http://dx.doi.org/10.15576/GLL/2014.3.17

GLL

Geomatics, Landmanagement and Landscape No. 3 • 2014, 17–32

DEVELOPMENT OF WATER SUPPLY AND SEWAGE SYSTEMS IN RURAL AREAS OF MAŁOPOLSKIE AND PODKARPACKIE VOIVODESHIPS

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Summary

The paper presents the development of water supply networks and sewage systems in rural areas of Małopolskie and Podkarpackie Voivodeships in the Polish context. The scope of the thesis includes the analyses of length of water supply networks and sewage systems, number of people using them, number of water and sewage connections and volume of used water and volume of discharged sewage. The results of the study were presented in the graphs. The research material was taken from the reports on municipal infrastructure published by The Polish Central Statistical Office (GUS) for 2002–2012 and Local Data Bank (BDL) for 1995–2001. Though there has been a significant improvement in water supply and sewage systems, Poland will have great difficulty in meeting the requirements concerning their development in rural areas by 2015.

Keywords

water supply network • sewage system • rural areas • sewage

1. Introduction

The development of water supply and sewage infrastructure – supplying water to its users and ensuring due discharge of sewage – is a condition of proper functioning of water management in rural areas. Already in the seventies there has been an intensive development of water supply systems. It was especially visible in the cities and towns, whereas in rural areas the period marks only the beginnings of water supply networks. The situation was much worse in terms of sewage discharge and treatment. Development acceleration in this respect was related to the adjustment of Polish law to the EU regulations, especially to the EU Water Framework Directive [Directive... 2000]. According to it (with respect to municipal sewage treatment) and according to Polish water resources and environmental laws [Ustawa z dnia 18 lipca... 2001, Ustawa z dnia 7 czerwca... 2001, Ustawa z dnia 27 kwietnia... 2001], Poland is obliged to appropriately develop water and sewage systems (including rural areas) by the end of 2015. The adaptation of legislative acts was related to the accession of Poland to the European Union. Provisions of the Water Framework Directive have been transferred to the Polish law,

mainly to the water law (Prawo wodne) with its executive acts, and to the acts on public water supply, public sewage discharge (Ustawa o zbiorowym zaopatrzeniu w wodę...), and to the law on environmental protection (Prawo ochrony środowiska). In the light of the water law provisions the problem of potable water supply to the population should be resolved together with the problems of sewage management. This obligation applies especially to rural areas, because of their highly diverse level of water supply and sewage infrastructure.

Despite considerable development of sewage systems in rural areas there still is a visible predominance of water supply networks [Kłos 2011]. In rural areas water supply networks were not built together with wastewater systems, which is why there is a substantial disproportion between water supply and sewage discharge [Ciupa 1995, Błaszczyk 1999, Eymontt 2000, Pawełek et al. 2004]. Recently, thanks to the EU funds, water supply networks and especially sewage systems have been intensely developed. According to the National Sewage Treatment Programme a public sewage system should be installed when there are no less than 120 inhabitants per 1 km of sewage network (not including the length of house sewers) [Heidrich and Stańo 2008]. 26% of rural areas in Poland have low-density housing and distances between homesteads are large, which makes construction of sewage network economically unreasonable [Sadecka 2008].

2. Objective and scope of the study

The article tries to show the development level of water supply and sewage systems in rural areas of Małopolskie and Podkarpackie Voivodeships. The scope of the study covers an analysis of length of water supply network and sewage systems, number of people using them, number of water and sewage connections and volume of used water and volume of discharged sewage. The research material consists of reports on municipal infrastructure published by The Polish Central Statistical Office (GUS) for 2002–2012 and Local Data Bank (BDL) for 1995–2001. The results of the study were presented in the form of graphs. After the analysis of the material conclusions were presented.

3. The results and discussion

3.1. The development of water supply systems

The state of water supply systems in Małopolskie and Podkarpackie Voivodeships in the context of overall situation in Poland is presented in Figures 1–3. Analysing the data shown in Figure 1, one can see that between 1995 and 2012 the length of water supply network in Poland has increased by 182%, whereas in Małopolskie Voivodeship – by 174,6%, and in Podkarpackie Voivodeship – by 176,7%. The average annual length increase of water supply network in Poland (Figure 1a) in the studied period is 7506.4 $km \cdot a^{-1}$, and in rural areas 6387.5 $km \cdot a^{-1}$. The numbers show that new networks were built mostly in villages (85.1%). Total length increase of water supply networks

in Poland in the above-mentioned period was 127 609.4 km – compared to the output data of 1995 it is an increase by 182.1% and in rural areas by 197,5%. In rural areas there is a very dynamic development of new water supply networks (108 586.7 km). Data in Figure 5a show that the intensity of new water supply networks construction has been decreasing over the years. For example in 1996 the increase was 12304.8 km, in 2004 – 5815.1 km, and in 2012 – 3663.9 km. It may mean that the needs of the population in this respect have been met.

Collected data (Figure 1b) on the development of water supply network in Małopolskie Voivodeship show that the average annual length increase of water supply networks in the analysed period was 454 km · a^{-1}, and in rural areas it was 376.6 km, which constitutes 83% of newly built water supply networks. Total length increase of water supply network during 17 years that were analysed was 7718 km – which, in comparison with the output data of 1995, is an increase by 175%. The smallest increase of 76 km · a^{-1} was observed in 2011, and the biggest in 1998 with 949 km · a^{-1}.

Data from Podkarpackie Voivodeship (Figure 1c) show that average annual length increase of water supply network was 351.1 km · a^{-1} (79%) – evidently the result of intensive building of new networks, especially in rural areas. Total length increase of water supply network in Podkarpackie Voivodeship during the studied period was 5968.7 km – which, in comparison with the output data of 1995, is an increase by 176.7%. It is slightly more than in Małopolskie Voivodeship. The smallest increase of 12.1 km · a^{-1} was observed in 2003, and the biggest of 1009.6 km · a^{-1} in 1997.

