GROUNDWATER IN THE HYDROGRAPHICAL BASIN OF THE VASLUI RIVER

Ionuț Jora, Gheorghe Romanescu.
"*Al.I.Cuza" University of Iasi, jora_iv@yahoo.com*

Abstract. From the point of view of water reserves, the hydrographical basin of the Vaslui River shows a deficit in groundwater resources, both phreatic and high-depth water. This is due to the thermo-pluviometric regime, geological substrate and other environmental factors. The most important groundwater resources are accumulated in the cracks and empty spaces of the limestone-sandstone complex, as well as in the sands that rest towards watershed surface. In this subunit lenticular groundwaters are regularly found, in the local permeable intercalations, situated at different depths and opened often on the hills. Although the groundwater resources are relatively evenly spead, the hydrographical basin of the Vaslui River is in severe water shortage, especially for the agricultural sector. High-depth aquifer waters are in significant amounts and offer optimal conditions for exploitation.

Keywords: *water body, phreatic hydrostructures, deep underground aquifer structures, piezometric level.*

Introduction

Hydrogeological researches made in Romania are actually connected to the geological ones. Before the 70's no mention can be made about researches focused on groundwater resources alone. Because of the industrial development and improvements of the agricultural techniques the water demand increased. After that, detailed investigations regarding groundwater resources began, first for phreatic hydrostructures, followed by high-depth waters.

Among the hydro-geological and geological studies that focused on the study of groundwater in the Moldavian Plateau, in which references regarding the hydrographical basin of the Vaslui river were made, one can mention: Băcăuanu et al., 1980; Brânzilă, 1997; Jeanrenaud, 1963; Oncescu, 1957; Panaitescu, 2008; Pascu, 1983; Romanescu, 2004; Saulea, 1966, 1968; Ungureanu, 1993, etc.

Regional setting

As a left tributary to the Bârlad river, the Vaslui river is situated in the Eastern part of Romania.

The area of the hydrographical basin represents 9.58% of the Bârlad river basin, which is the greatest river basin and the longest river in the Siret river basin (Fig. 1).

Materials and methods

The monitoring network of the Vaslui hydrographical basin has sufficient hydro-geological wells to make a detailed study about the groundwater resources.

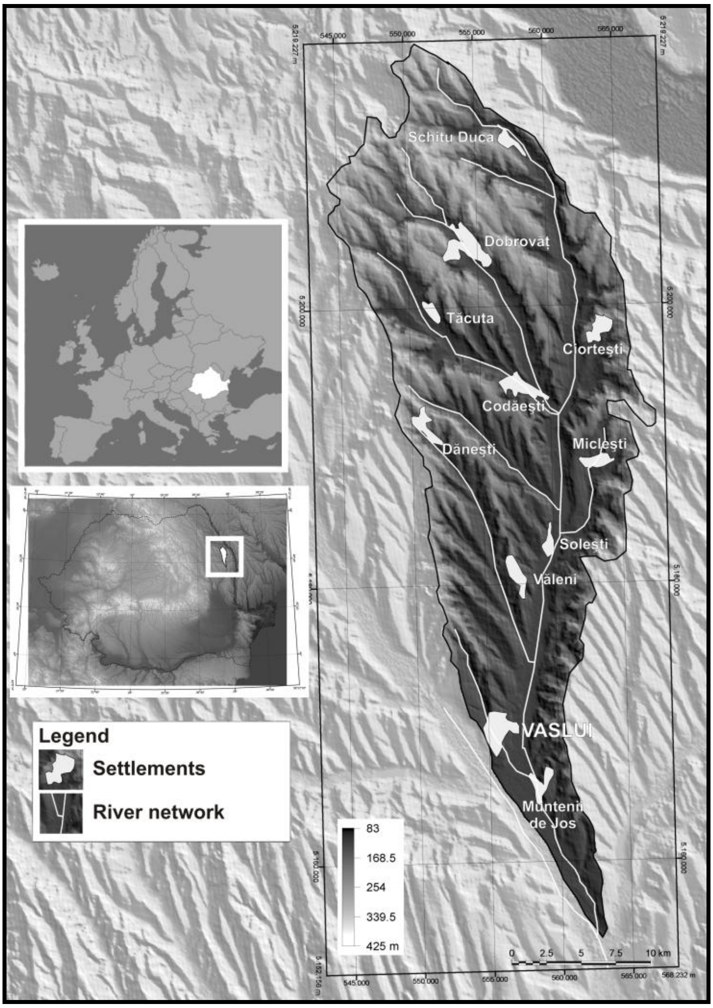

Figure 1 The position of Vaslui hydrographic basin in Romania

Groundwater monitoring, within water bodies, aims at providing information to assess long-term trends, as a result of the natural changes as well as a result of human modifications. In this stage the surveillance monitoring of the groundwater resources has to provide sufficient information in order to make a classification of the groundwater from both the qualitative and quantitative points of view.

