Executive Committee
International Foundation for the Aral Sea Rescue

PROJECT ON MANAGEMENT OF WATER RESOURCES AND ENVIRONMENTS

COMPONENT E

ECOLOGICAL MONITORING OF WETLAND SUDOCH'E

Annual report

SIEC «ECOTEX» (Uzbekistan)
IBS Technology, Inc. (United States of America)

December 2001

CONTENTS

SUMMARY

The final report "Ecological monitoring of Wetland Sudoch'e" is presented in the printed form on 120 pages containing 65 tables, 16 figures and references including 51 works.

The report provides the results of the ecological monitoring for the period 1999-2001 on the abiotic (hydrology and hydrochemistry) and biological indices (algae flora, periphyton, submersed, aquatic and coastal vegetation, parasite fauna, zooplankton, zoobenthos, fish fauna, avian fauna and mammalian fauna. Seasonal qualitative and quantitative characteristics of the main values of the monitoring are provided.

The extreme low water period of the years 2000 and 2001 is shown to have brought to the catastrophic state of the ecological regime in this wetland. As a result of shallowing, drying and salinization of the lakes, the whole groups of organisms have died, and the remaining biotope has undergone negative qualitative and quantitative changes. Under these conditions, rehabilitation and stabilization of the ecological regime in Wetland Sudoch'e will require a long and complicated period.

The objective assessment of the ecological effectiveness of engineering and technical measures on the rehabilitation and improvement of the water-salt regime in this wetland will require an extension of the monitoring.

INTRODUCTION

Changes in the hydrological regime of the River Amu Darya connected with a withdrawal of significant part of the water flow for irrigation of agricultural lands has resulted in the shallowing and drying up of most of intradelta water bodies.

The southern coast of the Aral Sea and water bodies situated in the delta of the River Amu Darya, which once boasted the richest biodiversity and availability of stable sources for the living of the local population, has been exposed to desertification and most remaining water bodies to salinization and degradation. All this has had an extremely adverse effect both on the unique flora and on fauna of the Aral Sea region, as well as the social status of the local population, and, therefore, necessitates implementation of targeted steps towards the rehabilitation and improvement of the ecological and social status of this region.

One of the ways to solve this problem is a rehabilitation of wetlands situated in the Aral Sea region through improvement of the water-salt regime in the water bodies of the delta of the River Amu Darya. A pilot project for the solution of this problem is the Project on management of water resources and environments – Component E of the Executive Committee of International Foundation of the Aral Sea Rescue.

The project consists of three components:

- A detailed projecting of the infrastructure of rehabilitation of Sudoch'e wetlands in the delta of the Amu Darya River;
- Ecological monitoring of Wetland Sudoch'e;
- Sociological monitoring of Wetland Sudoch'e.

Rehabilitation of the ecological state of Wetland Sudoch'e is of special importance, as until hitherto it has remained the most preserved area in the Aral Sea region that has not lost its exclusive importance as a zone of conservation and maintenance of the regional and global biodiversity.

In compliance with the contract concluded with JEF of the Executive Committee of International Foundation for the Aral Sea Rescue, the Consortium within Corporation "IBS Technology, Inc.", USA, and SIEC Ecotex carried out the development of the "Ecological monitoring of Wetland Sudoch'e". Duration of the contract is three years and six months (08.1999-12.2002). The team of investigators consists of the following experts:

1. Gromyko K.V.	- Head of project
2. Kurbanbaev E.	- Hydrology
3. Aparin V.	- Hydrochemistry
4. Bakhiev A.	- Geobotany
5. Shoyakubov R.	- Hydrobotany
6. Abdukadyrov A.	- Algae flora
7. Talski V.	- Periphyton, zoobenthos
8. Azimov D.	- Parasitology
9. Lebedeva N.	- Entomology (blood-sucking mosquitoes)
10. Mirabdullaev I.	- Zooplankton
11. Zholdasova I.	- Ichthyology
12. Khegay V.	- Ichthyology
13. Lanovenko E.	- Ornithology
14. Kreuzberg-Mukhina E.	- Ornithology
15. Karabekov M.	- Theriology
16. Abdunazarov B.	- Theriology

Due to the shallowing, drying up and salinization of Wetland Sudoch'e and virtual withdrawal of objects under study from the biota composition, the experts on alga flora, parasite fauna and entomology did not part on the development of the ecological monitoring in 2001.

1. GOALS, COMPOSITION AND WAYS OF ECOLOGICAL MONITORING IMPLEMENTATION

1.1. Goals and objectives of monitoring

The goal of the ecological monitoring is the surveillance, assessment and prognosis of the effect of engineering and technical measures on the ecosystem of Wetland Sudoch'e, which are aimed at rehabilitation and improvement of the water-salt regime in this area.

The main objectives of the monitoring are as follows:

1. A study on the state of the ecosystems of Wetland Sudoch'e prior to the original state and during the implementation of engineering and technical measures on the improvement of the water-salt regime;
2. Prognosis of the state of ecosystems of Wetland Sudoch'e and assessment of the ecological effectiveness of engineering and technical measures on the improvement of the water-salt regime;
3. Development of main principles of the ecological management and sustainable use of bioresources in Wetland Sudoch'e;
4. Expert assessment of qualification of Wetland Sudoch'e as an object subject to protection in compliance with the RAMSAR Convention;
5. Development of recommendations on dissemination of experience of rehabilitation of wetlands in the Aral Sea region.

1.2. Main stages of the monitoring

The ecological monitoring of Wetland Sudoch'e includes implementation of three stages (Fig. 1):

Stage I: Assessment of the current state of ecosystems in Wetland Sudoch'e (original data);

Stage II: Assessment of the state of ecosystems of Wetland Sudoch'e during the implementation of engineering and technical measures on the rehabilitation of its water-salt regime;

Stage III: Analysis, generalization and drawing up of the results of the ecological monitoring of Wetland Sudoch'e.

1.3. Objects and borders of monitoring

The object of the ecological monitoring is Wetland Sudoch'e within the borders of the implementation of engineering and technical measures on rehabilitation and improvement of its water-salt regime. The particular objects of the monitoring are water ecosystems of Wetland Sudoch'e and their coastal zones (Fig.2):

- Lake Akushpa and Taily
- Lake Karateren
- Lake Begdulla-Aidyn
- Lake Bolshoe Sudoch'e
- Collector KKC and GK

The coastal zone is a territory covered by hydrophilous vegetation. The natural border is an area where the hydrophilous vegetation is replaced by the xerophitous one.

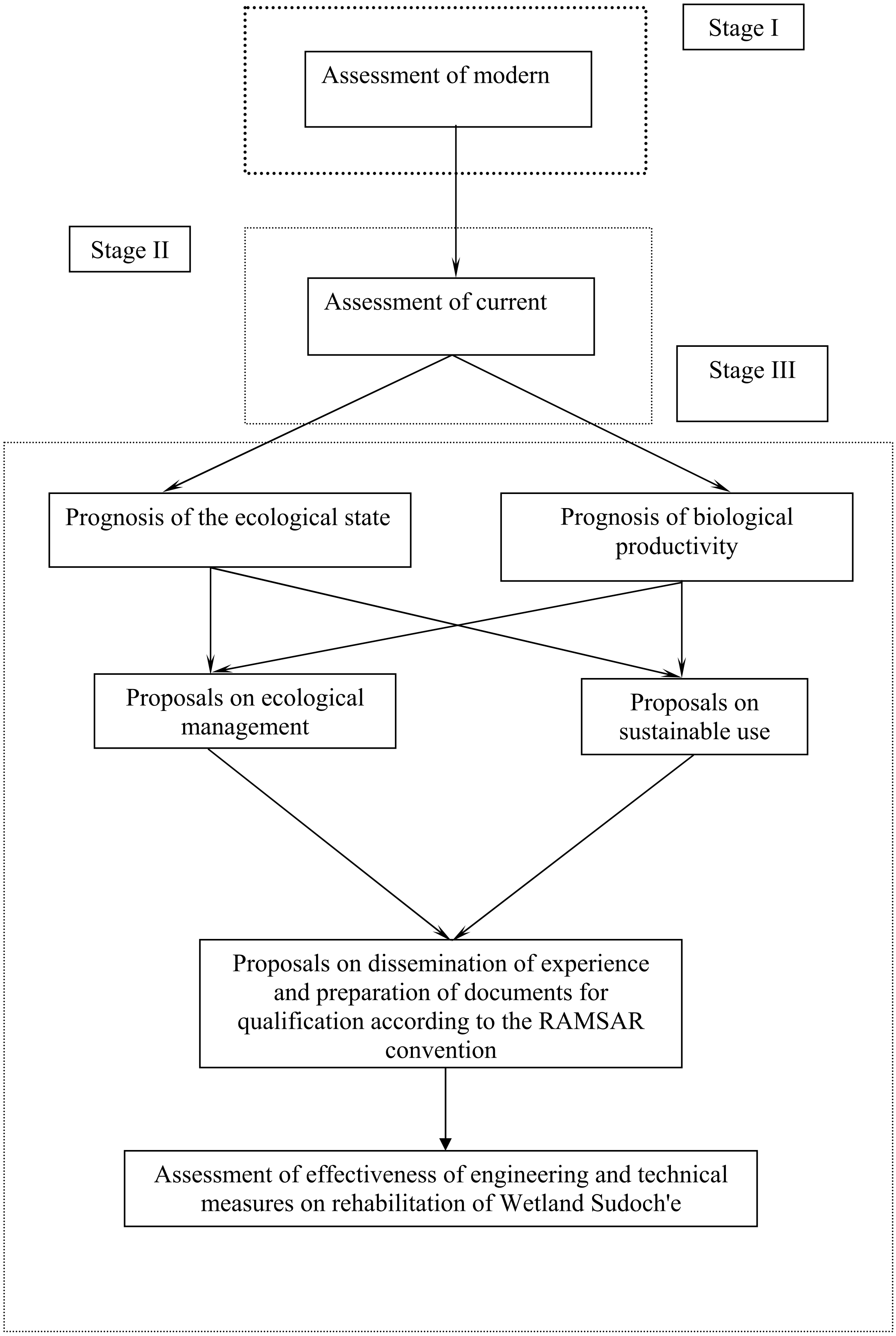


Fig. 1. Scheme of the ecological monitoring of Wetland Sudoch'e

1.4. Content of monitoring

The ecological monitoring of Wetland Sudoch'e provides a study, assessment and prognosis of the following values:

