land ownership, welfare and income of the population, volumes of capital investments and investments, zoning of the territory, condition of the bread market, etc. can be added to the above data set. As a result, it becomes possible to determine the effectiveness of planned or ongoing conservation measures, their impact on people's lives and agricultural economies. Researchers can go even further and add data on the spread of diseases and epidemics, establish whether there is a relationship between the rate of degradation of nature and human health, and determine the possibility of the emergence and spread of new diseases. In the end, it is possible to accurately assess all the socio-economic aspects of any process, for example, reducing the area of forestland or soil degradation [11-12].

GIS is successfully used to create maps of key environmental parameters. In the future, upon receipt of new data, these maps will be used to identify the extent and rate of degradation of flora and fauna. When entering data from remote, in particular satellite, and conventional field observations, it can be used to monitor local and large-scale anthropogenic impacts. Data on anthropogenic pressures should be superimposed on zoning maps of the territory with highlighted areas of particular interest from an environmental point of view, for example, parks, reserves. Assessment of the state and rate of degradation of the environment can also be carried out on the test plots allocated on all layers of the map. [14].

The functional integrated capabilities of GIS in the most explicit form are manifested and conducive to the successful conduct of joint interdisciplinary research. They provide the unification and overlapping of each other of any data types, if only they are displayed on the map. Such studies include analysis of the relationship between population health and a variety of (natural, demographic, economic) factors; quantitative assessment of the influence of environmental parameters on the state of local and regional ecosystems and their components; determination of landowners' income depending on the prevailing soil types, climatic conditions, remoteness from cities; identification of the number and density of distribution areas of rare and endangered plant species, depending on the height of the area [13-15].

3. Results

Figure 1 is a map of pollution in the lake Ulken Shabakty. On the map are given in terms of sampling, the results of hydrochemical and hydrobiological analysis identified a class of water quality of the reservoir. It was found that in the majority of samples Lake Ulken Shabakty refers to moderately polluted, as indicated in the sampling sites purple circle. According to hydrobiological analyzes found in the lake Burabay flowering reservoir for all sampling points, reflected on the map in green.

IOP Conf. Series: Materials Science and Engineering **901** (2020) 012017 doi:10.1088/1757-899X/901/1/012017

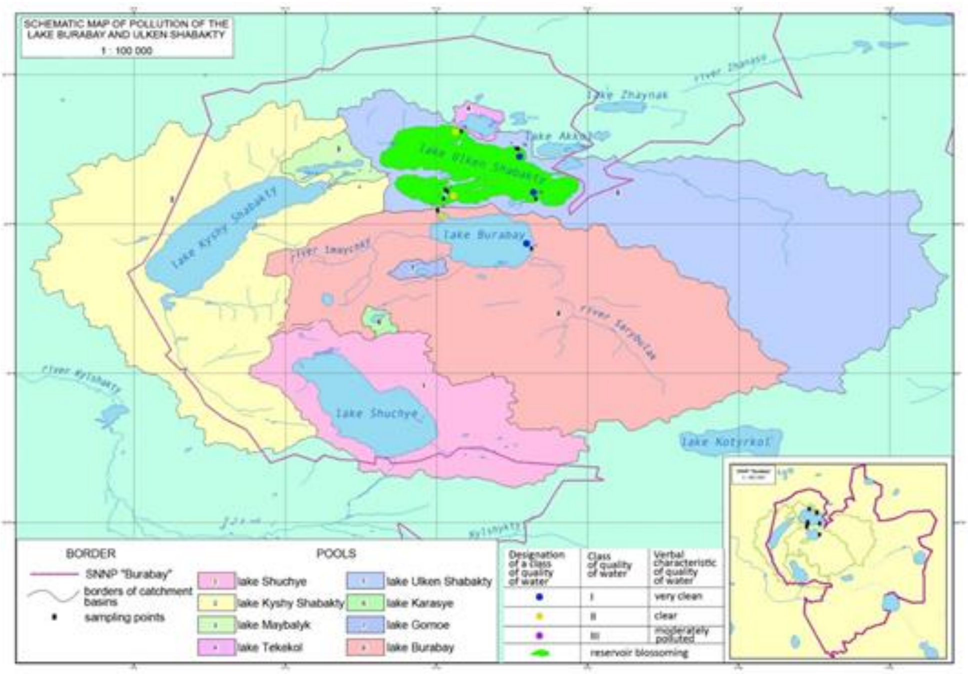

Figure 1. Map of pollution in the lake Ulken Shabakty for Q3 2013.

