JEE Journal of Ecological Engineering
Volume 19, Issue 2, March 2018, pages 255–262
https://doi.org/10.12911/22998993/84764

Received: 2017.12.18
Accepted: 2018.01.18
Published: 2018.03.01

The State of Water and Wastewater Management in the Municipalities of the Roztocze National Park

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ABSTRACT

The aim of this paper is to present the current state of water and sewage management in the communes where the Roztocze National Park (RNP) is located. The park is located in Lubelskie voivodship, in the territory of four communes: Zamość, Zwierzyniec, Adamów and Józefów, while its buffer zone is located in the communes of Krasnobród, Tereszpol and Szczebrzeszyn. The paper uses data from surveys conducted in these municipalities in 2016. On average, 68.9% of the population used the water supply system in the municipalities surveyed, while 33.4% of the inhabitants had the possibility of discharging sewage to the sewerage system. In the area of the communes, there are 10 collective, mechanical and biological wastewater treatment plants with a capacity exceeding 5 $m^3 \cdot d^{-1}$. The households which are not connected to the sewage network discharge wastewater mainly to non-return tanks. Four out of the seven surveyed communities had 64 domestic sewage treatment plants, including 60 systems with infiltration drainage, which do not ensure high efficiency of removing pollution and may even contribute to the degradation of groundwater quality. In order to solve the existing problems in the area of sewage and water management occurring in the communes where the Roztocze National Park is located, it is necessary to further develop collective sewage systems and equip the areas with dispersed buildings with highly efficient, residential sewage treatment plants, e. g. constructed wetlands.

Keywords: municipality, water supply, sewage system, sewage treatment plant, septic tank, national park

INTRODUCTION

Water is an important element of the environment and forms the basis for human existence. Along with the development of civilization, water was unfortunately treated as a common good, considering its resources to be unlimited. This way of thinking has led to the degradation of water quality, which was supposed to be a reserve of water for future generations. The human-induced degradation of the environment, as well as climate change, constituted an important factor in taking the legal steps to protect water resources [Rachoń 2011]. Directive 2000/60/EC [2000], establishing a framework for Community action in the field of water policy, the so-called Water Framework Directive (WFD), is an integrated legal act regulating the water management rules in the European Union. Its overarching task is to ensure that the present and future generations have access to water of good quality, as well as to enable the use of water for, inter alia, the purposes of industry and agriculture, while maintaining the principles of environmental protection.

Water occupies 72% of the Earth's surface, 97% of which is made up of the oceanic and marine waters that are unsuitable for consumption because of their salinity. The remaining 2.5% is fresh water, which is largely trapped in glaciers and snow. Fresh water, which is a source of

drinking water, is located underground, which accounts for only 0.6% of the Earth's water resources. Lakes and rivers are a very good source of drinking water as well, but they only account for 0.1% of the world's water resources. Currently, in Poland, water per capita is approximately 1,600 m^3/year and during droughts it even drops below 1,000 m^3/person per year, while for comparison, the average annual water per capita in Europe is around 4,500 m^3. Poland's water resources are small, compared to the European average. In order not to allow for the risk of water deficit, it is necessary to manage the water resources rationally and take appropriate measures to protect the waters [Małecki and Gołębiak 2012]. The actions aimed not only at protecting the quantity of water, but above all its quality, are very important [Jóźwiakowski et al. 2015, Grzywna et al. 2016].