a. **Abiotic:**
- hydrological factors
- hydrochemical factors

b. **Biotic:**

Flora:
- phytoplankton
- periphyton
- submersed vegetation (hydatophytes)
- semi-aquatic vegetation (hydrophytes)
- coastal vegetation.

Fauna:
- Parasite fauna
- Entomology
- Zooplankton and zoobenthos
- Fishes (ichthyofauna)
- Birds (avian fauna)
- Mammals (theriofauna)

1.5. First stage of monitoring

The first stage of the monitoring is aimed at the assessment of the ecological state of Wetland Sudoch'e prior to the realization of the engineering and technical measures on the rehabilitation and improvement of the water-salt regime (background characteristic).

In compliance with the Technical Rationale of the ecological monitoring, the duration of the first stage is one year (autumn 1999-autumn 2000). However, due to the extreme low water period of the years 2000 and 2001 and a delay in realization of the engineering and technical measures, this stage of monitoring extended for the entire following year.

1.6. Methodology of work

The ecological monitoring was conducted by carrying out seasonal integrated fieldwork on the collection of natural data with their subsequent processing and analysis at specialized research institutions. During the monitoring, seven field trips to Wetland Sudoch'e were made:

1999 – autumn field trip

2000 – spring, summer and autumn field trips;

2001 – spring, summer and autumn field trips.

Specialists of 14 scientific directions take part in the development of ecological monitoring, all of them having their own techniques of collection, processing and analysis of the field and laboratory material. All the used techniques are routine in ecological studies, therefore in this reporting we think it possible to limit ourselves to listing the methodical references used in the work of every scientific direction [1-30].

The quantitative development of organisms in the wetland biocenosis was estimated by using the 6-point scale of abundance:

1 – sole (very few)
2 – very rare (few)
3 – rare (moderate)
4 – not rare (many)
5 – often (very many)
6 – very often (abundant).

Identification of salinity, oxygen dissolved in water, electric conductance, temperature and active water reaction (pH) was conducted by using a field potentiometer “HORIBA U-21” (Japan). Representative water samples and bottom sediments were analyzed at the chemical laboratory of Geological Institution "Kyzyltepageologiya".

Heavy metals in water samples were analyzed by using an atomic-absorption method on spectrophotometer Perkin-Elmer 404 with electrothermic atomizer HGA-74 and deuterium background corrector. In the bottom sediments, these were analyzed by using a roentgen-fluorescent spectrometer SRS-3000 (SIMENS, Germany). While measuring heavy metals, a complex of nuclear-physical methods was applied: U, Th, Sr, Pb, Mo roentgen-spectral fluorescent (PCA) Co, Cr, W, As, Sb – instrumental neutron-inoactivation (INAA). The methos PCA was used to determine: U, Th, Sr, Pb, Moon analyzers of the type ARF-6 and ARAF-1. For the method INAA multi-channel analyzers of the impulses "Lokna – No 4900" with semiconductor detectors DGDK-63B were used with the activation of samples on reactor BP-CM (Institute of Nuclear Physics of Uzbek Academy of Sciences). The method INAA was used to identify Co, Cr, W, As, Sb. The oxide of vanadium was measured on spectrograph DFC-8-3, by using a quantitative-spectrographical method.

Soil samples were analyzed in Research-Industrial Center SANIIRI (Research Institute of Irrigation and Melioration), where the following was following was studied:

- Electric conductance in water extract 1:5 and in suspension 1:1;
- Total content of salts (thick residue);
- Content of ions of HCO''_3, Cl,' SO''_4, Ca, Mg,·· Na' and K in water extract 1:5 '.

All the analyses were made by using routine classical methods, identification of electric conductance was made by using portable conductometer, and the calculation was made according to the formula:

$ECe=K*EC_{1:1}$,

Where K – a transient coefficient equal to 3,3-3,7; and $EC_{1:1}$ – electric conductance of the suspension at the ration of the amounts of soil to water at 1:1. The unit of measurement of electric conductance was taken according to the international system of measurements – dS/m; levels of salinization were determined by the classification of FAO.

GPS-12 was used for fieldwork, which provided a precise determination of the geographic coordinates of the sites and points of observations and sampling. Fig. 3 shows these points of lake monitoring. However, in the year 2001 due to shallowing and drying of the lakes most monitoring points practically ceased to exist. In autumn this year, the full-scale monitoring was successfully carried out only on several central sites of Lake Karateren.

2. RETROSPECTIVE CHARACTERISTIC OF LAKE SUDOCH'E

Lake Sudoch'e emerged as a result of the formation of a large left-bank branch of the delta of the River Amu Darya, which was named Raushan. Until early 1960's of the last century, this lake was the largest intradelta water body of the Rvier Amu Darya. The area of the water surface reached 350 km^2; the width, 15 km; the length, 25 km. The deepest point 3 m; the average depth 2 m. The water mineralization ranged within 600-1700 mg/dm^3 (30).

Lake Sudoch'e is surrounded by thick growth of reeds on all sides and only at the foot of Plato Ustyurt were there open spaces of coasts. To the North and Northeast, the territory of the delta of the River Amu Darya was covered by a thick growth of reeds and cattail, among which lay separate groups of lakes. Of them, the largest lake is Karateren, which skirts Cape Urga of Plato Ustyurt. Between this lake and the Aral Sea stretched a navigable passageway called 'Motornaya'. The coast of the Aral Sea had no distinct shape in the place of adjoining lakes Sudoch'e and Karateren and was covered with dense growth of reeds growing in the zone of mixing of the lake and sea waters to as deep as 0.5-1.5 m.

For the whole period of the lake existence, the irrigation of the NW part of the delta of the River Amu Darya has been unstable, which has predetermined likewise unstable character of the hydrological and hydrochemical regimes inside the intra-delta lakes. Periods of the advance of the Aral Sea on the delta were alternated with the periods of the river waters on the Aral Sea. In the former case, the marine waters penetrated deep into the delta water bodies situated at a significant distance from the coastline, causing a sharp mineralization of the lake waters; in the latter case, the river waters displaced the mineralized waters of lakes, restoring their flowage and fresh water content.

Prior to the 1970's, the main sources of the nourishing of lakes Sudoch'e and Karateren were the branch of the River Amu Darya, the Raushan, and to a lesser degree, the canal Priem-Uzak.

In 1943, the source of the River Raushan was closed by a dam, after which the irrigation of NW part of the Amu Darya delta significantly deteriorated. In 1947, this branch was again open; however, in the first years of its operation, the water consumption was 35-50% lower than before its closure.

In 1950, an increase in the water flow along the canal Raushan caused a flooding of some part of irrigated lands in Kungrad oasis. In order to prevent a further flooding of the irrigated lands, the branch was completely dammed, which caused, in 1950-1951, a heavy drying up of the delta water bodies, particularly Lake Sudoch'e.

In January 1952 as a result of a big bank escape of the river Amu Darya, the flow along the canal Raushan was again restored. The amount of the flow in this current and canal Priem-Uzak in 1952-1953 was 2.3 km^3 a year, with maximum water consumption in summer of 200 m^3/s. As a result of the restoration of the flow along the canal Raushan, the water level in lakes Sudoch'e and Karateren grew by 1 m, and these lakes were again flowing. The flowing water caused changes in the mineralization levels. Hence, if in the northern part of Lake Sudoch'e the mineralization reached 7168 mg/dm^3 in June 1952, a month later this value dropped to as low as 556 mg/dm^3. In Lake Karateren the water mineralization reached 12064 mg/dm^3, in year's time it dropped to as low as 1298 mg/dm^3, and in September 1953 to as low as 618 mg/dm^3.