The following types of environmental maps were constructed based on long-term hydrochemical analyzes in the sampling points and lakes Burabay, Ulken Shabakty. Fig. 2 shows a schematic map of the average concentrations of phosphate per year in mg/dm2. The analysis shows that the concentration of phosphates in the lake Burabay was sharply exceeded in 2011 and the lake Ulken Shabakty phosphate since 2009 gradually increases from 0.004 to 0.01.

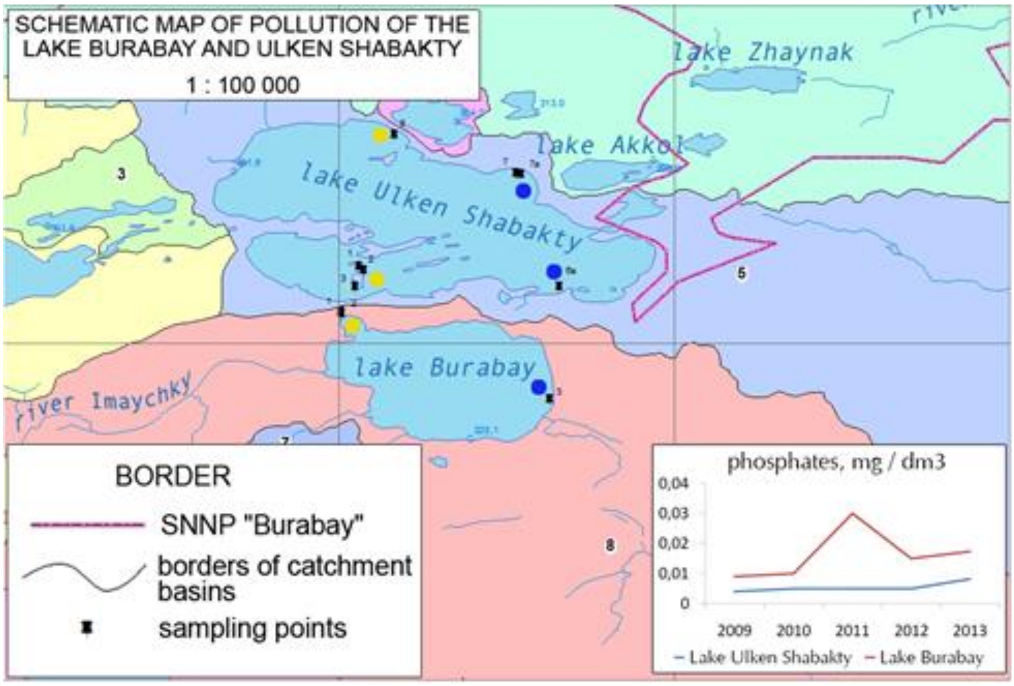

Figure 2. Schematic map of the indicators of phosphates in the lake Burabay and Ulken Shabakty.

In the next Fig. 3 was given changes in the nitrate concentration in mg/dm^2 for 2009-2013. In the sampling points, which shows a sharp increase in nitrite in 2011, and low levels of nitrite in the lake Ulken Shabakty. Nitrate concentration as major ions containing nitrogen, is of great importance in the assessment of rivers and lakes is given in the following Fig. 4. On the map is a visible upward trend in nitrate levels in both lakes. With this trend in 2011 was a sharp increase in the concentration of nitrates in Lake Burabay and the lake Ulken Shabakty. The concentrations of nitrates had elevated in nitrate levels in lakes in 2012, then again in 2013. The concentration of ammonia was increased from 2009 to 2011 and then in 2012 she went again and the lake Burabay and Lake Ulken Shabakty (Fig. 5).