The increasing number of water connections is an indication of development level of water supply networks. The data presented in Figure 2 show an increase of water connections in Poland from 2.9789 mln in 1995 to 5.1772 mln in 2012. The average annual increase of water connections number in Poland was 129.3 thousand items · a^{-1}. The biggest increase was recorded in 1997 (201.7 thousand items · a^{-1}) and the smallest in 2006 (16 thousand items · a^{-1}). The analogous situation in rural areas shows a considerable increase in number of water connections in the same period. The average annual increase of water connections in rural areas was 90.8 thousand items · a^{-1} – no less than 70% of new water connections in Poland. The biggest increase in rural areas was observed in 1997 (151.6 thousand items · a^{-1}), and the smallest in 2006 (11 thousand items · a^{-1}).

The analysis of data from Małopolskie Voivodeship (Figure 2b) shows an increase of number of water connections from 251.1 thousand items in 1995 to 430.5 thousand items in 2012. The average annual increase of water connections number in Małopolskie Voivodeship was 10.6 thousand items · a^{-1}. The biggest increase of water connections number was observed in 1997 and 1998 (18.3 thousand items · a^{-1} each year), and the smallest in 2006 (1.7 thousand items · a^{-1}). In rural areas of Małopolskie Voivodeship there was a significant increase of water connections number in the analysed period. The average annual increase in rural areas was 7.8 thousand items · a^{-1}. The biggest increase was observed in 1999 (14.6 thousand items · a^{-1}), and the smallest in 2009 (2.7 thousand items · a^{-1}).

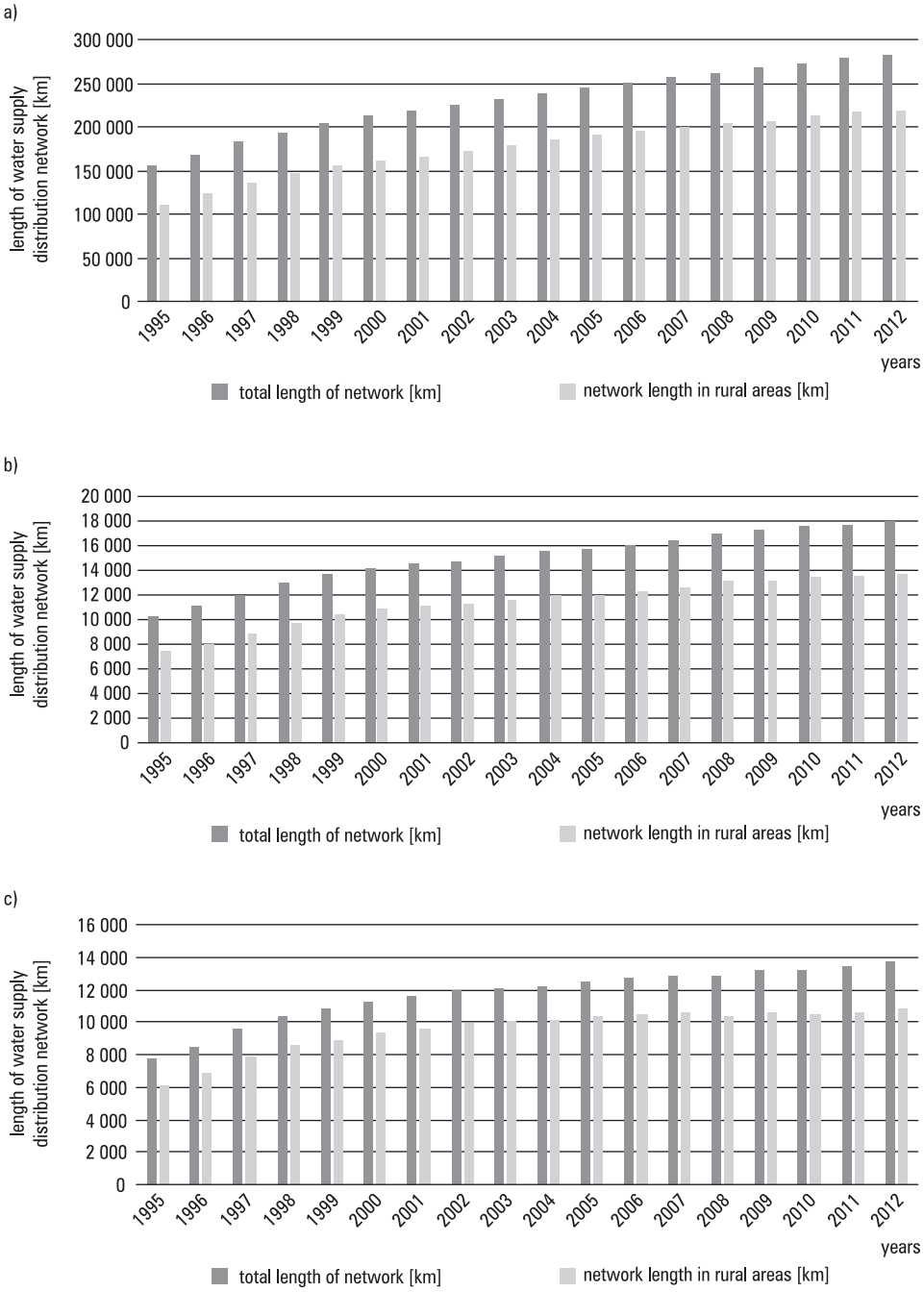

Fig. 1. Length of water supply distribution network in 1995–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

