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Degree of Development and Functionality of the Water Supply and Sewage Systems in Rural Poland

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Abstract

The development of water supply and sewage systems in rural areas in Poland is presented. Several factors characterizing progress in their construction are analyzed. The scope of analysis covers such factors as the percentage of population using the systems, increase in the length of the water supply and sewage networks, the number of connections to the systems, mean values of water consumption and sewage production for the water supply and sewage system connections, respectively, and the per capita water consumption. The source material is the data published by the Central Statistical Office and results of studies by other authors. Although the development of water supply and sewage systems has accelerated recently, delays in construction continue to be observed, especially in the case of sewage disposal and treatment infrastructure. Compliance by Poland with the decisions regarding its appropriate development in rural areas is a serious problem.

Keywords: rural areas, water supply system, sewage system, development

Introduction

Speaking of the development and organizational functionality of water supply and sewage infrastructure in rural Poland after WWII, it is convenient to single out several characteristic stages. They are the following: a stage of stagnation from the end of WWII to 1955, early moderate development up to 1979, and two substages of dynamic development—from 1979 to 1989 and after the year 1990. Each stage or substage was characterized by different conditions for the construction of water supply systems in rural areas. This had a significant effect, not only on the existing degree of water supply and the combined sewage disposal in rural areas but also on the present technical condition of such facilities. Economic conditions of the functioning of water supply and sewage systems were different in the respective periods of time, varying with their dependence on state agencies or local governments. In the pre-accession period and just after Poland became a member state of the EU, the construction and modernization of water supply and sewage systems in Poland accelerated. Transformations in rural Poland were also seen in the higher standard of living, changes in the structure and size of farms and agricultural production.

Water supply, commonly expected by all inhabitants, dominated initially the development of water supply and sewage infrastructure. Sewage disposal and treatment were postponed, mainly because of a shortage of funds but also a lack of awareness of the necessity to have such facilities in rural areas, which was observed initially among local communities. At present, both water supply in urban and rural areas and sewage disposal and treatment are regarded as priorities by local governments. Any problems that may result from such priorities are both caused by the state of water resources in Poland and have an effect on it (Knapik and Pawełek 2013).

This paper is intended to discuss the degree of development of water supply and sewage systems in rural Poland and to indicate factors that have had a significant effect on their development and functionality at present. This analysis is essentially based on official statistical yearbooks (Statistical Yearbooks of Poland) published by the Central Statistical Office of Poland (CSO) and

on the findings of long-term studies conducted at the Department of Sanitary Engineering and Water Management, University of Agriculture in Kraków.

1 Historical outline

The present degree of development of water supply and sewage systems in rural Poland is largely due to applicable laws or regulations adopted during the last 5 decades. One of the first laws, Law on Water Supply in Agricultural and Rural Areas, was adopted by the Sejm on 10 December 1965.[1] It enabled the construction of rural water networks to be budget-funded, thus causing an increase in water supply to rural Poland. Another law was the Regulation of the Minister of Agriculture of 5 January 1966 titled "Guidelines for calculating water demand in rural settlements".[2] Although water demand data were specified in the regulation, their values were too high for essential needs. Nonetheless, they were the source data upon which measurements for rural systems were to be based for some 3 decades. This resulted in oversized water supply networks, of which the capacity has never been used fully, merely in the range of 40%–50% (Tylek, Sroczyński, and Pawełek 1988). In 1988 the percentage of rural population using water supply systems was 68,2% (Szpindor 1998); this includes 29,9% for water networks and 38,3% for farmstead water supply systems; the number of the latter increased from 24 thousand to 720 thousand pieces in the years 1968–1988.[3]

A Resolution of the Council of Ministers "establishing provincial water service authorities for agriculture" (WZUW), of 1978.09.11 (Resolution no. 130/78, 1978), was good news for the rural water supply systems, of which the number had grown rapidly. Poland was then divided in 49 provinces. The water authorities were the first large-range organizational structure, covering all rural water supply systems partially funded by the budget. Their main responsibilities included the operation, maintenance, and repairs of collective water supply and collective sewage disposal facilities.

