# IMPACT OF THE RECENT DROUGHT PERIOD ON GROUNDWATER IN BULGARIA

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**Abstract:** The purpose of the present contribution is to clarify the influence of the recent drought period (1982—1994) on groundwater in Bulgaria. Taking into account the global climate change conception, this period may be considered as a model of future behavior of water resources. The groundwater regime in Bulgaria is described over the three main territorial units: Danube hydrological zone, Black sea zone and Aegean hydrological zone.

The investigation is based on available long-term observations (from 1960 up to 1999) for springs and wells without significant impact of human activity. Time series of spring discharge and groundwater level in wells were processed. The chronological structure of the respective time series was investigated. Most karstic springs had reduced discharge (15-25% in average) and wells showed lowering of the water table (0.20-0.30 m) during the 1982—1994 drought period. The strongest reduction in spring discharges is registered during 1985—1994 period. The situation is similar with water levels in wells. The corresponding values are 25-45 % and 0.30-0.45 m. From 1996—1997 the annually average discharges and groundwater levels have tendency to reach their multi-annual average values.

These phenomena took place as a result of the continuous period of decrease in rainfall in combination with increase in air temperature registered in Bulgaria since 1981. According to scenarios of Climate change given in Arnell, 1999, the reduction of river flow in Bulgaria with 25-50% is expected. These results are comparable to the effect of the drought period 1982—1994 for the groundwater.

The general conclusion is that the drought period reflected considerably on the groundwater. The reductions in spring flows were registered as well as lowering of groundwater levels. The results obtained give an idea of the reduction in aquifer recharge in condition of global climate change.

**Keywords:** groundwater, drought impact, spring discharge and water level

# 1 INTRODUCTION

Since 1981 in the territory of Bulgaria the continuous period of decrease in rainfall in combination with increase in air temperature has been registered. As a result the reduction in the river flow has been noticed in the country. The great interest to the event of drought is explained by the conception of global climate change, when water resources will be under threat (Trends'93, 1994; Arnell, 1999).

The drought period may be considered as a model of the future global changes. The recent study of water resources in Bulgaria during the drought period (Gerassimov et al., 1999) gives general characteristic of this period for the territory of the country. The mentioned above study concerns the three main hydrological zones in Bulgaria: (i) zone with direct discharge to the Danube river; *(*ii*)* zone with direct discharge to the Aegean sea and *(*iii*)* zone with influence of the Black sea.

The aim of the present study is to characterize the general behavior of groundwater regime in the three hydrological zones in Bulgaria. The influence of the drought 1982—1994 period on the regime of selected karstic springs and wells was estimated. For this reason the studies of variations in the groundwater time series were made for the longer 1960—1999 period.

# 2 ANALYSIS OF THE VARIATION OF THE SPRING DISCHARGES AND GROUNDWATER LEVELS

To study the effect of the drought period 1982—1994 to groundwater, the analysis of variations of the spring discharges and groundwater levels was applied.

### 2.1 Object of study and information base

In the present study we are dealing with the groundwater regime for the 1982—1994 drought period based on the analysis of the 1960—1996 observation period. Time series from National hydrogeological network that starts from 1958—1960 were used. The hydrogeological stations with long period of observation and minimal human impact were selected. They are springs and wells. Data series are spring discharges and water levels for the observation wells. For the chosen springs the measurements are made normally from 12 to 24 annually (once-twice in a month), using rating curves the daily data are obtained.

For the purpose of this study the variations of spring discharges and ground water levels during 1982—1994 period were estimated based on the all period of observation. 10 karstic springs and 3 wells were chosen from river basins located in the Danube basin, 5 springs and 5 wells for Aegean basin and 3 springs and 2 wells for the Black sea basin. Bulgaria is reach in karst springs. In the frames of the Danube and Black sea basins they are related to elevated massives of Triassic, Jurassic and Cretaceous limestones (Antonov et al., 1980). For the Aegean basin some important karstic massives are built from Proterozoic marbles. The selected wells refer to alluvial and proluvial deposits.

### 2.2 Quantitative assessments of the effect of the drought period to groundwater

The effect of the drought period 1982—1994 on the regime of groundwater was studied. For quantitative assessments the mean values of spring discharges for the periods 1960—1996,

1960—1981, 1982—1994 and 1985—1994 were obtained. Furthermore, the deviations of average values for spring discharges were calculated by

$$\varepsilon = \left( \frac{\bar{X}_n}{\bar{X}_N} - 1 \right) 100\%$$

where n refers to the short period and *N* - for the whole period.

The per cent deviations for shorter periods in comparison to the longest one are presented in Table 1, as well as data for hydrological basins and total river discharges for Bulgaria.

Similar information is presented in Table 2. In this Table the deviations for water level in the observation wells are given in absolute values. The results obtained show reduction of spring discharge up to 38% as well as lowering of water tables up to 0.57 m for the 1982—1994 drought period.

