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SESSION 04 WATER USES AND ENVIRONMENTAL FLOWS

Assessment of spawning conditions of endemic fish species in major tributaries of lake Sevan (Armenia) with a purpose to restore them

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INTRODUCTION

Lake Sevan (surface 1250 km^2, volume 35km^3) is the largest fresh-water lake in Armenia , in the Caucasus and in the Middle East. It is one of the largest fresh-water high-altitude lakes in the world, which has an important role in the water balance of the whole South Caucasus as well as the northern regions of Iran and Turkey. Lake Sevan is situated in the central part of the Republic of Armenia, at the altitude of 1,900 m above sea level. The basin of the lake is located on the junctions of Transcaucasus and Middle East Regions and has an elements of different nature zones: semiarid steppe, alpine meadows, broad-leaved forests. The total surface area of its basin is 4,902 km^2 (including the lake). The lake is fed by 28 rivers and streams.
On July 1993, Lake Sevan with its basin was included in the List of Wetlands of International Importance of the Convention on Wetlands (Ramsar, Iran, 1971).
In March 1978 Sevan National Park was established, the first national park in Armenia.
The biological diversity of plants is extremely high. Approximately 1,600 species of vascular plants have been registered in the basin of Lake Sevan. 6 of them are endemic .
The fauna of vertebrates consists of 36 species of mammals, 210 species of birds , 18 species of reptiles, 4 species of amphibians, and 9 species of fishes (three of them are endemic - Ishkhan (*Salmo ischchan* Kessler), Sevan Barbel (*Barbus lacerta goktchaicus* Kessler) and Sevan Khramulya (*Varicorhinus capoeta sevangi* Filippi, the rest 6 are invasive) .
Since the 1930's, the unsustainable use of water for irrigation and hydropower generation have led to the fact that by 2002, the water level of Lake Sevan dropped by 19.8 meters, and the volume was reduced from 58.5 to 31.6 billion cubic meters, a decline of 46%. These changes have strongly influenced both on the a variety of habitats and the species diversity of the lake. In particular, changes of the lake's ecosystem have resulted in considerable disturbance of habitats of endemic fish species, affecting their natural reproduction and feeding conditions (Rubenian, 1997; Gabrielyan, 2002).
Two out of four Sevan trout subspecies , Winter Ishkhan (*S. i. ischchan*) and Bojak (*S. i. danilewskii*), that were spawned in the lake, have disappeared completely. The other two subspecies, which are spawn in rivers – Summer Ishkhan (*S. i. aestivalis*) and Gegharquni (*S. i. gegarkuni*) have managed to survive due to artificial reproduction. However, due to the lack of natural spawning grounds their population strongly reduced and now both subspecies concodered as critically endangered.
Sevan Khramulya and Sevan Barbel classified as vulnerable.

Complex studies carried out by the Institute of Hydroecology and Ichthyology have revealed that at least 6 m water level increase is important in order to restore degraded conditions of the lake.

In order to increase the water level of Lake Sevan by 6 m till 2030, the Law «On approval of the annual and comprehensive measures


Salmo ischchan aestivalis


Salmo ischchan gegarkuni


Barbus lacerta goktchaicus


Varicorhinus capoeta sevangi

(Pictures: Red Data Book of Armenia)

for the conservation, restoration, reproduction and use of Lake Sevan ecosystem» was adopted in 2001. As a result of actions taken and favorable weather conditions the water level of the lake began to rise each year . According to the plan for 10 years, the level of the lake should be raised to 216 cm, but actual rise is by 380 cm.
The lake level by January 1, 2013, has reached a point 1900,13 m a.s.l. ,which corresponds to the water level of the lake in 1963.
Over the last decade, changes have also occurred in the estuaries of the rivers, tributaries flowing to Lake Sevan: morphometry of river mouth was changed due to the increased level of the lake and effect of water back pressure velocity of flow in the lower reaches of the rivers was decreased , on 4 rivers were built small hydro power plants.

