Hydrogeology of the Upper Aquifer, Dobrich Region, Northeastern Bulgaria

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Abstract: The upper aquifer of the Dobrich region, northeastern Bulgaria, is composed of limestone, calcarcinite, sand, and probably dolomitic limestone, of Messinian age; total thickness is 40-200 m. Most of the area is underlain by surficial deposits that include slightly permeable loess and highly permeable sand and alluvium. The nearly impervious substratum comprises marl and clay of varying age. In the aquifer as a whole, karstic processes are not very pronounced, based on observations of the small variations in the discharges of the springs that have been monitored. The lithology of the Quaternary-age surficial deposits strongly influences the hydrochemistry of groundwater in the aquifer. The main sources of pollution are related to agricultural activities, corralled livestock, and urban wastewater, as indicated by the high nitrate contents of the water in numerous wells. Seawater intrusion is occurring in some eastern parts of the region.

Résumé: L’aquifère supérieur de la Dobrogea (nord-est de la Bulgarie) est constitué par des calcaires, des calcarénites, des sables, et probablement des calcaires dolomitiques d’âge messinien, dont l’épaisseur totale varie de 40 à 200 m. Dans le plus grande partie de la zone il est recouvert par des matériaux détritiques à faible perméabilité (loess) et à perméabilité élevée (sables et alluvions). Des marnes et des argiles d’âges différents, selon les secteurs, constituent le substratum imperméable. L’ensemble peut être considéré comme un aquifère à fonctionnement karstique très peu accusé, à cause probablement de sa forte porosité, d’après la faible variation des débits des sources contrôlées. La nature de la couverture quaternaire joue un rôle important sur l’hydrogéochimie. Les principales sources de contamination sont liées aux activités agricoles, aux stabulations et aux eaux usées urbaines; la teneur élevée en nitrates des eaux de nombreux puits en témoigne. L’intrusion marine, en tant que processus polluant, semble commencer dans quelques secteurs du bord oriental.

Resumen: El acuífero superior de la región de Dobrich, al noreste de Bulgaria, está constituido por calizas, calcarcitas, arenas y probablemente calizas dolomíticas de edad messinense, con un espesor total que varía entre 40 y 200 m. En la mayor parte del área se encuentra recubierto por depósitos de materiales detriticos, desde escasamente permeables (loess), a muy permeables (arenas y aluviones). El sustrato impermeable está constituido por margas y arcillas de distintas edades. En el conjunto del acuífero, los procesos karsticos son muy poco acusados, según se deduce de la escasa variación de los caudales en las surgencias controladas. Se pone de manifiesto la importancia que desempeña en la hidroquímica la naturaleza del recubrimiento cuaternario, al tiempo que se deduce que los principales focos de contaminación están relacionados con las actividades agrícolas, las estabulaciones ganaderas y las aguas residuales urbanas, tal y como indica el elevado contenido en nitratos de las aguas de numerosos pozos. Fenómenos de intrusión marina parecen haberse iniciado en algunos sectores del borde oriental.

Introduction

In the last few decades, the quality of groundwater in the karstic aquifers in Bulgaria, especially in the northeastern part of the country, has deteriorated significantly, as a consequence of agricultural and industrial activity. In addition, seasonal overexploitation of the aquifers and decreasing annual rates of precipitation probably contribute to the decline of groundwater supplies. For all of these reasons, nitrate pollution is occurring and seawater intrusion and groundwater depletion are beginning.

The carbonate aquifers are almost the only source of fresh and drinking water in northeastern Bulgaria, and thus the present study was undertaken to provide an updated general description of the hydrogeological conditions of one of the two principal aquifers in the region. One of these aquifers is unconfined and shallow (upper aquifer) and the other is confined and deeper (deep aquifer). This article is limited to a description of the former, which is better known and for which more data are available.

