Groundwater recharge beneath Chernozems in Northwestern Bulgaria: Case study of the Ogosta River basin

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Drought periods often appear as anomalies of the water regime for Bulgaria. They are related to water shortages that are rather severe for particular periods and regions of the country. Water balance researches are important for the River Basin Directorates under the Bulgarian Ministry of Environment and Water for issuing permissions for groundwater utilization. Besides, quantification of groundwater recharge is an implicit requirement of the Water Framework Directive, which insists on the balance between groundwater abstraction and recharge (Art. 4).

The aim of the study is to clarify specific features of the water regime and balance within the Danubian Plain in Northwestern Bulgaria. A special attention is given to evaluation of the groundwater recharge.

The climate for the Danubian Plain is temperate with cold winters and hot summers. Typical rainfall sums are in the range 500-600 mm yearly. Spring and summer are the wettest seasons. The study region (Bazovets – Byala Slatina) is situated in lower part of the Ogosta River basin within the Danubian Plain. The major soil types here are Chernozems that are genetically related to the loess cover. For preliminary estimation of the yearly water balance, the semi-empirical relationship developed by Budyko was used.

The main method used in the study is the water budget equation on monthly basis, typical for multiannual period. Evapotranspiration and soil moisture fluctuations are important balance elements, controlled by climate, soils and vegetation. Data from soil moisture observations and characteristics of Bulgarian soils are used. For conditions of deep groundwater table, the water balance is described by equation, where R is total runoff (both surface and subsurface), dS/dt – change in the soil moisture storage. For plain areas subsurface runoff prevails and generates groundwater recharge.

The potential evapotranspiration is evaluated using the method of Thorntwaite based on mean monthly air temperatures typical for the study area, with yearly sum of 720 mm. The yearly precipitation sum for the rainfall station Krivodol is 654 mm. The aridity index for the study region is equal to 1.1 ($\phi = E_0 / P = 720/654$). According to the classification of climatic regimes, the plain part of the Ogosta River basin refers to the sub-humid region. Based on the value of ϕ, the yearly sum of actual evapotranspiration according to the Budyko relation is 477 mm.

For Bulgarian soils, the largest soil moisture capacity is usual for Chernozems: 180-220 mm and more for the soil layer 0 – 100 cm, and for the total soil profile (up to 200 cm) it may reach 300-350 mm. According to multiannual observation on agrometeorological stations in North Bulgaria, about 70% of precipitation sum during the cold period of the year (October – March) are spent to soil moisture storage in Chernozems. The mean value of precipitation sums 200-250 mm generates the soil moisture available for plants in the range 130-160 mm.

The typical features of the water balance for the Danubian loess Plain are presented on example of the study region. The data on soil moisture are from agrometeorological station in Bazovets. The mean seasonal cycle of soil moisture is used. According to the water balance data, the groundwater is recharged mainly during the period from November to March. The recharge value is 24 mm (or 0.76 l/s/km^2), which is 3.7% of the yearly precipitation sum. The groundwater recharge is controlled mainly by

the precipitation sum during the cold part of the year (October-March), maximum soil water storage capacity and evaporation during the above-mentioned period.

The estimated value of actual evapotranspiration for the period March-October is 589 mm, and the yearly sum – 630 mm. The last value exceeds with 23% this obtained from the Budyko curve (477 mm), and therefore the relation E/P according to these data is much more (0.96 compared to 0.73).

The obtained results are in conformity with both earlier studies on groundwater recharge in Northwestern Bulgaria and modern concepts of the water balance formation based on non-linear models with stochastic component. In general, stochastic models describe rather well seasonal fluctuations of the mean soil moisture typical for temperate climate, which are related to seasonal fluctuations in rainfall and evapotranspiration regimes. Partitioning of the rainfall input between evapotranspiration and deep percolation plus drainage is controlled by the parameter γ (relation between maximum soil water storage available to plants wo and mean rainfall depth α). The Budyko curve for average water balance coincides with theoretical solution of the water balance for γ=5.5, which for typical distribution of rainfall considered as Poisson process (α=15 mm) corresponds to maximum soil water storage available to plants w_o=82.5 mm. Under larger soil water storage capacity typical for Chernozems, the value of the parameter γ may be considerably higher, which results in increase of the relation E/P with respective decrease of the possibilities for groundwater recharge.

Keywords: water balance, groundwater recharge**,** Chernozems, Northwestern Bulgaria