Conception to set up a new groundwater monitoring network in Serbia

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Abstract2. The Water Framework Directive of the European Union (WFD) adopted in year 2000, outlines number of water policy and management actions, where monitoring is of primary importance. Following WFD principles Serbia adopted new legislation in water sector aiming to conserve or achieve good ecological, chemical and quantitative status of water resources. Serbia, as most of the countries of former Yugoslavia mostly uses groundwater for drinking water supply (over 75%). However, the current situation in monitoring of groundwater quality and quantity is far from satisfactory. Several hundred piezometers for observation of groundwater level under auspices of the Hydrometeorological Service of Serbia are located mostly in alluviums of major rivers, while some 70 piezometers are used by the Serbian Environmental Protection Agency for controlling groundwater quality.Currently only 20% of delineated groundwater bodies are under observation. This paper evaluates current conditions and proposes to expand national monitoring network to cover most of groundwater bodies or their groups, to raise number of observation points to a density of ca. 1 object /200 km² and to include as much as possible actual waterworks in this network. Priority in selecting sites for new observation piezometers or springs has to be given to groundwater bodies under threats, either to their water reserves or their water chemical quality. For the former, an assessment of available renewable reserves versus exploitation capacity is needed, while to estimate pressures on water quality, the best way is to compare aquifers’ vulnerability against anthropogenic (diffuse and punctual) hazards.

Key words: monitoring, groundwater, „good“ status, EU Water Framework Directive, Serbia.

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Introduction

The complex geology of Serbia and adjacent areas has produced hydrogeological heterogeneity and considerable variety in aquifer systems and groundwater distribution. The area is characterized by both, the presence of formations with small groundwater reserve (Paleozoic formations, magmatic and metamorphic rocks, Jurassic and Cretaceous flysch or deeper and thick sedimentary complexes), as well as Mesozoic carbonate rocks, and Tertiary or Quaternary alluvial and terrace deposits which can be very rich in groundwater. Serbia is therefore a relatively rich in groundwater reserves, deposited in different aquifer systems, but unequally distributed along the territory. The major groundwater reserves are accumulated in thick Quaternary and Neogene intergranular aquifers and in karstic aquifers which dominate in south-western and eastern regions of Serbia (STEVANOVIC 1995). Alluvial aquifers of large rivers (the Danube, Sava, Velika Morava and Drina) are particularly important and widely used for drinking water supply. Roughly 90% of the population has access to the public water supply, while some 75% of water for public water supply is abstracted from groundwater resources. In some areas, currently tapped resources are unable to quantitatively meet the population’s water demand. However, there are other considerable groundwater resources especially in alluvium of large rivers or in karstic aquifers which are still under-exploited. Artificial recharge is also not used to a large extent: Only around 1 m³/s of water is delivered by such sources, which represents less than 5% of the estimated prospect (DIMKIC et al. 2011).

Most resources deliver a good natural groundwater quality. The main exception is the northern Serbian province of Vojvodina where thick Pleistocene and Neogene sediments of the Pannonian basin formed sub-artesian aquifers. The organic material has been deposited in the natural sediments, and groundwater is frequently loaded with organic substances and ammonia, occasionally, also arsenic or boron.

Although large groundwater consumer Serbia is not properly organizes monitoring of groundwater quality and quantity. Situation is not very different in other countries of former Yugoslavia with exception of those which already become EU members. The obligations of Serbia and steps to be taken to achieve EU standards in environmental sector and particularly requirements of Water Framework Directive (WFD, 60/2000) should definitely include reorganization of current Monitoring network and strengthening of technical capacity of responsible institutions.

History of the existing hydrological network and groundwater monitoring

Systematic groundwater monitoring in Serbia began immediately after World War II. Network of groundwater monitoring stations were set up in 1947, under a decision of the Federal Administration of the Hydrometeorological Service of the Federal People’s Republic of Yugoslavia. In 1948, groundwater monitoring was initiated at 41 stations and as early as 1950, the number of stations grew to 233 and then in 1960 to 279. Unfortunately, some of the stations were shut down and abandoned from 1961 and 1990, such that in 1990, there were only 201 piezometers in place. However, after 1990, the Republic Hydrometeorological Service of Serbia (RHMS) placed increasing emphasis on groundwater monitoring. The number of restored and new piezometers grew and doubled by 2014. When the number of monitoring stations was 409 (Fig. 1). Groundwater levels and temperatures had been measured since the very beginning but groundwater sampling for analyses began in 1968, at 35 stations (piezometers). The number of stations has varied since 1969, from as low as 34 to a maximum of 84 (KOCIC 2004; NIKOLIC et al. 2012).

