Annals of Valahia University of Targoviste. Geographical Series (2017), **17**(1): 28-36
DOI: 10.1515/avutgs-2017-0003
ISSN (Print): 2393-1485, ISSN (Online): 2393-1493

WATER SUPPLY IN THE REPUBLIC OF SERBIA – STATE AND PERSPECTIVES

Marko Langovic, Vojislav Dedjanski
Faculty of Geography, University of Belgrade, Studentski trg 3/3, Belgrade, Serbia
E-mail: *markolangovic@yahoo.com, vojasd@gmail.com*

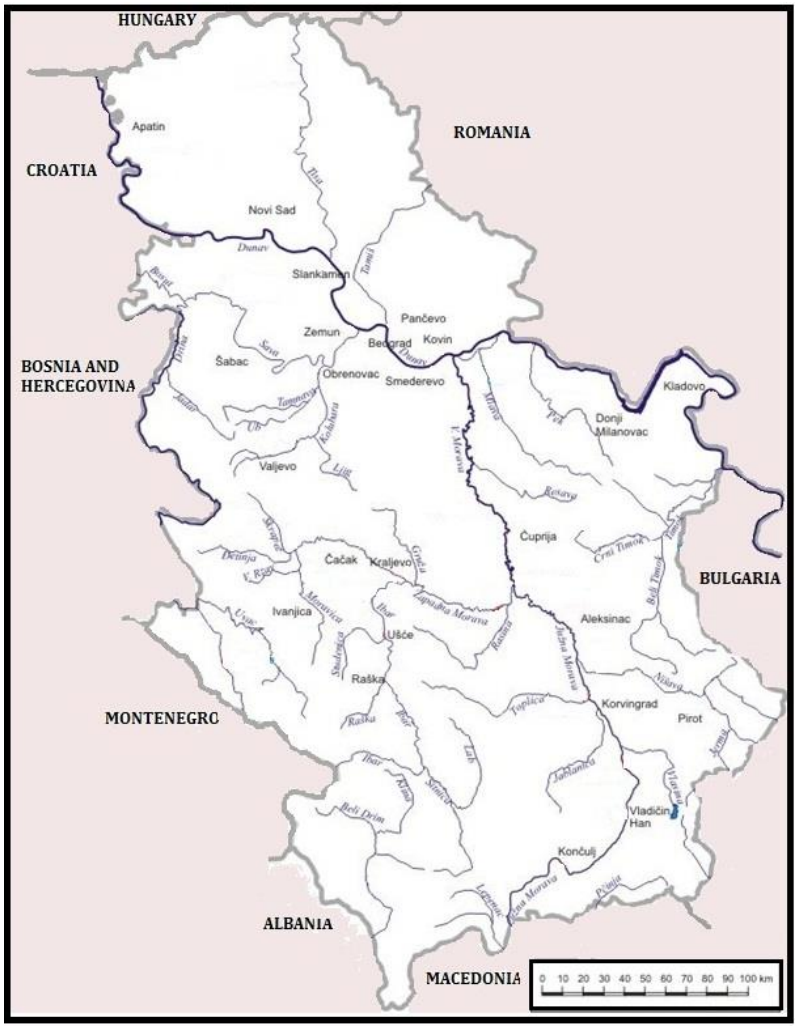
Abstract

Water supply has pronounced priority, over other forms of water use. The term water supply includes the ensure of high quality water in general terms, for households, public needs and economic activities. The Republic of Serbia disposes with considerable underground and surface water resources, which are used for supplying, but it is required their rational utilization. The aim of this study is to show the current state of water supply on the territory of Serbia based on the analysis of the different indicators. One of the goal is to scan prevalent conditions and problems related to it and to propose optimal solutions. The survey includes an explanation of the long – term needs of the Republic of Serbia for fresh water (as well as share of different sources in the total water supply) and estimation of the possibility of satisfying that needs from available resources. On the base of that, there are adopted conclusions about basic directions of further development in the field of water management and water supply in Serbia.
Keywords: water supply, Republic of Serbia, groundwater, accumulations, consumption