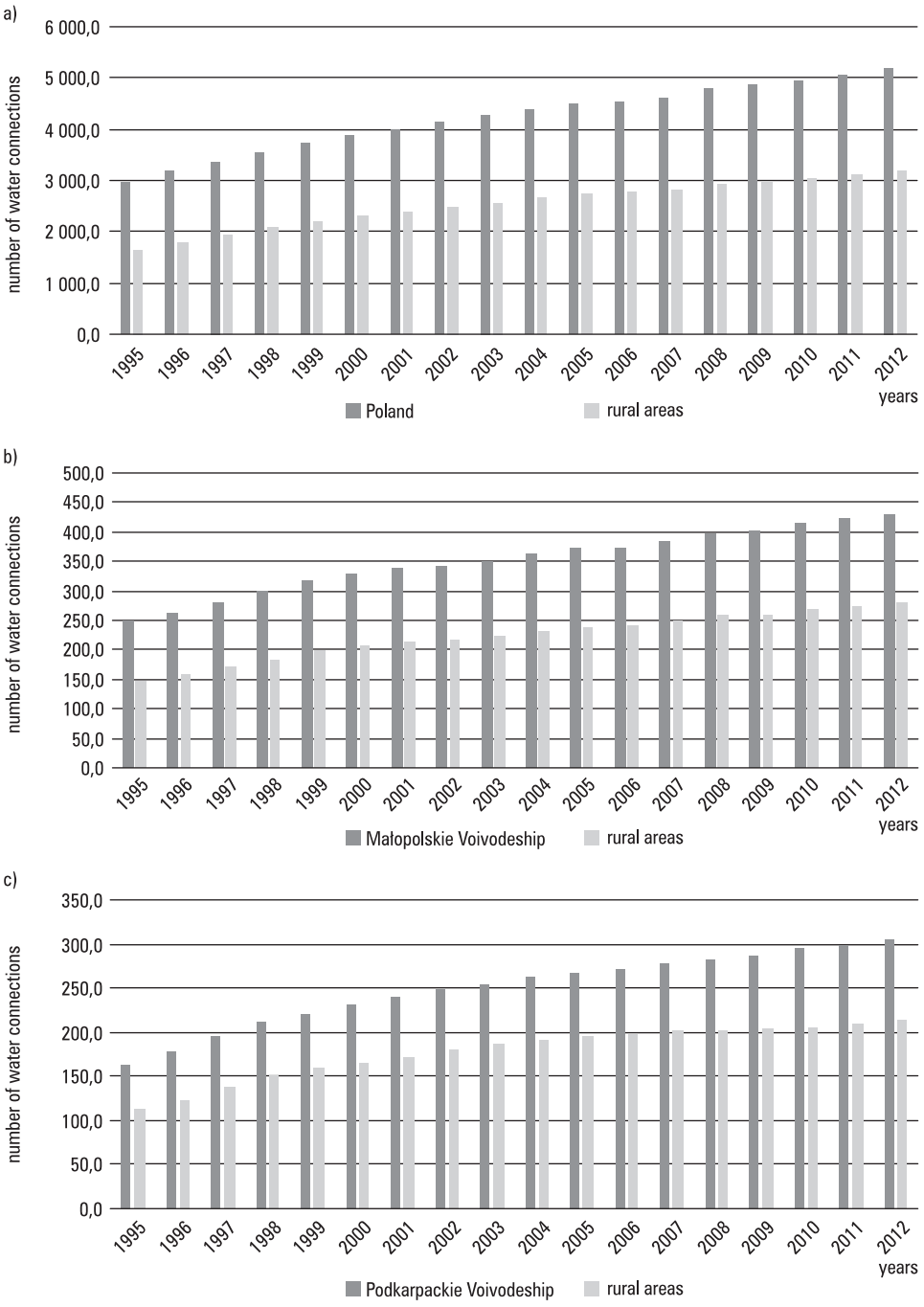

Fig. 2. Number of water connections in 2002–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

In Podkarpackie Voivodeship (Figure 2c) in 1995–2012 smaller number of new water connections was recorded (140 thousand items) than in Małopolskie Voivodeship (179.5 thousand items). In rural areas of the former province 100.5 thousand items of newly build water connections were recorded, whereas in the latter province in the same period it was 132.1 thousand items. The average annual increase of water connections number in the whole Podkarpackie Voivodeship was 8.3 thousand items $\cdot$ a^{-1}. The biggest increase was observed in 1997 (17.6 thousand items $\cdot$ a^{-1}) and the smallest in 2008 (3.6 thousand items $\cdot$ a^{-1}). In rural areas the average annual increase of water connections number was 5.9 thousand items $\cdot$ a^{-1}. The biggest increase was recorded in 1997 (14.6 thousand items $\cdot$ a^{-1}) and the smallest in 2008 (0.1 thousand items $\cdot$ a^{-1}).

The last issue considered in the context of water supply systems development is a volume of water consumption per person in 1996–2012 (Figure 3a). In the studied period in Poland it was 87.4 $dm^3 \cdot M^{-1} \cdot d^{-1}$, and the volume was smaller in rural areas with 66.5 $dm^3 \cdot M^{-1} \cdot d^{-1}$. In 2002 and 2003 the highest values of unit water consumption were recorded (above 91 $dm^3 \cdot M^{-1} \cdot d^{-1}$), probably because of economic reasons, which make more rational water consumption in households necessary. The influence of economic factors, price increase of water supplied by water networks and high rates of sewage discharge motivate people to more rational usage of water. From 2009 to 2012 in Poland one can observe a stabilized average volume of waterworks water consumption per one inhabitant, which is around 85.5 $dm^3 \cdot M^{-1} \cdot d^{-1}$. This value would probably remain the same in the future. In rural areas, however, much lower values of this index were recorded, that is 66.5 $dm^3 \cdot M^{-1} \cdot d^{-1}$, but in recent years (2008–2012) average water consumption per person is slightly higher, at about 70 $dm^3 \cdot M^{-1} \cdot d^{-1}$.

In Małopolskie Voivodeship (Figure 3b) average unit water consumption volume in the analysed period was 73.9 $dm^3 \cdot M^{-1} \cdot d^{-1}$. In 2002–2007 higher values were noted (around 76 $dm^3 \cdot M^{-1} \cdot d^{-1}$). In 2006–2012 the value remained pretty stable at around 73 $dm^3 \cdot M^{-1} \cdot d^{-1}$. One can assume that this value would be more or less the same in the next few years. However in rural areas of Małopolskie Voivodeship one can observe considerably lower average unit values of water consumption (41.9 $dm^3 \cdot M^{-1} \cdot d^{-1}$). In 2009–2012 the value remained stable at around 45 $dm^3 \cdot M^{-1} \cdot d^{-1}$. One can expect that this value would stay on the same level in the nearest future.