Fig. 1. Number of groundwater monitoring stations in Serbia after WW II.
of Kosovo & Metohija and Vojvodina. Figure 2 shows the distribution, along with the numbers and categories of stations.

Apart from monitoring groundwater that occurs in aquifers of the intergranular porosity type, regardless of the significance of the groundwater reserves, very little or no monitoring has been undertaken to date of the other types of aquifers (above all karstic aquifers). For instance, Vrelo Mlave (the source of the Mlava River) was the first karst spring where water level regime monitoring was started in 1949, at the Žagubica Station. Hydrometric surveys to determine the discharge rates of the spring began at that station in 1966, and monitoring and surveys of this spring have continued to the present.

In the mid-1990s, discharge measurements were made at 19 karst springs, but as part of only one or not more than two hydrometric survey campaigns. These springs included among others: Banja Spring (Rakova Bara), Krupaja Spring (Milanovac), Lešje Spring, Petnica Spring, Gradac Spring, Andrić Spring (Ravni), Tolišnica Spring, Gostilje Spring, Vapa Spring, Veliko vrelo (Strmosten) (ŠTEVANOVIĆ et al. 2012b). Unfortunately, monitoring of these springs was mostly cancelled in period 2004–2006.

Out of RHMS programme, monitoring of groundwater is also undertaken at city level, and source level (waterworks), as well as in a portion of riparian lands of the Danube, Sava, and Tisa rivers which are within the backwater zone of the Djerdap dam (Iron Gate Dam constructed at Danube). The late Monitoring programme was put in place in 1977, to record the effects of the Danube’s impoundment on the groundwater regime, to assess the effectiveness of drainage systems (new, reconstructed and non-reconstructed), to improve their operating modes, and to determine

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**GROUNDWATER NETWORK STATIONS**

In 2008 groundwater regime monitoring was performed on a total of 415 stations within 13 areas:

1. **VELIKA MORAVA** – 1 main station - 70 stations of the first level - 21 stations of the second level
2. **ZAPADNA MORAVA** – 1 main station - 7 stations of the first level - 12 stations of the second level
3. **JUŽNA MORAVA** – 1 main station - 15 stations of the first level - 18 stations of the second level
4. **VETERNICA** – 7 stations of the second level
5. **KOLUBARA** – 12 stations of the first level - 13 stations of the second level
6. **MLAVA** – 4 stations of the second level
7. **MACVA** – 1 main station - 16 stations of the first level - 31 stations of the second level
8. **PANCEVACKI RIT** – 3 stations of the second level
9. **METOHJA** – 9 stations of the second level
10. **PODUNAVLJE** – 1 main station - 4 stations of the second level
11. **BACKA** – 28 stations of the first level - 23 stations of the second level
12. **BANAT** – 46 stations of the first level - 38 stations of the second level
13. **SREM** – 14 stations of the first level - 10 stations of the second level

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Fig. 2. Network of groundwater monitoring stations of Serbia.
the need for and undertake timely interventions to protect the area. More than 700 piezometers were monitored during the past decades in order to define the groundwater regime and assess the Djerdap dam backwater impact on riparian lands (Đimkić et al. 2011).

Fig. 3. Distribution of piezometers in groundwater bodies of Serbia.
EU Water Framework Directive and Serbia’s implementation tasks

In October 2000, the European Parliament and the Council of the European Union adopted the Water Framework Directive (WFD, 2000/60/EC). In this directive, the European Union modified its previous approaches to recommend control of only heavy and specific pollutants such as nitrates, and established a new long-term strategy in the water sector. The WFD is founded upon the management of water resources at a river basin level. It identifies the conditions that are expected to ensure the implementation of sustainable water use and water protection, while its ultimate goal is to achieve “good status” of all natural water resources, or to ensure good chemical and ecological status of ground, and surface waters, respectively. The main EU objectives set forth in the WFD are:

- Comprehensive protection of all water resources;
- Good status of all water resources;
- Integrated river basin management;
- “Combined approach”;
- Appropriate water pricing; and
- Public participation.