In early 1960's, the leadership of the former USSR took a course at the intensive expansion of the irrigated agriculture, which caused an increased withdrawal of the waters of the rivers Amu Darya and Syr Darya and a resultant shallowing of their respective deltas and a drop in the inflow of the river runoff into the flood-land lakes. The consequence was a decrease of the water surface area of Lake Sudoch'e. A decrease in the water level in this lake caused an active inflow of the salty marine waters, which resulted in that the water salinity in Lake Sudoch'e in 1966 reached 24.300-41.000 mg/dm^3. A further decrease in the water level resulted in that in 1968 the lake completely split into a number of small and shallow water bodies.

In summer 1969, an extremely high overflow took place in the River Amu Darya owing to which the supply of Lake Sudoch'e with water was restored. This lake was again flowing; the water mineralization dropped in it to as low as 700-2500 mg/dm^3. However, in the subsequent years the water flow into the lake practically ceased.

In late 1960's, the construction of main collectors KKC and GK (Ustyurtsky) was completed and Lake Sudoch'e was fed with drainage and sewage waters. Since then the life of this lake was completely dependent on the hydrological regime in these collectors.

In late 1970's in order to compensate the losses of the Aral Sea, a discharge canal was dug through the Akkum Ridge, which separated Lake Sudoch'e from the Aral Sea; besides, a canal was constructed crossing the bottom of the lake, which was called "Ekologicheski prokop [Ecological dredge cut]". Resulting from the water outlet, the lake again began shallowing quickly, separating into separate small and shallow water bodies, and the surrounding territory was exposed to an intensive desertification. To prevent growing desertification, the discharge canal was again dammed in 1984 and Lake Sudoch'e again started being filled with collector waters.

Since that period until 1999, Lake Sudoch'e was an internal-drainage accumulator of mineralized collector waters. The total average runoff of these collectors (mainly KKC) reaches 0.64 km^3/year, and water mineralization 3-5 g/dm^3.

The analysis of long-term observations (until the year 2000) of the hydrological state of this lake shows that, except separate high water and low water years, the water surface level ranges from the absolute mark of 52.40 to the absolute mark of 52.75 m. A growth in the water surface level usually takes place in April-May and August-September. The first growth in the water surface level coincides with the period of the discharge of the wash water into Collector KKC, and the second with the discharge of waters from rice plantations.

An extreme low water period in the year 2000-2001 caused a sharp decrease, and in summer full cease of the runoff into collector KKC and the whole-year cease of the runoff in Collector KG. As a result, an increase in the water mineralization, shallowing and drying up of the lake took place.

A review of the retrospective state of Lake Sudoch'e shows that through its history several consecutive periods of changes of hydrological and hydrochemical regimes have taken place:

1. Periods of drops in water and mineralization growth.	Causes
1.1. 1943-1947	Damming of bed of branch Raushan
1.2. 1950-1951	Damming of bed of branch Raushan
1.3. 1960-1969	Shallowing of the Amu Darya River delta
1.4. 1979-1984	Construction of the discharge canal in the Akkum ridge and Ecologichesky prokop" in the lake bottom.
1.5 2000-2001	Extreme low water of the River Amu Darya

2. Periods of restoration of water amount and water mineralization drops	Causes
2.1. 1949-1950	Opening of the flow of branch Raushan
2.2. 1952-1960	Escape of water from branch Raushan
2.3. 1969-1979	A summer flood of 1969 and escape of collector waters into the lake.
2.4.1984-1999	Damming of the discharge canal in the Akkum ridge.

3. NATURAL CONDITIONS IN WETLAND SUDOCH'E

Wetland Sudoch'e occupies a shallow, but vast depression situated in the northwestern part of the River Amu Darya delta. The relief of the area occupied by this wetland is characterized with unavailability of big heights and depressions. Chink of the Plato Ustyurt adjoins to it on the west, with an average height of the ledge of 80-100 m. In the district of Lake Taily, the chink has the form of a steep slope with outcrops; in the area of Lake Karateren, it is more flat consisting of three or four descending terraces. The total length of the border of the lake system with the chink of Plato Ustyurt reaches 35 km.

The region of the wetland consists of Quaternary deposits, which, in the geological respect are represented by the following genetic types:

- Dealluvial-marshy deposits of the chink of Plato Ustyurt;
- Lake-marshy deposits of the dried delta of the River Amu Darya and Lake Sudoch'e;
- Marine deposits of the Akkum coast swell;
- Lake-alluvial deposits of the River Amu Darya;
- aeoline deposits

Dealluvial-proalluvial deposits are developed in the form of a narrow strip (150-200 m) situated along the chink of Plato Ustyurt. These deposits consist of the detritus rocks of limestone and marl with the loamy sand filler 2-3 m thick.

Lake-marshy deposits form the dry delta of the River Amu Darya and the bed of Lake Sudoch'e. The humus horizon of these deposits consists of the black reed peat 0.05-0.25 m think and is, in turn, underlain by lake-marshy loamy soils 0.5-1.0 m thick. A sea deposit consists of fine and dusty sands 1 m thick.

Aeolian deposits form sandy hillocks and sand dunes 0.3-1.5 m high.

Within the wetland range, meadow soils are usually most widespread. In the area of periodical floods, the upper layers of the soil in Wetland Sudoch'e consist of heavy solonchak (salt-marsh) soils.

An extreme flatness of the surface of Wetland Sudoch'e predetermines the absence of a distinct coastline in most water bodies; their periphery consists of thick growth of reeds and cattail impassable from either the sea or the land.

Besides the foot of the chink of Plato Ustyurt, only collectors KKC, GK and canal Sudochinsky, which inflow into the lake system of Wetland Sudoch'e, have an expressed solid coast. The locality, which is crossed by these water streams, is flat, large and small solonchaks can be recorded along their banks. The latter are overgrown by reeds and bushes, mainly, tamarisk.

Ground waters in the area of Wetland Sudoch'e flow northwards to the basis of draining (the Aral Sea). The gradient of the flow corresponds to the gradient of the surface of this locality and is 0.00025-0.00032. The depth of the ground waters depending on the annual water content and irrigation of the rice plantations in the state farm Raushan ranges within 0.1-5 m. The ground waters are saline, with the mineralization levels ranging from 15 to 50 g/dm^3.

The climate in Wetland Sudoch'e is characterized with the hot summer, relatively cold winter, an extremely insignificant amount of precipitations and high levels of evaporation. An average annual air temperature constitutes 11-13°C at the average temperature of 26°C in July and 7°C below zero in January. The highest air temperature reaches 44-45°C and the lowest is 30°C.

An insignificant amount of precipitations (63.1-179 mm/year; on average 132.9 mm/year) practically does not have any effect on the aquatic regime in the lakes of the Amu Darya delta. Intensive winds coupled with high air temperatures produce favorable conditions for an increased evaporation of the water surface and evapotransperations of the aquatic and coastal vegetation, which reach 1208-1600 mm/year.

The duration of frost-free period in the delta of the River Amu Darya is mush shorter than in the regions of Central Asia and lasts 200 days. The ice regime on the lake is characterized by the following parameters: an average date of the beginning of autumn ice period is 23 November; the earliest was recorded on 8 November 1958 and the latest 1 January 1962. An average date of the freezing-over is 6 December. A long-term average date of the clearing from ice is 12 March; the earliest date was on 1 February 1953, the latest was on 8 April 1953. The average duration of the ice period is 110 days.

4. CHARACTERISTIC OF LAKES IN WETLAND SUDOCH'E

Wetland Sudoch'e consists of a large number of small and four relatively big water bodies:

- Lake Akushpa, which includes Lake Taily;
- Lake Begdulla-Aidyn;
- Lake Bolshoe Sudoch'e;
- Lake Karateren.

The characteristic of the lakes in Wetland Sudoch'e is provided based on the conditions of the hydrological regime of the autumn 1999, which was the closest to the average long-term data.

Lake Akushpa occupies the western part of Wetland Sudoch'e adjoining the eastern border of the chink of Plato Ustyurt. The area of this lake is confined to the following coordinates: 43°13′51″ in the South, 43°26′18″ in the North; 58°21′05″ in the east and 58°06′48″ in the West.

Lake Akushpa is the largest water bodies of Wetland Sudoch’e. The maximum length of this lake is 20 km; width 6.5 km; the depth is 1.5-1.7 m. The area of the lake is 11.600 ha. The southern and western coasts adjoining the chink of the Plato Ustyurt are little indented, whereas the northern and eastern coasts are heavily indented and marshy. The total coastline extends to 62 km. The lake is surrounded by reeds, the height and density of which gradually reduces in its southern part. The shallowest southern part of the lake is rich in open stretches and large bays. The free surface of Lake Akushpa reaches 60% of its total area; the remaining part is covered by reeds.

The ground of the open stretches of Lake Akushpa consists of dark-gray silts with an insignificant content of plant detritus and a weak smell of hydrogen sulphide.

The thickest silt sediments with a large content of the plant detritus and hydrogen sulphide smell are located in the southern and central parts of Lake Akushpa. Here, in the dead-end pockets and poorly ventilated small bays surrounded by reeds, which exclude or hinder the wind-induced immixture of the water, the water has a saturated brown-yellow color. Macrobenthos is practically unavailable.

The watercolor changes with the depth and openness of the water surface from yellow-brown to marshy-green, especially typical for its southern and southwestern parts, which are free of reeds.