The further development and the quality of operation of rural water supply systems were determined by the Law on Local Governments, of 8 March 1990.[4] The law made local governments responsible for "own tasks of communes," including water networks, water supply, sewage systems, municipal sewage disposal and treatment, cleaning, and sanitary facilities. The law resulted in most water supply networks being overtaken by local governments from their previous owners—the provincial water service authorities, leading to their eventual collapse. The operation of water supply systems was then commissioned to assorted entities, including private one-man businesses, or other entities such as agricultural service cooperatives (Kółka Rolnicze), or assorted small businesses were established to handle water supply, sewage, rural roads, road lighting, waste disposal, etc. Especially in the first years, the changes affected the quality of operation of small systems—it had been much better before, however, which does not mean perfect.

An increase in the length of water supply lines and that of collective sewage systems is an essential indicator of progress in the development of rural water supply and sewage systems. Their comparison shows disproportions that may exist between the two kinds of systems. Assuming that the length of the sewage network must be approximately 0,65 of the length of the water supply network to eliminate any disproportions between the development of water supply system and sewage system (Szpindor 1998) then, according to data for 2014, roughly 47,2 thousand km of sewage lines ought to be built in Poland. This means that, even though progress in the development of sewage disposal systems in rural areas is rather observable, it is still far behind actual demand.

2 Development of water supply systems

The fast growing increase in water supply networks being built in rural areas starting from the 1970s resulted in a higher percentage of population having access to water from network systems. Table 1 shows the percentage of population in urban and rural Poland with access to water supply

1. See: Ustawa z dnia 10 grudnia 1965 r. o zaopatrywaniu rolnictwa i wsi w wodę. DzU z 1965 r. nr 51 poz. 314.
2. See: Dz. Bud. z 1967 r. nr 3 poz. 13.
3. [In the journal European practice of number notation is followed—for example, 36 333,33 (European style) = 36 333.33 (Canadian style) = 36,333.33 (US and British style).—Ed.]
4. See: Ustawa z dnia 8 marca 1990 r. o samorządzie terytorialnym. DzU z 1990 r. nr 16 poz. 95.

Tab. 1. Population with access to water supply systems in Poland (in %)

Year	Rural	Urban	Total
1990	29,9	90,0	66,8
2005	71,8	94,9	86,0
2010	75,3	95,3	87,8
2014	84,3	96,4	91,6

Source: Author's study on the data from Statistical Yearbooks of Poland

network systems. The data indicate a high dynamics of increase in the number of rural population using combined water supply systems.

Selected indicators of development of water supply systems in rural areas in comparison with data for Poland in general, collected from published statistical information from CSO, are shown in figures 1–3 (Statistical Yearbooks of Poland from years 1995–2014). The data in figure 1 indicate that the mean annual increase in the length of water supply network in Poland in the years 1995–2014 was 6 848,1 km per year, including 5 771,6 km per year in rural areas. This means that new water supply systems were built mainly in rural areas (84,3%). The total increase in the length of water supply network in Poland in the multi-annual period of interest was 136 962,6 km which was 88,1% more than the initial value for the year 1995. On the other hand, the increase in the length of water supply networks in rural areas was dominant: 115 431,9 km, or 103,6%. The data for rural areas also show a declining trend in the development of water supply networks over the years. For instance, the increase was 12 304,8 km in 1996, 5 815,1 km in 2004, and 3 300,0 km in 2014. This is attributable to the fact that the percentage of population with access to the water supply network was becoming higher and higher.

The quantity of water network connections was growing, indicating the development of water supply systems. The data for Poland in figure 2 show an increase from 2 978,9 thousand pieces in the year 1995 to 5 372,5 thousand pieces in 2014. Mean annual increase in the quantity of water network connections in Poland was 119,7 thousand pieces per year. The highest increase (201,7