An important aspect of water management is ensuring an adequate condition of sanitary infrastructure, both in towns and rural areas [Pawełek 2016]. Council Directive 91/271/EEC [1991] concerning urban waste water treatment obliges the local authorities to take action in the field of water and wastewater infrastructure development. According to the data from the Polish Central Statistical Office [GUS 2017a], in 2016 the length of the water supply system in Poland reached almost 301 thousand km, while the length of the sewage system amounted to 154 thousand km. In rural areas, 85% of the population was connected to the water supply system, while only 40.3% were connected to the sewerage system. These data indicate a huge discrepancy between the length of the water supply system and the sewerage system. Investments are needed, mainly for the construction of sewage network and sewage treatment plants [Pawełek 2016; Siwiec 2017]. According to data from GUS [2017b], only 41.3% of the rural population uses collective sewage treatment plants, while the remaining population carries wastewater mainly to non-return reservoirs. The number of non-return tanks has been steadily decreasing for several years, while the number of domestic sewage treatment plants has been increasing [Bugajski and Kaczor 2008, GUS 2017a; Pawełek and Bugajski 2017]. In the protected areas, and above all in national parks, due to the need to preserve the good environmental status, the implementation of investments in the area of water and sewage management should be one of the priorities [Kaczor et al. 2015; Jóźwiakowski et al. 2017a].

The aim of the study is to present the current state of water and sewage management in 4 communes, in which the Roztocze National Park is located (Zamość, Zwierzyniec, Adamów, Józefów) and 3 communes constitutingits buffer zone (Krasnobród, Tereszpol, Szczebrzeszyn). The study used the results of the surveys conducted in these communes (except for Szczebrzeszyn municipality) in 2016 by the Department of Environmental Engineering and Geodesy of the University of Life Sciences in Lublin. In the case of Szczebrzeszyn commune, the information contained in GUS studies was used.

THE CHARACTERISTICS OF THE ROZTOCZE NATIONAL PARK

The Roztocze National Park (RNP) was established in 1974 in south-eastern Poland in lubelskie province. The RNP includes a varied landscape of the Middle Roztocze in the upper Wieprz river valley, separating the Lublin Upland from the Sandomierz Basin. Currently, the area of RNP is 8.5 thousand hectares. These are mainly forest areas (95.5%), 1029 hectares of which were under strict protection (12.1%). The main objective of the creation of RNP was to protect diverse forest ecosystems. The diversity of habitat conditions in this area determines the presence of many interesting forest plant communities, with a rich vegetation stock, including numerous tree species.

The RNP covers part of the Middle Roztocze, with a diverse geological structure. The Roztocze hump is made up of the upper-edged rocks; in the edge zone there are tertiary formations, and in the Wieprz river valley and Zwierzyniec valley there are quaternary compositions. In the northern part of the park, there are predominantly brown hands and brown parachutes among the soils. In the rest of the area, there is greater variety, with the largest surface area being covered by sandy sapwood soils. Geomorphologically, Roztocze is a typically upland region, where the main elements of the sculpture show very close links with the geological structure. Characteristic of this area is the directionality of sculpture forms, marked in the arrangement of valleys and morphological edges. The limestone chains of hills up to 350 m above sea level, overgrown with forests and enclaves of cultivated fields, interspersed with the valleys of post-glacial sands, are present [Buraczyński 2013].

