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# Contents

# Application of the new sanitary protection zone legislation in Serbia Case study: Pancevo water supply system

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## ABSTRACT

Beside the fact that Serbia still possesses significant reserves of high quality water, the state of groundwater protection and quality is altogether inadequate. The main cause of numerous problems in this area has been the lack of adequate law regulations for years.

By bringing new law regulations in the area of determining sanitary protection zones of sources for drinking water supply from 2008, a large step was made. A good example of a quality approach to determining a sanitary protection zone for water supply is the source for water supply of the city of Pančevo. Although determining the SPZ of this source had begun before the arrival of new law regulations, this solution represents an important step forward in this area and adheres to the new regulations. Mentioned case is an example of good practice and a correct approach to solving the problem of determining sanitary protection zones of water supply sources. In the transition period, accepting new laws, example of the Pančevo groundwater source, indicates that finding the optimal solution lies in combining experience and expertise. A pure implementation of laws, without adaptation to specific situation, is almost impossible when the specificity of each individual case is kept in mind. Aim of this paper is to provide insight into problems which follow determining sanitary protection zones of water supply sources in Serbia.

Key words: groundwater, protection, sanitary protection zone, legislation

## INTRODUCTION

Groundwater is used in approximately 80% of all cases for providing drinking water in settlements on the territory of Serbia. They are tapped from all types of aquifers: intergranulary in alluvial and terrace deposits, artesian aquifers of neogene basins, and finally karst and fracture aquifers. Beside the fact that Serbia still possesses certain deposits of aquifer waters that represent real natural reserves of high quality water, with favorable conditions for protection, the state of groundwater protection and quality is altogether

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inadequate. The main cause of numerous problems in this area has been the lack of adequate law regulations for years. According to monitoring data in the period of 2007 to 2011, the quality of raw tapped water at most of the sources was satisfactory according to valid rulebooks about drinking water quality, but monitoring of all of the sources is not preformed regularly. In 2007, 155 central water supplies were controlled on the territory of Serbia, physical-chemical irregularity was registered in more than 20% of the tested samples, that is to say, 39% of the controlled water supply systems, while 29% of the water supply systems had simultaneous physical-chemical and microbiological irregularities. Of the 128 tested sources in 2011, only 36 had a completed Report about zones of sanitary source protection.

## PROBLEMS OF DETERMINING ZONES OF SANITARY PROTECTION FOR WATER SUPPLY SOURCES

When determining the sanitary protection zones (SPZ) around the water intake of groundwater, the basic question arises of hydrogeological methodology and criteria necessary for implementation when determining the position and scale of the zones is in question. Different natural hydrogeological and hydrodynamic conditions that are present from source to source negate the possibility of creating a template when determining the position of protection zones. This is best seen in the fact that the geological and hydrogeological characteristics of individual soils differ and those differences must be taken into account under specific conditions.

The problem of determining SPZs is even more complicated if the subject source is already under the influence of existing pollutants. The protection of groundwater of a certain source from pollution does not necessarily entail only water intake protection. It is a much more complex problem than determining the administrative zones around the objects themselves. In short, it can be said that the protection of a certain groundwater source entails “controlling” a much wider territory than that from which it is possible to directly or indirectly negatively influence the quality of the given source. The primary impact is, before all, anthropogenic activity and influence which arises as a result of those activities. All of those influences must be viewed and neutralized regardless of the distance from the source. For example, an alluvial source located alongside a river can be endangered due to a pollution hotspot located tens or hundreds of kilometers upriver. The complexity of the given problem is especially notable when the protection of alluvial sources near large rivers is in question, because the question of protecting the entire river flow and the entire water basin from pollution is raised. When determining sanitary protection zones, it is necessary to completely view the hydrogeological characteristics of the environment and hydrodynamic conditions of groundwater flow. If the source is endangered by a pollutant, it is crucial to define the conditions at the source of pollution, as well as the physical-chemical processes of interaction between the contaminating matter and the geological environment. Regardless of the complexity of the given problem matter, the Rulebook about the method of determining and maintaining zones and strips of sanitary protection of structures for drinking water supply (Official gazette SRS, no. 33/78), which was valid until 2008 when determining SPZs took into account the distance of the zone from the water intake[1].

