



Long-term changes of hydrophytes range as an indicator of lake shore zone vulnerability to transformations

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Lake shore zone management in conditions of changing climate and increasing anthropopression requires the identification of littoral zones particularly sensitive to changes. The following study assumed that one way of indication of such sites is a spatial picture of long-term changes of emergent and submerged hydrophytes range. Referring to the evaluation works describing pressure, naturalness or buffer capacities of the shoreline, a synthetic map was developed to assess the transformation degree of hydrophytes occurrence. Research in this area was carried out at the Institute of Meteorology and Water Management - National Research Institute within the EULAKES project ('European Lakes Under Environmental Stressors' is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF).

Studies were carried out based on the example of Lake Charzykowskie which belongs to the UNESCO World Network of Biosphere Reserves. It is a large ($A = 13.6 \text{ km}^2$) flow-through gutter lake with a small amplitude of water level (up to 1 m). In the shoreline zone the anthropopression intensity is varied. Most of the shore zone is covered by forest. Buildings constitute a small percentage. The ecological status of the lake is a subject to fluctuations. In the hydrophytes transformations study a 70-year time horizon was assumed. In the late '40s of the 20th century the studied lake was characterized by poor trophic status. These conditions were considered as reference. At the turn of the '80s and '90s (the period of hydrological drought and increased anthropopression) the lake state has deteriorated (hypertrophy, blooms on the lake). Nowadays, it is observed that the conditions improve to moderate eutrophy.

Archival materials from 1949 served as a reference point. A contemporary image was obtained on the basis of mapping of emergent and underwater vegetation range (made in 2011 and 2012) using modern measuring techniques (GPS and hydroacoustic equipment). However, in comparative studies of archival and contemporary materials there emerged a problem of heterogeneity of the obtained materials. The research methodology during the mid-20th century was adapted to the technical possibilities available at that time. The spatial picture was presented in the form of a plan made in a Cartesian coordinate system. The shoreline was mapped in a very simplified way. The 1949's plan was transformed to a common reference system (with the use of the ArcGIS software) together with the newly obtained materials.

The scope of possibilities of long-term comparative analysis is smaller than in contemporary short-term research (repeatability, comparability). However, it allows to capture the basic differences. In the studied case (within the whole lake), it was noted that the submerged vegetation range was reduced (by 24%) with a withdrawal from 6 m up to 2.5 m of depth. At the same time more than 19% of the shoreline length became overgrown. In 14%, the smaller plant associations merged to form compact structures. These processes occurred unevenly. Particularly resistant to overgrowing by reed proved to be the anthropogenically transformed coast and windward steep banks, in which the waves and erosion processes hinder the development of reeds.