**Journal of Ecological Engineering**
Volume 18, Issue 1, Jan. 2017, pages 176–182
DOI: 10.12911/22998993/66404 *Research Article*

# THE DEVELOPMENT OF WATER AND SEWAGE INFRASTRUCTURE IN THE SUBREGION OF WESTERN MALOPOLSKA IN YEARS 2003–2013

**Agnieszka Petryk[1], Piotr Petryk[2]**

[1] Department of Economy and Public Administration, Cracow University of Economics, Rakowicka 27, 31-510 Kraków, Poland, e-mail: agnieszka.petryk@uek.krakow.pl

[2] Department of Environmental Engineering and Geodesy, University of Agriculture in Krakow, Al. Mickiewicza 24/28, 30-059 Kraków, Poland, e-mail: petryk.piotr@gmail.com

Received: 2016.10.22
Accepted: 2016.11.10
Published: 2017.01.01

**ABSTRACT**
Saturation and dynamics of the change of water and sewage infrastructure in the subregion of Western Malopolska in the years 2003–2013 have been determined. It covers the area of four counties located farthest west and north of the Malopolskie Voivodeship that is Chrzanów county, Olkusz county, Oświęcim county and Wadowice county. In order to illustrate the condition of water-sewage economy of the subregion, the number of connections, the number of users and the length of collective sewerage system and the length of distributive water supply system have been evaluated.

**Keywords:** technical infrastructure, water supply, sewage system, the dynamics of change, the Water Framework Directive.

## INTRODUCTION

Technical infrastructure is crucial for increasing the capacity and efficiency of the region's economic and for improving the living conditions of the population whose needs should be met [Stawasz 2005]. The effectiveness of the investment process of building the technical infrastructure of a specific type and the consequences of its use show multiple relationships with the processes which take place in the social and economic sphere and above all spatial and environment sphere of the region concerned [Stawasz 2005]. Lack of systematic study and execution of local and regional policies relating to equipping particular settlement units, urban or rural as well as larger territorial units with technical infrastructure leads to a creation of development thresholds which generate much higher investment costs to be overcome than the expenditure rate incurred for the implementation of a timely harmonized policy of infrastructure development and the territorial development conjugated with it [Malisz 1982]. Undoubtedly, the negligence of infrastructure development leads to a decline, both in civilization standard and especially in the economic competitiveness of a given territorial unit [Michalek et al. 2000]. Poland's integration of with the European Union became a major impetus not only to obtain a suitably satisfactory level of alignment with the Community law, particularly the Water Framework Directive, legal solutions regulating the water economy of the country being in force in Poland, but above all to the implementation of specific investment projects, leading to overcoming development thresholds in the field of water-sewage economy of individual settlement and territorial units [Water Law 2001; Environmental Protection Law 2001; The Act on collective water supply and sewage disposal 2001]. Rural areas, which in spite of the progressive expansion of sewage systems in recent years have not still achieved a balanced development of the water and sewerage infrastructure hence the optimum degree of "water supply system" and "the sewage system" of the countryside". were affected significantly [Kłos 2011]. Nevertheless, the new water law which meets the needs of the EU requirements, implemented new water and wastewater policies of the country demanding complementary design activities in the

area of wastewater management and in the area of supplying people with drinking water. That led to positive transformation in this regard [Water Law 2001]. In this context, the identification of the degree of saturation and dynamics of changes in water and sewage infrastructure of particular subregions of the country, especially rural areas, and an attempt to diagnose the causes of disparities provide grounds for the research.

## METHODOLOGY OF RESEARCH

The aim of the study was to determine the saturation and dynamics of changes in water and sewage infrastructure in the years 2003–2013 in urban, rural communes and cities being part of the subregion of Western Malopolska. The data obtained allowed to determine if within a decade a growth of infrastructure saturation in constituent communes and cities was evident. The state of water and sewage infrastructure in the years 2003 and 2013 were described using saturation indexes which were determined by the length of collective sewerage system and distributive water supply systems and per surface of 100 km$^2$ [Gruszczyński, Kwapisz 2000]. The obtained results helped to determine the degree of saturation change and the saturation pace of the aforementioned infrastructure in the analyzed decade for cities, municipalities, rural-urban and rural communes of the studied area. To complete the characteristics of the water and sewage infrastructure development in the given time period the number of sewage and water connections as well as the number of people using the water supply and sewerage systems were assessed. The pace of change was estimated using the percentage index dynamic. The source data was collected on the basis of resources of Local Data Bank of CSO.