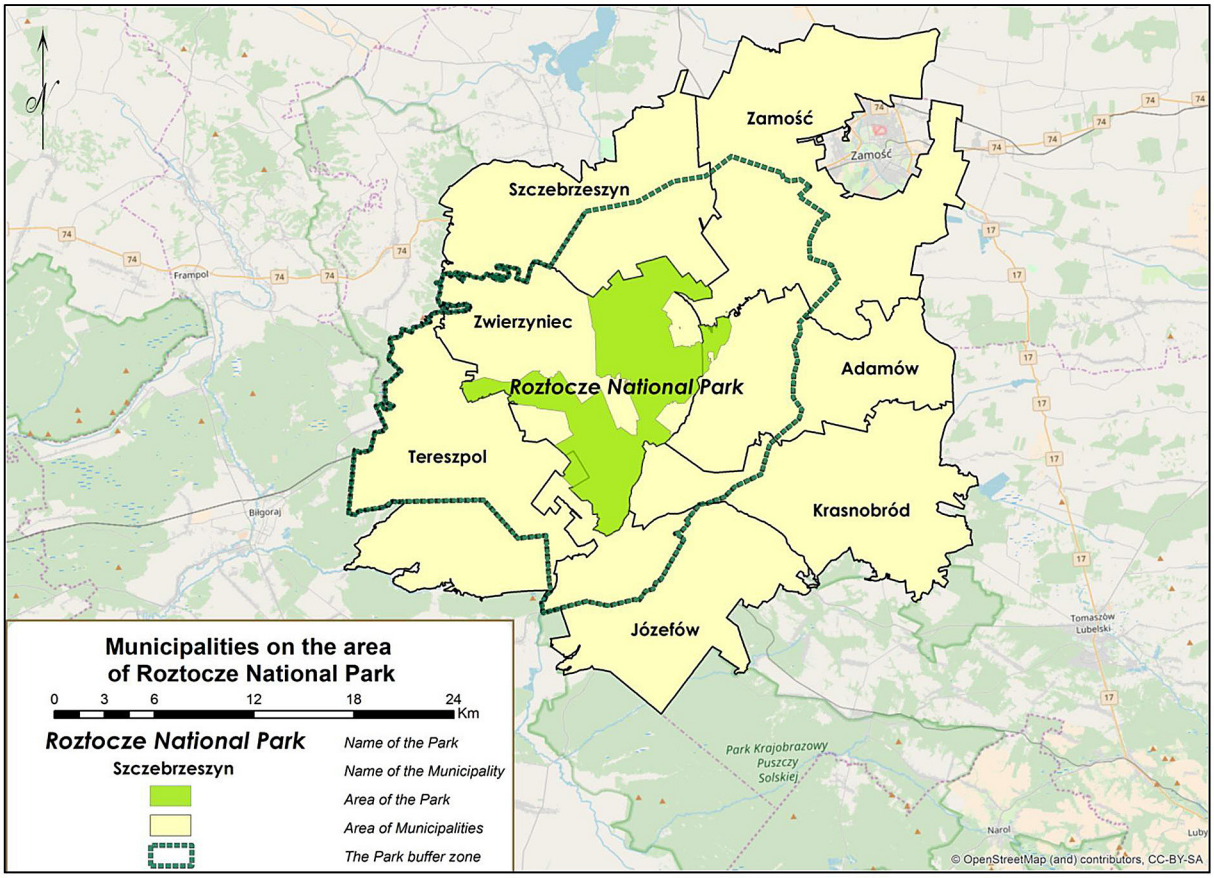

Fig. 1. Location of the Roztocze National Park in the analysed communes

The geological diversity, rich terrain relief, climatic and soil factors caused that 47 plant complexes (19 forest and 28 non-forest ones) can be found on a relatively small area. The RNP forests are characterized by high growth dynamics and good health, and many trees reach monumental height. The most common tree species are pine, fir and beech. The most numerous of the remaining about 30 native species are: oak, alder, hornbeam, birch, spruce. Among the 700 plant species, depending on their habitat and terrain, one can find typical lowland vegetation, as well as mountain and Atlantic species. The list of rare plants includes 65 taxa, and about 45 species protected; 125 species of birds, including Lesser Spotted Eagle and Black Stork, are nested in the park. In RNP, a refuge of Polish horse was set up, which became a symbol of the park. One can also find here many rare species of amphibians and reptiles [Nasiadka 2010].

The vertical construction of the Roztocze National Park has an impact on the distribution, size and the nature of the river network. There are four rivers, including one larger one, i.e. Wieprz, and three smaller ones: Świerszcz, Szum and Krupiec. The waters of the Świerszcz stream feed the complex of "Echo" ponds and a pond in the centre of Zwierzyniec. In turn, the geological structure determines the abundant occurrence of groundwater. The steep slopes of the hillsides are conducive to surface rafting, and usually they become the beginning of periodic watercourses. The dampness in the interior of the complex during the rainfall and snowmelt period is caused by the presence of forests on most of the park's terrain. This slows down the outflow of water, reducing draughts on rivers. The nature of the soils covering the RNP surface is determined by surface runoff, evaporation rate or absorption rate. The best properties are the loose, well-permeable white-tailed soils located in a large part of the park, while its storage and gradual release are responsible for brown soils and hand hands [http://roztoczanskipn.pl].

