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A case study for Monitoring and Assessment of Nutrient Removal Capacities of Riverine Wetlands

Restoration of Katlabuh Lake - Danube Delta, Ukraine



WORKING FOR THE DANUBE AND ITS PEOPLE

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ACRONYMS AND ABBREVIATIONS

BOC:	Biological oxygen consumption
COC:	Chemical oxygen consumption
WWF:	World Wide Fund for Nature
WWF – DCP:	World Wide Fund for Nature – Danube Carpathian Programme
WMB:	Odessa Oblast State Water Management Board
SSU:	State Standard of Ukraine

1. BACKGROUND

1.1. Project area:

Wetland name: Katlabuh Lake

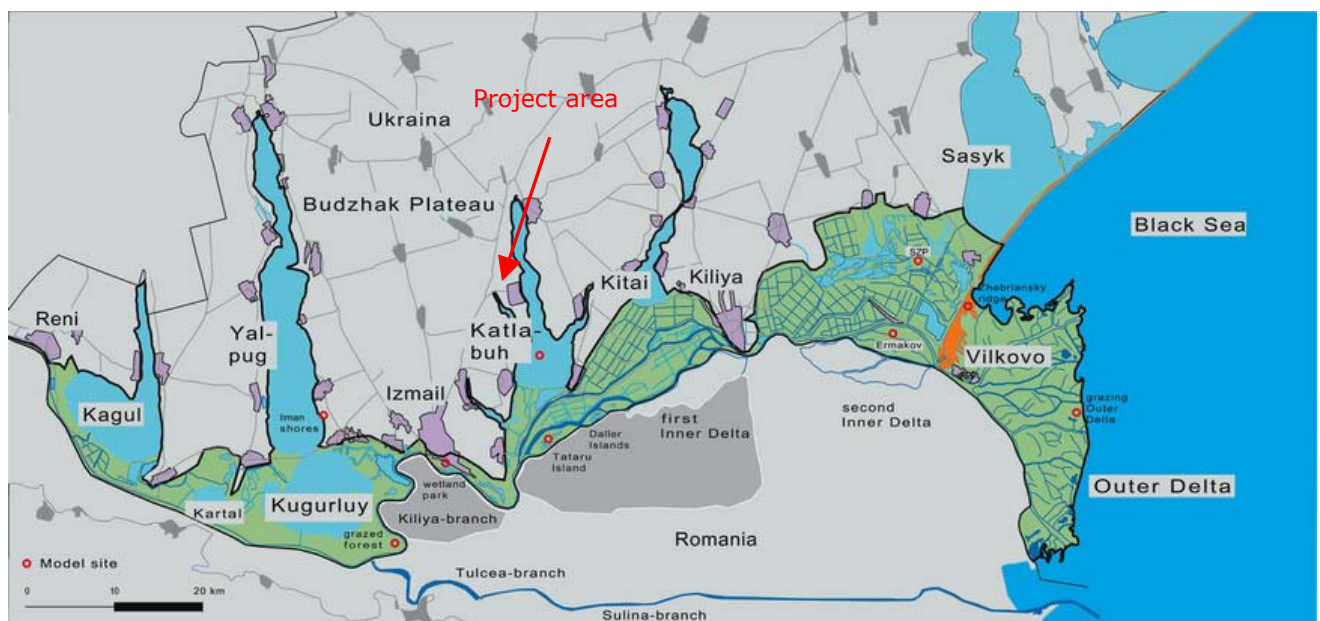
Coordinates: Latitude: 45° 25' N, Longitude: 28° 59' E

Country: Ukraine

Region: Danube Delta

Neighboring river: The River Danube

Fig 1. Project area



2. PHYSIOGRAPHY OF THE LAKE

Katlabuh lake is situated in Ukrainian Danube Delta, ten kilometers north-east from Izmail town. It occupies the territory of 68 square km, its average width is of 2 km, and maximum one is of 6 km. Katlabuh has steep cliff banks which that become gentle on the south descending to wetlands.

Under natural conditions (before embankment) the lake was a part of a larger wetland complex including reedbeds and smaller lakes of Safyiany.

The modern catchments of the Katlabuh lake is 1290 km, including the catchments of the small rivers of Tashbunal, Enika and Bolshoy Katlabuh with the total area of 1035 km.

According to Ramsar wetland classification it's type O – Permanent freshwater lakes (over 8 ha).

2.1. Climate

Katlabuh lake is situated in the moderate continental climate zone. The Black Sea, large lakes nearby and marshes mitigate the climate. Winter is short and mild with unsettled frosts, summer is continuous and hot, and autumn is warm.

Rare cyclones is a principal reason of relatively small quantity of precipitation. It is about 380...410 mm a year. Evaporation exceeds 800 mm. Most of precipitation (65...45% of a year norm) occurs in a warm year period as showers.

The area is characterized by high heat and a considerable deficit of water.

2.2. Hydrology

The Katlabuh lake consists of 4 parts: central part bordering on the Danube River and 3 narrow tips – the valleys of small rivers: Tashbunar. Bolshoy Katlabuh and Enika.

Central part of the lake is the deepest with the minimum depth of 1,0 m, while the upper tips are rather shallow with maximum depth of 0,5 m.

Before 1957 water regime of the lake was completely natural and depended on the exchange with the Danube and run-off of the small rivers. However, hydrological regime of the lake depends entirely on the Danube and the influence of the rivers is minor.

There were no hydrological observations of the lake under natural conditions.

In the 60's the dyke was built between the Katlabuh lake and the Danube River as well as the sluices at the canals connecting the lake to the Danube river. Thus, the lake was converted into a water reservoir, which resulted in a significant change of the water regime of the lake.

Under artificial regulation the water levels are maintained according to the main normative levels:

- normal affluent level (NAL),
- forced affluent level (FAL),
- dead storage level (DSL).

Hydrological and level regimes of the lake depend on the following factors:

- water inflow and outflow from the Danube;
- water inflow from the catchment area;
- precipitations
- evaporation
- morphology of the lake pan;
- hydraulic characteristics of the regulatory constructions.

The main principals of exploitation water management of the lake is to follow the natural water regime as much as possible with compulsory implementation of the requirements of the main water users and water consumers.

The main water regime provisions are:

filling in the lake in spring to NAL;

maintenance of the water level at NAL during summer and autumn in order to provide requested quality and quantity of the water to the water extractions;

discharge of the water to DSL in autumn;

maximum filling-in in autumn – winter but not higher than NAL;

discharge of the water to DSL before spring for water exchange;

to accommodate high floods, FAL level may be used that enables accommodation of high floods up to 1% probability.

Morphological measurements of the Katlabuh lake are listed below in the table I.

Table I. Morphology of the Katlabuh Lake

Length, km	Max width/average width	Max depth/average depth	Surface area km ² at NAL	Shallow water areas (up to 2 m) at NAL km ²	Total volume million m ³	Net storage volume million m ³	Length of the banks km	Normal affluent level (NAL) m Baltic system	Dead Storage level (DSL) m Baltic system	Forced Storage Level (FSL) m Baltic system
1	2	3	4	5	6	7	8	9	10	11
21	6,0 3,3	2,7 1,92	68,5	29,0	131	68,5	75,4	1,70	0,70	3,00 1%

Actual water levels do not always correspond to the normative levels due to technical reasons.

Average long-term water level in the lake is 1,35 m, maximum – 1, 83 m, minimum – 0,91 m.

Table II below presents average monthly levels in the Katlabuh lake.

According to the table NAL and DSL levels could not be reached each year which did not enable normal water exchange.

Table II. Average monthly water levels in the Katlabuh lake.

Year/month thmec.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
1985	130	137	159	183	172	157	165	161	153	130	102	107	151
1990	107	108	107	112	119	128	120	117	125	136	129	132	124
1979	115	123	132	146	169	149	139	122	119	129	132	140	139

1985 – high water year

1990 – low water year

1979 – average year

To improve the lake water quality it is necessary to increase filling with the Danube water. When solving problem it was taken into account that embankment also plays a positive role protecting ecosystems from pollutants flowing from the upper Danube.

2.3. Biota

Katlabuh lake is a typical floodplain wetland. As most of the central Danube lakes it has a large open water area with very narrow stretches of emerged aquatic vegetation dominated by reed *Phragmites australis* (Cav.) along the shores with somewhat larger reed-beds in the upper parts. The former extensive reed-beds of Katlabuh in the downstream part were cut-off from the lake in the 60's by the dam.

As most of the coast line is rather steep hills with clay cliffs in central parts of the lake, the main habitat types along the shores is the steppe vegetation. Steppe habitats are rather degraded due to intensive grazing.

Most of the slopes were planted with hedgerows of various tree species. The areas between the slopes and the water are largely covered with meadows. Most of the meadows are also degraded due to intensive grazing. In many places meadow turned into transition communities towards salt marshes and *Artemisia* communities. The *Artemisia* communities are probably secondary habitats replacing freshwater meadows due to intensive grazing pressure.

The most valuable areas in Katlabuh lake are the reed-beds along the Danube between the Katlabuh and Safiany lake. Central part of these reed-beds is a protected area of local importance. This is a mosaic marsh with many open water areas with abundant aquatic macrophytes: *Nuphar lutea*, *Nymphaea alba*, *Salvinia natans*, *Hydrocharis morsus-lutea*, and rare birds, such as the Pygmy Cormorant, Glossy Ibis, Squacco Heron, White-tailed Eagle, and other rare species of flora and fauna listed in the Red Data Book of Ukraine.

Reconnection of this marsh with Katlabuh lake is envisaged under the follow up of Katlabuh restoration project.

2.4. Land Use

The main economic activities in the area are fishery and agriculture.

There are several villages around the lake Izamil, Suvorovo, Utkonosovka, Pershotravnevoe, Bogatoo, Kislitsa. Population of these villages mostly uses the lands in the catchments of the lake and outside. However, the local people use the meadow and steppe communities on the shores of the lake for grazing of the livestock. The lake itself is rented by a fishery-agricultural enterprise "Pridunayskaya Niva". This company also owns the fish ponds downstream of the Katlabuh lake and stocks the lake. Moreover, this company is the only user of all the living resources on this wetland.

2.5. Fishery

Katlabuh is one of the most important water bodies for fishery industry in Odessa region. Though Katlabuh takes only 3.5% of the area of inner water bodies in the region its share in fish yield is from 13% to 21%. Fish catches in Katlabuh fluctuate from 263.3 t to 1,366.4 tons.

In 1950s before regulation of the water regime the lake fish fauna included almost all fish species which inhabited the lower Danube. The commercial catches registered *Cyprinus carpio* L., *Lucioperca lucioperca* L., *Abramis brama* L., *Carassius carassius* L., *Carassius auratus gibelio* L., *Vimba vimba* L., *Aspius aspius* L., *Tinca tinca* L., *Leuciscus cephalus* L., *Rutilus rutilus* L., *Scandinius erythrophthalmus* L., *Silurus glanis* L., *Exocoetidae* L., *Perca fluviatilis* L. and *Blicca bjoerkna* L.

In early 1970s in Katlabuh and other Danube lakes the fish stocking started. There were herbivorous fishes: *Hypophthalmichthys molitrix* Val, *Aristichthys nobilis* Rich and in less degree *Ctenopharyngodon idella* L.