## CHARACTERISTICS OF RESEARCH AREA

The analysis included the area of the Western Malopolska Subregion which covers an area of 2605 km$^2$, including 15 rural communes, 2 municipalities and 13 urban-rural communes. Western Malopolska is situated at the junction of four geophysical subprovinces: Silesian-Krakow Upland Malopolska Upland, Northern Podkarpacie and the Outer Western Carpathians (The Beskids). The population density stands at 213 km$^2$. The population fluctuates around 556 thousand people (2013), which represents 16.6% of the inhabitants of Malopolskie Voivodeship and puts the subregion in second place in the region – just after the Krakow Metropolitan Area. The coefficient of urbanization in 2013 reached 47.5% (Chrzanowski county) which is among the highest in the voivodeship. The most densely populated urban-rural municipalities are Chrzanów and Oswiecim, while the most densely populated rural commune is Osiek [Local Data Bank of CSO 2005; The report on the status of spatial development of Malopolska 2014].

Subregion has three urban centres of supra-local importance: Chrzanów. Oświęcim and Olkusz. Large heavy industry and numerous small and medium-sized enterprises dominate in economy. There are considerable economic ties with Upper Silesia. The unemployment rate remains at a high level, Western Malopolska is then an area of industrial character, well-developed settlement network and strong urbanisation, but also of polluted environment. manifesting itself in poor air quality, a large number of landfills and brownfield and significant land degradation that require urgent remediation [Subregional Development Programme 2020, Krakow 2015].

## RESULTS AND DISCUSSION

The total length of water supply system in rural communes of Western Malopolska Subregion amounted to 1167.5 km in 2003. All the analyzed communes had water supply system. The water supply infrastructure saturation index reached 138.9 km/100 km$^2$. By 2013 there was an increase of 163.2 km in the total length of water supply system. In the individual communes such as Przeciszów, Babice and Klucze an insignificant increase of water supply system was recorded in the analysed decade. Similarly. a saturation index of water supply infrastructure increased only by 14% after a decade (Table 1).

The total length of the sewage system in rural communes of the examined sub-region amounted to 101.8 km in 2003. Of the 15 rural communes, five of them namely Stryszów, Wieprz, Osiek, Przeciszów, Babice did not have a sewerage system. The sewage infrastructure saturation index was at a value of 12.1 km/100 km$^2$. By 2013

**Table 1**. Saturation of distributive water supply systems and collective sewerage systems in rural communes of Western Malopolska Subregion in 2003 and 2013

| Rural communes | The length of water supply system in km 2003 | The length of water supply system in km 2013 | The length of sewerage system in km 2003 | The length of sewerage system in km 2013 |
|---|---|---|---|---|
| Brzeźnica | 139.2 | 136.1 | 15.1 | 23.1 |
| Lanckorona | 26.8 | 82.5 | 2.6 | 9.5 |
| Mucharz | 26.4 | 59.2 | 47.4 | 74.0 |
| Spytkowice | 76.6 | 87.0 | 3.0 | 29.4 |
| Stryszów | 26.4 | 59.2 | 0.0 | 92.5 |
| Tomice | 98.9 | 101.4 | 8.0 | 8.2 |
| Wieprz | 121.0 | 134.0 | 0.0 | 0.0 |
| Osiek | 83.9 | 85.2 | 0.0 | 62.4 |
| Oświęcim | 164.7 | 169.9 | 4.7 | 15.5 |
| Polanka Wielka | 37.5 | 41.5 | 1.0 | 1.0 |
| Przeciszów | 57.6 | 58.8 | 0.0 | 36.3 |
| Babice | 61.8 | 62.2 | 0.0 | 17.9 |
| Bolesław | 40.4 | 44.9 | 6.3 | 42.1 |
| Klucze | 101.5 | 102.8 | 4.7 | 8.5 |
| Trzyciąż | 104.8 | 106.0 | 9.0 | 18.4 |
| Total length of systems for rural communes of WMS [km] | 1167.5 | 1330.7 | 101.8 | 438.8 |
| The area of rural communes of WMS [km$^2$] | 840.43 | | | |
| Saturation index for rural communes of WMS [km/100 km$^2$] | 138.9 | 158.3 | 12.1 | 52.2 |
| Dynamic index [%] | 14 | | 331 | |

