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Analysis of the Relationships Between the Phreatic Aquifer and Natura 2000 Habitats from ROSCI0224 Scroviștea

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Abstract

The analysis of the relationships between groundwater and terrestrial ecosystems contributes to the conservation of biodiversity and the quantitative and qualitative status of the aquifer.
The main goal of the paper is to analyze the relationships between the phreatic aquifer of ROIL16 (Vlăsia Plain) and the six Natura 2000 habitats from the Site of Community Importance (SCI) ROSCI0224 Scroviștea.
This work is based on hydrogeological, geological data, mathematical modeling of the phreatic aquifer (October 17-19, 2017), and the methodology used for study the relationship between groundwater bodies and terrestrial ecosystems, developed by the R.A.H. (2015).
The evaluation of the dependence (high - A, medium - B, nule - C) relations, between the phreatic aquifer and the habitats, is made mainly by correlating the depth of the hydrostatic level with the depth of the root system of plant and tree species.
The main findings based on the hydrogeological, ecological criteria, and analysis algorithms highlight the fact that most habitats and later the Scroviștea site are dependent on groundwater. The six Natura 2000 habitats (3150, 3160, 91M0, 91F0, 91E0 și 92A0) are analyzed individually concerning the depth of the groundwater level. In the evaluation of the degrees of dependence of the habitats, two other criteria are applied, maximum and arithmetic mean about their extension surface. Thus, four habitats (91M0, 91F0, 91E0, and 92A0) are identified with high dependence on groundwater, and two habitats (3150 and 3160) with nule dependence. Considering only this stage of analysis, it was considered that the SCI Scroviștea has a high dependence on the phreatic aquifer.
For a correct assessment of the dependence relations between groundwater and habitats, analyzes related to the hydrodynamic and hydrochemical regime of the groundwater aquifer and the correlation of this information with analyzes from specialized studies performed for plant and tree species are required.

Keywords: *aquifer, phreatic, habitat, Scroviștea, hydrostatic level, terrestrial ecosystems*

Rezumat. Analiza relațiilor dintre apa subterană și habitatelele sitului NATURA2000 ROSCI0224 Scoroviștea

Analiza relațiilor dintre apa subterană și ecosistemele terestre contribuie la conservarea biodiversității și a stării cantitative și calitative a acviferului.
Principalul obiectiv al lucrării este analiza relațiilor dintre acviferul freatic, reprezentat de către corpul de apă subterană ROIL16 (Câmpia Vlăsia) și cele șase habitate Natura 2000 din Situl de Importanță Comunitară (SCI) ROSCI0224 Scroviștea.
Această lucrare se bazează pe date hidrogelogice, geologice, modelarea matematică a acviferului freatic (17-19 octombrie 2017) și o metodologia de analiză a relațiilor dintre corpurile de apă subterană și ecosistemele terestre, elaborată de către A.H.R. (2015).
Evaluarea relațiilor de dependență (ridicată – A, medie – B, nulă – C) dintre acviferul freatic și habitate este realizată în principal prin corelarea adâncimii nivelului hidrostatic cu adâncimea sistemului radicular al speciilor de plante și arbori.
Principalele constatări bazate pe criteriile hidrogeologice, ecologice și algoritmii de analiză evidențiază faptul că majoritatea habitatelor și ulterior situl Scroviștea prezintă dependență de apele subterane. Cele șase habitate Natura 2000 (3150, 3160, 91M0, 91F0, 91E0 și 92A0) sunt analizate individual în raport cu adâncimea nivelului apei subterane. În evaluarea gradelor de dependență ale habitatelor sunt aplicate alte două criterii, maximal și media aritmetică în raport cu suprafața de extindere a acestora. Astfel, patru habitate (91M0, 91F0, 91E0 și 92A0), sunt identicate cu dependență ridicată (A) față de apa subterană iar două habitate (3150 și 3160) cu dependență nulă (C). Luând în considerare doar această etapă de analiză, s-a considerat că SCI Scroviștea are o dependență ridicată, față de acviferul freatic.
Pentru o evaluare corectă a relațiilor de dependență dintre apele subterane și habitate, sunt necesare analize legate de regimul hidrodinamic și hidrochimic al acviferului freatic și corelarea acestor informații cu analizele din studiile specializate efectuate pe speciile de plante și arbori.

Cuvinte-cheie: *acvifer, freatic, habitat, Scroviștea, nivel hidrostatic, ecosisteme terestre*

Introduction

In the current context of our time, the subject of protection and conservation status of groundwater and terrestrial ecosystems (Strat and Mihăilescu, 2017; Alberdi et al., 2019) is intensely discussed. Groundwater is an important resource for both terrestrial, aquatic, animal ecosystems and the quality of human life (Richardson et al., 2011).

The most important objective is to analyze the relationships between the phreatic aquifer and terrestrial ecosystems, respectively of Sites of Community Importance (SCI) through Natura 2000 habitats for identifying their conservation status and

factors that can lead to quantitative and qualitative deterioration (Budzisz et al., 2016).

This work is based on the main principles of groundwater and terrestrial ecosystems protection policy against pollution and deterioration included in Directive 2000/60 EC, Directive 2006/118/EC, and Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora.

Most European countries such as Austria, Belgium, France, Finland, Germany, Ireland, Luxembourg, Malta use available information on Natura 2000 habitats to identify groundwater-dependent ecosystems (Retike et. al, 2021). This process uses ecological and hydrogeological criteria, as well expert judgment to classify ecosystems according to the potential dependence on groundwater (T'jollyn et al., 2009; Whiteman et al., 2010; Rohde et al., 2017; Noorduijn, 2019; Terasmaa et al., 2020; Boulton, 2020;). By 2014, the Federal Ministry of Agriculture, Forestry, Environment and Water Management of Austria had identified 104 groundwater-dependent sites based on analysis of groundwater and Natura 2000 habitats. The National Institute for Environment from Hungary has identified 34 habitats, dependent on both surface water and groundwater. Ireland has prioritized 11 groundwater-dependent habitats using Annex 1 of Directive 92/43/EEC and the hydrodynamic conditions of wetlands and aquifers. The Water Management Agency from Luxembourg has also identified 10 habitats dependent on groundwater and surface water (E.U., 2014). Romania has conducted an analysis of the interdependence between groundwater and terrestrial ecosystems included in the National Management Plan 2016 - 2021 based on the methodology developed by R.A.H. (2015) and using multiannual averages of the hydrostatic level for the period 2000 - 2014. Only Sites of Community Importance with areas larger than 10 km2 were analyzed. Therefore, habitats 91F0 and 91M0 were identified with high dependence, and also the Site of Community Importance ROSCI0224 - Scroviștea was considered potentially dependent on groundwater (A.N.A.R. et al., 2016).

The main goal of the paper is to analyze the relationships between the phreatic aquifer, represented by the groundwater body ROIL16 - Vlăsia Plain and all Natura 2000 habitats from the Site of Community Importance ROSCI0224 Scroviștea, using data from the mathematical modeling of groundwater for October 17-19 2017.

