Analysis of the recent state of sewage network in Serbia

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Abstract. Serbia is among the countries with the lowest percentage of industrial and municipal wastewater treatment plants. Approximately 72.0% of the cities have a sewerage system, while only 60.0% of the population are connected to the sewerage network. This article is about recent state of sewerage and wastewater treatment in Serbia. It consists of an analysis of the development and the percentage of population connections to the sewerage network. It provides data on the state of wastewater treatment plants in Serbia, as well as on the amount and method of wastewater treatment. The paper aims to analyse the current situation in the field of wastewater treatment.

1. Introduction

The current state of Republic of Serbia in the area of water management shows several problems. The country faces some problems concerning the administrates and management of urban and industrial wastewater treatment plants, the lack of sewage infrastructure in cities, and the lack of development of wastewater treatment plants. The field of wastewater treatment requires a substantial investment cost, while the price of service, distribution, and wastewater treatment is too low, as data by the current situation of the sewage network. The construction of the sewerage network in Serbia was mostly carried out in the 1960s. The average life of the sewage network is estimated to be 35 to 40 years, while it is necessary to restore 10,400 km of sewage network and 359 wastewater treatment plants, which represents a significant investment cost for the future [1, 2, 3].

The accession of Serbia as a future member of the European Union must fulfill several requirements set in paragraph 27 (UWWTD 91/271/EEC) affecting the development and environmental protection. One of the first requirements was the amendment of the Water Act. In 2010, Serbia accepted the Urban Waste Water Treatment Directive (UWWTD 91/271/EEC) [4] under which was the Serbia Water Act (Službeni glasnik RS. No. 30/10 a 93/12 [5]) amended. The objective of the EU directive is to protect the surface waters from the adverse impact of wastewater discharges that directly endanger aquatic life and indirectly affect human health. The Directive also states that wastewater must be treated at least by secondary treatment in case of agglomeration of more than population equivalents (PE) of 2000 inhabitants. To meet UWWTD requirements Serbia had to develop a strategic document of water management. In 2015 a water management strategy was developed, which includes an assessment of the current management situation waters, water objectives, and guidelines, measures to achieve the water objectives set, as well as the projection of water development [2]. Currently, great attention is being paid to this problem, as evidenced by the increase in the number of inhabitants connected to the sewer system, as well as the rise in the amount of purified wastewater [2, 4].

The aim of this paper is to point out the issues affecting the current situation of the public sewerage network, the connection of the population to the sewerage network, and industrial and urban wastewater production. The main aim of the paper is to analyse the current state of industrial and municipal wastewater treatment plants as well as the method of wastewater treatment.
2. Analysis of the recent state

The current state of the sewerage network in Serbia is not similarly reviewed yet. The average age of the sewage network is estimated at 40 years. Existing sewerage network is gradually experiencing problems such as backfilling of soil, infiltration of atmospheric water into the sewer system, lack of measuring equipment, and monitoring the operation of the sewerage system. Also, the biggest problem is that large cities such as, Belgrade which has more than two million population does not have the wastewater treatment plant facilities. Industrial and municipal wastewater is discharged directly to the river – Danube or Sava. The urban cities like Novi Sad and Niš discharge municipal wastewater into the receiving water body. The major problem in water management in Serbia is the lack of wastewater treatment plant facilities. Other problems are that Public Municipal Companies, Water Supply and Sewage System do not fulfill their tasks. On the territory of Serbia, there are 178 Water Supply and Sewage System Companies, of which about 25 provides data to the Republican Agency. [1, 6]

On the territory of Serbia on the public sewerage network in 2000 was connected to approximately 80.0 % of the population, and only 10.0 % of municipal and industrial wastewater was subject to a treatment process [7]. The public sewer network was built only in cities like Belgrade, Novi Sad, Subotica, Sombor and other larger cities, while in smaller urbanities and villages municipal wastewater was discharge to cesspools or septic tanks. Wastewater Treatment Plant (WWTP), if any exists is progress by the primary (mechanical) or secondary (biological) phase of the process. The tertiary phase of the process is rarely only two wastewater treatment plants in Serbia have this phase of treatments. According to data provided by the Statistical Office in 2012, the produce of wastewater was 433 billion cubic, while 72.0 % of urbanities have a sewage system [2].

