http://dx.doi.org/10.15576/GLL/2013.2.7

GLL

Geomatics, Landmanagement and Landscape No. 2 • 2013, 7–14

ANALYSIS OF THE SEWAGE SYSTEM EXPANDABILITY IN MŚCIWOJÓW COMMUNE

Tomasz Bergel, Piotr Bugajski, Jan Pawełek

Summary

The aim of the study is to analyze the hydraulic conditions of the existing sewage system and the sewage treatment plant in the commune of Mściwojów. This is in relation to the aspect of connecting new buildings, as a part of the investments in the pilot project VITAL LANDSCAPES no. 2CE164P3. The analysis led to the conclusion that an increased wastewater inflow from the new buildings is manageable. The current capacity of the sewage treatment plant will be increased by 3 to 5%, which will not affect the stability of the existing treatment process. The hydraulic analysis of the sewer network proved that the existing sewer collectors can handle the increased flow.

Keywords

sewage system • expansion • sewage

1. Introduction

The draining and treating of sewage in Polish rural areas remains a serious and unresolved issue. The water supply network development in rural communes has led to an increase in water usage, which in turn has led to an increase in the amount of sewage [Pawełek et al. 2004]. The village population, who gained a convenient and unlimited access to water, were obliged to dispose of the sewage on their own. Until recently, the most common solution of this problem was to build a cesspool. The assumption was that the sewage was to be accumulated and systematically collected by vacuum trucks and taken to collective sewage treatment plants. However, in order to save money, many of the cesspool users have decided to drain the sewage from the cesspools to roadside ditches, streams or directly onto fields and meadows, thus polluting the natural environment [Bugajski 2009, Janik et al. 2012]. Currently, the expansion of the sewage systems, although a priority in many regions, has not caught up with the water supply network development [Bergel 2013]. An important aspect of the sewer system design process in rural areas, is the necessity to take into account the differences in the amount of sewage produced, the length of the network for a single household. These points as well as the density and the loads of the pollution, in comparison with large,

urban sewer networks must be taken into account [Bugajski and Bergel 2008]. The inhabitants, who had to use cesspools for many years, are used to saving water. After connecting these households to the network, they used less water when compared to the inhabitants of the cities. Designing the sewer network in rural areas based on the guidelines for urban areas resulted in the hydraulic underload of the sewage treatment plant and lead to it instability [Jóźwiakowski 2012]. Other factors, that lead to this include: uncontrollable rainwater and meltwater inflow and long transit sections, whose influence is often omitted in the planning stage of rural sewer networks. They may also lead to lower sewage treatment efficiency [Kaczor 2012]. According to EU recommendations, sewer systems in rural areas, where households are often scattered, should be complemented with individual sewage treatment system [Directive EWG 91/271]. This solution is recommended in the communes where large distances between the households would increase the costs of construction and use of the collective sewer system.

2. The aim and the scope of the study

The aim of the study is to analyze the hydraulic conditions of the existing sewage system and the sewage treatment plant in the commune of Mściwojów. This in relation to the aspect of connecting new buildings, as a part of the investments, in the pilot project "Valorization and sustainable development of cultural landscapes using innovative participation and visualization techniques – VITAL LANDSCAPES" no. 2CE164P3. An additional goal of the study is to develop a concept for a sewer network expansion and for sewer network construction in the villages located in the commune. These do not have either a collective or individual sewer system and sewage treatment plant.

The study includes a concise description of the existing sewer system and a hydraulic analysis of the suggested solutions of its expansion, along with sewage treatment plants.

3. Description of the terrain and the sewage system

The commune of Mściowojów is located south from Legnica. Since January 1st 1999 it has been a part of Lower Silesia. It is one of six communes that make up the recreated Jawor district. The commune borders with Wądroże Wielkie and Legnickie Pole on the north, Strzegom, Dobromierz and Paszowice on the south, and the city of Jawor on the west. The municipal office of Mściwojów is located 65 km from Wrocław, 55 km from Jelenia Góra, 35 km from Wałbrzych, 25 km from Legnica and 5 km from Jawor. Its area equals 7183km^2. It consists of 12 villages inhabited by a population total of 4166. It is located in the mesoregion of Wzgórza Strzegomskie, macroregion of Przedgórze Sudeckie, subprovince of Sudety. The average height above sea level ranges from 190 to 210 m. The terrain relief is low undulating and low hilly. The Mściwojów commune is located in a piedmont area of a pluvio-thermal region [Woźnicka et al. 2006].