1. INTRODUCTION

Water supply represents the most important aspect of water use. Every year, million and a half of the world's population dies from preventable diseases caused by inadequate water supply. More than one billion people have difficulties to get to drinking water. In recent decades, a combination of climate changes, load accumulations, extensive droughts and increased human activities have resulted in increasing the problems connected with water use (Bladon et al, 2014). Drinking water has no alternatives; therefore, it is imperative to cleverly manage with available water resources and monitor the quality of surface water, which is used as a raw material for drinking water production (Takic et al., 2011). One of the current economic, existential and, in broader context, civilizational problem is lack of quality drinking water (Ristic, 2007). Access to safe drinking water has been important national goal in most of the developing countries (Hoque et al, 2006), also including Republic of Serbia. The term water supply includes supply of the fresh water for a community and population, through the delivery systems.

Common water supply of towns and villages is present on the territory of Serbia in the distant past (Rome, Byzantine, Serbia and Turkey). However, these technically very "*modern*" systems served the smaller part of the population (fortified cities, palaces, religious buildings), while the majority of people supplied individually from the immediate surroundings, locating their habitats along the water. Until the mid – nineteenth century, mentioned systems did not have a wider application. A high number of epidemics in Europe and Balkan countries had an impact on development of a common water supply of population. Only Belgrade and other biggest towns in Serbia had some form of public water supply. After First World War, some institutions and organizations had taken measures to improve situation of water supply – there has been eighteen settlements that used public water systems for supply (Institute of Water Management "Jaroslav Cerni", 2001).



Picture 1. Geographical position of the Republic of Serbia (Source: Authors)

After Second World War we have a new trend of growth of population that uses a public water supply system in all regions of Serbia (especially rapid trend in Central Serbia). This grow is connected with growing trend of population of Serbia in general, but also to modernization of supply systems in cities. The process that had very big impact on mentioned trend, were migrations "*village to city*" which become more pronounced. Growth rate of population (1948-1991) was 2.28%. Observed by time intervals, the standard consumption has a constantly growth. For example, for urban centers in Central Serbia it is changed from about 100 l/cons. per day in 1950, or 214 l/cons. per day in the 1963 to 460 l/cons. per day in 1991. Over the last few years there was stagnation in development in a significant number of municipalities. On the beginning of the 21st century Republic of Serbia is faced with the dilemma of sustainability of water supply systems. Runoff water (with basins on the territory of Serbia, including Kosovo and Metohija region) is only 181 mm effective precipitations per year and total inflow of water from the other countries is 1843 mm (Djordjevic, 1995).

The water supply of settlements is based on a strategic commitment to exploit the maximum sustainable local resources of ground and surface water, and that the lack of water has supplemented from the regional systems of water supply (Petkovic, 2004). The base of this conception is in use of surface water accumulations. Surface accumulations are formed in peak areas basins, in accordance with the following principles: suitable configuration of the terrain; low level of population density and urbanization; negligible level of pollution in the basin; appropriate water quality. For Vojvodina region, focus is on the exploitation of groundwater from deeper aquifers and alluvial springs.

Table 1. Freshwater resources (bilion m^3/year) in Serbia and countries in region

	Internal flow	External inflow	Freshwater resources
Serbia	12.8	162.6	175.4
Hungary	7.5	108.9	116.4
Bulgaria	17.6	89.1	106.7
Romania	39.4	2.9	42.3
Croatia	26.1	85.6	111.1

Source: Eurostat

Water resources refer to water available for use in a territory and include surface water and groundwater. Freshwater resources are calculated as the sum of internal flow and external inflow. If we look Table 1 we can conclude that Serbia has highest amount of freshwater resources in region. Also Serbia is one of the countries in Europe with the highest dependency on transborder water resources (ec.europa.eu) (92% are from external inflow).

