Iranica Journal of Energy & Environment 5 (3): 247-258, 2014
ISSN 2079-2115
IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology
DOI: 10.5829/idosi.ijee.2014.05.03.04

BUT

# Analysis of Ecological Condition of Lakes Burabai and Ulken Shabakty in Republic of Kazakhstan

*[1]A.A. Ismailova, [1]A.K. Zhamangara, [2]Park S. Ya,*
*[2,3]A.I. Abakumov, [1]A.A. Adamov and [1]R.M. Muratov*

[1]L.N. Gumilyov Eurasian National University, Astana, Kazakhstan
[2]Institute of Automation and Control Processes, FEB RAS, Vladivostok, Russia
[3]Far Eastern Federal University, Vladivostok, Russia

Date of Received: July 4, 2014; Date of Accepted in Revised Form: August 4, 2014

**Abstract:** The information-analytical system (IAS) "Monitoring of aquatic ecosystems" was developed for the analysis of ecological lakes condition in Kazakhstan. It consists of a database on hydrochemical and hydrobiological characteristics for lakes Burabai and Ulken Shabakty in Shchuchinsk-Borovoye resort area of the Republic of Kazakhstan, as well as a set of statistical data processing methods. Qualitative analysis of data was made on the lakes. Data on biogenic substances for the years 2007-2013 were analyzed based on statistics. Dynamic characteristics and seasonal features of changes were identified in the concentrations of biogens. There is an absence of significant relationships between the concentrations of various biogenic substances in lakes and between lakes. Nitrogen substances were compared. The phosphorus compounds have a large stability that can contribute to a more stable life of phytoplankton species which are related to phosphorus.

**Key words:** Statistical analysis · Hydrobiology · Hydrochemistry · Classification of lakes · Mathematical modeling

## INTRODUCTION

Shchuchinsk-Borovoye resort area has great recreational and tourist value. At the same time, the ecological status of the region is quite complicated. Pollution exceeding maximum permissible concentration (MPC) dozens of times are captured in a village Borovoye. Major complexes of recreation institutions, fixed on the coast lakes Burabai, Shuchye, Ulken (Big) and Kishi (Small) Shabakty and extends along the highways. As a result of irretrievable water intake for industrial and drinking and sanitary needs, plowing on the slopes, deforestation in the catchment area pollutants and organic substances are washed away, which increases the processes of lake siltation [1].

Compared to the surrounding areas, the territory of the state national park characterized by an abundance of water resources, mainly, fresh or brackish lakes, whose number reaches 22, fourteen of which are classified as large, such as Kishi Shabakty, Ulken Shabakty, Borovoye, Shuchye, Katarkol and so on.

Lakes are located in scenic locations in the foothills completely or partially surrounded by forests. The shores, on the one hand are steep, rocky, on the other - the lowest often sandy. Also the structure of lake shores correspond to the relief of their basins: in the cliffs lakes have the greatest depth and underwater slope is steep and precipitous.

Currently, the level of all lakes is lowering except Lake Borovoye, which maintained a constant water balance. Lakes are mainly fed by groundwater, but precipitation also plays a significant role in the nutrition of lakes.

Area is characterized by poor development of the river network. Small river basin of lakes Borovoye - Sarybulak and spring Imanaevsky are the most significant

**Corresponding Author:** A.I. Abakumov, Far Eastern Federal University, Vladivostok, Russia. E-mail: a.ismailova@mail.ru .

**Please cite this article as:** A.A. Ismailova, A.K. Zhamangara, Park S. Ya, A.I. Abakumov, A.A. Adamov and R.M. Muratov, 2014. Analysis of Ecological Condition of Lakes Burabai and Ulken Shabakty in Republic of Kazakhstan. Iranica Journal of Energy and Environment, 5 (3): 247-258

of watercourses, in the basins of lakes Shchuchye, Katarkol and Maybalik there's no watercourses, the basin of the lake is dominated by temporary streams of Kishi Shabakty. In the Lake Ulken Shabakty creek Arykpay is regulated, runoff in watercourses is practically absent; the runoff in the river Gromotukha depends on the threshold of flow from lake Borovoye. Rivers fed mainly due to spring snowmelt and summer rains, also partly due to groundwater.

Almost all lakes are characterized by the significant shrinkage of their water area in recent decades, with the speed of 14-17 cm per year. Apparently, the reasons are: reducing the inflow of melted water resulted by a small amount of snowfall in the winter and holdup melted water runoff by dams on the rivers and temporal watercourses, an increase of evaporation and water consumption by consumers.

## MATHERIALS AND METHODS

**Ecological and Geographical Description:** Lake Burabai (Auliekol) - located within Kokshetau Highland, at the eastern foot of Kokshe, north of Lake Shchuchye (Fig. 1). Area of water surface is approximately 11 square kilometers. The average depth of the lake is 3.4 m, maximum depth is observed in the north and makes up to 7 m. Water surface of the lake is mostly open, only the western and north-western coasts covered with reeds and rushes.

The bottom is flat sloping to the north, the coast is sandy and rocky, silty in the middle and the power of silt in the northern part of the lake Burabai is 0.5-1.0 m, 1.6 m in the southern part. The lake has several small bays. In the northwestern gulf a rocky island "Sphinx" is located shaped like a fungus and towering over the water at 20 m. Southern, western and northern shores of the lake are composed of granite, sometimes rising above the water in the form of the cliffs. The eastern shore is sandy, gently sloping; there's a berm near the water's edge with width 2.5 m and height 1.5 m. Lake is flowing.

It is filled by the river Sary-Bulak in the southeast, creek Imanaevsky and two unnamed creek in the west. Lake Kurkureuk with 1.5 km long flows from the lake to its north-eastern part and discharge water into the nearby lake Aynakol. Monitoring observations on lakes had been conducting in North Kazakhstan hydrogeological station since September 1945 [1, 2].

Lake Ulken Shabakty (Aynakol) - the largest lake among Burabai group which is located 16.5 km to the north of Schuchinks (Fig. 1). Water surface area is about 23 square kilometers. The average depth of the lake is 11.1 m, maximum - 33.3 m. The lake is open without aquatic vegetation, which is explained by the presence of the great depths. The northern and eastern shores of the lake are gentle, southern and western shores are steep formed by the mountain massif slopes. There are several small islands on the lake which form seamounts and ridges. The bottom of the lake is composed of yellowish-brown clay, silt covered with capacity of up to 2 m. The lake is closed. In the western end of the lake there is a vast shallow to 1.5 meters deep bay, the soils of which are coarse sand and gravel. Pebble and gravel soils are also located around the ridge of islands, but they are highly silted. In the middle of the lake soils are presented as silts. There are mountains on the southern side covered with mixed forests with a predominance of conifers and hilly plain on the north side covered with steppe grasses [1, 2].