RESULTS AND DISCUSSION

Water supply

The survey conducted in 2016 shows that in the municipalities where RNP and its buffer zone are located, the degree of water supply is quite

high. The municipality of Tereszpol has the shortest water supply system – 31.36 km; however, it supplies all inhabitants of the municipality with water. The same situation is observed in the area of Józefów commune, where all inhabitants have the possibility to use the municipal waterworks and its length is 65 km (Table 1, Fig. 2). In turn, in the municipality of Zamość, there is the longest water supply system – 114.6 km, and only 40.7% of the inhabitants use it. In the Zwierzyniec commune, a water supply system with the length of 108.7 km allows for supplying water to 98.7% of the commune population. The situation is less favourable in the communes of Krasnobród and Szczebrzeszyn, where about 88% of the inhabitants have the possibility to draw water from the water supply network. On the other hand, a small percentage of the population using waterworks were found in the Adamów commune – 45%.

The average percentage of inhabitants using the water supply system (80%) in all communes in the Roztocze National Park is slightly higher than that recorded by Jóźwiakowski and others [2017a] (79.1%) in the communes where the Poleski National Park is located and almost 12% lower than the figure reported by GUS [2017a] for rural areas in Poland (91.9%).

Sewage system

According to Błażejewski [2012], there are 400 city dwellers per one kilometre of the sewage system in Poland, and only 74 village dwellers. It is assumed that sewerage system construction is technically and economically justified, when the length of sewerage system is greater than 120 persons per one kilometre and in the case of the areas under special legal protection – greater than 90 persons [Regulation of the Minister of Environment 2014].

The RNP area is characterised by dispersed development, which creates significant problems in the development of technical infrastructure. This applies in particular to the discharge and waste water disposal. The choice of an appropriate wastewater treatment system in the protected areas should be made taking into account various criteria, which should take into account the principles of sustainable development [Jóźwiakowski et al. 2015].

The survey shows that in the municipality of Tereszpol, the largest proportion of the population – 86.7% – has the possibility of discharging wastewater into the sewerage system, and the length of this network is 40 km (Fig. 2). On the other hand, the municipality of Zamość has the longest sewage system (71.62 km); however, it allows only 20.7% of the inhabitants of this commune to dispose of sewage. In contrast, in Zwierzyniec municipality, a 49.2 km long sewerage system ensures collection of sewage from 70% of the population. In the municipalities of Krasnobród, Szczebrzeszyn and Józefów, the possibility of sewage disposal to the sewerage network corresponds to about 30% of inhabitants. The lowest percentage of sewerage systems is found in the Adamów commune and it does not even reach 1%, and the length of sewerage system is only 1.6 km. In the area of the Adamów commune, the wastewater is mostly delivered to collective treatment plants by means of service trucks.

The survey shows that in contrast to water mains, the lengths of sewerage networks are much smaller and thus they serve a much smaller number of inhabitants. In 2016, an average of 39.8% of the population used sewage system in the districts in the Roztocze National Park. It was a value similar to that given by GUS [2017a] for rural areas in Poland (40.3%) and much higher than the one reported by Jóźwiakowski et al. [2017a] (22.5%)

Table 1. Number of inhabitants using the water supply and sewage system in the communes where RNP and its buffer zone are located

