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CHARACTERISTIC FEATURES OF WATER YEAR 2002 FOR GROUNDWATER IN BULGARIA

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ABSTRACT

The purpose of the present contribution is to clarify the impact of the temperature and precipitation anomalies during the Water Year 2002 on the groundwater regime in Bulgaria. The analysis is based on data from National Hydrogeological Network: spring discharges and water levels for observational wells. Mean monthly temperatures and monthly precipitation values originate from synoptic stations in Bulgaria.

The period November 2001 – February 2002 is characterised with precipitation sums below normal. As a result very low spring discharges and groundwater levels were registered. Heavy rainfalls in March in combination with snowmelt caused very high springflows. Then primary maximums for karstic springs in most regions of the country were observed.

The summer 2002 was very wet. During September and October the precipitation sums were above normal. The secondary maximums for springs were registered in October or August.

INTRODUCTION

The problem of water resources in Bulgaria is of common interest, especially after the drought period 1982-1994. Gerassimov et al. (2001) analysed the impact of this drought period on water resources in Bulgaria. The behaviour of the groundwater was analysed as well (Bojilova et al., 2000; Orehova et al., 2001 and 2001a; Andreeva et al., 2001).

A comparison between Water Years (WY) 2000 and 2001 for groundwater in Bulgaria was made by Orehova (2002a). Summer droughts 2000 and 2001 caused reduction of spring discharges. Extremely dry beginning of the WY 2001 had strong negative impact on groundwater as well. The end of the Water Year 2001 was very dry.

The aim of the present study is to characterize the general behaviour of the groundwater regime in Bulgaria during the Water Year 2002. The influence of the dry and wet periods on the regime of selected karstic springs and observational wells was estimated. For this reason the variations in the groundwater time series were studied in relation to the previous observational period. In Bulgaria the beginning of Water (Hydrological) year is accepted on the 1st November of the previous calendar year. It lasts exactly 12 months.

INFORMATION DATA BASE

Data from National Meteorological and Hydrogeological Networks located in the National Institute of Meteorology and Hydrology were processed. For this study, time-series of precipitation, air temperature, discharge for karstic springs and water level for observational wells were utilized.

The hydrogeological stations with long period of observation and minimal human impact were selected. Time series from National hydrogeological network that starts from 1958-1960 were used. They are spring discharges and water levels for the observation wells. For the chosen springs the measurements are made usually from 12 to 24 annually (once-twice in a month). For some springs the daily data are obtained using rating curves. Water level in observational wells is measured usually once in a month. Some of the stations are observed several times monthly. Water level recorders are available only for small number of the stations.

For the purpose of this study, some representative springs were chosen related to elevated massifs of Mesozoic limestone and Proterozoic marbles (Antonov et al., 1980; Boyadjiev, 1964). The selected wells refer to porous aquifers in alluvial and proluvial deposits.

The variations of spring discharges and ground water levels during the Water Year 2002 were estimated expressed in relation to the 1961-1990 periods.

ANALYSIS OF THE PRECIPITATION AND THE TEMPERATURE ANOMALIES

The Water Year 2002 started in November 2001 with lower rainfall amounts relative to normal in most regions of Bulgaria. The tendency continued during the next month December. The temperature anomalies were below normal almost everywhere during this period. The two winter months – January and February were warm. February was extremely warm – with the anomalies 6-7 °C above normal. The rainfall totals were below normal everywhere with some exceptionally heavy daily falls bringing totals between ½ and ¾ to the month normal. For all period November 2001 – February 2002 the rainfall amounts were below normal.

Rainfall during the spring was about normal in more regions and above normal in Northeast Bulgaria. The wettest month on record in most places was March.

The summer was very wet. The wettest month was July with rainfall amounts between two and three times above normal. September was cool and wet everywhere. The rainfall amounts were up to five times the month normal at the Black Sea region. September 2002 was extremely wet. The tendency was preserved during the second autumn month, October. For all period November 2001 – October 2002 the rainfall amounts were about and above normal.