Information-analytical system "Monitoring of aquatic ecosystems": Information-analytical system (IAS) consists of information and analytical subsystems. Analytical subsystem is currently provided by the computer applications Microsoft Excel 2007 and STATISTICS which are connected to the information subsystem. An analysis of the aggregated data is carried out by standard statistical methods of research with the help of these packages [6-10]. Details about structures included in the methods of analytical subsystem are represented in the following sections together with an analysis of data on the lakes. Here are the structure and function of the information subsystem.

An information subsystem was created which consists of a database that contains geographical, hydrobiological and hydrochemical data on reservoirs of Kazakhstan. At the moment data on lakes Burabai and Ulken Shabakty are assembled and filled in [2].

Information subsystem includes two databases:

- Primary hydrobiological data;
- Hydrochemical data.

The data are dated and may be supplemented; the system monitors the correctness of records; extensions are given for data listed by user. The system requires a mandatory registering or logging in with passwords. To search, choose and view the information standard system is used to query the database with a specially designed system of menus and dialogs.

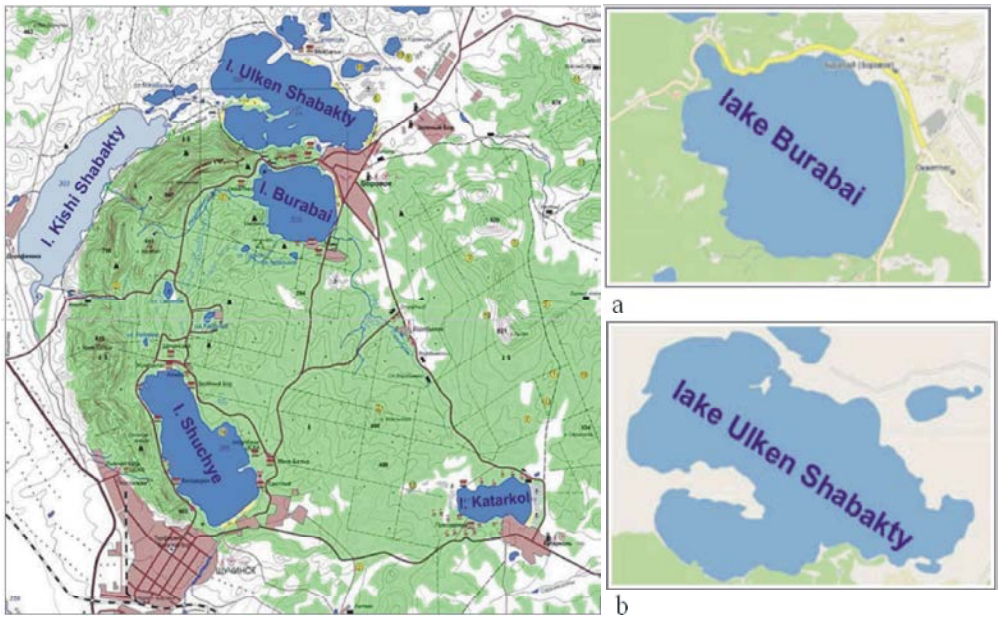


Fig. 1: Lakes in Shchuchinsk-Borovoye resort area: a - lake Burabai, b - lake Ulken Shabakty

The basic functionality of the information subsystem:

- Input, editing and processing information;
- Implementation of a variety of database queries, search for objects in the tables;
- Quick extract of required information (by years, by type, by name);
- Calculation of the maximum, average, total value of the selected search parameter;
- Calculation of period of time and values exceeding MPC of harmful substances for fishery reservoirs according to certain parameters;
- Output of results in various forms, including printing.

Subsystem includes comments and links to data sources.

Hydrobiological database includes primary hydrobiological data on the place, date and sampling conditions, taxonomic supplies quantity biomass, as well as ecological groups and functional characteristics of aquatic organisms (phytoplankton, zooplankton, bacterioplankton, periphyton, zoobenthos, pigment composition of microalgae, macrophytes) and the corresponding iconography.

Hydrochemical database consists of following main tables: "Information about system users", "Choice of reservoirs," "Properties, gas composition, major ions," "organic pollutants" "Biogenic components and inorganic contaminants".

The table "Biogenic components and inorganic contaminants" contains the following data: sampling time, date (dd / mm / yy), ammonium nitrogen (mg / l), nitrite nitrogen (mg / l), nitrate nitrogen (mg / l), the amount of nitrogen (mg / l), plumbum (mg / l), vanadium (g / l), molybdenum (µg / l), iron (3 +) (mg / l), cobalt (mg / l), mercury (mcg / l), phosphate (mg / l), silicon (mg / l), total phosphorus (mg / l), cadmium (mg / l), silver (mg / l), total iron (mg / l), iron (2 +) (mg / l), cuprum (mg / l), lead (mcg / l), manganese (mg / l), arsenic (g / l), zinc (mg / l), fluorides (mg / l), nickel (mg / l), cyanide (mg / l), total chromium (mcg / l), chromium 6 + (g / l), chromium 3 + (g / l), thiocyanates (mg / l), boron (mg / l).

The table "Properties, gas composition, major ions," contains the following data: sampling time, date (dd / mm / yy), width, depth (m), speed of current (m / s), water flow (cubic meters / s), the sample storing time (in days), the flow of waste water ($m^3$/s), smell (pts), salinity (mg / l), transparency (cm) temperature (°C), hydrogencarbonate (mg / l), suspended substances (mg / l), carbonates (mg / l), pH, sodium (mg / l), oxygen (mg / l), potassium (mg / l), oxygen saturation (%), calcium (mg / l), carbon dioxide (mg / L), transparency according to a DB (m), hydrogen sulfide (mg / l), magnesium (mg / l), chloride (mg / l), sulfates (mg / l).

The table "Contaminants organic" contains the following data: sampling time, date (dd / mm / yy), color, dichromate oxidation (µg / l) BOD5 (biochemical oxygen demand) (µg / l) volatile phenols (mg / l), alpha-HCH

(hexachlorocyclohexane) (g / l) resin and asphalt (µg / l), gamma-HCH (hexachlorocyclohexane) (µg / l), oil products (µg / l), Council-HCH (hexachlorocyclohexane) (µg / l), fats (µg / l), dicofol (mg / l), detergents (synthetic surfactants active ingredient) (µg / l) HCB (hexachlorobenzene) (µg / l), phenols sum (µg / l), xanthogenates (µg / l) carbohydrate (µg / l).

