

ARTICLES

WATER MANAGEMENT IN SANITARY PROTECTION ZONES OF VARAŽDIN COUNTY**AUTHORS****Melita Srpak**

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ABSTRACT**Water management in sanitary protection zones of Varaždin County**

The urbanization of settlements and cities and the development of industry increase the need for water, while on the other hand the discharge of wastewater increasingly affects heavier pollution of surface and groundwater, and space in the broader sense. By failing to take appropriate measures and endangering the quality of groundwater and spring water, further degradation of its quality can lead to undesirable consequences on water supply, especially in the lowland area of Varaždin County. It should be borne in mind that for some parts or areas, especially those with dispersed individual construction, wastewater drainage cannot be solved through the public drainage system, but the solution is based on individual, basically personal operations (collecting and septic tanks). In this paper the sanitary protection zones of water supply sources for Varaždin County are described, in accordance with the laws and regulations. The aim of this paper is to provide appropriate instructions or guidelines for their protection and performance in order to minimize the possible negative impact on groundwater or the environment in the broader sense.

KEY WORDS

groundwater, soil protection, water protection zones, water well Varaždin

1.Introduction

Varaždin County is characterized by numerous watercourses (the river Drava with the most significant tributaries of Plitvica and Bednja in the Drava basin, the river Lonja in the Sava basin) and significant reserves of potable groundwater (high quality and abundant reserves on the gravel valleys of the river Drava) and springs of the mountain Ivanščica, Ravna Gora and Kalnik. Geographically, the boundaries of the County are defined in the north by the river Drava and the artificial reservoirs, in the west by the Macelj hills and the eastern Haloze; in the southeast mainly by the Kalnik Ridge; and in the southwest by heights of the Ivančica mountain (The Spatial Plan of Varaždin County, "Official Gazette of Varaždin County" No. 8/00, 29/06 and 16/09). It is necessary to conceptualize water management on the principles of "sustainable development", while communal enterprises need to be enabled to manage, maintain and develop water supply systems. The area of the Varaždin County - the lowland part, ie the river Drava hinterland is foreseen by the Strategy and Programme as an integral part of the potable groundwater reserve in the northwest part of Croatia. (Strategy of Spatial Planning of the Republic of Croatia (June 27, 1997, and Official Gazette 76/13)) This fact gives a new dimension to the protection of space and the environment, as well as the management of water resources in this area.



Figure 1. Territorial - administrative structure of Varaždin County Source: Situation Report of Varaždin County for years 2010-2015(2016)

2.General information on the County

Territorial - administrative structure of Varaždin County

Varaždin County is located in the extreme northwestern part of the Republic of Croatia and borders in the north with Međimurje County, in the west with the Republic of Slovenia, in the south with Krapina-Zagorje and Zagreb County, and in the east with the Koprivnica-Križevci County. Its borderline character is also accentuated by the proximity of neighbouring countries: Slovenia (with which it shares a border), Austria and Hungary. Belonging to the smaller counties of the Republic of Croatia (1. 261, 49 km²), it comprises 28 territorial units: 6 cities and 22 municipalities. Figure 1 shows the cities of Varaždin County: Ivanec, Lepoglava, Ludbreg, Novi Marof, Varaždin and Varaždinske Toplice, and municipalities: Bednja, Breznica, Breznički Hum, Beretince, Cestica, Donja Voća, Gornji Kneginec, Jalžabet, Klenovnik, Ljupcec, Mali Bukovec, Martijanec, Maruševec, Petrijanec, Sracinec, Sveti Đurđ, Sveti Ilija, Trnovec Bartolovečki, Veliki Bukovec, Vidovec, Vinica and Visoko. There are 302 settlements in the Varaždin County area. The city of Varaždin is the seat of Varaždin County. According to the 2011 Population Census, Varaždin County has 175, 961 inhabitants, data from the County of Varaždin County Report for the period 2010-2015 ("Official Gazette of Varaždin County" No. 9/16).

3.Physical - geographical features

Varaždin County has great traffic significance as two important transport corridors are crossed in this area: the transversal with primary significance (which is the shortest and the most convenient link between the Central Danube Region and the North Adriatic) and the longitudinal with secondary significance, following the Drava flow and connecting the Republic of Croatia with western and eastern neighbouring areas. In addition to these road corridors, other important infrastructure corridors (railway corridors, power lines, gas transmission systems, telecommunication and other corridors) pass through the County.

Furthermore, what is fundamental and important from the viewpoint of hydrographics, with the title of water - economic relations, the area of the Varaždin County consists of two main parts: the larger, which belongs to the Drava basin and the smaller belonging to the Sava basin. These parts are separated by the mountain ranges of Ivančica and Kalnik. To the north of this line is a more spacious Podravina part that is predominantly lowland with hills in the south and west. The southern part is smaller, mostly hilly and elongated in the north - south direction along the river Lonja, which flows into the Sava river.

4. Geological and hydrogeological features

According to the hydrogeological characteristics described by the Water Protection Study of Varaždin County (AT-Consult, 2007), the County can be divided into the Quaternary deposits area of the Drava valley (Varaždin aquifer as the main source for water supply) and the karst of Croatian Zagorje (composed mainly of Thracian carbonate rock). The Varaždin depression is the westernmost part of the Drava valley in Croatia. It is elongated parallel to the Drava and has an alpine direction of providing (east-west) distinct from the general Dinaric direction (northwest-south-east) of the Drava graben. The eastern and western boundaries of the Varaždin depression are related to the Kalnik anticlinal structure, the so-called Legrad Threshold, i.e. the anticline structure of Ravna Gora and the "Ormož-Selnica anticline", the so called "Ormož Threshold", as one might name their sunken extension. Of the other structural units, the depression of Varaždin is separated in the south by the so-called southern boundary fault of the Mura depression. The northern boundary of the depression is also defective, and represented by the Čakovec fault. The hydrogeological unit of the Varaždin aquifer is located on the edge of an aquatic complex in which the natural regime of groundwater movement is strongly disturbed by the construction of hydropower plants and the use of groundwater for water supply. The aquifer itself consists of gravel and sand of high water permeability, in which a surface hydrographic network is intercepted. In the gravel deposits of the aquifer appear lenses and pastures of clay and dust. In the overlaying deposits, there is a change of sandy-clay marl, sandstone, sand and clay.

