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Quality of Kazakhstan lakes water in contemporaneous period (for example of Kopa lake)

Herein the authors set the question of the possible hydro-ecological crisis due to the development of water use. The article is devoted to the study of Kopa, hydro ecological lake, which is one of the main sources of water supply of Kokshetau city (Republic of Kazakhstan). Based on the calculation of water pollution index (WPI) and oil concentration in the water it proves the influence of anthropogenic factors on the hydro chemical regime of the Kopa lake.
Kazakhstan continental lakes, including Kopa lake, accumulate river water, groundwater and aerial water. Mixing with each other and with lake water – is not just a simple physical mixing, but also a chemical process, causing generation of recent saline composition of lake water. These processes are united into the common conception "metamorphization". In metamorphization of chemical compositions of natural water the main role is for: wind mixture and oxygen saturation of water masses; alongshore movement of drifts, their flotation (abrasion, segregation), saturation of water with colloid-clay substances and some other processes.
***Keywords**:* quality of natural waters, main ions, index of pollution waters.

Introduction

Nature complexes, including lakes, react in different ways on anthropogenic loadings and display one or another level of stability against various types of influence, and also have various relaxation ability, finally changing the evolutionary development trend of natural complexes. It is appearing more and more problematic to keep Kopa lake in current state for requirements of developing natural economy. Decreasing of Kopa lake water level, salt concentration increasing and deterioration of water quality lead to the degradation of surrounding nature and made it difficult to use the lake as the water supply source. During the long time period the lake is under the anthropogenic pressure, relating directly to the anthropogenic impact. Nowadays these ecologic phenomena are of regional significance [1-5]. Besides, Kopa lake water is the environment, where there are definite hydrochemical processes, influencing hydroecology of nature-economical system. The fundamental approach to the study of them is for ideas of ecosystems integrity and interrelations unity in natural and nature-technical complexes. That is why the investigations on identification of hydroecology consequences of anthropogenic impact in water basins based on complex study of functioning conditions of nature-economical system are very actual.

The goal of investigations is elimination of hydroecological consequences of anthropogenic impacts on Kopa lake. In order to achieve the goal, the following tasks were solved one-by-one:

1) studying of up-to-date hydrochemical regime of Kopa lake and elimination of basic factors, influencing it;

2) finding of water quality coefficients;

3) defining of oil products content in water.

Practical importance of the work is in possibility to develop scientifically-based recommendations and activities on improvement of ecological situa-

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tion of Kopa lake in conditions of is level fluctuating.

Materials and methods

Kopa lake was chosen as the object, typical continental water basin of arid zone. Special attention was paid for the processes of formation of lake water quality.

For the investigation period there were organized 3 expedition trips and there were made 3 hydrochemical surveys of lake water area. There were taken about 100 samples of lake water for chemical analysis. Besides, there were made observations of regime of instable components of basin water chemical composition with sampling every 2 hours during 2 days. Deep water sampling was made by Molchanov's bathometer GR-18. In order to find out the vertical stratification of chemical composition components, the water sampling was made in surface (0.5m) and bottom layers.

According to the recommendations (Methodical recommendations 2010) definition of instable water components (pH, HCO_3^-, CO_3^{2-}, NO_2^-, NH_4^+, oxidability O_2, CO_2) was made right after the sampling, and of the rest components – in the laboratory after conserving by the related reagents.

In order to define the water chemical composition components, there were applied standard hydrochemical methods [6-9]. Chlorides were defined by volumetric argentometric method, sulphates – by gravimetric method, hydrocarbonates and carbonates– by volumetric acidimetric method, calcium – through titration of sample by Trilon B solution in appearance of Murexid indicator, magnesium and total hardness – through titration of sample by Trilon B solution in appearance of black chromogen indicator, Sodium and potassium – by the method of flame photometry, oil products- by gravimetric method, pH values and content of oxygen in the water – by electrometric method.

Verification of the stated methods showed, that the error percent didn't exceed accessible values of errors. All samples of water and ground were analyzed three times, as a minimum. Mathematic processing was applied in order to get reliable conclusions.

As the natural waters are fundamentally the solutions of natural matters of mineral and organic origin, they were considered, as naturally balanced physical-chemical systems, consisting of water and compositions, dissolved in it. The laws and theories of solutions and individual matters are applicable here.