**Source**: Own study based on Local Data Bank of CSO in Warsaw.

there was an increase in total network length of 337 km. In the group of rural communes after 10 years the commune of Wieprz still had no sewage system. In Polanka Wielka commune no increase in the length of the system was observed. During the analyzed decade it was invariably 1km. In the commune of Tomice the length increased only by 200 metres. However, in the analysed decade there was a significant increase of 331% in the sewage infrastructure saturation index for analysed communes (Table 1).

The total length of water supply system in urban and urban-rural communes of Western Malopolska Subregion amounted to 2030.2 km in 2003. Of the 15 urban and urban-rural communes all had water supply system. The water supply infrastructure saturation index was equivalent to 115.1 km/100 km$^2$. By 2013, there was an increase of 180.2 km in the length of water supply system. In Chełmek municipality a slight increase of 700 m in the length of the system was found. In the considered decade, a growth of 8.9% of water supply infrastructure saturation index was observed in comparison with the year 2003 (Table 2).

The total length of the sewage system in urban and semi-urban areas of the subregion amounted to 824.1 km in 2003. All the analyzed communes had the sewage system. Saturation index was equal to 46.7 km/100 km$^2$. By 2013 there was an increase in the total length of the sewage system of 549.2 km. Thus, a growth of 66.7% of water supply infrastructure saturation index was observed (Table 2).

The number of water supply connections in rural communes of Western Malopolska Subregion amounted to 27393 units in 2003. Of the 15 rural communes all had water supply connections for. By 2013, the number of connections increased by 17.4% (Table 3).

The number of sewage connections in rural communes of the subregion equalled 1.545 units in 2003. Of the 15 rural communes residents of five of them namely Stryszów, Wieprz, Osiek, Przeciszów, Babice did not have sewer connections. By 2013, the number of connections increased by 505.5%. After ten years there were still no sewer connections in Wieprz commune (Table 3).

**Table 2**. Saturation of distributive water supply systems and collective sewerage systems in municipalities and urban-rural communes of Western Malopolska Subregion in 2003 and 2013

| Municipalities and urban-rural communes | The length of water supply system in km 2003 | The length of water supply system in km 2013 | The length of sewerage system in km 2003 | The length of sewerage system in km 2013 |
|---|---|---|---|---|
| Andrychów | 170.8 | 199.5 | 151.3 | 182.9 |
| Kalwaria Zebrzydowska | 127.7 | 138.2 | 9.2 | 16.2 |
| Wadowice | 106.0 | 125.0 | 98.1 | 157.9 |
| Brzeszcze | 95.7 | 126.2 | 33.0 | 65.6 |
| Chełmek | 53.1 | 53.8 | 15.9 | 27.6 |
| Kęty | 187.6 | 205.0 | 32.9 | 142.0 |
| Zator | 93.9 | 101.4 | 71.4 | 108.8 |
| Alwernia | 148.5 | 153.5 | 28.3 | 46.6 |
| Libiąż | 114.6 | 117.1 | 32.5 | 53.4 |
| Trzebinia | 202.5 | 223.4 | 55.5 | 162.5 |
| Chrzanów | 177.3 | 185.4 | 105.3 | 170.4 |
| Olkusz | 178.1 | 185.2 | 59.1 | 75.3 |
| Wolbrom | 234.7 | 236.5 | 20.4 | 25.2 |
| Oswiecim – city | 105.9 | 115.6 | 83.5 | 117.5 |
| Bukowno – town | 33.8 | 44.6 | 27.7 | 22.0 |
| The total length of systems for municipalities and urban-rural communes of WMS [km] | 2030.2 | 2210.4 | 824.1 | 1373.9 |
| The area of municipalities and urban-rural communes of WMS [km$^2$] | 1764.6 | | | |
| Saturation index of systems for municipalities and urban-rural communes of WMS [km/100 km$^2$] | 115.1 | 125.3 | 46.7 | 77.9 |
| Dynamic index [%] | 8.9 | | 66.7 | |