The Law «On Lake Sevan» (2001) has clear provisions on restoration of ecosystem of Lake Sevan, including its tributaries as spawning grounds for endemic fish species. During 2003-2012 two million fingerlings of Ishkhan were released in the lake. However, for their natural reproduction completely degraded spawning grounds in the rivers of lake basin are required to restore.
In 2010-2012 a complex assessment program “Study of biological data of endemic fishes, their natural spawning areas and assessment of current situation in rivers of Lake Sevan basin” was conducted in seven tributaries of Sevan by the Institute of Hydroecology and Ichthyology of Scientific Center for Zoology and Hydroecology NAN RA.

MATERIAL AND METHODS

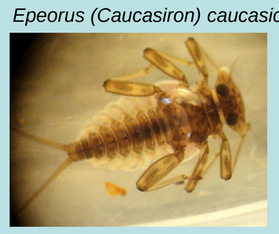
In order to assess of natural spawning areas of endemic fishes and current situation in rivers of Lake Sevan basin, the samples of macrozoobenthos were collected from the main tributaries of Lake Sevan - Gavaraget, Dzknaget, Argichi, Lichq, Vardenik, Makenis and Masrik rivers . Simultaneously evaluated the hydrological and hydro-physical parameters of studied rivers (the form and shape of river bed, the degree of development of coastal vegetation, temperature, flow velocity , microhabitat coverage, the degree of development of the periphyton and macrophytes), as well as possible impediments to spawning fish. Benthic samples were collected with a special quantitative frame (a “surber sampler”) from upper, middle and lower reaches of each of river. Biological analysis for determination of the degree of pollution and trophic status of the river was carried out by modern, generally accepted methods (Manual for the Application of the AQEM System)

RESULTS

Restoration of the endemic fish fauna of Lake Sevan is impossible without the restoration of the main tributaries where fish spawning takes place. The results showed that favorable conditions for spawning and high diversity of plants and animals were observed in upstream of the tributaries (table 1). There have been recorded sensitive to pollution taxons of benthic animals., such us common species of stoneflies of the family Perlidae in Gavaraget and Dzknaget rivers.
Species of stoneflies gen. Leuctra, Protonemura, Perlodes usually occur in Vardenis and Masrik rivers. Mayflies in the upstream of rivers presented by *Epeorus (Epeorus) zaitzevi, Ecdyonurus s. str., Epeorus (Iron)) sp.) , Baetis (Baetis*) gr. rhodany. Baetis (B.) gr.lutherii) familes, *Ephemerella ignita*. On the silted plots *Caenis horaria* is common. It is characteristic that only in the river Dzknaget that, in contrast to other investigated rivers originates from Pambak ridge, occur mayflies *Habroleptoides sp*. and *Epeorus (Caucasiron) caucasicus.*

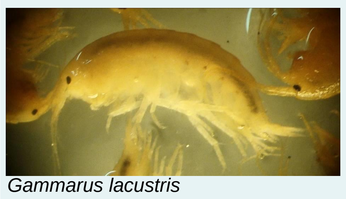

Protonemura sp.


Epeorus (Caucasiron) caucasicus.




Upsteam of river Dzknaget

Among the caddis flies only in the upper reaches of the rivers were marked by endemics of the Caucasus *Drusus caucasisus* and *Sericostoma grusiense.* In the middle and lower reaches of the rivers the most common caddis flies are *Halesus digitatus, Potamophylax sp. Apatania subtilis, Hydropsyche pellucidula,H. acuta. Rhyacophila armeniaca, Rh. nubila, Psychomia pusilla.* On slow flowing river sections, where a thicket of macrophytes are formed , 2 species amphipods*: Gammarus lacustris and G. pulex.*occur in large quantities


Gammarus lacustris


Rhyacophila armeniaca


Construction of HPP
on river Vardenik.


