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Surface and groundwater drought evaluation with respect to aquatic habitat quality applied in Torysa river catchment, Slovakia

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Abstract

Natural conditions of drought occurrence are often combined with human activities strengthening drought consequences. Occurrence of meteorological, surface and groundwater droughts was analysed for the upper part of the Torysa river catchment. The influence of water abstraction was evaluated. Habitat suitability curves derived according to IFIM methodology were constructed for Barbus carpathicus. Minimum flow, bellow which unfavourable life conditions for barbel occur, was estimated on 0.300 $m^3 s^{-1}$. The longest period of drought with the discharge below the minimum flow occurred during the multiyear drought 1986-1987. The problem of minimum flow preservation should be solved in the upstream part of the catchment, where natural streamflows are strongly influenced by water abstraction. Such an approach is fully compatible with the requirements of the integrated water resources management strategy.

Key words: surface water, groundwater, drought, IFIM methodology, natural regime, abstractions

1. Introduction

Drought is one of the natural hazards, which is more and more often studied at present. This interest was evoked by more frequent occurrence of extreme climatic situations, leading to unexpected and undesired consequences for environment and various spheres of the state economy. Drought is defined as a prolonged deviation from normal conditions, sustained and regionally extensive occurrence of bellow average natural water availability (Tallaksen, van Lanen 2004). Drought starts in the atmosphere (lack of precipitation) and propagates through the hydrological cycle affecting the surface water discharges, soil moisture and groundwater

storage. Drought affects water availability for plants, animals and human society. Natural conditions causing drought are often combined with the human interferences into the environment. Lack of water in the nature increases at the same time needs for surface and groundwater in many types of human activities (agriculture, air conditioning, etc.).

Drought can be identified within the low flow phase of the flow regime. Flow regime is considered for one of the most important conditions influencing quality of the river ecosystems. Many studies on ecological consequences of changes in flow regime for aquatic biodiversity were already published. Results on research of basic principles and ecological consequences of altered flow regime for aquatic biodiversity were published by Bunn and Arthington (2002). Das Gupta (2008) published results on impact of environmental flow in river basin management. Kashaigili *et al.* (2005) studied environmental flows in the Great Ruaha river catchment in Tanzania. Predicative mapping of the natural flow in France was done by Snelder *et al.* (2009). Bejarano *et al.* (2010) studied flow regime pattern and their controlling factors in the Ebro basin, Spain. Environmental flow regime is one of the conditions to be preserved within the integrated water resources management strategy (Carvajal-Escobar 2008). As confirmed by Bunn and Arthington (2002), the impacts of flow change manifest across broad taxonomic groups including riverine plants, invertebrates and fish. Essential flow requirements of river fish communities were summarized by Arthington and Pusey already in 1994. In Spain, Navarro *et al.* (2007) showed the influence of regulation and stabilization of flows in the Júcar river basin as the factor of critically threatening one endemic cyprinid fish species. According to Directive 2000/60/EC (EU 2000) called often as Water Framework Directive (WFD), all surface water bodies must be evaluated from the point of view of their ecological status in context of the integrated water resources management concept. The member states of the European Union were obliged to transpose the directive into the national legislation. The objectified assessment of the habitat quality of the mountain and piedmont streams by IFIM methodology is one of the measures proposed to be used in Slovakia for implementation of the WFD requirements. Generalization of preferences of main abiotic characteristics for modelling in IFIM simulation system was studied by Macura *et al.* (2008), Macura *et al.* (2009) published results of bioindication utilization for estimation of minimum (ecological) discharges in Torysa and Topla river catchments. Research results of Jalčovíková (2011) were generalized and interpreted to be used directly for evaluation of surface water bodies' ecological status (in the frame of WFD requirements fulfilment), revitalization actions or minimum (ecological) flow determination.

The influence of drought on water availability was the subject of the research within the project No. APVV-0335-06 leaded by Comenius University in Bratislava with the scientific contribution of the Slovak University of Technology and the Slovak Hydrometeorological Institute, as well as within the VEGA grant No. 1/0783/08. The research goals were oriented into three areas: to propose methods for assessment of the drought occurrence in surface and groundwater; to study influence of human activities on drought occurrence and its intensity; and to estimate river habitat suitability conditions during the drought periods.

The aim of this paper is to show the influence of water abstraction on minimum river flows in connection to river habitat suitability with the special attention paid to drought occurrence in the catchment.

2. Materials and methods

Several methods were used to estimate meteorological and hydrological drought events and their influence on river habitat conditions.

2.1. Drought estimation

It was necessary to estimate both, meteorological drought as the initial impulse, and consequently surface and groundwater drought.

Meteorological drought occurrence was estimated using the method based on classification of the year wetness. Year wetness classification is based on the ratio of yearly precipitation amount to the long-term average. Values between 0.9 and 1.1 indicates normal conditions, values below 0.9 dry conditions (lack of precipitation), values over 1.1 indicate wet conditions (Majercakova *et al.* 2007).

The threshold level method was applied in order to determine drought occurrence in surface and groundwater. The method was introduced by Yevjevich (1967), and widely used by many authors, as Zelenhasic and Salvai (1987), Tallaksen *et al.* (2009), Tallaksen and van Lanen (2004) and others. The threshold is a value below which the drought conditions for the considered variable occur. The drought starts when the value of a variable falls below the threshold, and ends when the threshold is exceeded again. The threshold level can be chosen as a fixed value (the same value used over the whole evaluated period) or as a variable (seasonal, monthly, daily). Characteristic values of the flow duration curve (FDC) are often used as threshold values. They can be estimated using the flow duration master curve FDMC (averaged discharges labelled