The WFD outlines the water strategy action that needs to be taken, where monitoring is of primary importance (ŠTEVANOVIĆ & VUČETIĆ 2006, QUEVAUVIL LER 2008). Serbia adopted the Regulation on the Designation of Surface Water and Groundwater Bodies in order to conserve or achieve good ecological, chemical and quantitative status of groundwater resources. A body of groundwater designated within a geological formation was taken as the basis for groundwater monitoring, or the smallest unit for monitoring network planning (UNITED KINGDOM TECHNICAL ADVISORY GROUP 2005a). All designated groundwater bodies (GWBS) have been classified as intergranular, karstic or fractured groundwater bodies. Following detailed analyses and several delineation stages, the initial number of GWBS of 208 (ĐURIĆ et al. 2004), was ultimately reduced to 153 (OG 96/2010). This was the first step towards WFD implementation concerning groundwater management.

Spatial distribution of monitoring objects – piezometers on delineated GWBS is shown on figure 3. The list of GWBS with established monitoring is presented in Table 1. It can be concluded that only 34 out of 153 or around 20% of all GWBS, have continual observation of groundwater table. The figures 4a and 4b present percentage of GWBS with number of observation points per 100 km². As an example 9% of GWBS has 5 or more observation points per 100 km². In contrast, 13 GWBS or 38% has between 0.5 to 0.177 piezometers per 100 km². This is equal to density of 1 object per 200 km² and 500 km², respectively (Fig. 5).

The figure 6 shows positions of the springs which were included in the observation by RHMS for certain period of time.

The next important step in implementation of WFD was GWB characterization, which allowed for the integration into groups of GWBS. The characterization included the determination/description and quantification of geological and hydrogeological conditions, particularly the geometry of the GWBS, the nature of the aquifer roof and floor, the rate of water exchange, and the dependence of terrestrial ecosystems on infiltrated or discharged groundwater (UNITED KINGDOM TECHNICAL ADVISORY GROUP 2005b). The focus was on chemical quality pressures—diffuse and point sources of pollution, as well as quantity pressures—abstraction rates and artificial recharge, if any (ŠTEVANOVIĆ 2011). The WFD introduced surveillance monitoring and operational monitoring, depending on the nature of groundwater pressures. Operational monitoring requires a higher monitoring frequency and surveying of specific components, critical to water quality.

In the WFD, the groundwater level is the main parameter that defines the quantitative status. There is no exact limit, but it needs to ensure that long-term use will not threaten the available groundwater resource, that the environmental objectives of associated surface water bodies will be achieved and that there will be no threat to terrestrial ecosystems. Given that there was some doubt as to what over-exploitation means and when it occurs (CUSTODIO 1992; BURKE & MOENCH 2000), it was necessary to stay within relative categories. The problem with determining the chemical status is that maximum permissible concentrations have not been defined, except for a few parameters. To achieve objectives, if good status cannot be restored or attained, then the chemical status must be at least that which existed before applicable legislation was adopted, or before its implementation began.

RHMS has transferred its duties related to groundwater quality monitoring by means of piezometers to
Table 1. Groundwater bodies under systematic observation and actual number of piezometers.