The sewage system in Mściwojów consists of two separate collective systems: "Mściwojów" and "Snowidza".

The sewage system "Mściwojów" serves the following villages: Mściwojów, Niedaszów, Zimnik, Targoszyn, Luboradz and Drzymałowice. The sewer network has a total length of 34 km and is made of PVC, the pipe diameter DN varies from 150 to 200 mm. The sewage is drained by a gravitational collector into a sequential collective treatment plants, type SBR. The treated water flows into the stream of Osina. The treatment plant has been designed for the inflow of 525 $m^3 \cdot d^{-1}$. The Population Equivalent PE, assumed in the project, equals 1440. The allowable pollution indexes in the water permit (O.Ś. 6341.37.2011), issued by the district governor of Jawor, equal:

- BOD_5 – 40 $mgO_2 \cdot dm^{-3}$,
- COD – 150 $mgO_2 \cdot dm^{-3}$,
- Total suspended solids – 50 $mg \cdot dm^{-3}$,
- Total nitrogen – 35 $mgN_{og} \cdot dm^{-3}$,
- Total phosphorus – 5 $mgP_{og} \cdot dm^{-3}$.

The sewage system "Snowidza" serves 60% of the houses in the village of Snowidza. The sewer network is 5.4 km in length and made of PVC, its diameter is DN 200 mm. The sewage is drained by a gravitational collector into a biomechanical treatment plant with a flow type biological reactor. The treated water flows into the stream of Modzel. The treatment plant has been designed to handle 140 $m^3 \cdot d^{-1}$. The Population Equivalent PE assumed in the project equals 700. The allowable pollution indexes in the water permit (O.Ś. 6341.37.2011) issued by the district governor of Jawor equal:

- BZT_5 – 40 $mgO_2 \cdot dm^{-3}$,
- ChZT – 150 $mgO_2 \cdot dm^{-3}$,
- General slime – 50 $mg \cdot dm^{-3}$.

4. Hydraulic analysis of sewage treatment plant

Based on the proportions between the water consumption and the amount of sewage that flows into the treatment plants in Mściwojów, it was stated that a large part of the sewage is in both the infiltration water and the rainwater. During the last years of operation of the sewage treatment plant in Mściwojów, the average daily sewage inflow was 296.9 $m^3 \cdot d^{-1}$ and the water consumption was 154.4 $m^3 \cdot d^{-1}$. This means that the addition of infiltration water and random waters was 92%. The sewage treatment plant under analysis is designed for 525 $m^3 \cdot d^{-1}$, whereas the actual sewage inflow is 56% of the assumed value. The above calculations indicate that at present the sewage treatment plant in Mściwojów is hydraulically underloaded. This means that the inflow will be increased as a result of construction of the buildings that make up the resort. The estimated amount of new sewage, that will flow out of these buildings ranges from 10 to 15 $m^3 \cdot d^{-1}$. After the construction of these buildings, assuming that they will be fully occupied, the sewage inflow will increase by 3 to 5%. The sewage treatment plant will still be underloaded hydraulically. It is recommended

that the amount of inflowing sewage be increased by connecting more villages to the system or by increasing the amount of sewage delivered by vacuum trucks.