When creating a database of information subsystem MySQL 5.5.20 was used; this is included in WampServer 2.2 and operates harmoniously with technology Java. NetBeans was used - a free integrated development environment (IDE) on programming languages Java, Python, PHP, JavaScript, C, C + +, Ada and several others. In recent years cloud technologies are available for NetBeans and special plugins are required to set that make it easy to work with applications. Data may be stored in a cloud; it simplifies the management applications process. NetBeans IDE provides many opportunities for the DBMS. We can create a database on registered server directly from NetBeans, connect it immediately by opening the context menu of connection, to create a table, open it using the command View Data, go to the fill mode button InsertRecords and fill the table with all the required data [3, 4].

The created database is not final and may be supplemented by new data and other reservoirs.

**The Data Analysis:** Analytical subsystem consists of deterministic and statistical data processing methods [5-9]. Deterministic methods are limited to simple tools for sorting data averaging, calculating the maximum and minimum values. Statistical methods are presented in the form of sequence graph and contain the analysis of the type of probability distribution, point and interval estimation of parameters, hypothesis testing, regression and dispersion analysis and multivariate statistical methods.

In this paper information on biogenic substances are selected to illustrate the application of the methods. These mineral substances are based on nitrogen and phosphorus. They provide phytoplankton with food during photosynthesis and play an important role in the ecosystem of the reservoir [10]. Study of biogenic substances allows to identify patterns of condition and dynamics of hydrobiological indicators. In turn, this leads to an assessment of the environmental condition of the reservoir. The ratio of nitrogen to phosphorus compounds is particularly important. For the analysis concentration of nitrogen in the nitrite compounds, nitrates and ammonium salts and the total phosphorus in the two investigating lakes are selected. In addition, the dynamics of integrated concentration of biogenic elements have analyzed as reservoirs are interconnected. Data on their specific concentrations in the composition of samples taken per month for 7 years, from 2007 to 2013 were used to construct the seasonal dynamics of each of the observed elements. On Lake Ulken Shabakty data were analyzed for six years, starting from 2008. In the Figs. 2-5 below the vertical axis is the concentration of substance in mg/l and the horizontal axis - the time in months. Tables 3-7 are the concentrations of substances in mg/l.

## RESULTS AND DISCUSSION

**Classification of Lakes by Hydrochemical Indices:** The water of lake Burabai is fresh, the mineralization of water is 216 - 251 mg/l. Ionic composition of the water refers to hydro-class sodium group of the first type. Environment reaction is slightly alkaline; pH in the range of 7.64 - 8.35. The lake water is soft; hardness does not exceed 2.23 mEq/l. BOD5 quantity (1.55 - 2.61 mg $O_2$/l), the oxygen content ranges from 8.57 to 9.28 mg $O_2$/l.

Lake Ulken Shabakty is salted, total mineralization of water is about 853 - 918 mg/l. Ionic composition of the lake water of Ulken Shabakty refers more to the first rather than the second type of hydro-class sodium group. Environment reaction is slightly alkaline - alkaline, pH is about 8.2. The water in lake has a medium hardness - 7.24 mEq/l. Biochemical oxygen demand (BOD5) (1.10 - 1.88 mg $O_2$/l), concentration of dissolved oxygen in water varies from 6.6 to 9.00 mg/l.

By the degree of pollution, the lakes Burabai and Ulken Shabakty can be currently classified as between "clean" and "moderately polluted" (Table 1). Font number indicates in Table 1 the status of the lake: normal font signifies very pure status, italic font signifies pure status, bold font signifies moderately polluted status. Not specified units are given in the description of the IAS.

It should be noted that in 2009, all indicators of the lakes belonged to the "pure" and in subsequent years, such parameters as dissolved oxygen, ammonia nitrogen and pH indicate some water pollution.

Data on phosphorus load presented in Table 2 show that in 2007-2008 lakes were close to oligotrophic and in 2012-2013 have already approached the mesotrophic reservoirs [2, 11, 12].

Currently, according to the classification of the content of total phosphorus, both lakes relate to mesosaprobic type [3, 5].

Table 1: Chemical, physical and organoleptic characteristics of condition of lakes Burabai and Ulken Shabakty in 2009-2013

| | Dissolved oxygen in mg/l | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lakes | Summer | Winter | % of saturation $O_2$ | BOD5 mg/l | Ammonia nitrogen (mg/l) | Suspended substances | Smell | pH |
| 2009 | | | | | | | | |
| Lake Burabai | 9.18 | 11.4 | 89 | 1.2 | 0.06 | 10.3 | 0 | 8- 8.75 |
| Lake Ulken Shabakty | 9.18 | 11.4 | 87.8 | 1.5 | 0.06 | 10.3 | 0 | 8 - 8.75 |
| 2010 | | | | | | | | |
| Lake Burabai | 8 | 8 | 75.5 | 1.6 | 0.2 | 9.33 | 0 | 6.25-8.65 |
| Lake Ulken Shabakty | 8 | 12.3 | 86.5 | 1.3 | 0.15 | 8 | 0 | 8.25-8.70 |
| 2011 | | | | | | | | |
| Lake Burabai | 8.86 | 10.6 | 78 | 1.5 | 0.15 | 6.7 | 0 | 7.45-8.65 |
| Lake Ulken Shabakty | 8 | 11 | 85 | 1.04 | 0.23 | 5.9 | 0 | 8.50-9.25 |
| 2012 | | | | | | | | |
| Lake Burabai | 8.81 | 10.28 | 82 | 1.7 | 0.2 | 2 | 0 | 7.25-8.55 |
| Lake Ulken Shabakty | 9.2 | 11.2 | 83.8 | 1.14 | 0.08 | 5 | 0 | 8.6-9.25 |
| 2013 | | | | | | | | |
| Lake Burabai | | 8.55 | 90 | 1.3 | 0.2 | $0.8_{min}$-$3.6_{max}$ | 0 | 8.6 -8.7 |
| Lake Ulken Shabakty | 8 | 10.12 | 81 | 1.1 | 0.08 | 5.6 | 0 | 8.85-9.00 |

Table 2: Phosphorus load of lakes Burabai and Ulken Shabakty (2007-2013)

| Years | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|
| | Lake Burabai | | | | | | |
| Annual average of total phosphorus, mg/l | 0.011 | 0.013 | 0.014 | 0.024 | 0.023 | 0.025 | 0.033 |
| | Lake Ulken Shabakty | | | | | | |
| | - | 0.009 | 0.010 | 0.020 | 0.023 | 0.021 | 0.026 |

Basic elements exceeding the maximum permissible concentrations in the lakes Ulken Shabakty and Burabai are sulfates, magnesium, fluoride, iron, aluminum, manganese and molybdenum. It is worth noting that according to data MPC the lake Ulken Shabakty has worse position. In the lake Burabai chemical elements, exceeding the norms MPC, comparatively less either by the quantity and the multiplicity of exceedance [2].

