If to take the Baltic Sea as a lake…

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It is customary to think that lake is one of the underlying surface agents for runoff formation. It influents on the river runoff as well as other agents such as wetland, karst, forest etc., and cannot express any regional water resource parameters. The possible deviation of lake outflow from "regional runoff norm" depends on lake's sizes and cannot be the simple variation of different water catchments within one climate zone.

Using the method of lake usable storage coefficient elaborated by author [1] it is possible to divide and estimate quantitatively zonal (as the background) and local fluctuation of runoff (lake outflow) due to different grounds, karst, wetlands, afflux events and so on. For example, the M = f(K,A) ratio, where M is lake outflow in L/s.sq.km, K is lake area index, A – lake level altitude in meters, for different catchments of Estonia looks as the following:

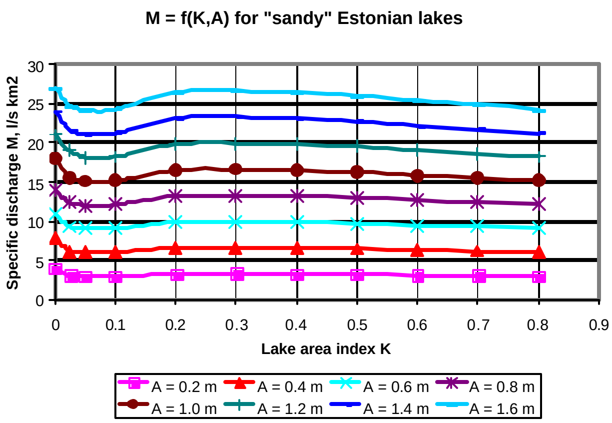


Fig.1 M = f(K,A) ratio for sand-gravel rocks, karst (discharge zone)

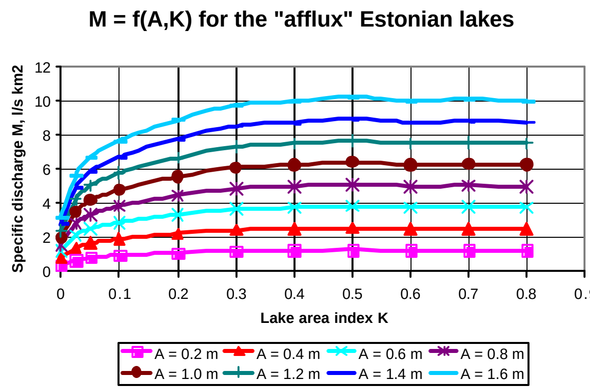


Fig. 2 M = f(K,A) ratio for afflux and backwater events

The normal (background) dependencies of M = f(K,A) for Kola Peninsula, Estonia and Middle Ural looks as following:

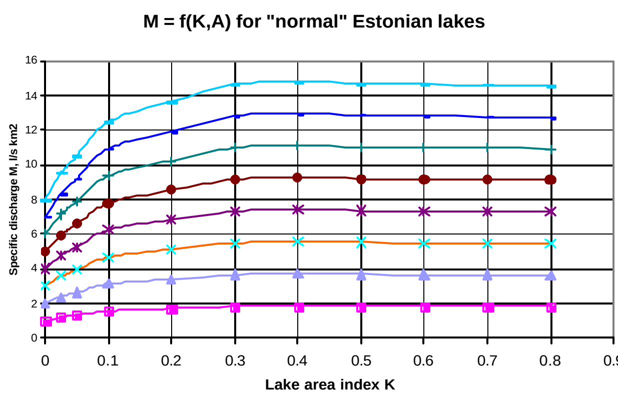


Fig. 3 Normal M= f(K,A) ratio for Estonia.