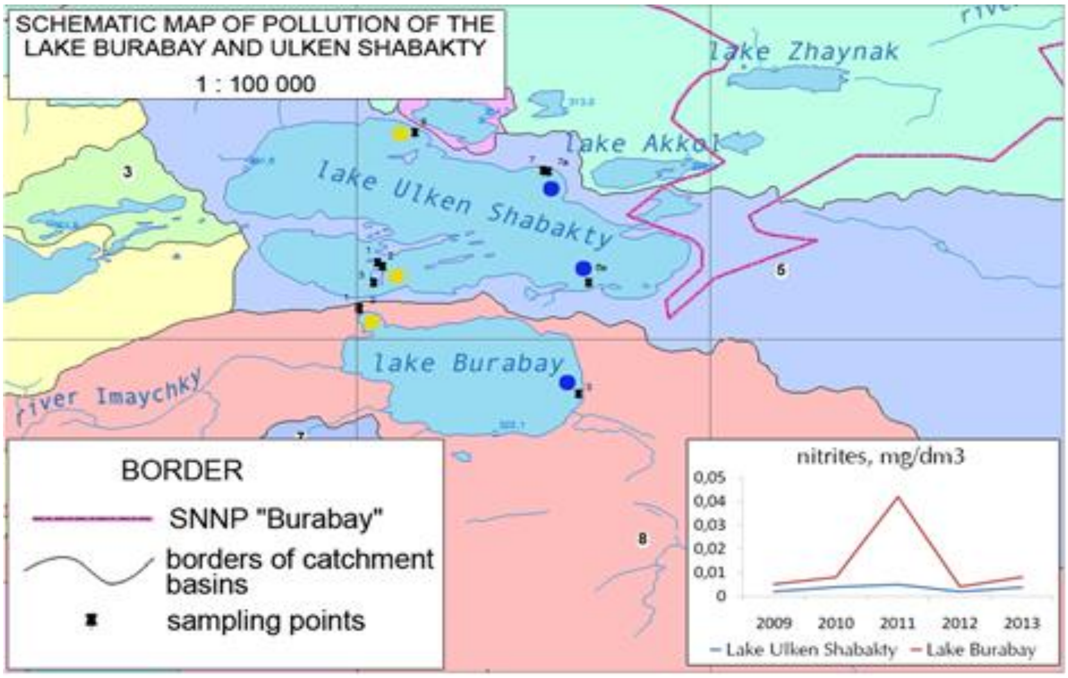

Figure 3. Schematic map of the indicators of nitrite in the lake Borovoe and Ulken Shabakty.

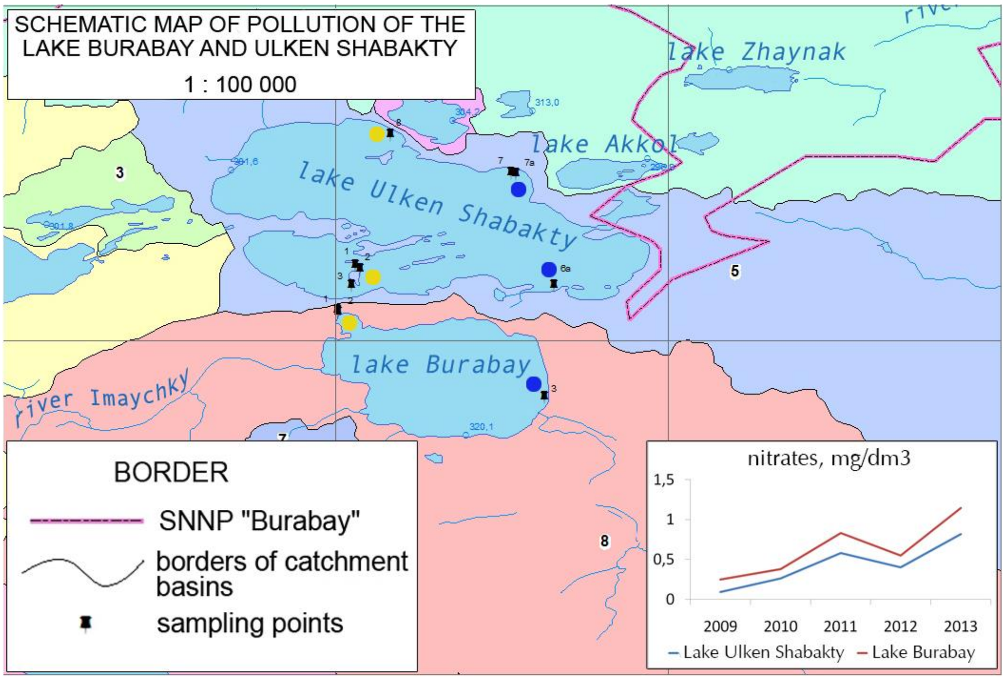

Figure 4. Schematic map of the indicators of nitrite in the lake Burabay and Ulken Shabakty.