Discussions

Kazakhstan territory – is the least water supplied republic in Central Asia. Among 85 thousand rivers and temporary watercourses only 200 are more than 100 km long and only 6 – are more than 1000 km; out of 48 thousand lakes of Kazakhstan only 270 have water surface space more, than 10 km^2 each, 16 – more than 100 km^2, and only two – Balkhash and Alakol – more, than 2000 km^2. By water exchange terms, most part of the lakes in the republic are the closed lakes. In relation with natural dynamics of moisturizing and economical activities, there are transfers of freshwater lakes into the salina, periodical drying up of lakes or their complete disappearance.

Investigating Kopa lake is located on the territory of Akmola region close to the foot of Kokshetau Elevation, near to north-west part of Kokshetau city [10-11]. As the lake water quality depends on various factors, there is a short description of physics-geographical and other terms of formation below.

A number of peculiarities: hydrophysical, hydrological, hydrochemical and hydrochemical, define emergent property of the lake.

Akmola region is located in North-central part of Kazakhstan, together with forest, forest-steppe and steppe zones and most concentration of natural water ecosystems.

In total, there are 2200 rivers and temporary water flows, 552 lakes, 40 storage ponds, 6 ditches, 134 ponds, 57 dams on the territory of Akmola region. The square of Kopa lake's collecting area is 3860 km^2. Most part of it is for lake inflows: from south-west – Chaglinka river, from south east – Kylshakty river, and quite insignificant part (80 km) – is for the lake itself. Maximum depth is – 3,1 m; length – 5,3 km; width – 3,6 km.

Lake collecting area is the hilly plain, formed by loamy soils in lower parts and by solid rocks and gristly soils – on hills. 50-70 m-high hills come close to the lake from south -west.

Water surface of the lake is mainly open. Along the west and north shores there is reed bed of 0.3-1 km width, and rush bed of 300 m average width. The bottom is smooth, miry, covered with layer of clay and loam mud and sand with mud of 0,5 – 2,8 m depth, up to 6 m (north part), average depth is

up to 2 m. Along the south and east shores there is sand-pebble bank; north-west shore is low, sloping, covered with water plants, the edge is not clear.

Due to shallowing, increasing of water heating, increasing pollution level by waste waters and agriculture fertilizers, washed into the lake, the water plants attacks water mirror, its square is about 50% of the square of all Kopa water area [1].

Chaglinka river flows into the lake from south-west and flows out from the north part, therefore, Kopa lake regulates flow of Chaglinka river in its lower stream. Water mirror square is 13,1 km^2, or 1300 hectare. Chaglinka river – is the biggest feeder of Kopa lake. It originates between knolls in Dzhilandy and Zerenda mountains, and is flowing here in rock banks, taking in some feeders. Its length is 234 km, water collecting square is – 9220 km^2 . Total river decline is 314 m., average inclination is -1,3%.

Water collecting in top and middle parts, before the river falls into Kopa lake, is hilly, and in the lower part is flat plain, covered with steppe forbs (feather grass, wormseed, fescue). The soils are mainly chernozem, medium-humus; in upper reach there is mountain chernozem.

The valley up to Kopa lake is clearly expressed, mainly box-type. The prevalent width is 1 – 1,4 km, the least is 10-15 m., right slope is steep, cut with ravines and gullies, in upstream is covered with forest; the left one, as a rule, is a little lower, than the right, temperately steep, matted. Slopes average height is 10-15 m, the valley is slightly expressed and almost joins adjacent zone from Kopa lake to the mouth.

River flood is usually violent and is lasting for 20-40 days. In the middle of June stable spring-autumn low water appears and is lasting till freezing over. Water level can rise by 1.0-1.5 m from rare rainfalls (1 time in 5-10 years). Regulating influence of Kopa lake onto the river flow in various years (by water volume) goes unequally. In water-short years the lake totally accumulates waters of the upper part of the basin, that is why feeding of the lower part of the river goes by insignificant snow storages of the lower part of the valley and ground waters, without any lake water. In high-water and middle-water years excess of Kopa lake waters are fallen into the river. Downstream riverbed during low water is broken by separate stretches. In middle-water years flow is holding stable along the river, In high-water years Kopa lake does not significantly affect the river flow. Spring ice-drifting is a rare phenomenon, and happens not every year. In separate high-water years ice-drifting is intensive and is accompanied by powerful rafts at scrolls.

In winter, at the end of December – start of January, the river freeze up to the bottom, excluding some reaches and places with ground waters boils.

Mineralization of the water of high part of the river (up to Pavlovka village) in the period of spring flood is changing within the period 20-60 mg/l, and hardness – within 1,5-6,0 mg-eqv. (soft and moderately hard).