<table>
<thead>
<tr>
<th>No</th>
<th>Groundwater body - GWB</th>
<th>Area F (km²)</th>
<th>Number N'</th>
<th>Number N''</th>
<th>N' / F</th>
<th>N'' / F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severozapadna Bačka - top aquifer</td>
<td>1232.43</td>
<td>5</td>
<td>1</td>
<td>246</td>
<td>1232</td>
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<tr>
<td>2</td>
<td>Telečka - top aquifer</td>
<td>2643.55</td>
<td>11</td>
<td>3</td>
<td>240</td>
<td>881</td>
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<tr>
<td>3</td>
<td>Gornja Tisa - top aquifer</td>
<td>1772.02</td>
<td>30</td>
<td>4</td>
<td>59</td>
<td>443</td>
</tr>
<tr>
<td>4</td>
<td>Severni Banat - top aquifer</td>
<td>1545.78</td>
<td>19</td>
<td>3</td>
<td>81</td>
<td>515</td>
</tr>
<tr>
<td>5</td>
<td>Srednja Bačka - top aquifer</td>
<td>2068.06</td>
<td>16</td>
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<td>129</td>
<td>689</td>
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<td>6</td>
<td>Donja Tisa - top aquifer</td>
<td>1099.78</td>
<td>5</td>
<td>1</td>
<td>220</td>
<td>1100</td>
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<tr>
<td>7</td>
<td>Srednji Banat - top aquifer</td>
<td>1013.72</td>
<td>3</td>
<td>0</td>
<td>338</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Jugozapadni Banat - top aquifer</td>
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<td>2</td>
<td>139</td>
<td>1114</td>
</tr>
<tr>
<td>9</td>
<td>Vršačke planine</td>
<td>257.63</td>
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<td>1</td>
<td>129</td>
<td>258</td>
</tr>
<tr>
<td>10</td>
<td>Jugostočni Banat - top aquifer</td>
<td>2298.93</td>
<td>25</td>
<td>3</td>
<td>92</td>
<td>766</td>
</tr>
<tr>
<td>11</td>
<td>Beograd right bank of Sava</td>
<td>179.68</td>
<td>7</td>
<td>2</td>
<td>26</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>Pančevački rit</td>
<td>413.74</td>
<td>4</td>
<td>1</td>
<td>103</td>
<td>414</td>
</tr>
<tr>
<td>13</td>
<td>Negotin Kladovo - alluvium</td>
<td>462.86</td>
<td>4</td>
<td>1</td>
<td>116</td>
<td>463</td>
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<tr>
<td>14</td>
<td>Kličevac</td>
<td>604.28</td>
<td>4</td>
<td>1</td>
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<tr>
<td>15</td>
<td>Kostolac</td>
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<td>4</td>
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<td>16</td>
<td>Kučaj i Beljanica</td>
<td>726.52</td>
<td>2</td>
<td>2</td>
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<td>17</td>
<td>Velika Morava alluvium left bank</td>
<td>468.26</td>
<td>27</td>
<td>3</td>
<td>17</td>
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<tr>
<td>18</td>
<td>Velika Morava alluvium right bank</td>
<td>429.31</td>
<td>28</td>
<td>3</td>
<td>15</td>
<td>143</td>
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<tr>
<td>19</td>
<td>Levač</td>
<td>718.98</td>
<td>2</td>
<td>1</td>
<td>359</td>
<td>719</td>
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<td>20</td>
<td>Velika Morava Neogene - south</td>
<td>1321.17</td>
<td>38</td>
<td>3</td>
<td>35</td>
<td>440</td>
</tr>
<tr>
<td>21</td>
<td>Kučaj - west</td>
<td>288.06</td>
<td>1</td>
<td>1</td>
<td>288</td>
<td>288</td>
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<tr>
<td>22</td>
<td>Južna Morava Neogene - north</td>
<td>1153.38</td>
<td>21</td>
<td>3</td>
<td>55</td>
<td>384</td>
</tr>
<tr>
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<td>Leskovac - Neogene</td>
<td>914.31</td>
<td>22</td>
<td>2</td>
<td>42</td>
<td>457</td>
</tr>
<tr>
<td>24</td>
<td>Rasina</td>
<td>497.41</td>
<td>1</td>
<td>1</td>
<td>497</td>
<td>497</td>
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<tr>
<td>25</td>
<td>Zapadna Morava - alluvium</td>
<td>588.04</td>
<td>21</td>
<td>3</td>
<td>28</td>
<td>196</td>
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<tr>
<td>26</td>
<td>Mačva Basic water bearing layer</td>
<td>763.41</td>
<td>40</td>
<td>3</td>
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<td>254</td>
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<tr>
<td>27</td>
<td>Kolubara - Neogene</td>
<td>656.57</td>
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<td>4</td>
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<td>164</td>
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<tr>
<td>28</td>
<td>Valjevo</td>
<td>542.81</td>
<td>6</td>
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<td>29</td>
<td>Lelić - karst</td>
<td>306.83</td>
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<td>1</td>
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<tr>
<td>30</td>
<td>Ljig</td>
<td>565.82</td>
<td>1</td>
<td>1</td>
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<td>Loznik polje</td>
<td>243.88</td>
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<td>2</td>
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<td>Povlen</td>
<td>322.37</td>
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<td>33</td>
<td>Zapadni Srem - Pliocene</td>
<td>1172.92</td>
<td>11</td>
<td>2</td>
<td>107</td>
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<td>Istočni Srem - Pliocene</td>
<td>2248.99</td>
<td>10</td>
<td>1</td>
<td>225</td>
<td>2249</td>
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</table>