The aquifer is elongated parallel to the Drava and its thickness rises from west to east. The lateral boundaries of the aquifer are at the edge of the surrounding ridge and are generally faults. The longitudinal axis of the deepest part of it is further south from the present stream of the river Drava. From Varaždin to the west it coincides with the direction of Petrijanec-Križovljan, while in the east it continues in the direction of Hrženica-Imbrijovec-Hlebine. Generally, along the longitudinal axis of the Drava, the thickness of the gravel deposits is the smallest between Križovljan and Ormož. Along the northern boundary fault (at the Ormož bridge), the thickness is only 5m, while it is increasing in the south, reaching over 15m along the boundary. Continuing to the east, the thickness of the gravel deposits increases so that at Svibovec (HPP Varaždin engine room) it amounts to about 30m, northwest of Varaždin about 60m, southeast of Vularija (HPP Čakovec engine room) 112m, to the south of Prelog or at its deepest part, it reaches a maximum of 148m. Downstream, the gravel deposits are decreasing and at Sv. Marija their thickness is reduced to about 60 m. The largest thickness in the area of the so-called Legrad threshold is probably about 50m, while at the northern edge, that is, the today's bed of the river Drava at Legrad, the thickness is 14m, and at Đelekovac 12m.

Downstream from the Varaždin aquifer, gravel deposits are thickening. Lateral in the central area, their thickness decreases faster in the southern (Varaždin) area than in the northern (Međimurje) area. On the Nedelišće water well, the thickness of alluvial deposits is around 30m, while in the north, between Čakovec and Dunjkovec, it barely exceeds 20m. The borderline of the gravel-sandy deposits of the Drava is located at the edge of the Međimurje hills and the Čakovec plain and is a fault. According to geophysical survey data, the largest thickness of about 40m in this marginal area is expected in the line from Pribislavec to Gardinovec. Deposits in the valley of the Drava were deposited during the quaternary period. The transition between the Belvedere deposits and the Quaternary deposits, generally in the river Drava, is characterized by a layer of clay to a clayey powder of 2 to 5m thick, within which the peat pasture appears. At the location of the engine room HPP Čakovec IT is drilled at a depth of about 55m and at Totovec at 42m. It was later identified by numerous wells in Međimurje and the wider area of Varaždin, where the thickness ranges from 1m to several meters. Northwest of Varaždin, this layer is located at a depth of about 40m, on the Nedelišće water well in Međimurje at about 20m and northwest of Čakovec at about 8m deep. At Svibovec and Legrad, that is, in the longitudinal axis at Kapela, it is found to be missing in the western and southwestern or southeast regions. The clay layer is divided by the Varaždin aquifer in two gravel layers, since clay and clayey dust are followed by gravel with sand and sand.

The mountain part of the County, viewed from the western end, consists of the elevated area of Ravna Gora, about 15 km long, with the direction NE -SW. On the surface of the massif, Triassic carbonate rocks lying on impermeable clastites are predominant. The area is very well karstified with deeply cut canyons, steep cliffs, caves, pits and karst springs (Ravna Gora, Sutinska, Meljan and several smaller springs). The mentioned springs were created thanks to the large proportion of water-soluble limestone and tectonic disturbance of the terrain (faults and cracks), so that rainwater flows through underground cracks and cavities, and in some locations emerges on the surface in the form of mountain springs. The mountain range of Ivančica represents an elevated area of about 55 km with the direction EW. It was built from the Triassic and Upper Baden karstic carbonate rocks. The Triassic deposits occupy an area of 150km² and are represented by dolomites, dolomite breccia and, only sporadically, limestone. There are relatively few karstic forms developed, and the karstification of the Triassic rocks is reflected in their hydrogeological function. Precipitation water strains through the numerous cracks into the underground. A part of the water flows through the karstified dolomites to the south and refills the thermal springs of the central part of the Croatian Zagorje. On the northern side of Ivančica, the Triassic carbonate rocks are cut off by strong faults and are in contact with permeable Egerian clastites.

This allows groundwater flow to the north. Along this contact there is a number of stronger mountain springs (Mrzljak, Žgano Vino, Bistrica, Beli Zdenci, Šumi and others). The mountains of Varaždinske toplice represent a series of Hum-Brda-Željeznica-Varaždinske Toplice with the direction E-W. The karstic area is a terrain made of Upper Baden limestone, and on the surface neogenous marls and clastic are present. The erosion base is represented by the level of the Bednja River. The bed of the Bednja is around 190 m above sea level in this area, and there are several smaller water springs at this height.

Kalničko Gorje is located in the eastern part of the County. It is a mountain range with an E-W direction, about 30km long. It is characterized by its complex tectonics with overlapped layers and reverse faults. The surface is dominated by the rocks of the Cretaceous volcanogenic-sedimentary complex and the clastic neogenous deposits. Triassic tectonically insulated blocks of limestone and dolomite limestones in the area of Ljubelj occupy an area of 1.5km² and are considered to represent the collecting area of the waters passing through and heating up below the thick neogenous deposits, and spring up as a thermal spring in Varaždinske Toplice. In the area north of Kalnik there is a deep karst, developed in Triassic carbonate rocks, which allows the circulation of water between Ljubelj and Varaždinske Toplice.