Lake Burabai in 2007-2008 in terms of water pollution index (WPI) classified as "pure" [13, 14]; there are no substances exceeding MPC during this period. In 2009, only fluoride exceeded MPC with the maximum excess of 16 times in June. Beginning from 2010 to 2011, in addition to fluoride, MPC exceeds copper, general iron and less often manganese. According to the WPI, the lake transit from "pure" to the class three, "moderately polluted". In the second quarter of 2012 in the lake Burabai the number of substances exceeding MPC increases significantly: fluoride, copper, total iron, zinc, total phosphorus, aluminum, cobalt, chemical oxygen consumption (COC). In the following months of 2012 exceeding of the MPC of such elements as zinc, cobalt and total phosphorus were not marked. In 2013, the list of substances with a high MPC includes only fluoride, molybdenum, manganese and total iron.

In the lake Ulken Shabakty in 2007 - 2008 years there is an excess of the maximum permissible concentration (MPC) of sulfate from 1.0 to 2.5 with the highest values in March and November. From 2009 to 2011 sulfates exceed the MPC 2.2 times, 2.6 times the magnesium and fluoride 17.7 times. Deterioration in water body begins with the second quarter of 2012. It is observed that there is an excess of MPC in not only previously mentioned magnesium, copper, sulphate, fluoride and also in total iron, aluminum, manganese, molybdenum and chemical oxygen consumption (COC). Heightened concentrations of these elements (except aluminum and indicators COC) were established also in 2013. Lake Ulken Shabakty, according to its water pollution index (WPI), refers to pollution class 4 [12]. It should be noted that the biogenic substances in both lakes do not exceed the norm.

Trend analysis of biogenic substances: We analyzed the smoothed dynamics of biogenic substances concentrations as trends. Data on nitrite, nitrate, ammonium and phosphorus from 2007 to 2013 were used for the statistical analysis of lakes condition. Samples were made monthly. To smooth the data over time, firstly, we examined the trends (moving averages) for four of these substances. Figs. 2 and 3 show moving averages with "windows" of averaging for 3 and 12 months. Averaging over three months allows you to see the seasonal features of the dynamics of substance concentrations. Averaging over 12 months shows interannual dynamics.

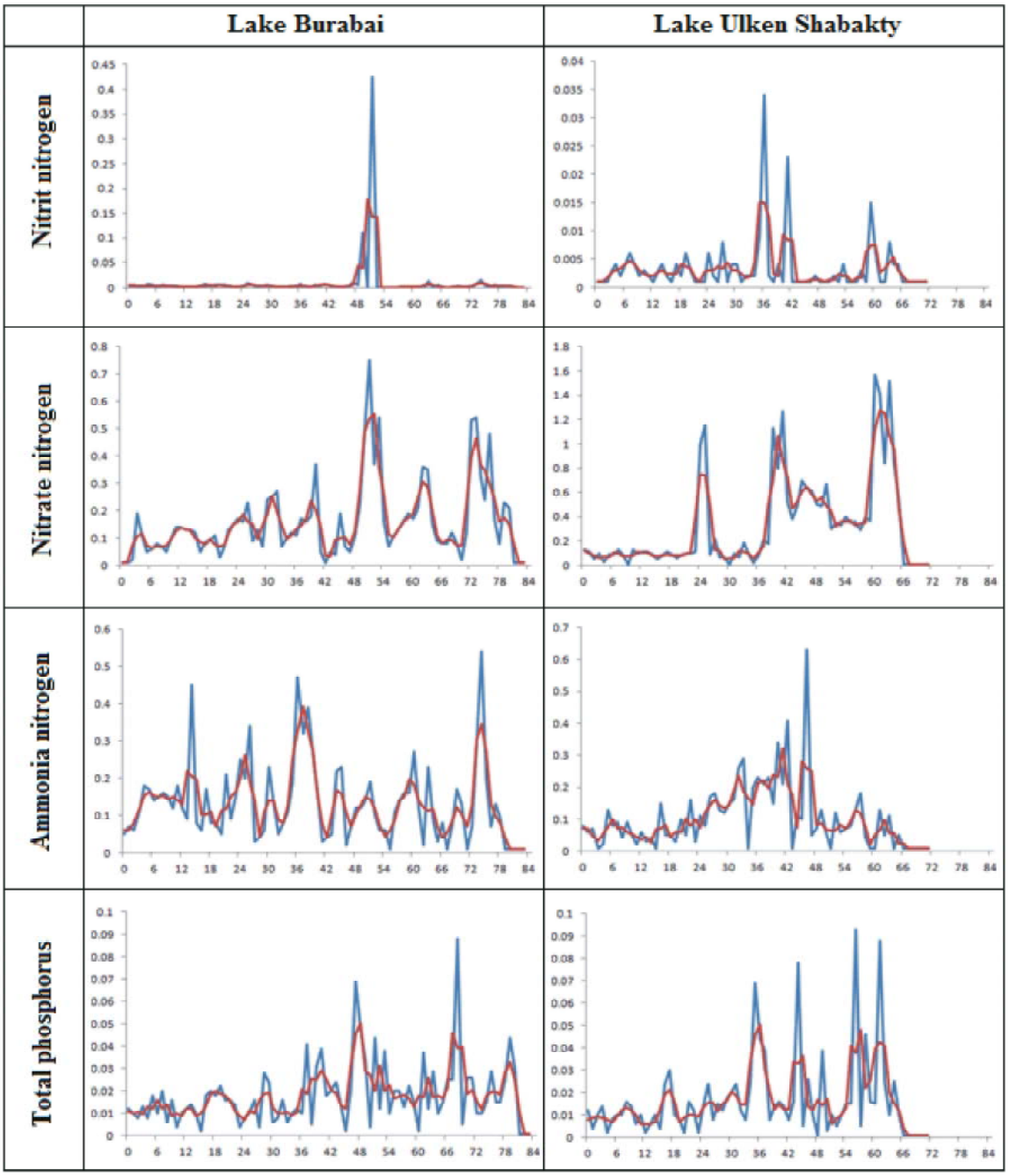


Fig. 2: Trends of biogens concentrations in two lakes with a three-month averaging

Seasonal fluctuations are amplified in the second half of the considered period. It is possible to assume that this effect indicates the increased human activity in the second decade of the XXI century.