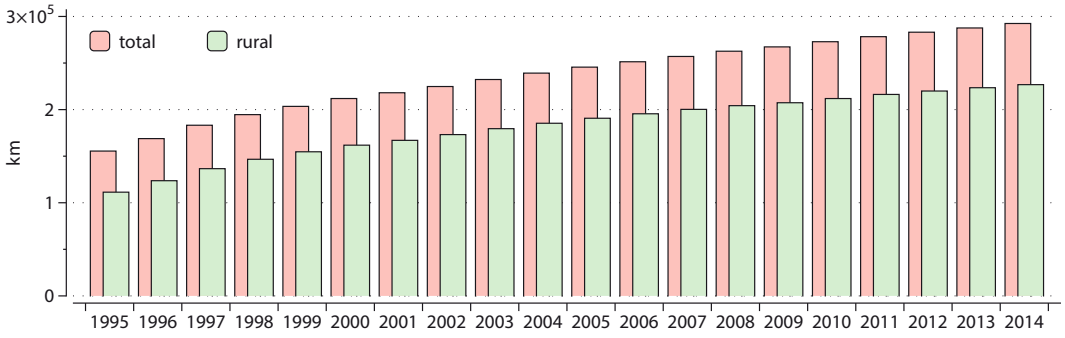

Fig. 1. Change in the length of water distribution network in Poland in the years 1995–2014

Source: Author's study on the data from Statistical Yearbooks of Poland

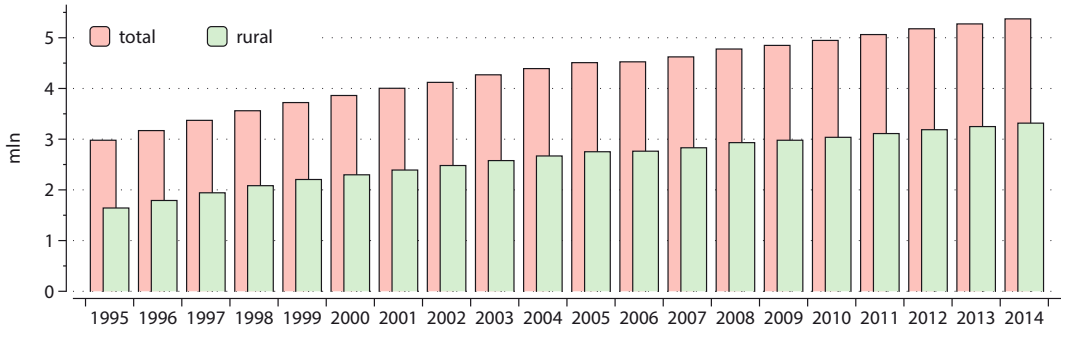

Fig. 2. Change in the quantity of water network connections in Poland in the years 1995–2014

Source: Author's study on the data from Statistical Yearbooks of Poland

thousand pieces per year) was seen in the year 1997 and the lowest (16,0 thousand pieces per year) in 2006. Taking into account the data for rural areas only, the increase in the quantity of water network connections in that period of time is quite evident. Their mean annual increase in rural areas was 83,7 thousand pieces per year, which accounts for as much as 69,9% of newly built water network connections in Poland. The highest increase in the quantity of water network connections in rural areas (151,6 thousand pieces per year) was observed in 1997 and the smallest (11,0 thousand pieces per year) in 2006.

One important characteristic of water supply system is per capita consumption of tap water. Figure 3 shows per capita consumption of water in Poland and in rural areas in the years 2002–2014. The general data for Poland indicate a declining tendency in the consumption of tap water in the decade. This is attributed, among other things, to economic factors. Higher costs of water supply and of sewage disposal had the effect that the consumption of water in households was rationalized as consumers were more inclined to control the volumes of water consumed and sewage produced. From 2009 to 2014, the mean per capita consumption of tap water in Poland was more or less stable at 85,5 dm^3 per person day. The value is rather likely to stay at that level in the near future. On the other hand, an increasing trend is observed in rural areas of Poland. Mean per capita consumption of tap water was 60,8 dm^3 per person day in the year 2002, compared with 70 dm^3 per person day in the years 2008–2014.

