Sewage system design for the Čierna Lehota - Slavošovce – Rochovce agglomeration

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Abstract. The development of public sewerage systems in Slovakia is significantly behind in the state of supply of drinking water. The number of inhabitants connected to the public sewerage system in Slovakia is considerably lagging behind in the state of the population supplied with drinking water, by about 28.4% less in the number of connected inhabitants. Designing sewerage in urbanized areas improves the quality of the environment and the quality of life of townspeople and municipalities. The aim of the paper is the processing of basic information about the current status of the affected area, designing alternative solutions for the sewerage subject area, a comparison of alternatives for proposed activity and the rationale for the selection of the optimal solution. An area of interest for the design of sewerage is the Čierna Lehota – Slavošovce – Rochovce agglomeration, which is located in the Košice Region in eastern Slovakia. The problem of this agglomeration is the method for the disposal of wastewaters, which are disposed of in non-ecological septic tanks or discharged directly into a local stream. In the paper are three proposals in the form of three different variants of sewage system according to relevant standards and documentation. At the end of this paper, an evaluation of the individual variants is presented.

1 Introduction

The concept of drainage in cities, which aims to mitigate the impact of urbanization on the hydrological regime of the country and on aquatic ecosystems, comes from our experiences and knowledge of the current method of sewerage. Although a new concept of capture and use water from surface run-off provides a platform for new technical and non-technical measures, the classic ones are still used [1, 2]. The rate of precipitation varies in time and over a catchment [3, 4]. Concerning the proportion of evaporation, infiltration and runoff, rainwater infiltration can contribute essential benefits to the harmonization of the natural water balance, and also positively influence soil, weather, fauna and vegetation conditions. The necessary surface holding and drainage systems are important [5, 6]. In fact, the engineer will never know at the design stage what the maximum flow through their storm drains will be. They can only estimate likely flows from an analysis of past date. The development of public sewerage systems in Slovakia is significantly behind int the state of

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their supply of drinking water. Designing sewerage in residential areas improves the quality of the environment and the quality of life of people in urban areas. Detail surveys must be carried out in residential areas to determine the interaction between water and residential development [7, 8, 9].

The main objective of the paper is to design a sewage system in the agglomeration Čierna Lehota - Slavošovce - Rochovce in 3 variant solutions. This area is located in eastern Slovakia in Košice Region. In the area under consideration, the sewerage network has not yet been built up to the extent that it would be necessary. Some family houses have wastewater outlets discharging directly into the local creek or into road gutters.

1.1 Legislation in the field of the drainage and sewerage of municipalities in the territory of the Slovak Republic

When designing, implementing and operating sewer networks, applicable legislative and normative regulations must be respected. Current EU legislation related to the drainage and treatment of wastewater includes:

• Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy;

• Directive 91/271/EEC – urban wastewater treatment.

Legislative and strategic materials in the Slovak Republic:

• Act of law no. 409/2014 Coll. from 2. December 2014, amending Act no. 364/2004 Coll. on Water and on Amendments to the Act of the Slovak National Council no.372/1990 Coll. on offenses as amended (the Water Act);

• Regulation of the Government of the Slovak Republic no. 398/2012 Coll. of 28 November 2012 amending and supplementing the Decree of the Government of the Slovak Republic no. 269/2010 Coll., laying down requirements for achieving good status of waters;

• Act no. 394/2009 Coll. of 10 September 2009 amending Act no. 442/2002 Coll. of Public Water Supply and Public Sewerage and on Amendment to Act No. 276/2001 Coll. of regulation and network industries as amended.

The basis for the development of public sewerage systems in Slovak Republic is the application of sustainable development principles that respect environmental care and ensure all legal claims for the use of water (water resources) [10].

The plan for the development of public sewers in the territory of the Slovak Republic (SR), which was developed by the Ministry of the Environment, aims to increase the protection and improvement of natural water resources, which will have a beneficial effect on the development of urban infrastructure [10].

1.2 Current state of waste water drainage and treatment in the Slovak Republic

The number of inhabitants connected to the public sewerage system in Slovakia is considerably lagging behind in the state of the population supplied with drinking water, by about 28.4% [9]. The percentage of inhabitants connected to the public sewerage system in 2015 is listed in Figure 1.

