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Research paper

Possible impacts of floods and droughts on water quality

Tomáš Hrdinka [a,*], Oldřich Novický [a], Eduard Hanslík [b], Mark Rieder [c]

[a] T.G. Masaryk Water Research Institute, Department of Hydrology, Podbabská 2582/30, CZ 160 00 Prague 6, Czech Republic
[b] T.G. Masaryk Water Research Institute, Department of Radioecology, Podbabská 2582/30, CZ 160 00 Prague 6, Czech Republic
[c] T.G. Masaryk Water Research Institute, Podbabská 2582/30, CZ 160 00 Prague 6, Czech Republic

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Abstract

The gradual climate change symptoms in many places on Earth have been observed during the last 20 years. There is a significant increase in frequency and extremity of meteorological and hydrological events (EEA, 2007) that lead to distinct excess or lack of water in landscape. These phenomena affect not only actual quantity of water but also its quality with direct and indirect impacts on aquatic organisms. From the environmental impact point of view, drought events are considered to be more dangerous due to their medium-term to long-term characteristics and large spatial impacts. However, this study presents that the particular flood event had significantly greater impact on water quality than the period of drought even if for only a very short time The paper reviews changes in water quality with all its consequences during selected extreme hydrological situations in the Czech Republic in last 10 years and compares them with the knowledge of impacts of floods and droughts on water quality collected from literature.

Keywords: Flood; Drought; Water quality; Czech Republic

1. Introduction

In the last 15 years, the Czech Republic has been affected by three extreme floods with return period exceeding frequently 100 years (locally even 500−1000 years). The 1997 and 2002 floods were caused by long-term regional rainfalls that affected substantial part of the country. The spring 2006 flood (at the end of March) was less extensive in its devastating effect, despite greater return periods than the 2002 flood at several water gauging stations. Particularly the southern part of Bohemia and Moravia was highly affected by intensive precipitation strengthened by a quick snow cover melting in the lowland areas. The severe heat wave, which began in Europe in June 2003 and continued through July until mid-August, was reflected in raising summer temperatures by 20−30% as compared to the seasonal average over a large portion of Europe. Consequent drought in 2003 caused vast environmental damages in the European countries particularly in southern and Western Europe. This drought also affected almost the whole area of the Czech Republic with exception of several mountain regions.

Increasing frequency and severity of the hydrological extreme events is mostly attributed to impacts of already ongoing climate change. This was discussed in great number of literature sources, including those focused on conditions in the Czech Republic, such as Kašpárek et al. (2006b), (2008), Novický et al. (2005), (2009a) and (2010).

2. Data and methods

On March 28, 2006, 35 mm of rainfall was recorded over some areas of the Czech Republic (Fig. 1a). The rainfall together with 50 cm mean snow cover (Fig. 1b) and several preceding days with maximum temperature over 20 °C led to intensive floods (VRB, 2006; Kašpárek et al., 2006a). Impacts

* Corresponding author. Tel.: +420 220 197 337.
E-mail addresses: tomas_hrdinka@vuv.cz (T. Hrdinka), oldrich_novicky@vuv.cz (O. Novický), eduard_hanslik@vuv.cz (E. Hanslík), mark_rieder@vuv.cz (M. Rieder).

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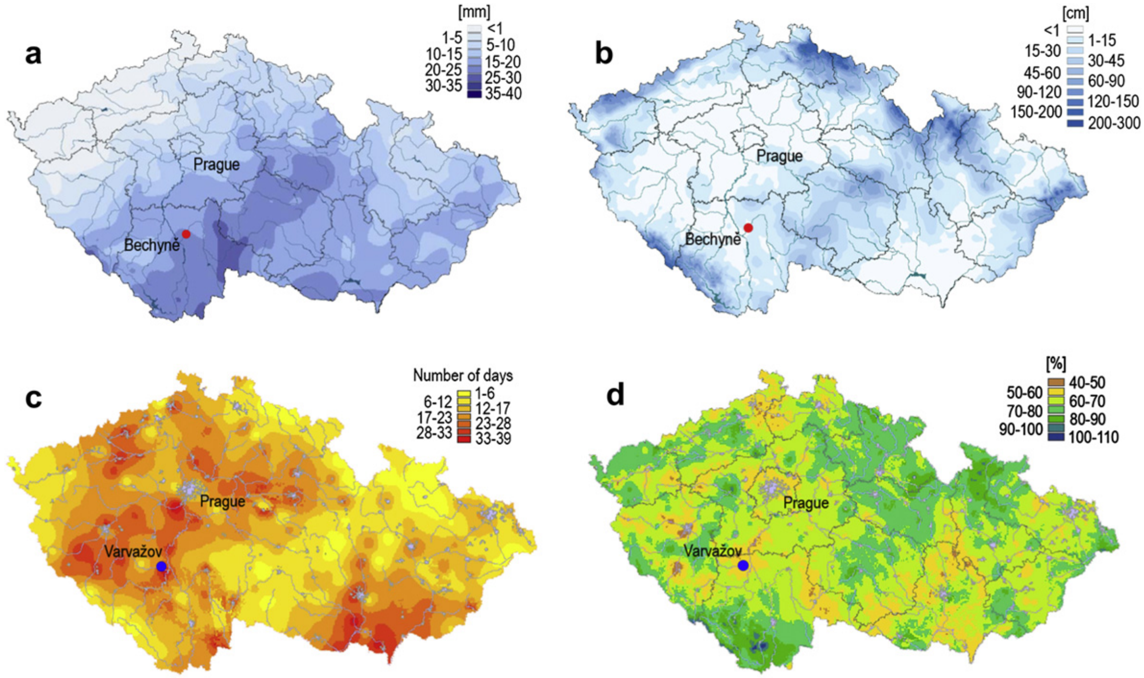