An important issue regarding the quantitative and qualitative monitoring is the periodical testing under all the aspects of the high-depth drillings from the state hydrological network. Technical difficulties, involving complex endowments and high costs, led to the fact that these drillings have been pumped (hydrogeologically tested) only at the execution. The fluctuations of the hydrostatical levels is the only process that has been under the tracking. Under these conditions, water samplings, made expeditionary, are not relevant, because the sampling were made only at the superior parts of the drillings, in conditions of the existence of water „non-circulated" for years.

The monitoring system consists in: the measurement of the piezometric level once every 3, 6 or 15 days for the phreatic groundwater and every semester for the high-depth waters; the measurements of the discharge at the periodical experimental pumping; temperature measurements in the aquifer strata; water sampling for determining its physical and chemical properties etc. (Panaitescu, 2008).

A series documents and cartographic materials have been used: Topographic Maps, scale 1:25.000 (1984); Atlas of Water Survey in Romania. Part I (1992); Hydro-geological yearbooks (1970-2008); Preliminary hydrogeological studies and Final hydrogeological studies (1970-2009) etc.

Results and discussions

Groundwater bodies and their main characteristics

In order to identify the underground water bodies in the hydrographical basin of the Vaslui river, the Frame Regulation 60/2000/E.C has been used. In this way, 2 underground water bodies were identified and delimited:

-GWPR03 – the floodplains and terraces of the Barlad river and of its tributaries;

-GWPR05 – Central Moldavian Plateau, water body with trans-basin and transboundary extension (Fig. 2).

The code of underground water bodies has the following structure: GW = groundwater; PR = Prut hydrographical basin; 03 = the number of water body in the hydrographical basin of Prut.

Although the river Barlad belongs tot the hydrographical basin of the river Siret, the encoding contains the name of Prut hydrographical basin due to fact that the Barlad hydrographic basin belongs to the Prut - Bârlad Water Basin Administration, with its headquarters in Iasi.

The extension and the intensification of water exploitation in the high-depth aquifer structures can lead to significant modifications, especially from a quantitative point of view, in the natural regime of the groundwater. The sizing of water catchments and correct calculations of the optimal discharge exploitation can be made only by knowing exactly the behaviour in time of the source. These arguments determined the policy makers to start a program of experimental pumping for high-depth drillings. These experimental pumping, that are measurements of groundwater discharges, will be followed by water samplings in order to make some physical, chemical and bacteriological analysis.

GWPR03 is an underground water body of porous-permeable type, developed in the floodplains and terraces of the Bârlad river and its tributaries; its age is Quaternary (Panaitescu, 2008).

GWPR05 is an underground water body of porous-permeable type, accumulated in deposits of Sarmatian age, with trans-basin and trasboundary character. This water body is developed on the territory of Neamț, Bacău and Vaslui counties, as well as the Republic of Moldavia.

Exploration drillings made in the area of this water body, investigated all the aquifers crossed, and the discharges measured during the experimental pumping represent the cumulative value of the aquifer possibilities from different hydrostructural unities.

The area of the hydrostructures is not exactly known. This is why an exact evaluation of the high-depth aquifer resources corresponding to each structure is not possible, especially that there are significant non-investigated areas. The trans-basin and transboundary character of the high-depth aquifer structures, as well as the undifferentiated way of investigation are elements that make the evaluation of aquifer reserves in every hydrostructure a difficult task.