In general, a terrestrial ecosystem is dependent on the groundwater when between the two systems, ecological and hydrogeological, there are exchanges of abiotic and biological flows Thus, the existence and quality of such terrestrial ecosystems are based on the contribution and characteristics of groundwater (e.g. variation of hydrostatic level, flow, temperature, chemical composition) (Scrădeanu et al., 2015).

Study area

The phreatic aquifer studied is part of the groundwater body ROIL16 – Vlăsia Plain. This groundwater body belongs to the basin of the Ialomița River, located in the south of Romania. The groundwater body is crossed by the Ialomița River in the NV-SE direction on a length of approximately 58 km (Fig. 1).

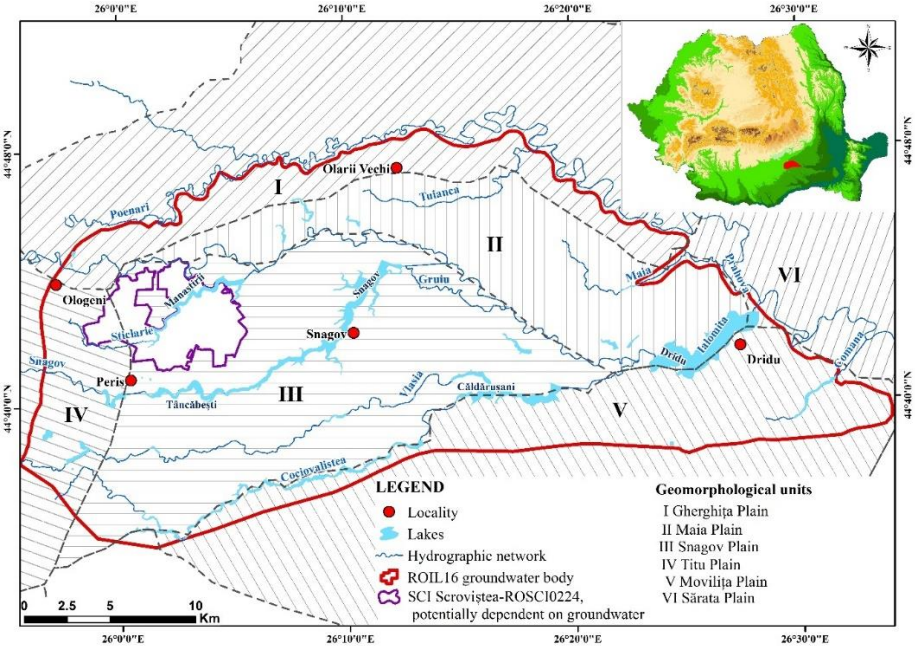

Fig. 1: Location of the ROIL16 groundwater body

The groundwater body ROIL16 is located on the largest surface in Vlăsia Plain, on the subunits Maia, Snagov, Gherghița, Movilița, and Titu Plains (Badea et al., 2011). The altitude decreases from 120 m in the northwest of the groundwater body to 64 m in the southeast.

The study area is characterized by a temperate-continental climate with slight excessive nuances. For the period 1950 and 2000, the average annual air temperature recorded at the weather station in Tâncăbești was 9.9°C and in Snagov 10°C. During the same period, the average annual quantities recorded in case of precipitation were 648.2 mm in Periș and 671.8 mm in Tâncăbești (Niță, 2012). In October 2017, in the study area, the average temperature was 10-12°C and precipitations had values between 101 – 150 mm (www.meteoromania.ro).

The type of soil, its degree of permeability, and its thickness influence, on the one hand, the infiltration capacity of precipitation and surface water in the phreatic aquifer and on the other hand manage the interdependence relations between terrestrial ecosystems and groundwater. The ROIL16 – Vlăsia Plain groundwater body is characterized by the presence of five soil classes: molisols, argiluvisols, cambisols, hydromorphic and undeveloped soils (Roșu, 1980).

The hydrodynamic relationships between rivers/lakes and the phreatic aquifer are important in identifying terrestrial ecosystems dependent on these water sources. The ROIL16 groundwater body is dominated by the Ialomița and Prahova rivers and their tributaries: Snagov, Sticlărie, Gruiu, Vlăsia, Cociovaliștea, Poenari, Țuianca, Maia and Comana. Also, the area is rich in natural lakes (Snagov, Căldărușani, Mânăstirii) of accumulation (Dridu, Vlăsia I and II, Balta Neagră, Podișor, Petrești, Maia) and fish lakes (Tâncăbești, Căciulați, Comana, Corbeanca).

The groundwater body ROIL16 – Vlăsia Plain has a surface of about 729.58 km^2 and includes many localities. The average number of inhabitants in the period 1991 - 2009 for some localities in the study area was: Corbeanca, Nuci, Ciolpani (< 5000 inhabitants); Snagov, Moara Vlăsiei, Gorgota (5001-6000 inhabitants); Balotești, Gruiu (6001 – 7000 inhabitants); Periș (7001 – 8000 inhabitants) and Puchenii Mari (> 8001 inhabitants) (Buzăianu, 2012).

The phreatic aquifer develops between depths of 2.0 and 30.0 m and is represented by sands, sands, and gravels, sometimes with boulders and finer sands with intercalations of clayey sands and sandy clays with a general thickness of 0.5 - 5 m. The age of this formation is Upper Pleistocene – Holocene (Săndulescu et al., 1968).

The oldest information about the studied area comes from the preliminary and definitive hydrogeological studies from the execution of the observation wells from the National Hydrogeological Network, in which the phreatic aquifer is described and characterized (Sindile and Safta, 1969; Simionaș and Safta, 1969; Pantea, 1971). The most recent data are represented by the studies for the water supply of the localities, or the dimensioning of the sanitary protection zones and the hydrogeological protection perimeter in the case of drinking groundwater sources (Malancu and Baciu, 2020; Malancu and Baciu, 2021).

The Site of Community Importance Scroviștea – ROSCI0224 was declared by Order 1964/2007 and modified by Order 2387/2011 and is located in the northwestern part of the groundwater body ROIL16, between the localities Ologeni – Ciolpani - Periș. The site has an area of 3.391 ha, is crossed by the Sticlărie River, and is bounded on the north by the Ialomița River and the south by the Snagov River (A.P.M. Ilfov and UNESCO Pro Natura Ecological Club, 2016). The Scroviștea site has a double community protection status because, in addition to the Site of Community Importance ROSCI0224, it also contains the special avifaunistic protection area ROSPA0140. The importance of this site is due to the Natura 2000 natural habitats and the protected wild species for which it was delimited. The six Natura 2000 habitats that are found in the Scroviștea site include a great diversity of flora species (Brînzan et al., 2013; A.P.M. Ilfov and UNESCO Pro Natura Ecological Club, 2016), (Fig. 2):

- 3150 – *Natural eutrophic lakes with Magnopotamion or Hydrocharition – type vegetation*: Lemna minor, Salvinia natans, Utricularia vulgaris, Stratiotes aloides, Sagittaria sagittifolia etc.;
- 3160 – *Natural dystrophic lakes and ponds*: Nymphaea alba, Nuphar luteum, Potamogeton natan, Trapa natans, Sparganium erectum, etc.;
- 91M0 – *Pannonian-Balkanic turkey oak – sessile oak forests*: Quercus cerris, Quercus petrae, Carpinus betulus, Tilia tomentosa, Acer tataricum, Rhamnus cathartica, Euonymus Verrucosa, Crocus sativus, Hieracium pilosella, Achillea millefolium etc.;
- 91E0 – *Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)*: Salix alba, Fraxinus excelsior, Alnus glutinosa, Telekia speciosa, Clematis vitalba, Angelica archangelica etc.;
- 92A0 – *Salix alba and Populus alba galleries*: Populus alba, Salix alba, Populus nigra, Sambucus nigra, Cornus sanguinea, Phragmites australis, Viola odorata, Ulmus laevis, Carex acutiformis, Shoenoplectus lacustris etc.;
- 91F0 – *Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)*: Quercus robur, Fraxinus excelsior, Populus alba/nigra, Salix alba, Prunus

padus, Rhamnus frangula, Leonurus cardiaca, Aegopodium podagraria etc.