International law regulations, however, have the estimated "time of travel" of the potential polluting matter as a primary criterion. Processes of "mass change" of the contaminating matter are also taken into account (number of calculations equals the number of contaminating matter). According to this criterion, it is primary to find the distance (contour distance) from the water intake from which an eventual appearance of pollution will be neutralized while underground (T), having in mind the speed of groundwater movement in aquifers. Complete disappearance (effect of microorganisms) is taken into account, as well as the transformation in to harmless products or influences only when the foreseen work period of the water intake is over. This is why T has a wide scope of 5 days to 50 years (this last value most commonly in Russian hydrogeological practice).

In the past years, in the EU, when determining zones of sanitary protection in karst sources, it is mandatory to complete a so-called Map of vulnerability or a Map of endangerment of the given area. These maps, combined with the maps of potential contaminating matter for groundwater, help to identify possible risks. The identification and evaluation of risk is necessary for undertaking measures against the pollution of water supply plants, along with the previously determined SPZ. Serbia is the first country in the region for which a vulnerability map of groundwater on a national level was completed (1:500 000), which gives a good foundation for future spatial planning, as well as preventive protection of the most significant water resources, regardless of the national scale.

By bringing new law regulations in the area of determining sanitary protection zones of sources for drinking water supply from 2008, a large step was made. On the other hand, putting this regulation into effect has created difficulties in practice, which is especially true for the application of new regulations on existing sources. Many of these sources have been in function for years or decades and their environment has been notably changed. Intensive urbanization and industrialization have made the determination of SPZs in accordance with the new regulations difficult.

Still, a good example of a quality approach to determining a sanitary protection zone for water supply is the source for water supply of the city of Pančevo. Although determining the SPZ of this source had begun before the arrival of new law regulations, this solution represents an important step forward in this area and adheres to the new regulations in great measure. Due to this, the groundwater source of Pančevo will be presented in this work as a successful example of the protection of a water supply source in Serbia and under conditions of a large influence of the urban environment as well as a large number of potential pollutants.

## CASE STUDY – PANCEVO ROUNDWATER SOURCE

The city of Pančevo as one of the largest industrial centers in the Republic of Serbia has great problems with environmental protection. Cases of aero pollution are especially common due to a developed petrochemical industry. Along with that, during the NATO bombing of Serbia, the city and wider area went through an ecological disaster, so immense soil and groundwater pollution within the industrial zone occurred.

The source from which the city taps drinking water is made up of three entities that take up the right bank of the Tamiš and left bank of the Danube rivers ("Sibnica", "Filter" and "Gradska šuma") that have a total capacity of 500-600 l/s Fig. 1.