**Source**: Own study based on Local Data Bank of CSO in Warsaw.

**Table 3**. Water supply and sewage connections in rural communes of Western Malopolska Subregion in years 2003–2013

| Rural communes | The number of water supply connections 2003 | The number of water supply connections 2013 | The number of sewerage connections 2003 | The number of sewerage connections 2013 |
|---|---|---|---|---|
| Brzeźnica | 2255 | 2600 | 161 | 349 |
| Lanckorona | 412 | 1246 | 14 | 128 |
| Mucharz | 280 | 901 | 513 | 1151 |
| Spytkowice | 2027 | 2426 | 35 | 572 |
| Stryszów | 427 | 835 | 0 | 1268 |
| Tomice | 1626 | 1841 | 280 | 386 |
| Wieprz | 2025 | 2397 | 0 | 0 |
| Osiek | 1716 | 1919 | 0 | 605 |
| Oświęcim | 4132 | 4672 | 246 | 721 |
| Polanka Wielka | 865 | 1083 | 34 | 137 |
| Przeciszów | 1526 | 1614 | 0 | 624 |
| Babice | 2352 | 2588 | 0 | 271 |
| Bolesław | 2178 | 2180 | 9 | 988 |
| Klucze | 3678 | 3815 | 38 | 166 |
| Trzyciąż | 1894 | 2043 | 215 | 444 |
| The total number of connections for rural communes of WMS | 27393 | 32160 | 1545 | 7810 |
| Dynamic index [%] | 17.4 | | 505.5 | |

**Source:** Own study based on Local Data Bank of CSO in Warsaw

The number of water supply connections in the urban and urban-rural communes of Western Malopolska Subregion amounted to 63870 units in 2003. Residents of all communes had water supply connections. By 2013, the number of connections for a group of 15 communes increased by 6.9%. However, in the municipality of Trzebinia the number of connections decreased by 242 in relation to 2003 (Table 4).

The number of sewage connections in urban and semi-urban communes of the subregion reached 15072 units in 2003. Inhabitants of all communes possessed sewer connections. By 2013, the number of connections increased significantly by 86.1% (Table 4).

The percentage share of the population of rural communes of Western Malopolska Subregion utilising the water supply system equalled 19% in 2003. An increase of 9.7% in the number of residents of all rural communes using the water supply infrastructure was observed in the researched decade. In Boleslaw and Trzyciąż communes; however, a decrease in the number of users of water supply system was noted (Table 5).

The percentage share of the population of rural communes of the subregion utilising the sewage system equalled 1.7% in 2003. In the group of 15 rural communes residents of five of them namely Stryszów, Wieprz, Osiek, Przeciszów and Babice were not users of the sewage system. After a decade, the number of users considered globally of that infrastructure for all the inhabitants of rural communes increased by 184.7%. Nevertheless. residents of Wieprz commune still did not have access to the sewage system in 2013 (Table 5).

The percentage share of the population using the water supply system in urban and urban-rural communes of Western Malopolska Subregion reached the level of 69.4% in 2003. The increase in the number of people using the water supply infrastructure in the analysed decade was relatively small and amounted to 0.71%. In communes such as Bukowno, Oswiecim, Wolbrom, Olkusz, Chrzanów and Libiąż a decrease in the number of network users was found (Table 6).

The percentage share of the population using the sewage system in the urban and urban-rural communes of Western Malopolska Subregion was equal to 42.9% in 2003. After a decade the number of users of sewage infrastructure increased by 13.8%. In communes such as Bukowno, Oswiecim and Wolbrom a downward trend of sewerage supply users in the researched period was reported (Table 6).