Over the last 25 years the silver carp is the main commercial fish species. Its average annual yield in 1980s was 800 tons. In 2003 In Katlabuh there were caught 150.8 tons of the silver carp, 63.8 tons of the bream, 87.8 tons of the crucian, 5.2 tons of the sander, 0.1 tons of the pike and 0.1 tons of the redeye.

An important commercial object in 1950-1970s in Katlabuh was the crayfish *Pontastacus cubanius daucus* (*Pontastacus leptodactylus natio danubialis* Brodsky, 1967). In 1970s Katlabuh gave up to 39% of the total yield of this crayfish in Ukraine and near 24% of the total yield of the former USSR. Over the period 1959-1977 in Katlabuh there were caught 2,673.4 tons of the crayfish. It means 133.7 tons a year in average. At present Katlabuh population of the crayfish is depressed, and no commercial trade of it is taken.

Restoration of the constant water exchange between Katlabuh and the Danube will favor increase of the species diversity of the lake fish fauna and improvement of spawning conditions for indigenous fish species. It also will assist returning huge yields of the crayfish.

2.6. Agricultural water supply and agricultural usage of water

Nearby to Katlabuh there are such localities as Izamil, Suvorovo, Utkonosovka, Pershotravnevoe, Bogatoo, Kislitsa. The resources of the storage lake are mainly used for irrigation, fishery and agriculture.

An important factor for functioning and socio-economical development of the searched area is supply of the economic complex with water.

This region is a zone of intensive land development with irrigation. The concentration of irrigated lands directly influences on the structure of cultivated areas of different agricultural enterprises.

Cultivation of agricultural plants on the irrigated lands is a leading branch in the region. The area of the irrigated lands in the Katlabuh basin is 16,894 ha. From them 15,560 ha are state irrigation systems, and 1,334 ha are irrigated with local systems. During recent years the quantity of the water taken for irrigation decreased. It is related to reforms in an agrarian branch of economics (including land laws), and imperfect and unstable policy of taxation, credits and prices. So in 1980 54.5 mln m³ was taken from Katlabuh, in 2002 it was 2.81 mln m³, and in 2003 only 1.97 mln m³ of water.

Land drainage for agriculture resulted in reducing species of local flora and fauna. Apart from this fact fields often border with the water edge without any buffer zones. From villages situated near the lake the untreated domestic sewage water and wastewater from cattle farms flow into water bodies. Such an impact worsens ecological state of the lake. It also affects social environment of the residents.

The floodplain areas are almost completely used for fish-breeding ponds with regulated water supply and artificial water exchange.

At present on the polder area there are agricultural territories of different kinds – fields, fallows, recultivated pastures and haylands, useless lands, field buildings, canals.

Agricultural enterprises use about 60% of all land resources of the area. Share of the arable land around the Katlabuh lake is the highest in the region. It is near 90%.

3. SHORT HISTORY OF WETLAND

3.1. Embankment and its consequences

Before the embankment, the Katlabuh lake and adjacent areas were regularly flooded by the Danube following the seasonal dynamics of the river. After embankment only a narrow strip of the floodplain along the Danube is inundated. The lake was totally embanked in 1957. But because of the filtration under dykes the level of underground water raised and sometimes it caused death of agricultural crops and soil salinization.

The embankment protected about 2,500 ha of the lands from inundation but had dramatic consequences:

- Break of the complex ecological balance; natural meadows disappeared, spawning grounds and natural forests decreased;
- Floodplain development stopped;
- Foreshore is eroded by water;
- Vast reedbeds stopped filtering sediments and nutrients from the Danube water;
- Accumulation of salt and growth of mineralization and pollution of the water due to limited water exchange;
- Decline of the natural fish stock and a need for artificial stocking.
- Volumes of the annual water exchange decreased; the water quality deteriorated.

Embankment, removal of natural channels and construction of artificial canals changed natural hydrological processes in the lake. Before embankment the process was the following: while the water level in the Danube exceeded the level of the lake the water filled in the Katlabuh. When the water level in the Danube fell the water from Katlabuh gradually drained into the river. So the higher aquatic vegetation at marshes served as a natural filter, accumulating considerable part of silts.

4. MAIN PROBLEMS

Altered water regime led to significant deterioration of water quality and ecosystem of the lake. Because of growing salinity, water consumption that provides 16.000 people with drinking and irrigation water has dropped 5 times from 1995 to 2001. High water level throughout the year has contributed to heavy bank erosion and part of the riverbank has been lost.

In collaboration with the Odessa Oblast State Water Management Board and local organisations, a restoration of natural connection of the Lake and the Danube River was initiated in order to revive fluctuation of water levels in the lake and natural fish stocks in the lake.

Water-salt balance calculations for Katlabuh indicate that in order to maintain mineralization of water at the natural level of 1-1,6 g/l in 75% water probability year and with minimum water extraction, water exchange at the peak of flood (Aipril) must be up to 80 m³ per second or 71 million m³ in total.

Restoration of the old channel between the lake and the Danube nearby Kislitsy village that would discharge 50-60 m³ per second will bring 50-60 million m³ of water, which will significantly improve water quality and water exchange.

Restoration of natural water exchange is expected to lead to a significant decline in salt contents of the lake to the levels close to the Danube water. However, on the short term after the opening of the lake some negative effects are possible for both the Katlabuh lake and the Danube river. These effects relate first of all to washing out bottom deposits and return of chemical substances, especially such as nutrients to the Katlabuh lake and thus the Danube river. As historical data on water quality show, Katlabuh lake should still play a significant role in reducing nitrites and nitrates for the Danube. However, concentrations of ammonium and other chemicals are expected to increase at least on the short term. On the long term though, the effect of restoration on nitrogen transport needs to be further investigated as after reopening of the lake, positive changes are expected in the ecosystem of the lake related to development of aquatic vegetation and thus increase of removal capacity of the lake for the nutrients.

Nutrient pollution is the second problem after mineralization for most of the Danube lakes that are artificially managed. Water eutrophication along with altered natural connection has significantly changed the aquatic communities of the lake. These changes mainly relate to decline of emerged aquatic vegetation and valuable habitats as well as to decline and change of the natural fish communities.

Moreover, Katlabuh lake as well as most of the floodplain wetlands, played an important role in processing of nutrient loads from the catchments as well as in removal of nutrients from the Danube water. Flood water entering the Katlabuh lake would lose nutrient loads in the wetlands and filtered water returned to the Danube after flooding. This important process was stopped as a result of embankment of the almost entire floodplain on Ukrainian section of the Danube, which has contributed to pollution of the Danube river, and thus the Black Sea.

Therefore, this project aims to be the first experience in returning the floodplain functions to large lakes along the Danube and assess the role of these wetlands in transport and removal of nutrients from the Danube.

5. STATUS OF THE WETLAND

5.1. Protection status:

None; protected area of the local importance is located at the marsh area downstream of the Katlabuh lake, which used to be a part of Katlabuh. Further restoration plans aim to reconnect this marsh system to the Katlabuh lake.

5.2. Restoration works:

The ongoing restoration works include reopening of the old channel between the Katlabuh lake and the Danube. (Fig 2 and 3).

Fig. 2. Start of restoration works: construction of opening to the Danube with a bridge



Fig. 3. Ongoing restoration works



Overall restoration objectives:

- 1. to implement the restoration of natural connection of the Katlabuh lake and the Danube river for improvement of water quality, especially salt contents in the lake**
- 2. to develop and introduce a new water regime and use of the lake under the conditions close to the natural water exchange between the reservoir and the river**
- 3. to develop and introduce water protection regime within water protection zone**
- 4. to develop and introduce monitoring scheme based on the current monitoring scheme of WMB.**

The restoration activities were started in spring 2006. The first phase of restoration – reopening of the old channel and connection of the lake to the Danube River – should be finalized in spring 2007.

After reopening of the lake the first visible results will be available with the first flooding in spring – autumn 2007.

Total cost of restoration is about 400,000 USD. Percent of total cost of project used for nutrient control measurements about 22 000 USD or 8% of the total project costs.

5.3. Management of the wetland

The Katlabuh lake as most of the wetlands along the Danube is managed by Odessa Regional State Water Management Board who is a representative of the Ukrainian State Water Management Committee at the county or province level.

The management of the lake is aimed to fulfill the requirements of the main water users and water consumers in the area.

Management will change after restoration to adopt water uses (fishery and water extraction for irrigation and drinking) to dynamic water levels.

The Katlabuh lake borders several other wetlands: Lung – Safiany lake system (former reedbeds of Katlabuh lake), 3 small rivers discharging to Katlabuh form the catchment: Enika, Tashbunar and Bolshoy Katlabuh as well as Danube river.

Entire lake as well as the adjacent agricultural lands and fishponds are used and a property of a fishery-agricultural enterprise “Pridunayskaya Niva”.

The main economic activities this company runs in the area are fishery and agriculture. However, the lake also plays an important role in water supply to 5 villages around the lake including drinking water supply and irrigation. Yet, as all the large wetlands under artificial management, Katlabuh lake is used as a water reservoir for accommodation of flooding especially in cases of high floods with respective management prescriptions described in a chapter on hydrology of the lake.

6. PROJECT DESCRIPTION

6.1. Project outline and objectives

Katlabuh restoration model project is an important step towards a large-scale implementation of A VISION FOR UKRAINIAN DANUBE DELTA (a vision document may be downloaded from www.panda.org/dcpo), that was developed together with the key partners and stakeholders in Ukraine) and a contribution to the Lower Danube Green Corridor agreement.

Restoration of the old channel between the lake and the Danube nearby Kislitsy village will significantly improve water quality and water exchange. Moreover, this option is the most feasible and cost effective as the dam between the lake and the Danube river is used as an important road between large towns in the region and thus any restoration would include expensive construction of bridges to maintain this road access.

The water quality monitoring data will be used firstly to investigate the impact of wetland restoration on nutrient loads secondly to further advocate wetland restoration in Ukraine (through cooperation with WMB) and in the Danube basin (through WWF DCP).

Experience gained as a result of this project will enable substantially revise water management practices in Ukrainian Danube Delta and be a foundation for a large-scale wetland restoration and change of wetland management policies in the region.

Regular observations of water quality in the lake prior and after the restoration efforts form an essential component of the project. This data should prove and give first experience in mitigation and removal of harmful impact of water control to the ecosystem of the lake. It's expected that restoration of the natural connection of the lake to the Danube river will significantly improve water quality, especially the mineralization of the water. Influence of the restoration efforts on nutrient loads in the lake will be monitored to see how the restoration efforts on large lakes in Ukrainian Danube delta may revitalize water purification capacities of the Danube wetlands.

However, for a better understanding of the role of Katlabuh lake in transport and utilization of nutrients as well as spatial and temporal distribution of nutrients additional sampling needs to be done after completion of restoration works.