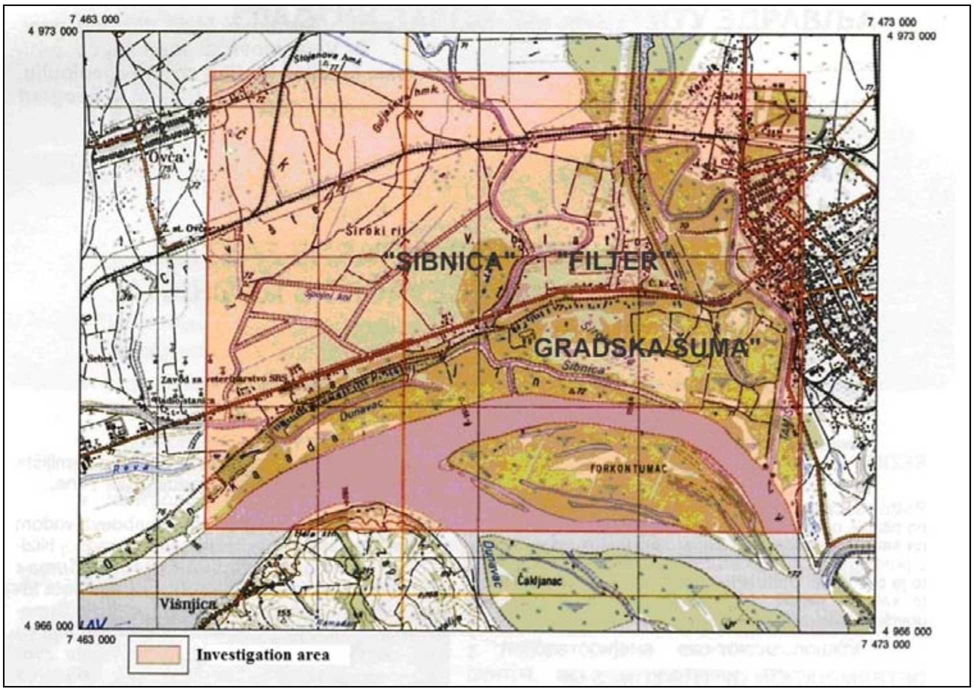


Figure 1. Geographical position of the investigation area [2]

Ongoing problems of water supply are mostly connected to the heightened capacity of the source, that is to say, the quickened well aging (lowered discharge). Although the water quality did not represent a problem in the past, as can be seen through the newest analyses, the source is jeopardized due to several factors. The fact that a large part of the source is located in the Belgrade municipality of Palilula represents an additional problem, so a conflict of interests exists.

As a foundation for determining the sanitary protection zones based on hydrogeological (hydrodynamic) criteria during 2002, hydrogeological investigations were undertaken. In the scope of these investigations, specific detailed geological and hydrogeological mapping of the terrain was performed, as well as identifying all of the pollutants, forming a monitoring network for changes in groundwater and surface water levels. Monitoring of changes in groundwater and surface water levels in the period of one year (one hydrological cycle) was performed from all of the monitoring structures. Samples were taken periodically from the groundwater of representative wells from all three sources, as well as surface waters and river sediments of the Tamiš, Sibnica rivers and channel in “Gradska šuma”. As a result of all of these investigations, a hydrogeological simulation model of the investigation area was performed based on which the hydrogeological parameters were defined, along with the borders of the sources in plan and profile, directions and speed of groundwater flow and determining the sanitary protection zone, as well as a presentation of the existing and potential pollutants in the wider protection zone.

## HYDROGEOLOGICAL SIMULATION MODEL OF THE WATER SUPPLY SOURCE OF PANCEVO

The simulation of aquifer dynamics under current and future conditions of aquifer water exploitation from the source of Pančevo city was completed in a hydrogeological simulation model which was performed based on a geological and hydrogeological terrain model. The geological terrain model, made only for the needs of a mathematical model, took up the area containing alluvial deposits of the left bank of the Danube and right bank of the Tamiš rivers up to a depth of 60m. The model encompasses an area of approximately 70km$^2$ and takes up the left side of the Danube all the way to the Tamiš delta. The southern border of the model is represented by the Danube, while the eastern border is the river Tamiš. In the north, the model encompasses parts of Jabučki rit, and spreads to the Reva pond and Ovča railway station in the east. The total area of the model has been quantified with 15000 rectangular elements. The size of the elements, or rather the thickness of the net varies depending on the expected hydraulic gradients. The net is thicker in areas of the future exploitation, that is to say, in areas of steeper gradients Fig. 2 [3].