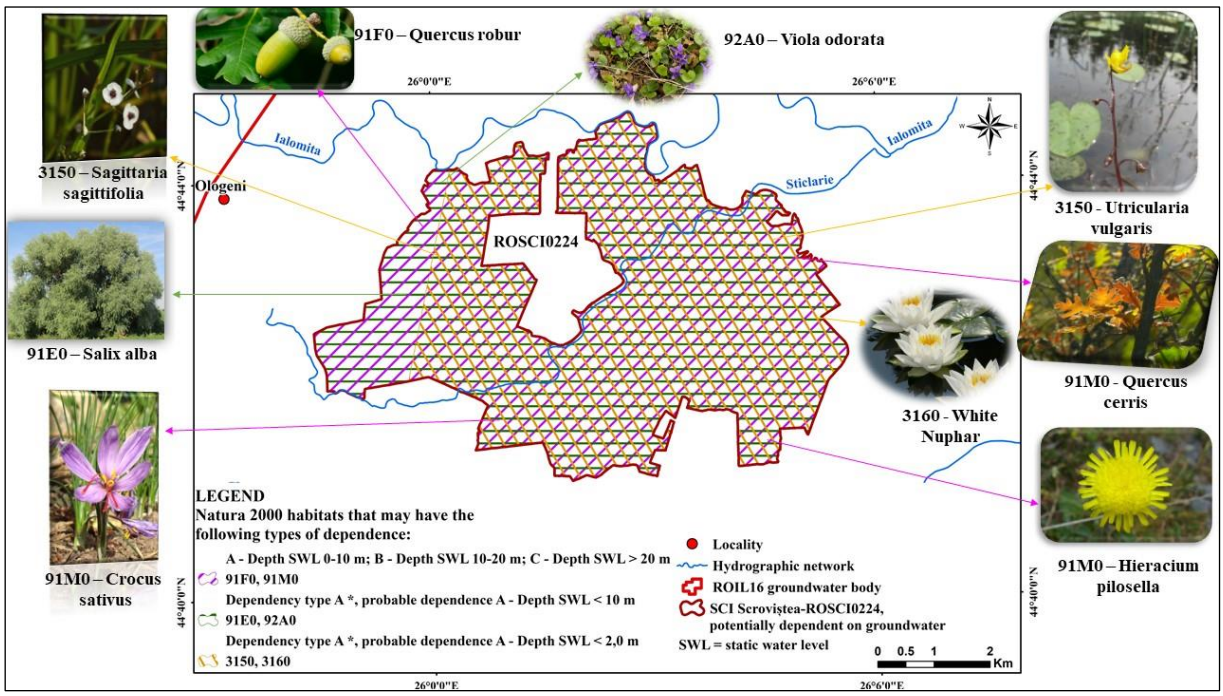

Fig. 2: Location of the Site of Community Importance Scroviștea – ROSCI0224 and Natura 2000 habitats (Source pictures: www.portugal.inaturalist.org)

Data and methods

The first step was to identify and analyze separately the phreatic aquifer and Natura 2000 habitats in the study area. Based on hydrogeological and ecological information it was possible to evaluate the relationships between these two complex systems.

The phreatic aquifer was represented in a simplified way through a conceptual model (Dijksma and Avis, 2016; Manea, 2020). This was achieved through three main stages: spatial, parametric, and hydrodynamic schematization. In this process, the geometry of the hydrostructure, the distribution of hydrogeological parameters, and the dynamics of groundwater in an uninfluenced regime were identified, determined, and studied. The conceptual model of the phreatic aquifer was created based on the following data:

- the geometry of the phreatic aquifer was determined based on information from 145 hydrogeological boreholes (lithology, experimental pumping data, and constructive characteristics of the wells) taken from the National Hydrogeological Network of the National Institute of Hydrology and Water Management – N.I.H.W.M.;
- the hydraulic conductivity was calculated based on the data from the drilling pump tests; these data were statistically processed, obtaining histograms, directional variograms, surface variograms, isovariograms, anisotropy parameters that were used to determine the spatial variation of the hydraulic conductivity;
- the stage of rivers (Ialomița, Prahova, Sticlărie, Snagov, etc.) and lakes (Căldărușani, Snagov, Mânăstirii, etc.) personal field measured from October 17-19, 2017, in 55 observation points;
- groundwater levels from October 17-19, 2017, in 39 hydrogeological wells, provided by the Buzau Ialomita Basin Water Administration;
- the stage rivers recorded at hydrometric stations (Siliștea Snagovului) from October 17-19, 2017, date taken from N.I.H.W.M;
- amount of precipitation from N.I.H.W.M.

Using all the information from October 17-19, 2017, the hydrodynamic spectrum of groundwater flow was realized. Based on this, the hydraulic relations between the groundwater aquifer and the surface waters were initially identified. Also, using the hydrodynamic spectrum, the boundary conditions of the mathematical model for groundwater flow were established. The mathematical model of groundwater flow was developed through the MODFLOW 2005 program, integrated in the FREEWAT platform developed within the European Union's Horizon 2020 project. This mathematical model highlighted the fact that the hydrographic network was fed mainly from

the phreatic aquifer for the analyzed period. Based on the mathematical model of groundwater flow, a map was made with the depths of the hydrostatic level that was used in the analysis of this paper.

The analysis of the relationships between the groundwater aquifer and the Natura 2000 habitats of the Site of Community Importance Scroviștea was performed using:

- the map with the depths of the hydrostatic level resulting from the mathematical model, for the period 17-19 October 2017;
- the spatial data set in GIS format with the limits of Sites of Community Importance and Natura 2000 habitats, provided by the Ministry of the Environment, Waters and Forests (updated in 2017);
- the stages of the methodology developed by the R.A.H. (2015): *"Study on the Methodology for analyzing the interdependence between groundwater bodies and terrestrial ecosystems with the identification of terrestrial ecosystems directly dependent on groundwater in accordance with the provisions of the Water Framework Directive 2000/60/EC and Directive 2006/118/EC".*

Natura 2000 habitats are represented at national level in the form of a square network of 10x10 km^2. This network was superimposed with ROSCI0224 Scroviștea from where resulted the surfaces of the habitats within the site, which were analyzed (Fig. 3-6).