BASIC FEATURES OF THE GROUNDWATER REGIME

To reveal anomalies of the groundwater regime during the Water Year 2002, the basic features of it are presented. The natural groundwater regime in Bulgaria is described here for some common cases of karstic and porous aquifers.

Mean yearly values for the Water Year 2002

In this section, average values of spring discharges and water level for observational wells are presented. The groundwater regime during the Water Year 2002 is executed in deviations for some representative karstic springs (see Table 1).

Table 1. Deviations of the mean yearly spring discharge for the Water Years 2000 - 2002.

WR, river basin	Spr. N	Village	2000 ε, %	2001 ε, %	2002 ε, %
the North Bulgaria					
18, Iskar	25	Zl.Panega	-23	-33	-26
23, Jantra	396	Musina	-18	-70	-19
43,Kamchia	48	Kotel	-24	-56	-20
32, Dobr.r.	130	Voden	-22	-15	-20
the Upper Struma basin					
51, Struma	86	P.Skakav.	-19	-47	-59
51, Struma	40	Drugan	-20	-45	-51
the mountain Pirin					
52, Mesta	59a	Razlog	-32	-66	-35
the mountain Rhodopes					
72, Maritza	39a	Beden	-27	-39	-42
the Southeast Bulgaria					
83, Veleka	63	M.Tarnovo	-33	-10	-31

The deviations of mean yearly values for spring discharges were calculated in respect from their multiannual values by

$$\varepsilon = \left(\frac{Q}{\overline{Q}_N} - 1 \right) 100\% \tag{1}$$

where N refers to the period 1961-1990. This period was chosen taking into account the recommendation of WMO for defining of normals (WMO, 1984).

For the Upper Tracian Kettle in the Maritza watershed, the regime of the groundwater during Water Years 2000 - 2002 is characterized on the base of water levels in observational wells (see Table 2). The deviations for water levels are given in absolute values in respect from their multiannual values for the climatic period 1961-1990.

Table 2. Deviations of the mean yearly water levels in wells for the Water Years 2000 - 2002.

WR, river basin	Well N	Village	2000, m	2001, m	2002, m
17, Scat	442	B.Slatina	-0.15	-0.25	-0.49
72, Maritza	208a	Rakovski	-0.63	-1.10	-1.17
72, Maritza	266	V.Levski	-0.54	-0.74	-0,41
73, Maritza	526	Trakia	-0.26	-0.41	-0.23
73, Maritza	287a	Sabrano	-0.09	-0.65	-0,82
74, Tundja	271	Tulovo	-0.15	-0.27	0.24

The number of the water region (WR) is indicated in the beginning of the first column in Tables 1-2. It refers to the watershed of one river or to part of the watershed for larger river body (i.e. Maritza).

The analysis shows the reduction of spring flow and falling of water levels for most of stations for the years 2000-2002. In average, the decrease for the Water Year 2001 was stronger - about 42% for spring flow compared to 24% and 34% for the Water Years 2000 and 2002 respectively. Low values of spring discharge and water levels were typical for the year 2001 due to extremely dry beginning of the Water Year and dry summer.

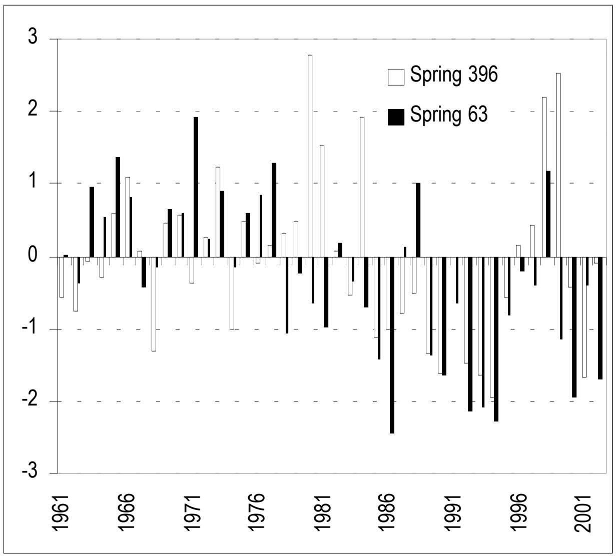

Figure 1. Discharge of springs 341and 63 in relative deviations

The chronological structure for two karstic springs is presented in Figure 1. The deviations here are dimensionless and are calculated using annual discharges:

$$\psi = \frac{Q - \overline{Q}}{\sigma_Q} \tag{2}$$

where $\overline{Q}$, σ_Q are average values and standard deviations for the 1961 - 1990 period respectively. Low values of spring discharges for years 2000 - 2002 are evident.

Interannual regime for karstic springs

The predominance of drought during the first 4-month period of the WY 2002 resulted in very low spring discharges. An additional reason for this was extremely dry October 2001 that finished the previous WY 2001 (Orehova, 2002a).

Heavy rainfalls in March in combination with snowmelt caused floods in rivers and increased discharges of karstic springs especially in Northern Bulgaria. The primary maximums for the rivers and springs were observed in the country in March - April.

The wet period July-October caused high springflows and water levels. Then secondary maximums were observed.

Some examples of the interannual regime for karstic springs from the North and Southeast Bulgaria are presented in Figures 2-5. Due to predominance of drought during the first 4-month period of the WY 2002, very low discharges and levels were registered. The primary maximum was registered during March or April and the secondary one – in October or August.

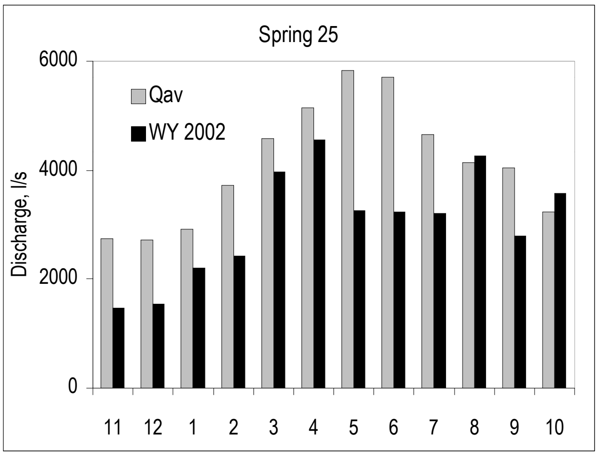

Figure 2. Regime of spring 25 in the North Bulgaria.

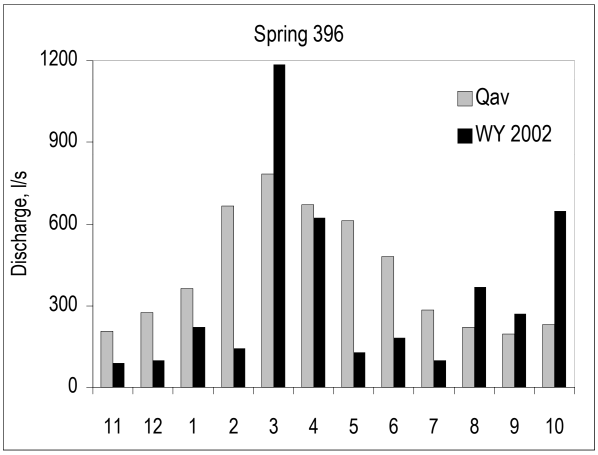

Figure 3. Regime of spring 396 in the North Bulgaria.