**Table 4**. Water supply and sewage connections in urban and urban-rural communes of Western Malopolska Subregion in years 2003–2013

| Urban and urban-rural communes | The number of water supply connections 2003 | The number of water supply connections 2013 | The number of sewerage connections 2003 | The number of sewerage connections 2013 |
|---|---|---|---|---|
| Andrychów | 4956 | 5403 | 3538 | 4496 |
| Kalwaria Zebrzydowska | 3268 | 3930 | 294 | 369 |
| Wadowice | 4352 | 5048 | 721 | 1969 |
| Brzeszcze | 3389 | 4109 | 403 | 1800 |
| Chełmek | 1887 | 2173 | 360 | 586 |
| Kęty | 5643 | 5725 | 722 | 2835 |
| Zator | 1824 | 2192 | 981 | 1745 |
| Alwernia | 2934 | 3141 | 384 | 988 |
| Libiąż | 4441 | 4558 | 613 | 1106 |
| Trzebinia | 7234 | 6992 | 873 | 3224 |
| Chrzanów | 6205 | 6551 | 2497 | 4095 |
| Olkusz | 7189 | 7406 | 784 | 1427 |
| Wolbrom | 5231 | 5507 | 998 | 1284 |
| Oswiecim – city | 3136 | 3350 | 1051 | 1430 |
| Bukowno – town | 2181 | 2197 | 853 | 691 |
| The total number of connections for rural communes of WMS | 63870 | 68282 | 15072 | 28045 |
| Dynamic index [%] | 6.9 | | 86.1 | |

**Source**: Own study based on Local Data Bank of CSO in Warsaw.

**Table 5**. The number of people using the water supply and collective sewage systems in the rural communes of Western Malopolska Subregion in years 2003–2013

| Rural communes | Users of water supply system 2003 | Users of water supply system 2013 | Users of sewage system 2003 | Users of sewage system 2013 |
|---|---|---|---|---|
| Brzeźnica | 8230 | 8550 | 533 | 960 |
| Lanckorona | 1202 | 3209 | 52 | 589 |
| Mucharz | 1295 | 2488 | 1801 | 2862 |
| Spytkowice | 8871 | 9700 | 125 | 1219 |
| Stryszów | 860 | 2088 | 0 | 3484 |
| Tomice | 5174 | 6076 | 1131 | 1766 |
| Wieprz | 9415 | 10200 | 0 | 0 |
| Osiek | 7315 | 7688 | 0 | 2157 |
| Oświęcim | 15727 | 17341 | 1074 | 3244 |
| Polanka Wielka | 4037 | 4190 | 173 | 179 |
| Przeciszów | 6527 | 6609 | 0 | 1540 |
| Babice | 8325 | 8706 | 0 | 950 |
| Bolesław | 7624 | 7609 | 29 | 2704 |
| Klucze | 14278 | 14658 | 3588 | 4121 |
| Trzyciąż | 6732 | 6720 | 1044 | 1410 |
| Percentage share in relation to the total population WMS [%] | 19.0 | 20.8 | 1.7 | 4.9 |
| Dynamic index [%] | 9.7 | | 184.7 | |
| Population of WMS (2013)[thousand] | 556 | | | |

**Source**: Own study based on Local Data Bank of CSO in Warsaw.

**Table 6**. The number of people using the water supply and sewage systems in the urban and urban-rural communes of Western Malopolska Subregion in years 2003–2013

| Rural and rural-urban communes | Users of water supply system 2003 | Users of water supply system 2013 | Users of sewage system 2003 | Users of sewage system 2013 |
|---|---|---|---|---|
| Andrychów | 34523 | 35516 | 28206 | 30327 |
| Kalwaria Zebrzydowska | 10557 | 12637 | 1636 | 1769 |
| Wadowice | 27880 | 29590 | 20732 | 25158 |
| Brzeszcze | 21352 | 21523 | 12916 | 14691 |
| Chełmek | 12244 | 12507 | 6307 | 6992 |
| Kęty | 30233 | 31349 | 12349 | 19010 |
| Zator | 8440 | 8804 | 4497 | 5723 |
| Alwernia | 12211 | 12668 | 2901 | 4755 |
| Libiąż | 22388 | 22202 | 12475 | 13619 |
| Trzebinia | 33425 | 33722 | 14252 | 25243 |
| Chrzanów | 49390 | 47410 | 37600 | 39859 |
| Olkusz | 49154 | 48753 | 32342 | 33468 |
| Wolbrom | 22515 | 22511 | 8251 | 8225 |
| Oswiecim – city | 40801 | 39095 | 37390 | 36118 |
| Bukowno – town | 10699 | 10283 | 6785 | 6658 |
| Percentage share in relation to the total population WMS [%] | 69.4 | 69.9 | 42.9 | 48.9 |
| Dynamic index [%] | 0.71 | | 13.8 | |
| Population WMS (2013) [thousand] | 556 | | | |