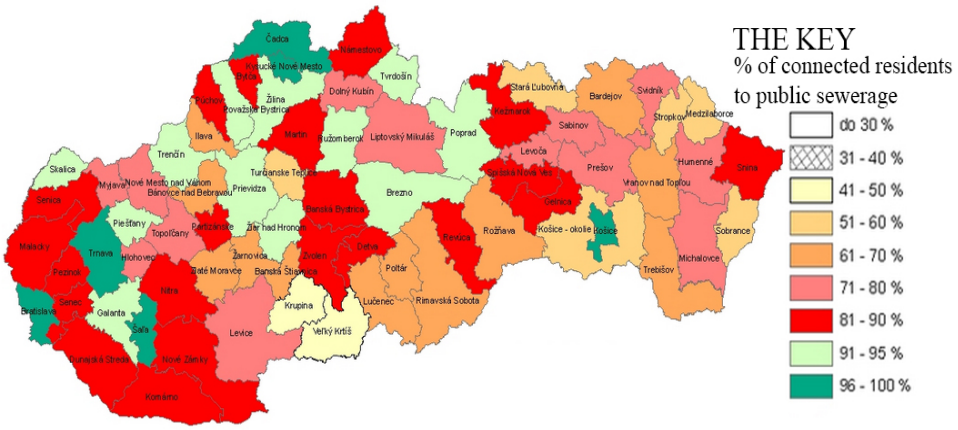

Fig. 1. The percentage of inhabitants connected to the public sewerage system in Slovakia [11].

A comparison of the percentage increase of the population connected to the public sewerage system in 2004 and in 2015 is shown in Figure 2, where the largest increase in the number of inhabitants connected to the public sewerage system is especially visible in the regions of Trnava, Trenčín, Nitra and Žilina; and on the contrary, almost no increase in the Košice Region, where the agglomeration from this work is located [12].

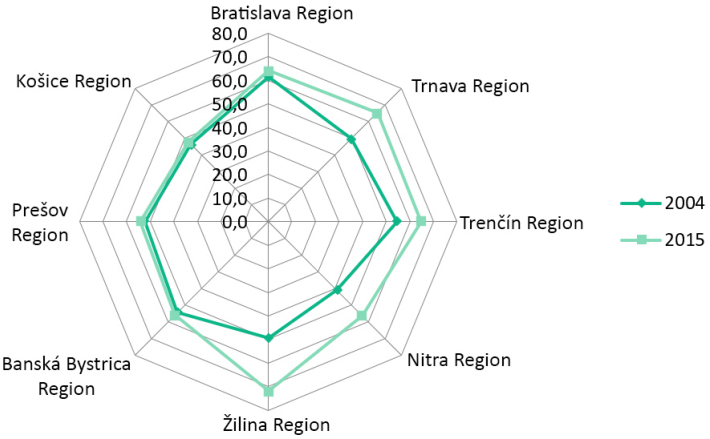

Fig. 2. A comparison of the percentage increase of the population connected to the public sewerage system in 2004 and in 2015 [10].

2 Study area

The municipalities of Rochovce, Slavošovce and Čierna Lehota (Figure 3) were selected for the design of the sewerage system. The municipalities are located in eastern Slovakia in Košice Region in the Rožňava district. In the Rožňava district, there has not yet been much progress in the implementation of new public sewers (see Figure 2). The mentioned agglomeration fulfills the condition of the number of 2 000 - 10 000 equivalent inhabitants, which results from the provisions of Act no. 364/2004, as amended, on the need for securing and discharging municipal wastewater by the end of 2015.

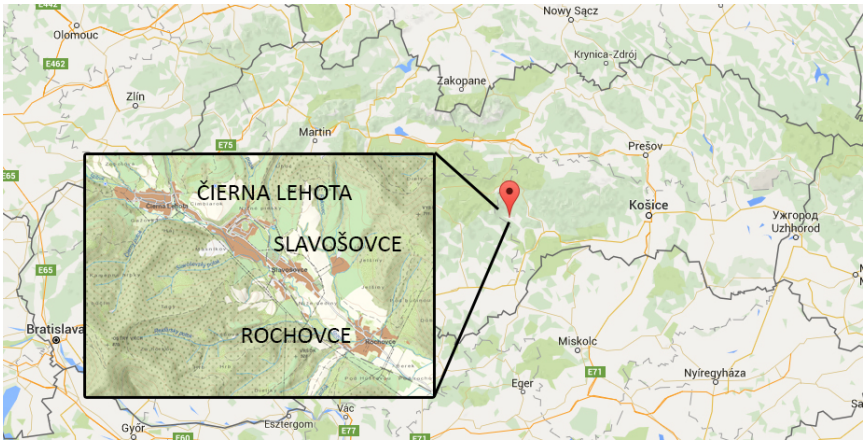

Fig. 3. The location of the study area within the Slovak Republic [13].

Basic data on the municipalities of Rochovce, Slavošovce and Čierna Lehota, which are located in the solved agglomeration, are presented in Table 1.

Table 1. The basic informations of Rochovce, Slavošovce and Čierna Lehota municipalities [14-17].