In recent years water management in Serbia has made significant progress. In the cities and municipalities, the construction and renewal of the public sewerage network are underway. Based on statistical data, the length of the sewerage network has increased by 4.2 % over the last two years, which had an impact on increasing the number of inhabitants connected to the publish sewerage network. The increase in the population connected to the public sewerage network is presented in Figure 1, which shows data for the years 2009 to 2018 [8 - 16].

![Figure 1](image)

**Figure 1.** Population connected to wastewater treatment plants in Serbia from 2009 – 2018 [8-16].

Today, about half of the population of the Autonomous Province of Vojvodina (APV) and Central Serbia are connected to the public sewerage network, while four times less is in the southern and eastern regions. According to the Statistical Office of Serbia from 2016, in the Autonomous Province of Vojvodina, about 49.8 % of the population is connected to the publish sewer network. In Belgrade 87.0 %, and in Šumadija and the west region 58.8 %, while in the south and east regions the percentage of population connected to the sewerage network is only 48.3 %. [17]. The average number of populations
connected to the public sewerage network in Serbia is 61.3 % [17]. In comparison with other European countries where the average is higher than 95.0 %, it can be stated that the sewer system is relatively underdeveloped [6].

3. Production of wastewater

Currently, Serbia is among the countries with the lowest percentage of industrial and municipal wastewater treatment plants. Approximately 58.0 % of the total amount of municipal wastewater produced discharge to the sewerage network, of which 12.0 % of wastewater was subjected to a purification process, the remaining 46.0 % of wastewater was discharged directly to the receiving water body (river, lake) without any degree of the purification process [7]. Compare to the type of treatment about 1.3 % of the population connect to the primary treatment process, 8.7 % connect to the secondary treatment process, and tertiary treatment about 1.9 % [7].

According to regional distribution, the highest amount of wastewater that is subject to the treatment process is in the Šumadijski region (41.0 %), while in the south and east regions is less than 9.0 %. The wastewater treatment in Vojvodina is about 25.0 %, while the Belgrade region does not have the wastewater treatment plant [17].

Based on the Statistical Office in Serbia (2011 – 2018), the total wastewater production is gradually decreasing from year to year, as can be seen in Figure 2. The highest amount of wastewater comes from households, which is about 200 mil.m$^3$ per year. The wastewater from industrial and other users is around 40 to 50 mil.m$^3$ per year [8-16].

![Figure 2. Wastewater discharged into the sewer network in Serbia form period 2018 - 2011 [7 - 15].](image)

4. Wastewater treatment plants in Serbia

On the territory of Serbia, there are about thirty-nine wastewater treatment plant facilities with a capacity of more than 2000 PE [5]. Most of the wastewater treatment plants are placed in the central and northern parts of the country, and just a few facilities are in the southern part of Serbia. Some of the WWTPs are over fifty years old but still in operating even if they do not meet the EU requirements a require extensive reconstruction. The facilities that are in operating are facing the number of problems that affect their cleaning process such as sanding, outdated and defective equipment, understaffed personal, entry of atmospheric waters. Nowadays, only twenty wastewater treatment plants facilities are in operation, and six meet the criteria set by the Urban Waste Water Treatment Directive (UWWTD 91/271/EEC). Most
facilities are provided only with the primary and secondary phase of the cleaning process with activated sludge. Overview of wastewater treatment plants that are in operating, with capacity over the 2000 PE, hydraulic capacity and treatment process are listed in Table 1 [2, 6].