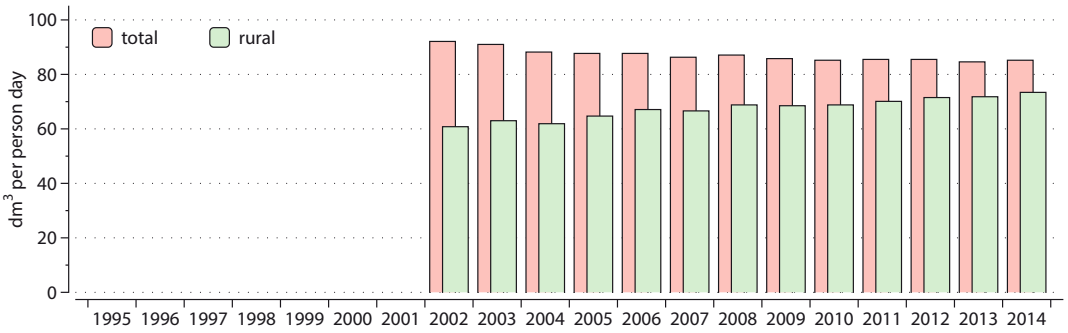

Fig. 3. Per capita consumption of tap water in Poland in the years 2002–2014

Source: Author's study on the data from Statistical Yearbooks of Poland

Some other important characteristics of water supply systems include: mean water consumption per 1 km of water network and per connection, and the length of water network per connection (tab. 2). Water consumption data showed a highly declining tendency in the years 1995–2014. The decline in water consumption was especially observable in cities: in 2014 in comparison with 1995, down to 39,6% for water consumption per 1 km of water network and down to 38,3% for water consumption per network connection. In rural areas, the values were 64,6% and 64,9%, respectively. The third parameter in table 2 (i.e., length of water network per network connection) varies slightly both for urban and rural areas.

The data in table 2 indicate also that water supply systems in rural areas are specific: the length of the water network per network connection in rural households is nearly twice that in urban areas and, for instance in 2014, was in rural households 118,5% of that in urban households. Moreover, in rural areas in 2014, mean consumption of water per network connection was only 32,2% of that in urban areas. A longer water network combined with the sale of less water per network connection puts rural water supply systems in a less advantageous economic position as it accounts for higher operating costs in the case of water distribution systems and customer service costs per 1 m^3 of water sold. These factors may result in a higher price of 1 m^3 water in rural areas.

Economic conditions stimulate more and more the emergence of larger and more complex systems of water supply, especially around large cities. The requirement to provide good quality water, given the rising cost of its treatment and compliance with legal requirements, has encouraged some local governments to seek opportunities to cut the costs of water supply. This could be achieved to a considerable extent by aggregating the water supply systems. Regardless of any opportunities

Tab. 2. Selected characteristics of water supply systems in Poland in the years 1995–2014

	Water consumption (m^3 per km per year)			Water consumption per network connection (m^3 per year)			Length of water network per network connection (m)		
Year	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1995	2 787,3	30 339,3	10 659,3	189,9	1 000,0	556,5	68,1	33,0	52,2
2000	1 977,7	20 758,4	6 418,1	139,3	664,9	352,2	70,4	32,0	54,9
2005	1 822,8	15 879,8	4 965,0	126,3	496,2	270,4	69,3	31,2	54,5
2010	1 785,7	13 434,4	4 389,5	124,6	428,9	242,9	69,8	31,9	55,2
2014	1 802,0	12 001,5	4 089,5	123,2	382,9	222,6	68,4	31,3	54,4

to reduce the costs of water supply, when its sales show a falling tendency, it is natural for the cost of maintenance of fixed assets per 1 m^3 to rise. Therefore, regardless of any other factors that may have had an effect on the economic conditions of the functioning of water and sewerage companies, the cost of water supply to consumers has obviously had to grow higher. The factors that have an impact on the price of water supply include also water losses and they continue to be high in some water supply and sewage systems (Bergel 2012a, 2012b; Bergel and Kaczor 2007; Pawełek and Bergel 2001).

3 Development of sewage systems

An important and reliable factor indicating the level of civilization is the degree of development of sewage disposal and treatment systems. In rural areas, sewage disposal systems handle mainly household sewage and that generated by public buildings and small service, processing or production companies. The volume of sewage disposed of in comparison with water consumption volume is much lower in rural areas than in urban areas because a portion of the water is not returned as sewage. That portion is called non-returnable consumption and may vary between 14 and 26% of water consumption volume, depending on the specific nature of the rural areas (Bergel 2005). In rural areas, sewage is disposed of from large territories because most villages, especially in the south and east of Poland, are characterized by scattered housing. This is one of the main reasons why the construction of sewage systems in those regions of Poland requires higher investment costs and, consequently, is also one of the reasons of the delay in their construction.