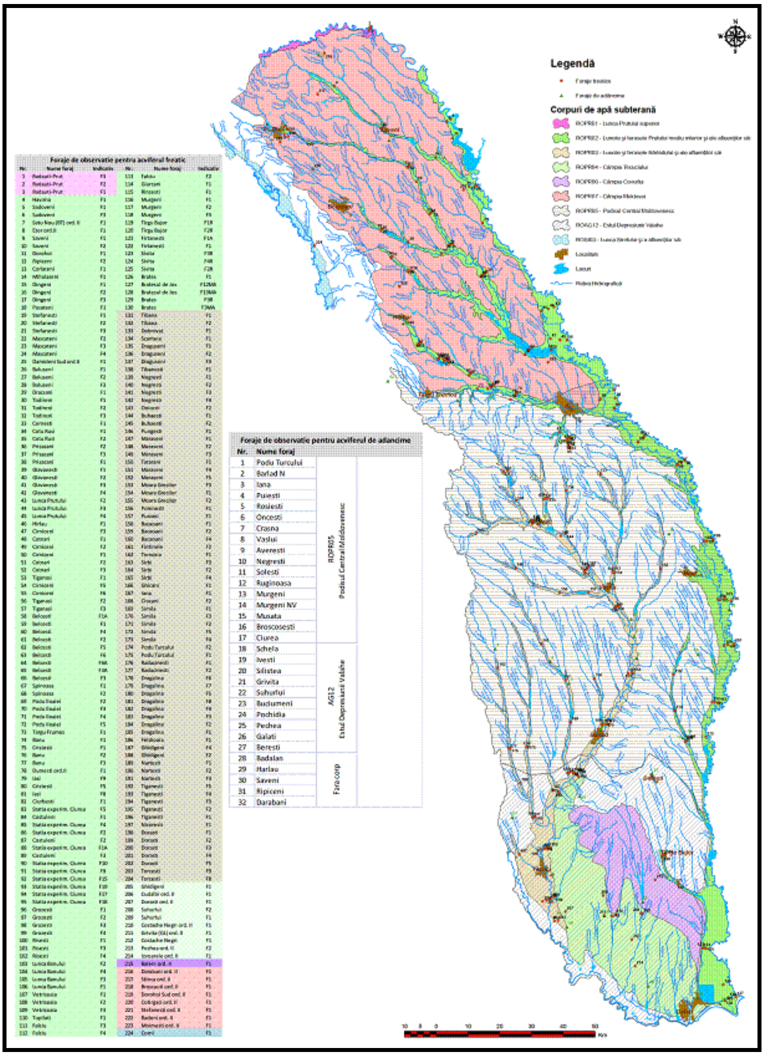

Figure 2 Underground water bodies belonging to the Prut – Bârlad Water Basin Administration and the underground water network monitoring

Phreatic hydrostructures

The phreatic aquifer is directly influenced by the climatic and hydrologic regimes. Also, the relief factor, especially through the geomorphologic processes influences to the natural hydrological regime of the area.

Economically, groundwater bodies have only local importance, being unable to supply exploitable flows, which need to be provided for long periods of time, for use in industry and irrigations. The aquifer reserve maintains a constant level, and the natural regime is not directly influenced by the anthropic factors.

Groundwater bodies have been signalled both in plateau deposits or the slope area, where it shows bleeding aspects, or even as small helocrene springs, and also in the alluvionary deposits of the surface watercourses. There are no real aquifer layers on the plateau and slopes, the water circulating preferentially, the replenishing of the reserves and supplying of the springs and bleedings is made entirely from meteoric water. In the riverside area, groundwater is established into an aquifer layer fairly well determined, in constant extension, which is fuelled both from precipitations and the hydrodynamic exchange with the river.

In 1971, the Vaslui river major waterbed alluvionary, near the village Moara Grecilor, was the object of a hydrogeological study based on 3, completed drillings, each 10 m deep. The drillings are laid following an alignment perpendicularly to the watercourse, set on the East-West direction, with a total length of the profile of 836 m.

Through the work undertaken, Sarmatian and Quaternary were met. The Sarmatian appears at a depth of 7 m, consisting of purple marls or marly clays with sand intercalations. The Quaternary, shown by Holocene, appears as a pack of clay and sand layers, succeeding accordingly: a layer of gravel contained in a mass of coarse sand, or coarse sand with scarce gravel; next, a layer of fine and medium grained yellow conchiferous sands; at surface a horizon of black clay or dust, onto which lays the vegetal soil.

Around drilling F2, a lens of grey sandy silt is present. The total thickness of the Quaternary deposits varies between 7.0 to 7.8 m. In this complex, the gravel and coarse sand layers represent the water bearing layer.

The aquifer layer appears at depths varying between 2.7 to 7.8 m and is made of medium and coarse sands, gravel and pebbles. The thickness of the aquifer horizon has medium values between 1.6 to 4.3 m.

The piezometric (groundwater) levels were established by design to 1.50 m at F1, 0.00 meters at F2 and 0.50 meters at F3. These values are confirmed through the bathymetric map, from which we can tell that in the area of the hydrogeological section Moara Grecilor, the groundwater depth varies between 0 to 2 m.

After completing the drillings, experimental and sand-removing pumping were made. The maximum flows were achieved at drilling F1, from the coarse sand layer with scarce gravel (3.3 l/s), and the minimum flow at drilling F3 (0.7 l/s).