Lake Karateren bends Cape Urga of Plato Ustyurt. The lake is limited to the following coordinates: in the south 43°27′08″, in north 43°31′25″, in the east 58°25′51″ and in the west 58°21′53″.

The maximal length of this lake is 6 km, the width 1,25 km; an average width is 0,5 km; the depth in the central part reaches 1,8-2.2 m, the average depth is 1,0-1,2 m; the area of the water surface 475 ha. The coastal line of lake, adjoining to Plato Ustyurt, is little indented; the opposite part, especially its northern part, is characterized by a heavily indented and marshy coastline. The general extent of a coastline of lake is 17 km.

On all sides, Lake Karateren is surrounded by a continuous growth of reeds and cattail. Collector KKC flows into its southern end, the outflow of surplus of water occurs in its northern part through Canal Vzryvnoi. The basic stretch of the water in this lake has no continuous growth of emergent vegetation.

Dark-gray silts with a varying content of vegetative remnants cover the bed of these open stretches of water. In the growth of the aquatic vegetation, the bed is formed by thick sediment of black silts with a mass of vegetative remnants and a strong smell of hydrogen sulphide.

The color of water is marshy-green, in a southern part of lake it has a greenish shade.

Lake Begdulla-Aidyn is located in the central part of Wetland Sudoch'e. The water area of lake is limited to the following coordinates: in the south 43°09′48″, in the north 43°13′45″, in the east 58°23′55″ and in the west 58°21′18″.

Lake Begdulla-Aidyn has the round form with a little indented coastline, the length of which is 11 km. The maximal length of this lake reaches 4 km, the width 2,5 km, and the depth is less than 1,4-1,5 м, the average depth is equal to 0,6-0,8 m, the area 1850 ha.

Collector ККС adjoins Lake Begdulla-Aidyn from its western part; a one-kilometer canal flows out from its eastern part flows out connecting it with Lake Bolshoe Sudoch'e. Most part of the water area of Lake Begdulla-Aidyn has no more or less significant weeds of emergent vegetation; however, the coast of Begdulla-Aidyn is covered with dense growth of cattail and to a much lesser degree with reeds.

The ground of lake consists of grey and dark grey silts containing vegetative detritus and weak smell hydrogen sulphide. In the growth of water vegetation, the ground consists of black silts with a mass of the plant detritus and a strong smell hydrogen sulphide.

The water had a slightly expressed green color, which grows grey with prolong winds, stirring-up the bottom sediments.

Lake Bolshoe Sudoch'e is located in the southeast part of Wetland Sudoch'e. It is confined to the following coordinates: in the south 43°06'31", in the north 43°13′42″, in the east 58°30′32″ and in the west 58°23′05″.

Lake Bolshoe Sudoch'e in prolong is shape, the maximal length is 10 km, the width 4,5 km, the depth is less than 1,2-1,4 m, the area is 5100 ha. The lake, especially its southern and eastern part, has little indented coastline, the length of which is 32 km. A canal connecting it with the neighboring Lake Begdulla-Aidyn runs into the western part of lake; in the northeast end of the lake inflow the waters of Collector GK (Ustyurtsky) and canal Sudochinsky.

At the distance of 3 km from Lake Bolshoe Sudoch'e, the formed canal of collector GK is sharply discontinued against the wall of reeds. From this place, the collector waters run into lake in a wide front breaking into several canals and spreading in the reeds. At the terminal part of the collector, the canal Sudochinsky flows 100-150 m away from it flows in the parallel direction. Two kilometers from the western coast of Lake Bolshoe Sudoch'e, the canal breaks up into separate beds and is subsequently lost in coastal reeds of this lake.

The main stretch of water in this lake practically has no weeds of emergent vegetation, the coast of northern bay of this lake is covered with the growth of reeds forming in this area numerous islands of vegetation; on the remaining part of the coastline dominate cattail associations.

The bed of the main stretch of water in this lake consists of grey and dark grey silts with a slightly expressed smell of hydrogen sulphide and a high content of clay fractions. In weeds of the emergent vegetation, the bottom sediments consist of thick black silts with high contents of the vegetative detritus and a strong smell of hydrogen sulphide.

Water had a slightly expressed green color, acquiring a grey shade after the long and strong winds.

The water in all lakes of Wetland Sudoch'e in the autumn 1999 was transparent to the bottom. With a reduction of depth in the lakes, turbidity and coloration of water, as well as the deterioration of its transparency took place. In the autumn 2000, the bottom was not practically seen in deep-water sites of lakes; in shallow parts, it could be hardly seen even at the absence of excitement and stirring of the bottom sediments.

Throughout the history of Lake Sudoch'e, the flowage of this water body provided preservation and restoration of the water quality. The discontinuation of this flowage has inevitably resulted in an increase of water mineralization.

At the present stage, the lakes in Wetland Sudoch'e are characterized by a various degree of flowage. The largest lake, Akushpa, is stagnant and represents a land-locked accumulator of part of the drain from the collector ККС. Lakes Begdulla-Aidyn and Bolshoe Sudoch'e are slightly flowing and only Lake Karateren is not stagnant. However, because of an extremely low water period in 2000-2001 and a practical discontinuation of the drain of collector-drainage waters, all lakes in Wetland Sudoch'e are deprived of flowage and in the last two years have turned into stagnant water bodies.

The water temperature in the lakes of Wetlanda Sudoch'e is determined by the air temperature. In spring, on deep-water sites of Lake Akushpa the water warms up to 15,9°-17,0°C, in the remaining part of this lake the water temperature reaches 17,8°-21,9°C. In Lake Karateren, the water warms up to 19,2°-20,4°C, in Lake Begdulla-Aidyn up to 20,1°-20,3°C, and in Lake Bolshoe Sudoch'e up to 19,6°-20.1°C.

In summer, the water temperature in Lake Akushpa reached 24,0°-28,2°C, and on the site Taily 27.2-29.0°C. In lake Karateren, the water warms up to 23.8°-26,4°C, in lakes Begdulla-Aidyn and Bolshoe Sudoch'e up to 22,7- 26,8°C.

In autumn on deep-water sites of Lake Akushpa the water temperature ranged from 16.4° to 17.9°C, on shallow sites of the main part of the lake from 11,2° до14.6°C. In lake Karateren, the water temperature reached 15,4°-17,3°C; in lakes Begdulla-Aidyn and Bolshoe Sudoch'e 8,7°-9,3°C.

5. CHARACTERISTIC OF ABIOTIC CONDITIONS IN WETLAND SUDOCH'E

The analysis of a retrospective status of Lake Sudoch'e shows that hydrological and hydrochemical regimes of water objects are the basic abiotic factors determining the development of water ecosystems.

5.1. Hydrological regime of lakes

The hydrological regime of lakes in Wetland Sudoch'e entirely depends on the volume of inflowing water from collectors ККС and GK.

In abundant-water years (1984,1992), the amount of the runoff from these collectors reaches 931.0-1016.2 million m^3, the amount of the monthly average of water discharge reaches 33.9-51.4 m^3/sec.

In the moderate-water years (1990) the volume of the runoff of collector waters reaches 579.4 million m^3, a monthly average of water discharge is 26.0 m^3/sec.

In low-water years (1982, 1986 and 1989), the annual runoff in collectors ККС and GK in the mouth reaches 521.7-538.9 million m^3/year, a monthly average water discharge 19.8-21.1 m^3/sec.

An average long-term (1980-1999) runoff in these collectors reaches 568,2 million m^3, the water discharge 18,03 m^3/year. An average long-term level of water line in the lakes has changed from 52,33 up to 52,74 m of absolute mark, its monthly average size has reached 52,61 m of absolute mark.

The annual distribution of the collector runoff depends on the water content during a year and the character of agricultural activities. The maximal discharge occurs in April, when the mass discharge of wash waters from the irrigated fields takes place, and in August, when there is a discharge of water from the rice checks. The lowest discharges of water are in November-December, when irrigation of agricultural crops ceases.

The volume of the winter runoff in low-water and abundant-water years have no significant differences, as the collector-drainage runoff in this period of year is formed mainly on the basis of ground waters.

The runoff of the River Amu Darya in the years 2000-2001 appeared to be the smallest in the history of the hydrological monitoring. The sharp reduction in the runoff of the River Amu Darya began from April 2000 and to the end of 2001. Consequently, an extreme decrease in the volume of the collector-drainage water took place. The runoff of collector KKC in 2000 reached 321,36 million m^3, of which 249.7 million m^3 took place in the first four months of year. The monthly average discharge reached 10,4 m^3/sec. The runoff of the collector GK in the period since January till April rached 29,7 m^3/sec and then completely stopped. In 2001 the collector GK had no water discharge, the whereas the discharge of collector KKC was only 46,24 million m^3 (Table 1).

5.1.1. Hydrological regime in 2000

In the winter 2000 along the irrigation canals adjoining Wetland Sudoch'e, water was used for washing the ground and watering pastures and grasslands. Thus, the surplus of water was discharged into the collector-drainage network, which has resulted in an increase its discharge in collectors KKC and GK: So, if the long-term average size of the water discharge in collector KKC was 12.6 m^3/sec in January, in February 14.1 m^3/sec and in March 21.9 m^3/sec, in the year 2000 it was, respectively, 19,8; 25,1 and 29,1 m^3/sec.