Again, there is some increase in interannual estimation of substance concentrations in the second half of review period.

Averaging the assessment of standard deviations, they all, except nitrates, have the same order as the average values. For nitrates deviations are an order less than the trend values. By increasing the "window" of averaging from three to twelve months, standard deviations, of course, increase, but not significantly. For nitrates the increase is slightly higher. These facts indicate that the monthly deviations are large enough.

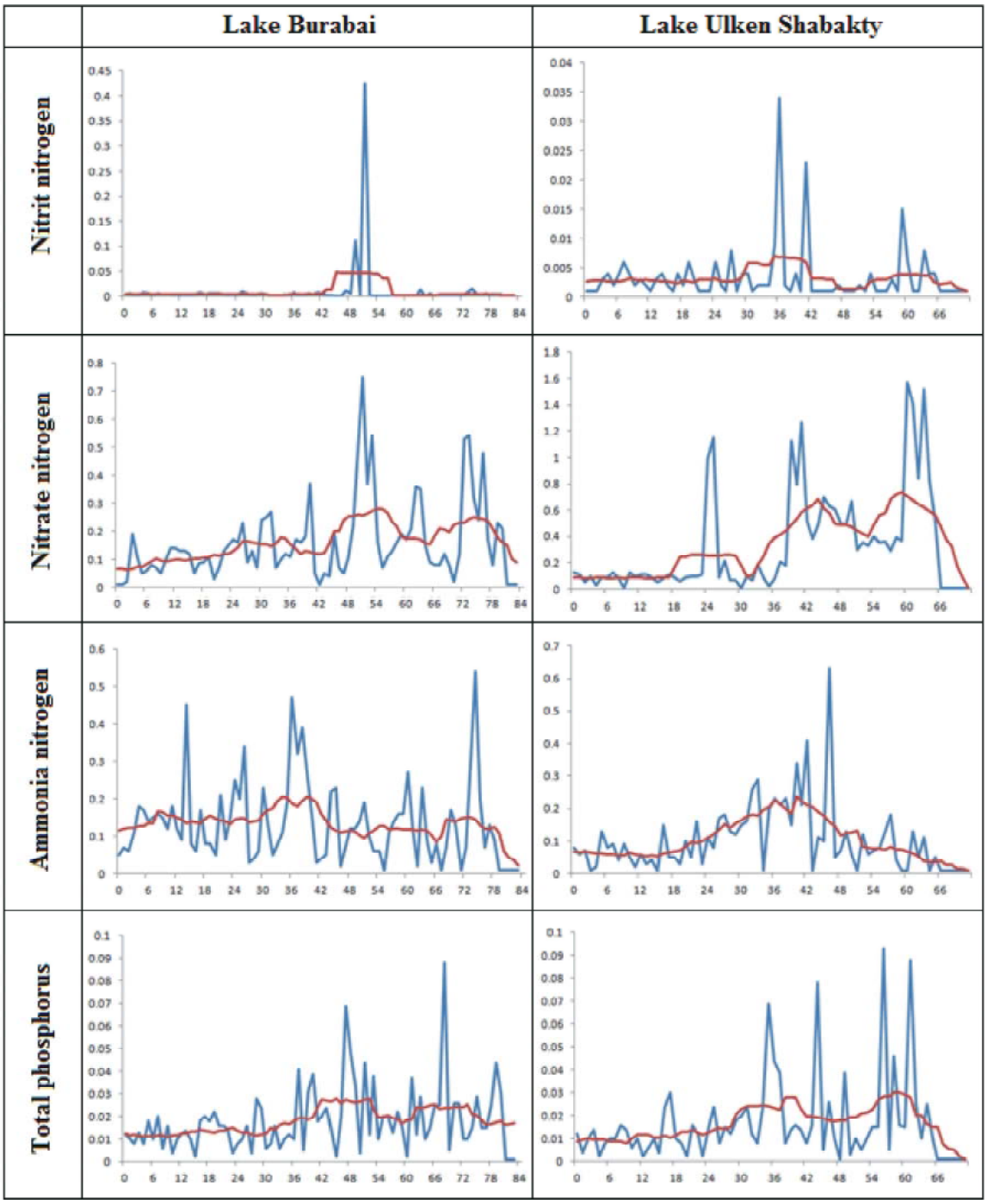


Fig. 3. Trends of biogenics concentrations in the two lakes with the twelve-month averaging

It is known that in different seasons in the reservoir ecosystem is dominated by various types of phytoplankton. Among other factors this is due to the amount of available mineral nutrition. However, there is a question for research which remains open about the qualitative composition of the substrate consumed by phytoplankton. In particular, it is useful to evaluate how significant seasonal fluctuations in concentrations of individual biogens in compare to their interannual variability. To construct such evaluations one way ANOVA (analysis of variance) scheme was used. These evaluation results are shown in Table 3.

Table 3: The value of Fisher criterion obtained in compare to intra annual variations

| | Nitrite nitrogen | Nitrate nitrogen | Ammonia nitrogen | Total phosphorus | Limit value at the level of 0.05 |
|---|---|---|---|---|---|
| Lake Burabai | 1.460 | 1.604 | 1.639 | 1.699 | 1.93 |
| Lake Ulken Shabakty | 1.914 | 1.434 | 0.987 | 0.503 | 1.94 |

Table 4: Pearson criterion values for the lognormal distribution compared to the limit values for the two levels of significance

| | | | | | Limit value for degrees of freedom 4 and 3 | |
|---|---|---|---|---|---|---|
| | Nitrite nitrogen | Nitrate nitrogen | Ammonia nitrogen | Total phosphorus | At a significance level of 0.05 | At a significance level of 0.01 |
| Lake Burabai | 25.8982 | 4.9588 | 4.6859 | 2.5660 | 9.49 (7.81) | 13.3 (11.3) |
| Lake Ulken Shabakty | 8.6031 | 9.8137 | 2.9480 | 5.5084 | | |

The results also show that the seasonal fluctuations are large enough compared to the interannual. Seasonal factor plays a significant role in changing biogenic substances concentrations.

**Statistical Data Analysis on Two Lakes:** Trend analysis showed that seasonal oscillations of concentrations of substances are sufficiently large. In an attempt to answer the question about the reliability of the data, we tested the hypothesis about their lognormal distribution (which is quite reasonable to assume for the tested data) and the number of "unnatural" values in the data. The presence of the lognormal distribution provides to use traditional criteria Student, Pearson, Fisher, etc. to analyze the data in a logarithmic scale [5, 6].

Assuming that the detection of a component in the sample is limited by the sensitivity of the device-analyzer, zero concentration approximated to the minimum value of the observed multi corresponding element. At the beginning, data from all four biogens are tested on the lognormal distribution for each lake. We use Pearson criterion for this test.