Name of the commune	Total number of inhabitants	Number of inhabitants using the system		Percentage of inhabitants using the system [%]	
		Water supply system	Sewage system	Water supply system	Sewage system
Zamość	22 881	9 316	4 740	40.7	20.7
Szczebrzeszyn	11 200	9 860	3 021	88.0	27.0
Józefów	7 218	7 218	2 487	100.0	34.5
Krasnobród	7 337	6 414	2 840	87.4	38.7
Zwierzyniec	7 041	6 950	4 950	98.7	70.3
Adamów	4 912	2139	23	45.0	0.5
Tereszpol	4 100	4 100	3 554	100.0	86.7

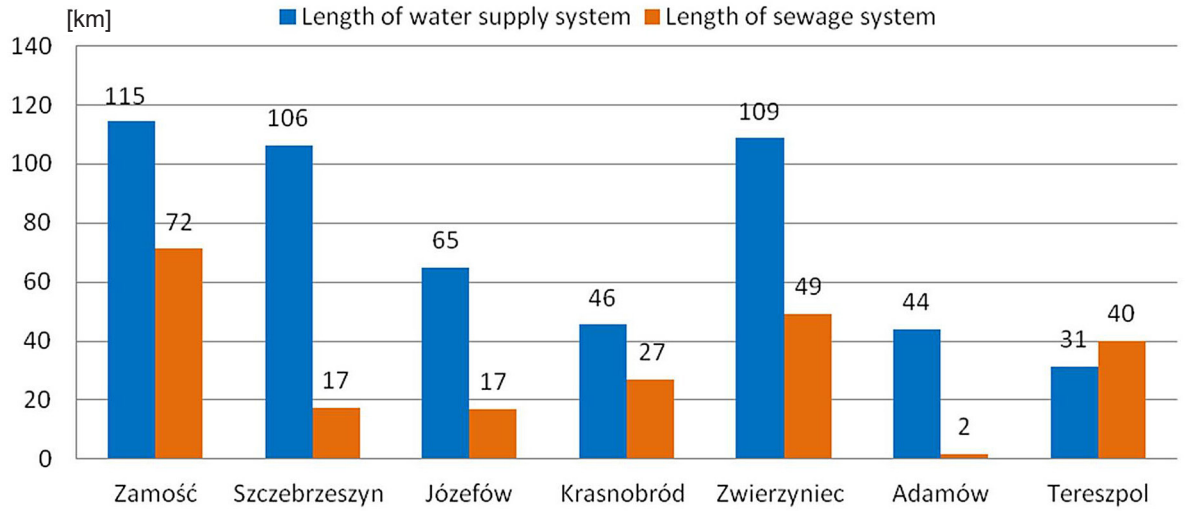

Fig. 2. The length of the water supply and sewage system in the communes where the RNP and the buffer zones are located

in the communes where the Poleski National Park is located. The analysis of the data shows that domestic wastewater produced by other inhabitants in the communes within the territory of RNP is discharged into non-return tanks.

Collective wastewater treatment plants

Collective wastewater treatment plants, together with the sewer network, constitute a collective wastewater collection and treatment system covering the whole or part of the settlement unit. According to the National Urban Wastewater Treatment Program [Górski et al. 2010] the use of a centralised (cumulative) sewer system is justified if there are at least 120 inhabitants per kilometre of the sewer network. This means that the unit length of the sewage system should not exceed about 8 metres per habitant. Exceeding the listed length indicators of the sewer network proves the necessity of using a decentralised sewer system, consisting in the construction of residential (individual) sewage treatment plants [Heidrich and Stańko 2008; Pawełek and Bugajski 2017].

According to a survey conducted in 2016, there are 11 collective sewage treatment plants with a capacity of more than 5 $m^3 \cdot d^{-1}$ in the communes in which RNP and its buffer zone are located, mainly mechanical and biological treatment plants. The largest number of buildings, i.e. 4, is located in the Adamów commune. In addition, 2 wastewater treatment plants are located in the territory of the municipality of Zamość, and one facility per Zwierzyniec, Krasnobród, Tereszpol, Józefów and Szczebrzeszyn municipalities (Table 2).