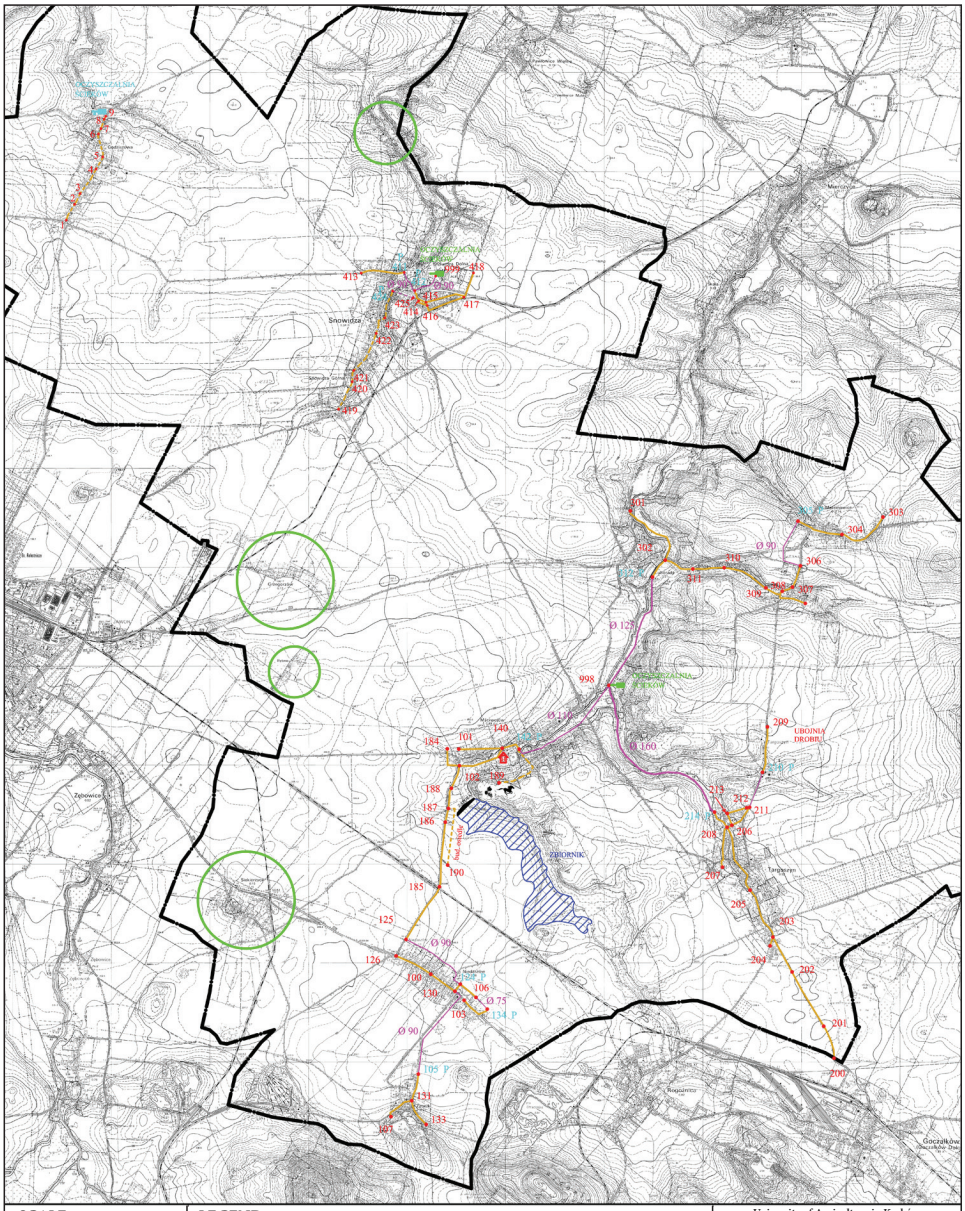
The sewage treatment plant "Snowidza", similarly to "Mściwojów", is hydraulically underloaded. Its actual average daily sewage inflow equals 100 $m^3 \cdot d^{-1}$. The hydraulic load makes up 71% of its designed capacity. In this case, there is also a significant inflow of extraneous waters into the sewer system. The average daily water consumption for the residents equals 77.7 $m^3 \cdot d^{-1}$. This is seen drain water into the system. The extraneous waters equals 22.3% of the sewage drained into the sewage treatment plant. In order to increase the hydraulic capacity of the object, it is recommended that the sewer network and that the amount of sewage delivered by vacuum trucks is increased

The significant inflow of infiltration waters into the sewer network in the commune of Mściwojów, is the result of poor condition of the sewer collectors. Lack of tightness of connections between collectors, cracked pipes, lack of tightness of sewer drains and high groundwater level (above the pipes) are the reasons for such a big inflow of infiltration waters. The high inflow of rainwater in the precipitation periods, indicates illegal connections of rain gutters to the network. Actions should be undertaken to decrease the inflow of infiltration waters and rainwater.

