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Analysis of links between groundwater recharge and discharge areas and wetland plant communities distribution in Middle Biebrza Basin, Poland

Mateusz Grygoruk (1,2), Okke Batelaan (2,3), Tomasz Okruszko (1), Wiktor Kotowski (4), Marek Rycharski (5), Jaroslaw Chormanski (1), and Dorota Miroslaw-Swiatek (1)

(1) Department of Hydraulic Engineering and Environmental Restoration, Warsaw University of Life Sciences, Warsaw, Poland (mateuszg@levis.sggw.pl), (2) Department of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel, Brussels, Belgium, (3) Department of Earth and Environmental Sciences, Katholieke Universiteit Leuven, Leuven, Belgium, (4) Institute of Botany, University of Warsaw, Warsaw, Poland, (5) Institute for Land Reclamation and Grassland Farming, Raszyn, Poland

Natural evolution of wetlands is strongly dependent on groundwater dynamics, soil aeration and climate. These environmental factors determine the constant development of wetland plant communities and peat forming processes. Depending on spatial distribution of groundwater flow systems and recharge and discharge conditions, shallow groundwater can also be influenced by phreatophytic plants. Such feedback plays an important role in wetland development, especially when landuse or climate changes occur. Thus, understanding the links between dynamics of biotopic and biocenotic relations is crucial for wetland management aimed at the comprehensive set of conservation strategies.

Main aim of this study was to review links between valuable wetland plant communities and the groundwater recharge/discharge conditions of particular habitats of Middle Biebrza Basin, Poland. The study area consists of various types of wetland landscapes, of which the dominant are fens. Organogenic top layer is intersected locally by sandy dunes and glaci-fluvial residual plateaus. The northern boundary of the study area is covered with an outwash plateau.

A three-dimensional regional groundwater flow model was set up to quantify groundwater system and flow paths. Model calibration involved measured heads of the unconfined organogenic top layer and the underlaying, confined sandy aquifer. Measured thickness of unsaturated zone as well as physical parameters of organogenic layer were taken into account in interpretation of shallow groundwater dynamics. Recharge to groundwater was spatially distributed in accordance to analysis of measured precipitation-groundwater level relationships. Cell-by-cell flow analysis and groundwater exfiltration analysis were applied to map groundwater recharge and discharge areas within the modelled area. Results of groundwater modelling were validated with phytosociologic research combined with remote-sensing based spatial analysis of wetland habitats distribution.

Results indicated spatial distibution of water balance components of different wetland habitats. In areas of fen plant communities, modelled intensity of vertical upward groundwater flow to the top layer is significantly higher than in ombrotrophic habitats. Research indicated, that spatial patterns of groundwater recharge/discharge intensity is strongly linked to areal distribution of water quality dependent phreatophytic plant communities. In certain areas, simulated drainage conditions increased the thickness of the unsaturated zone, which explains a crucial response of wetland evolution in the last centuries: redirection of groundwater flow towards artificial canals resulted in diminished throughflow in organogenic layer, which causes accumulation of acidic rain water and - consequently - development of ombrotrophic habitats.