Ionic composition is characterized by prevalence of ions HCO_3^- (40-22% eqv.) and Ca^{2+} (30-21% eqv.), rarely Na^+ (28-21 % eqv.); drinking quality of the water is good. On the river there are some temporary soil dams. The water is used for drinking, watering of cattle and for basin irrigation. 10 km from mouth there is a ground dam with rock dump of 1,5 m high for masin irrigation; square of irrigation in various year is 3 – 7 thousand hectare.

Hydrobiological processes in Kopa lake. The problem of water objects protection against falling polluting materials and biogenic elements is very actual due to rising volumes of undercleared sewages dumping into the water objects and growth of deficit of biologically rigorous fresh water.

Climate and hydromorphometric factors stipulate uniqueness of water basins biologic systems. Here most part of mineral salts, brought into the lake, is being involved into trophic chain and participate in desalination of water basin.

Main role in composition of water ecosystems is for the hydrophytic plants. They are divided by morphological and anatomical peculiarities into lower (microphyts) and higher (macrophyts).

Trophic chain starts with phytoplankton, assimilating mineral salts directly from the water. Phytoplankton is being ate by zooplankton, the food for multiple mollusks and worms, existing on the bottom of the water basin in its friable clay deposits (zoobenthos). Zoobenthos is a feed base for ichthyofauna (fish and other animals), who are the food for birds, animals and people. Zoobenthos is presented by larva of dragonfly, diving beetle, mollusks. Average biomass – 26,1 g/square m. [10].

Zooplankton is especially well developed in spring: faphnids, amphipods, rotifers. Species composition and quantity rates of various groups of zooplankton are changing in multiple-year cycle. Zooplankton biomass volume was significantly in-

fluenced by observed square reduce and worsening of hydrological and hydrochemical regimes.

Ichthyofauna: perch, roach, ide, pike, zander, bream (acclimatized), crucian. The water level is lower from year to year. Suffocation of fish in the lake is being observed yearly, as a rule it is for – perch, bream, ide, ruff. The catch is mainly consists of bream (80%). Abiotic conditions for fish habitation, sources of pollution of the water basin restrict possible increase in fish reproduction. Dynamics of reduction of typical content of aboriginal fish is explained by prevalence of bream. In year 2001 in Kopa lake huge fish suffocation happened (perch, roach, ide, pike, zander, bream, crucian). At the moment the lake is on stage of recovery of fish volume. Regular annual fishery in the lake started in year 1964.

As on the lake basin there were no any complex hydrochemical investigations since 1993, we resumed hydrochemical investigation of Kopa lake in years 2009- 2010. The research allowed to obtain modern view on composition and quality of the water of Kopa lake. Chemical composition of the waters mainly depends on geography factors, on intensity of matters transformation processes in river water basins, on human activities and others.

Physics-chemical classification of the components of natural waters chemical composition assigns conservative, nonconservative and heterophase components. The conservative class includes such gross composition components, as chlorides, sodium, calcium and some others, concentration of them in natural waters is defined by the balance of coming in, dilution and dispersion. The table shows average concentrations of main ions and mineralization. It is stated, that on water hardness (8,25 mmol/l eqv) the water is qualified as of medium hardness.

Turbidity investigations made showed, that: turbidity index in spring period is equal to 4,15 mg/l, and in summer period it increases up to 4,70 mg/l. Such increasing is caused by difference in floods, as the melting water, flowing down from the city, is coming to the lake together with various pollutions. It leads to increasing concentration of insoluble and colloid matters of organic inorganic nature.

Content of oxygen, dissolved in water is fluctuating from 1,79 up to 12,22 mg/l. Low values of dissolved oxygen were observed in March. Average volume was 7,01 mg/l. Oxygen concentration in water satisfies water objects standards.

Lake water by pH value relates to weakly alkalescent or alkalescent (7,48 – 9,27). Average value of water pH for the season is 8,39.

Table 1 – Average chemical composition of water in Kopa lake, mg/l

Place of sampling	pH	$HCO_3^-+CO_3^{2-}$	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Sum of salts
Beach zone	7,42	209,8	1,8	230,5	122,4	46,3	276,1	9,5	896,5
Chapayev str.	9,40	72,6	52,2	227,0	20,5	10,6	275,1	9,6	613,2
Old airport	8,36	298,9	90,3	229,8	106,5	90,8	275,7	9,7	1071,8
Average-season value	8,39	193,8	48,1	229,1	83,2	49,2	275,6	9,6	888,6

It is known, that appearance of the main ions in the water (HCO_3^-, CO_3^{2-}, SO_4^{2-}, Cl^-, Ca^{2+}, Na^+, K^+) defines water mineralization and its chemical composition. Water mineralization after spring lake filling was changing from 0,64 up to 1,10 g/l, and hardness decreased from 12,94 down to 1,85 mmol/l eqv. Ionic composition of water for this time is characterized by sharp prevalence of ions Na^+ (12,0 mmol/l eqv.) and $S0_4^{2-}$ (4,76 mmol/l eqv.). on classification of O.A.Alyokin, Kopa lake water relates to the sulphate class, group of sodium, second type, water index S^{Na}_{II}). Second type waters are mixed, as their composition relates to sediments, from which various salts are being leached.