Despite the great efforts made to build facilities and systems, the situation in the field of water supply is very unfavorable. The current consumption of drinking water is about one billion cubic meters per year. It is estimated that in the next twenty years, needs in these waters on the territory of Serbia will rise over two billion cubic meters per year. The development of water supply in the Republic of Serbia should move towards increasing provision to supply water to users and to improve the quality of water delivered. Given that the water needs to the fullest degree outgrown the ability of local water sources water supply, already formed the contours of the regional water supply system that will enable more reliable supply of water. On the one side, the large number of harmful substances had coming with the transit waters (Danube, Sava, Tisa rivers), and on the other, systems of water supply in Serbia had not been protected from pollution sufficient, which leads to many problems.

Necessary complex and expensive systems will not be possible to build without significant organizational and economic transformation of the entire municipal water management within the water, or without accepting the fact that drinking water should have its economic price. Therefore it is necessary, in line with modern approaches to the world, reformed institutions that take care of the water and provide greater involvement and influence public (Isailovic and Petkovic, 2009). Also, before construction of any water supply system, it is necessary to do environmental and economic evaluation (Calatrava and Garrido, 2005).

2. METHODS

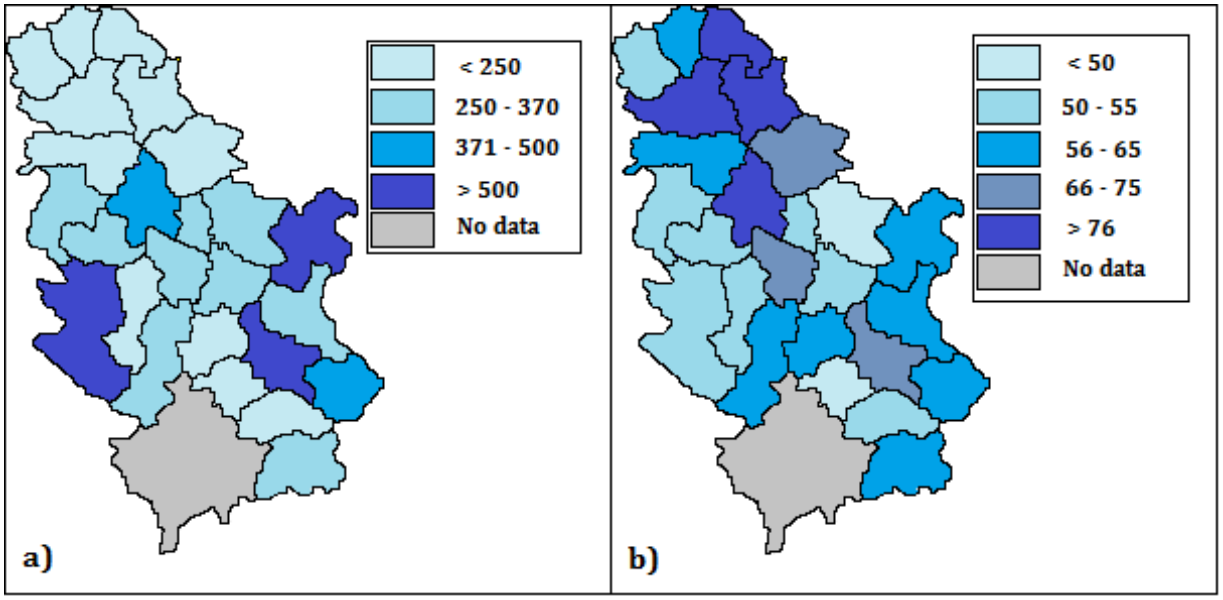
The quantity of water delivered and used for households, is an important aspect of domestic water supplies, which influences hygiene and therefore public health (World Health Organization, 2003). There are many indicators that represent states in water supply in one country, region and municipality. Main indicator is water consumption per consumers per year (specific consumption of water). It represents quotient of the total water consumed in households, institutions, public utilities and industries, and the total number of water consumers. With second indicator we can follow the number of population that is connected to public water supply in the relation to the total population. It is called "percentage of the population connected to public water". The data of volume of abstracted water that is used for water supply, are also significant for this thematic.