**Source**: Own study based on Local Data Bank of CSO in Warsaw.

## CONCLUSIONS

The conducted analysis shows that within the decade of 2003–2013 there was a sharp increase in the saturation of water and sewage infrastructure of Western Malopolska. The high degree of development of the settlement system is indicated by the fact of owning the water supply system in all rural, urban and rural-urban communes of the subregion. This is due to high industrialization and population concentration in local towns, especially in such local centres as Olkusz, Chrzanów and Oswiecim. It is also the result of low availability of groundwater sources, their high pollution caused by long-term operation in deep mining of coal, zinc and lead ore as well as opencast mineral materials and the ensuing reduction in the level of these waters, which makes it virtually impossible to supply households with water coming from deep wells.

A significant improvement in the water sewage infrastructure saturation of the study area was observed, which confirms a well-organized system of planning and utilization of the EU funds. Operational Programme Infrastructure and Environment 2007–2013 under the Water Framework Directive among others. In this respect. rural communes (eg. Przeciszów and Polanka United), which had had no sewage system until then where the main objective of investment projects was the improvement of the surface waters and land in the context of the previously induced pollution by the direct discharge of sewage into sumps, stand out. Communes which by 2013 had not undertaken the construction of the sewage system (Wieprz commune) and numerous cases of communes (Stryszów, Przeciszów, Babice) which carried out and successfully finalized the investment process were identified.

There was no significant increase in the number of people using the water supply system in urban and urban-rural communes. This demonstrates the stabilization of their urbanization functions. However, a marked increase in the number of users of water supply and sewerage system in the area of rural communes was observed.

A large disparity between the total length of the water and sewage systems can still be seen in all rural communes. which indicates a lack of balance of water-sewage economy. The rationale of the trend might be the functional type of aforementioned communes, their agricultural, horticultural and greenhouse orientation, as well as a significant increase in the scattered residential development on their land. It seems that this trend will continue in the near future. Only the largest municipal units (Chrzanow, Oswiecim, Olkusz) of the subregion have a balanced ratio in this regard.

It must be concluded that the subregion of Western Malopolska, despite the lack of socio-economic cohesion and optimally balanced water-sewage economy is an active beneficiary of the EU and national funding structures, satisfactorily capitalising the investment leading to the increase of saturation of water and sewage infrastructure. Previous actions constitute a good basis for further participation in the aid programs in order to carry out further tasks in the field of sustainable development of infrastructure in years 2014–2020.

## REFERENCES

1. Gruszczyński J., Kwapisz J. 2000. The state of technical infrastructure Malopolska against the country. Zeszyty Naukowe of University of Agriculture in Krakow, No. 356, Scientific session 72, 157–168.
2. Kłos L. 2011. The state of water and sewage infrastructure in rural areas in Poland and the requirements of the Water Framework Directive. Studies and Works WNEiZ, No. 24.
3. Malisz B. 1982. The outline of the theory of forming settlement arrangements. Arkady, Warszawa, 73–79.
4. Michałek R., Gruszczyński J., Kwapisz J., Woźniak A. 2000. Technical infrastructure and ecology of rural areas. Science Notebooks of University of Agriculture in Krakow.
5. Stawasz D. 2005. Technical infrastructure and city development. Lodz University Press.
6. Subregional Development Programme 2020. Annex to Resolution No. 1810–1815 ZWM of 29 December 2015, Krakow 2015.
7. The Act of 18 July 2001. Water Law. Journal of Laws of 2005, No. 239, item 2019 as amended.
8. The Law of 7 June 2001 about public water supply and public wastewater removal. Journal of Laws of 2006, No. 123, item 858.
9. The Act of 27 April 2001. Environmental Protection Law. Journal of Laws of 2006, No. 129, item 902 as amended.
10. The Act of 18 July 2001. Water Law. Journal of Laws of 2005, No. 239, item 2019 as amended.
11. The report on the status of spatial development of Malopolska 2014. Appendix to Resolution No. 912/14 of the Board of Malopolska Region of 26 August 2014.