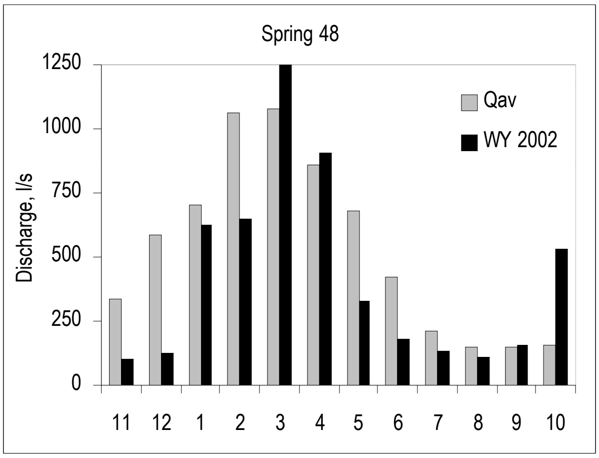

Figure 4. Regime of spring 48 in the North Bulgaria.

Regime of springs in mountainous regions

The karstic springs with watersheds in high mountains Pirin and Rhodopes are characterized with specific regime. Their maximal springflows are observed later due to later snowmelt.

During the first half-year period of WY 2002 extremely low discharges were registered, whereas in September and October the values about or above their multi-annual norms were observed (Fig. 6-7}. The maximal monthly discharge for spring 59a was registered as usual in June, and for spring Beden 39a – in April.

The drainage basin of the spring 59a is located in preserved area of Pirin mountain. Pirin mountain is included in the list of United Nations Organization as a part of World natural heritage.

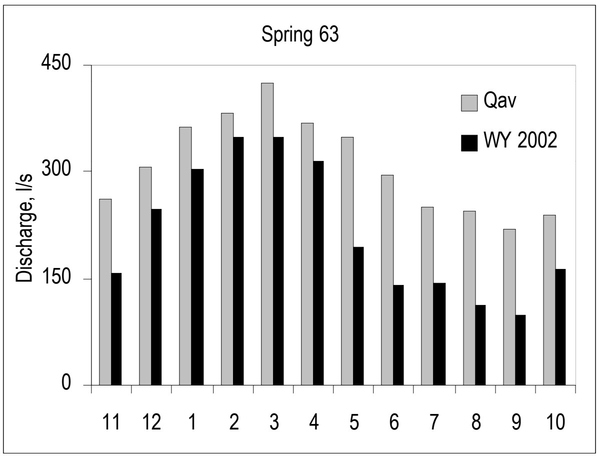

Figure 5. Regime of spring 63 in the Southeast Bulgaria.

Regime of water levels in porous aquifers

Aquifers in porous media in alluvial and proluvial deposits do not show quick reaction to the precipitation occurrence as karstic springs. They however are sensible to droughts or wet periods. The drought during the first several months of the WY 2002 caused falling of water tables (Figures 8-9).

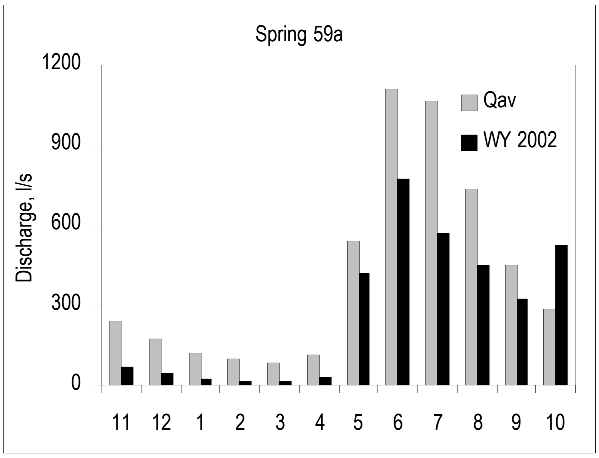

Figure 6. Regime of spring 59a in the mountain Pirin from the Southwest Bulgaria.