By using statistical program and method we can show a degree of correlation between two variables. The quantity r, called the linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables. The value of r is such that $-1 < r < +1$. The

+ and – signs are used for positive and negative linear correlations. If two variables have a strong positive linear correlation, r is close to +1, and otherwise. We also use coefficient of determination r^2, because it gives the proportion of the variance of one variable that is predictable from the other variable (www.mathbits.com). Other than statistical, we used cartographical and comparative methods to present changes that occur in the uses of different water sources for water supply in the Republic of Serbia, and in smaller administrative units – regions and districts.

3. RESULTS AND DISCUSION

Most important indicator of water consumption, ***specific consumption of water***, on the territory of Serbia has different values. Observed by districts, the range of specific consumption is very wide (Picture 2a). However, the mentioned indicator is difficult to determine for lower administrative levels, primarily because of the determination of this parameter (because part of the abstracted water goes to municipalities outside the district). The lowest values of this indicator have a region of Vojvodina (around 180 l/cons/day), Western Serbia and Sumadija (320,2 l/cons/day), Eastern and South Serbia (360 l/user/day) and Belgrade (480.5 l/user/day) (Statistical office of the Republic of Serbia, 2014). Only Region of Belgrade has a value higher than the average for the Republic of Serbia (without the Kosovo and Metohija). In all of the regions, it is expressed tendency of growing of consumption of water, per population per day, and it is higher than the European average. This tendency is based on the achieved levels of urbanization and industrialization. General specific consumption in all sectors depends on the economic structure, housing conditions and habits of the population.

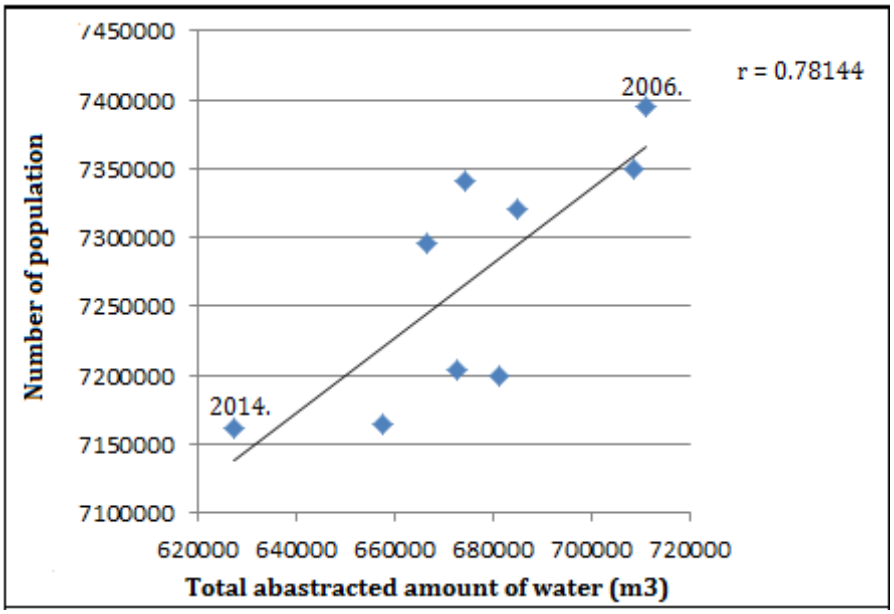


Picture 2. Water consumption per consumer per year (a) and percentage of the population connected to public water (b) by districts of Republic of Serbia in 2014. (Source: Authors - processed according to the data of the Statistical office of the Republic of Serbia, 2014)

The percentage of the population connected to public water is around 80% for the territory of Serbia. Districts that have highest percentage are Belgrade district, and Juznobacka district (with the center Novi Sad) – which are the most populated districts in Serbia (around 35% of total population of Serbia lives in these two districts). If we look at the Picture 2b, we will see that only four districts have this indicator higher than average. Because of the high concentration of population in these four districts, we have a high value of the indicator for the entire Serbia. This data show us fact that water supply infrastructure is most developed in mentioned districts. The

lowest value of those who use water from public water systems, have district where most of the people lives in rural areas (Branicevo, Toplica, Jablanica districts). These areas are characterized by depopulation, poor infrastructure and undeveloped economy sector.