Total 32755.06 409 34

Note:
* - total number of piezometers for groundwater table observation
** - total number of piezometers for groundwater quality observation

Fig. 4. a, Distribution of GWBs without or with piezometers and density (1 object per X km²); b, Percentage of GWBs with number of piezometers per 100 km².
Fig. 5. Groundwater bodies which possess some monitoring boreholes (piezometers) and their density per 100 km².
Fig. 6. Groundwater bodies in which some karstic springs were temporarily observed by RHMS.
Fig. 7. Distribution of piezometers used for groundwater quality observation.
the Serbian Environmental Protection Agency (SEPA). In 2013, this network included 70 piezometers, while analyses comprise the determination of 66 physical, chemical and biological parameters. SEPA has been reporting to the public via its website and also to the European Environment Information and Observation Network (EIONET). Spatial distribution of piezometers which are used for groundwater quality observation, is shown on figure 7.

Criteria and conditions for Serbia’s new groundwater monitoring network

In most of European countries, the density of water quality monitoring networks is lower than that of the networks that monitor groundwater level fluctuations. The main reasons lie in operating expenses (costly analyses) and the feasibility of collecting information from other entities (water users) in an organized manner. The network density is also a result of numerous other factors, such as the size of the country, assessed aquifer vulnerability to pollution, and population density. The effect of population density is, for example, apparent in Finland and the Netherlands. In sparsely populated Finland there are only 0.02 monitoring stations per 100km², while in the densely populated Netherlands, where groundwater is the main drinking water resource, there is one monitoring station on average per 10km² (Števanović 2011).

Monitoring of groundwater quality and quantity is a highly complex task and an obligation according to the WFD. However, considerable financial resources are needed to implement the WFD (Foster & McDonald 2014). For Example, Austria spends about 2 million € every year and Hungary as much as 4 million € solely on routine groundwater regime monitoring. Countries are also allowed to specify lower objectives for certain groundwater bodies, as needed, if the achievement of good status is not possible without major spending. Consequently, if an efficient approach is followed and if, for example, the obligations of water supply operators and other users are regulated, the water regime database can be substantially enlarged (Števanović 2011).

A number of strategic hydrogeological projects implemented from 2007 to 2001, including “Groundwater Monitoring” (Grupa Autora 2010) have been major contributors to the improved knowledge of groundwater resources and the initial steps towards the establishment of a new monitoring network (Števanović et al. 2012a; Milanović et al. 2014). One GWB has been selected per aquifer type and experts from the University of Belgrade-Faculty of Mining and Geology, the Jaroslav Černi Institute for the Development of Water Resources and the Serbian Geological Survey were commissioned to implement pilot monitoring projects following WFD principles. Unfortunately, funding ceased in the final stages of the projects, such that the proposal of a new monitoring network has been postponed.

Given Serbia’s circumstances (size, complex geology, hydrogeological conditions), it is believed that at least one groundwater monitoring station per 200 km² is needed. This means a total of 400–500 objects in function. This number is close to the existing number of monitoring stations, at least with regard to groundwater quantity, but the way they are currently deployed is inadequate. Only the so-called “top aquifers” (i.e. alluviums of the largest rivers) are monitored. Systematic monitoring has to be the basis for proper GWB characterization and protection from potential polluters and accidental pollution.