In Podkarpackie Voivodeship (Figure 3c) average unit volume of waterworks water consumption used was 61.5 $dm^3 \cdot M^{-1} \cdot d^{-1}$. In rural areas of this voivodeship one can observe much lower values of the same index (44.2 $dm^3 \cdot M^{-1} \cdot d^{-1}$). Practically in the whole studied period the index remained stable at around 45 $dm^3 \cdot M^{-1} \cdot d^{-1}$. One can assume that this value would stay the same in the next few years.

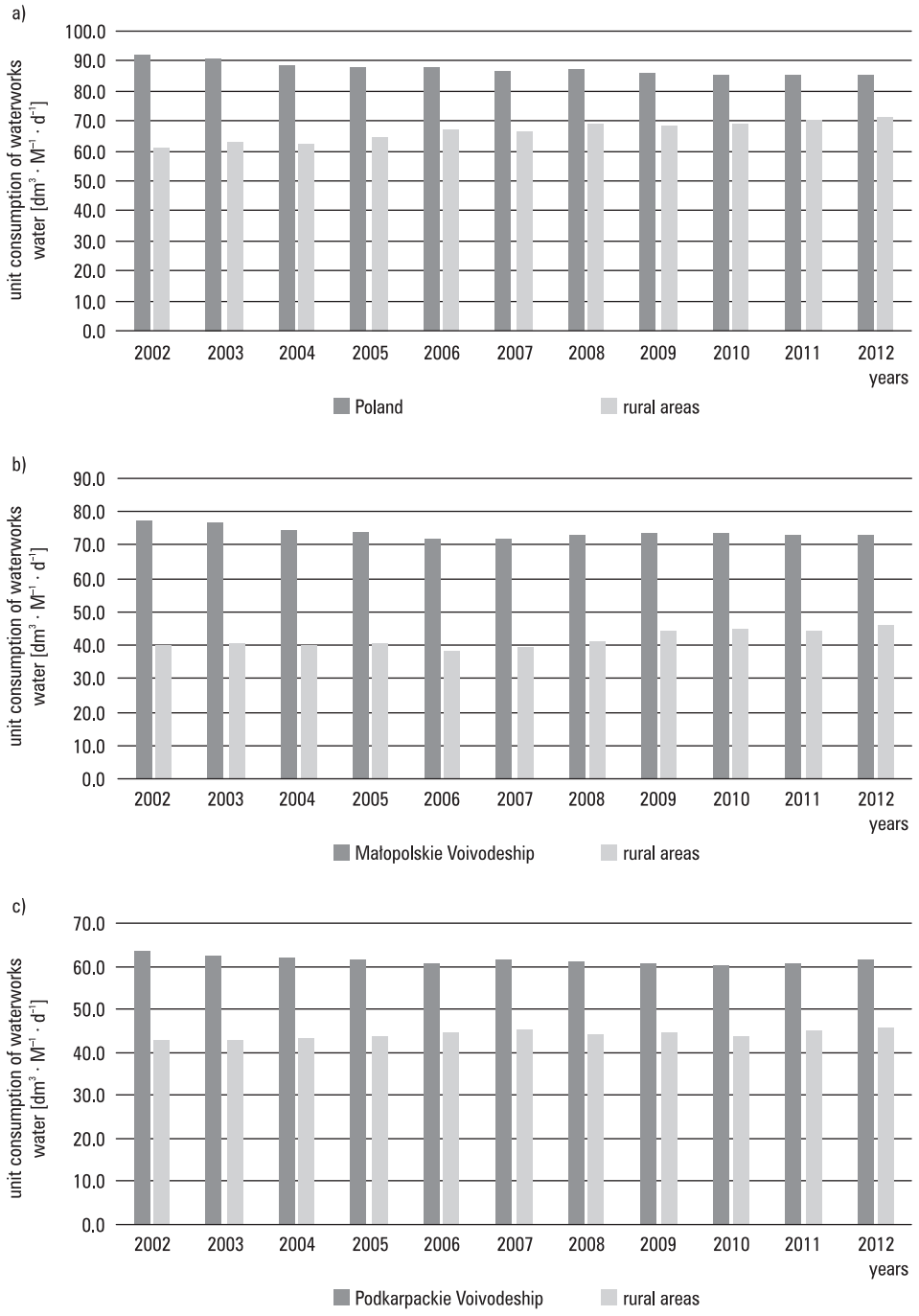

Fig. 3. Unit consumption of waterworks water in 2002–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

3.2. The development of sewage systems

Equally important and reliable indicator of civilization level is the development of sewage discharge and sewage treatment systems. Their development in the analysed voivodeships is shown in Figures 4–7. In the studied period (1995–2012) there has been a noticeable improvement in the sewage network length. In Poland (Figure 4a) the annual average increase of sewage network length was 5414.5 km · a^{-1}, and in rural areas it was 3788.7 km · a^{-1}. The total length increase of sewage network in the analysed period was 92045.7 km, which in comparison with the output data of 1995 is an increase by 374%, and in rural areas it is no less than 1298% increase. The density of sewage networks in rural areas in Poland rose from 1.8 km · 100 km^{-2} in 1995 to 24 km · 100 km^{-2} in 2012. The analysis of years before Poland's accession to the EU shows that the average annual increase of sewage network length was 4481 km · a^{-1}, whereas in 2005–2012, that is after Poland's accession to the EU, it was 6464.2 km · a^{-1}. Equally visible influence of our accession to the EU can be seen with respect to length increase of sewage networks in rural areas: in 1995–2004 it was 3003 km · a^{-1}, and in 2005–2012 – 4672.6 km · a^{-1}. It is obvious then that sewage networks in Polish rural areas have developed dynamically. However, in the next years the increase of sewage networks length would be slower, which is already visible in the data from 2012. The reason of this can be an end of good and easy investments, where the lie of the land was favourable to designing and building of sewage systems. In less favourable terrains and in low-density housing areas an independent sewage utilization systems would probably be developed in the form of onsite wastewater systems.

