Water resources

Lake Sevan

A vulnerable resource under threat

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Lake Sevan is situated in north-eastern Armenia, at an altitude of 1900 metres above sea level and surrounded by peaks that rise up to 3600 metres. With a maximum length of about 70 kilometres and a maximum width of about 50 kilometres, it is one of the largest Alpine lakes. A narrowing of the lake at one point serves to divide it into two, Great and Minor Sevan. It is the largest lake in Armenia, and the only large body of fresh water in the Caucusus. It is not only an important source of food, irrigation, and electrical power, but a prospective source of drinking water for Armenia and neighbouring countries, and has an important role in the development of the Armenian economy. However, anthropogenic and natural pressures are endangering its vulnerable ecosystem and its biodiversity. It has already changed from being oligotrophic (low in nutrients) to eutrophic (over-rich in nutrients).

Anthropogenic pressure

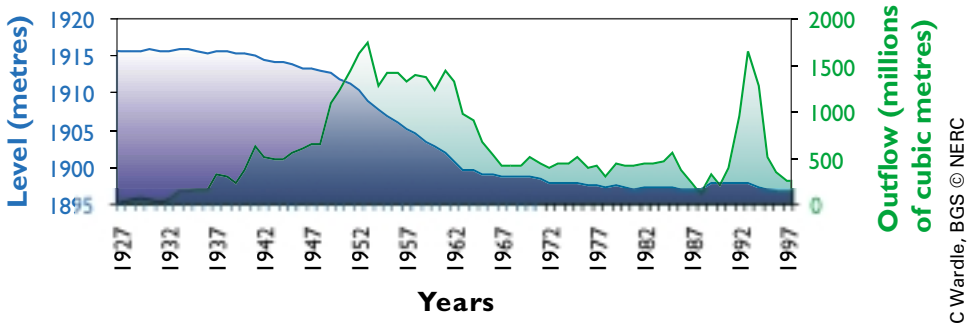
Pollution is significant, but a more serious problem is the removal of water, for irrigation and hydroelectric power, at a faster rate than it can be replenished. Water level was at its maximum in 1927–33. However, considerable quantities of water were taken from the lake, particularly during the 1950s and 1960s, resulting in a rapid drop in water level. This was slowed, and even reversed for a short time during the 1980s. But between 1991 and 1995, water level dropped again (by 1.78 metres) and this trend continues. The water level has fallen by 20 metres compared to its 1927 level and the volume of water has decreased from 58.5 to 33 cubic kilometres. This has had the effect of changing the annual temperature regime and water chemistry with a concomitant influence on the food chain.

Prior to the lowering of water level, winter temperatures were such that the lake was covered by ice only once every 15–20 years. After the drop in water level, however, the surface froze more frequently (every 3–4 years) and, since 1971, it is covered by ice most winters. As a consequence of the reduced heat capacity of the lake, winter water temperatures drop to a low of 2ºC in Minor Sevan and 1ºC in Great Sevan. Before 1930 the average surface temperatures, were 3–4ºC in Minor Sevan and 4–5ºC in Great Sevan. After the fall in water level, the average water temperature rose to 4.2–5.0ºC and 8–12ºC respectively. Average bottom water temperature in the central part of Great Sevan during the autumn was only 8–9ºC when water levels were high, but this increased to 14ºC with the drop in water levels.

The increase in temperatures during spring, when the young of many species appear, is much more rapid in the modern lake and the April–June temperatures are up to 5ºC higher compared to those of the 1920s and 1930s. In addition, the early autumn water temperatures fall more rapidly. The drop of water level has resulted in the disappearance of the low temperature hypolimnion (the lower layer of water in a stratified lake) in Great Sevan, which once isolated the bottom of the lake from active circulation, and its absence has had a significant impact on the ecosystem.

During the past 100 years, the chemical components of the lake water have also changed, although in some cases not significantly. Although the proportions of Ca^{2+} and Mg^{2+} show oscillations, there has been a tendency for the former to decline since 1970 and the latter to increase. Some parameters show only slight variation but, for example, the proportion of chlorine has been rising steadily since the 1940s and there has been a noticeable jump between the 1976–84 average and the analyses carried out during the present study. The lowering of the level of the lake has been accompanied by an increase in the concentration of nitrogen, which influences the processes taking place on the lake bed, causes water pollution, and contributes to the death of macrophytes.