6.2. Nutrient monitoring scheme

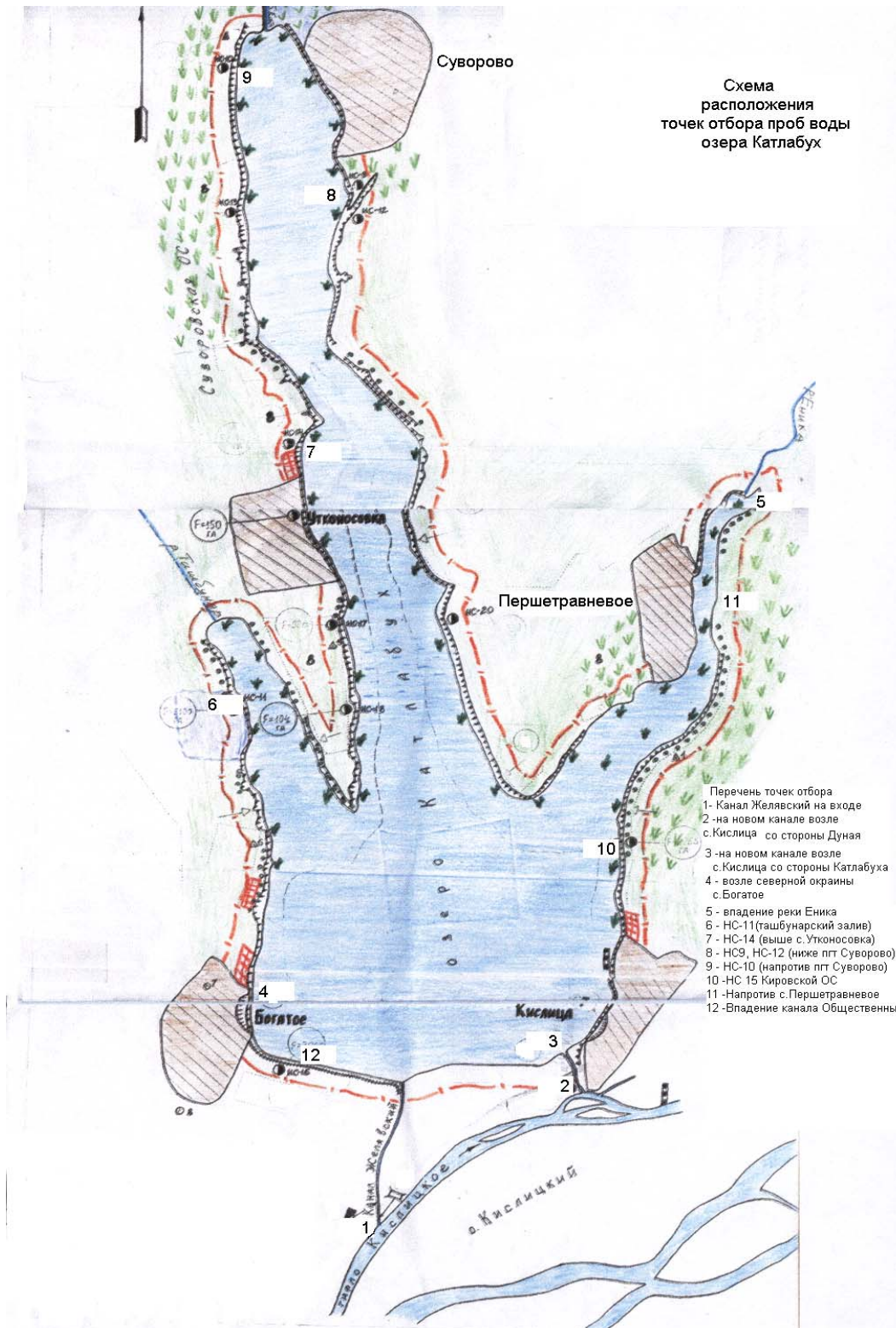
Analyses of the historical data still cannot fully demonstrate mutual influence of the Danube and the Katlabuh lake in terms of nutrient transport and utilization. The main reason for that is the fact that sampling was made only at a few points and does not demonstrate the spatial variation of nutrient loads in the Katlabuh lake.

Therefore, it was suggested to make additional sampling at 13 points around the lake (Fig. 4) in order to get a full understanding of spatial and temporal distribution of nutrients in the Katlabuh lake as well as mutual influence of the Danube River and the Katlabuh Lake.

Objectives for nutrient monitoring:

- 1. to assess the impact of restoration measures on nutrient loads in Katlabuh and the role of the lake in transport of nutrients to the Danube river on short and long term;**
- 2. to develop recommendations on the role of floodplain wetlands in transport and utilization of nutrient loads for TGD and advocacy further wetland restoration projects in Ukrainian Danube delta.**

Fig. 4. Scheme of water sampling points at Katlabuh lake for nutrient monitoring.



Monitoring of the water quality in the lake was done on the basis of the Ukrainian State Monitoring Programme for surface waters. This programme stipulates taking samples on monthly basis for various indexes including the nutrients.

Table III. Water quality indexes covered by state monitoring programme.

➤ pH	➤ Surface active anions
➤ Chlorides	➤ COC
➤ Phosphates	➤ Nitrite ions
➤ Ca & Mg	➤ Nitrates
➤ Sulfates	➤ Total Fe
➤ Dissolved oxygen	➤ Cu
➤ BOC	➤ Suspended matter
➤ H ₂ S and sulfides	➤ Hydrocarbonates
➤ Total phosphorus	➤ Nitrogen total
➤ Phenols	➤ Al
➤ Color	➤ Hardness
➤ Ammonium	➤ Smell
➤ Mn	➤ Cd
➤ Dry substance	➤ K, Li and NA
➤ Cr and Zn	➤ Alkalizes

Sampling was done in the autumn – winter 2006. The first sampling at 7 points was already performed in October 2006 at the beginning of the autumn flooding. Additional sampling at 13 points was done in November and December at peak and after the autumn flooding on the Danube. Thus there were 52 water samples processed under this project (each sample is take 2 times according to the Ukrainian standard methods).

The results of sampling are presented in Annex 1.

Water sampling in Katlabuh lake was done according to the national standards of Ukraine “Water quality, part 4” (state standard of Ukraine (SSU) ISO 5667-4:2003) at the points indicated at the scheme above and according to the methods listed below (Table IV.)

Samples were taken from the shore from the layer right under the surface of water.

The samples were delivered in clean hermetic and light-proof plastic bottles to the hydrographical laboratory in Odessa.

Samples were processed instantly or conserved by standard methods for later analyses.

During the sampling, special forms were filled in indicating temperature and transparency of water as well as physical-chemical parameters, which may change during transportation.

Special emphasis was paid to nutrients, which are the substances important for living organisms or the products of living organisms. These are the nitrogen and phosphorus substances.

Table IV. Samples processing methods.

Parameter	Measurement method	Comment
pH	(ISO 10523:1994, MOD) SSU 4077-2001	At sampling
Chlorides	Argentometry titration MBB 081/12-0004-01 Mercurrometry КНД 211.1.4.037-95	In the lab
Phosphates	Photometry MBB 081/12-0005-01	In the lab
Ca and Mg	Titration MBB 081/12-0006-01	In the lab
Sulphates	Gravimetry MBB 081/12-0007-01	In the lab
Dissolved oxygen	Iodometric titration MBB 081/12-0008-01	At sampling
BOC	BOC ₅ measurement MBB 081/12-0014-01 BOC measurement КНД 211.1.4.024-95	In the lab
H ₂ S and Sulfides	Photometry MBB 081/12-0017-01	In the lab
Total phosphorus	With persulfate oxidation MBB 081/12-0018-01	In the lab
Phenols	With aminoantipirine MBB № 081/12-0119-03	In the lab
Colour	Photometry MBB 081/12-0020-01	In the lab
Ammonium ions	Photocolormetry with Nesler reagent MBB № 081/12-0106-03	In the lab
Mn	Photocolormetry with persulfate of ammonium MBB № 081/12-0107-03	In the lab
Dry leftover	Gravimetry MBB № 081/12-0109-03 Gravimetry КНД 11.1.4.042-95	In the lab
Cr (VI) and Cr (III)	Extraction – photocolormetry with definile carbazide MBB № 081/12-0114-03	In the lab
Zn	Photocolormetry MBB № 081/12-0173-05	In the lab
Anion surfactives	Extraction photometry with methylene blue КНД 211.1.4.017-95	In the lab
COC	COC measurement КНД 211.1.4.020-95	In the lab
Nitrite ions	Photometry with Grise reagent КНД 211.1.4.023-95	In the lab
Nitrates	Photometry with salicylic acid КНД 211.1.4.027-95	In the lab
Total Fe	Photometry КНД 211.1.4.034-95	In the lab
Cu	Extraction photometry КНД 211.1.4.035-95	In the lab
Suspended matter	Gravimetry КНД 211.1.4.039-95	In the lab
Hydro carbonate ions	Potentiometer titration РД 52.24.24-86	In the lab
Total nitrogen	Oxidations with persulfate of potassium РД 52.24.13-84	In the lab
Al	Photometry	In the lab
Hardness	Chelatometry	In the lab
Smell	Organoleptic evaluation	In the lab
Cd	Photometry	In the lab
K	Flame photometry	In the lab
Li	Flame photometry	In the lab
Na	Flame photometry	In the lab
Alkalizes	Volume measurement	In the lab

The background historical data on water quality in Katlabuh lake and adjacent wetlands was done under the Ukrainian State Monitoring Programme, with the following frequency:

- Katlabuh Lake – 7 times per year
- Danube river (at Izmail town) – 7 times per year
- Rivers Bolshoy Katlabuh, Maly Katlabuh, Enika and Tashbunar – 4 times per year.

6.3. Monitoring results

6.3.1. Biological Oxygen Consumption.

BOC index used in this study is BOC₅ which is consumption of the oxygen during 5 days.

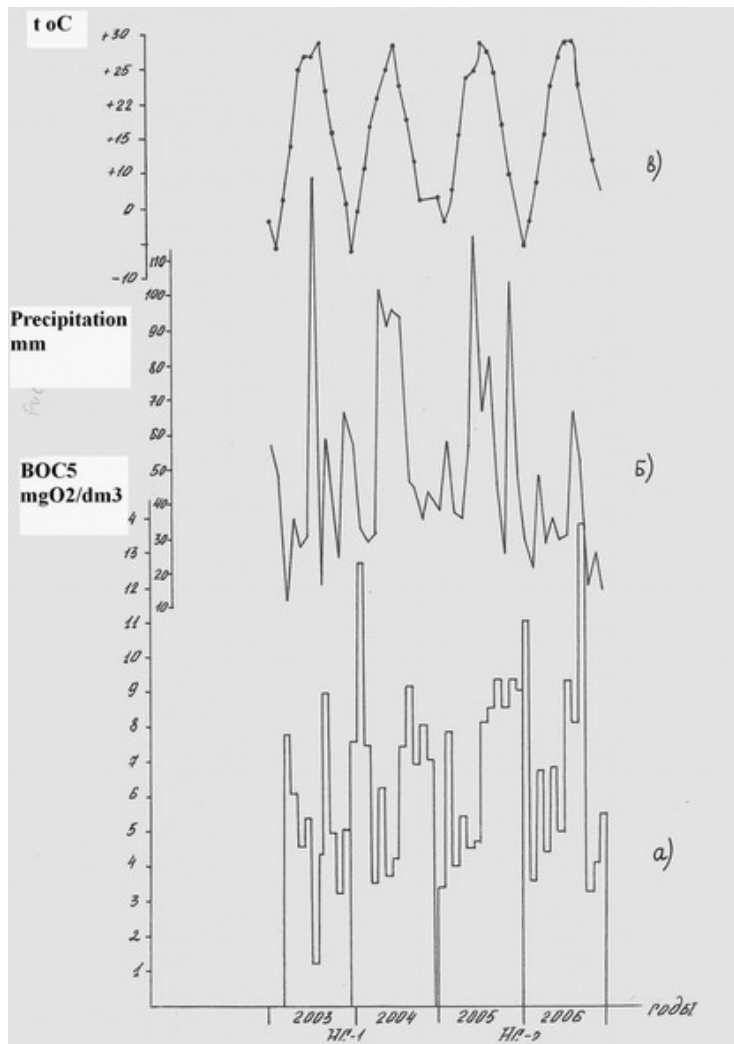
In the surface waters BOC₅ normally varies from 0,5 to 4,0 mg/dm³ and depends on the season. Seasonal changes depend mainly on the temperature variations and on the original concentration of dissolved oxygen. Diurnal changes are determined by concentration of dissolved oxygen and may vary by 2,5 mg/dm during a day. Significant changes of BOC₅ occur in polluted wetlands.