The methodology involves analysis based on hydrogeological and ecological criteria for the identification of groundwater-dependent ecosystems and an algorithm for assessing the degrees of dependence for each Natura 2000 habitat and subsequently for the entire Site of Community Importance (Scrădeanu et al., 2015).

The algorithm for assessing the intensity of dependency relationships between Natura 2000 habitats and the phreatic aquifer applies only to potentially groundwater-dependent ecosystems identified in the study area. Hydrogeological and ecological criteria can generate three dependency levels: high dependence (A), medium dependence (B), and nule dependence (C) (Scrădeanu et al., 2016). After applying the algorithm, a potential groundwater-dependent ecosystem will have some indices (A/B/C) that will be equal to the number of ecological (EC) and hydrogeological (CH) criteria applied. The degree of dependence will be established based on the maximum dependency index in the category of indices obtained from hydrogeological and ecological criteria.

Here, the identification of ecosystems potentially dependent on the phreatic aquifer was performed for ROSCI0224 Scroviștea and associated habitats that are included in Annex 1 of Directive 92/43/EEC and Annexes 1a and 1b of the methodology developed by the R.A.H. (2015).

The assessment of the dependence of Natura 2000 habitats on groundwater was performed by analyzing the depth of the hydrostatic level concerning the depth of the root system of plants and trees, using data from mathematical modeling of the phreatic aquifer and levels recorded in observation wells for October 17-19, 2017. During the analyzed period, in the area of the ROIL16 groundwater body, the variation of the hydrostatic level depth was between 0.74 and 14.63 m.

Results and Discussion

The application of hydrogeological and ecological criteria has led to the fact that ROSCI0224 Scroviștea is potentially dependent on groundwater, as it develops on the surface of the phreatic aquifer that communicates through the capillary area and the unsaturated zone with the land surface.

Considering Annexes 1a and 1b within the interdependence analysis methodology developed by R.A.H. (2015), Natura 2000 habitats may have the following types of dependence on groundwater, depending on the depth of the root system of plants and trees (Scrădeanu et al., 2015):

- 91F0 and 91M0: A - if the depth of the static water level (S.W.L.) is between 0-10 m, B - if the depth of the S.W.L. is between 10.0 - 20.0 m and zero dependence (C) if the depth of the S.W.L. is greater than 20.0 m;
- 92A0, 91E0, 3150, and 3160: has a probable type of dependence which is determined based on the position of the static water level of the aquifer and the share of the underground supply of surface water bodies (A*).

Habitat 91M0 - Pannonian-Balkanic turkey oak – sessile oak forests within the ROSCI0224 site are developed in the area where the depth of the static water level varies from 4.0 m in the north of the site to more than 10.0 m in its south-west, on a total area of 29.74 km^2 (Fig. 3).

In this situation, the dependency levels for the 91M0 habitat were established as follows:

- areas "A" have been delimited where the depth of the static water level was less than 10.0 m and where the dependence on groundwater is high;
- area "B" has been delimited where the depth of the static water level was greater than 10.0 m and where the dependence on groundwater is considered medium.

The highest degree of dependence identified for habitat 91M0 was type A - high dependence. Habitat 91M0 showed high dependence of type A, on an area of 24.52 km^2 and medium dependence of type B on 5.22 km^2. The degree of dependence of the habitat 91M0 depending on the surface on which it develops, according to the criterion of the arithmetic mean, is type A - high dependence.