The frequencies for the concentrations of nitrite nitrogen distributed with three degrees of freedom, other substances with four.

The lognormal distribution can be questioned with a sufficiently low level of significance for nitrates and nitrites. Perhaps such behavior of data associated with the drainless of the second lake and therefore, a small number of factors affecting the concentration of nitrogen. We will use them to the traditional criteria, maintaining alertness, indicated in Table 4.

Further, interval estimations of the annual dynamics of biogens concentrations are built for each of the lakes and lakes for both together (Fig. 4). For each lake and for both of them together averaged dynamics of year and its interval estimations were constructed.

In the averaged year dynamics of biogens are more diverse in the spring and early summer compared with the second half of the year, although "outbursts" do happen in the ammonium and phosphorus in the fall and early winter (Figs. 4 and 5). Spring effects may be associated with the arrival of melt water and intensive development of phytoplankton. Flashes also occur in autumn in the phytoplankton biomass, which can affect the concentrations of ammonium and phosphorus.

Data which are not included in the confidence intervals were allocated. When data were reanalyzed it is revealed that there are indicators, the absolute values of which lie outside the boundaries of the confidence intervals. The proportion of such points varies from 0.083 to 0.286. These deviations do not have any natural character of manifestations; that is they do not depend on the season or on the reservoir in which they are recorded. Number of such points is almost always within 20%. In our view, this indicates a satisfactory quality of data collection and a good reliability.

Further, two lakes were compared with each other on the object identity of their dynamics to the same general set (Table 5). On the one hand, a small river flows from the lake Borovoye into the lake Ulken Shabakty. This can contribute to a synchronous behavior of the concentration of substances in both lakes. On the other hand, the lake Ulken Shabakty is drainless that, in general, contributes to the increased biogens content in it. Statistically, the task of comparing lakes can be formulated as follows: Is the set of specific concentrations of some element of the two lakes samples from the same set or not? To do this, we used Student's test (Table 5) [6, 7].

For all substances, except for nitrates, the hypothesis about one general set confirmed. The number of degrees of freedom in all cases is in the range from 105 to 145.

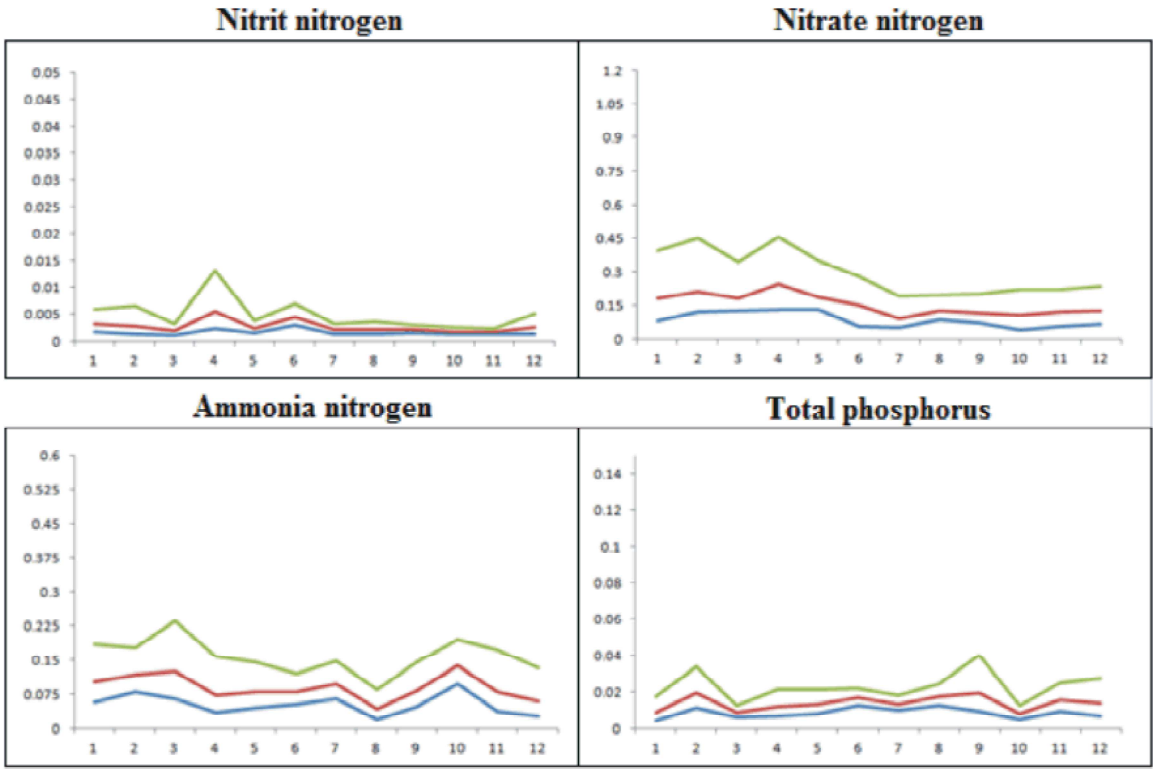


Fig. 4: Average annual dynamics of biogens with confidence intervals at a significance level of 0.05 over both lakes. Red denotes the average long-term. Green and blue colors represent lower and upper bounds of interval estimations

Table 5: Values of Student's criterion for the two lakes

| | Nitrite nitrogen | Nitrate nitrogen | Ammonia nitrogen | Total phosphorus |
|---|---|---|---|---|
| Value of Student's test | 0.905 | 4.090 | 1.291 | 0.194 |

Table 6: The correlation matrix of biogens communication for the lakes Burabai (above the main diagonal) and Ulken Shabakty (below the main diagonal)

| | Nitrite nitrogen | Nitrate nitrogen | Ammonia nitrogen | Total phosphorus |
|---|---|---|---|---|
| Nitrite nitrogen | 1.000 | 0.465 | 0.072 | 0.233 |
| Nitrate nitrogen | 0.154 | 1.000 | 0.216 | 0.137 |
| Ammonia nitrogen | 0.116 | 0.157 | 1.000 | -0.123 |
| Total phosphorus | 0.134 | 0.236 | 0.204 | 1.000 |

Table 7: The correlation matrix of biogens communication in lakes

| | | Lake Burabai | | | |
|---|---|---|---|---|---|
| | | Nitrite nitrogen | Nitrate nitrogen | Ammonia nitrogen | Total phosphorus |
| Lake Ulken Shabakty | Nitrite nitrogen | -0.029 | 0.018 | -0.095 | -0.013 |
| | Nitrate nitrogen | -0.045 | 0.272 | -0.036 | -0.013 |
| | Ammonia nitrogen | 0.322 | 0.093 | 0.035 | 0.167 |
| | Total phosphorus | -0.117 | 0.096 | -0.011 | 0.042 |

The corresponding limit value of Student's t test for them is 1.98. Consequently, we can neglect the differences between lakes in concentrations of all substances except nitrate nitrogen compounds. The obtained value exceeds the limit criterion 3.37 even at a significance level of 0.001. This could be the termination of communication between the reservoirs in winter, as significant differences in the concentrations of nitrate nitrogen is observed between the lakes in the first half of the year, that is in spring and early summer period. After June there is a "leveling" of these indicators. The value of Student's t test obtained for total phosphorus, in contrast, is much less than the limit.