Waterways for fish (fish ladders)

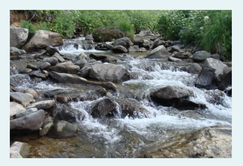

Makenis river: upstream and downstream one of 3 HPPs.

Table 1 Conclusive evaluation for examined river (1-upstream, 2 -middle stream, 3- lower stream)

	The main tributaries of lake Sevan																	
	Dzknaget			Gavaraget			Argichi			Lichq			Vardenik		Makenis			Masrik		
	1	2	3	1	2	3	1	2	3	1	2	3	1	3	1	2	3	1	2	3
Degree of development of the periphyton																				
Naturalness of form and shape of river bed																				
Naturalness of structure the river bottom																				
Extended Biotic Index (EBI)																				

Examination results	exelent	good	temperate	unsatisfactory	bad
Color scale	blue	green	yellow	orange	red

As seen in Table 1, the level of saprobity increases along a watercourse, especially where sewage and municipal solid waste from localities falls into the the riverbed. The process of eutrophication is enhanced under conditions of low water levels due to water withdrawal in the upper reaches for irrigation and hydropower plants purposes.
A major step to solving the problem of water pollution and hydroecosystems restoration was the commissioning of sewage treatment plants for the three major cities of Sevan basin. Today, according to BOD5 data The quality of water in estuaries Gavaraget, Makenis, Dzknaget, Argichi Vardenik corresponds to the α-mezosaprobic and only in the waters of the river Masrik consistent with α-oligosaprobic waters.
The next step problem solving the issue of solid waste that needs a full machining solution: educational work with local communities, the construction of landfills.




Upstream and downstream of river Gavaraget

The problem of water overusing for small hydropower plants is particularly acute. In summer and autumn riverbeds downstream became dry, which affect to the fish reproduction. In general, in addition to disturbance of water balance in rivers, concerns from the construction and exploitation of small hydropower plants in rivers Vardenik, Masrik , Makenis and Argichi arise in regard to the disturbance of fish species spawning, their death in turbines and decrease in irrigation water supply to rural communities whose land areas are located on the spot of water collection for HPPs.
Small hydropower plants situated on rivers Vardenik, Mashriq, Makenis and Argichi. Only on the small river Makenis (longitude is 24 km) there are 3 small hydropower plants without special channel for the passage of fish, which is making it impossible for fish to spawning in the upper reaches of the river. The same situation in River Masrik.

In 2010 the Ministry of Nature Protection recognized illegal construction of small hydropower plants on the river Argichi. However the HPP was not dismantled, and now started the construction of a new hydropower plant in the upstream of the river. Both the public and the Institute Hydroecology and Ichthiology are doing every effort to suspend the construction. On the stage of completion is hydroelectric power station on the river Vardenik. Here are present special waterways for fish (fish ladders), but they are too narrow and small.
Given the these threats and protests of local villagers, National Academy of Science and environmental NGOs, in 2012 the Government Decision on not permission of small hydropower plant construction in the rivers of Lake Sevan basin was adopted .


Dry riverbed of middle stream of Masrik river as a result of water withdrawal by SHPP

CONCLUSION

The results of studies (hydrology, hydrobiology) to determine the water and habitat quality of rivers on comparative basis showed that the water quality of the rivers of the Sevan basin upstream corresponds to oligosaprobic class. In the middle and lower reaches of the degree of contamination depends on the intensity of the anthropogenic factor. Construction of sewage treatment plants for 3 towns of Lake Sevan basin will largely contribute to the restoration of rivers.

The problem of design of small hydroelectric power stations on the medium and small rivers in Armenia needs standards fixed by law, depending on the water amount , water regime and fish populations. Detailed methodology for calculating the environmental flows in rivers is need to develop. A ban on the construction of new power plants in the Lake Sevan adopted by government will greatly assist in the restoration of rivers.
For existing hydropower plant it is imperative to adopt the government decision on mandatory building a waterways for fish.


Upstream and downstream of Argichi river