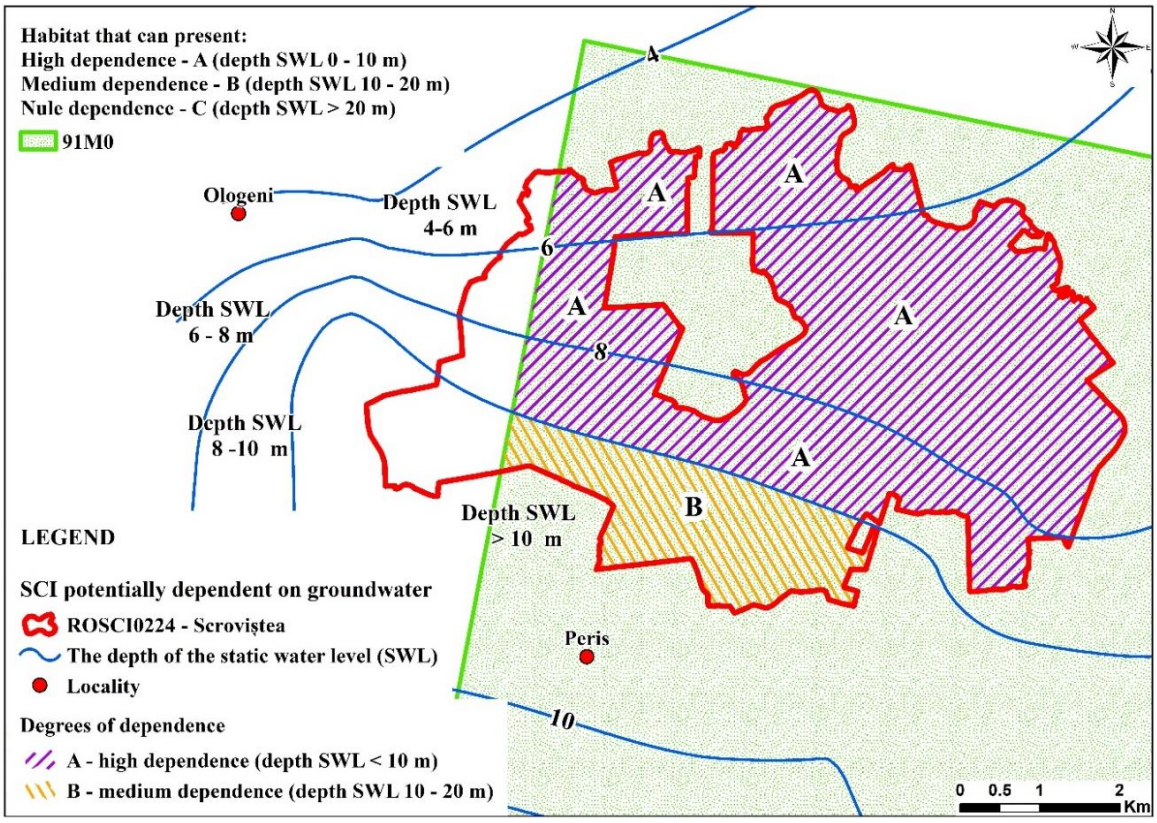

Fig. 3: Degrees of dependence on groundwater for habitat 91M0

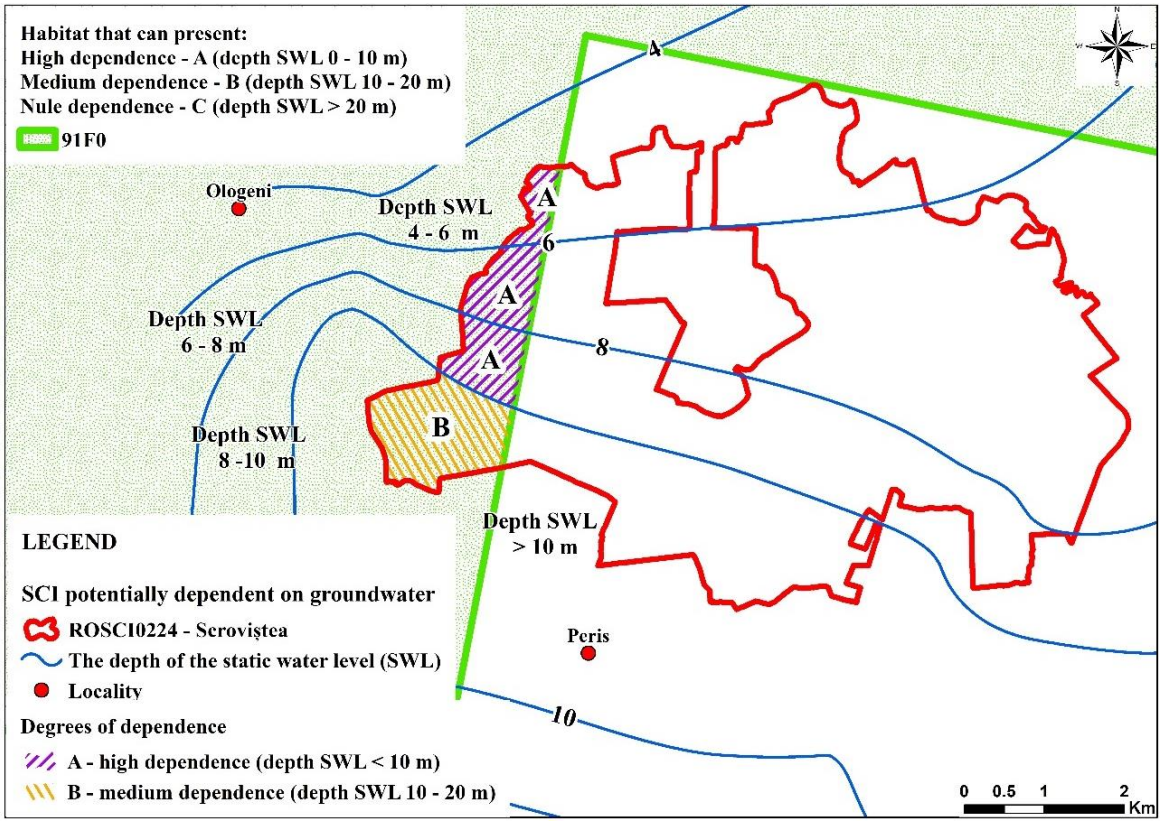

Fig. 4: Degrees of dependence on groundwater for habitat 91F0

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Habitat 91F0 - Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris) within the site ROSCI0224 develops in the area where the depth of the static water level varies from 4.0 m in the north of the site to more than 10.0 m, in its southwest, on a total area of 3.72 km^2 (Fig. 4).

Thus, the degrees of dependence for habitat 91F0 were identified:

- areas "A" have been delimited where the depth of the static water level was less than 10.0 m and where the dependence on groundwater is high;
- area "B" has been delimited where the depth of the static water level was greater than 10.0 m and where the dependence on groundwater is considered medium.

The highest degree of dependence identified for habitat 91F0 was type A - high dependence. Habitat 91M0 had high dependence of type A, on an area of 1.88 km^2 and medium dependence of type B on 1.84 km^2. The degree of dependence of the habitat 91M0 depending on the surface on which it develops, according to the criterion of the arithmetic mean, is type A - high dependence.

Habitats 3150, 3160, 91E0, and 92A0 have a probable type of dependence which is determined based on the position of the hydrostatic level of the aquifer and the share of the underground supply of surface water bodies (A*). To identify the degrees of dependence of these habitats, the characteristics of some species, the depth of the hydrostatic level of the phreatic aquifer, and the relationships between groundwater and surface water resulting from the mathematical model of groundwater flow were analyzed.

Habitats 3150 and 3160 occupy the same area, of 29.74 km^2, within the Site of Community Importance. The two habitats 3150 and 3160 develop in the area where the depth of the water static level varies from 4.0 m (north of the site) to more than 10.0 m (southwest of the site) (Fig. 5).

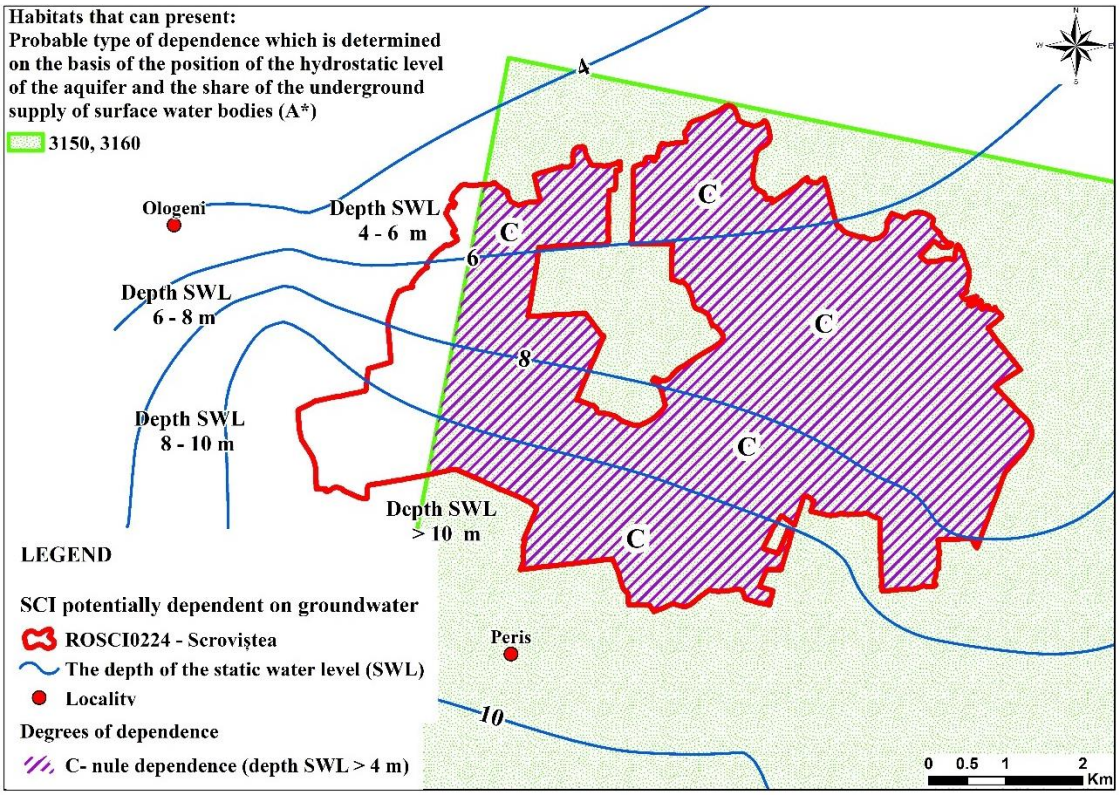

Fig. 5: Degrees of dependence on groundwater for habitats 3150 and 3160

Taking into account the depth of the hydrostatic level and that of the root system for certain component species within the habitats, it was considered that habitats 3150 and 3160 may have the following types of dependence: A – the depth of the S.W.L. is between 0 – 2.0 m, B – depth of S.W.L. 2.0 -.4.0 m and C – depth of S.W.L. > 4.0 m.