According to [2,3] water quality indexes for various uses, limits should not exceed 5 mgO₂/dm³, while the limits for fishery waters should not exceed 3 mgO₂/dm³.

In the samples taken at Katlabuh lake BOC₅ varied from 2,26 to 7,93, at the average oxygen concentration of 8,9 mgO₂/dm³, which is on average 3 times of the limits for fishery wetlands varying from 1 to 4. At the sampling point 11 (Fig. 4) near Perhsotravneve village BOC₅ exceeded the 23 and 20 times in November and December respectively. This is probably a result of embankment and drying out of this part of the lake. During the sampling there was also high fish mortality at this section.

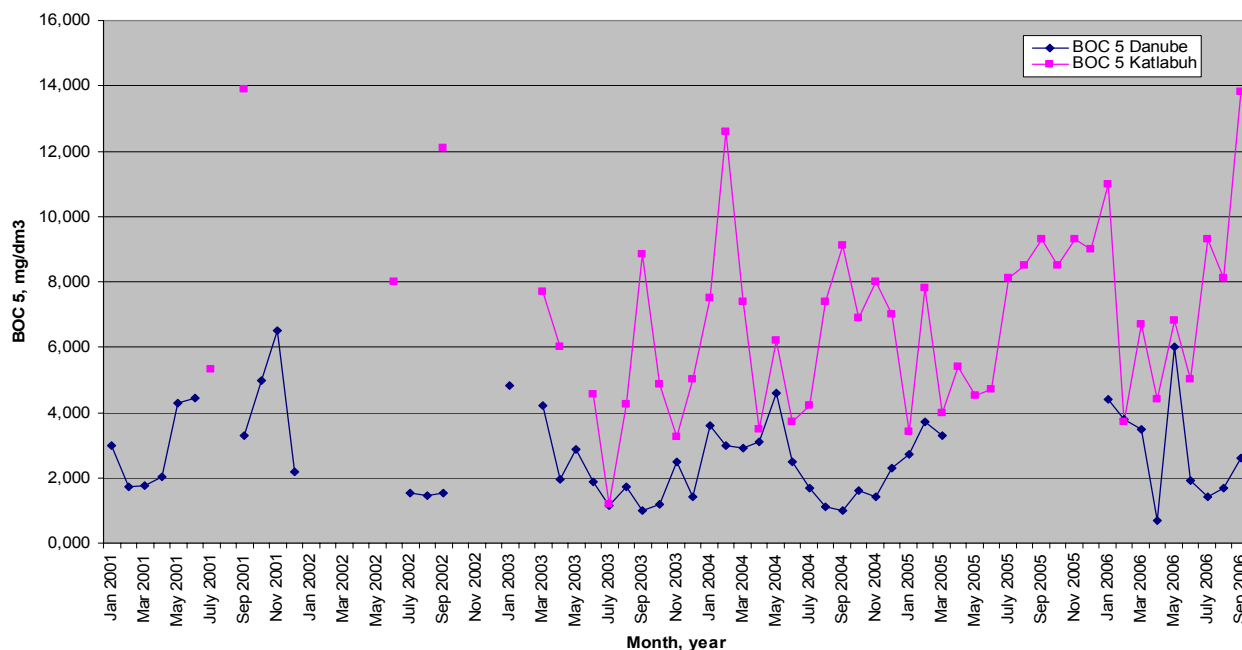
At sampling points 1,3,12,13 (Fig. 4) BOC₅ varied from 2,34 to 10,9 mgO₂/dm³, with the average of 5 mgO₂/dm³. These points are located outside of the lake at inflows and outflows and at the mouth of Enika river.

Fig. 5. BOC and its relation to other factors in Katlabuh lake in 2003-2006.



According to historical data in the upstream part of the lake (points 8 and 9), BOC₅ has cyclic dynamics depending on the temperature, precipitation and water regime of the lake. Moreover BOC₅ index for the Katlabuh lake is influenced by the small rivers discharging into the lake, which should be taken into account in further monitoring works.

Fig. 6. Long-term changes of BOC in Katlabuh lake and the Danube river.



6.3.2. Chemical Oxygen Consumption

Chemical oxygen consumption is used as an indicator of organic substances in the waters. According to UA standards, COC should not exceed 25mgO/dm³.

In the Katlabuh lake COC varied from 34 to 326 mgO/dm³ with the average of 140-187 mgO/dm³. Maximum values were stably registered at point 11 near Pershotravneve village exceeding the limit 13 times with average values 5,6 -7,5 times of the limit.

At points 1,3,12,13 COC varied from 8,6 to 193 mgO/dm³, with the average of 90 mgO/dm³. Minimum values were registered at point 1 (inflow canal form the Danube), while the maximum was registered at point 13 at the mouth of Enika river.

6.3.3. Nitrogen

In the natural wetlands inorganic nitrogen occurs is ammonium ions (NH₄⁺), nitrites (NO₂⁻) and nitrates (NO₃⁻). These chemicals have common origin and easily transform from one to another. Therefore they are normally combined into one group. In the natural environment ammonium ions are the very unstable transforms into other nitrogen forms. Bacteria transform ammonium ions to nitrites provided enough oxygen content in the water. Nitrification than normally goes further and bacteria transform nitrite ions further to nitrate ions (NO₃⁻). Thus nitrate ion is an end product of the complex mineralization process of the organic matter.

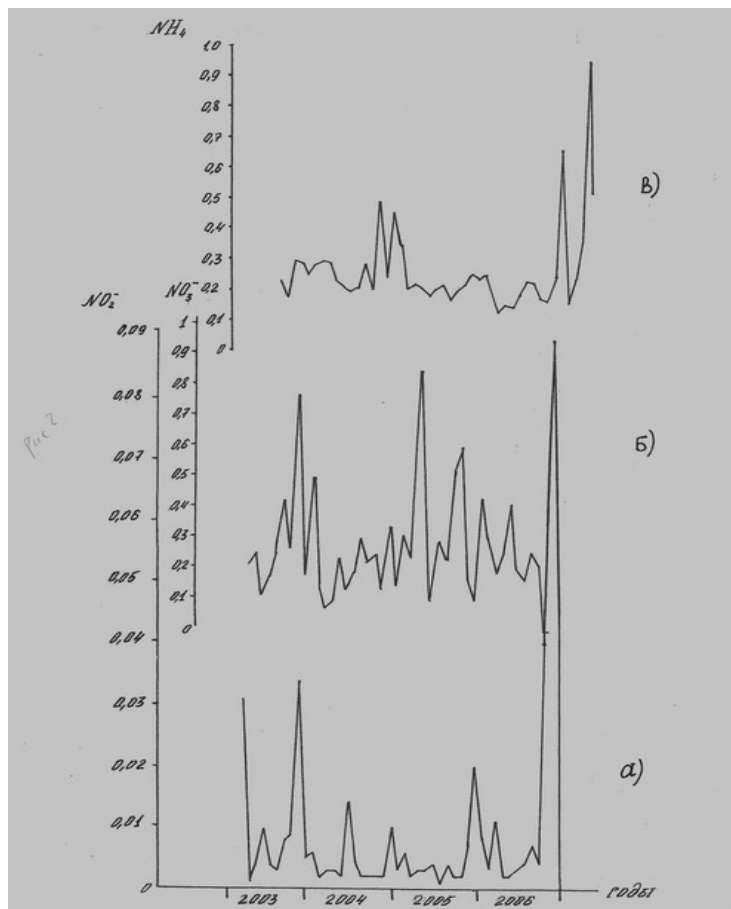
Ammonium content in the water is an important environmental index and depends on water temperature and pH.

Concentrations of NH_4^+ normally increase during die out of the aquatic organisms.

Ammonium ions may be produced in anaerobic conditions as a result of reduction of nitrates and nitrites. Most of ammonium comes with surface run-off and precipitation. High ammonium concentrations are usual for sewage especially from settlements and indicate deterioration of sanitary conditions of the waterbodies.

Nitrites usually indicate faecal pollution of waters. Concentrations of nitrites tend to grow during summer stagnations as a result of either reduction of nitrates or activity of phytoplankton. High concentrations of nitrogen chemicals indicate pollution of a waterbody with the organic substances.

Fig. 7. Ammonium and nitrite dynamics in Katlabuh lake in 2003-2006.

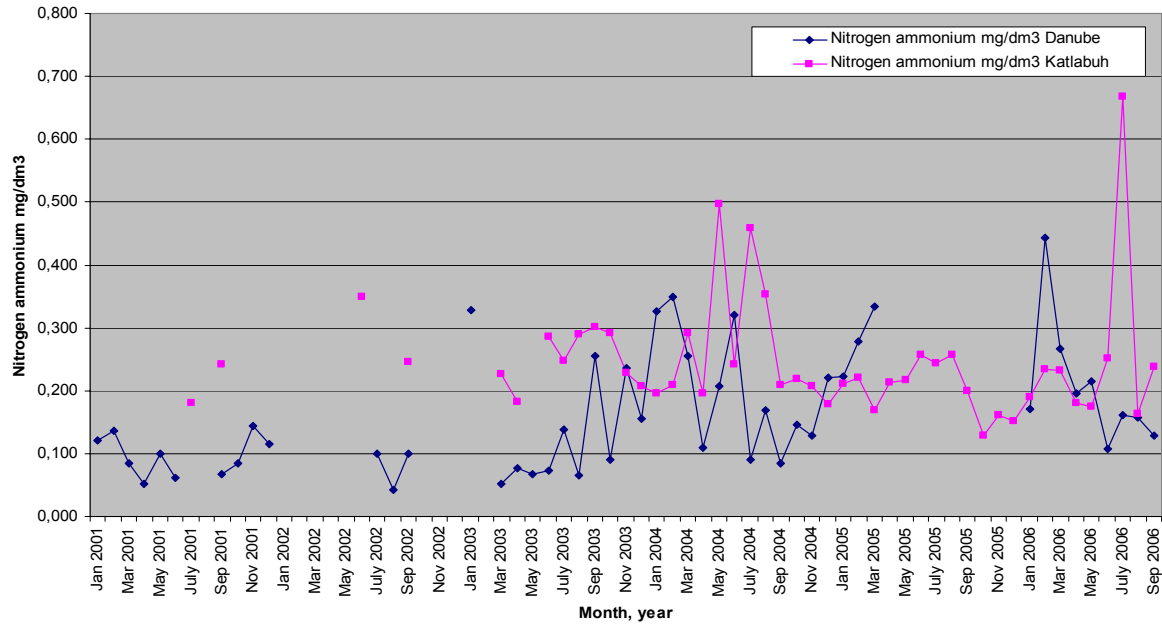


Official limits in UA for fishery wetlands for ammonium (NH_4^+), nitrites (NO_2^-) and nitrates (NO_3^-) should not exceed 0,5, 0,02 and 45 mg/dm^3 respectively.