5. Hydraulic analysis of the sewage network

In order to determine whether increased sewage flow in the existing sewer network is possible, after connecting the new resort buildings, the hydraulic conditions regarding the capacity and repletion of the collectors were analyzed. The analysis indicated that the maximum repletion level of the collector ranges from 30 to 40 mm. This is about 20% of the diameter of 200 mm, while the recommended level is between 50 to 70%. The increased sewage inflow will increase the level by only 2 to 3 mm. Based on the hydraulic analysis, it was determined that more buildings can be connected to the existing sewer collectors. The increased sewage inflow to the network will not only improve its efficiency, but will also prevent slime sedimentation on the bottom of the collector from collecting.

In addition to the existing sewage system in the commune of Mściwojów, a concept for a sewage system expansion in the villages of Snowidza and Godziszowa has been developed. At present, 60% of households in Snowidza are connected to the collective sewer system. The concept suggests an expansion of the network, by building a gravitational collector 1590.5 m in length, 200 mm in diameter. In the village of Godziszowa, the concept suggested construction of a sewer system which will include a graviatational sewer 1179.0 m in length, 200 mm in diameter and a biomechanical sewage treatment plant of the capacity of 20 $m^3 \cdot d^{-1}$. The sewage treatment plant in this village should be of sequential type SBR, as this kind of object is less likely to be affected by uneven sewage inflow and uneven contamination in the raw sewage. Table 1 presents the lengths of (along with the diameters) of particular sewage collectors at the present state and after expansion. The sections marked with nodes 1 to 412 are presented on a map.


SCALE:
1:17 000
0 500 1000 m
LEGEND:
Ø 200 gravity pipeline Ø200
Ø 75 pressure pipeline Ø75
Ø 90 pressure pipeline Ø90
Ø 110 pressure pipeline Ø110
Ø 125 pressure pipeline Ø125
Ø 160 pressure pipeline Ø160
Ø 200 designed gravity pipeline Ø200
Ø 90 designed pressure pipeline Ø90
border of the commune
998 compute node
P pumping station
hotel and restaurant
stud
vineyard and restaurant
wastewater treatment plant – existing
wastewater treatment plant – proposed
household sewage treatment plant
University of Agriculture in Kraków
Department of Sanitary Engineering
and Water Management
31-120 Kraków, Al. Mickiewicza 21
Phase: Conception
Figure title: ILLUSTRATIVE MAP Sewage network
Scale 1:17000
Figure number: B
Elaborated: dr inż. Tomasz Bergel, dr inż. Bugajski, dr inż. Jacek Myczka
Elaboration date: June 2012

Taking into account the decreasing population, scatter of the buildings and the significant distances from the existing treatment plants in the villages of Grzegorzów, Barycz, Godziszowa and Siekierzyce, it is recommended that an individual sewage treatment plants be built. It is economically justified and feasible not only in terms of connecting each building to the sewer network but also in terms of its future use. When choosing the right technology for treating small amounts of sewage, one should take into account the legal regulations and give detailed instructions to the future users.

Table 1. List of the existing and projected length and diameters of sewage collectors in Mściwojów commune

Village	Number	Diameter of pumping collector [mm]	Length [m]	Length of gravitational collectors DN 200 [m]	Total length of gravitational sewage network DN 200 [m]
Present state					
Snowidza	411–412	90	230.8	450.0	1878.7
	412–999	90	276.5	1428.7	
Marcinkowice	305–306	90	622.5	2170.5	3184.0
	312–998	125	1119.5	1870.5	
Targoszyn	214–998	160	919.0	4009.5	4476.5
				467.0*	
Niedaszów	134–106	75	165.2	323.0	1319.7
	124–125	90	779.0	996.7	
Mściwojów				3644.5	5046.5
				1402.0*	
Zimnik	105–130	90	1008.0	853.7	853.7
Total			6120.5	14757.1	14757.1
After expansion (under development)					
Snowidza	419–424			1590.5**	1590.5
Godziszowa	1–9			1179.0**	1179.0
Total					17527.1

* Length of sewage system complementary for existing sewage systems

** Length of sewage system after expansion

6. Conclusions

The hydraulic analysis of the sewage treatment plant "Mściwojów" has proved that an increased sewage inflow from the buildings that are a part of the investment, is manageable. The current sewage inflow, is 56% of the designed capacity of the object. The new sewage inflow from the full use of the buildings will increase the flow by 3 to 5%. After a capacity analysis of the existing sewage treatment plants in the commune, it has been noted that a large part of the sewage includes infiltration water and random water. In order to prevent this situation, it is recommended that renovation work be performed on the network, in the most depreciated sections. Along with recommended the elimination of connections of gutters and courtyard drains to the network, either made by mistake or illegally. Eliminating extraneous waters from the sewage will improve the sewage treatment and decrease the operational costs of the treatment plant [Kaczor 2009].