Given that in the area of habitats 3150 and 3160, the depth of the hydrostatic level at the time of the analysis was greater than 4.0 m, it was considered that they have nule dependence (type C) on groundwater, being likely dependent on surface water and other sources (precipitation, humidity). Because the mathematical model of groundwater flow developed for the study area (October 17-19, 2017)

showed that the phreatic aquifer fed the Ialomița and Sticlărie rivers, habitats 3150 and 3160 could be considered potentially dependent on groundwater due to the hydraulic connections.

Habitats 91E0 and 92A0 within the ROSCI0224 site are developed in the area where the depth of the static water level varies from 4.0 m in the north of the site to more than 10.0 m in its south-west, over a total area of 29.74 km^2 and 3.72 km^2 respectively (Fig. 6).

Taking into account the greatest possible depths of the root systems characteristic of certain component species within the habitats and those of the hydrostatic level, it was considered that habitats 91E0 and 92A0 may have the following types of dependence: A - depth of S.W.L. 0-10 m, B - depth of S.W.L. 10-20 m and C - depth of S.W.L. > 20m.

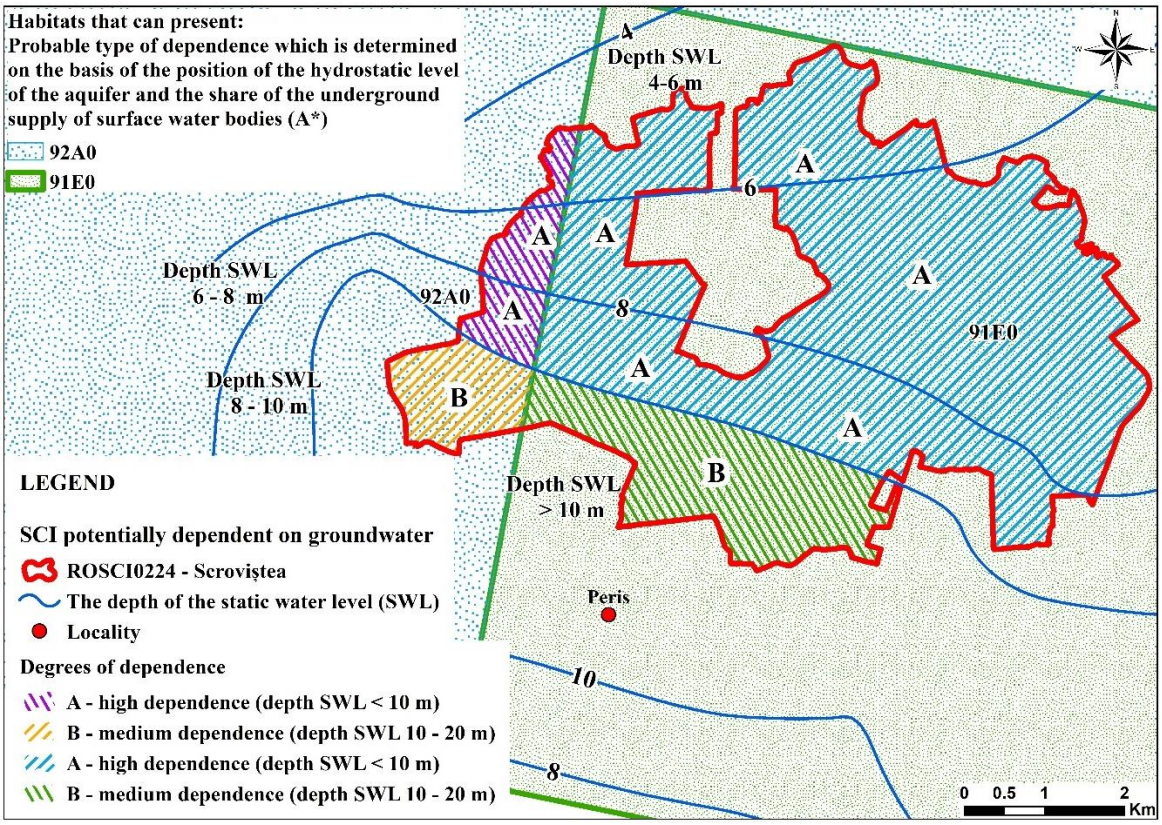

Fig. 6: Degrees of dependence on groundwater for habitats 91E0 and 92A0

The two habitats are characterized by plant and tree species that have different depths of root systems. For species that do not develop their roots up to a maximum depth of 10.0 m, but would fall into the categories of 0 - 2 m or 0 - 4 m, it was taken into account that the aquifer feeds the Ialomița and Sticlărie rivers, thus ensuring a possible dependence on hydraulic connections.

In this case, the degrees of dependence for habitats 91E0 and 92A0 were determined as follows:

- areas "A" have been delimited where the depth of the static water level was less than 10.0 m and where the dependence on groundwater is high;
- areas "B" have been delimited where the depth of the static water level was greater than 10.0 m and where the dependence on groundwater is considered medium.

The highest degree of dependence identified for habitats 91E0 and 92A0 was type A - high dependence. Habitat 91E0 had high dependence of type A, on an area of 24.52 km^2 and medium dependence of type B on 5.22 km^2. Also, habitat 92A0 showed high dependence of type A, on an area of 1.88 km2 and medium dependence of type B on 1.84 km2. The degrees of dependence of habitats 91E0 and 92A0 depending on the areas on which they develop, according to the criterion of the arithmetic mean, are type A - high dependence.

Based on the two types of criteria applied (maximum and arithmetic mean), four of the Scroviștea site habitats (91M0, 91F0, 91E0, and 92A0) showed high dependence (A) and two (3150, 3160) nule dependence on groundwater (C) (Tabel 1).

The degree of dependence of a site calculated based on the arithmetic mean criterion, for which habitat development areas are taken into account, may lead to a reduction in the number of habitat

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types identified as dependent on groundwater. Therefore, for habitat with high dependence (A) on a smaller area than the one in which the medium or nule dependence (B/C) has been identified, the importance of plant and tree species in the balance of the ecosystem cannot be estimated at the level of the current degree of knowledge (Scrădeanu et al., 2015). For this reason, the degree of dependence of ROSCI0224 Scroviștea was established based on the maximum criterion, also called the "prudence" criterion.

Tabel 1: Degrees of dependence (A, B, C) on groundwater for all six habitats

Habitats Natura 2000	Criteria					
	The maximum			The arithmetic mean area (km²)		
	A*	B*	C*	A	B	C
91M0	A	B		24.52	5.22	
Degree of dependence categorically 91M0	A			A		
91F0	A	B		1.88	1.84	
Degree of dependence categorically 91F0	A			A		
3150			C			29.74
3160			C			29.74
91E0	A	B		24.52	5.22	
Degree of dependence categorically 91E0	A			A		
92A0	A	B		1.88	1.84	
Degree of dependence categorically 92A0	A			A		

A*= high dependence; B* = medium dependence; C*= nule dependence.