In the same period of year, in the part Wetland Sudoch'e there was a runoff of water from Karadjarsk-Mashankul system of lakes. In January 2000 the discharge of this drain reached 1,78 m^3/sec, in February 1,05 m^3/sec, and its total volume reached 7,2 million m^3.

In total in the winter 2000 in the lakes of Wetland Sudoch'e 327,0 million m^3 was discharged, of which the share of collector KKC was 288,0 million m^3 and GK 28,9 million m^3.

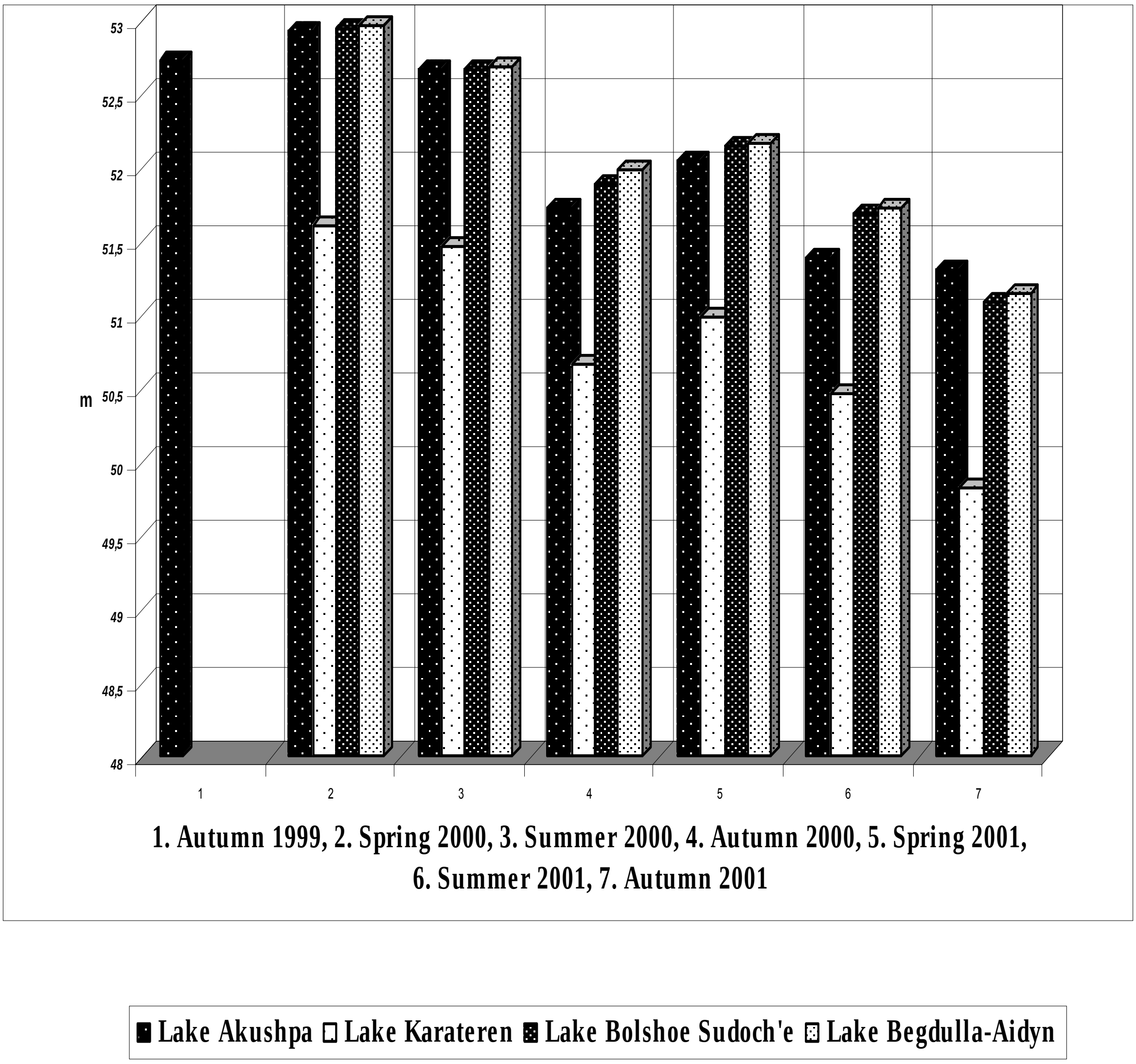
The consequence of this increase in the collector-drainage runoff was a growth in the level of water line in the lakes of Wetland Sudoch'e: if in October 1999, the level of water in Lake Akushpa reached 52,73 m of absolute mark, in January it increased up to 52,953 m, in February up to 52,960 m of absolute mark, and in March up to 52,949 m of absolute mark. In Lake Karateren these values were 51,655; 51,649 and 51,613 m of absolute mark, respectively (Table 2, Fig. 4).

The discharge of water from lakes Wetland Sudoch'e takes place through the Vzryvnoi canal. In January-March 2000, the amount of this discharge reached 5,86-6,38 m3/sec, the total volume 52,3 million m^3, which constituted 18,2% of the total volume of the runoff of collector-drainage water.

In the spring, the reduction of volume supply into the irrigation canals caused a reduction of water discharge into the collectors. At the same time, the outflow of water through the Vzryvnoi canal did not decrease, reaching 9.6 m^3/sec in April (24,9 million m^3/year). The outcome of such a hydrological regime and a rather intensive warming of water was a decrease in the level of the water line in the lakes of Wetland Sudoch'e - in lake Akushpa it decreased in April to as low as 52,831 m of absolute mark, in Lake Karateren 51,61 m of absolute mark (Table 3).

The depth of water in Lake Taily reached 1.7-1.75 m in spring, the average depth 1,5 m. In lake Akushpa, the depth of water was less than 1,4 m, the average depth ranged at 1,2-1.3 m. On Lake Karateren, the maximum depth was 2.0 m; the average was 1.2-1.4 m. The depth in lakes Begdulla-Aidyn and Bolshoe Sudoch'e was less than 1.35 m, the average depth being 1.1-1.2 m.

Fig. 4. Dynamics of the water level in lakes of Wetland Sudoch'e.



In summer, the runoff in collector KKC reached 1,37-2,9 m^3/sec, in collector GK the water discharge was completely absent. The reduction of the runoff of collector-drainage waters at a high level of natural evaporation has resulted in an intensive decrease in the level of water in lakes. The level of water line in Lake Akushpa has decreased to 52,41 m of absolute mark; in Lake Karateren up to 51.223 m of absolute mark. The coastline in the southern end of Lake Akushpa has moved from its spring place as far as 300-500 m, and in the western coast along the chink of Plato Ustyurt as far as 50-200 m, and on lakes Begdulla-Aidyn and Bolshoe Sudoch'e as far as 100-150 m. This resulted in a reduction of the area of shallow sites and drying of the coastal areas.

In comparison with a spring level, the depth of water in lakes of Wetland Sudoch'e has decreased by 38-42 cm.

In autumn, the discharge of water in collector KKC reached 2.09-3.2 m^3/sec, collector GK and Canal Sudochinski had no water. The level of water line in Lake Akushpa dropped in October as low as 51,819 m of absolute mark, in Lake Karateren 50,673 m of absolute mark, in lakes Begdulla-Aidyn and Bolshoe Sudoch'e 52.090 m of absolute mark.

In comparison with the spring level, the depth of water in the lakes Wetland decreased by 0,95-1.0 m.

The depth of water in Lake Taily and the northern part of Lake Akushpa ranged from 0,6 to 0,9 m, in the central and southern part of lake Akushpa it did not exceed 0.2-0,4 m. In Lake Karateren the average depth of water was 0.5-0.9 m, in Lake Begdulla-Aidyn 0,15-0,6 м and in Lake Bolshoe Sudoch'e- 0,25-0,4 m.

The coastline in the southern part of Lake Akushpa moved from the spring position as far as 600-1200 м, in the western part along the chink of Plato Ustyurt as far as 250-400 m, on lakes Begdulla-Aidyn and Large Sudoch'e as far as 300-400 m. The result of a decrease in the level of water in lakes was the drying up of the coastal growth of reed and cattail.

5.1.2. Hydrological regime in 2001

During the whole 2001, a strain water-management situation was developing in the lower reaches of the River Amu Darya, which resulted in a sharp reduction of the area of irrigated lands, which in turn brought to the general drop in the level of ground waters on irrigated lands and respectively to a decrease in the volume of collector waters. If the average long-term monthly discharge of water in collector KKC was 18,03 m^3/sec, in 2001 the average size of this value (with the exception of December) has appeared to be equal to 2,28 m^3/sec (Table 1). In the period from June to October of this year, in collector KKC there was no current of water at all and, as a result, no inflow of water into the lakes of Wetland Sudoch'e. Collector GK remained dry during all the year. The total inflow of water in the lakes for the period January-November 2001 constituted 12% of the long-term values (Table 4).