IOP Conf. Series: Materials Science and Engineering **901** (2020) 012017 doi:10.1088/1757-899X/901/1/012017

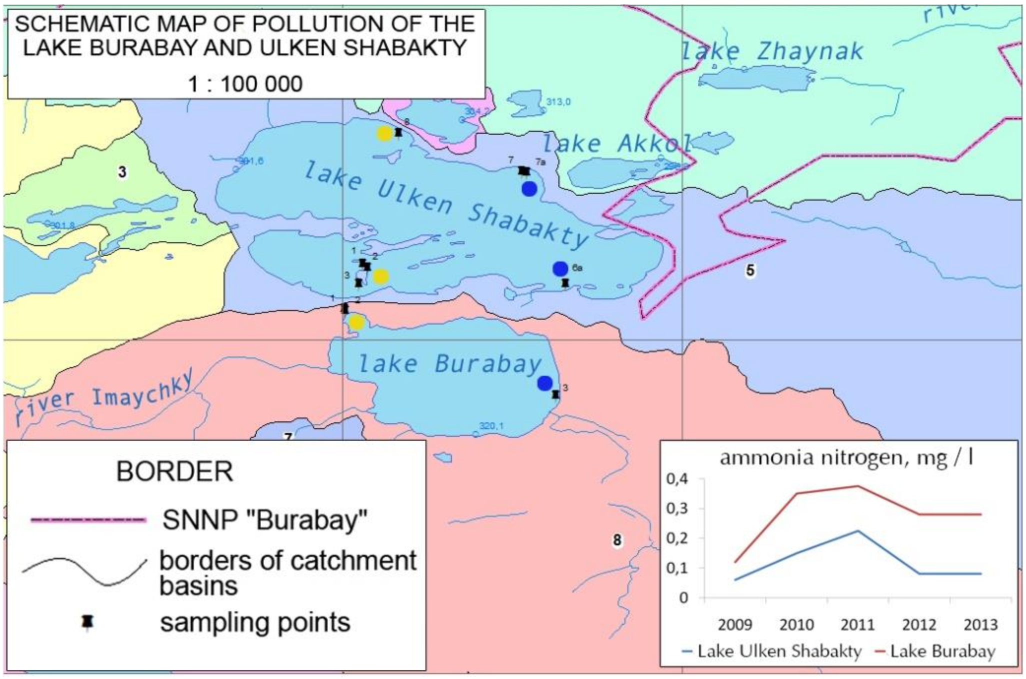

Figure 5. Schematic map of the indicators of ammonium nitrogen in the lake Burabay and Ulken Shabakty.

4. Discussion

Thus, started to develop pollution maps allows us to reflect data obtained from field studies in the form of complex maps for better integration of diverse environmental information. Integrated card fully and accurately represents the ecological state of the territory, make it possible to take fully into account changes in the nature and their impact on human, allow displaying a set of interrelated objects and develop recommendations for the organization and monitoring "flowering" of water.

- Development of maps of water pollution, drinking, and fishing industry.
- Creation of integrated environmental maps to reflect the status of water bodies and to identify the localization of environmentally favorable and unfavorable regions.

When monitoring surface water quality, observe the following principles: comprehensive and systematic observation of the terms of their consistency with the characteristic hydrological situations determination water-quality uniform methods. Mass development of some algae in reservoirs, lakes, and ponds leads to a malicious "blooming" of water. Harmfulness of mass development of algae, especially cyanobacteria (blue-green algae), is the production of a large number of dangerous to human health and animal potent toxins, reducing water quality, aesthetic appearance of a violation of the reservoir, and others. The products of cyanobacteria were hardly utilized by representatives of the upper trophic level. Algal blooms, ultimately, leads to an overall degradation of aquatic ecosystems. This phenomenon in recent years in the world is becoming one of themselves negative processes affecting the functioning of all living things. "Blooms" entails a chain of negative consequences in the form of a fish kill, mass mortality of benthos, plankton and neuston animals and waterfowl and mammals. Also, another problem for a person associated with a change in flowering water it is smell and taste in the water security.