In Katlabuh lake concentrations of ammonium varied from 0,24-1,00, with the average of 0,53 mg/dm^3 , which is slightly over the limit. The highest concentrations were registered at point 5 in November and December exceeding the limits 4,7 and 5,4 times respectively.

At points 1,3,12,13 content of ammonium varied from 0,00 to 4,00 mg/dm^3 , with the average of 0,8 mg/dm^3 .

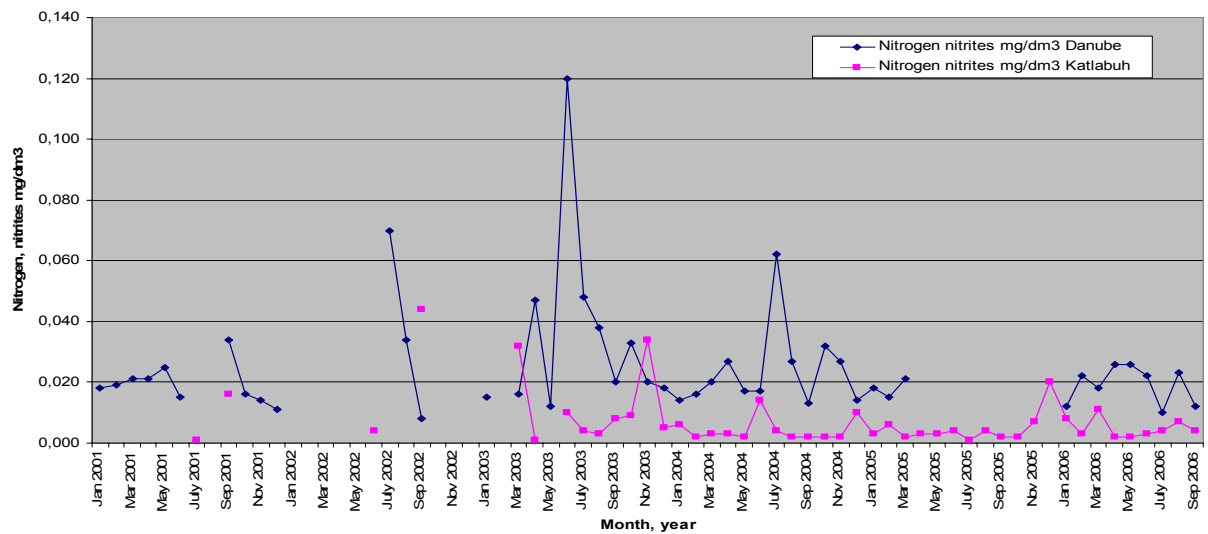
Fig. 8. Long-term changes of ammonium in Katlabuh lake and the Danube river.



Content of nitrites (NO₂⁻) varied from 0,00 to 0,90, with the average of 0,058 mg/dm³, which is 2,9 times of the limit varying from 3,5 to 4,5 times of the limit. At point 11 concentrations exceeded the limit 5,5-9,3 times.

At points 1,3,12,13 content of NO₂⁻ varied from 0,00 to 0,08 mg/dm³, with the average of 0,027 mg/dm³. At point 12 (inflow canal) content of nitrites was stably high from 0,150 to 0,174 mg/dm³, which is 7,5-8,7 times of the limit.

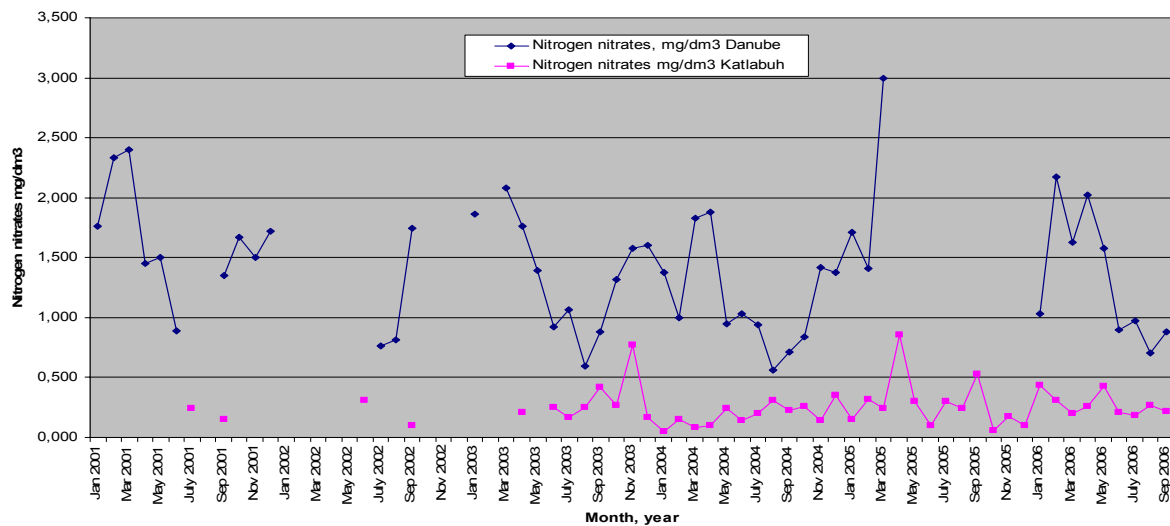
Fig. 9. Long-term changes of nitrites in Katlabuh lake and the Danube river.



Content of nitrates (NO_3^-) varied from 0 to 17 mg/dm^3 , which is much lower than official limits.

At points 1,3,12,13 content of nitrates varied from 0-8,2 mg/dm^3 .

Fig. 10. Long-term changes of nitrates in Katlabuh lake and the Danube river.



6.3.4. Chlorides and sulfates

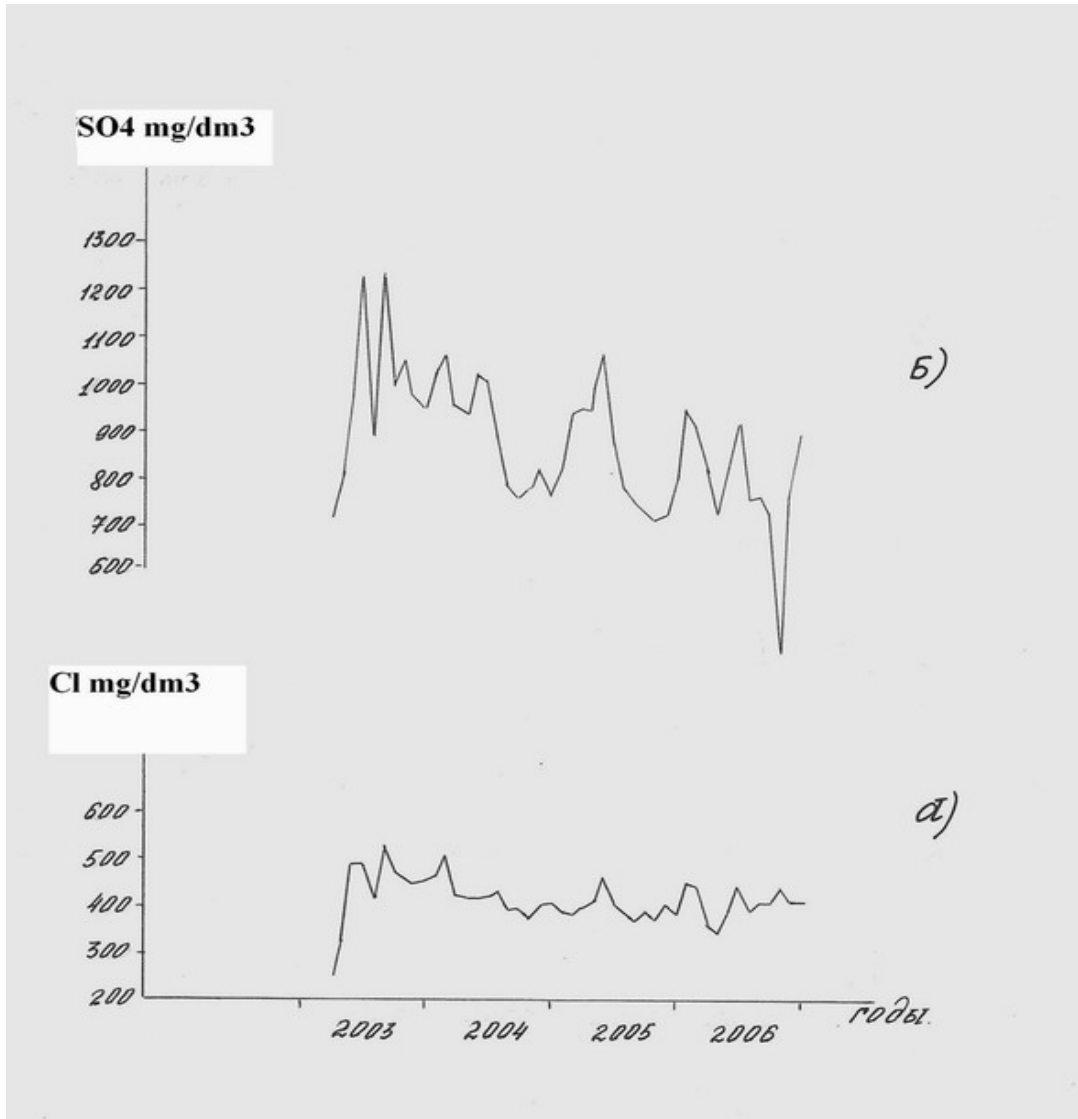
Chlorides occur in surface waters as anions. Most of the chlorides come from the atmosphere as well as from sewage waters. Concentrations of chlorides have distinct seasonal dynamics and depend on the total water mineralization.

Concentrations of chlorides and their dynamics especially diurnal may serve as one of the indicators of sewage pollution.

Sulfates the most common anions in all surface water and also prevail in Katlabuh lake. Concentration of sulfates also depends on the total mineralization of the water.

Sources of drinking water supply and domestic supply should have not more than 350 mg/dm^3 of chlorides and 500 mg/dm^3 of sulfates.

Fig. 11. Content of sulfates and chlorides in Katlabuh lake in 2003-2006.



Content of chlorides and sulfates in Katlabuh lake varied from 230 to 798 mg/dm³ and 104-2340 mg/dm³ respectively. Average values were 450 and 779 mg/dm³ varying from 439 to 461 mg/dm³ for chlorides and from 762 to 805 mg/dm³ for sulfates. Similar concentrations were registered during the last 3 years.

Fig. 12. Long-term changes of sulfates in Katlabuh lake and the Danube river.