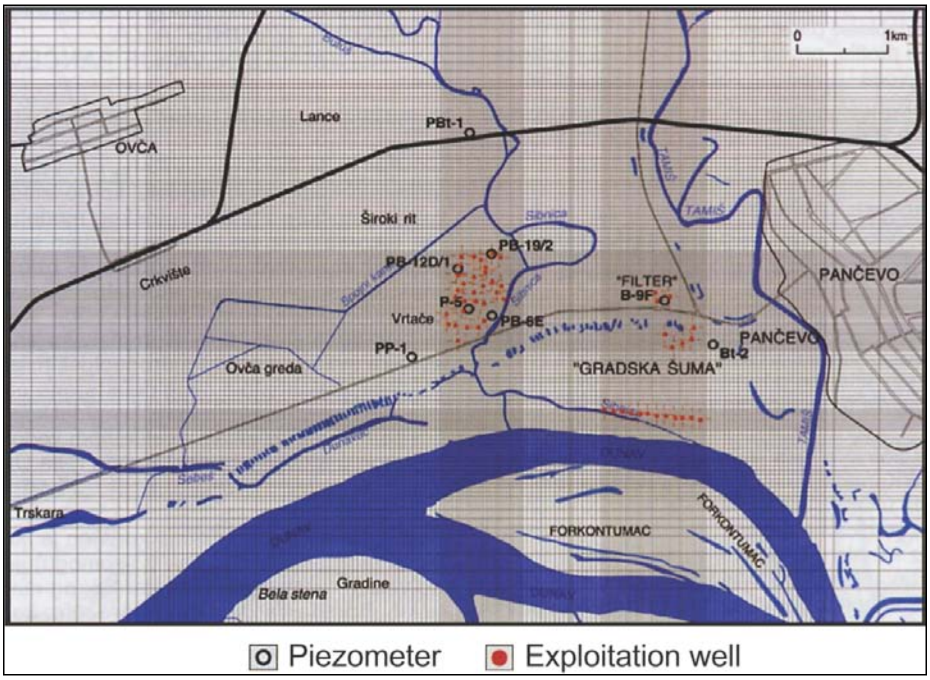


Figure 2. Discretization net of the hydrogeological model with border conditions

Vertically viewed, the model has been quantified as a three-layered porous environment. The first environment, or first layer, represents an overlaying layer of the water bearing horizon. The thickness of these overlaying sediments varies from 2 to 7m. The filtration coefficient of these sediments varies within borders of $3*10^{-6}$ do $1*10^{-7}$m/s. The second environment is represented by sands and clayey sand in places. These sediments represent the main exploited water bearing layer. The thickness of these sediments moves in limits of 22 to 44m. The calibration size of the filtration coefficient for this environment in the whole area of the model is in borders of $1.5*10^{-4}$ do $5*10^{-4}$m/s. the third environment is represented by clays that are the water impermeable base of the water bearing sediments.

The completion, calibration and verification of the mathematical hydrogeological model were completed in two phases. Within the first phase of the model, the dynamics of the aquifer in current exploitation conditions was simulated. The aim of this simulation was obtaining piezometric levels that match the conditions of July and August 2002, and their accordance with the measured data. The hydrogeological model of the current state, as a result of the first phase, has served as a beginning model when completing the second phase model, or rather, simulation of the aquifer dynamics when exploiting 1000 l/s. Having in mind that an adequate accordance between the measures and piezometric levels obtained through the mathematical model was achieved; this model can serve as a simulation for the aquifer dynamics in different exploitation conditions.

## DETERMINING THE SANITARY PROTECTION ZONE OF THE PANCEVO SOURCE

Although it wasn’t required by the Rulebook of the time, when determining the sanitary protection zone of the Pančevo source, other parameters of the environment were taken into account, and not only the distance of the zone border to the water intake structure. The lack of an adequate Serbian law regulation conditioned the use of foreign experiences in this problem. For defining the sanitary protection zone, time of travel data was used (TOT) of the ideal particle from the recharge area to the exploitation wells themselves or the complete source, defined by the U.S. Environmental Protection Agency – EPA. As an example of the law regulations in this area in countries from the region, the “National program of groundwater protection in Hungary” was used.

Determining the sanitary protection zones of the Pančevo source was completed based on general hydrogeological, geomorphological, hydrological conditions, the geological-hydrogeological mathematic model, as well as based on the sanitary protection zones defined by EPA. The inner area of sanitary protection was defined for all three sources separately, for: "Sibnica", "Filter" and "Gradska šuma” as presented in figure 3. The inner sanitary protection zone for the “Sibnica” source was determined based on the time of travel of the ideal particle, lasting 250 days. The inner sanitary protection zone for the “Filter” source is somewhat wider in relation to the time of travel of the ideal particle lasting 250 days, so it spreads to the embankment in the east and to the Pančevo-Belgrade road in the west. A part of this inner belt is inside a zone of the constant pollution of an unhygienic settlement. The inner zone of sanitary protection of the new “Gradska šuma source” is bordered by embankments, which naturally represent border lines of the inner sanitary protection zone.

For the exact definition of the wider sanitary protection zone, a map with isochrones for 1000 l/s exploitation was used, while we took isochrones 5 years in the north and 50 years in the east and west Fig. 3 [3].