Selected factors of the development of sewage systems in Poland, based on statistical information published by CSO, are illustrated in figures 4–7. The multi-annual period 1995–2014 saw a definite increase in the length of sewage networks. Its mean annual increase (fig. 4) was 5 467,1 km per year, including 3 799,5 km per year in rural areas. The total increase in the length of sewage networks in Poland in the multi-annual period of interest was 102 341,2 km, which is 426% of the initial value for 1995. In rural areas, the increase was spectacular — as much as 1 513,2%. The density of the sewage network in rural areas in the same period of time was 1,8 km in 1995 and increased to 27,9 km per 100 km^2 by the year 2014.

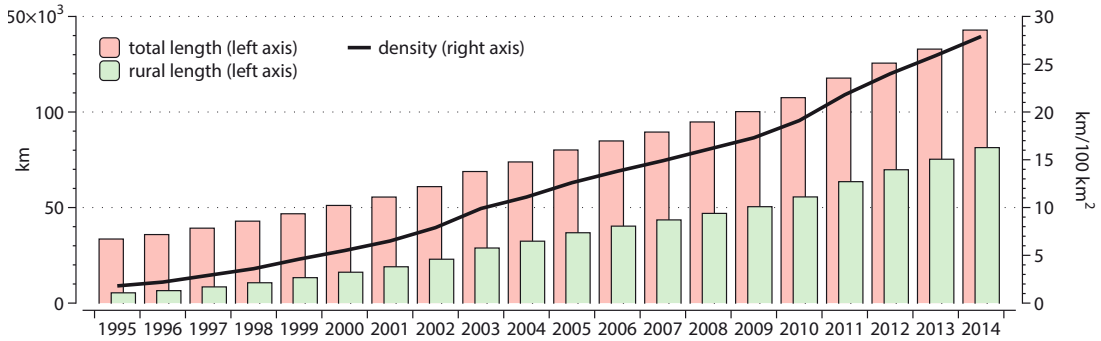

Fig. 4. The length and density of sewage systems in Poland in the years 1995–2014

Source: Author's study on the data from Statistical Yearbooks of Poland

When analyzing data for the years before and after Poland's accession to the European Union, the effect of Poland's membership is quite observable. The increase in the length of sewage networks in rural areas in the years 1995–2004 was 3 003,0 km per year, compared with 4 454,7 km per year in the years 2005–2014. A shorter length of newly built sewage networks can be expected in the near future, as indicated by its much smaller increase in the years 2013–2014. This is attributable to the depletion of so-called "easy investment projects" in areas where the designing and construction of sewage systems are favored by terrain features. In areas where terrain features are less advantageous and scattered housing prevails, households will be provided with individual sewage handling systems in the form of mini-sewage treatment plants (Bugajski and Kaczor 2008).

Taking into account the development of sewage networks in the national dimension (fig. 5), it is easy to observe a definite increase in the number of users. The percentage of users of sewage systems in Poland was 56,7% in 2002 and increased to 68,7% by the year 2014. In rural areas, the increase is more noticeable: from 14,2% in the year 2002 to 37,3% in 2014. The percentage of rural population using sewage systems increased in the years 2002–2014 from 2 078,5 thousand to 5699,8 thousand (i.e., by 174,2%).

The development of sewage systems is also shown by the growing number of sewage network connections. In the period of interest, Poland saw an increase in the number of sewage network connections from 732 532 pieces in the year 1995 to 2 912 600 pieces in 2014 (fig. 6). The highest increase was observed in 2011 (174 956 pieces per year). Taking into account just the data for rural areas, an observable increase in the number of network connections is seen in that period of time: mean increase was by 60 255 pieces per year, the highest (109 260 pieces per year) in the year 2011. Another important parameter, the volume of sewage handled by sewage systems (fig. 7) shows a definite declining tendency until 2003, the beginning of rationalization of water consumption by households due to higher costs of water supply and sewage disposal, among other things. In the following years, it stabilized at just above 1 200 million m^3 per year. In rural areas, although the value was higher, it constituted merely 9,5% of total sewage volume.