In densely built-up areas, public water supply and sewage disposal should be provided in a collective manner, while in dispersed built-up areas – individually [Górski et al. 2010]. Distributed development of dispersed buildings in the analysed communes is not conducive to the construction of sewerage networks and collective treatment plants; therefore, the basic method of sewage management is the collection in non-return tanks, the so-called septic tanks, or to neutralization in household sewage treatment plants.

Non-return tanks

Non-return tanks are characterised by relatively low investment outlays, but are expensive to operate due to high waste water disposal costs. In addition, they pose a potential sanitary risk to

Table 2. Collective Wastewater Treatment Plants with a capacity of more than 5 m^3/d in the communes in which RNP and its surroundings are located

The name of the sewage treatment plant / the Commune	The capacity of the treatment plant [m^3/d]
Zamość (Zamość)	390
Zwierzyniec (Zwierzyniec)	500
Suchowola (Adamów)	160
Szewnia Górna (Adamów)	30
Bondyrz (Adamów)	150
Adamów (Adamów)	120
Hutki (Krasnobród)	400
Tereszpol (Tereszpol)	365
Józefów (Józefów)	200
Szczebrzeszyn (Szczebrzeszyn)	800

shallowly located groundwater, often used as a source of water supply for inhabitants [Heidrich 1986; Siemieniec and Krzanowski 2000]. However, it is important to note that the number of non-return tanks is decreasing in favour of the domestic sewage treatment plants. In 2015, there were 2,256,000 cesspit tanks, while in 2016, their number amounted to 2,117,000, while the number of domestic sewage treatment plants increased from approximately 203,000 to about 217,000 [GUS 2017a].

The survey shows that in 2016, 14209 non-return tanks were registered in the seven analysed communes. The largest number of septic tanks is located in the area of Zamość (4850 units) and Józefów (4731 units) municipalities. In the commune of Zwierzyniec, 1850 units were recorded and in the commune of Krasnobród – 1275 units. On the other hand, 971, 387 and 145 tanks are operated in the communes of Szczebrzeszyn, Adamów and Tereszpol, respectively. The widespread use of such solutions may constitute an important element of pressure on the natural environment, mainly due to potential leakage of reservoirs and the possibility of pollutant migration to groundwater.

Household sewage treatment plants

As an alternative to non-return tanks, household sewage treatment plants are available. These solutions are much cheaper to operate than septic tanks [Karolinczak et al. 2015]. Household sewage treatment plants are defined as facilities serving up to 50 inhabitants [PN-EN 12566-3+A1:2009]. Their maximum capacity in Poland is 5 m^3/d, according to the Water Law Act [2001] and 7.5 m^3/d according to the Construction Law Act [2003]. They are constructed as two-stage objects, consisting of mechanical and biological removal of contaminants [Pawęska et al. 2011]. In 2016, in four of the seven communes where RNP is located, there were 64 household sewage treatment plants operating together with the buffer zone; the highest number, i.e. 29, was found in the commune of Zamość (Fig. 3).

In this group, 60 systems with infiltration drainage were found, as well as one sewage treatment plant with activated sludge and 3 constructed wetland sewage treatment plants. The high proportion of systems with an infiltration drainage system (93%) is worrying. According to numerous authors, they should not be accepted for common use, as they can contribute to the degradation of surface and groundwater quality [Jucherski and Walczowski 2001, Pawełek and Bugajski 2017). Therefore, it is suggested to limit the use of these systems, as they discharge the sewage treated only mechanically into the ground [Jóźwiakowski et al. 2015]. The optimal solution for waste water disposal consists of constructed wetland systems, which are easy to operate, ensure high reliability and efficiency of the removal of contaminants, as well as minimize the amount of waste water discharges to the environment and limit their negative impact on the water quality [Czernaś et al. 2012, Gizińska et al. 2016, Jóźwiakowski 2017b].