Total abstracted amount of water (m³) for the territory of Serbia is 627, 2 million m^3 for the 2014 year. In last ten years the total abstracted amount of water has decreased by 13%. This decrease is correlated with number of population which is also characterized by decrease in the observed period. On the graph 1, we show correlation between these two variables (how strongly two variables are related to each other). Correlation coefficient is 0.78144, which show us that these two variables are positive correlated. On the graph is shown that the linear decline of one variable is corresponded to a linear decline of other variable. That type of correlation is known as "*positive, but not maximum correlation*". Analysing by regions we can see the similar decline trend of total abstracted amount of water for water supply (except in the case of region of Belgrade)

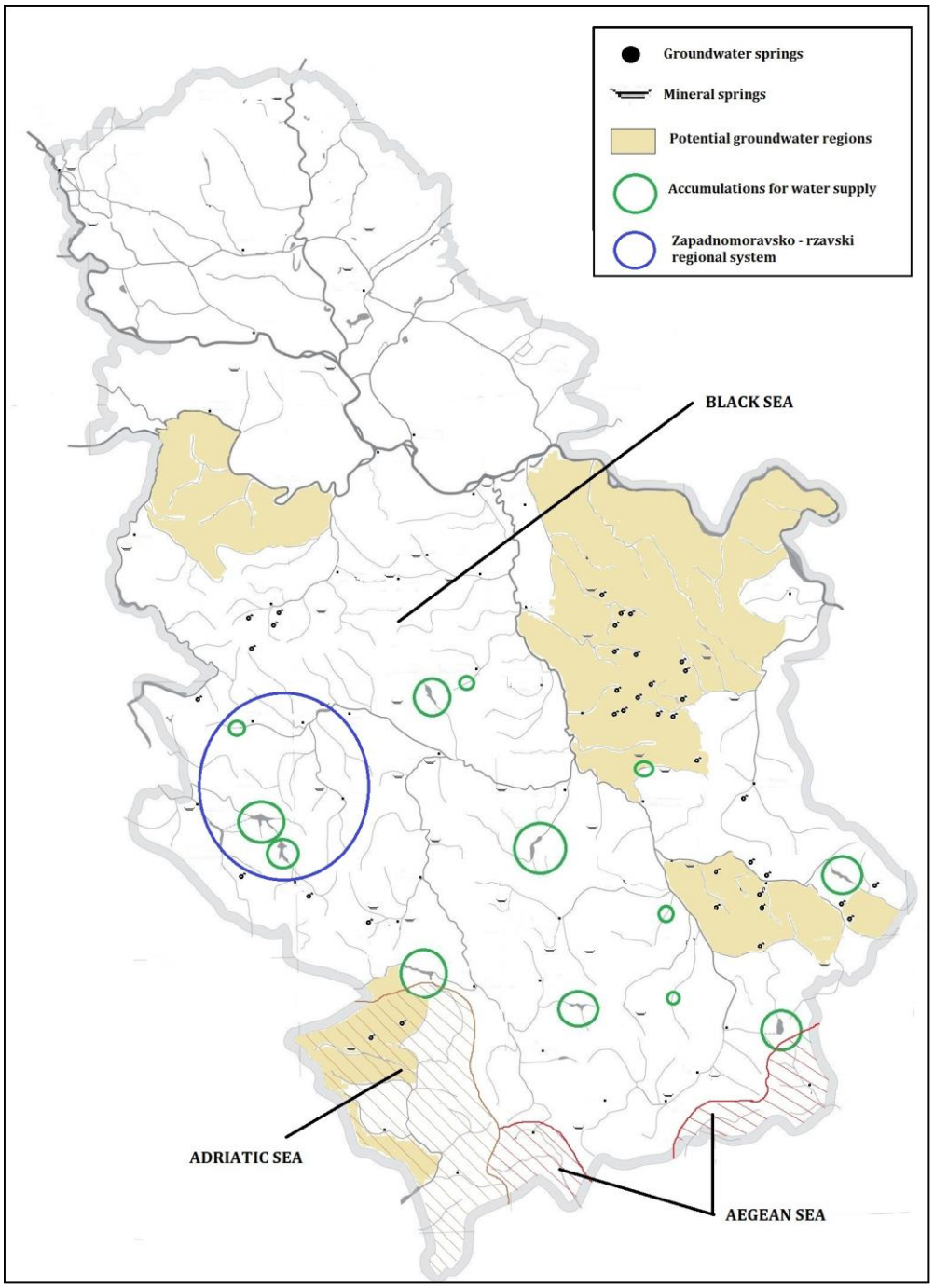


Graph 1. Corelation between total abstracted amount of water and population number (2006 -2014) (Source: Authors - processed according to the data of the Statistical office of the Republic of Serbia, 2014)

Groundwater and surface water represent two main sources of water supply of the Republic of Serbia. Surface waters are taken from a live flow or from reservoirs (accumulations), and underground waters are used from alluvial waters, karst waters, waters from aquifers, under the Neogene sediments and aquifers of fracture porosity (SEPA, 2015). The origin of abstracted water for public supply, in the period 1991 – 2012, shows that the prevailing exploitation of groundwater in Serbia is 2.5 times more than the surface water (Table 2). However most of the groundwater was prepared by infiltration of surface water. Total abstracted amount of groundwater for the public supply of population and industries is 18, 5 m^3/s in Serbia. The biggest part of the groundwater is abstracted from alluvial river flows (12, 1 m^3/s), while from all other water resources is abstracted smaller quantities (6.4 m^3/s). Alluvial deposits of large rivers, are generally larger thickness and they were cut by river flows, from where stems the fact that there are good conditions for natural recharge aquifers (Institute of Water Management "Jaroslav Cerni", 2001)