5. Water management systems

As part of the activities of the water management systems, the supply of drinking water to the population is significant. As already mentioned, Varaždin County has abundant potential for potable groundwater. Consequently, in Varaždin County, great attention is paid to the protection of drinking groundwater, and water supply systems are based on the exploitation of larger springs (Varaždin, Vinokoščak and Bartolovec), i.e. smaller springs (Belski dol, Ravna gora, Ivanščica). In order to protect drinking water, and according to the Water Protection Study prepared for the needs of Varaždin County, priority should be given to protecting the existing and planned water resources (and to comply with the prescribed protection measures established through the decisions taken on protection of springs) and to complete the started public sewerage systems in towns along the river Bednja that is exposed in these parts to increased loads. With the protection of the Drava aquifer, it is also necessary to protect the particularly endangered surface waters of the river Bednja downstream from Lepoglava to the mouth of the river Drava. In accordance with the Study, activities are underway to prepare the necessary documentation, and partly to build water drainage and purification systems in these areas.

The fact is that water resources are becoming increasingly polluted every day, so that in surface waters plant and animal world is being increasingly endangered, as well as the quality of groundwater, thus endangering the direct use of this water for the needs of water supply.

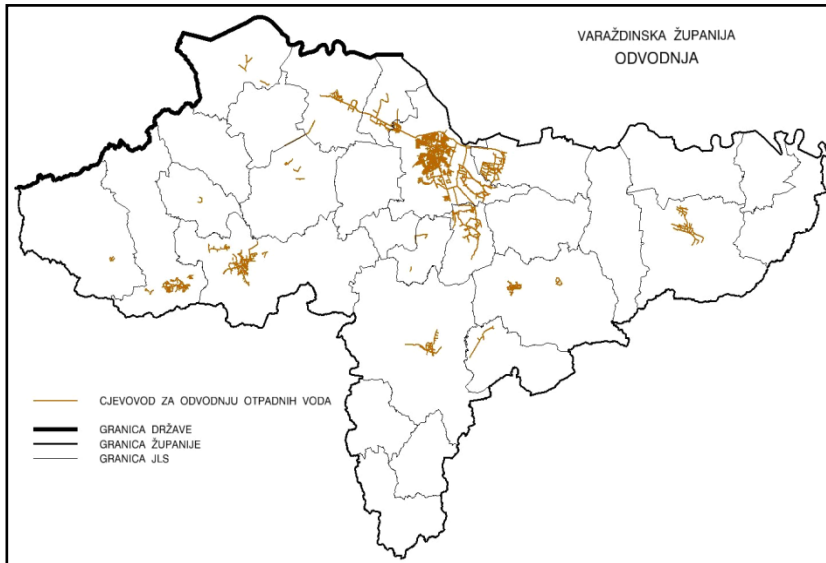


Figure 2. Drainage in the Varaždin County area Source: Situation Report of Varaždin County for years 2010-2015 (2016)

Failure to take appropriate measures of protection and the endangering of the quality of groundwater and spring water, which supply the entire area of Varaždin County with drinking water, could ultimately lead to unwanted consequences. Wastewater can cause adverse effects on the human environment and on people's health, so there is an urgent need to solve public wastewater management and in this way, along with the help of wastewater treatment facilities, remediate the already present unfavourable ecological situation. The public drainage system involves collecting, transporting, cleaning and discharging purified wastewater into the receiver. By this definition, only Varaždin has a fully built public drainage system (in all its elements). If we look at the existing state of the public drainage system it can be basically stated that apart from the city of Varaždin, where the wastewater treatment plant is already built, all other settlements have not solved this problem. An exception is made up of individual industrial plants with separate treatment facilities. Concerning this, it should be noted that for some settlements there is a project documentation that addresses the issue of wastewater and rainwater drainage, and some have already accessed the construction works as shown in Figure 2. However, these works only relate to wastewater extraction outside the inhabited area, without proper purification.

This primarily applies to the cities: Novi Marof, Ivanec, Lepoglava, Ludbreg and Varaždinske Toplice, and the areas of Gornji Kneginec, Trnovec, Maruševec, Bednja, Vinica and Cestica. In all other settlements of wastewater are discharged into septic tanks which have become too small after the introduction of water supply, so that spillage on the surface of the ground or discharge into inappropriate receivers occurs, which affects the environment negatively and creates a potential ground for possible occurrence of waterborne diseases. Unfortunately, in some settlements, wastewater is discharged directly to the road drainage system (open ditches or sections for piped sewers) that are drained to the nearest watercourses.

6. Water resources of Varaždin County

As already mentioned Varaždin County (Figure 3) has a very well developed river network and is a significant hydrographic junction in Croatia. The main watercourse is the river Drava, with rivers Bednja and Plitvice flowing in at its right. The flow direction of the river Drava west - east has determined the longitudinal orientation of the whole network. The southern part of the area is drained by the river Lonja.

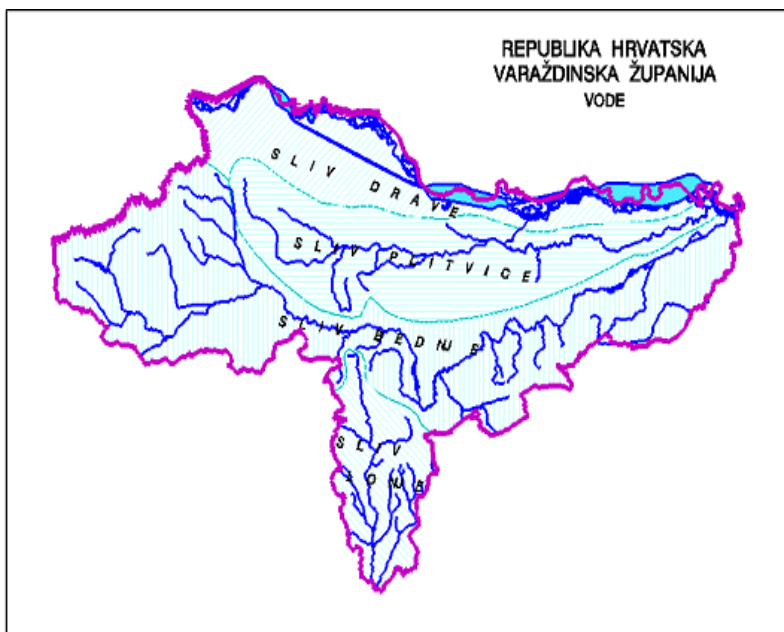


Figure 3. Water resources of Varaždin County Source: Spatial Plan of Varaždin County(2000)