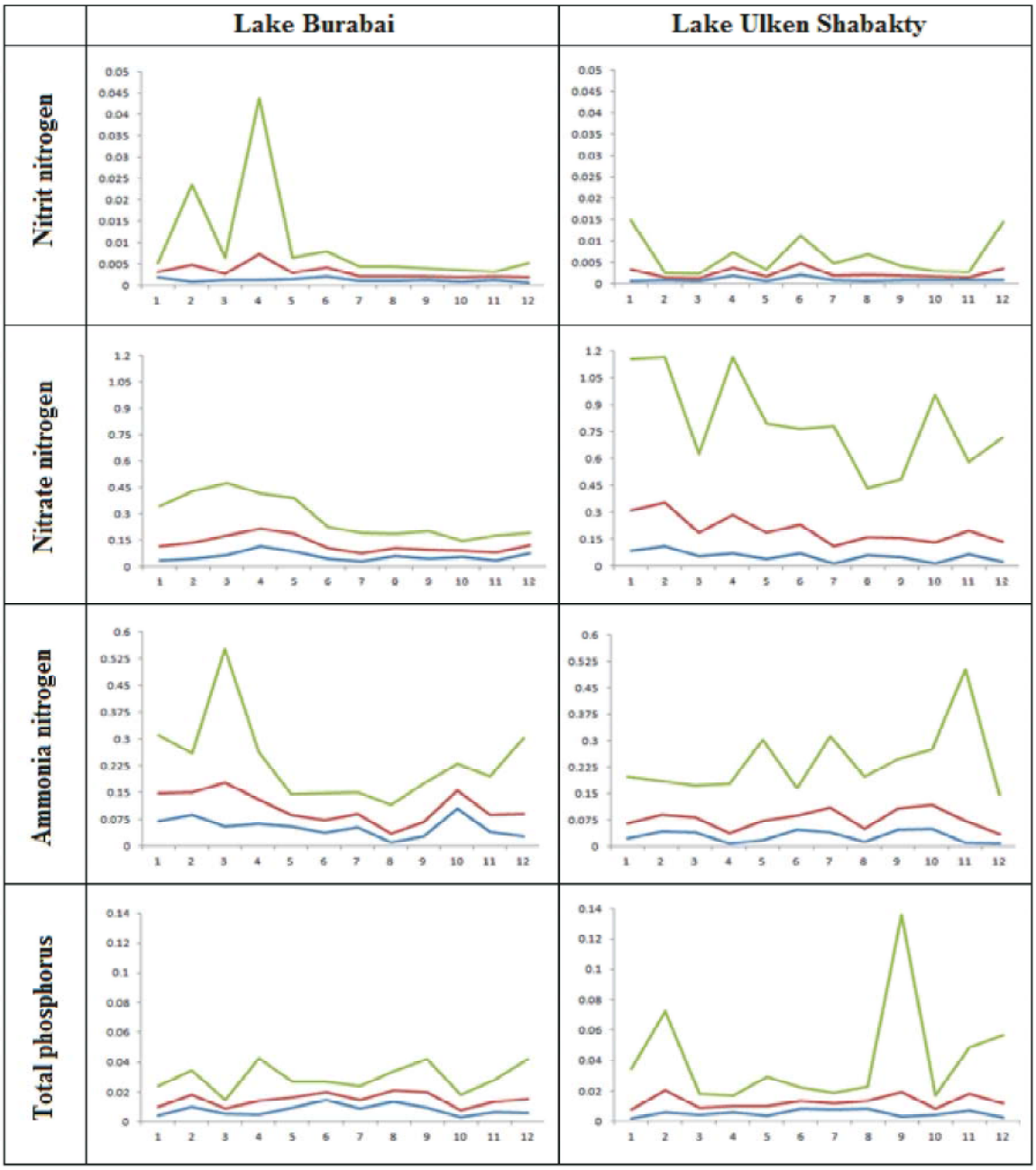


Fig. 5: Average annual dynamics of biogens for each lake with confidence intervals at a significance level of 0.05. Red color denotes the average long-term. Green and blue colors represent lower and upper bounds of interval estimations

This suggests that phosphorus compounds have approximately equal concentration changes in both lakes, not depending on the communications between them. Consequently, we can expect that those kinds of lake plant communities that have priority in phosphorus mineral nutrition, will be stable throughout the growing season.

Comparison of biogens: Biogenic substances come to lake with inflows at various concentrations, similar to the case with the outward flow. Concentrations of substances also change during evaporation. Phytoplankton is consumed at different speeds. They come into the water with different speeds as a result of destruction of organic matter by bacteria. At the same

time, the concentration of these substances in the lake can be correlated between them as a result of the total effect of all of these processes. The problem of such a correlation was considered for each lake and between lakes (Tables 6 and 7) [8].

Rigid links between the concentrations of substances in each lake are not separately identified, substances behave relatively independently. Only nitrates and nitrites of Burabai lake have significant connections (Table 6). The correlation matrix is symmetric, so the correlation coefficients in Table 6 for the lake Burabai are indicated above the main diagonal and for the lake Ulken Shabakty are below (italic).

This may mean that their delivery to the lake and phytoplankton consumption are not synchronized, that is substances come from various sources and converted with independent to each other speeds.

Visible connection between lakes is only seen in nitrates (Table 7). Nitrates are dominated by weight of among biogens; their connection has a great importance. The correlation coefficient in the nitrates which is 0.272 can mean interconnectedness of lakes and total dependence on the sources and nitrate runoff.

## CONCLUSION

For the analysis of the ecological state of lakes in Kazakhstan the information-analytical system was developed. It consists of hydrochemical and hydrobiological data and analytical subsystem of deterministic and statistical methods of data processing.