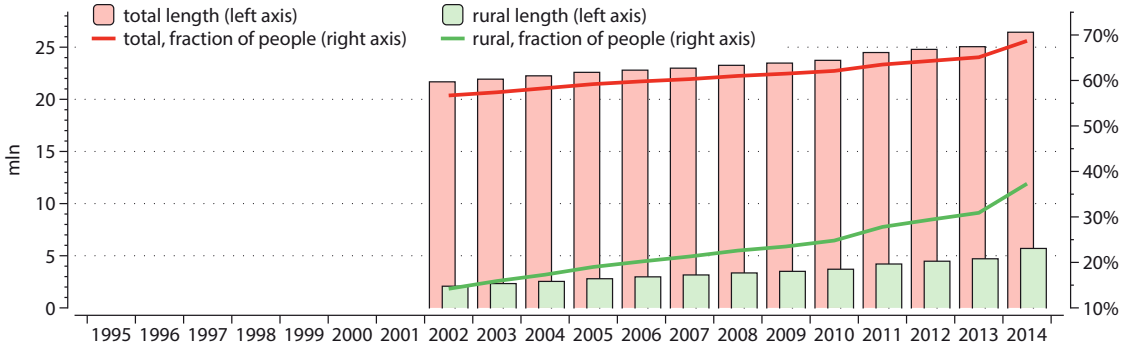

Fig. 5. The number of users and percentage of population using sewage systems in Poland in the years 2002–2014

Source: Author's study on the data from Statistical Yearbooks of Poland

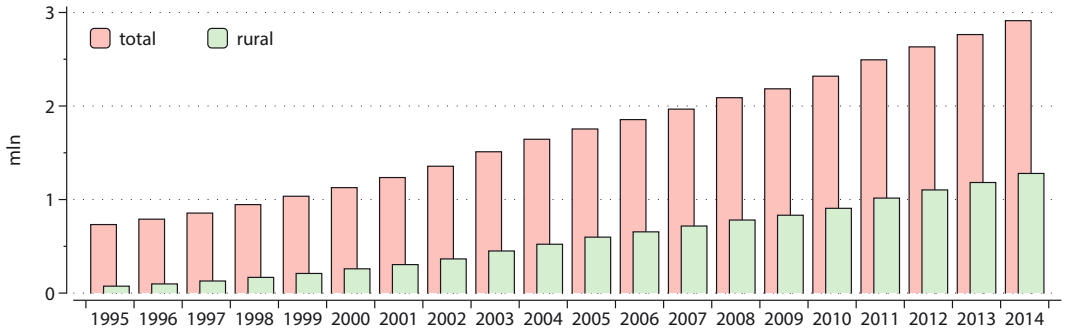

Fig. 6. Increase in the number of sewage network connections in Poland in the years 1995–2014.

Source: Author's study on the data from Statistical Yearbooks of Poland

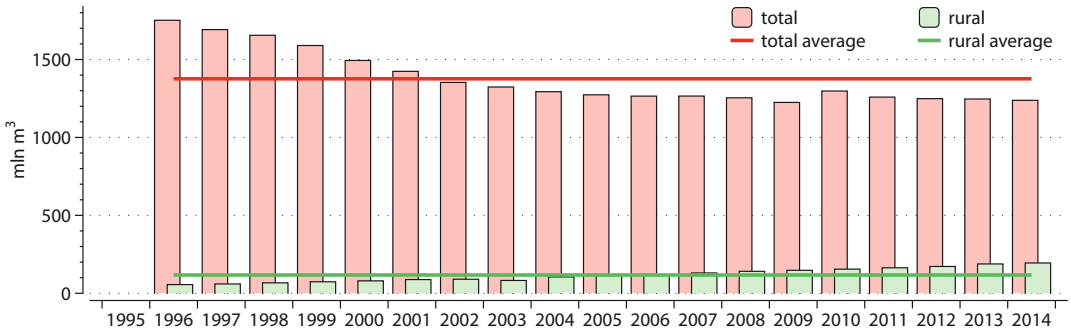

Fig. 7. The volume of sewage discharged by sewage systems in Poland in the years 1996–2014.