Rochovce	Slavošovce	Čierna Lehota
• The altitude of the municipality is from 362 to 387 m above sea level. • The current population is 333 inhabitants. • The village does not have a public water system or a public sewer system - drinking water is collected from water wells and wastewater is discharged into septic tanks.	• The altitude of the municipality is from 413 to 456 m above sea level. • The current population is 1869 inhabitants. • The village has a public water supply system and a public combined sewerage system is built in a small part of the village.	• The altitude of the municipality is from 468 to 535 m above sea level. • The current population is 617 inhabitants. • The village has a public water supply system but does not have a public sewerage system.

The problem of this agglomeration is a method of disposal for wastewater, which is disposed of in non-ecological septic tanks or discharged directly into a local stream. This suggests the need to design sewerage in this area. Sewerage construction will not only improve the protection of underground and surface water, but also the quality of life and the housing culture of the inhabitants of these municipalities.

3 Design of sewerage system

The current state of drainage and wastewater treatment is not satisfactory in the agglomeration. Therefore, 3 variant solutions for drainage of the municipalities were designed, which were compared in economic, technical, social and ecological terms. Variants are described in Table 2.

Table 2. Description of three designed variants.

Variant 1	• The combined sewerage system in the settlement, and the separate sewage system in the historical part of Slavošovce which remains. • Čierna Lehota, Slavošovce and Rochovce have designed a new separate sewage system with one common wastewater treatment plant (WWTP) in the southern part of Rochovce. • The entire sewer system will be gravitational.
Variant 2	• A new sewer system for the entire agglomeration has been designed, with the existing combined sewer system to be replaced with a new separate sewage system and WWTP which will be built in the southern part of Rochovce, as in Variant 1.
Variant 3	• Each municipality has its own sewer network with a small wastewater treatment plant. • The existing separate sewage system in Slavošovce will remain, but the existing combined system in a part of municipality will be replaced with a new combined system. A new WWTP has also been designed. • Čierna Lehota and Rochovce have designed a new gravitational separate sewage system and new wastewater treatment plants for each municipality.

3.1 Technical solution of variant 1

The existing combined sewage system in the Slavošovce settlement and also the separate sewage system in the historic part of the village will be retained in this variant. Because of the good conditions for rainwater detention in the area, there is no need to build up rainwater drainage, so a new separate sewage system has been designed. The length of designed sewage system is 9911 m, of which 2937.5 m is in Rochovce, 1811.5 m is in the historical part of Slavošovce and 5162 m is in the remaining part of Slavošovce and in Čierna Lehota. There are 265 manholes in this variant.

The amount of wastewater in the Slavošovce settlement being discharged was calculated on the basis of the amount of rainwater and the pipe dimension was designed based on the maximum rainfall during 15 minutes, as it is a combined sewer system. The amount of wastewater in Čierna Lehota, Rochovce and in the historical part of Slavošovce was calculated on the basis of water consumption per capita per day. The total number of inhabitants for which the new separate sewage system was proposed is 1445. A new storm overflow tank has been designed for the conduit from the Slavošovce settlement.

3.2 Technical solution of variant 2

In the design of the second variant, the whole agglomeration is drained by a new separate sewage system. The existing combined sewage system at Slavošovce and the separate sewage system in the historical part of Slavošovce (as the technical condition of sewerage is not known) will be replaced by a new and separate sewage system. Wastewater (domestic and industrial wastewater) will be gravitationally driven through the agglomeration in one network.

The amount of sewage wastewater is expressed from the total population in the Rochovce - Slavošovce - Čierna Lehota agglomeration. The total population is 3101. The length of the designed sewage system is 13198.5 m.

3.3 Technical solution of variant 3

When designing the 3 variants, the drainage of all three municipalities separately is being considered. The village of Rochovce will be drained by a separate sewage system, which will be conducted gravitationally. The conduit will be connected to its own WWTP. In Slavošovce the existing separate sewage system will be preserved in the historical part. The combined sewage system will be replaced by a separate sewage system. The existing sewage plant will be eliminated and replaced with a new one. The village of Čierna Lehota will be drained by a separate sewage system, which will be conducted gravitationally. The conduit will be connected to its own WWTP.

The amount of wastewater was determined separately for each municipality, based on the number of its inhabitants. The number of inhabitants in Rochovce is 366; in Slavošovce it is 2056; and in Čierna Lehota it is 679. The length of conduits is 3937.5m in Rochovce; 3816 m in Slavošovce; and 3899 m in Čierna Lehota. Each village have designed its own WWTP.

Schematics for the three variants and the method of calculation of the designed flows are shown in Figure 4.