Table 4. Annual volume of the collector water inflow into lakes of Wetland Sudoch'e

Source	Periods and years	Volume of water inflow into lake, million m^3			Discharge from lake
		Total	Including		
			Freshwater	Collector	
Collectors KKC and GK, and canal Sudochinski	1980-1999	568,2	-	-	No data
	2000	355,0	4,3	350,8	76,09
	2001*	46,24	-	46,24	0

- Period January- November

A decrease in the volume of water inflow resulted in a considerable drop in the water line in lakes of Wetland Sudoch'e (Table 5). The level of water line in Lake Akushpa dropped from 52,06 to 51,33 m of absolute mark, in Lake Karateren from 51,02 to 49,81 m of absolute mark, Lake Begdulla-Aidyn from 52,17 to 51,16 m of absolute mark and Bolshoe Sudoch'e from 52.15 to 51.1 m of absolute mark. The water line in the lakes dropped by 0.73-1.21 m. As a result, vast shallow parts of lakes Taily and Karateren, previously flooded by water, either fully dried up or solonchak marshes emerged on their places. Lakes Begdulla-Aidyn and Bolshoe Sudoch'e, as well as the southern and central parts of Lake Akushpa are fully dried up. Table 5 provides data on the areas of lakes under different values of isobaths.

Table 5. Areas of separate isobaths at different elevations of water in lakes of Wetland Sudoch'e

Absolute mark	Akushpa		Bolshoe Sudoch'e		Begdulla-Aidyn		Karateren	
	Area, ha	km^2	Area, ha	km^2	Area, ha	km^2	Area, ha	km^2
51.00	-	-	-	-	-	-	355	3,5
51.50	2795	27,9	110	1,1	62,5	062	445	4,4

52.00	6868	68,6	2827,5	28,2	581,25	5,81	flood	flood
52.50	8884,7	88,8	4090	40,9	1495	14,9	flood	flood
53.00	12515	121	5450	54,5	1945	19,4	flood	flood

In autumn, the area of water surface in Lake Akushpa was only 285 ha or 2,45%, that of Lake Karateren was 31,25 ha or 6,58% against the values of the spring 2000 (Table 3).

An analysis pf hydrological regime shows that by all the values it is not typical for Wetland Sudoch'e. In 2000, the cause of it was, on the one hand, a discharge of irrigation waters in the non-vegetative period into the collector-drainage network, and, on the other hand, an extremely low-water year of during the vegetative period of the year. The outcome of the former was an increase in the level of the water line in the lakes of Wetland Sudoch'e in winter; the outcome of the latter was an extreme drop of the water line in summer and autumn. In the year 2001, the extremely low water caused a drop in the runoff of the collector-drainage runoff and as a result to a complete drying up of the lakes.

Table 1. Average monthly and annual discharges of water from canals of Wetland Sudoch'e

Years	values	Months												Per annum
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Collector KKC														
1980-1999	Q, m^3/sec	14,1	15,2	20,6	21,3	18,7	21,2	26,7	32,0	16,9	8,8	8,9	12,0	18,03
	W, million m^3	37,7	35,8	55,1	55,2	50,0	54,9	71,5	85,7	43,8	23,5	23,0	32,1	568,2
2000	Q, m^3/sec	19,8	25,1	29,1	21,6	8,8	2,9	2,55	1,37	2,09	2,30	3,2	3,9	10,22
	W, million m^3	53,0	62,9	77,9	55,9	23,5	7,51	6,82	3,66	5,41	6,16	8,2	10,4	321,36
2001	Q, m^3/sec	2,53	4,48	5,7	2,1	1,61	1,4	0	0	0	0,29	0,16		1,52
	W, million m^3	6,77	10,8	15,2	5,4	4,3	3,62	0	0	0	0,02	0,13		46,24
Collector GK														
2000	Q, m^3/sec	2,46	4,2	2,5	2,38	0	0	0	0	0	0	0	0	2,88
	W, million m^3	6,5	10,4	6,7	6,1	0	0	0	0	0	0	0	0	29,7
2001	Q, m^3/sec	0	0	0	0	0	0	0	0	0	0	0		
	W, million m^3	0	0	0	0	0	0	0	0	0	0	0		
Canal Sudoch'e-Yab.														
2000	Q, m^3/sec	0,22	0,66	0,27	0,60	0	0	0	0	0	0	0	0	0,43
	W, million m^3	0,58	1,50	0,72	1,5	0	0	0	0	0	0	0	0	4,3
2001	Q, m^3/sec	0	0	0	0	0	0	0	0	0	0	0		
	W, million m^3	0	0	0	0	0	0	0	0	0	0	0		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Canal Vzryvnoi														
2000	Q, m^3/sec	5,86	8,16	6,3	9,6	0	0	0	0	0	0	0	0	7,48
	W, million m^3	15,6	19,7	16,9	24,9	0	0	0	0	0	0	0	0	76,9
2001	Q, m^3/sec	0	0	0	0	0	0	0	0	0	0	0		
	W, million m^3	0	0	0	0	0	0	0	0	0	0	0		

Table 2. Fluctuations in levels of water line in lakes of Wetland Sudoch'e in 1980-1999, 2000 and 2001 (absolute mark)

Periods	Months											Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Lake Akushpa													
1980-1999	52,56	52,59	52,68	52,74	52,72	52,95	52,70	52,83	52,69	52,46	52,41	52,33	52,61
2000	52,95	52,96	52,94	52,94	52,75	52,68	52,68	51,98	51,84	51,81	51,78	51,80	52,42
2001	51,7	51,9	51,9	52,06	51,85	51,66	51,40	51,38	51,36	51,35	51,31	-	-
Lake Karateren													
2000	51,65	51,64	51,61	51,61	-	-	51,47	50,85	50,77	50,67	-	-	-
2001	50,77	50,92	51,02	51,00	50,80	50,61	50,47	50,22	50,02	49,89	49,81	-	-
Lake Bolshoe Sudoch'e													
2000	53,03	53,07	52,98	52,96	-	-	52,67	52,05	51,90	51,96	-	-	-
2001	51,85	52,10	52,08	52,15	52,00	51,76	51,69	51,38	51,10	-	-	-	-
Lake Begdulla-Aidyn													
2000	53,01	53,06	52,98	52,98	-	-	52,69	52,09	51,93	51,99	-	-	-
2001	51,86	52,11	52,08	52,17	52,00	51,89	51,73	51,40	51,16	-	-	-	-

Table 3. Dried up areas of lakes in Wetland Sudoch'e in 2000-2001

Lakes	Lake area, ha					Area of drying, ha			Area of drying, **%**		
	2000		2001			Spring-Autumn 2000	Autumn-Spring 2001	Spring-Autumn 2001	Spring-Autumn 2000	Autumn-Spring 2001	Spring-Autumn 2001
	Spring	Autumn	Spring	Summer	Autumn						
Akushpa	11600	7200	7725	2700	285	4400	3875	7440	37,9	33,4	96,3
Begdulla-Aidyn	1850	750	885	470	0	1100	965	885	59,45	52,1	100
Bolshoe Sudoch'e	5100	2750	2880	1180	0	2350	2220	2880	46,0	43,5	100
Karateren	475	437	446	290	31.25	38	39	414,75	8,0	6,1	93,0
Total	19025	11137	11936	4640	316,25	7888	7089	111619,8	41.5	63,6	97,3

5.2. Hydrochemical regime of lakes in Wetland Sudoch'e

The hydrochemical regime in the lakes of Wetland Sudoch'e is predetermined by the hydrological regime and water quality of the water sources, levels of flowage and activity of the insolation process.

The analysis of hydrochemistry of water in lakes and canals of Wetland Sudoch'e shows significant fluctuations in mineralization and chemical content of water, especially in the extremely low-water years 2000-2001 (Fig. 5).

In the 1999 autumn, the water mineralization in Lake Akushpa reached 16,1-30,61 g/dm^3, and in lakes Karateren, Begdulla-Aidyn and Bolshoe Sudoch'e 3,28-4,37 g/dm^3. In the spring 2000, in spite of the fact that in winter there were higher discharges of water in collectors feeding lakes, general mineralization in the lakes did not undergo essential changes: in lake Akushpa it was 16,3-29,56 g/dm^3, in lake Karateren 3,0-5,78 g/dm^3 and in lakes Begdulla-Aidyn and Bolshoe Sudoch'e 3,5-4,92 g/dm^3 (Table 6).

The extreme low water of the vegetative period of the year 2000 has resulted in a reduction of the water dicharge in the collectors, and by the end of a summer and beginning of autumn in its complete termination. The result of the reduction of the volume of inflowing water, the loss of flowage and a high level of natural evaporation was a sharp increase in the water mineralization in all lakes of Wetland Sudoch'e. In Lake Akushpa water mineralization in the autumn 2000 reached 21,3-70,0 g/dm^3, in Lake Karateren 10,9-15,5 g/dm^3, in Lake Begdulla-Aidyn 6,6-7,7 g/dm^3 and in Lake Bolshoe Sudoch'e 11,9-13,1 g/dm^3. In comparison with the autumn 1999, water mineralization in these lakes increased 2-3 times.