7. River Drava

According to the data from the Spatial Plan of Varaždin County ("Official Gazette of Varazdin County" No. 8/00, 29/06 and 16/09), the river Drava is the largest watercourse in the County. It has fluvio-glacial water regime with the lowest flow in January and February, and highest in May and June. Rivers Bednja and Plitvica flow into the Drava at its right.

Through the wide alluvial valley from Maribor to the mouth of Mura, about 125 km long, the Drava has a relative drop of close to 0.1%. The energy use of the Drava hasn't begun until this century. Up to now, a total of 23 water stairs have been built throughout the river Drava, and in Croatia, from the planned 8, 3 have been constructed (Varaždin, Čakovec and Dubrava).

Due to the existing characteristics of the water regime, Drava is a favourable for hydro-energy use because it is well complemented by hydroelectric resources of the Dinaric karst. The significant relative decline of the Central Drava with the bed in the gravel terrain, and large flows, have in the past caused many meanders and changes of course. Erosion of the coast, sandbars, islands and swamps are a regular occurrence in this part of the Drava, so that its bank has been replaced significantly over a long period of time. Because of the change in the riverbed, floods have sometimes been devastating for agricultural crops and have endangered nearby settlements and populations.

8. River Plitvica

The River Plitvica springs in the northeast hills of Maceljско Gorje, at the foot of Vinica hills, which only slightly exceed 300m above sea level. At the beginning, Plitvica flows in the southeast direction between the hills, from which it receives numerous tributaries, and in the village of Greda it changes direction and flows eastwards almost parallel to the Drava River, in a very curving course. After about 65km of watercourse it flows into the distributary of the Drava near Veliki Bukovec. Apart from the streams in the hills, Plitvica, in its lowland flow, receives most of the southern tributaries from the northern slopes of Toplička gora (Varaždin Breg), but also on the north side several lowland streams that are prevented to run-off into the Drava by the back of the Drava coast.

The basin of Plitvice is about 144 km². In the north and northwest there is the immediate basin area of the Drava River, and in the south and southwest the area of the Bednja River. The southern boundary towards Bednja is narrow and goes along the ridge of the hills of Varaždinske Toplice to Ludbreg, where Plitvica and Bednja flow in the plain, so the ridgeline is difficult to determine.

The Plitvica and Drava ridgeline are also fairly unclear. It can be said that the area of Plitvice and the immediate Drava basin is actually a unique area. Almost the whole valley of the Plitvica is made up of the Drava deposit (gravel and sand) that covers a fairly thin layer of humus. The small drop of the Plitvica is further reduced by the mill's constitutions, and the curved bed (not particularly pronounced) is even more opaque and overgrown. The watercourse on the part of the leak-off canal to the mouth of the Drava does not dry up, and the more moderate precipitation is causing floods.

According to the data from the Water Protection Study of Varaždin County (AT-Consult, 2007), the Plitvice River length, which was planned for construction, totals in its lower part downstream of the Varaždin-Lepoglava road to 51,67 km. The uphill part of this line from the km 26.7 to the km 51.67 is already furnished, and a part of the downstream section (about 1 km on the road Varaždin - Ludbreg and approx. 8 km at the mouth of Plitvica into Drava). At 31km, the river Plitvica is connected by a drainage channel with the Drava so that the great waters of the Plitvica upstream from the km 31 are drained by a canal directly into the Drava and thereby dissipate the downstream part of the river.

9.River Bednja

The river Bednja is the largest watercourse after the Drava River in Varaždin County. It springs in the western part of the County below Brezova Gora, and after passing through the Trakošćan Lake flows in the general west - east direction and affects the river Drava near the village of Mali Bukovec. The surface area of the basin area of the Bednja River is about 65,100 ha, of which 12,500 ha is in the floodplain. The length of the watercourse is about 106 km. A very disadvantageous form of the basin area, which has been expanded in an fanlike manner in the upper part with an unfavourable precipitation distribution (the largest precipitation is precisely on the fanlike expanded part of the basin) and unfavourable runoff conditions (sudden flooding of precipitation into the bed from the slopes of Ivančica, Ravna Gora and Kalničko Gorje) are the main characteristics of the river Bednja regime. The rapid formation of large water waves causes very frequent floods, large bed destruction, and in this regard, the transfer and settling of large-scale deposit.

Due to the sudden arrival of precipitation from the upper part of the basin of the Bednja River, 37 accumulations- retentions of the total volume of approximately 8.000.000 m³ are planned for the calming of the water waves, according to the Conceptual Solution of the Water System Plitvice – Bednja (Varaždin 1989).

Torrential streams will need to be refurbished by partitions and staircases, and it is imperative to construct a river basin management and maintenance system to reduce sudden floods and erosive areas. These torrential watercourses have weaker or stronger torrential action, depending on the terrain configuration and the geological and pedological characteristics. Therefore, every basin has to be processed in detail, in order to intervene with the right solution in time to prevent more damage. The fact is that, in the event of delays, the works, and hence the costs, are considerably increased. Thus, by recording and treating erosive processes, many damages can be avoided in advance.