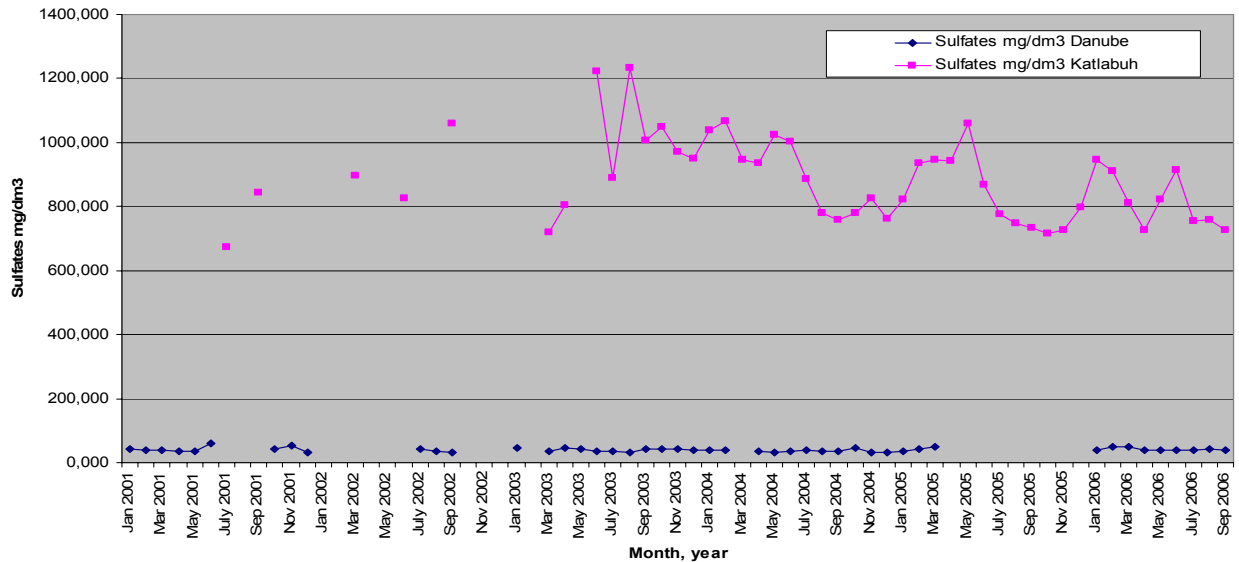
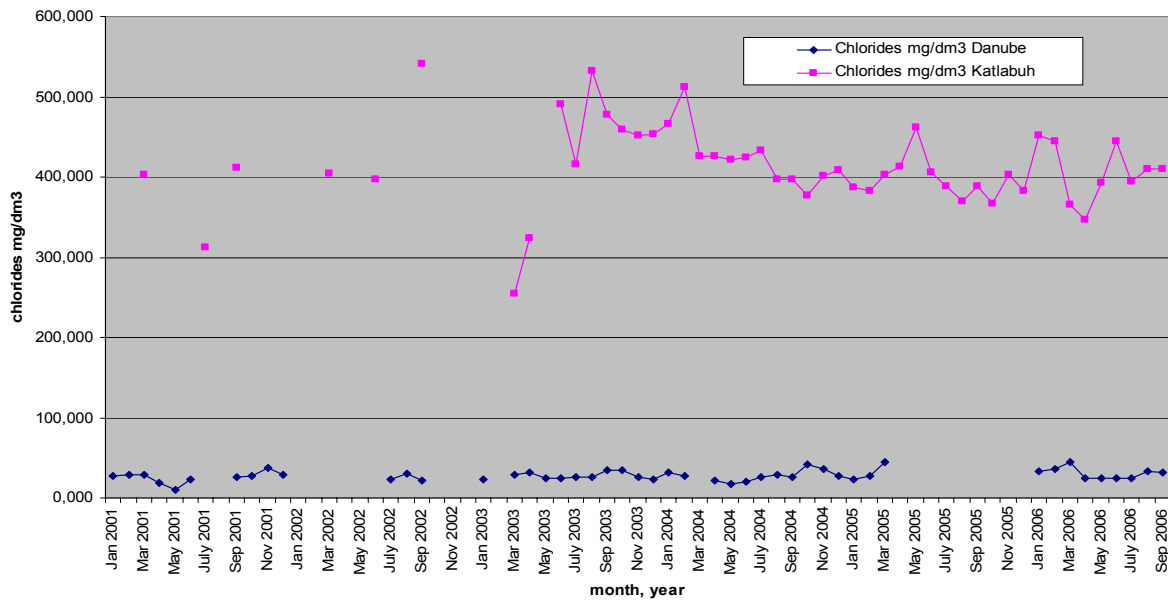


Fig. 13 . Long-term changes of chlorides in Katlabuh lake and the Danube river.



At points 1,3,12 content of chlorides and sulfates hardly exceeded official limits and varied from 35 to 283 and from 6 to 445 mg/dm³ respectively. Content of chlorides and sulfates at point 13 (mouth of Enika river) was over the limit, which qualified the water as chloride-sulfate type. Long-term observations showed the same situations. Thus Katlabuh lake receives considerable loads of chlorides and sulfates from the discharge of small rivers.

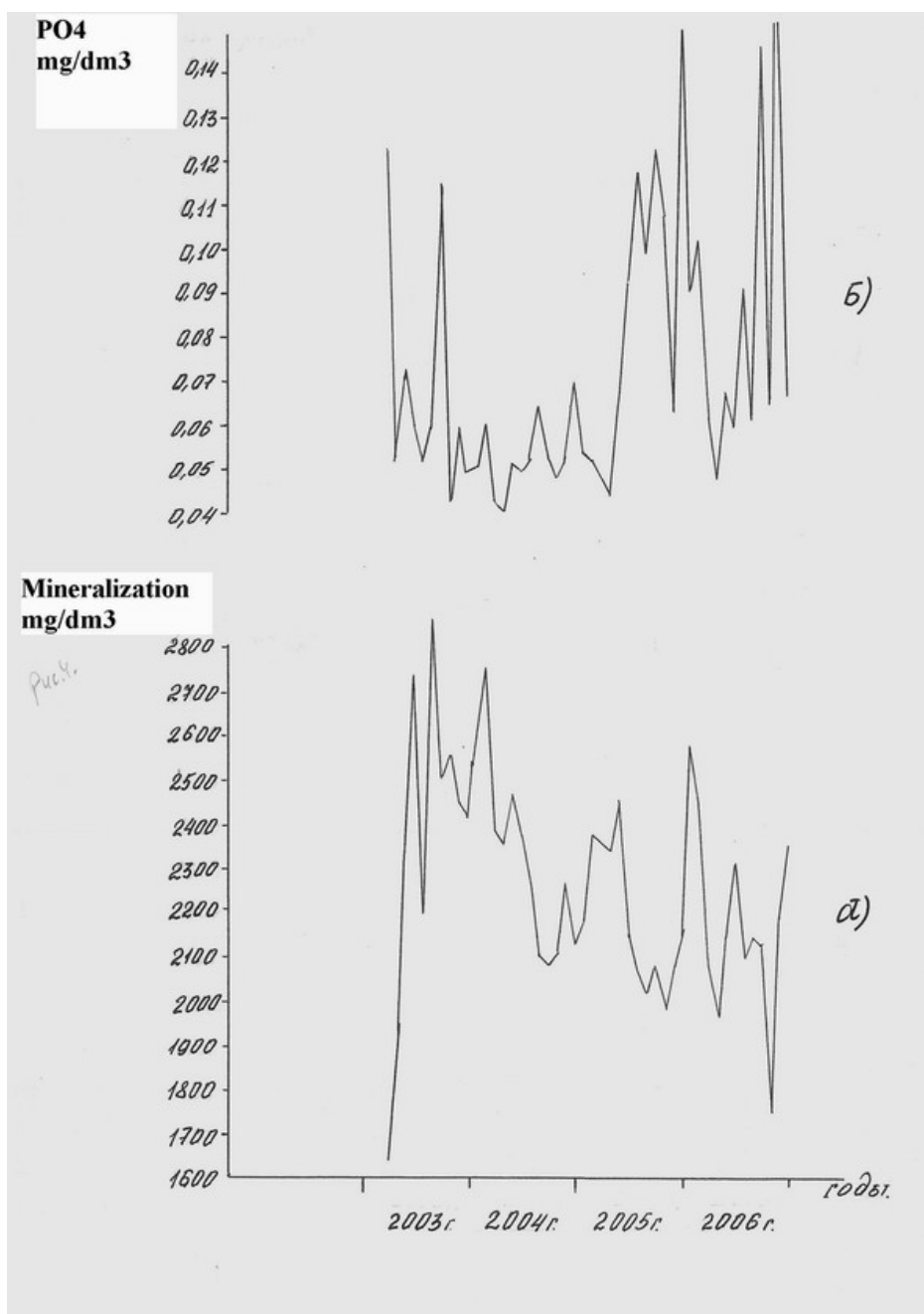
6.3.5. Mineral phosphorus (phosphates)

Phosphorus is one of the main nutrients affecting productivity of the wetlands. Phosphate pollution is usually a result of intensive use of phosphorus fertilizers in agriculture. Organic phosphorus substances are the products of biological reduction of organisms as well as the biological treatment of domestic and industrial sewage.

Content of phosphorus has a clear seasonal dynamics and depends on photosynthesis and biological reduction of organic matter.

Minimum concentrations of phosphates occur in spring and summer, while the maximum in autumn and winter. Official UA limits for phosphates is $0,2 \text{ mg/dm}^3$ and $0,5 \text{ mg/dm}^3$ for total phosphorus.

Fig. 14. Content of phosphorus in Katlabuh lake in 2003 – 2006.

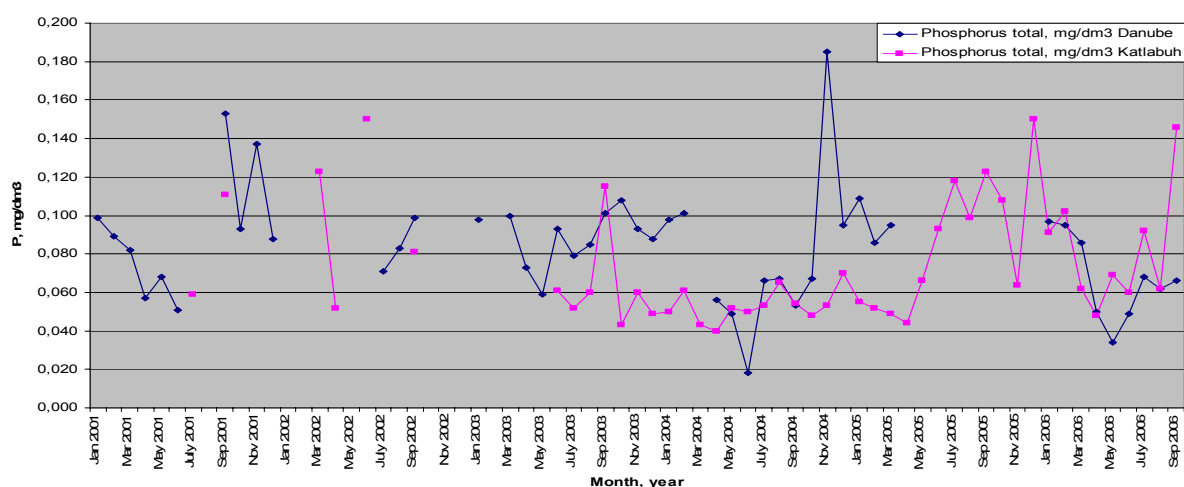


In the samples taken at Katlabuh only the total phosphorus was measured. Its content varied from 0,047 to 0,390 mg/dm³ with the average of 0,087 - 0,112 mg/dm³. Maximum concentrations were registered at points 11 and 5 (0,660 and 1,490 mg/dm³).