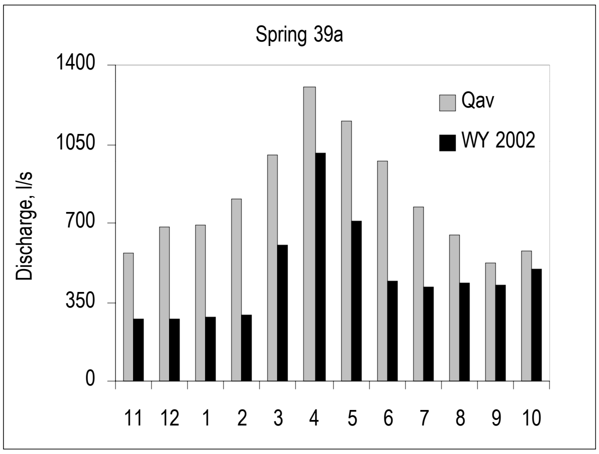

Figure 7. Regime of spring 39a in the mountain Rhodopes from the South Bulgaria.

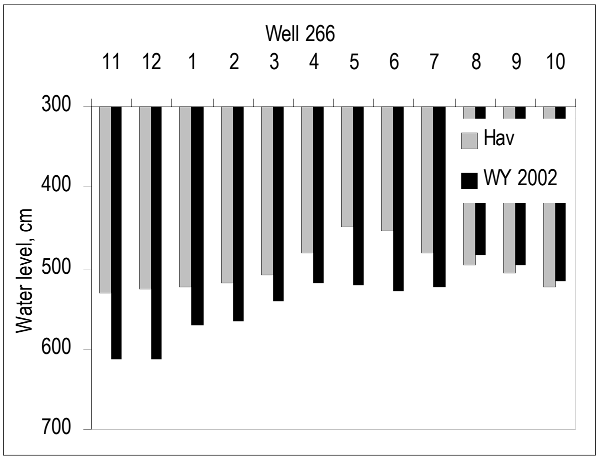

Figure 8. Regime of observational well 266 in the Upper Tracian Kettle.

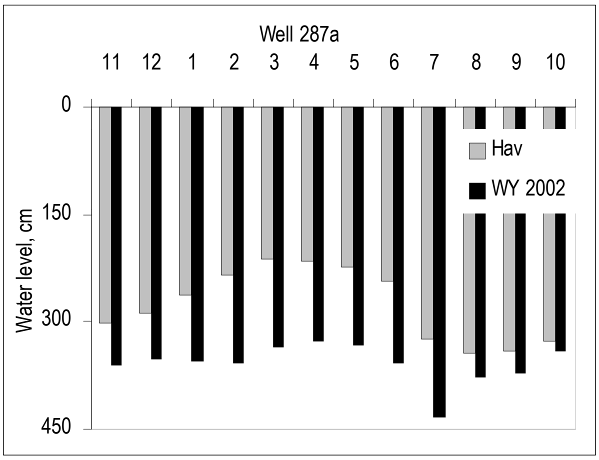

Figure 9. Regime of observational well 287a in the Upper Tracian Kettle.

March was very wet month, and precipitation together with snowmelt contributed to effective recharge of porous aquifers. The highest water levels however were observed later during April.

Precipitation amounts during summer were used to evapotranspiration by plants, and regardless of very wet summer they did not contribute to important recharge of groundwater.

Minimal water levels were registered in July or in the beginning of the WY 2002 – in November-December.

September 2002 was extremely wet, followed by wet October. The autumn precipitation contributed to recharge of porous aquifers in the country.

CONCLUSION

Long lasting drought during November 2001 – February 2002 caused low values for spring discharges and water levels in wells during Water Year 2002.

The reduction of the precipitation during the winter (December, January and February) had strong negative impact on groundwater regime in WY 2002. The last winter month February - extremely warm, had negative impact on the rainfall amount and on the springflows and water levels.

The first spring month March was the wettest month on record and caused the highest discharges for springs in the country. The secondary maximum for springs and wells were observed during October. Precipitation amounts about and above normal during autumn had positive influence on the groundwater recharge.

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