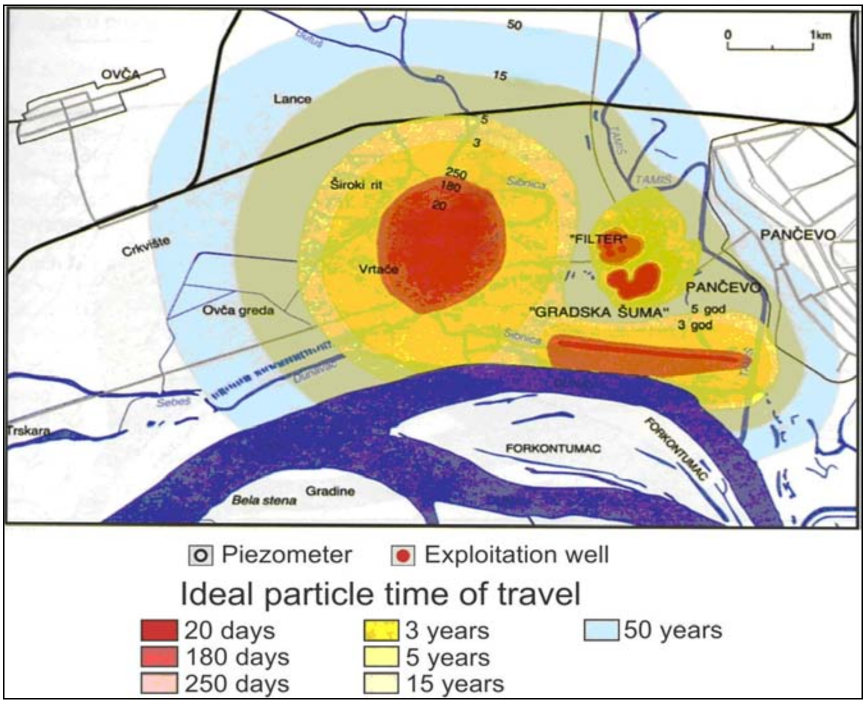


Figure 3. Map of the isochrones of Pančevo’s groundwater: "Sibnica", "Filter" and "Gradska šuma" (exploitation 1 000 l/s)

However, to limit the area of the wider sanitary protection zone having only these isochrones in mind is not enough without viewing the hydrogeological, geomorphological and hydrological conditions within the source itself and its surroundings. Due to this, the wider sanitary protection zone encompasses a somewhat greater area Fig. 4. The eastern border of the wider sanitary protection zone is represented by the Tamiš river, the southern by the Danube and the western by an imagined line that follows the local road from the railway to the highway, cuts the Sebeš channel and goes along the Danube. The northern border is located approximately 100m north of the Pančevo – Belgrade railroad and follows the tracks.