Source: Author's study on the data from Statistical Yearbooks of Poland

4 The functioning of systems

The proper functioning of rural water supply and sewage systems depends on their correct operation in addition to their correct design and execution of construction works in accordance with the design and construction practice. In a proper design, the selected technology is suitable for the prevailing conditions and the system has been sized appropriately. The water volume supplied is one of the essential factors affecting the size of water supply facilities. The operation of existing systems indicates that most of them have been designed incorrectly, they are usually over-sized (Bergel and Pawełek 2008), the quality of construction works was not good enough in many cases. When combined with rather poor quality of building materials, this resulted in high water losses, high cost of water supply, and often insufficient quality of the water, etc. (Bergel 2012c; Bergel, Kaczor, and Bugajski 2013).

In a long-term study on water consumption in rural settlements, performed at the Department of Sanitary Engineering and Water Management, University of Agriculture in Kraków, it has been found that significant differences exist between the actual water consumption and its calculated demand, based on which the water supply and sewage systems were designed. Most rural water supply systems do not work at their full design capacity even after a dozen years of operation. Their actual capacities are typically in the range 40%–50%, including water losses in water supply systems (Bergel and Pawełek 2008). It is worth noting that in market conditions, where water is a commodity and its price usually corresponds to the actual cost of supply, such differences will continue to be observed. In some cases, even where the cost of water is high and water consumption meters are used, its consumption may tend to be even further reduced.

Although the problem of water losses in the case of rural water supply systems in Poland has not been examined thoroughly yet, scientists from the Department found in their studies that water losses were very high in practice. An analysis of water production volume and its actual consumption for one of rural water supply systems indicates that, for the system under investigation, water losses were in the range 27,6%–35,2% of the water being pumped into the supply network (Bergel 2012a, 2012b; Pawełek and Bergel 2001). This is in agreement with data observed for water supply networks in some urban areas, according to other sources (Dohnalik 2000).

Water consumption is the principal factor affecting the volume of household sewage, its discharge dynamics and its inflow to treatment facilities. According to long-term studies on the dynamics of sewage inflow to rural treatment facilities, results observed for the systems under investigation indicate that the incoming streams of household sewage comprise a large volume of run-off and infiltration water (Kaczor 2012). The run-off water accounts for higher daily and hourly irregularities in the inflow of sewage to treatment facilities. They also dilute the sewage which, for instance, in the work of active sludge, has a major impact on the purity of the outgoing stream.

Summary

Water supply and sewage systems are major consumers of water resources. The volume and manner of water consumption are an important determinant of the quality of life and development of civilization. Collective water supply and sewage disposal and treatment are responsibilities of local governments, which use water resources according to their water permits. All the same, by discharging spent water, they have a major effect on the quality of the water resources. Uncontrolled discharges of spent water originating from areas with prevailing scattered housing or from agricultural regions with poor sewage management account for a rather high pollution of river water.

In Poland, the coverage of the water supply network and that of the sewage network are disproportionate. This is due to high costs of the construction of sewage systems. Furthermore, the problem is intensified by the prevalence of scattered housing over a major territory of Poland, with long distances between residential buildings; this raises the cost of the construction of sewage systems even more. Poland's accession to the European Union has brought about the benefit of increasing expenditure on water supply and sewage systems. In recent years, sewage systems have been provided mainly in rural areas. However, "attractive locations" for the construction of sewage systems are going to be less and less available. This is because sewage systems are built, first of all, in areas where cluster housing prevails so the per capita cost of their construction is lower. What remains is areas with scattered housing, where it is simply unprofitable to build combined sewage systems, therefore, individual households are provided with mini-treatment plants located in the premises. The number of mini-treatment plants is growing higher and will continue to grow higher in the years to come.

In rural Poland, water supply and sewage systems have longer piping per network connection in comparison with urban systems: by 119,5% for water supply (urban 31,3 m; rural 68,4 m) and by 73,4% for sewage systems (urban 36,5 m; rural 63,3 m). The foregoing are data for the year 2014. In 2014, water consumption in rural areas per 1 km of water supply network was 1 802 m^3 per year (just 15,0% of urban consumption). On the other hand, rural water consumption per network connection was 123,2 m^3 per year (32,2% of urban consumption amounting to 382,9 m^3 per year). Existing systems indicate that most of them have been designed incorrectly, they are usually over-sized, the quality of construction works was often quite poor; when combined with a rather insufficient quality of building materials this resulted, for instance, in high water losses in supply systems, high inflow of incidental waters and this raises the cost of water supply.