Conclusions

In this paper, a stage of analysis of the relations between the phreatic aquifer in the study area and the Natura 2000 habitats from ROSCI0224 Scroviștea was performed.

The assessment of the dependency relationships between Natura 2000 habitats and groundwater was mainly done based on the information resulting from the mathematical model of groundwater flow and the stages within the methodology developed by R.A.H. (2015).

At this stage in which the dependence degrees of Natura 2000 habitats were evaluated, four highly dependent habitats (91M0, 91F0, 91E0, and 92A0) and two nule dependence (3150, 3160) were identified. Based on the analysis and the hydrogeological and ecological criteria used, it was considered that ROSCI0224 Scroviștea has a degree of dependence of type A on the groundwater aquifer. The results of this paper are consistent with those presented in the National Management Plan 2016-2021 (A.N.A.R et al., 2016), even if the hydrogeological and ecological information comes from different periods. Similar results have been observed in analyzes carried out in Estonia, Austria, Luxembourg, France, Finland, Germany, Ireland, Malta (Kilroy et al., 2008; T'jollyn, et al., 2009; Sundseth et al., 2013; Boulton, 2020) and the main cause is that the correlation between groundwater and terrestrial ecosystems is based on research into the main elements of soil, surface water, wetlands, groundwater, and ecosystems.

However, the analysis of whether a site is dependent on groundwater is much more complex and contains several stages. The analysis presented applies similarly to the land use categories of Corine Land Cover 2000. The next step is to perform an analysis of the hydrodynamic regime of the hydrostatic level because the phreatic aquifer is influenced mainly by natural factors (precipitation, temperature) and anthropogenic factors (groundwater catchment, irrigation systems) (Badiu et al., 2014). Then an assessment of the dependence of terrestrial ecosystems on the hydrochemical regime of the phreatic aquifer is needed (Meenalochini and Annal, 2017). Specialist studies on plant and tree species are also needed to observe their behavior depending on the quantitative and qualitative characteristics of groundwater (Dumitrașcu et al., 2012; Strat, 2014; Metcheva et al, 2016; Sensula et al., 2017; Sharma et al., 2020). Using all information, geological, hydrogeological, chemical, and ecological, a correct assessment of ecosystems with groundwater can be made.

The results of the study serve to complement the knowledge of groundwater and terrestrial ecosystems to protect these systems and to improve the management of groundwater resources and biodiversity conservation.

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References

Alberdi, I., Nunes, L., Kovac, M., Bonheme, I., & Canellas, I. (2019). The conservation status assessment of Natura 2000 forest habitats in Europe: capabilities, potentials and challenges of national forest inventories data. *Annals of Forest Science, Springer Nature/EDP Science*, 10.1007/s13595-019-0820-4, hal-02532728

Badea, L., Buza, M., Sandu, M., Sima, M., Micu, M., & Jurchescu, M. (2011). Unitățile de Relief ale României V, Câmpiile Pericarpatice, Câmpia Banatului și Crișanei, Câmpia Română, Lunca Dunării, Delta Dunării și Câmpia Litorală, *Editura Ars Docendi, Universitatea din București*, p. 99-105

Badiu, D., Iojă, C., & Pătroescu, M. (2014). The environmental impact of arable land in a protected area of community interest. Case study: ROSCI0123 Măcin Mountains, Romania. *Forum geografic*, XIII(1), 59-65. doi:10.5775/fg.2067-4635.2014.132.i

Boulton, A. J. (2020). Editorial: Conservation of groundwaters and their dependent ecosystems: Integrating molecular taxonomy, systematic reserve planning and cultural values. *Aquat. Conserv. Mar. Freshw. Ecosyst*. 30, 1-7. doi.org/10.1002/aqc.3268

Brînzan, T., Bădărău, A., Murariu, D., Staicu, C., Patriche, N., Ciubuc, C., Hulea, D., Petrovivi, M., Groza, A., Groza., M., Mănoiu, T., Maxim, I., Art I.K.S., Asociația Exclus Prod, S.C. Exclus Prod, & Ministerul Mediului și Schimbărilor Climatice – Direcția Generală Protecția Naturii (2013). Catalogul habitatelor, speciilor și siturilor Natura 2000 în România, *Editura Fundația Centrul Național pentru Dezvoltare Durabilă*, București

Budzisz, M., Budzisz, M., Cieśliński, R., & Woźniak, E. (2016). Effect of changes in groundwater levels on selected wetland plant communities. *Forum geografic*, XV(Suppl. 2), 19-29. doi:10.5775/fg.2016.032.s

Buzăianu, F. (2012). Dinamica așezărilor rurale din spațiul adiacent axei București – Ploiești, Universitatea din București, Facultatea de Geografie, Școala Doctorală "Simion Mehedinți – Natura și Dezvoltare Durabilă", *Teză de doctorat*, București

Dijksma, R., & Avis, L. (2016). Measuring and modelling water transport on Skaftafellsheioi, Iceland. *Forum geografic*, XV(Suppl. 2), 66-72. doi:10.5775/fg.2016.069.s

Dumitraşcu, M., Kucsicsa, G., Grigorescu, I., Dragotă, C., & Năstase, M. (2012). Invasive terrestrial plant species in the Romanian protected areas. Case study: Fallopia japonica in the Maramureş Mountains Natural Park. *Forum geografic*, XI(1), 45-53. doi:10.5775/fg.2067-4635.2012.031.i

Kilroy, G., Dunne, F., Ryan, J.,O'Connor, A., Daly, D., Craig, M., Coxon, C., Johnston, P., & Moe, H. (2008). A framework for the Assessment of Groundwater Dependent Terrestrial Ecosystems under the Water Framework Directive. ISBN: 978-1-84095-005-2. *Environmental Protection Agency*, Ireland

Malancu, F., & Baciu, C. (2020). Studiu hidrogeologic privind posibilitatea alimentării cu apă din sursă subterană proprie pentru investiția "Locuință unifamiliară P+M, grajd cai, anexe", comuna Nuci, sat Nuci, județul Ilfov, S.C. Hidro Cad S.R.L.

Malancu, F., & Baciu, C. (2021). Studiu hidrogeologic privind dimensionarea zonelor de protecție sanitară și delimitarea perimetrului hidrogeologic a forajelor de alimentare cu apă a sistemului centralizat din comuna Adâncata, județul Ialomița, S.C. Hidro Cad S.R.L.