In Małopolskie Voivodeship (Figure 4b) the average length increase of sewage systems in the analysed period (1995–2012) was 519.8 km · a^{-1}, and in rural areas it was 383.3 km · a^{-1}. Total length increase of sewage network during this period was 8 836.9, which in comparison with the output data of 1995 is an increase by 446%. The smallest increase of 192.2 km · a^{-1} was observed in 1996, and the biggest in 2009 at 789.9 km · a^{-1}. The density of sewage systems in rural areas of Małopolskie Voivodeship rose from 2.8 km · 100 km^{-2} in 1995 to 51 km · 100 km^{-2} in 2012. The analysis of years before Poland's accession to the EU shows that the average annual increase of sewage network length was 436 km · a^{-1}, whereas in 2005–2012, that is after Poland's accession to the EU, it was 613.9 km · a^{-1}. Considerable influence of Poland's accession to the EU is also visible in an analysis of annual length increase of sewage systems in rural areas – in 1995–2004 in Małopolskie Voivodeship the systems were longer by 310.2 km · a^{-1}, and in 2005–2012 by 456 km · a^{-1}g.

The data shown in Figure 4c prove that in Podkarpackie Voivodeship average length increase of sewage network in the analysed period was 765.7 km · a^{-1}, and in the rural areas it was 632.6 km · a^{-1}, which is a sign of intensive improvement, especially in rural areas. The total increase in the analysed period (1995–2012) was 13 017.5 km, which in comparison with the output data of 1995 is an increase by 989%, and in rural areas – no less than by 2863%. The last value is much higher than in Małopolskie Voivodeship. The smallest increase of 304.1 km · a^{-1} was observed in 1996, and the biggest in 2011

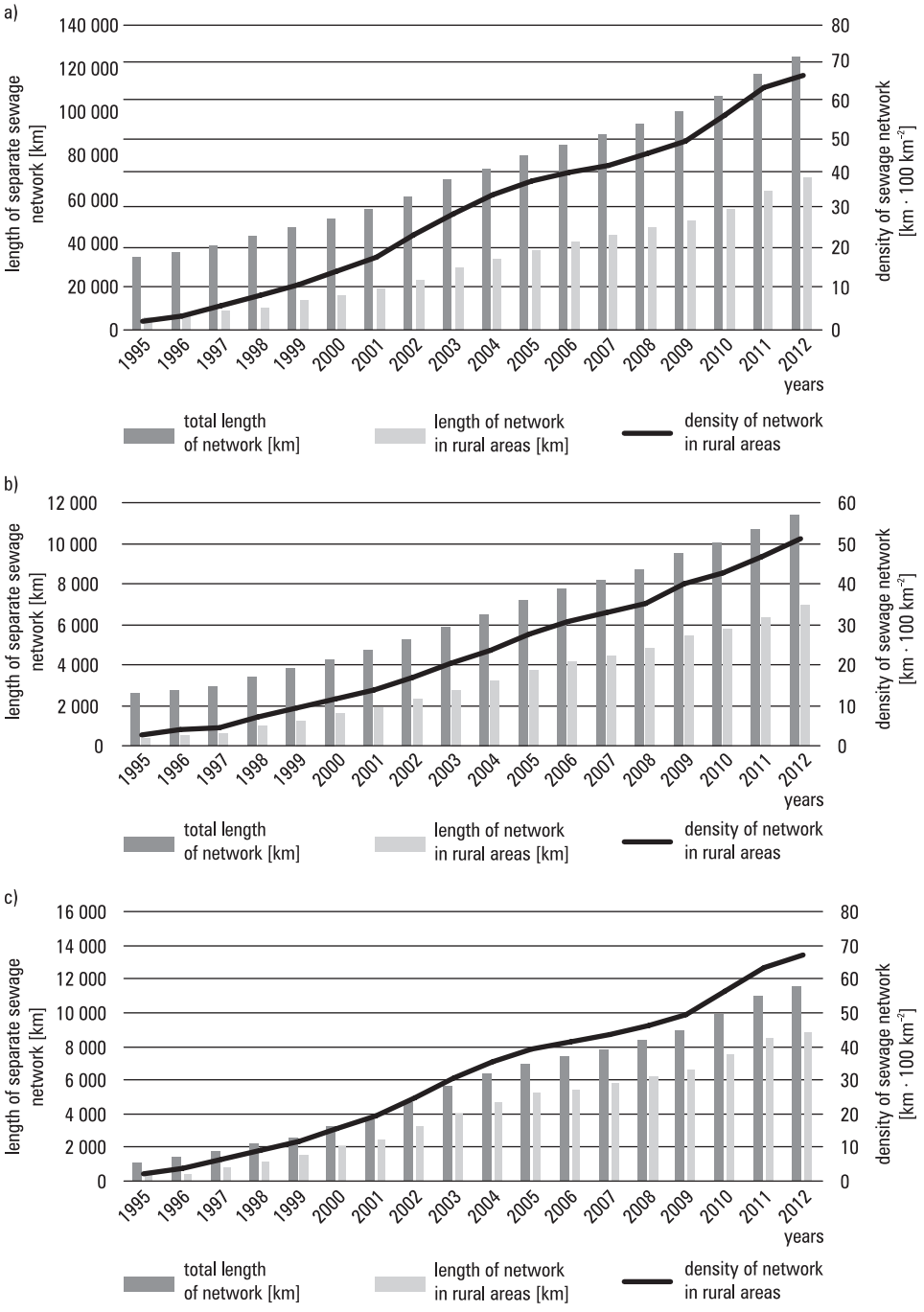

Fig. 4. Length and density of separate sewage network in 1995–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

– 1365.1 km · a^{-1}. Considerable annual increase in 2002 (1148.2 km · a^{-1}) and 2003 (1106.2 km · a^{-1}), that is before Poland's accession to the EU is noteworthy. The density of sewage network in rural areas of Podkarpackie Voivodeship rose from 2.3 km · 100 km^{-2} in 1995 to 66.9 · 100 km^{-2} in 2012. The analysis of years before Poland's accession to the EU shows that the average annual increase of sewage network length in Podkarpackie Voivodeship was 728 km · a^{-1}, whereas in 2005–2012, after Poland's accession to the EU, it was 808.1 km · a^{-1}. The influence of Poland's accession to the EU is less visible, if an annual increase of the length of sewage systems in rural areas is considered: in 1995–2004 the systems were longer on average by 618.4 km · a^{-1}, whereas in 2005–2012 it was 648.7 km · a⁻1. The dynamic development of sewage network in Podkarpackie Voivodeship had been intensified already before Poland's accession to the EU, thanks to the pre-accession resources.