The obtained results on trends indicate that seasonal variations are large enough compared to the interannual. Seasonal factor plays a substantial role in changing nutrient concentrations. Testing for normal distribution of the substance concentration logarithms shows that the lake Burabai "lives" mainly due to natural factors or many small artificial factors. In the lake Ulken Shabakty there are probably artificial sources of nitrites and nitrates, "concealing" lognormal distribution patterns.

In the averaged year dynamics of biogens are more diverse in the spring and early summer compared with the second half of the year, although there are "outbursts" in the ammonium and phosphorus which occur in the fall and early winter. Spring effects may be related to the intensive development of phytoplankton. Autumn is also an outbreak of phytoplankton biomass, which can affect the concentrations of ammonium and phosphorus. In general, the concentration of phosphorus compounds is more stable, which may favorably affect the life of phytoplankton species which are fond of phosphorus.

Intense links between the concentrations of substances have not been identified, substances behave relatively independently. This may mean that their delivery to lakes and phytoplankton consumption are not synchronized, that is, substances come from various sources and converted with independent to each other speeds.

Refilling the database on lakes would enhance data processing, including statistical data processing. It is anticipated that there is a possibility of using a dynamic mathematical model for the joint analysis of hydrobiological and hydrochemical information [10, 15-19]. These models give us the possibility for analysis of functioning of aquatic ecosystems in seas and lakes [17, 18, 20]. These ecosystems show by functioning many different effects.

## REFERENCES

1. State Report, 2000. “A condition of natural resources and environment in the Republic of Kazakhstan”, 2000. Book 1. The general ecological state on the Republic and implementation of the plan of measures for 1998-2000 years. Kazakhstan.
2. Newsletter on a state of environment in Shchuchinsk-Borovoye resort area, 2013. For 2008-2013 years. Kazakhstan.
3. http://www.netbeans.org/.
4. Borovikov, V.P., 2001. Program “Statistics” for engineers. Moscow Computer Press.
5. Bendat, J.S. and A.G. Piersol, 1980. Engineering Applications of Correlation and Spectral Analysis. John Wiley & Sons.
6. Handbook of Applicable Mathematics, 1986. Volume VI: Statistics. John Wiley & Sons.
7. Aivazyan, S.A. and V.S. Mkhitaryan, 1998. Applied statistics and fundamentals of econometrics. Moscow YuNITI.
8. Dubrov, A.M., V.S. Mkhitaryan and L.I. Troshin, 1998. Multidimensional statistical methods. Moscow, Finance and Statistics.
9. Al-Badaii, F. and M. Shuhaimi-Othman, 2014. Heavy Metals and Water Quality Assessment Using Multivariate Statistical Techniques and Water Quality Index of the Semenyih River, Peninsular Malaysia. Iranica Journal of Energy & Environment, 5(2): 132-145.
10. Forecasting of Ecological Processes, 1986. Editor O. M. Kozhova. Novosibirsk Science Publ., Russia.

11. Vollenweider, R.A., 1968. The scientific basis of lake and stream eutrophication, with particular reference to phosphorus and nitrogen as eutrophication factors. Techical Report OECD. Paris DAS/CSI/68. 27: 1-83.
12. Datsenko, Yu S., 2007. Eutrophication of aquatic basins. Hydrological and hydrochemical aspects. Moscow State Univ., Geographical Department GEOS.
13. Schitikov, V. K., G.S. Rosenberg and T.D. Zinchenko, 2003. Quantitative hydroecology: methods of system identification. Tolyatti IEVB RAS, Russia.
14. Abakumov, V.A., N.G. Bulgakov, A.P. Levich, S.V. Mamikhin, E.P. Nikitina, V.A. Nikulin and S.V. Sukhov, 2000. Analitical information system "Ecology of Fresh Waters in Russia" as instrument for biological researches. Messenger of the Moscow State University. Biology Series, 2: 38-42.
15. Abakumov, A.I., V.A. Silkin and L.A. Pautova, 2012. Biomass dynamics of the phytoplankton under impact of the nutrient. 18th Biennial ISEM Conference On Ecological Modelling for Global Change and Coupled Human and Natural System. Book Series: Procedia Environmental Sciences, 13: 105-110.
16. Abakumov, A., A. Ismailova and A. Adamov, 2014. Modeling of Microbial Communities of Plant Organisms in Aquatic Ecosystem. Information. An International Interdisciplinary Journal, 17(1): 209-218.
17. Blenckner, T., 2008. Models as tools for understanding past, recent and future changes in large lakes. Hydrobiologia, 599: 177-182.
18. Silkin V.A., A.I. Abakumov, L.A. Pautova, A.S. Mikaelyan, V.K. Chasovnikov and T.A. Lukashova, 2011. Co-existence of non-native and the Black sea phytoplankton species. Invasion hypotheses discussion. Russian Journal of Biological Invasions, 2(4): 256-264.
19. Fathi, M. and A. Honarbakhs, 2012. River Channel Change Simulation of Khoshke Rud Farsan River and Bank Erosion Process Using a Numerical Depth Averaged Model, CCHE2D. Iranica Journal of Energy & Environment, 3(4): 299-306.
20. Jeppesen, E., J.P. Jensen, M. Sendergaard, T. Lauridsen and F. Landkildehus, 2000. Trophic structure, species richness and biodiversity in Danish lakes: changes along phosphorus gradient. Freshwater Biology, 45: 201-218.


## Persian Abstract

*DOI: 10.5829/idosi.ijee.2014.05.03.04*


**چکیده**

سیستم اطلاعات تحلیلی (IAS) "نظارت بر اکوسیستم‌های آبی" برای تجزیه و تحلیل وضعیت دریاچه‌های اکولوژیکی در قزاقستان توسعه داده شد. این سیستم شامل یک پایگاه داده ویژگی‌های هیدروشیمی و هیدروبیولوژی برای دریاچه‌های Burabai و Ulken Shabakty در منطقه Shchuchinsk-Borovoye جمهوری قزاقستان است و مشابه مجموعه‌ای از روش‌های پردازش داده‌های آماری می‌باشد. تجزیه و تحلیل کیفی داده‌ها بر روی دریاچه انجام شده است. داده‌های مواد بیوژنیک برای سال ۲۰۰۷-۲۰۱۳ بر اساس آمار تجزیه و تحلیل شد. ویژگی‌های پویا و ویژگی‌های فصلی تغییر در غلظت بیوژن‌ها مشخص شد. رابطه مهمی بین غلظت مواد مختلف بیوژنیک در دریاچه‌ها و بین دریاچه‌ها وجود ندارد. در مقایسه با مواد نیتروژن دار، ترکیبات فسفردار پایداری زیادی دارند که می‌تواند به زندگی پایدارتر گونه‌های فیتوپلانکتون کمک کند.