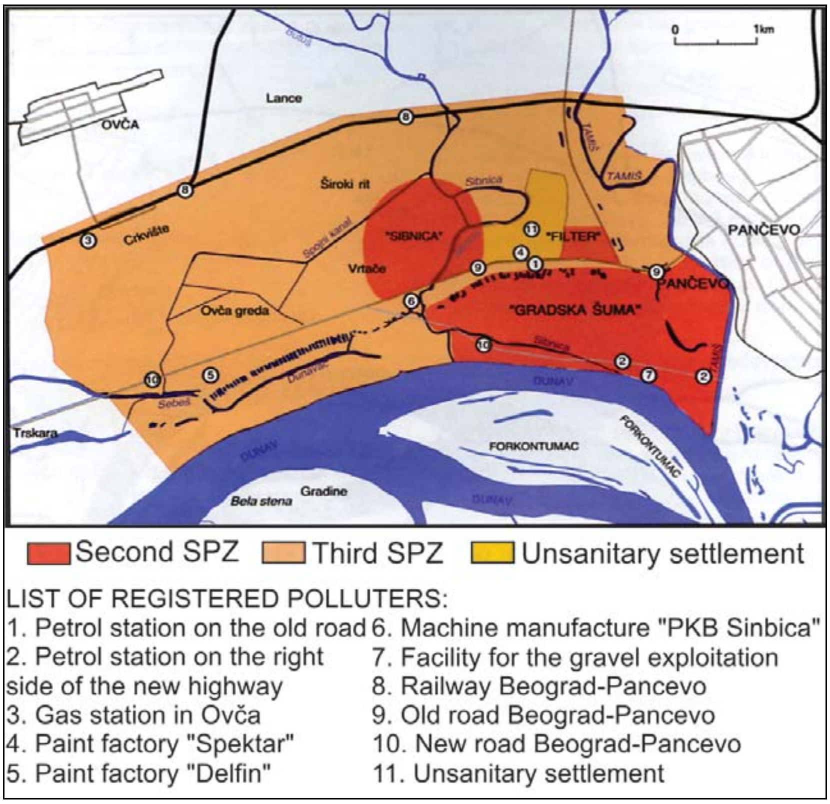


Figure 4. Sanitary protection zone of the Pančevo source

## NEW RULEBOOK ABOUT GROUNDWATER SOURCE SANITARY PROTECTION ZONES FOR WATER SUPPLY

The need for improving the law regulations in this area and the complete adaptation of our law regulations with EU standards have led to the accepting of a new Rulebook about the method of determining and maintaining sanitary protection zones for water supply ("Official gazette RS, no. 92/2008) [4].

The new rulebook, beside the distance of the water intake structure from the protection zone, takes into consideration the time of filtration that the water spends underground. As an important factor of soil and groundwater interaction, and groundwater self-purification, the hydrogeological environment is analyzed. Through the specificity of all of the environments; karst, fracture and intergranularly porous environments are treated separately. The time of infiltrated water propagation for the second zone of sanitary protection in a porous environment of an intergranulary type takes up 50 days, while it takes one day in a porous environment of a karst-fracture type. In conditions of an aquifer under pressure, or the existence of a protective layer that neutralizes the impact of pollutants from the surface of the terrain, the second zone is based on the second, and the third on the second. On the other hand, areas of high water intake, such as sink-holes, chasms and faults as very vulnerable are placed in the first zone of sanitary protection.

Without entering individual clauses of this Rulebook, it can be said that its arrival, the law regulations in the area of groundwater protection for water supply have been notably improved and that they are completely in accordance with the recommendations and valid rulebooks of the EU in this area. On the other hand, the question of the possibility of applying these new rules on existing sources, which have been functioning for years, is posed.

## CONCLUSION

Accepting the directives and recommendations of the EU has resulted in bringing new laws in the area of environmental protection and managing natural resources. The Rulebook about sanitary protection zones of water supply sources has been significantly improved in regards to the old one. It reflects the knowledge stemmed from practice to date, and has been completed with regards to valid rulebooks of other countries.

Beside the great improvement in view of bettering regulations, engineers still encounter the same problems. The development of industry and the spread of cities are commonly obstacles to a throughout implementation of the laws in this area. Beside that, the combination of conditions that are present at the source itself, as well as all the other factors that directly or indirectly impact it, make every case different, which further implies the necessity for new, unique solutions.

The example of the Pančevo source, although completed before the application of the new Rulebook, is an example of good practice and a correct approach to solving the problem of determining sanitary protection zones of water supply sources. Today, this task is greatly eased for hydrogeological experts, having the improvement of regulations in mind, but still requires their engagement in all phases of projecting, performing and completing source monitoring.

Generally, the laws and regulations in all areas, are mostly adapted to EU standards, but that is only part of the work. Their future implementation and work on the remediation of past bad practice is a more difficult task. Having that in mind, including hydrogeological experts in all phases of projecting, completing and monitoring sources may be more important than "blindly" following the new regulations. In the transition period, accepting new laws, example of the Pančevo groundwater source, indicates that finding the optimal solution lies in combining experience and expertise. A pure implementation of laws, without adaptation to specific situation, is almost impossible when the specificity of each individual case is kept in mind.

Urbanization and industrialization are inescapable in the time we live in, while at the same time the necessity for environmental and natural resources imposes itself. The environment and all of the activities within it should be regarded as dynamic processes and followed, through adequate monitoring systems, in the aim of solution optimization and preventing excess situations.

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