10. River Lonja

The river Lonja basin only affects the southern part of the territory of the County (Novi Marof area). The bed of the Lonja River in our area has not yet been regulated. A study is being prepared to provide a watercourse solution with longitudinal falls, cross-sectional profiles and structures, as well as possible accumulations (retentions) that would serve as fishponds. The length from the spring to Bisag is approximately 18 km. It is, together with its tributaries, of torrential character in this area. In the upper streams erosion occurs, and in the lower flooding of fields and meadows. There is a number of tributaries in this area. The left tributaries of Kračevac, Visoka and Sudovec are mostly regulated, as well as the right bank of Breznica with Manjevac and Trstenik. All other streams are not yet regulated, and should be with regard to the damage they cause. They do not run directly through settlements, so there are damages mostly to agricultural crops.

11. Zones for sanitary protection of water sources

The Regulation on the Determination of Zones for Sanitary Protection of Water Sources (Official Gazette No. 66/11, 47/13) prescribes the conditions and manner of determining the areas of sanitary protection, measures to protect sources from pollution or other impacts that may adversely affect their yield, quality and sanitary accuracy, guidelines for determining a special fee for the required increased investment in the public water supply system and the public wastewater collection system in the area and the procedure for issuing a decision on source protection. Generally, a source used or reserved for public water supply must be protected against pollution and deliberate or accidental pollution and other impacts that may adversely affect the health of water or its yield. The protection of water sources used for public water supply is carried out on the basis of the measures stipulated by the decision on water source protection.

For the planned sources for public water supply, a space reservation is made in the spatial planning document based on the elaboration of the zone determination. Protective water source zones, sanitary and other maintenance conditions of the zone, and protective measures in the area of the zone are determined on the basis of previous water research work, which determines the existence, distribution, quantity, quality and mobility of groundwater in a given area. The boundary of certain water source zones is determined on the basis of the hydrogeological and hydrological characteristics of the affected aquifer, depending on the type of aquifer (thickness and permeability of the coverings), the manner and size of the aquifer supply, the groundwater flow velocity towards the source and the capacity of the surface cover and aquifers.

Passive and active protection is implemented within the boundaries of the protective zone of the water source. The passive protection of the source means the prohibitions of construction and accommodation of certain buildings, and the execution of certain activities within a particular zone. Active source protection includes regular monitoring of the water quality in the inflow area of the water source and measures for its improvement, in particular the construction of water facilities for public water supply and sewerage, the introduction of clean production, the organization of organic agricultural production, the installation of containers of hazardous and polluting substances with additional multiple protection, and other measures that improve the water status. Legal entities managing the sources are obliged to issue the Regulation on the Implementation of the Protection and Land-use Measures within Zone I in accordance with this Decision and to comply with it, and also to adapt the pumping regime to the ground floor condition. The sanitary protection zones are defined according to the type of aquifer for: groundwater sources: from aquifers with intergranular porosity and from aquifers with crack and crack-cavernous porosity, as well as water sources with surface water abstraction: from accumulation, lakes and from open watercourses. The protection of underground aquifers with intergranular porosity is carried out in accordance with the Regulation through three basic zones of sanitary protection.

Restriction and Control Zone (Zone III)

The subject zone is established to reduce the risk of groundwater pollution from heavily biodegradable hazardous substances and pollutants. It covers an area beyond the boundaries of Zone II up to the boundary of the supply area for the minimum water retention time in the underground for a period of 5 years of horizontal flow before entering the water intake building. In Zone III the following is prohibited: discharge of untreated wastewater, storage and disposal of waste, construction of waste landfills other than remediation of existing ones for the purpose of its closure, waste management facilities including waste incinerators and facilities for processing, recovery and disposal of hazardous waste, construction of chemical industrial installations of hazardous substances

and pollutants of water and water environment, construction of gas stations with no double-walled tank, automatic detection and leak detection device and protective structure (bundwall), underground and surface exploitation of mineral raw materials except geothermal and mineral water, construction of roads, airports, parking lots and other traffic and manipulative surfaces without controlled drainage and the appropriate purification of contaminated rainwater before the discharge into the natural receiver. It should also be noted that in Zone III of sanitary protection of water sources with the abstraction of water from the aquifer with intergranular porosity, it is permissible to build a waste management centre, in accordance with specific waste regulations, under the following conditions.

Strict Restriction and Control zone (Zone II)

It is designed to reduce the risk of groundwater contamination by pathogenic microorganisms and other adverse effects that may occur while retaining groundwater. It covers the area beyond the boundaries of Zone I to the line from which the groundwater has a minimum retention time in the underground 50 days prior to entering the water intake structure. In the zone concerned, bans from Zone III apply with the addition of bans for: agricultural production, except for organic production with the application of permitted fertilizers and plant protection products according to special regulations, cattle production, with the exception of the farm with up to 20 livestock units, with the implementation of protection measures of water prescribed by the appropriate program of water protection against pollution caused by nitrates of agricultural origin and principles of good agricultural practice the discharge of cleaned and untreated wastewaters from the roads, the creation of new cemeteries and expansion of the existing ones, the storage and disposal of waste, the construction of waste landfills other than the remediation of the existing ones with the aim of their closure, waste management facilities including waste incinerators, regional and county waste management centres, recycling yards and waste transfer stations if there are no plans to implement water protection measures and facilities for processing, recovery and disposal of hazardous waste, performing exploration and exploitation drill holes other than those related to water supply operations for public water supply and renewable energy sources.