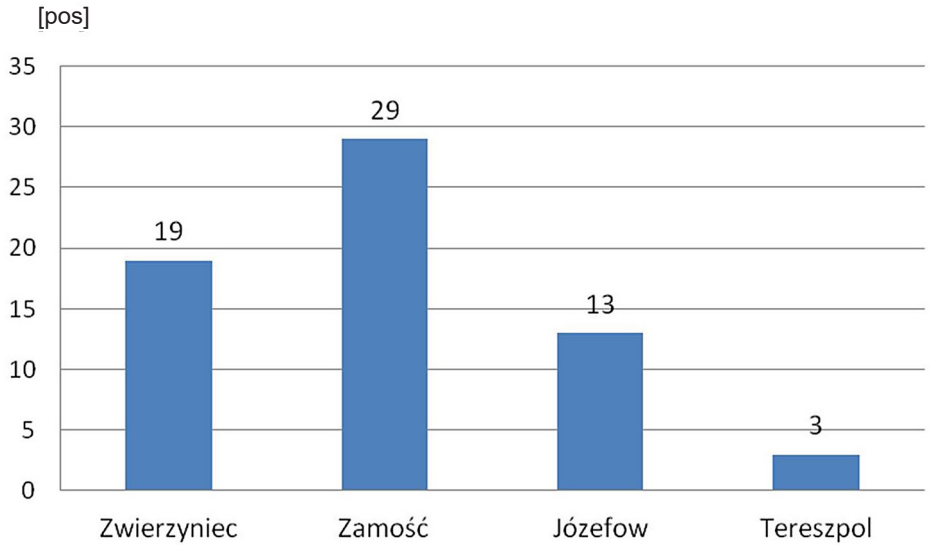

Fig. 3. Number of household sewage treatment plants in the communes where RNP and its buffer zone are located

CONCLUSIONS

1. The current state of water and sewage management in the communes where the Roztocze National Park is located is not satisfactory and may contribute to the pollution of the aquatic environment in the park.
2. In the communes in which RNP and its buffer zone are located, there was a large disproportion between the development of the water supply and sewage system. It was determined that the water supply system is used by 80% of the population in the analysed communes on average, while the sewage system is used only by 39.8%.
3. The worst water supply situation prevails in the municipalities of Zamość and Adamów, where 40.7% and 45% of the population, respectively, have direct access to running water. In the communes of Szczebrzeszyn, Krasnobród and Zwierzyniec, the percentage of inhabitants using the water supply network exceeds 87%, and in the communes of Józefów and Tereszpol, all inhabitants have direct access to water.
4. There was a wide variation in the degree of sewerage of individual municipalities. The highest percentage of the population uses the sewage network in the communes of Zwierzyniec and Tereszpol – 70.3% and 86.7%, respectively. On the other hand, the worst situation is in the Adamów commune, where only 0.5% of the population uses the sewage system. In this commune, a large part of the wastewater is transported to the collective treatment plants by means of service trucks.
5. In the discussed communes, there are 10 collective, mechanical and biological sewage treatment plants with a capacity of more than 5 m^3/d**.** On households which are not connected to the sewage system, wastewater is mainly discharged to non-return tanks, the number of which in 2016 was 14209 units.
6. Domestic sewage in some households is treated in household sewage treatment plants (64 units), among which the systems with infiltration drainage (93%) are dominant. The use of these systems on a larger scale may contribute to the degradation of groundwater quality in the park. Therefore, further development of the household sewage treatment plant network should be based on proven solutions guaranteeing high efficiency of disposal, e.g. based on constructed wetland systems.
7. The results of surveys conducted in the communes in the Roztocze National Park indicate the need to implement the investment measures aimed at the development of communal sewerage systems, and in areas with dispersed development – of highly efficient household sewage treatment plants.

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