At inflow canals and small rivers (points 1, 3, 12 and 13) content of phosphorus varied from 0,056 to 1,780 mg/dm³ with the average monthly values of 0,250 - 0,502 mg/dm³.

Long term data for the points 8 and 9 are similar to seasonal changes.

Fig. 15. Long-term changes of phosphorus in Katlabuh lake and the Danube river.



6.3.6. Total salt

Total content of different salts in the chemical analyses of the water is called mineralization of the water. Mineralization is important for the sources of drinking and domestic water supply and should not exceed 1000 mg/dm³. Monitoring results showed all the samples at all points have high mineralization varying from 1,11 to 4,97 g/dm³ with average values 2,22 – 2,27 g/dm³.

At points 1 and 12 mineralization was within the limits on average 0,47 and 0,94 g/dm³ respectively. Mineralization at the mouth of Enika river was stably high from 2,75 to 2,81 g/dm³. Similar values for this point are indicated in the long-term database.

7. CONCLUSIONS

Hydrological regime of Katlabuh lake depends entirely on the influence of the Danube River. The Danube floods are of big duration: about 4 months on the average. Before protective dykes were built, the floodplain had been inundated during floods, and the water level in the lake increased to 2.5 m. While water level in the river came down, the water drained from the lake. Continuous and regular floods cleaned the lake ecosystem and washed out salt, which concentrated because of evaporation from water and soil during hot summer. Likewise, ecosystem of Katlabuh lake was processing the chemicals coming from the Danube with flood. Under the natural conditions, nutrients and some other chemicals were removed from the water by living organisms.

To conclude the results mentioned above, we should say that content of nutrients in Katlabuh lake depends on a number of different factors, which need further clarification.

7.1. Influence of the catchment and small rivers

This is first of all the human influence on the catchment of the Katlabuh lake and the small rivers (dump sites, illegal mining, ploughing and use of mineral fertilizers, sewage inflows from the villages etc.) as well as climate conditions, hydrological regime, influence of the small rivers.

Growing content of pollutants in the lake is caused by inflow from the Danube and small rivers such as Big Katlabuh, Tashbunar, Enika. Analyses of the long-term data shows seasonal dynamics, i.e. water quality improves in spring and summer with flooding and worsens in autumn winter with the minimum water levels in the lake. Apart from embankment of Katlabuh lake itself, the small rivers were seriously modified as well: increase of arable lands and deforestation, dredging and regulation of their drainage caused decrease of water discharges, increase of evaporation from the water surface and thus deterioration of water quality in small rivers. Their surface water is naturally hyper-mineralized from 2.2 to 7.5 g/l.

7.2. Influence of the Danube

Water quality in the Danube is different to Katlabuh lake according to several indexes.

General water mineralization in the Danube is significantly lower than in the lake and does not exceed 0,5 mg/dm³ varying from 0,27 to 0,44 mg/dm³.

Content of sulfates and chlorides 10 times less than in the lake with the average of 39,6 and 28,8 mg/dm³.

The situation with other components is similar: content of NO₂ in the Danube varied from 0,012 to 0,064 mg/dm³ with the average of 0,026 mg/dm³. Content of NH₄ in the Danube varied from 0,065 to 0,35 0,026 mg/dm³ with the average of 0,18 mg/dm³. BOC₅ in the Danube varied from 0,7 to 6,0 mgO₂/dm³ with the average of 2,58 mgO₂/dm³.

Removal capacities of the Katlabuh lake for the phosphorus are still not clear and the historical data do not show yet any trends or mutual dependence of the Katlabuh lake and the Danube. Although at some small rivers discharging into the lake, content of phosphorus is higher than official limit, but by and large it hardly affects the general phosphorus concentration in the Katlabuh water.

Serious exceeding of the limits for a number of indexes in Katlabuh lake (BOC5, COC, NO₂⁻, Cl⁻, SO₄²⁻, PO₄⁻ etc.) may result in drastic changes of the aquatic ecosystem of the lake.

Therefore, it's clear that in order to improve water quality in Katlabuh lake, a natural extend of water exchange with the Danube River needs to be restored.

7.3. Expected changes after restoration

Restoration of natural water exchange is expected to lead to a significant decline in salt contents of the lake to the levels close to the Danube water. However, on the short term after the opening of the lake some negative effects are possible for both the Katlabuh lake and the Danube river. These effects relate first of all to washing out bottom deposits and return of chemical substances, especially such as nutrients to the Katlabuh lake and thus the Danube river. As historical data on water quality show, Katlabuh lake should still play a significant role in reducing nitrites and nitrates for the Danube. However, concentrations of ammonium and other chemicals are expected to increase at least on the short term.

On the long term, the effect of restoration on nitrogen transport needs to be further investigated as after reopening of the lake, positive changes are expected in the ecosystem of the lake related to development of aquatic vegetation and thus increase of removal capacity of the lake for the nutrients.

Moreover, the next phase of restoration works after reopening of the lake to the Danube, implies re-connection of extensive reedbeds in the downstream part of the lake. These reedbeds played an important role in filtering the Danube water flowing into the lake as well as Katlabuh water flowing into the Danube.

Therefore in order to fully assess the mutual influence of Katlabuh lake and the Danube river, it's necessary to continue monitoring works after reopening of the lake and especially on reconnection of the reedbeds to the Katlabuh lake.

8. LESSONS LEARNED AND OUTLOOK

The future tasks for restoration under this project include completion of the construction of the bridge and opening of the lake to the Danube river. These works are expected to finish by spring 2007.

The restoration works will be followed by implementation of the water protection zones around the lake (100 m. strip according to UA water code). These measures will include removal of the dump sites, restoration of vegetation and regulation on land use. Thus, this component should include an important step to control pollution from the catchment of the lake that serves as the main source of both nutrient loads and salts for the lake.

Future plans expected to start in 2007 include development and implementation of the project to reconnect Safiany – Lung lake system, a former reedbeds area between the lake and the Danube. These works are expected to significantly improve hydrological conditions of the Safiany – Lung lakes as well as to return their filtering capacity for both the Katlabuh lake and the Danube river.

Monitoring of nutrients will continue beyond the timeframe of UNDP-GEF 4.3 project under the Ukrainian state monitoring programme. Thus, the data to be obtained under the UNDP-GEF project will serve as a basis for further monitoring of nutrients for evaluation and long-term of impact of restoration measures on nutrient reduction.

Further monitoring will be performed by WMB in cooperation with hydrographic laboratory as a part of their regular state duty.

The results of the project will be used by WMB as a necessary experience for planning of water management practices for other wetlands along the Ukrainian stretch of the Danube as well as other wetlands in Odessa Oblast.

Moreover, Katlabuh project has been proposed by WMB for restoration and nutrient monitoring as a pilot model project in advocacy for restoring natural regimens of other big lakes in Ukrainian Danube delta

9. DATABASE

Water Management Board has a long-term database on the key water quality indexes (Table III) sampled under the State monitoring programme for surface waters.

Such data are also available for adjacent wetlands such as small rivers discharging to Katlabuh lake as well as the Danube.

Moreover, under the regular hydrological monitoring, the long term data is also available for water levels and discharges of the Danube and all the large lakes in Ukrainian Danube Delta including the Katlabuh lake.

All this data exist as internal reports and can be obtained in a Russian language on the request to Odessa Oblast State Water Management Board.

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ANNEX 1: RESULTS OF CHEMICAL ANALYSES OF WATER SAMPLES FORM KATLABUH LAKE UNDER THE PROJECT.

Date of Sampling: 17.11.2006.															
Location: Katlabuh lake and adjacent wetlands															
№	Sampling point	pH	Measure	Anions				Cations			Σ Cations and anions	Calcul. Dry remain	Hardness mg-equiv/L	Cr mg/L	Cu mg/L
				CO ₃	HCO ₃	SO ₄	Cl	Ca	Mg	Na					
1	9 pumping station	8.70	Mg/l	8.4	366	773.28	407.67	100	139.72	399.97	2195.05	2012.05	16.5	0	0
			Mg-equiv/l	0.28	6	16.11	11.5	5	11.5	17.39	67.78				
			% equiv	1	17.7	47.5	33.9	14.8	33.9	51.3					
2	7 Utkonosovka village	9.25	Mg/l	18	317.2	720	389.95	120	115.42	374.9	2055.47	1896.87	15.5	0	0
			Mg-equiv/l	0.6	5.2	15	11	6	9.5	16.3	63.6				
			% equiv	1.88	16.4	47.2	34.6	18.9	29.9	51.3					
3	6 Pumping station	9.18	Mg/l	12	329	778.56	354.5	90	133.65	379.96	2078.07	1913.37	15.5	0	0
			Mg-equiv/l	0.4	5.4	16.22	10	4.5	11	16.52	64.04				
			% equiv	1.25	16.9	50.7	31.2	14.1	34.4	51.6					
4	4 Bogatoe village	8.06	Mg/l	0	366	638.4	389.95	130	91.12	374.9	1990.37	1807.37	14.0	0	0
			Mg-equiv/l	0	6	13.3	11	6.5	7.5	16.3	60.6				
			% equiv	0	19.8	43.9	36.3	21.5	24.8	53.8					
5	12 canal	8.12	Mg/l	0	366	160.8	141.8	100	48.6	100.05	917.25	734.25	9.0	0	0
			Mg-equiv/l	0	6	3.35	4	5	4	4.35	26.7				
			% equiv	0	44.9	25.1	30	37.5	30	32.6					
6	1 canal	7.60	Mg/l	0	207.4	198.72	53.17	90	42.52	23.9	615.74	512.04	8.0	0	0
			Mg-equiv/l	0	3.4	4.14	1.5	4.5	3.5	1.04	18.08				
			% equiv	0	37.6	45.8	16.6	49.8	38.7	11.5					
7	3 canal	8.03	Mg/l	0	512.4	305.28	148.15	120	91.12	189.98	1466.93	1210.73	13.5	0	0
			Mg-equiv/l	0	8.4	6.36	7	6	7.5	8.26	43.52				
			% equiv	0	38.6	29.2	32.2	27.6	34.5	38					