Water collected from drillings F1 and F2 fit into the bicarbonated, magnesian and sodium-bicarbonated waters category, and the one collected from drilling F3 to sodium-sulfatic waters.

In 1974, in the floodplain of Dobrovat river, in Dobrovat village, an 8 m deep drilling was made. Through the drilling, the alluvionary deposits were established to be present at a depth of 5 m, laid over the Sarmatian-aged deposits consisting in grey clay.

Considering the lithology of the catchment basin of Dobrovat river, the lithology seen in the drilling from the hydrogeological station Dobrovat, as well as the transversal profile to the direction of the valley, we can state that the old riverbed of Dobrovat has not been intercepted, in which coarse elements, gravel or fragments from the Sarmatian sandstone plate were to be found.

The captured aquifer layer, with a thickness of 2.2 m, is located between 3.1 to 5.3 m, and the groundwater level, after completion, stabilized at 1.4 m.

One can observe a vertical variation of the particle size, in the upper horizon, with a thickness of approximately 1.4 m (fine sand), under which follows a fine and medium sand. The roof of the aquifer layer is made up of clay dust, with a thickness of 1.5 m, over which dusty clay follows, and after that, the soil horizon. The bedding, crossed over a thickness of 2.7 m, up to the relative altitude of 8 m, is made of compact, grey, Sarmatian-aged clay, with yellow traces.

The aquifer layer within the alluvionary deposits of the floodplain is under pressure, the groundwater level (measured in pumping) rising to about 2.4 m above the aquifer roof.

In the area of the hydrogeological station Dobrovat, the connection between the ground water and surface water is reduced, because the river Dobrovat has its riverbed dug into low permeable deposits. The phreatic horizon supply comes from the area of the slopes or from the river, in areas situated upstream of village Dobrovat.

During experimental pumping, the maximum flow obtained after completing the works was 0.941 l/s. The water is bicarbonated, magnesian, undrinkable (according to the *Scholer-Berkaloff* diagram), because of the high magnesium concentration.

High depth aquifer structures

In the Central Moldavian Plateau the deep aquifer is accumulated almost exclusively in hydrostructures belonging to Sarmatian. The research of such structures was done by means of drillings belonging to the state hydrogeological network, as well as other drillings (Panaitescu, 2008). The analysis of the results points out important zonal quantitative and qualitative differences. The quantitative differences are more obvious horizontally and they are caused by the different particle size of the Sarmatian deposits. These deposits are mainly made up of sands and gravels in the west, at the contact with the Carpathian orogen, while the particle size in the east is finer.

The differences in the marine facies (salmastre, weakly salmastre or drinking water) of the Bessarabian or Kersonian deposits, determine the qualitative differences as well. In the Bessarabian deposits, two levels of drinking water fauna of molluscs have been identified.

The deep underground aquifer structures are situated, most of the times, under the base level of the valley. The deep hydrostructures are intercepted in exploration drillings, and rarely in exploration-exploitation drillings. Usually, the deep hydrostructures are of multilayer aquifer type, with significant thickness, with water under pressure, rarely manifested artesian, and their pressure increases constantly from north to south.

The deep aquifer reserves are significant quantitatively and they offer optimum conditions for exploitation. Most of the times, these reserves are appropriate from the point of view of their physical-chemical aspect, and they present a true natural protection; both hydrogeologically as well as sanitary.

In the Vaslui hydrographic basin, only 2 depth drillings with exploration-exploitation character have been executed for the state hydrogeological network. In 1994, to the north of Soleşti, on the left bank of the Vaslui river, downstream of the confluence with the Dobrovăț river, the deep drilling FA Soleşti was executed. From a geological point of view, the drilling is situated in the area where Sarmatian formations are found.

By analysing the samples that were taken every 25 m, a weak micro fauna of foraminifera and ostracods could be determined, as well as unidentified lamelibranchiate. On the basis of this micro fauna and of the lithological descriptive data, the following conclusions on the age of the intercepted formations were drawn: between 0.15 – 15.0 Quaternary; between 15.0 – 100.0 Kersonian; between 100.0 – 200.0 Bessarabian. The upper half of the sequence belongs to upper Sarmatian, and the lower part belongs to middle Sarmatian. The roofs and the beds of the 4 bearing water aquifer layers are made up of compact (impermeable) marly clays and grey marly clays.

From a hydrogeologic point of view the respective strata were treated globally, in a complex, considering the reduced distance between them and the common age. The piezometric level is artesian, as the aquifer layers are under pressure.