When the development level of sewage systems in the entire country is concerned (Figure 5a), a substantial increase of the population number using them is visible. In 2002 percentage of population using sewage systems was 56.7%, whereas in 2012 it was 64.3%. In the rural areas the growth was even more considerable: from 14.2% in 2002 to 29.4 in 2012. In Poland's rural areas the number of people using sewage systems in 2002–2012 rose from 2.0785 mln to 4.4748 mln, which is a rise by 215%.

The data presented in Figure 5b show that in Małopolskie Voivodeship the number of people using sewage system in 2002–2012 rose from 1479.2 thousand to 1848.6 thousand, which is an increase by 24.9%. In 2002 the percentage of population using sewage systems was 45.4% and in 2012 it rose to 55.1%. In rural areas considerable increase of number of people using sewage system is visible, since it rose 2.5 times in 11 years. The increase was very small in 2002 – 10.4%, whereas in 2012 an increase to 26.1% was recorded.

As shown in Figure 5c, in Podkarpackie Voivodeship the number of people using sewage system in 2002–2012 rose from 936.9 thousand to 1.3099 mln, which is an increase by almost 40%. The percentage of people using sewage system in 2002 was 44.7% and in 2012 it rose to 61.5%. In rural areas of Podkarpackie Voivodeship one can see a noticeable increase of population number using sewage system – 313 thousand-persons and 44% of the rural population used sewage system in 2012. It was almost twofold increase than in Małopolskie Voivodeship.

The growing number of house sewage connection (sewage laterals) is likewise an indication of sewage systems development. Data presented in Figure 6a prove show an increase of house sewage connection number from 732 532 items in 1995 to 2 632 391 items in 2012. The average annual increase of sewage lateral number in Poland was 111 756 items · a^{-1}. The biggest increase was recorded in 2011 (174 956 items · a^{-1}) and the smallest at the beginning of the studied period, that is in 1996 (57 858 items · a^{-1}). In Polish rural areas one can see a considerable increase of sewage lateral in the studied period with an average annual of 60 528 items · a^{-1}. The biggest increase in rural areas was recorded in 2011 (109 260 items · a^{-1}) and the smallest at the beginning of the studied period, that is in 1996 (24 022 items · a^{-1}).

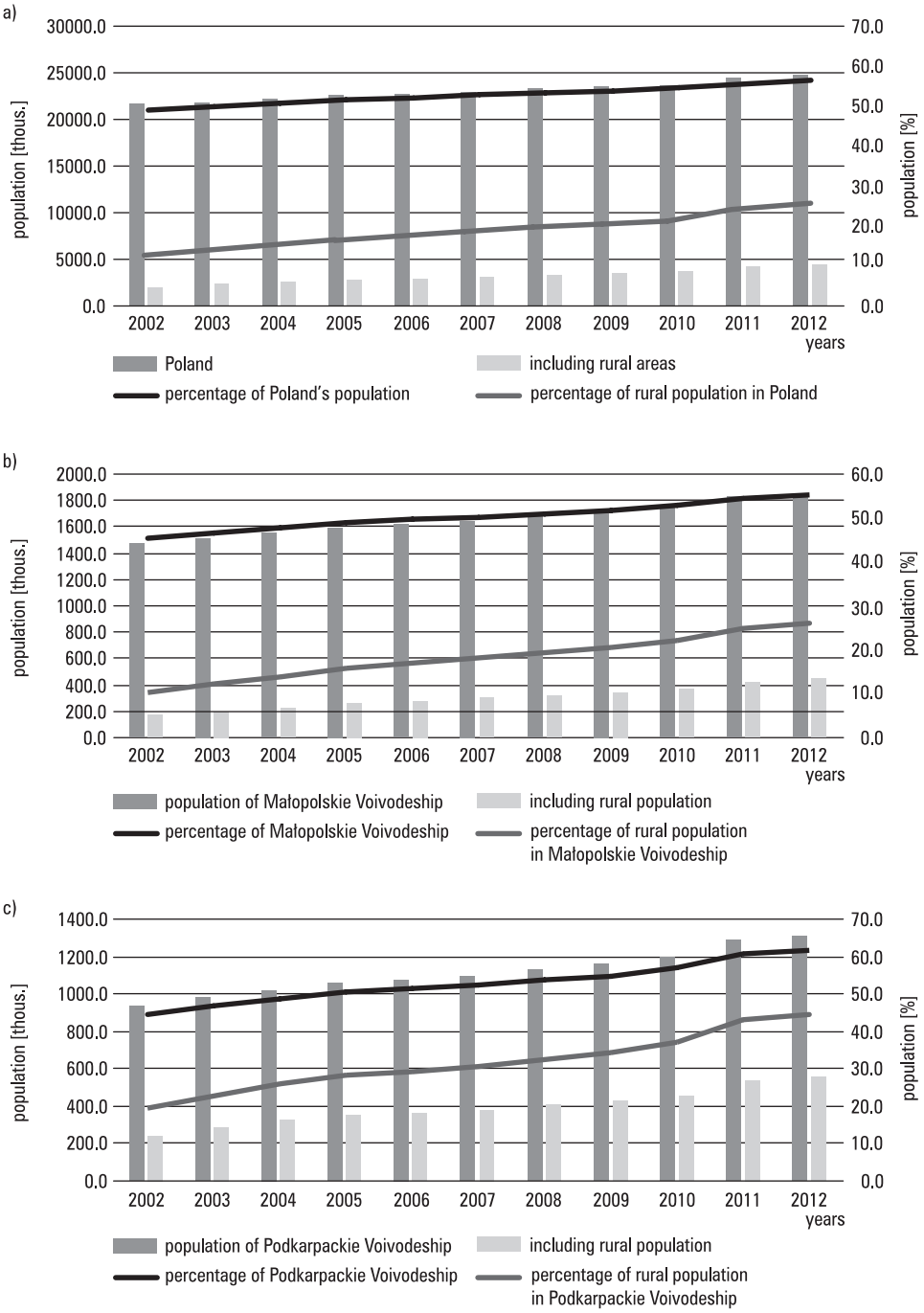

Fig. 5. Population and percentage of people using separate sewage network in 2002–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