Date of Sampling: 17.11.2006.															
Location: Katlabuh lake and adjacent wetlands															
№	Sampling point	pH	Measure	Anions				Cations			Σ Cations and anions	Calcul. Dry remain	Hardness mg-equiv/L	Cr mg/L	Cu mg/L
				CO ₃	HCO ₃	SO ₄	Cl	Ca	Mg	Na					
8	2 Kislytsy village	8.86	Mg/l Mg-equiv/l % equiv	6 0.2 0.63	317.2 5.2 16.4	763.2 15.9 50	372.22 10.5 33	80 4 12.6	139.72 11.5 36.2	374.9 16.3 51.3	2053.25 63.6	1894.65	15.5	0	0
9	10 pumping station	9.20	Mg/l Mg-equiv/l % equiv	24 0.8 2.13	329.4 5.4 14.4	925.44 19.28 51.4	425.4 12 32	100 5 13.3	170.1 14 37.4	425.04 18.48 49.3	2399.38 74.96	2234.68	19.0	0	0
10	Enika river	8.73	Mg/l Mg-equiv/l % equiv	6 0.2 0.44	488 8 17.6	781.44 16.28 35.8	744.45 21 46.2	220 11 24.2	255.15 21 46.2	310.04 13.48 29.6	2805.08 90.96	2561.08	32.0	0	0
11	5 Pershetravneve village	8.78	Mg/l Mg-equiv/l % equiv	6 0.2 0.53	488 8 21.4	320.16 6.67 17.8	797.62 22.5 60.2	80 4 10.7	273.37 22.5 60.2	250.01 10.87 29.1	2215.17 74.74	1971.17	26.5	0	0
12	11 Pershetravneve village	9.16	Mg/l Mg-equiv/l % equiv	18 0.6 1.38	329.4 5.4 12.5	1072.8 22.35 51.6	531.75 15 34.6	120 6 13.8	157.95 13 30	560.05 24.35 56.2	2789.95 86.7	2625.25	19.0	0	0
13	8 Pumping station	9.23	Mg/l Mg-equiv/l % equiv	24 0.8 2.29	305 5 14.3	868.32 18.09 51.8	389.95 11 31.5	80 4 11.5	164.02 13.5 38.7	399.97 17.39 49.8	2231.26 69.78	2078.76	17.5	0	0

№	Sampling point	surfactives	COC	Fe	BOC ₅	O ₂	NH ₄	NO ₂	NO ₃	PO ₄	Color	Susp-d matter	Mn	Oil produc	K
		Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³
1	9 pumping station	0.456	137.2	0.00	4.05	5.66	0.96	0.090	0.0	0.390	>100	16	0	0.009	7.8
2	7 Utkonosovka village	0.656	107.8	0.00	5.95	1.35	0.50	0.035	0.0	0.050	>100	26	0	0.001	8.2
3	6 Pumping station	0.672	88.2	0.00	9.60	1.97	0.40	0.030	0.0	0.144	>100	36	0	0.018	8.2

№	Sampling point	surfactives	COC	Fe	BOC ₅	O ₂	NH ₄	NO ₂	NO ₃	PO ₄	Color	Susp-d matter	Mn	Oil produc	K
		Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³
4	4 Bogatoe village	0.206	156.8	0.00	9.65	2.09	0.40	0.082	6.0	0.050	85	20	0	0.009	8
5	12 canal	0.186	78.4	0.00	7.80	1.72	0.90	0.170	2.0	0.175	>100	46	0	0.006	8.6
6	1 canal	0.126	29.4	0.11	10.90	2.34	0.05	0.030	8.2	0.210	35	18	0	0.001	3.7
7	3 canal	0.327	78.4	0.00	4.58	6.27	1.04	0.075	0.0	0.506	>100	12	0	0.010	8
8	2 Kislytsy village	0.167	120.6	0.00	7.50	1.60	0.20	0.015	0.0	0.050	>100	12	0	0.010	8.7
9	10 pumping station	0.253	160.5	0.00	13.30	2.71	0.76	0.040	0.0	0.075	>100	28	0	0.010	8.5
10	Enika river	0.376	193.4	0.00	2.75	9.47	0.00	0.010	0.0	0.108	60	18	0	0.009	4.5
11	5 Pershetravneve village	0.733	202.2	0.39	68.90	0.12	2.36	0.000	0.0	0.660	>100	150	0	0.002	11.2
12	11 Pershetravneve village	0.233	198.2	0.00	4.13	4.73	0.60	0.185	8.0	0.060	>100	22	0	0.023	8.7
13	8 Pumping station	0.214	267.3	0.00	4.17	6.76	0.70	0.077	4.0	0.047	>100	22	0	0.076	8

Date of Sampling: 12.12.2006.															
Location: Katlabuh lake and adjacent wetlands															
№	Sampling point	pH	Measure	Anions				Cations			Σ Cations and anions	Calcul. Dry remain	Hardness mg-equiv/L	Cr mg/L	Cu mg/L
				CO ₃	HCO ₃	SO ₄	Cl	Ca	Mg	Na					
1	9 pumping station	8.20	Mg/l	0	366	891.36	407.67	100	139.72	450.11	2354.87	2171.87	16.50	0	0
			Mg-equiv/l	0	6	18.57	11.5	5	11.5	19.57	72.14				
			% equiv	0	16.6	51.5	31.9	13.9	31.9	54.3					
2	7 Utkonosovka village	9.10	Mg/l	24	317.2	768.96	389.95	80	151.87	379.96	2111.94	1953.34	16.50	0	0
			Mg-equiv/l	0.8	5.2	16.02	11	4	12.5	16.52	66.04				
			% equiv	2.42	15.7	48.5	33.3	12.1	37.9	50.0					
3	6 Pumping station	9.26	Mg/l	24	341.6	863.52	372.22	90	157.95	399.97	2249.26	2078.46	17.50	0	0
			Mg-equiv/l	0.8	5.6	17.99	10.5	4.5	13	17.39	69.78				
			% equiv	2.29	16.1	51.6	30.1	12.9	37.3	49.8					
4	4 Bogatoe village	9.35	Mg/l	36	280.6	844.32	389.95	100	145.8	399.97	2196.64	2056.34	17.00	0	0
			Mg-equiv/l	1.2	4.6	17.59	11	5	12	17.39	68.78				
			% equiv	3.49	13.4	51.5	32.0	14.5	34.9	50.6					
5	12 canal	8.23	Mg/l	0	366	286.08	177.25	100	60.75	160.08	1150.16	967.16	10.00	0	0
			Mg-equiv/l	0	6	5.96	5	5	5	6.96	33.92				
			% equiv	0	35.4	35.1	29.5	19.5	29.5	41.0					
6	1 canal	7.70	Mg/l	0	219.6	95.52	53.17	70	30.37	15.07	493.74	383.94	6.00	0	0
			Mg-equiv/l	0	3.6	1.99	1.5	3.5	2.5	1.09	14.8				
			% equiv	0	50.8	28.1	21.2	49.4	35.3	15.4					
7	3 canal	8.10	Mg/l	0	488	445.44	265.87	200	60.75	224.94	1685.00	1441.00	15.00	0	0
			Mg-equiv/l	0	8	9.28	7.5	10	5	9.78	49.56				
			% equiv	0	32.3	37.4	30.3	40.4	20.2	39.5					
8	2 Kislytsy village	8.50	Mg/l	36	305	748.8	372.22	100	133.65	374.9	2070.57	1918.07	16.00	0	0
			Mg-equiv/l	1.2	5	15.6	10.5	5	11	16.3	64.6				
			% equiv	3.71	15.5	48.3	32.5	15.5	34.1	50.5					
9	10 pumping station	8.80	Mg/l	36	317.2	839.52	425.4	120	151.87	399.97	2289.96	2131.36	18.50	0	0
			Mg-equiv/l	1.2	5.2	17.49	12	6	12.5	17.39	71.78				
			% equiv	3.34	14.5	48.7	33.4	16.7	34.8	48.5					

Date of Sampling: 12.12.2006.															
Location: Katlabuh lake and adjacent wetlands															
Nº	Sampling point	pH	Measure	Anions				Cations			Σ Cations and anions	Calcul. Dry remain	Hardness mg-equiv/L	Cr mg/L	Cu mg/L
				CO ₃	HCO ₃	SO ₄	Cl	Ca	Mg	Na					
10	Enika river	8.50	Mg/l	18	488	713.28	762.17	230	261.22	275.08	2747.76	2503.76	33.00	0	0
			Mg-equiv/l	0.6	8	14.86	21.5	11.5	21.5	11.96	89.92				
			% equiv	1.33	17.8	33.1	47.8	25.6	47.8	26.6					
11	5 Pershetravneve village	9.20	Mg/l	36	488	104.16	744.45	80	212.62	250.01	1917.24	1671.25	21.50	0	0
			Mg-equiv/l	1.2	8	2.17	21	4	17.5	10.87	64.74				
			% equiv	3.707	24.7	6.7	64.9	12.4	54.1	33.6					
12	11 Pershetravneve village	9.05	Mg/l	24	341.6	1206.7	460.85	110	194.4	529.92	2867.49	2696.69	21.50	0	0
			Mg-equiv/l	0.8	5.6	2	13	5.5	16	23.04	89.08				
			% equiv	1.79	12.6	25.14	29.2	12.3	35.9	51.7					
13	8 Pumping station	9.20	Mg/l	30	305	978.72	389.95	100	182.25	399.97	2385.89	2233.39	20.00	0	0
			Mg-equiv/l	1	5	20.39	11	5	15	17.39	74.78				
			% equiv	2.67	13.4	54.5	29.4	13.4	40.1	46.5					

№	Sampling point	surfactives	COC	Fe	BOC ₅	O ₂	NH ₄	NO ₂	NO ₃	PO ₄	Color	Susp-d matter	Mn	Oil produc	K
		Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³	Mg/dm ³
1	9 pumping station	0.488	206.4	0.00	55.10	0.98	0.52	0.044	3.0	0.067	>100	30	0	0.026	8.4
2	7 Utkonosovka village	0.740	137.6	0.00	6.35	7.19	0.56	0.070	12.0	0.080	>100	26	0	0.004	8
3	6 Pumping station	0.802	154.8	0.00	4.12	4.49	0.40	0.040	2.2	0.055	>100	26	0	0.008	8.7
4	4 Bogatoe village	0.253	137.6	0.00	4.87	6.03	0.40	0.050	9.5	0.065	>100	22	0	0.094	8.5
5	12 canal	0.253	146.2	0.00	3.41	3.57	0.70	0.150	4.4	0.080	>100	22	0	0.005	5.8
6	1 canal	0.167	43	0.24	59.40	0.12	4.00	0.000	1.8	1.780	>100	38	0	0.016	5.4
7	3 canal	0.380	120.4	0.00	3.59	3.69	1.02	0.080	0.0	0.056	>100	34	0	0.010	7.8
8	2 Kislytsy village	0.213	137.6	0.00	5.59	7.76	0.60	0.025	0.0	0.180	>100	24	0	0.010	8.5
9	10 pumping station	0.300	154.8	0.00	4.56	4.61	1.00	0.050	0.0	0.095	>100	20	0	0.008	8.8
10	Enika river	0.440	189.2	0.00	3.57	7.69	0.10	0.010	0.00	0.090	60	18	0	0.006	4.8
11	5 Pershetravneve village	0.786	223.6	0.33	60.50	0.43	2.70	0.000	6.2	1.490	52	120	0	0.016	12.6
12	11 Pershetravneve village	0.287	206.4	0.00	3.50	3.81	0.70	0.110	9.4	0.085	>100	18	0	0.026	8.5
13	8 Pumping station	0.267	326.8	0.00	7.61	7.87	0.64	0.190	11.0	0.067	>100	20	0	0.046	8.2

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