The study area has a surface area of about 4,600 km² and is in the northeastern part of Bulgaria, between the geographical coordinates 27° 32' to 28° 42' longitude E and

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43°22’ to 44°00’ latitude N. The geographical and political boundaries are: to the north, the border with Romania; to the east and southeast, the Black Sea; to the south, the Batova River valley; and to the west, the Suha River valley. The most important cities within the area are Dobrich, Balchik, Kavarna, General Toshevo, and Shabla. Because Dobrich is situated in the central part of the study area and is one of the major administrative centres, the study area is termed the Dobrich Region. Locations of the study area and regional geographic features are shown in Figure 1.

From an economic point of view, this region is predominantly agricultural; it is the primary producer of wheat and corn in Bulgaria. The amount of land under irrigation is small, compared with size of the area studied. Livestock installations are numerous; pig farms predominate and form the greatest concentration of such farms of the entire Balkan Peninsula. The main industrial activity is centred in the city of Dobrich, although industry is also present in Balchik and Kavarna. The entire coastal sector bordering the Black Sea has a relatively high level of tourism.

No accentuated relief or pronounced slopes occur in the study area. The area is nearly flat; altitudes range from 0 m a.s.l. along the Black Sea to 380 m in the southwestern part of the region. This monotonous flatness is interrupted only by narrow valleys with depths of as much as 200 m from the altitude of the plateau, especially in the southern part (Batova River) and in the western part (Suha River). In the plateau, at least 13 shallow closed depressions occur that affect the terrain; these depressions are mostly between Dobrich and General Toshevo. Each of these depressions, which are of karstic origin, has an area of more than 1 km², and some are as large as about 20 km².

Average annual temperature in the city of Dobrich during the last 50 years is 11°C (Bulgarian Hydrometeorological Service, 1983); monthly averages range from -2°C to 23°C during the year. The annual average for the coastal area is only one degree higher, and the monthly range over the year is somewhat narrower (16-17°C).

Annual precipitation ranges from 380-460 mm and increases from the coastal zone toward the interior of the country (Bulgarian Hydrometeorological Service, 1983). Monthly precipitation is rather uniform and ranges from 30-60 mm. Figure 2 shows the monthly distribution of precipitation and evapotranspiration for Varna and Dobrich. The monthly precipitation maxima in the coastal area (Varna) occur in November, April, and January, with a secondary maximum in June and July. By contrast, in the central part of the study area (Dobrich), far from the sea, the maximum values are observed between June and August, with a secondary maximum in November (Miklanek and Dimitrov, 1995).

Monthly potential and actual evapotranspiration, estimated for the meteorological stations by a complex method (Fig. 2) for 1976-88, show that only during November to February is there insufficient energy to evaporate the available water. During the other months of the year, the energy is far greater than necessary, and evaporation is limited by water availability. The actual annual evapotranspiration is 23-27 percent of the total precipitation, and the mean is about 132 mm/yr. The total recharge during 1976-88 was about 80 mm/yr. Assuming that the net water budget is almost zero, the quantity of water that flows to the Black Sea and to the Romanian part of the aquifer is about 50 mm/yr.

The first studies to characterize the hydrogeology and hydrochemistry of the region date from the 1970’s (Raykova and Danchev, 1972; Antonov, 1973). Later studies provided data concerning the hydrogeological and hydrogeochemical properties and values of hydraulic parameters (Danchev et al., 1981). More recently, an electric analog model was made to estimate the subsurface discharge (Betsinski et al., 1990).

Geologic Framework

Lithology and Boundaries
The upper aquifer consists of limestone, calcarenite, sand, and probably dolomitic limestone of Miocene age. These units are shown in the geologic map of Figure 3. Porosity is generally high as a result of intergranular spaces in the calcarenites, the heterogeneous solution of fossil shell remains, and the processes of karstification; fracturing is quite uncommon. The aquifer, although mostly overlain by Quaternary-age loess, is generally unconfined. Layers are horizontal or have slight dip toward the east (Black Sea). Thicknesses range from 30-250 m, as shown in Figure 4. The minimum thicknesses occur in the western part along the Suha River and tributary valleys; in this area, the base of the aquifer crops out, due to the deep vertical excavation of these valleys.

The eastern boundary of the aquifer is the Black Sea. Between Cape of Kaliakra and Durankulak, the coast has progressively more cliffs toward the north. Along a large part of the coast, the aquifer dips beneath the sea, although the