The water is hydrocarbonated, chloro-suphato-sodic. The interpretation of the ionic concentrations on the *Scholler-Berkaloff* analyse diagram, indicates a water with a content of sodium exceeding the admitted limit, exceptionally, even being non-drinking.

In 1990, in order to investigate the structure of middle and upper Sarmatian in the area of Vaslui municipality, and to discover the productive aquifer strata necessary to the supply with water, the deep FA Vaslui drilling was executed.

The micro-palaeontologic analyses on the samples taken from the drilling, every 25 m, point out a fauna characteristic to the Bessarabian. The water is of carbonato-suphato-chloro-magnesian-sodic type.

Groundwater regime

As a result of the level measurements taken in the hydrogeological drillings, the solving of the following problems was aimed at:

- study of the natural regime of phreatic waters;
- determination of phreatic water balance;
- determination of phreatic water reserve fluctuations.

The regime of underground water levels implies the analysis of their variation in time, and their interdependence with all the causes that could influence this variation, in different geological and hydrogeological conditions. The natural regime of the levels can be influenced by two categories of factors: constant factors (geological structure and lithology); variable factors (climatic, hydrological, bio-pedological, anthropic activity, biotic and physico-chemical processes, etc.).

The values referring to the levels are reported to the surface of the land. The analysis of the general elements characterizing the regime of phreatic waters must fit the second criterion, which refers to the consideration of the evolution of these elements as being dynamic, and in time. Considering the dynamic aspect of the underground flow, the elements of the regime can be separated into two main groups: the annual daily flow, the multiannual daily flow and the annual monthly flow and mutiannual monthly flow.

An analysis of the daily values is beneficial for agriculture, where the multiannual, annual and monthly maximum daily piezometric levels, as well as their period and the duration they maintain, have a determinant role in the schedule of watering or dissecation in the respective regions. For the supply with water of certain objectives, the analysis of the flow is required to be done on the basis on the regime elements characterizing the multiannual and annual monthly flow.

Conclusions

As a result of the local physical-geographical factors the phreatic groundwater present a reduced importance in industry and agriculture. The only important reserves are represented by the high depth groundwater.

Although high depth groundwaters do not have good drinking qualities, they can be successfully use din agriculture and industry.

The groundwaters which are mostly used are represented by the reserves accumulated in the floodplains. There are few attempts to use high depth waters in the irrigation systems.

Acknowledgements

Our thanks go to the Hydrologic Station in Vaslui within the Water Management System in Vaslui, for providing us with the hydrological material necessary for the realization of this paper, and also to the management of Prut Water Headquarters in Iasi.

References

Băcăuanu V., Barbu N., Pantazică M., Ungureanu Al., Chiriac D., 1980. *Podişul Moldovei. Natură, om, economie*, Edit. Ştiinţifică şi Enciclopedică, Bucureşti.

Brânzilă M., 1999. *Geologia părţii sudice a Câmpiei Moldovei*, Edit. Corson, Iaşi.

Jeanrenaud P., 1963. *Contribuţii la studiul stratelor de apă dulce din sarmaţianul platformei Moldoveneşti*, Anal. Ştiinţificie ale Univ. Al.I.Cuza, Iaşi, 9(2):39-58.

Oncescu N., 1957. *Geologia Republicii Populare Române*, Edit. Tehnică, Bucureşti.

Panaitescu E.V., 2008. *Acviferul freatic şi de adâncime din bazinul hidrografic Bârlad*, Casa Editorială Demiurg, Iaşi.

Pascu M.R., 1983. *Apele subterane din România*, Edit. Tehnică, Bucureşti.

Romanescu G., 2004. *Caracterele hidrologice ale Coastei de tranziţie a Iaşului*, Lucrările Seminarului Geografic "Dimitrie Cantemir", 23-24:127-136.

Saulea E., 1968. *Harta geologică. Bârlad (scara 1:200.000)*, Comitetul de Stat al Geologiei-Institutul Geologic, Bucureşti.

Ungureanu Al., 1993. *Geografia podişurilor şi câmpiilor României*, Edit. Univ. Al.I.Cuza, Iaşi.

*** 1992. *Atlasul Cadastrului Apelor din România. Partea 1 – Date morfo-hidrografice asupra reţelei hidrografice de suprafaţă*, Ministerul Mediului, Bucureşti.

*** 1970-1990. *Anuare hidrogeologice*, Arhiva Administraţiei Bazinale de Apă Prut-Bârlad, Iaşi.

*** 1970-2009. *Studii hidrogeologice preliminare* şi *Studii hidrogeologice definitive*, Arhiva Administraţiei Bazinale de Apă Prut-Bârlad, Iaşi.