The increase in water mineralization in lakes has resulted in reorganization of chemical content of water, which has changed in the most of them from anionic sulphate-chloride composition towards the an increase in chlorine up to chloride-sulphate composition with the prevalence of cations of sodium and magnesium. An active reaction of water in the lakes Wetland Sudoch'e was slightly слабо alkaline (pH 7,1-8,26) and in the period of 1999 to 2000 it did not undergo essential changes.

In the 2001 vegetative period, the inflow of water into the lakes of Wetland Sudoch'e practically ceased. It has resulted in a strong shallowing and partial drying of lakes in the summer and in a complete drying of the most reservoirs by autumn and as the consequence in a sharp increase water mineralization (Tables 6 and 7).

The basic hydrochemical characteristics of lakes in Wetland Sudoch'e for 2001 are given below.

Lake Akushpa

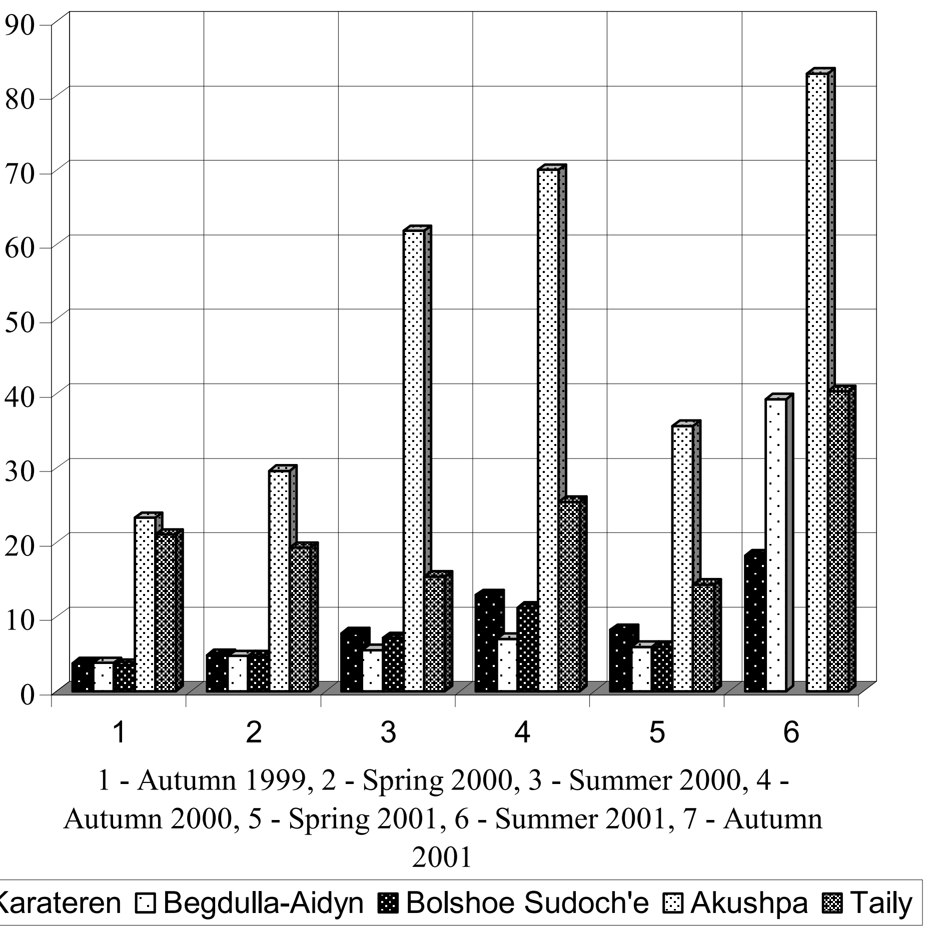
Water mineralization in this lake was on the average 35,6 g/dm^3 in spring. The distribution of salt in the area of the lake was heterogeneous. The Northern part of lake Akushpa (about 20%) showed water mineralization ranging 24 to 30 g/dm^3, the central part from 30 to 45 g/dm^3 and the shallow southern part from 45 to 48 g/dm^3 (Fig. 6). In summer, water mineralization increased up to 83 g/dm^3 and in autumn Lake Akushpa completely dried up. By the classification of water salinity, Lake Akushpa is saline, than 35 g/dm^3.

The active reaction of water was slightly alkaline, pH ranged from 8,1 to 8,4.

Electric conductance of water in this lake in spring ranged from 28 to 46 mCm/cm and in summer from 56 to 100 mCm/cm. The electric conductance of water depends on the concentration of dissolved salts and the temperature. The amount of electric conductance is caused by ions Na^+, K^+, Ca2$^+$, Mg^{2+}, Cl^-, SO_4^{2+}, HCO_3^- and is directly related to the degree water mineralization. In the international practice, this parameter is applied as the indicator of water pollution.

Water turbidity in this lake (by the scale from 0 up to 100 units) changed in the northern part of lake from 8 to 25, in the central part of lake from 25 to 55 and in the southern part from 55 to 163 units. Turbidity depends on water mineralization and a degree of susceptibility to the wind-induced agitation of water. The oxygen content dissolved in water changed from 9 up to 11 mg/dm^3, which corresponds to 95% of saturation. In summer, the oxygen content in the water is a little decreased. The deficiency of oxygen was recorded only in small enclosed embayments located in reeds.

Fig. 5. Average mineralization in lakes of Wetland Sudoch'e



In cationic water composition, the ions of potassium and sodium constituting 51-63% of all cations prevailed. The content of potassium and sodium in Lake Akushpa changed from 4,6 to 11,5 mg/dm^3, increasing to the end of the year by 2-2,5 times. The concentration magnesium reached 1,7-3,3 mg/dm^3, calcium 0,6-1,1 mg/dm^3. The content of calcium ions in Lake Akushpa is least subject to seasonal fluctuations.

In the anionic group, the ions of Cl^- and SO_4^{2+} prevailed, in spring the anions of only SO_4^{2+} prevailed, in summer the content of these anions was equal, and in autumn anions of Cl^- prevailed. The content chlorides in Lake Akushpa changed in spring from 6,8 to 16 g/dm^3, summer from 31 up to 37 g/dm^3. Because of high migration ability, weak sorption properties and non-consumption by aquatic organisms chlorides are capable of accumulating and dominating in saline water bodies, dramatically inhibiting the biotic environments. The content of sulphate ions in spring reached 8,2 to 15,7 g/dm^3, in summer up to 35 g/dm^3. The hydrocarbonate ion had a low concentration all the year round. The content of HCO_3- in the water of Lake Akushpa changed from 0,45 to 0,56 g/l.

Across the water area of Lake Akushpa, chloride-sulphate-sodium-magnesium type of water prevailed.

An average content of ammonium ions ($NH4^+$) in the water of Lake Akushpa reached 0,06 g/dm^3, which is almost 10 times as low as the amount of maximum permissible concentration for fishery water bodies (0,5 g/dm^3). The content of nitrite reached, on the average, 0,02 g/dm^3 in the spring; in summer it increased up to 0,1 g/dm^3. The content of nitrates reached, on the average, 217.1 g/dm^3 in spring; the maximal values reached 332 g/dm^3. In summer, it decreased to 89-142 g/dm^3. The average content of phosphorus in Lake Akushpa was 9,5 mkg/l in spring, in summer the content of phosphorus increased ten-fold, reaching a maximum of 91 mkg/l.

The analysis of the content of heavy metals in Lake Akushpa show that by polluting elements are aluminum, potassium and strontium (Table 8).

The composition of bottom sediments in Lake Akushpa is carbonate-silica-alumina. The bottom sediments consist of clay of a fine-dispersed fraction, with a mixture of gypsum - from 5 to 15 %, in sites with a higher water mineralization the content of gypsum grows to as high as 26-50%. The sulphate component of SO_3 ranges from four to 7%, increasing in highly mineralized waters to as high as 18-31 %. Of heavy metals, strontium, arsenic and uranium are recorded in rather high amounts in bottom sediments (Table 9).

Lake Taily

Lake Taily constitutes a single system with Lake Akushpa, but is more subject to the effect of collector KKC. In spring water mineralization was, on the average, 14,3 g/dm^3, and in summer 40,3 g/dm^3. The distribution of salt in the area of Lake Taily was heterogeneous. In spring, the eastern part of Lake Taily showed mineralization from 10 to 13 g/dm^3, in summer from 37 to 40 g/dm^3, farther to the west the water mineralization increased, respectively, to 15-16 g/dm^3 and 40-46 g/dm^3. In spring, Lake Taily was assigned to water bodies with increased salinity (10-35 g/l) in spring, whereas in summer to brine ones. (Fig. 6).

Values of pH across the entire area of Lake Taily was homogeneous and changed from 8,06 to 8,26. According to the classification of natural waters, Lake Taily is attributed to slightly alkaline waters (pH 7,5 to 8,5)

The electric conductance of the water of Lake Taily changed in spring from 15 to 19 mCm/cm and in summer from 40 to 49 mCm/cm. Turbidity of water changed from six up to 53, decreasing in creeks, which are not subject to the wind effect, and increasing in open sites. The contents of the oxygen dissolved in water reached 9-11 g/dm^3, which corresponds to 95% saturation.