| Region         | No. of facilities | Capacity (PE) | Name of WWTP | Treatment process | Hydraulic capacity [m³/day] |
|----------------|-------------------|---------------|--------------|-------------------|---------------------------|
| Borski         | 1                 | 10 000        | Kladovo      | I                 | -                         |
| Zaječarski     | 1                 | 5 000         | Soko Banja I,II | 6.000             |
| Jablanički     | 2                 | 10 000        | Vlasotnice I,II | -                 |
|                |                   | 6 000         | Medveda      | -                 |
| Kolubarski     | 1                 | 110 000       | Valjevo      I,II | -                 |
| Moravički      | 1                 | 50 000        | Gornji       I,II | 11.300            |
| Pirotinski     | 2                 | 9 500         | Dimitrograd I,II | -                 |
|                |                   | 20 000        | Bela Palanka | -                 |
| Podunavski     | 1                 | 35 000        | Velika Palanka I,II | -                 |
| Pomoravski     | 2                 | 45 000        | Jagodina I,II | -                 |
|                |                   | 35 000        | Praćin       | -                 |
| Šumadijksi     | 4                 | 25 000        | Arandelovac I,II | -                 |
|                |                   | 4 000         | Arandelovac  | -                 |
|                |                   | 125 000       | Kragujevac   | -                 |
|                |                   | 8 000         | Topola       | 1.200             |
| North Bačka    | 1                 | 160 000       | Subotica I,II,III | 36.000            |
| West Bačka     | 1                 | 180 000       | Sombor I,II  | 16.000            |
| South Bačka    | 3                 | 50 000        | Bečej I,II   | 7.700             |
|                |                   | 13 000        | Bač I,II     | 2.000             |
|                |                   | 120 000       | Vrbas I,II   | -                 |
| North Banat    | 1                 | 40 000        | Kikinda I,II | 11.000            |
| South Banat    | 1                 | 90 000        | Vršac I,II   | 8.000             |

I,II,III – primary, secondary, tertiary phase of process, WWTP – wastewater treatment plant, PE – population equivalent.

Except for listed wastewater treatment plants, there are several smaller WWTP with a capacity of up to 2000 PE. The facilities are primarily using for wastewater treatment from small villages or parts of cities. These wastewater treatment plants consist of two parts; the first part is forming by the biological rotate filter and the second part is from the combination of the previous anaerobic and the following biologic process with activated sludge [2, 6].

5. Wastewater treatment plants in Subotica, Vrbas and Kragujevac

In Serbia, there are only two wastewater treatment plants, that provide all three processes – WWTP in the Subotica and WWTP in the Vrbas. The wastewater treatment plant in Subotica was built in 1975 for 150 000 PE. Currently, it is the largest WWTP in Serbia, which meets the EU requirements (Figure 3). Before the reconstruction, the WWTP provides only two phases of the process – mechanical and biological. The mechanical process was through the coarse and fine grate, and sand and oil trap. The biological process was in a biological reservoir, activated sludge with subsequent purification in lagoons. On this WWTP were carried out three reconstructions: first in 1989, when the hydraulic capacity was an increase from 15,400 m³.h⁻¹ to 26,000 m³.h⁻¹, then in 2003 the reservoir was remediated, and a deep aeration system was introduced. The last reconstruction was in 2009 when the hydraulic capacity was an increase to the original (36,000 m³.h⁻¹), and the nitrogen and phosphorus removal process was improved. Also, the sludge treatment process has been added to the WWTP [18].
Figure 3. Wastewater treatment plant in Subotica [18].

The wastewater treatment plant in the Vrbas is a newly built WWTP, which was put into trial operation on March 2017. It is a second WWTP in Serbia which is meeting the EU criteria. The wastewater treatment plant is designed for equivalent population of 120,00 PE, including the industrial wastewater from the nearby village. The main priority of the construction of this treatment plant is to reduce the pollution of the Bački Canal into which the wastewater was discharged. [19]

Near the city of the Kragujevac, there is a wastewater treatment plant Cvetojevac (Figure 4). The construction of the wastewater treatment plant began in 1987 and 1990 was put into operation system. The function of the treatment plant is to ensure the purification of industrial and municipal wastewater. The projected capacity of WWTP is 1,520 l.s⁻¹, and currently uses about 1/3 of the available. The treated wastewater is discharged into the receiving water body – Lepnica. [20]

Figure 4. Wastewater treatment plant Cvetojevac [20].