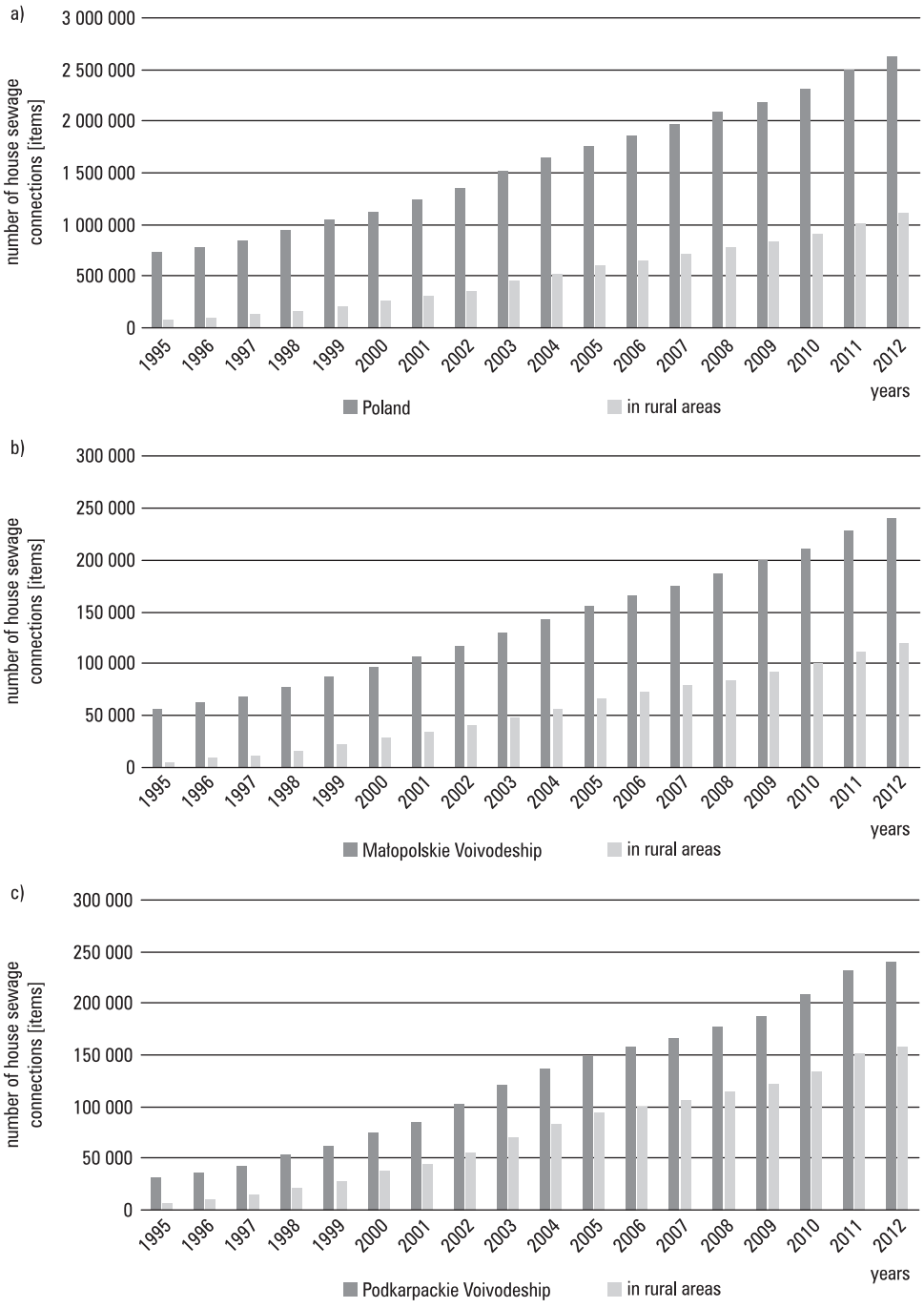

Fig. 6. Number of house sewage connections in 2002–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

When analysing the data from Małopolskie Voivodeship (Figure 6b) one can see an increase of house sewage connection number from 57 553 items in 1995 to 239 262 items in 2012. The average annual increase was 10 689 items · a^{-1}. The biggest increase was recorded in 2011 (17 081 items · a^{-1}) and the smallest in 1997 (4 663 items · a^{-1}). The average annual increase of house sewage connection number in rural areas was 6 714 items · a^{-1}. The biggest increase in rural areas was recorded in 2011 (10 146 items · a^{-1}) and the smallest in 1997 (2 144 items · a^{-1}). The conclusion can be drawn that in rural areas of Małopolskie Voivodeship there has been a considerable increase of house sewage connection number in the studied period.

In 1995–2012 in Podkarpackie Voivodeship a larger number of new house sewage connections (209 026 items) has been noted than in Małopolskie Voivodeship (181 709 items). The same applies to rural areas: in Podkarpackie Voivodeship there was 152 248 of house sewage connections and in Małopolskie Voivodeship – 114 137 connections. The average annual increase of house sewage connections in Podkarpackie Voivodeship was 12 296 items · a^{-1}. The biggest increase was in 2011 (21 953 items · a^{-1}) and the smallest at the beginning of the studied period, that is in 1996 (4 564 items · a^{-1}). In rural areas there was a considerable average annual increase of number of house sewage connections in the studied period, namely 8 956 · a^{-1}. The biggest increase was in 2011 (17 502 items · a^{-1}) and the smallest at the beginning of the studied period, that is in 1996 (3 574 items · a^{-1}).

