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Tracing man's impact on groundwater dependent ecosystem using geochemical an isotope tools combined with 3D flow and transport modeling: case study from southern Poland

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Thorough understanding of the link between terrestrial ecosystems and underlying groundwater reservoirs is an important element of sustainable management of groundwater resources in the light of ever growing anthropogenic pressure on groundwater reserves, both with respect to quantity and quality of this vital resource. While association of terrestrial ecosystems with surface water (rivers, streams, lakes, etc.) is visible and recognized, their link to underground components of the hydrological cycle is often forgotten and not appreciated.

The presented study was aimed at investigating possible adverse effects of intensive exploitation of porous sandy aquifer on groundwater dependent terrestrial ecosystem (GDTE) consisting of a valuable forest stand and associated wetlands. The Bogucice Sands aquifer and the associated GDTE (Niepolomice Forest) are located in the south of Poland. The principal economic role of the aquifer, consisting of two water-bearing strata is to provide potable water for public and private users. Eastern part of the shallow phreatic aquifer is occupied by Niepolomice Forest. The Niepolomice Forest is a lowland forest covering around 110 km2. It is protected as a Natura 2000 Special Protection Area "Puszcza Niepołomicka" (PLB120002) which supports bird populations of European importance. Additionally, a fen in the western part of the forest comprises a separate Natura 2000 area "Torfowisko Wielkie Bloto" (PLH120080), a significant habitat of endangered butterfly species associated with wet meadows. Dependence of the Niepolomice Forest stands on groundwater is enhanced by low available water capacity and low capillary rise of soils. Groundwater conditions in the Niepolomice Forest, including Wielkie Bloto fen have been affected by meliorations carried out mostly after the Second World War and by forest management. In September 2009 a cluster of new pumping wells (Wola Batorska well-field) has been set up close to the northern boundary of Niepolomice Forest. There is a growing concern that continued exploitation of those wells may lead to lowering water table in the Niepolomice Forest area and, as a consequence, may trigger drastic changes in this unique ecosystem.

A dedicated study was launched with the main aim to quantify the interaction between Niepolomice Forest, with the focus the Wielkie Bloto fen, and the underlying Bogucice Sands aquifer. The work was pursued along three major lines: (i) vertical profiling of the Wielkie Bloto fen aimed at characterizing chemical and isotope contrast in the shallow groundwater occupying the Quaternary cover in order to identify upward leakage of deeper groundwater in the investigated area, (ii) regular monitoring of flow rate, chemistry and environmental isotopes of the Dluga Woda stream draining the Wielkie Bloto fen, and (iii) 3D modeling of groundwater flow in the vicinity of the Wielkie Bloto fen focusing on quantifying the impact of the Wola Batorska well field on the regional groundwater flow patterns.

The results of isotope and chemical analyses confirmed existence of upward seepage of groundwater from the Bogucice Sands aquifer in the area of Wielkie Bloto fen. Preliminary assessment of the water balance of Dluga Woda catchment indicates that the baseflow originating from groundwater seepage is equal approximately 16% of the annual precipitation. Results of 3D flow model applied to the study area indicate that prolonged operation of the well-field Wola Batorska at maximum capacity may lead to substantial lowering of water table in the Niepolomice Forest area and, as a consequence, endanger further existence of this unique GDTE.

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