Strict Regime of Protection and Restriction Zone (Zone I)

It is defined for the purpose of protecting the water source from the aquifer with intergranular porosity for the protection of water sources, water intake structures and their immediate surroundings of any damage, water pollution and other accidental or intentional adverse impacts. The boundary of the subject area must be at least 10 m away from water intake structures and must be fenced off with a stable fencing of a height sufficient to prevent entry to unauthorized persons. In Zone I, all activities, except for those involved in abstraction, conditioning and transporting water into the water supply system

are prohibited. Zones of sanitary protection of the water source with the abstraction of water from the aquifer with the crack-cavernous porosity are determined to reduce the risk of aquifer contamination with cracks and crack-cavernous porosity. According to the abovementioned Regulation, these are: Restriction Zone – Zone IV, Restriction and Control Zone - Zone III, Strict Restriction and Control Zone - Zone II., and Strict Protection Regime and Control Zone – Zone I.

12. Water wells of Varaždin County

The water-bearing horizons in gravel drainage slabs are good yields and provide quality, natural and filtered water. These horizons represent the most important water supply area of the County, especially because they are in the area of the strongest urbanization and the greatest water consumption. Water supply of Varaždin County is based on the groundwater drainage of Varaždin aquifer. There are several sources in the Varaždin County area:

- a) The area of the Drava valley where the available water reserves are in the underground and where their use is foreseen from the existing water wells of "Bartolovec", "Varaždin" and "Vinokovščak";
- b) The area of the northern slopes of Ivančica and the southern slopes of Ravna Gora (the area of Ivanec), where a series of springs emerge in mountainous watercourses and are already used for water supply to gravitating consumers;
- c) The area of the eastern slopes of Ivančica, the water source in the area of Belski Dol
- d) Other sources in the area of Varaždin County, which are of lesser capacity and which do not provide the opportunity for more efficient use in the process of the final water supply solution.

In order to protect the reservoirs of potable groundwater and in accordance with the Regulation on the Conditions for Establishing the Sanitary Protection Zone of the Water Source (Official Gazette No. 66/11 and 47/13), the Decision on Protection of Water Sources Varaždin, Bartolovec and Vinokoščak (Official Gazette of Varaždin County No. 6/14) has been issued, and the Study of their remedy is in progress. New Studies are being drafted for the sources of Belski Dol, Ivančica and Ravna Gora, according to which conditions and protection measures will be revised through new decisions, and until then, the decisions made earlier apply (Declaration on the Protection of the Water Source Belski Dol , "Official Gazette of Varaždin County 14/10), and the Decision on Sanitary Zones for Protection of Water Source "Bistrica", "Beli Zdenci ", "Žgano Vino "and" Šumi "(" Official Gazette of Varaždin County "No. 4/98) and Decision on Protection of Water Sources of "Ravna Gora" and "Sutinska" ("Official Gazette of Varaždin County" No. 9/98).

In the meantime, new decisions have been made on the protection of the water sources in the area of neighbouring counties, whose zones also extend to the area of our County: for the Koprivnica-Križevci County the Decision on Protection of the Water Well Vratno was issued ("Official Gazette of Koprivnica-Križevci County" No. 2 / 10 and "Official Gazette of Varaždin County" No. 6/10 - Decision on Accepting the Decision on Protection of the Water Well Vratno), for the Krapina-Zagorje County the Decision on Protection of the Water Source Lobor was issued ("Official Gazette of Krapina-Zagorje County" no. 15/14 and Official Gazette of Varaždin County No. 42/14), and the Decision on Protection of the Water Source Nedelišće, Prelog and Sveta Marija ("Official Gazette of Međimurje County" No. 8/14) was issued for the area of Međimurje County. In 2011, the Decision on Protection of the Ivanščak Water Source in the Koprivnica-Križevci County ("Official Gazette of Koprivnica-Križevci County" No. 6/11) was issued and according to which the part of Zone II of sanitary protection area was extended to the area of Varaždin County (eastern part), so the County Assembly of Varaždin County passed the Decision on Accepting the Decision on Protection of Water Source Ivanščak ("Official Gazette of Varaždin County" No. 18/11). In 2014, the County Assembly of the Koprivnica-Križevci County passed the Decision on Protection of the Water Source Ivanščak ("Official Gazette of Koprivničko-Križevci County" No. 15/14), which amended the earlier Decision, and the sanitary protection zones of this source no longer extend to the area of Varaždin County. The display of the water source protection zone is shown in Figure 4.

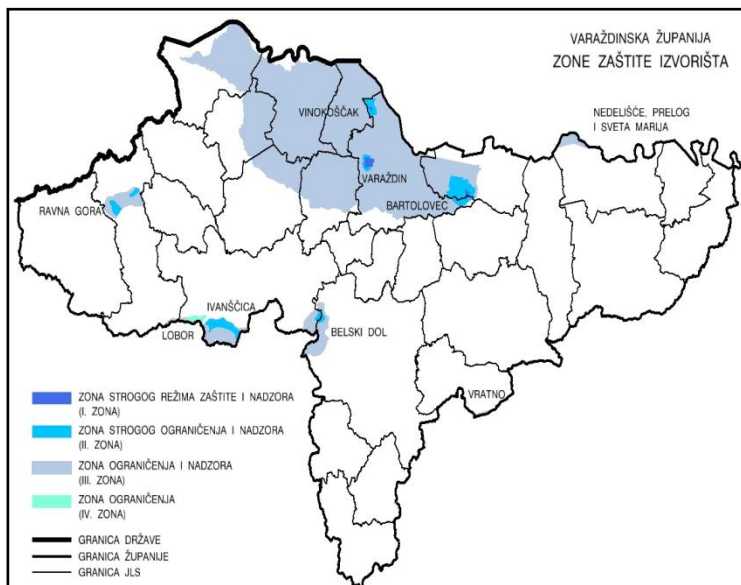


Figure 4. Decisions on Protection of Water Sources in the Varaždin County Area Source: Situation Report of Varaždin County for years 2010-2015 years(2016)

a) Water Well “Varaždin”, “Bartolovec” and “Vinokovščak”

Water Well “Varaždin”

According to the data of the Water Protection Study of Varaždin County (AT-Consult, 2007) there are eleven wells at the water well “Varaždin” point (1), of which a part of the wells is excluded from operation because of the possibility of pollution by the city (Near the Varaždin cemetery area). One test well was drilled which abstracts the lower aquifer layer, where the concentration of nitrate is found below the permitted limit. Due to increased concentration of nitrate, today, the Varaždin water well is being used to a much lesser extent than the installed capacities because priority is given to water wells “Bartolovec” and “Vinokovščak” because of the lower concentration of nitrate in water (below 50 mg / l NO₃). The “Varaždin” water well is used only as a supplement to the water wells “Bartolovec” and “Vinokovščak” in periods when the same cannot meet all water needs (under the conditions of present-day construction).