Macrophytes play an important role in the lake's ecosystem, as they are the food source of many organisms in the benthonic community and a substrate for others, such as ostracods. However, as a



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Considerable quantities of water were taken from Lake Sevan during the 1950s and 1960s, and again between 1991 and 1995, contributing to a drop in water level of 20 metres since 1927.

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Lake Sevan, one of the largest Alpine lakes and the largest body of fresh water in the Caucusus. The peninsular shown was an island in 1933 prior to the 20 metres drop in water levels.

result of the drainage and contraction of the lake margins, the biomass of algae and water plants has decreased (by 30 to 40 times). Prior to the drop in water level there were more than 20 species of common macrophytes living in the lake, but now their number has decreased to 14, of which only one is common. This is in part due to changes in water transparency (pellucidity). Prior to the drop in water level there was a very high light pellucidity, and macrophytes reached depths of 17 metres, but today light pellucidity has decreased almost four times. A change in sedimentation is important to pellucidity, for whereas 70 years ago sands and gravels dominated the littoral zone, today 75% is mud and silt.

Natural pressures

Lake Sevan, however, is not only under anthropogenic pressures, but natural parameters also cause profound and rapid changes in the environment. The lake is situated on an active geological fault system, which is the cause of catastrophic earthquakes, 'tsunamis', and the source of a number of natural elements, gases and metals which enter the water. Seismic activity causes increased circulation, enrichment of surface waters with organic material, and changes in water dynamics and conditions at the sediment–water interface. As a result 'blooms' of phytoplankton and zooplankton, at the base of the food chain, often occur.

The pH of the lake water controls the development and growth of many water plants and micro-organisms as well as affecting chemical processes in the lake sediment. For much of the past five decades, the pH has been at about 8.7–8.8, but marked decreases result from high-energy earthquakes, such as those of 1983 and 1988. During seismic activity, the mixing of the low pH lake-bed sediments with higher pH lake water results in an overall decrease in the pH.

The seismically active fault zones in Armenia, including those that cross Lake Sevan, are the source of high emissions of fluorine and methane. They are also responsible for anomalously high levels of vanadium, zirconium, manganese, zinc, copper, cobalt, lead, nickel, cadmium, and chromium. These emissions appear to be the cause of a number of changes in the lacustrine ecosystem. But they also have an influence on the surrounding region. Examples noted in the literature include: abnormally large growth of bushes and fungi, karyotype polymorphism in rodents, limb deformation of lizards, and caries in humans.

In conclusion, changes to the ecosystem in and around Lake Sevan have both natural (seismic) and anthropogenic causes. This vital source of food, irrigation, power, and drinking water is under threat, and a fate similar to that of the once freshwater, now saline, Aral Sea needs to be averted. This resource needs careful monitoring and management to ensure that its delicate ecosystem is not irreparably damaged.

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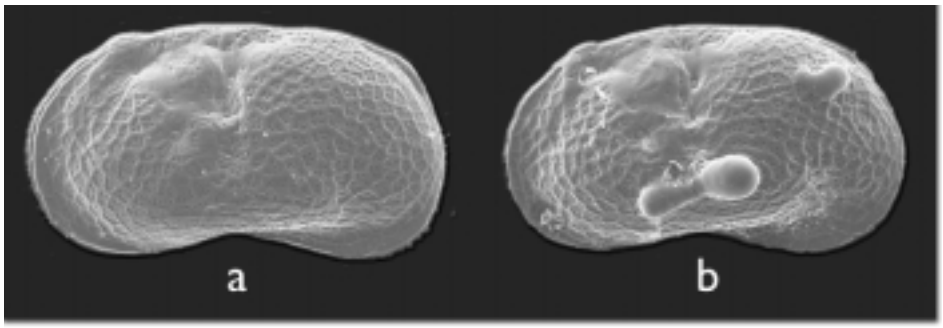
Map of Armenia showing the position of lake Sevan and the seismically active fault zones that cross the country.



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Both non-noded (a) and noded (b) morphs of the fresh water ostracod Limnocythere *occur in Lake Sevan as a consequence of environmental conditions. A link with the emissions from the fault zones that cross Lake Sevan is suggested.*