6. Conclusion

At present, in the territory of Serbia, the sewerage of the municipality is satisfactory, although not at the required level. One of the major problems is the discharging of municipal and industrial wastewater into the recipient without prior treatment. This leads to the degradation not only of surface water but also underground sources of drinking water. Another problem is the lack of wastewater treatment plant facilities. It is necessary to restore 10,400 km of sewage network and 359 wastewater treatment plants, which represents a significant investment cost. Adoption of the Urban Waste Water Treatment Directive (UWWTD 91/271/EEC) has had a significant impact on water management in Serbia. The state started to invest heavily in the construction of a public sewer network and related facilities as well as wastewater treatment plants. The connection of the population to the public sewerage network was increased, and so was the amount of treated wastewater.
By 2025, large-scale projects are planned, the renewal of the old sewerage network and the construction of a new one, the problem of the atmospheric water and the construction of wastewater treatment plants, which should ensure at least a secondary degree of wastewater treatment. Also, the state has decided that by 2025 all industrial plants, such as butchers, dairies, and other plants producing chemical wastewater other than municipal wastewater must have their wastewater treatment plant.

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References
[1] Water supply and Sewage system, Journal Public Waste Management Company „Water supply and Sewage system“ 2018 320
[2] Bovana M, Stojanović B M, Dalmacija B, Radovanović Jović H 2015 Utilization and treatment of utility and industrial wastewater in Republic of Serbia (Serbia: Central European Development Forum CEDE, Provincial Secretariat for Urbanism, Construction and Environmental Protection APV)
[3] Dalmacija B et al. 2019 Water supply and water protection strategy in Autonomous Province of Vojvodina (Novi Sad: University of Novi Sad, Faculty of Sciences, Department of chemistry) p 248
[4] Urban Waste Water Treatment Directive (UWWTD 91/271/EEC), Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment
[5] Water Act, Official Gazette of RS, No. 30/2010, 93/2012 and 101/2016
[6] Đukić A 2012 Sewage systems and urban wastewater treatment in the Republic of Serbia - status and perspectives, Civil Engineeringrs (online)
[7] Veljković N et al. 2018 Water and sanitation 47 (1) 5-16
[8] Wastewater from urban cities in Republic of Serbia, 2010, Environmental statistics, Statistical Office in Republic of Serbia, No. 153, y. LXI, 10.06.2011. ISSN 0353-9555
[9] Wastewater from urban cities in Republic of Serbia, 2011, Environmental statistics, Statistical Office in Republic of Serbia, No.131, y. LXII, 11.06.2012, ISSN 0353-9555
[10] Wastewater from urban cities in Republic of Serbia, 2012, Environmental statistics, Statistical Office in Republic of Serbia, No.129, y. LXII, 14.06.2013, ISSN 0353-9555
[11] Wastewater from urban cities in Republic of Serbia, 2013, Environmental statistics, Statistical Office in Republic of Serbia, No.106, y. LXIV, 13.06.2014, ISSN 0353-9555
[12] Wastewater from urban cities in Republic of Serbia, 2014, Environmental statistics, Statistical Office in Republic of Serbia, No.120, y. LXV, 29.05.2015, ISSN 0353-9555
[13] Wastewater from urban cities in Republic of Serbia, 2015, Environmental statistics, Statistical Office in Republic of Serbia, No.125, y. LXVI, 27.05.2016, ISSN 0353-9555
[14] Wastewater from urban cities in Republic of Serbia, 2016, Environmental statistics, Statistical Office in Republic of Serbia, No.118, y. LXVII, 26.05.2017, ISSN 0353-9555
[15] Wastewater from urban cities in Republic of Serbia, 2017, Environmental statistics, Statistical Office in Republic of Serbia, No.128, y. LXVIII, 25.05.2018, ISSN 0353-9555
[16] Wastewater from urban cities in Republic of Serbia, 2018, Environmental statistics, Statistical Office in Republic of Serbia, No.101, y. LXIX, 24.05.2019, ISSN 0353-9555
[17] Gavrilović D., Region in Republic of Serbia 2017, Statistical Office in Republic of Serbia in Beograd, Beograd (2018), pp. 47, ISSN 2620–1275
[18] Public Municipal Companies 2019 Water Supply and Sewage System in Subotica (Online)
[19] Central wastewater treatment plant 2019 (Online)
[20] Public Municipal Companies 2019 Water Supply and Sewage System in Kragujevac (Online)