Water Well “Bartolovec”

It was built in 1971 with the intent to serve for the water supply of Varaždinske Toplice and part of the area of the former Ludbreg municipality. Two wells were drilled, which capture the upper aquifer. In the area of “Bartolovec” point (2) there is a possibility of the purposeful use of water from the deeper aquifer. Namely, it is found that at a depth of about 36 to 52m there is a weak permeable layer which is gradually dies out in the direction of the west, and serves as protection from pollutants from the surface layers. To date, there are four additional wells set up on this water well, two shallow and two deep with total capacity of about 360 l/s. Consequently, it can be concluded that the location of “Bartolovec” can be utilized as a main water resource in the water supply problem in the Varaždin County, i.e. within the regional awater supply system of Varaždin (if water supply is needed from the existing water wells “Vinokovščak” and “Varaždin”).

Water well “Vinokovščak”

The site “Vinokovščak”, point (3), i.e. on the area between the old Drava river basin and the derivation channel “Varaždin”, the possibility of efficient operation of significant amounts of groundwater that can be used for the needs of the regional water supply Varaždin was identified. It was originally intended to preserve and protect this area as a reserve for future water supply needs, but due to insufficient water quality at the Varaždin water well and insufficient quantities of water from the “Bartolovec” water well, this one is included in the water supply system of the regional water supply system “Varaždin”. Today, at the site of the “Vinokovščak” water well, three wells (total capacity $Q = 160$ l / s) are installed, with internal pipelines, and the necessary water supply and infrastructure facilities.

The accommodation and display of the “Varaždin”, “Bartolovec” and “Vinokovščak” water wells can be seen in Figure 5.

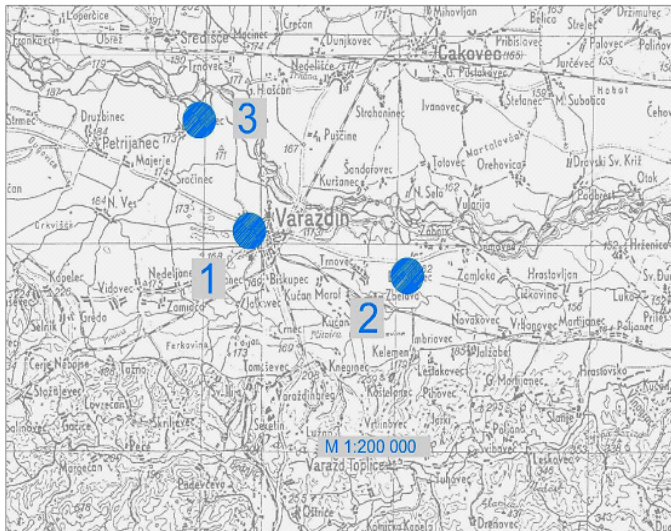


Figure 5. The location of the “Varaždin”, “Bartolovec” and “Vinokovščak” water wells Source: Water Protection Study of Varaždin County(2007)

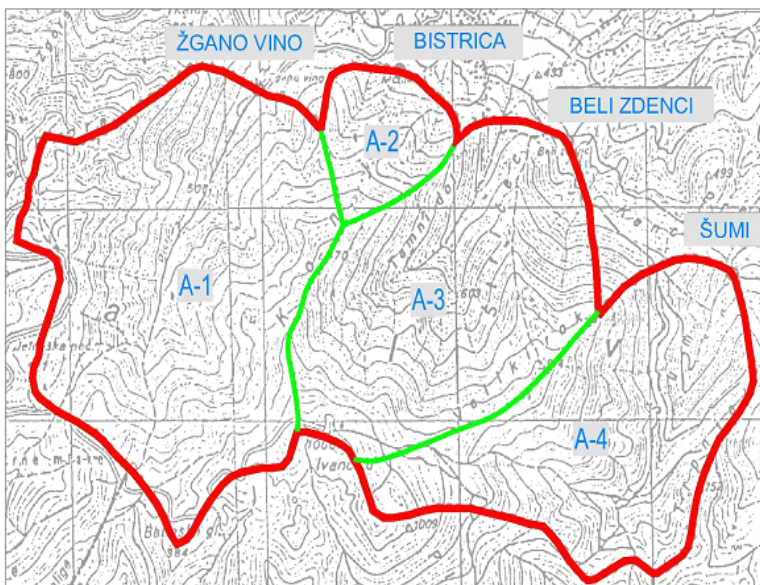


Figure 6. Ivančica spring location with the boundaries of the basins Source: Water Protection Study of Varaždin County (2007)

b) The area of the northern slopes of Ivančica and the southern slopes of Ravna Gora