Finally, a new monitoring network has to be gradually built. The target for its completion should be the year 2027. In order to get feasible and non-expensive network the existing waterworks and companies that got concessions for water extraction, must be obliged to fulfill their obligations to regularly observe discharges, water tables and chemistry of tapped springs and wells and to deliver this data to responsible authorities. As such, the number of regularly observed water points would increase along with network density. However, certain number of new boreholes would be required as many of GWBs do not have any intakes. In addition to, for objective assessment some piezometers have to be located outside radius of extraction wells used by waterworks.

As set up of monitoring network will rise in stages, prioritization in selection of monitoring sites should be given to GWBs under already recognized pressures. In term of pressure to groundwater quantity, an assessment of available renewable reserves versus exploitation capacity would be needed for each of GWB. When pressures to groundwater quality are considered, the best way for realistic assessment would be to compare aquifers’ vulnerability against anthropogenic (diffuse and punctual) hazards. In Serbia, the aquifer vulnerability map in scale 1:500,000 has already been completed under above-mentioned project “Groundwater Monitoring” (Fig. 8).

For regional analysis of diffuse hazards the Corine Land Cover Map (EEA, 2006) can be very useful, while SEPA’s data on pollutants and their distribution and loads can be used for an assessment of punctual (point) pressure.

Conclusion

Consistent WFD implementation and the setting up of a new groundwater monitoring network in Serbia are extremely important for improving knowledge about groundwater resources and their active protection. As an EU member-candidate, Serbia declared its commitment to the WFD back in 2003, but primarily a lack of funds and still unregulated water user obliga-
Conception to set up a new groundwater monitoring network in Serbia

Fig. 8. Groundwater Vulnerability Map of Serbia (Milanović et al. 2010).

tions have lead to an unsatisfactory state of affairs in the monitoring of groundwater resources, which for the most part support drinking water supplies and are used by some 75% of Serbia’s population.
Despite the fact that groundwater level regimes are monitored by more than 400 special-purpose piezometers in Serbia, nearly all of them have been deployed in the same type of alluvial aquifer, where groundwater levels are largely a reflection of river stages (which are also monitored). This is certainly a departure from hydrogeological “logic” and from the preferred approach to national groundwater monitoring, which needs to include all types of aquifers. As such, phreatic (“top”) aquifers in Serbia’s geological circumstances need to include aquifers in mountainous regions (e.g. karst aquifers are found in more than 30% of western and eastern Serbia), which have virtually not been monitored to date. Consequently, RHMS’s concern for aquifers in the alluviums of large rivers, evident from the facts on the ground, needs to be (re)defined. The best solution would be to entrust the setting up of a monitoring service for other types of aquifers and the monitoring task itself to the Serbian Geological Survey. Strictly applied regulations to waterworks and concessionaires to measure and provide data on groundwater quantity and quality would relax needed investment in operation and maintenance of the new Monitoring network.

A new and efficient monitoring network, which covers all, or most of GWBs and all major tapped aquifers (not only alluvial, as at present), determined on the basis of hydrogeological exploration, and systematic groundwater quality and quantity data collection with active involvement of water users, are both national needs and obligations. Proposal is to reach relaxation needed investment in operation and maintenance of the new Monitoring network.

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**References**


Резиме

Концепт формирања нове мреже за мониторинг подземних вода у Србији


Директива посвећена је подземним водама и преузима њихову управу у оквиру Водног рамка да би осигурало рационалну употребу вода и последици њених полагања. Оквирна директива стоји најближе целој намени према усвојеном амбициозном императиву "добрих" услова градње подземних водених система.

Измењени су законски прописи и донет нови За-
кон о водама (2010), извршена су делинеације и
преминарне анализе водних тела подземних во-
da (ПВТ) као основних јединица за планирање
осматрачке мреже, а у припреми су и планови
управљања речним сливовима.

Након спроведених детаљних анализа као и ви-
ше фаза рада на делинеацији, утврђен је број од
153 ПВТ у Србији (сл. 3). Други важан корак је тзв.
характеризација водних тела, која подразумева
одређивање – опис и квантификацију геолошких,
хидрогеолошких услова терена, посебно геоме-
трије водног тела, карактера повлаче и подине, бр-
зине водозамене, зависности еко система на повр-
шини терена од инфилтрираних или истеклих под-
земних вода. Посебно се разматрају притисци у на-
хијски квалитет – дифузни и концентрисани из-
вори загађивања, као и притисци на квантитет –
обим експлоатације, и уколико постоји и вештачко
прихрањивање.