Table 1 Deviation of average values for discharges for the periods: 1960—1981, 1982—1994 and 1985—1994 from the mean values for the 37 years period of observation

| Basin or river | Station name | 1960-96ε, %* | Qav** m3/s | 1960-81, ε, % | 1982-94, ε, % | 1985-94, ε, % |
|---|---|---|---|---|---|---|
| Lom | 341 - Krachimir | | 0.176 | 10.9 | -17.9 | -28.2 |
| Ogosta | 340 - Paly lula | | 0.252 | -3.9 | 5.4 | 2.0 |
| Iskar | 30 - Iskretz | | 2.300 | 23.0 | -37.7 | -45.8 |
| " | 446 - Krapetz | | 0.210 | 16.3 | -16.1 | -18.1 |
| Iskar / Vit | 25 - Glava Panega | | 3.940 | 13.3 | -21.4 | -21.8 |
| Vit | 379 - Bulgarsky izvor | | 0.140 | 2.3 | -10.7 | -9.9 |
| Osam | 450 - Krushuna | | 0.127 | 15.8 | -31.0 | -35.8 |
| Jantra | 437 - Gabrovo | | 0.030 | 3.5 | -3.6 | -8.3 |
| " | 394 - Belekovetz | | 0.058 | 17.5 | -25.2 | -32.8 |
| " | 396 - Musina | | 0.386 | 16.3 | -27.1 | -43.7 |
| *Danube* | *Danube drainage basin* | *-6.0* | | *20.5* | *-32.3* | *-39.0* |
| Struma | 86 - P.Skakavitza | | 0.096 | 14.2 | -18.3 | -24.7 |
| " | 415 - Marvodol | | 0.064 | 12.8 | -16.6 | -25.5 |
| Mesta | 59 - Jazo | | 1.047 | 15.9 | -19.5 | -22.6 |
| " | 59a - Kjoshka | | 0.381 | 18.0 | -24.8 | -32.8 |
| Vacha | 39a - Bedenski | | 0.778 | 14.6 | -19.3 | -30.0 |
| *Aegean* | *Aegean drainage basin* | *-3.9* | | *14.6* | *-25.3* | *-34.0* |
| Kamchia | 33 - Targovishte | | 0.068 | 12.7 | -19.2 | -22.5 |
| " | 48 - Kotelski | | 0.517 | 12.5 | -20.5 | -24.9 |
| Veleka | 63 - M.Tarnovo | | 0.300 | 9.9 | -15.9 | -20.0 |
| *Black sea* | *Black sea drainage basin* | *4.9* | | *14.8* | *-29.9* | *-38.9* |
| *Bulgaria* | *TOTAL RIVER DISCHARGE* | *-3.9* | | *17.0* | *-27.7* | *-35.8* |

* In relation to the period 1890—1995

** For the period 1960—1996

Table 2 Deviation of average values for water levels for the periods: 1960—1981, 1982—1994 and 1985—1994 from the mean values for the 37 years period of observation

| Basin or river | Station name | Hav*,m | 1960-81, m | 1982-94, m | 1985-94, m |
|---|---|---|---|---|---|
| *Danube hydrological zone* | | | | | |
| Ogosta | 423 – Hajredin | 3.63 | 0.17 | -0.22 | -0.30 |
| Scat | 442 – Bjala Slatina | 6.45 | 0.12 | -0.13 | -0.22 |
| Osam | 592 – Levski | 2.76 | 0.24 | -0.27 | -0.35 |
| *Aegean hydrological zone* | | | | | |
| Maritza | 537 – Gelemenovo | 3.82 | 0.56 | -0.57 | -0.81 |
| " | 262 - Banja | 3.36 | 0.28 | -0.42 | -0.46 |
| " | 526 - Trakija | 7.85 | 0.18 | -0.22 | -0.34 |
| " | 289a - Zagortzi | 2.06 | 0.14 | -0.20 | -0.27 |
| " | 508 - Djadovo | 7.56 | 0.22 | -0.33 | -0.46 |
| *Black sea zone* | | | | | |
| Sredezka | 552 - Svetlina | 4.34 | 0.30 | -0.30 | -0.30 |
| " | 555 - Grudovo | 4.58 | 0.25 | -0.19 | -0.39 |

* For the period 1960—1996

### 2.3 Chronological structure

The chronological structure for the selected spring discharges is presented in Figures 1-3. The examples for the three main hydrological zones are given. The deviations for the figures are calculated using annual discharges:

$$\psi = \frac{X - \overline{X}}{\sigma_X}$$

where $\overline{X}$, $\sigma_X$ are average values and standard deviations for the 1960—1996 period respectively.