In Serbia there are 216 sources of groundwater with capacity over 20 l/s (of which 65% has capacity over 100 l/s). Percentage of sources that are not in use is 31%, and percentage of those who are partially in use is 35%. The most significant potential groundwater areas for water supply in Serbia are: in alluvium of Drina river in the Macva region, whose reserves are estimated at 5.5 – 15 m^3/s, on the edge of Metohija valley (6 m^3/s) and in Eastern Serbia in the form of dispersed karst springs – 7,8 m^3/s (Picture 3). Most of karst springs are located in the basin of Black Timok, Nisava River and on mountains of Beljanica and Kucaj (Picture 3) (Gavrilovic & Dukic, 2014).

The most important sources of surface waters are artificial accumulations. They have intended to water supply of the population, next to this basic function, may affect the repair of small water regime, alleviating of floods, sediment retention, and can have other economic purposes. Thus they also indirectly effect on the water supply, increasing the water quality downstream from the reservoir (Jovicic M., et al, 1995). In Serbia there are 27 accumulation who have a role in water supply – most in Basin of West Morava River. Total volume of these accumulations is 608, 2 million m^3. The oldest one is from 1938, and it is called Grosnica (for water supply of city of Kragujevac), and the youngest ones are Barje and Prvonek (in South-eastern part of Serbia). The biggest accumulations used for water supply are: Gazivode on river Ibar (370 mil m^3), Kokin Brod (273 mil m^3) and Sjenica (213 mil m^3) on river Uvac.



Picture 3. Surface and groundwater resources of Serbia (Source: Authors)

From a live flow it is taken around 2,5 m^3/s of water, and from accumulations around 3,5 m^3/s. Surely, it is possible that from river flow we take a higher amount of water, but that is a

question of a quality of water in flow. The protection of water is difficult, even under the condition that it was taken "*modern*" measurs of water purifications (this represents a limitation of the higher use of the river flow as a source of drinking water). In significantly measures, flows are used like sources of drinking water in Belgrade (river Sava) and in Western Serbia (river Rzav).