Water chemical composition indexes are distributed irregularly along the lake basin. There were not found vertical stratification of mineralization and main ions due to shallow water of arid water basin, intensive wind mixing of water masses, sum radiation influence. Similar phenomenon was also found on other water basins of Kazakhstan (Romanova 2008), that differs them from water basins of humid regions.

The authors of the article were the fist, who cal-

culated waters pollution index by main ions (WPI_{mi}) for Kopa lake by the advanced method [8] in order to estimate pollution rate and water quality. For WPI calculation there were used hydrochemical data for year 2009.

Water pollution index is fluctuating between 0,89 and 1,59 mg/l. For main ions the basic polluting components are Mg^{2+} (WPI 0,265- 2,270) and SO_4^{2-} (WPI 2,270-2,300). WPI_{mi} along lake length is changing from 0,9 till 1,59 and conforms to rise of total water mineralization. Average season value for WPI by main ions is 1,16, it is for third class and is moderately polluted (see the figure below).

Excess of MPC (maximum permissible concentration) of oil products for the spring of year 2009 was equal to 4,6.

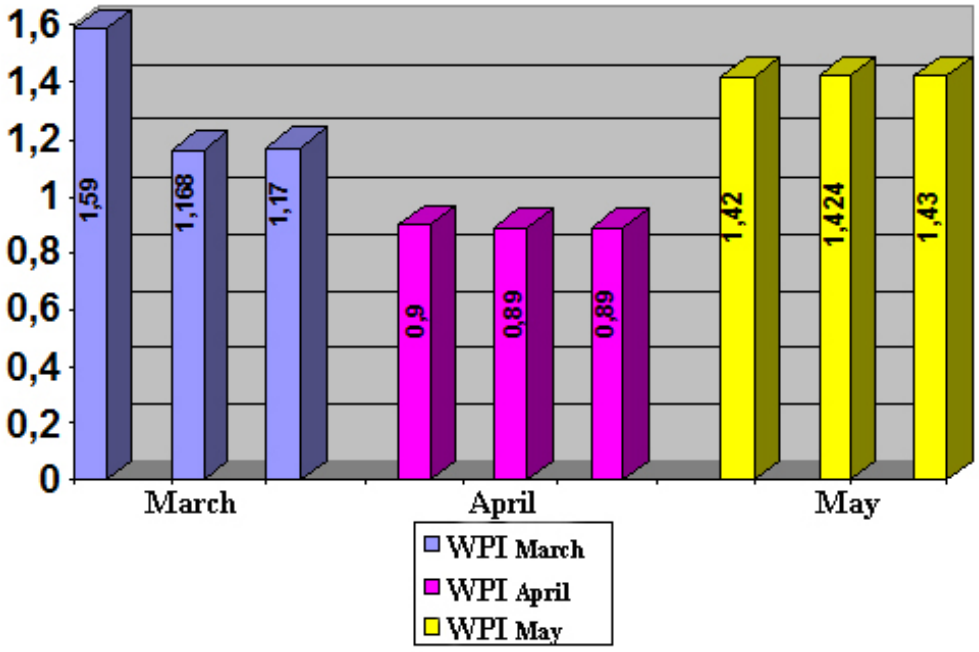

Figure 1 – Fluctuations of WPI_{mi} for Kopa lake, spring 2009

Conclusions

For Kopa lake, accumulating flows of various types and concentrations of waters, in years 2009-2010 it was found the horizontal stratification of mineralization (2.2 times growth) and ionic composition (unequal growth).

Shallow water of Kopa lake, as arid water basin, intensive wind mixing of water masses, impact of sun radiation further to absence (in most cases) of vertical stratification of almost all components of chemical composition, it differs them from humid regions water basins.

WPI on main ions, excess of oil products MPC shows on anthropogenic impact onto Kopa lake. We can consider appearance of geoecological aspect of hydroecology crisis.

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