Manea, V. (2020). The Buzău river alluvial fan – a groundwater modeling approach to sustainable exploitation. *Forum geografic*, XIX(2), 175-183. doi:10.5775/fg.2020.018.d

Meenalochini, J., & Annal, F. (2017). Assessment of groundwater quality and its suitability for irrigation in Dindigul Corporation of Dindigul District, Tamil Nadu, India. *Forum geografic*, XVI(2), 114-118. doi:10.5775/fg.2017.88.d

Metcheva, R., Beltcheva, M., Naumov, B., Yankov, Y., Michev, T., Profirov, L., & Goranov, S. (2016). Faunistic Study of the Tsibar Danube Island. *Forum geografic*, XV(2), 152-161. doi:10.5775/fg.2067-4635.2016.141.d

Niță, M. (2012). Dinamica rezidențiatului din zona metropolitană a Municipiului București și evaluarea proiecției ei în starea mediului, *Editura Universității din București*

Noorduijn, (2019). Protecting groundwater levels and ecosystems with simple management

approaches; *Hydrogeology Journal* (2019) 27: 225-237

Pantea, C. (1971). Studiu hidrogeologic definitiv pentru postul hidrogeologic de ordinul II Ion Lahovari, *Sectorul de Meterologie și Hidrologie, Serviciul Ape Subterane-Colectivul Lucrări Geologice*, București

Retike, I., Kalvāns, A., Priede, A., Tarros, S., Terasmaa, J., Türk, K., Bikše, J., Demidko, J., Koit, O., Küttim, M., Lode, E., Pärn, J., Popovs, K., Vainu, M., Valters, K., Abreldaal, P., Babre, A., Bīviņa, I., Caune, K., Marandi, A., Polikarpus, M., Raidla, V., Rieksta, M., & Sisask, K. (2020). Joint management of groundwater dependent ecosystems in transboundary Gauja-Koiva river basin (GroundEco), *Interreg Estonia-Latvia project No. Est-Lat62, Final Report*, Estonia-Latvia.

Richardson, S., Irvine, E., Froend, R., Boon, P., Barber, S., & Bonneville, B. (2011). Australian groundwater-dependent ecosystems toolbox part 1: assessment framework. ISBN: 978-1-921853-52-4, *National Water Commission*, Australia

Rohde, M.M., Froend, R., Howard, J. (2017). A Global Synthesis of Managing Groundwater Dependent Ecosystems Under Sustainable Groundwater Policy. *Groundwater* 55:293-301. doi: 10.1111/gwat.12511

Roșu, A. (1980). Geografica Fizică a României, *Editura Didactică și Pedagogică București*, București, p. 149-154; 82-103

Săndulescu, M., Ghenea, C., Motaș, I., & Bandrabur, T. (1968). Harta Geologică 1:200.000, foaia 36 Ploiești, Notă explicativă, *Comitetul de Stat al Geologiei, Institutul Geologic*, București, p. 27-42.

Scrădeanu, D., Palcu, M., Iordache, V., & Scrădeanu, M. (2015). Studiu privind metodologia de analiză a interdependenței dintre corpurile de apă subterană și ecosistemele terestre cu identificarea ecosistemelor terestre direct dependente de apa subterană în conformitate cu prevederile Directivei Cadru Apă 2000/60/EC și Directivei 2006/118/EC, *Asociația Hidrogeologilor din România*, București.

Scrădeanu, M., Iordache, V., Palcu, M., & Scrădeanu, D. (2016). Analysis of correlation between the state of groundwater and the state of terrestrial ecosystems including wetlands, *INCD ECOIND - International Symposium - SIMI, The Environment and the Industry, Proceedings Book*, DOI:10.2169/SIMI.2016.0040

Sensula, B., Wilczynski, S., Monin, L., Allan, M., Pazdur, A., & Fagel, N. (2017). Variations of tree ring width and chemical composition of wood of pine growing in the area nearby chemical factories. *Conference Proceedings of the 12th International Conference "Methods of Adbolute Chronology"*. GliwicE-Paniowki, Poland. ISSN 1897-1695. doi: 10.1515/geochr-2015-0064

Simionaș, C., & Safta, C. (1969). Studiu hidrogeologic preliminar postul hidrogeologic de ordinul I Lacu-Turcului, *Sectorul de Meterologie și Hidrologie, Serviciul Ape Subterane-Colectivul Lucrări Geologice*, București

Sindile, C., & Safta, C. (1969). Studiu hidrogeologic preliminar postul hidrogeologic de ordinul II Tigănești sud, *Sectorul de Meterologie și Hidrologie, Serviciul Ape Subterane-Colectivul Lucrări Geologice*, București

Sharma, P., Tripathi, S., & Chandra, R. (2020). Phytoremediation potential of heavy metal accumulator plants for waste management in the pulp and paper industry. *Elsevier Ltd*. doi.org/10.1016/j.heliyon.2020.e04559

Strat, D. (2014). Conservation Status and Conservation Strategies of threatened aquatic fern Marsilea quadrifolia L. in Europe. *Forum geografic*, XIII(2), 193-202. doi:10.5775/fg.2067-4635.2014.122.d

Strat, D., & Mihăilescu, S. (2017). Conservation Status of Habitat Types of European Community Interest in the Alpine Biogeographic Region of Romania. *Forum geografic*, XVI(1), 59-69. doi:10.5775/fg.2017.132.i

Sundseth, K., Venn, O., Roth, P., Fourli, M., Zafirov, I., Olmeda, C., Chvojkova, & Gubbay., S. (2013). Case Studies on the Article 6.3 Permit Procedure Under the Habitats Directive, *Ecosystems LTD*, Brussels.

T'jollyn, F., Bosch, H., Demolder, H., DeSaeger, S., Leyssen, A., Thomas, A., Wouters, J., Paelinckx, D., & Hoffmann, M. (2009). Criteria voor de beoordeling van de lokale staat van instandhouding van de NATURA2000-habitattypen. *Rapporten van het Instituut voor natuur- en Bosonderzoek 2009* (46). Instituut voor Natuur- en Bosonderzoek, Brussel.

Whiteman, M., Brooks, A., Skinner, A., & Hulme, P. (2010). Determining significant damage to groundwater-dependent terrestrial ecosystems in England and Wales for use in implementation of the Water Framework Directive.

*** Administrația Națională Apele Române [A.N.A.R]., Ministerul Mediului Apelor și Pădurilor, Administrația Bazinală de Apă Buzău-Ialomița, Institutul Național de Hidrologie și Gospodărire a Apelor (2016). Planul de Management actualizat al spațiului hidrografic Buzău – Ialomița., București

*** Agenția de Protecție a Mediului Ilfov [A.P.M], Clubul Ecologic UNESCO Pro Natura, (2016). Planul de Management al sitului Natura 2000 Scroviștea ROSCI0224 și ROSPA0140, București

*** European Union, (1992). Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora
*** European Parliament and the Council of the European Union, (2000). Directive 2000/60/EC establishing a framework for Community action in the field of water policy
*** European Union [E.U.], (2014). Technical Report on methodologies used for assessing groundwater dependent terrestrial ecosystems, number 8, Water Framework Directive (2000/60/EC)
*** European Parliament and the Council of the European Union, (2006). Directive 2006/118/EC on the protection of groundwater against pollution and deterioration
www.rowater.ro (accessed 2017, 2021)
www.mmediu.ro (accessed 2017, 2021)
www.meteoromania.ro (accessed 2017)
www.portugal.inaturalist.org (accessed 2017, 2021)