References

Bergel, T. 2005. *Objętość ścieków odprowadzanych z gospodarstw wiejskich do kanalizacji w zależności od struktury zużycia wody wodociągowej*. Doctoral dissertation, Faculty of Environmental Engineering and Land Surveying, University of Agriculture in Kraków, Kraków.

———. 2012a. „Analiza wskaźnikowa strat wody wodociągowej w gminach wiejskich i miejsko-wiejskich w Polsce (cz. 1)." Gaz, *Woda i Technika Sanitarna* (8):302–325.

———. 2012b. „Analiza wskaźnikowa strat wody wodociągowej w gminach wiejskich i miejsko-wiejskich w Polsce (cz. 2)." *Gaz, Woda i Technika Sanitarna* (10):413–415.

———. 2012c. „Awaryjność sieci wodociągowych małych wodociągów grupowych w Polsce." *Gaz, Woda i Technika Sanitarna* (12):536–538.

Bergel, T., and G. Kaczor. 2007. „The Volume of Wastewater Discharged from Rural Households to the Sewer System in the Light of Tap Water Consumption Structure." *Polish Journal of Environmental Studies. Hard Olsztyn* no. 16 (2A Part 2):109–112.

Bergel, T., G. Kaczor, and P. Bugajski. 2013. „Stan techniczny sieci wodociągowych w małych wodociągach województwa małopolskiego i podkarpackiego." *Infrastruktura i Ekologia Terenów Wiejskich* (4):291–304.

Bergel, T., and J. Pawełek. 2008. „Quantitative and Economical Aspects of Water Loss in Waterworks Systems in Rural Areas." *Environment Protection Engineering* (3):59–64.

Bugajski, P., and G. Kaczor. 2008. „Ocena działania wybranych przydomowych oczyszczalni ścieków w warunkach zimowych i letnich." *Przemysł Chemiczny* no. 87 (5):424–426.

Dohnalik, P. 2000. *Straty wody w miejskich sieciach wodociągowych.* Bydgoszcz: Polska Fundacja Ochrony Zasobów Wodnych.

Kaczor, G. 2012. *Wpływ wód infiltracyjnych i przypadkowych na funkcjonowanie małych systemów kanalizacyjnych, Zeszyty Naukowe Uniwersytetu Rolniczego im Hugona Kołłątaja w Krakowie.* Rozprawy. Kraków: Wydawnictwo Uniwersytetu Rolniczego.

Knapik, K., and J. Pawełek. 2013. „Gospodarowanie wodami w jednostkach osadniczych na tle stanu gospodarki wodnej w kraju." In *Praktyczne działanie przedsiębiorstw wodociągowo-kanalizacyjnych w warunkach rosnących wymagań ekologicznych, ekonomicznych i społecznych*, edited by B. Więzik, 53–70. Bielsko-Biała.

Pawełek, J., and T. Bergel. 2001. „Ograniczenie strat wody w wiejskich systemach wodociągowych jako istotny czynnik racjonalnego gospodarowania wodą." *Inżynieria Rolnicza* no. 8 (28):181–191.

Szpindor, A. 1998. *Zaopatrzenie w wodę i kanalizacja wsi.* 2nd ed. Warszawa: „Arkady".

Tylek, W., J. Sroczyński, and J. Pawełek. 1988. „Wyposażenie mieszkań w budownictwie wiejskim w urządzenia wodociągowo-kanalizacyjne a zużycie wody." In *Problemy modernizacji budownictwa rolniczego. Sesja Naukowa. Referaty*, edited by E. Komarnicki, 129–138. Kraków: Biuro Studiów i Projektów Budownictwa Wiejskiego w Krakowie; Polska Akademia Nauk, Oddział w Krakowie; Komisja Budownictwa i Gospodarki Wodnej w Rolnictwie.