Fig. 1. Weather patterns over the Czech Republic prior to the 2006 (a,b) and 2003 (c,d) extreme hydrological events – a) daily precipitation on March 28, 2006; b) snow cover on March 27, 2006; c) tropical days from Jan 1, 2003 to Aug 19, 2003; d) precipitation from Jan 1, 2003 to Aug 20, 2003 related to the 1961–90 average.

of the flood on water quality were assessed by using data from the Lužnice River basin (Table 1), which was highly affected. At Bechyně water gauging station, located close to the mouth of the Lužnice River, which is a tributary of the Vltava River, the return period of the peak discharge reached almost 50 years.

In the period from June to September 2003, the Czech Republic experienced only 60% of the normal precipitation (Fig. 1d) and river flows in most of Czech streams consequently fluctuated between 15% and 65% of the long-term means (Řičicová et al., 2004; CHMI, 2004). The mean temperature in this period exceeded that from the reference period (1961–1990) by 2.5 °C and an extreme occurred particularly in a number of tropical days (Fig. 1c). The drought impact analysis was carried out for the Skalice River (Table 1)

Table 1
Principal characteristics of the Lužnice River and the Skalice River basins.

Lužnice River at Bechyně sampling station		Skalice River at Varvažov sampling station	
Source elevation	970 m a.m.s.l.	Source elevation	678 m a.m.s.l.
Supe elevation	615.9 m	Super elevation	297.5 m
Length of river	197.4 km	Length of river	48.7 km
Slope of river	3.1 ‰	Slope of river	6.1 ‰
Catchment area	4055.13 km^2	Catchment area	368.53 km^2
Annual discharge Q_a	23.6 m^3	Annual discharge Q_a	1.51 m^3
Flood discharge Q_1	111 m^3	Drought discharge Q_{330}	0.182 m^3
Flood discharge Q_{50}	488 m^3	Drought discharge Q_{355}	0.087 m^3
Flood discharge Q_{100}	577 m^3	Drought discharge Q_{364}	0.032 m^3

in central Bohemia, whose discharges dropped to 5%–20% of the long-term monthly means. The data for the analysis were available for Varvažov water gauging station, which is located close to the confluence of the Lomnice and Vltava Rivers.

It is a rather difficult problem to collect data for the analysis of water quality during a flood because most hydrological activities during a flood are commonly focused on evaluation of the flows. For the 2006 flood, the water quality data were available from regular monitoring conducted with monthly frequency and from several short-term monitoring programmes performed during the flood (selected indicators only). For the purposes of the study, the water quality data from approximately one month before and after the flood were used as reference conditions. The conditions during the flood were represented by water samples taken at the beginning of the flood (March 28, 2006), and two and seven days after the occurrence of the flood peak. The values of water quality shown in Fig. 2 represent in situ measurements (water temperature, dissolved oxygen content) and the results of laboratory analyses (biological and chemical oxygen demand, metals, suspended and dissolved solids, specific organic compounds, microbiology). The data were provided by Vltava River Basin state enterprise and Czech Hydro-meteorological Institute.

To assess the drought impact, the water quality data from the 2003 drought (June to September) were compared with those from two previous and two following years. The values of the water quality characteristics shown in Fig. 3 were calculated as arithmetic averages of the results from point water sample analyses made in the individual years in the periods from June to September. The water samples were taken annually approximately in identical days. This method