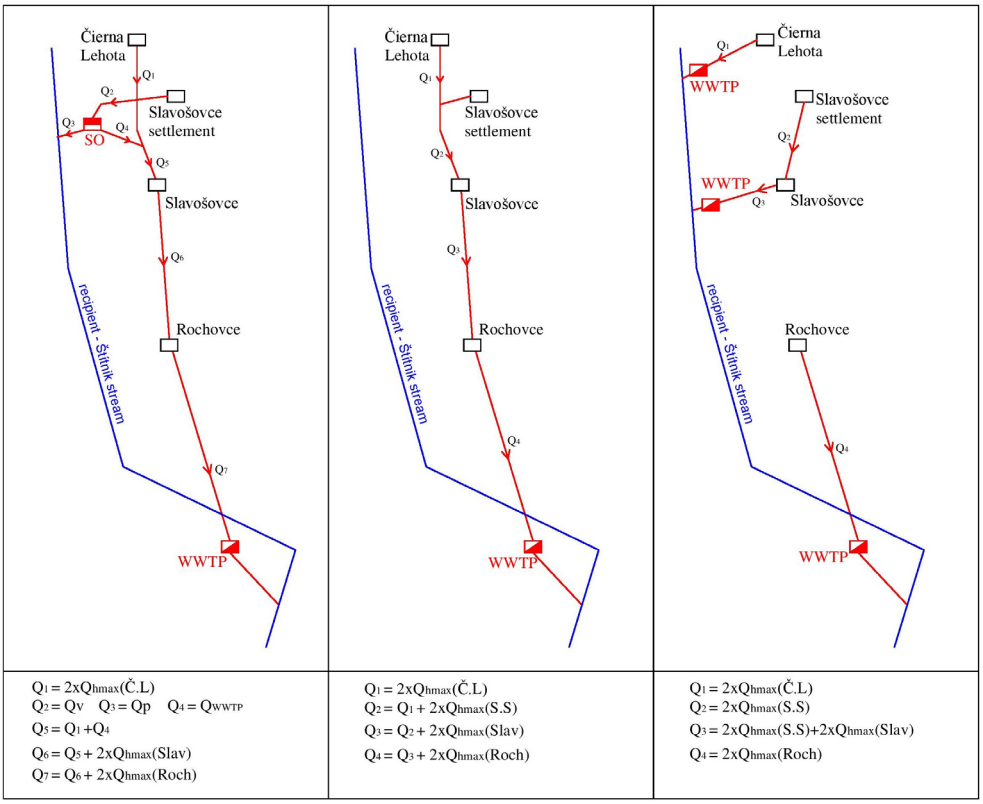

Fig. 4. Schematics for variants 1, 2 and 3 with designed flows, SO – storm overflow tank, WWTP – waste water treatment plan.

3.4 Economic evaluation of variants

All three variants are compared to each other. The most important criteria in this selection are mainly the length of the newly constructed sewerage pipe, the number of manholes and

the type of WWTP. Prices were calculated according to the current price list. The total cost of construction of the first variant is €2.418M, of the second variant is €2.711M. and of the third variant is €2.715M. Therefore, the cheapest variant is variant 1. A Comparison of the prices for the variants is shown in Figure 5.

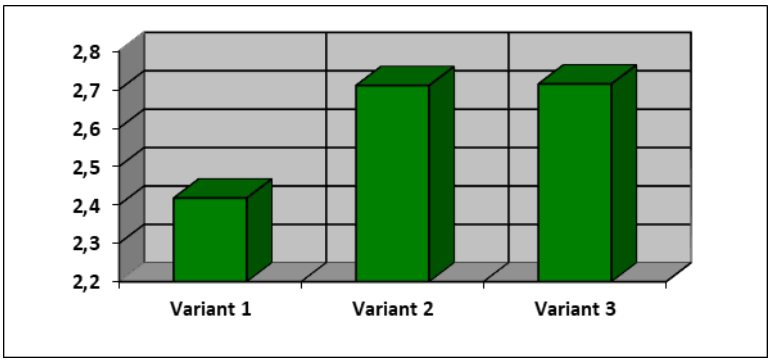

Fig. 5. Comparison of prices (in million €) of variant 1, 2 and 3.

4 Conclusion

The basic aspects of environmental protection include the protection of surface and underground water, which we can ensure through sewerage in the area. The work is focused on the design of sewerage in the Čierna Lehota - Slavošovce – Rochovce agglomeration, located in eastern Slovakia. In this work, 3 variant solutions for agglomeration drainage were developed. This region lags in the number of new sewers. The drainage design was developed in accordance with valid legislation and technical standards. The most economically advantageous is the 1st variant, which keeps the existing sewerage system in Slavošovce, proposes a new storm overflow tank and proposes a new sewerage network in Čierna Lehota and Rochovce. In this area, it is necessary to carry out the sewerage of the surrounding municipalities as much as possible to improve the quality of the environment.

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