Анализа указује да је у 2015. години само на не-
што више од 20% ПВТ успостављена одговарају-
ћа осматрачка мрежа. Тачније, само на 34 од укупно
153 издвојена водна тела постоје пијезометри за
праћење нивоа подземних вода. Девет ПВТ има 5
или више осматрачких објеката на 100 km² (сл.4).
Укупно 13 водних тела (или 38%) има 0.5 до 0.177
пијезометра на 100 km² што би дакле одговарало
густини од једног објекта на 200 km², односно 500
km² површине територије (сл. 5,6).

Који су неопходни кораци за проширење мреже
и како је погустити? Први услов за испуњавање
ове обавезе у процесу даљег придруживања ЕУ
(област Животна средина) је обезбеђивање сред-
става за рад РХМЗ и САЖС како би повећали број
објеката (сл.7), спровели истраживачки монито-
ринг и успоставили потребну фреквенцију осма-
трања параметра квантитета и квалитета подзем-
них вода. Такође, стриктним спровођењем већ
прописаних обавеза постојећих водоводима или
другим корисницима да врше осматрања и податке
dостављају недлежним службама, може се обезбе-
dити значајан фонд допунских података о режиму
вода.

У нашим условима (површина територије, ком-
pлексна геологија, хидрогеолошки услови) сматра
се да би био потребан најмање један успоставље-
ни осматрачки пункт за праћење подземних вода
на сваких 200 km². То би значило да је потребан
брож од око 400–500 пунктов осматрања. Број
јесте приближан садашњем, бар када је у питању
режим квантитета, али је концентрација објеката
потпуно неадекватна и прате се само тзв. „праве
издане“, заправо алувијони највећих речних то-
кова. Континуиран мониторинг треба да буде
основа да се свако ПВТ адекватно окарактерише и
da се заштити од могућих потенцијалних и екцес-
них загађивача.

Нова мрежа се може и поступно развијати како
би до 2027. године била приближно комплетирана.
Приоритете за нове објекте би требало дефиниса-
tи на бази утврђених притисака који се могу оце-
nити на следећи начин:

Притисци на квантитет. Најбољи начин за
ову оцену је утврђивање односа експлоатисаних
количина у односу на обновљиве (природно и ве-
штачки) резерве подземних вода. Практични про-
блем може бити недостатак података о режиму
издашности или ослицинација нивоа, као и непоуз-
dаност података експлоатације. Билансне методе
су најпоследње за оцену величине обновљивих
ресурса.

Притисци на квалитет. Треба да буду базирани
на односу природне разновиности издани и ПВТ са
једне стране, и с друге стране хазарду присутном
из присуства дифузних и пунктуелних загађивача.
Резултат треба да буде израда карата ризика (према
dифузним и пунктуелним загађивачима) и она
треба да садржи класификацију нивоа ризика (са-
mим тим и притисака) услед антропогених
активности. Регионалне карте разновиности издани су
незаменљива подлога ових оцена (за територију
Србије ову карту у размери 1:500,000 је израдила
група аутора тзв. Стратешких пројеката реализова-
них у периоду 2007–2011, сл.8), док за карту дифу-
зног хазарда корисно може послужити
Corine land cover map
израђена од стране Европске агенције за
заштиту животне средине.

Подземне воде у Србији, као уосталом на целом
простору бивше СФРЈ, су основни извор пијаћег
снабдевања вода становништва (преко 75%).
Стога постоје и посебне обавезе државе и њених
институција, као и стручних и научних капацитета
у погледу њихове превентивне и систематске за-
штите, обезбеђивања алтернативних изворишта и
регулације постојећих у циљу повећања њиховог
капацитета, а у условима све већих притисака иззв-
званих антропогеним активностима и климатским
променама. За испуњење ових циљева, први и
основни услов је постојање података прикупље-
них систематским мониторингом квантитета и ква-
литета подземних вода.