In cation composition of water, the ions potassium and sodium prevailed. In spring, the content of potassium and sodium changed from 1,6 up to 2,9 11 g/dm^3, by summer it has increased as high as 1,3 times, reaching 7-8 g/dm^3. The contents magnesium and calcium did not undergo essential seasonal changes and was respectively 0,7-1,1 g/dm^3 and 0,5 - 0,6 g/dm^3.

Of the anionic group prevailed ions of Cl^- and SO_4^{2+}. The concentration of chlorides changed from 2,9 to 4,6 g/dm^3, sulphates from 3,6 to 5,6 g/l. The content HCO_3- in waters of Lake Taily was insignificant and reached 0,003 -0,004 g/dm^3.

The type of water in Lake Taily varies between sulphate-chloride-calcium-sodium-magnesium and chloride-sulphate-sodium-magnesium.

The ion of ammonium (NH_4+) was contained in water of this lake in minimal quantities, less than 0,05 g/dm^3. The concentration of nitrites (NO_2-) was, on the average, 0,04 g/dm^3, increasing in summer up to 0,1 g/dm^3, nitrates (NO_3-), on average, 112,1 g/dm^3, reaching 115-123 g/dm^3. The concentration of phosphorus in Lake Taily was 2,5-4,0 mkg/l.

With the exception of strontium and potassium, heavy metals in water were in a low concentration (Table 8).

Gypsum is contained in bottom sediments ranging from 2.7 to 3.5%. Of heavy metals strontium 1234-1404 mg/kg and arsenic 36.7-41 mg/kg were notable (Table 9).

Lake Karateren

The hydrochemical regime in Lake Karateren under conditions of the cease of collector water feeding has undergone dramatic negative changes. Hence, in spring the mineralization of water was, on average, 8.2 g/dm^3 and 18,2 g/dm^3 in summer, in autumn it had grown to as high as 54,0 g/dm^3. By the classification of the salinity, in spring this lake was attributed to as a lightly saline lake, in summer as a saline and in autumn as a brine-water lake. The distribution of salinity across the lake area was heterogeneous: the southern part was least mineralized, farther northwardly the salinity grew (Fig. 7).

The value pH changed from 7.7 to 8.0. According to the classification of the natural waters, the water in Lake Karateren was a slightly alkaline (pH 7.5 to 8.5). The electric conductance in Lake Karateren ranged in spring within 7.3-12,5 mCm/cm; in summer within 7 to 10 an in autumn from 37 to 66 mCm/cm. The water turbidity reached values 4 to 18. The content of the dissolved oxygen in Lake Karateren reached 8-9 g/dm^3, which corresponds to 80-85% saturation.

In the cation content, ions of potassium and sodium prevailed. In spring, the content of potassium and sodium ranged within 0.9-1.79 g/dm^3, in summer 3.4-4.6 g/dm^3 and in autumn 6-15 g/dm^3. The content of magnesium was 0.3-0.7 g/dm^3, reaching 1.9-4.8 g/dm^3; the content of calcium ranged at 0.5-0.9 g/dm^3.

In spring and summer, of the anionic group in the lake water prevailed ions of SO_4^{2+}. The content of sulphates reached 2.7-3.7 g/dm^3; in summer 6-9.1 g/dm^3 and in autumn 2.4-10 g/dm^3. The content of chlorides (Cl-) was, respectively, 1.6-2.7 g/dm^3, 4.3-6.6 and 9.9-20 g/dm^3. The content of HCO_3^- in the lake water was stable at 0.32-0.57 g/dm^3.

In spring, Lake Karateren was of sulphate-chloride-sodium-magnesium-calcium type; in summer, it was of a mixed sulphate-chloride-sodium-magnesium-calcium and chloride-sulphate-sodium-magnesium-calcium type; and in autumn it was of chloride-sulphate-sodium-magnesium-calcium type.

The concentration of ammonium (NH_4^+) reached in spring, on average, 0.07 g/dm^3; in summer 0.7 g/dm^3 and in autumn 0.2 g/dm^3; that of nitrites (NO_2^-) in spring it was 0.01 g/dm^3, in summer and autumn –<0.01 g/dm^3. Nitrates (NO_3^-) in spring reached 63.2 g/dm^3; in summer 43 g/dm^3; and in autumn 48 g/dm^3. Phosphorus was, respectively, 9.2 mkg/l, 7 mkg/l and 14 mkg/l.

The content of heavy metals in the water of Lake Jarateren was insignificant (Table 8). In the bottom sediments, gypsum ranged within 4-5%; of heavy metals strontium (1443-1503 mg/kg), arsenic (25,3 mg/kg), zinc (114 mg/kg) and nickel were recorded (81.2 mg/kg) (Table 9).

Lakes Begdulla-Aidyn and Bolshoe Sudoch'e

In spring, the mineralization level in Lake Begdulla-Aidyn was, on average, 5.9 g/dm^3; in summer it increased by 40-50 g/dm^3. Lake Bolshoe Sudoch'e showed an average mineralization of 8.9 g/dm^3 in spring, with the highest level recorded at 10.5 g/dm^3. The water of these two lakes was of the saline type (3-10 g/l), in summer it was of a brine type. The salt distribution across the lake area was heterogeneous (Fig. 8).

Values pH changed within 7.7-8.18. According to the classification of natural waters, the water in these lakes ranged within 7.13-12.3 mCm/cm; water turbidity within 8-132. The oxygen content in the water of lakes Begdulla-Aidyn and Bolshoe Sudoch'e reached 9-10 g/dm^3, which corresponds to 90% saturation.

In the cation content, the ions of potassium and sodium prevailed in the water, the content of which ranged within 0.8-1.2 g/dm^3 in Lake Begdulla-Aidyn, and within 1.4-1.9 g/dm^3 in Lake Bolshoe Sudoch'e. The concentration of magnesium and calcium ions reached, respectively, 0.3-0.4 g/dm^3 and 0.3-0.5 g/dm^3.

Of the anion group, anions of SO_4^{2+} prevailed, the content of which in spring was 2.3-3.9 g/dm^3. The concentration of chlorides (Cl^-) ranged within 1.3-2.4 g/dm^3. The content of HCO_3^- in the water of these two lakes was stable at 0.2-0.3 g/dm^3.

By the ionic composition Lake Begdulla-Aidyn is of sulphate-chloride-sodium-magnesium-calcium type; Lake Bolshoe Sudoch'e is of sulphate-chloride-calcium-sodium-magnesium type.

The content of ammonium ions (NH_4^+) in these lakes was, on average, 0.08 g/dm^3, nitrites (NO_2^-) 0,01-0,44 g/dm^3 and nitrates (NO_3^-) 47,9-67,7 g/dm^3. The concentration of phosphorus in Lake Begdulla-Aidyn reached 14.9 mkg/l; in Lake Bolshoe Sudoch'e 12.3 mkg/l.

Collector KKC

The mineralization of water in Collector KKC in spring was, on average, 5.2 g/dm^3; in summer it reached 14.4 g/dm^3 and in autumn 9.7 g/dm^3. By the classification, the water in his collector is saline (3-10g/l) and that of higher salinity.

Values of pH ranged within 7.5-7.8. According to the classification of natural waters, the water in Collcetor KKC is of slightly alkaline (pH 7,5-8,5). The electric conductance of water was within 6.5-7.1 mCm/cm; the water turbidity ranged from 17 to 49. The content of dissolved oxygen was higher than 8-9 g/dm^3, which corresponds to 80-85% saturation.

The content of sodium and potassium in spring reached 0.8-0.9 g/dm^3, in summer 2.7-3.6 g/dm^3 and in autumn 0.8-3.3 g/dm^3. The concentration of calcium ions constituted 0.3-0.8 g/dm^3; that of magnesium ions constituted 0.2-0.3, 0.9-1.2 and 0.2-0.8 g/dm^3 in spring, summer and autumn, respectively.

Of the anionic group, ions of SO_4^{2+} prevailed, the content of which in spring reached 1.8-2.2 g/dm^3; in summer 5.1-6.4 g/dm^3 an in autumn 1.7-5.1 g/dm^3. The concentration of chlorides (Cl^-) in spring changed within 1.2-1.4 g/dm^3; in summer from 3.6 to 5.0 g/dm^3 and in autumn from one to 5 g/dm^3. The content of HCO_3^- in the water was stable at 0.2-0.3 g/dm^3.

The water in Collector KKC was of sulphate-chloride-sodium-magnesium-calcium type; in summer, it changes from the sulphate-chloride-sodium-magnesium-calcium to chloride-sulphate-sodium-magnesium-calcium type, and in autumn chloride-sulphate-sodium-magnesium-calcium type.

The concentration of the ammonium ions (NH_4^+) in spring was 0.07 g/dm^3; in summer 0.1-0.6 g/dm^3; and in autumn less than 0.2 g/dm^3. The content of nitrites (NO_2^-) in spring reached 0.19 g/dm^3; in summer 0.1-0.5 g/dm^3; in autumn less than 0.01 g/dm^3. The content of nitrates (NO_3^-) was 46,3 g/dm^3, 33-38 g/dm^3 and 8-16 g/dm^3. The content of phosphorus was 11,2 mg/dm^3, 8 to 27 mg/dm^3 and 5-10 mg/dm^3, respectively.