Similarly to the case of sewage treatment plants, based on the hydraulic analysis of the sewage system, it has been established that an increased flow, resulting from connecting the new buildings to the network, is possible with the existing sewer collectors.

To connect all the households in the commune of Mściwojów to the sewer network, it is necessary to expand the system in the village of Snowidza and to build a sewer system (sewer network along with a sewage treatment plant) in the village of Godziszów. In other villages: Grzegorzów, Barycz, Godziszowa and Siekierzyce, that currently are not connected to any sewer network, it is suggested that individual sewage treatment plants be installed due to economical and demographical reasons.

References

Bergel T. 2013. Zużycie wody w wiejskich i miejsko-wiejskich wodociągach w Polsce. Gaz, Woda i Technika Sanitarna, 2, 99–101.

Bugajski P., Bergel T. 2008. Wielkości wybranych stężeń zanieczyszczeń w ściekach bytowych odpływających z terenów wiejskich. Gaz, Woda i Technika Sanitarna, 9, 28–29.

Bugajski P. 2009. Zagrożenia wód eutrofizacją odbiorników w wyniku stosowania indywidualnych systemów oczyszczania ścieków. Gaz, Woda i Technika Sanitarna, 9, 4–5.

Dyrektywa Rady Europy z dnia 21 maja 1991 roku dotycząca oczyszczania ścieków komunalnych. 91/271/EWG.

Janik M., Jucherski A., Walczowski A. 2012. Gospodarowanie ściekami w zabudowie rozproszonej cz. I. Prz. Komun. 7, 52–60.

Jóźwiakowski K. 2012. Badania skuteczności oczyszczania ścieków w wybranych systemach gruntowo-roślinnych. Kraków. Infrastr. Ekol. Teren. Wiej., 1, 2012.

Kaczor G. 2009. Otwory we włazach studzienek kanalizacyjnych jako jedna z przyczyn przedostawania się wód przypadkowych do sieci rozdzielczej. Kraków. Infrastr. Ekol. Teren. Wiej., 9, 155–163.

Kaczor G. 2012. Wpływ wód infiltracyjnych i przypadkowych na funkcjonowanie małych systemów kanalizacyjnych. Kraków. Zesz. Nauk. UR w Krakowie, 495, 2012, 372.

Pawełek J., Kaczor G., Bergel T. 2004. Wybrane zagadnienia ilościowo-jakościowe ścieków bytowych odprowadzanych wiejskimi systemami kanalizacyjnymi. Materiały konferencyjne – Ogólnopolska Konferencja Naukowo-Techniczna pt. Kanalizacja Wsi – Stan Obecny, Perspektywy Rozwoju. Poznań, 18–20 lutego 2004, 1–24.

Woźnicka A., Dziędzioła W., Foryś M. 2006. Program gospodarki odpadami dla gminy Mściwojów. Stowarzyszenie na rzecz Zrównoważonego Rozwoju Gminy Mściwojów – przy współpracy z Urzędem Gminy Mściwojów.

Dr inż. Tomasz Bergel
Uniwersytet Rolniczy w Krakowie
Katedra Inżynierii Sanitarnej i Gospodarki Wodnej
30–059 Kraków, Al. Mickiewicza 24/28
e-mail: t.bergel@ur.krakow.pl

Dr inż. Piotr Bugajski
Uniwersytet Rolniczy w Krakowie
Katedra Inżynierii Sanitarnej i Gospodarki Wodnej
30–059 Kraków, Al. Mickiewicza 24/28
e-mail: p.bugajski@ur.krakow.pl

Prof. dr hab. inż. Jan Pawełek
Uniwersytet Rolniczy w Krakowie
Katedra Inżynierii Sanitarnej i Gospodarki Wodnej
30–059 Kraków, Al. Mickiewicza 24/28
e-mail: rmpawele@cyf-kr.edu.pl