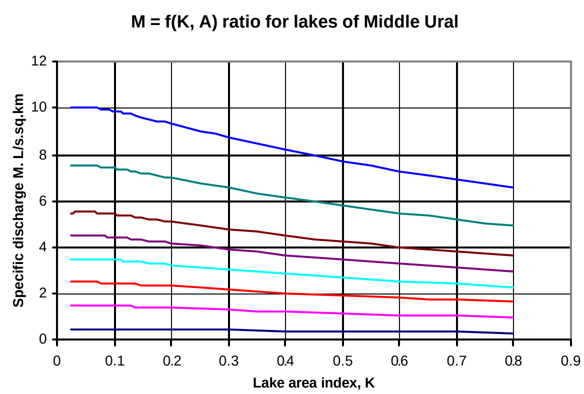
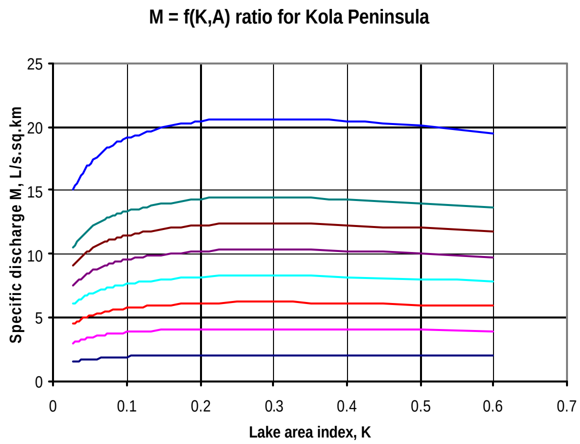


Fig. 4 Normal M=f(K,A) ratio for Middle Ural

The difference between different regions depends on runoff losses due to evapotranspiration and evaporation from lake surface if K> 0.05. So, the differences between precipitation and total evapotranspiration (P-E) for these regions are 615, 258 and 136 mm. These losses are from catchment surface.



A = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 m
for Estonia (from bottom to top)

A = 0.1, 0.3, 0.5, 0.7, 0.9, 1.1, 1.5, and 2.0 m
for Middle Ural

A = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 1.0 m
for Kola Peninsula

Fig. 5 Normal M = f(K,A) ratio for Kola Peninsula

The crossed points of M-axis show M = f(A) ratio for rivers without lakes (K = 0). These were estimated for the same lakes in supposing of lake absence.

The average error of outflow estimation for lakes with known sizes and lake level altitudes amounts to 8%, and altitude estimation for lakes with known sizes and outflow amounts to 10% (this result was obtained for known lakes of Kola Peninsula, North European Part of the former USSR, Estonia, Middle Ural). The main feature of these graphs is that they are efficient for lakes with any size of water mirror and catchment area – from small pond to great sea. The only demand on its creating and using is the examined lake has to have the natural regime of water level fluctuation.

The Baltic Sea is the largest brackish water body in the world with a total surface area of 377 400 km2 and watershed area of 1 628 000 km2 [5]. Its area index K amounts to 0.232. Supposing the average difference between precipitation and evapotranspiration for entire watershed is equal to 250 mm as it is in the geometrical center of this body, in Estonia [4,5], it i8s possible to use Estonian diagrams and relations for the water level altitudes and outflow estimation. The water level altitude can be assessed using level fluctuation's dependence on the average depth of lake associated with Estonian lakes located in moraine deposits [2,3]. For lakes with depth more than 6 m as well as for Baltic Sea the water level altitude is equal to 0.4 m. And then knowing the Sea area index (0.232), level altitude (0.4 m) and having the M = f(A,K) ratio (fig.2) for Estonian lakes with afflux events (Baltic Sea has an afflux events from the North Sea, Skagerrak and Kattegatt Straits) we can estimate the outflow from Baltic Sea. It is equal to 2.4 L/s.km2 (92.3 mm) or 151.8 km3 a year. Knowing the long-term amount of precipitation – 680 mm, - it is possible to estimate evapotranspiration from the Baltic Sea watershed: 588 mm.

These level altitude and outflow are caused by precipitation, evaporation and river inflow to the Baltic Sea and can be called as balance's.

References:

1. R. Vedom. Global regularity of lake adjustment to river runoff// Authoreferat of the Ph. D. thesis; State Hydrological Institute of Russia, May 16, 1995, St.-Petersburg, - 1995, - 23 p (Rus).
2. R. Vedom. Estonian lakes: origin and water regime// Estonian Marine Academy. – Tallinn. 1995.
3. R. Vedom. Estonian lakes: water level altitude dependence on the ground water table fluctuations// SOLUTIONS'95 – Intern.Congr.XXVI/Intern.Assoc.Hydrogeol. – Alberta, 1995
4. R. Vedom. Water balance of Estonia// European Conf. on Applied Clim. Norrkopping 7-10 May, 1996, p. 203-204.
5. Bergstrom S., Carlsson B. River runoff to the Baltic Sea: 1950-1990. Ambio Vol. 23. No. 4-5, July 1994.