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Lakes-paleolakes cascade system and its role in shaping the runoff and chemical properties of water in the young-glacial catchment - example from the Tuchola Pinewood Forest (Northern Poland)

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The impact of paleolake basins, filled up with organic mineral deposits, in the transformation of the chemical properties of the outflow is generally ignored. Defining their role and importance in the water and matter cycles is one of the objectives of the hydrological and hydrochemical monitoring, which has been run in the catchment of Lake Czechowskie since mid-2012.

The axis of the Lake Czechowskie catchment is a hydrographical system made of river and lake sections. Lake sections are not only present-day lakes (Głęboczek and Czechowskie), but also basins of the lakes functioned in the past, which are now biogenic plains. Lake sections of the system are connected by short valley sections, mostly of a gap character. The size and variability of surface water runoff from the basin is mainly affected by groundwater and the size of evaporation. Stable groundwater table provides stability of the river discharge, even during the periods of significant precipitation deficit.

Groundwater fluctuation ranges registered during the period from May 2012 to September 2015 were between 0.17 and 1.25 m. The smallest were in the deepest piezometers located in watershed areas, and the largest in the shallow groundwater of lake terraces. The small dynamics of the groundwater states is reflected by slight fluctuations of water levels in Lake Czechowskie, which in the analyzed period amounted 0.40 cm.

The surface of paleolake Trzechowskie, cut by a system of drainage ditches, is the area where an essential part of the surface runoff from the monitored catchment is formed. Large water resources in this part of the catchment are evidenced by the specific runoff value, which amounts to 25 $dm^3s^{-1}km^2$. It is much larger than the whole basin specific runoff which reaches 11 $dm^3s^{-1}km^2$. The measurements showed that the average surface runoff from Lake Czechowskie in the analyzed period was 0,065 m^3s^{-1} and was similar to the size of the water influx via watercourses supplying the lake. On the basis of this value it was calculated that the theoretical time to replace the water in Lake Czechowskie is 2.8 years.

The hydrochemical study showed that the studied ground- and surface waters represent the same bicarbonate-calcium-sulphate hydrochemical type. Against the background of a homogeneous ionic composition, the spatial variation of their overall salinity is very large. This is reflected by the values of electrolytic conductivity, which in the study period ranged from 76 to 1218 $\mu S \cdot cm^{-1}$. The most mineralized (700-800 $\mu S \cdot cm^{-1}$) are the waters of streams migrating in the organic-carbonate formations of the paleolakes and shallow groundwater in these areas. The lowest mineralization is showed by the groundwater circulating in sandy sediments of outwash plains. Mineralization of the Lake Czechowskie water of approx. 340 $\mu S \cdot cm^{-1}$ is a result of supplying the lake from both sources and the effect of biogeochemical processes occurring in the lake. The hydrochemical monitoring results showed that the zones of water enrichment in salts are associated with paleolake basins filled with the organic-carbonate sediment, while the salt precipitation zones with lakes.

The results of the study of matter flow in the basin of Lake Czechowskie showed that paleolakes equally affect the runoff volume and the transformation of the chemical properties of the water circulating in the basin as the lakes functioning today. The lakes and paleolakes create a cascade system of interconnected basins. Depending on the place they occupy in the cascade, their effect on the water circulation and transformation of matter is different.

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