Analysis of the efficiency of sewerage with the illegal rainwater inflow

J Hrudka¹, I Marko¹, M Šutúš¹ and Š Stanko¹

¹ Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Sanitary and Environmental Engineering, Slovakia

Abstract. In our research, we are focused on analysing the impact of illegal rainwater connections on the sewage network. During the normal operation of the sewage network, rainwater cannot be present. These heavy rains flows are extreme during rain events and the sewerage system is significantly overloaded and functionality it is reduced. Our study is based on the real data of the sewerage network and selected area of interest. In the assessment of illegal connections of rainwater, we use rainfall data according to the relevant ombrographic station.

1. Introduction
The basic function of the sewerage infrastructure is to protect the population and the environment from the adverse effects of the produced pollution in municipal waste water. The waste water disposal and treatment process must respect the principles of sustainable development, environmental protection and the application of legal and conceptual requirements for water management [1]. The Public Sewer Development Plan also mentions a reduction in the gap between the quantity and quality of water consumed and the water supplied by the sewage system to the aquatic environment, as well as the trouble-free and safe drainage and treatment of wastewater under any operating condition without formation and discharge. Urcikán and Rusnák [1] also describe the issue of rainwater today: Rain surface runoff is gradually less and less naturally draining. The number of impermeable areas increases and the outflow of rainwater increases. Rainwater draining from asphalt and concrete roads washes away surface pollution caused by human activity. There are also known negative impacts such as lowering of groundwater level, increase of urban wastewater, but also worsening of self-cleaning conditions in watercourses [1] [2].

The Member States of the European Union have agreed on the conditions for the disposal and treatment of municipal waste water pursuant to Council Directive 91/271 / EEC on urban and waste water treatment. The Slovak Republic has also undertaken to fulfill these conditions through conceptual and strategic plans, such as the Plan for the Development of Public Sewerage Systems for the Territory of the Slovak Republic. The goal of fulfilling public sewerage development plans is, on the one hand, the development of municipal infrastructure, the improvement of sanitation, housing comfort and the standard of living of the population and, on the other hand, increased protection and improvement of the natural resources in order to achieve the WFD (Water Framework Directive) objective of achieving good water status [2].

2. Methods
We chose the sewage network of the municipality of Veľký Lapáš as an interest site for our research. The branch under consideration is located in the newly built part of the village, there are localized new residential buildings with adjacent paved areas (pavement and parking). The selected locality is located in the southern part of the village (figure 1).
According to rainfall and duration we divide the rains into normal (normal) and extreme (abnormal). Extreme rainfall events are either short-lived (downpours, flushes) or long-term (regional, landraces). In terms of the design of sewer profiles, short-term, more intense rains are more significant. [2]

For calculations of characteristic runoff from roads, roofs, sidewalks and yards in urban areas of precipitation are defined only by rainwater. We use boundary rains to calculate the design rain flow. The boundary rain represents an idealized rain intensity profile characterized by a statistically determined periodicity p (r-1) or a repetition time T (r). [2] In this case, a rain curve from the NITRA ombrographic station was used. For periodicity p = 0.50, rain duration 15 min. The resulting boundary model rain rate is q15 = 156.94 l / s / ha (figure 2).

Figure 1. Sewerage network in village.

Figure 2. Rainfall curve- Nitra ombrographic station.
3. Results and discussion
To assess the impact of black rainwater connections of buildings was chosen sewer A113, where there are newly built apartment buildings. Figure 5 shows the situation.

Water from the roof of apartment buildings and parking spaces next to them shall be taken into account when calculating the impact of black rainwater connections. Table 4 shows the area sizes of the individual objects that we are assessing.

**Table 1. List of objects on sewer network - branch A113.**

| Object | Area (m²) | Area (ha) |
|--------|-----------|-----------|
| 1      | 209.9     | 0.0209    |
| P1     | 300.1     | 0.0300    |
| 2      | 214.3     | 0.0214    |
| P2     | 297.7     | 0.0297    |
| 3      | 214.3     | 0.0214    |
| P3     | 311.0     | 0.0311    |
| 4      | 214.3     | 0.0214    |
| P4     | 264.0     | 0.0264    |
| 5      | 224.2     | 0.0224    |
| P5     | 43.8      | 0.0043    |
| 6      | 176.8     | 0.0176    |
The issue of incorrect operation of the sewer network is devoted to a number of authors who primarily examined the effect of rainwater for use [3] [4] [5]. Connection of rainwater to sewage is prohibited in the Slovak Republic. It is due to the enormous flows from rain events, but also because of sediment flowing with rainwater [6].

4. Conclusion

The assessment of black-connected objects consists of the gradual connection of the objects to the existing sewage system. By gradually adding drains from roofs and parking lots, it was ascertained whether they affect the designed pipe width, which is determined by the calculated flow rate. The aim is to increase the flow of rainwater so much that the already designed pipeline will not be sufficient for the incoming water and it will be necessary to use a larger profile.

Table 2. Analysis of the impact of black connections on sewage.

| Objects | Area (ha) | Rainwater inlet (l/s) | Manhole 159 - Branch A |
|---------|-----------|-----------------------|------------------------|
| Flat house | 0 | 0 | 12.69 |
| Parking spot | 0.0509 | 7.98 | 28.65 |
| 1 | P1 | 0.1545 | 24.24 |
| 1,2,3 | P1,P2,P3 | 0.2247 | 35.26 |
| 1,2,3,4,5 | P1,P2,P3,P4 | 0.2466 | 112.68 |
| 1,2,3,4,5,6 | P1,P2,P3,P4,P5 | 0.2466 | 89.87 |

By connecting an area of 0.2247 ha, which corresponds to 5 apartment buildings and 4 parking areas, on the sewer A113 it was found that the designed profile DN 300 is not able to carry the connected amount of rain flow. In this case, the lower shafts on the sewer network may be flooded, which would mean flooding of the third class road - 1642 and houses and cellars in the affected area.

5. References

[1] Stanko Š, Kriš J and Škultétyová I 2011 Type of sewer system - technical and environmental advances and arrangements doi:10.1007/978-94-007-0280-6_11
[2] Urcíkán P and Rusnák D 2011 Stokovanie a čistenie odpadových vód I. Navhovanie stokových sietí (Bratislava) p 324 ISBN 978-80-227-3435-6
[3] Dillman M, Snyder D and Chandramoul V 2013 Calibrating a sanitary sewer system for low and high flows World Environmental and Water Resources Congress 2013: Showcasing the Future - Proceedings of the 2013 Congress pp 129-134
[4] Chow M F and Yusop, Z 2014 Characterization and source identification of stormwater runoff in tropical urban catchments Water Science and Technology 69(2) pp 244-252 doi:10.2166/wst.2013.574
[5] Campisano A, Nie L M and Li P J 2013 Retention performance of domestic rain water harvesting tank under climate change conditions doi:10.4028/www.scientific.net/AMM.438-439.451
[6] Sercu B, Van De Werfhorst L C, Murray J L S and Holden P A 2011 Sewage exfiltration as a source of storm drain contamination during dry weather in urban watersheds Environmental Science and Technology 45(17) pp 7151-7157 doi:10.1021/es200981k

Acknowledgments

This work was supported by the Scientific Grant Agency of the Ministry of Education, Youth and Sports of the Slovak Republic and the Slovak Academy of Sciences within the project VEGA 1/0574/19, cofunded by the European Regional Development Fund and by the Slovak Research and Development Agency under the contract No. APVV-18-0203.