Despite numerous studies conducted by foreign scientists, the study of the genesis of toxic and odor-producing substances and controls on toxic organisms remains an urgent problem and has a national character in many countries. In the future, it might turn into a global problem. Analysis of hydrochemical state of water lakes Ulken Shabakty and Lake Burabay (control), enabled to establish changes in the environment, or anticipating the coming of the "blooming". In the first two reservoirs during field studies, we noted the "blooming" of water, but in such a lake Burabay phenomenon was not observed, we find that the water content before flowering nitrite nitrogen is reduced and the ratio of nitrogen to phosphate is reduced in the range of 30-65. However, this phenomenon should be studied more detailed.

IOP Conf. Series: Materials Science and Engineering **901** (2020) 012017 doi:10.1088/1757-899X/901/1/012017

It is noted also that the "bloom" in natural waters is always observed high water temperatures from 23-25°C up to 28°C and increasing the pH from 8 to 8.5. At the "bloom" there is a tendency to reduce the content of dissolved oxygen, which increases immediately after the end of the "blooming".

5. Conclusion

According to the results of research, the following conclusions can be drawn out: Development of an electronic map of contamination of water bodies will be a significant contribution to improving the quality of the monitoring, modeling, and forecasting of ecological status of potable water, fishery and recreational facilities.

References

[1] I.A. Sutorikhin, Mathematical-cartographic support for the creation of information-analytical system "Water and ecology of Siberia. IA Sutorikhin, OV Lovtskaya, IN Rotanova//Computational technologies. - 12 T - Special Issue 3, (2007) 66-72.

[2] Geoinformatics: Trainee for schools., Edited by V.S. Tikunova. - M.: Publishing Center "Academy". 2005, pp. 475-480

[3] C.W. Fetter, Applied Hydrogeology, Prentice-Hall, 4th Edition. 2001, pp. 125-132

[4] J.P. Wilson, Fotheringham, A.S. The Handbook of Geographic Information Science, Malden, MA: Blackwell Publishing., (2007) 3-6

[5] M.Y. Dubinin, Open Desktop GIS: an overview of the current situation /M.Yu.Dubinin/ Newsletter GIS Association. №5 (72), 2009, pp.20-27.

[6] A.S. Tulebekova, Control equipment for pile test according to American and Kazakhstan standards, Modern Applied Science, 2015, pp. 192-198.

[7] A.S. Turashev, A.S. Tulebekova, T. Muzdybayeva, and E.T. Uzak, Analysis of the interaction between construction and soil ground under influence of the static load. 14th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, 2011.

[8] M.F. Goodchild, Twenty years of progress: GIScience in 2010, Journal of Spatial Information Science, 2010 DOI:10.5311/JOSIS.2010.1.2.

[9] V.V. Shcherbakov, Information systems. Structure GIS techniquesю Creation and use. Ekaterinburg, (2002) 9-11

[10] S.L. Dingman, Physical Hydrology, Prentice-Hall, 2nd Edition, 2002, pp.235-245

[11] Y. Korolev, Overall Geoinformatics - M: "The Academy". 2001, pp. 450-458

[12] S. Harbaugh, Current and future geographic information system projects within the eastern Gulf of Mexico, and the potential for one universal application. Int. Oil Spill Conference, British Columbia, Canada, 2003.

[13] K.S. Meiramkulova, M. Zhumagulov, G.Y. Saspugayeva, Zh. Zhakupova, M. Mussimkhan, Treatment of poultry slaughterhouse wastewater with combined system. Potravinarstvo Slovak Journal of Food Sciences, 13(1), 2019, pp.706-712

[14] N.Y. Ramazanova, Z.G. Berdenov, S.K. Ramazanov, N.B. Kazangapova, S.M. Romanova, S.T. Toksanbaeva, J. Wendt, Landscape-geochemical analysis of steppe zone basin Zhaiyk, News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, 2019, № 4(436) pp. 33-41

[15] G.S. Aidarkhanova, G.E. Saspugayeva, K.B. Massenov, E.T. Abseitov, K.M. Satova, Ecological assessment of the quality of crop production supplied to the markets of major cities in Central Kazakhstan. The study of contamination of agricultural plants radionuclides and heavy metals, Oxidation communication. №2, 38, Bulgaria, 2015 pp.900-904