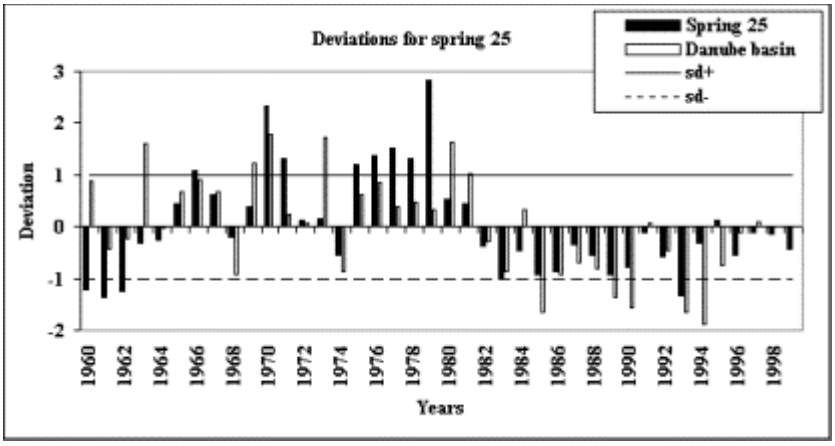


Fig.1 Discharge for spring 25 and Danube basin in deviations.

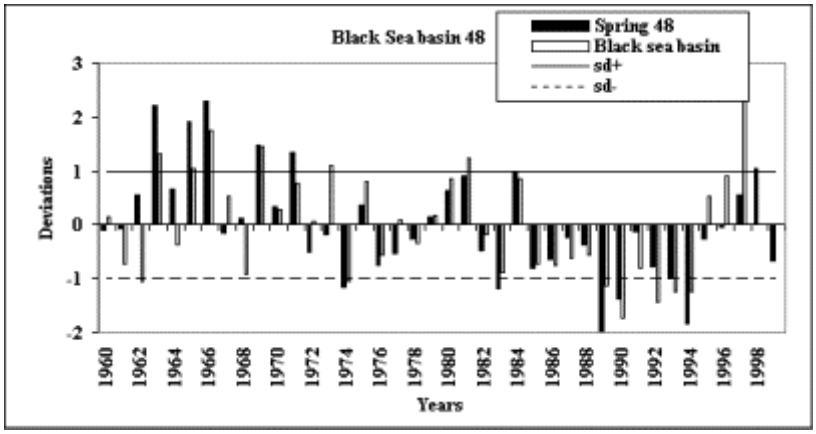


Fig.2 Discharge for spring 48 and Black Sea basin in deviations.

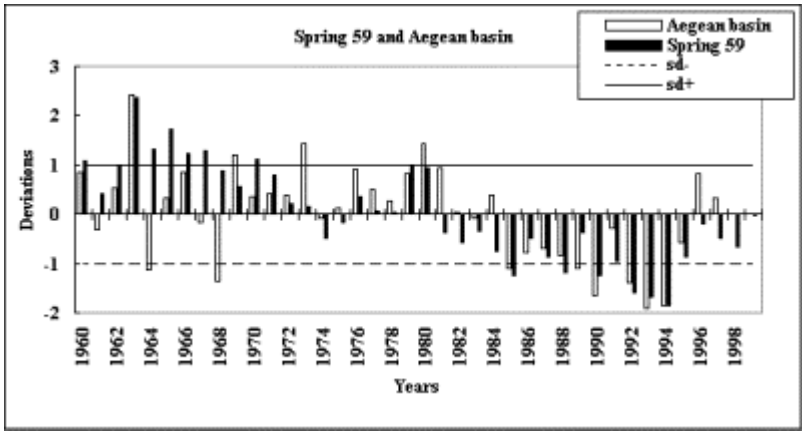


Fig.3 Discharge for spring 59 and Aegean basin in deviations.

The information presented in Tables and Figures allows us to make the following conclusions:

- the drought period 1982—1994 and especially the short one 1985—1994 are characterized with low depression for the groundwater in whole Bulgaria;
- the deviations for the groundwater are in similar range as for river discharges in the main hydrological zones;
- the chronological structure of the drought is similar to this of the river discharge in the three main hydrological zones with minimal values for spring discharges and water levels for wells during 1993, 1994 or 1995.

# 3 CONCLUSIONS

Natural variations in groundwater regime in Bulgaria were analyzed. The chosen karstic springs and observation wells are without evident human impact. The influence of the drought period 1982-1994 on the spring discharges and water levels was estimated owing to

the long period of measurements (1960—1999) in the frames of National Hydrogeological Network.

The drought reflected considerably on groundwater in the three main hydrological zones. The results showed essential reduction in spring discharge during the drought period (20% in average) and lowering of the water table in observation wells (about 0.30 m). The shorter period 1985—1994 is characterized with stronger influence (in average 25% for spring discharges and 0.40 m for water levels). Since 1996 the yearly average discharges and groundwater levels have tendency to reach their multi-annual average values.

The chronological structure of the spring flow in Bulgaria is similar to this for the river runoff in the respective zone, with minimal values for spring discharges and water levels during 1993—1995.

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