In the process of solving the water supply problem of the area of Ivanec, in addition to the water from the regional water supply, water from local sources located in this area is also foreseen. There are six local springs in the area, four of which are located on the southern slopes of Ivančica ("Žgano Vino", "Bistrica", "Beli Zdenci" and "Šumi"), while the other two are located in the northwest area of the former Ivanec Municipality ("Ravna Gora" and "Sutinska"). Figure 6 shows that the largest basin belongs to the spring "Žgano Vino" and the smallest to the spring "Bistrica", while their yields have completely opposite relationships. The drainage study indicated the stability of the corresponding underground connections, which do not accept the boundaries of the hydrographic basins, meaning that everything should be observed in terms of communion, with the connection to the hydrogeological relationships in the underground. Field visit should point out that the area of the northern slopes of Ivančica and the southern slopes of Ravna Gora are afforested and uninhabited and that, given this situation, there are no significant opportunities for degradation of spring waters and the need for special protection measures. But what should be done is to align the attitudes with the forest economy to avoid "bare" deforestation of larger-volume that could cause increased erosion and consequently cause blurring of these springs. What can actually be concluded from the research of the exploitation of these sources and the water demand balance in the area of the Town of Ivanec can cover all the requirements for long-term planning as a supplement to the amount of water that will be delivered from the regional water supply "Varaždin".

c) The area of the eastern slopes of Ivančica

In the area of Novi Marof, springs at the location of Belski Dol are primary. There are two major sources here: "Belski Dol I" and "Belski Dol II". In the area of the eastern slopes of Ivančica the spring "Bela" is also located. It can be concluded that little attention has been paid to this spring so far. Practically, no research in terms of determining the spring water genesis or the possibility of obtaining larger quantities was carried out.

d) Other springs

In Varaždin County, as cited by the Water Protection Study in the Western and Southern Water Supply Zone, there is a number of local captured springs that serve to supply water to certain settlements. The following sources are located in the west zone: in the area of Ivanec: Vuglovec, Melišće and Beli Zdenci; In Lepoglava area: Mrzljak Močvarci; in the area of Bednja: Brdo Benkovec and Želimor, and in Klenovnik.

The following sources are in the area of the south zone: Markovac at Presečno settlement, Lužec, Ljubavoda I and II, Kapela Kalnička, Podevčevo, Pišćenovci, Petkovec, Hrastovec, Mađarevo Podrute, in the area of Breznički Hum: Petrusi, Donji Radešić, Gornji Radešić and Breznica. In the settlement of Čanjevo there is the spring Viničko, and in the settlement Visoko and Sudovec.. Based on the analyses and guidelines of the Water Supply Plan of Varaždin County, only the regional water supply system Varaždin and the group water supply pipeline Ivanec are foreseen for public water supply, while all other local sources will be put out of function and may be conserved for use in incident situations.



Figure 7: Vulnerable areas in the Varaždin County area Source: Decision on Determination of Vulnerable Areas in the Republic of Croatia Note: Following the adoption of the Decision, a territorial change occurred between the Municipality of Martijanec and the Town of Ludbreg in the way that the village Poljanec is separated from the Municipality of Martijanec and belongs to the City of Ludbreg, and so the Ludbreg area is designated as a "vulnerable area" but is not listed in the list of the Decision.

e) Protection areas of special interest

The protection of springs from pollution or other impacts that could adversely affect the health safety of water and its availability is carried out through decisions on the protection of springs, which prescribe the protection and sanitation measures of the springs, and sanitary and other conditions. In Varaždin County there are protected areas of special interest and vulnerable areas belong in this category as well.

Vulnerable areas are defined by the special Decision on the Determination of Vulnerable Areas in the Republic of Croatia (Official Gazette 130/12). Vulnerable areas have been identified in the Danube River basin and in the Adriatic water area, where more stringent measures are needed to protect water from contamination with nitrates of agricultural origin. In the Varaždin County area, 11 units of local self-government were identified as vulnerable areas as shown in Figure 7, namely the City of Varaždin and the Municipalities Beretinec, Martijanec, Gornji Kneginec, Jalžabet, Maruševac, Sveti Đurđ, Sveti Ilija, Vidovec, Vinica and Veliki Bukovec. Vulnerable areas occupy about 31% of the County. In areas designated as vulnerable areas, measures to protect surface and groundwater from nitrate contamination of agricultural origin should be carried out.

13. Conclusion

One of the most prominent strategic goals of the State in the County area is the protection of drinking water reservoirs. To this end, it will be necessary to complete the processes of defining water protection areas and their protection in accordance with the new regulations and to incorporate them appropriately into spatial plans through the procedures of their amendments.

According to the Water Protection Study prepared for the needs of Varaždin County, it is necessary, along with a primary protection of existing and planned water wells, to complete the started public drainage systems in the towns, especially along the river Bednja, which is subject to increased loads on certain sections. Also, along with the protection of the Drava aquifer, it is necessary to protect the particularly vulnerable surface waters of the river Bednja downstream from Lepoglava to the mouth of the river Drava, for which areas the necessary documentation is under preparation, and partly the construction of drainage and water purification system, in accordance with the Water Protection Study.

14. References

- Prostorni plan Varaždinske županije („Službeni vjesnik Varaždinske županije“ br. 8/00., 29/06. i 16/09.)
Strategija prostornog uređenja Republike Hrvatske (27. lipnja 1997. god. i NN br. 76/13.)
Program prostornog uređenja Republike Hrvatske (NN br. 50/99. i 84/13.)
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Studija zaštite voda Varaždinske županije (AT-Consult, 2007. god.)

Pravilnik o uvjetima za utvrđivanje zona sanitarne zaštite izvorišta (NN br.66/11 i 47/13)

Odluka o određivanju ranjivih područja u Republici Hrvatskoj (NN br. 130/12.)
Izješće o stanju u prostoru Varaždinske županije za razdoblje 2010. – 2015. god. („Službeni vjesnik Varaždinske županije“ br. 9/16.)

Izješće o stanju okoliša za razdoblje 2010. – 2013. god. (Zaključak o prihvaćanju Izješća „Službeni vjesnik Varaždinske županije“ br. 29/14.)