Analyzing by regional areas we reach more significant share of underground waters in total abstracted drinking waters (Table 2.). Although, the use of underground water is predominantly in the observed period, it can be seen a greater utilization of surface waters, particularly in some parts of the state (Belgrade Region – around 42% is share of surface water). Region of Vojvodina still rely only solely on groundwater abstractions from three types of aquifers: alluvial aquifers, the main water-bearing complex, and Pliocene aquifers (Institute of Water Management "Jaroslav Cerni", 2001). If we look on lower administrative levels, like district we will find that only 15% of all district use dominantly surface water for water supply (Sumadija, Toplica and Rasina district). In these regions accumulations are the most significant water sources – Grosnica, Celije accumulations etc.

Table 2. Comparative review of abstracted drinking waters in Serbia (1991 – 2012)

(10^6 m^3 / year)

	1991.				2012.		
	Total	Groundwater	Surface water		Total	Groundwater	Surface water
Republic of Serbia	753.5	575.5	164.6		681.2	471.1	210.2
Belgrade Region	222.5	175.4	45.9		225.3	129.1	96.2
Central Serbia	311.5	232	79.5		310.3	196.3	113.9
Vojvodina	137.5	137	0.5		145,6	145	0.6

(Source: Authors - processed according to the data of the Statistical office of the Republic of Serbia, 2014)

CONCLUSION

At the beginning of the 21st century, Republic of Serbia has not get solution to the issue of water supply. Despite the great efforts made to build facilities and systems, the situation in the field of water supply is very unfavorable (Petkovic, 2004). Total abstracted amount of water is decreasing (same as the population), but consumption of water per consumer per year is rising (especially in big cities). Groundwater is still dominant like source of water supply but in some future perspectives accumulations and regional systems of water supply are planned to take the dominant role.

The most important problems with water supply are adverse water quality in terms of physical – chemical properties, in some districts of Serbia. Quality of surface water in some measure has influence on quality of groundwater. The second problem includes unequaled pluviometric regime – in critical dry months, when the needs of population are the biggest, most districts and municipalities has not enough capacity of existing water sources. The third group of problems refers to erosion and accumulation of erodible material, which damages sources of water. This problem is the most prominent in reservoirs, where we have a process of deposition of sediments – capacity of reservoirs are smaller, and its functions are difficult to maintain or they are

almost extinguished (for example reservoirs Ovcar and Medjuvrsje on West Morava river).

The development of water supply in Serbia must keep moving towards increasing a provision to delivery water to users and to improve the quality of water supplied. Given the fact that the water needs already outgrown the ability of local sources of water supply, it must be formed the regional water supply systems that will enable more reliable supply of water. These systems have already been implemented and from them will supply the largest number of settlements, as well as those technological processes with the necessary water of the highest quality. The spatial plan predicts development of nineteen big and small regional systems. The most important and potential the biggest source of water of the highest quality is ‘’Zapadnomoravsko – rzavski regional system” which includes basins of West Morava, Rzav and Uvac in Western Serbia. For its potential capacity, this system exceeds the needs of the area, and it is provided translation of drinking water to deficit region of Belgrade

Current consumption of drinking water is estimated at 800 million m^3 per year. Estimates show, that in the next 20 years, needs for fresh waters on the territory of Serbia will rise over two billion cubic meters per year (SEPA, 2015). Further development perspectives require greater investment measures to prevent water resources management problems caused by water supply, as well as the involvement of institutions at the national, regional and local level, how water would not become a limiting factor in the development of society. Preserving water resources and improving water supply, it’s necessarily bringing laws to accordance, and supporting joint actions of national, regional and local communities.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors. Authors warrant that this paper has not been published in any other magazine. This manuscript is original work of authors.

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