Another important issue is the volume of wastewater discharged by sewage systems (Figure 7a). The average volume of wastewater discharged by sewage systems in Poland in the studied period is 1 392.1 $hm^{-3} \cdot a^{-1}$, whereas in rural areas it is 108.6 $hm^{-3} \cdot a^{-1}$, which is only 7.8% of all wastewater volume. From 1996 to 2002 one can see a distinct decrease of the volume of discharged wastewater, which can be a result of more rational use of waterworks water in households, related to the rise of prices of water and rates for wastewater discharge.

In Małopolskie Voivodeship (Figure 7b) the average volume of wastewater discharged by sewage network in the studied period was 105.1 $hm^{-3} \cdot a^{-1}$ and in rural areas it was only 9 $hm^{-3} \cdot a^{-1}$, which is 8.5% of the total volume of discharged sewage. The sewage network development in rural areas presented in Figure 4b means that more volume of sewage is discharged (Figure 7b). In 1996 there was 3.2 $hm^{-3} \cdot a^{-1}$ discharged by means of sewage network, and in 2012 it was 15.2 $hm^{-3} \cdot a^{-1}$, which is an increase by 475%. Substantial volume increase of discharged sewage in 2010 (17.5 $hm^{-3} \cdot a^{-1}$) could be caused by the flood that took place in these areas in May and June.

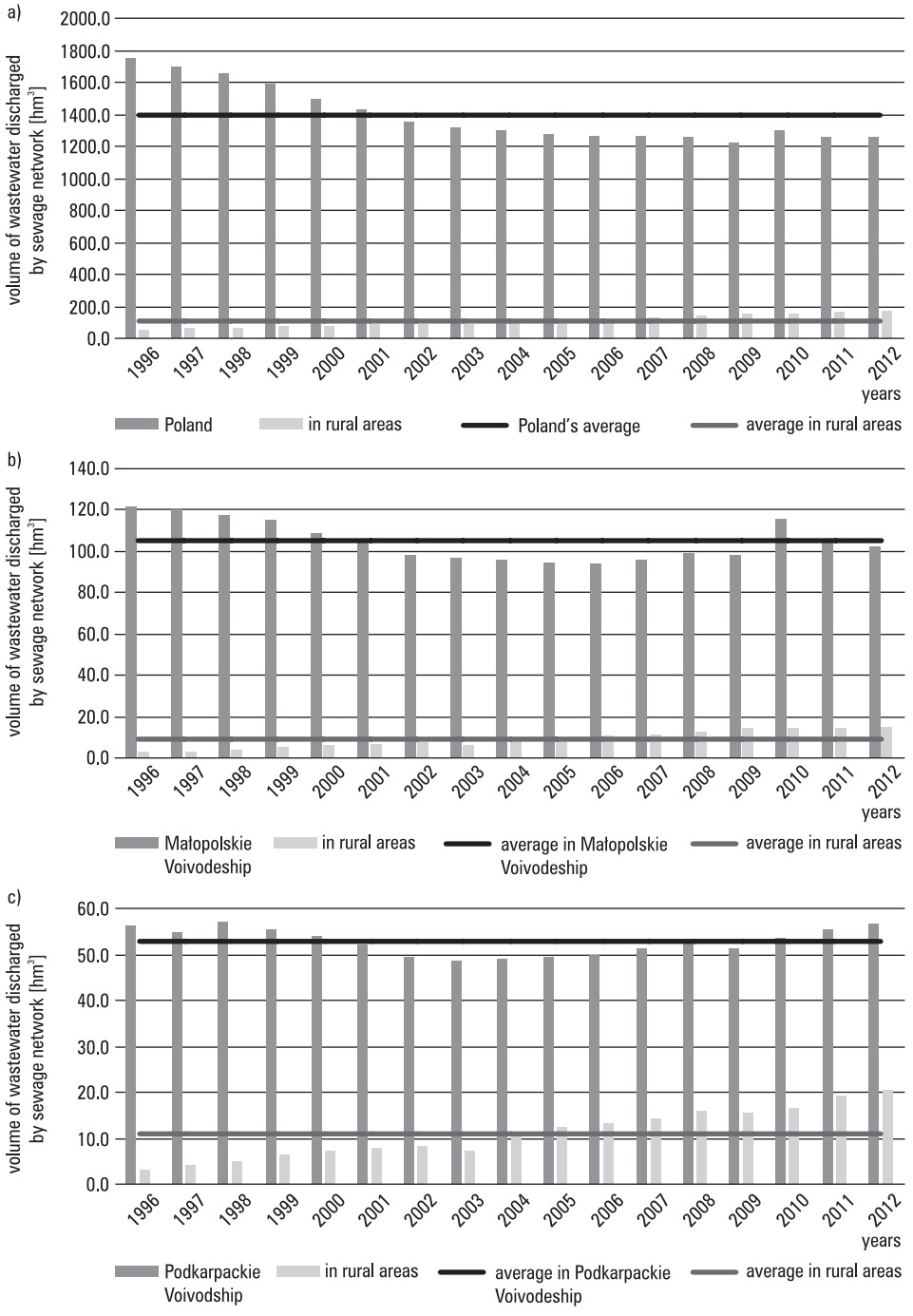

Fig. 7. The volume of wastewater discharged by means of sewage network in 1996–2012: a) in Poland, b) in Małopolskie Voivodeship, c) in Podkarpackie Voivodeship

4. Conclusions

The analysis of the collected data proves that there are disproportions between accessibility of water supply and sewage systems both in Poland and in Małopolskie and Podkarpackie Voivodeships. The situation can be the result of high construction costs of sewage systems. Moreover, one needs to keep in mind the factor of unfavourable low-density housing in both voivodeships, which in turn increases the costs of building sewage systems.

The increase of expenditure for water supply and sewage systems are positive aspect of Poland's accession to the EU structures. As presented in the paper, recently in rural areas mainly sewage systems have been developed. However, one should remember that in the future new systems will have to be constructed in less favourable conditions. The systems so far have been built in more favourable areas, where unit construction costs are relatively low. The remaining terrains are characterized by low-density housing, where building new sewage public systems would be expensive and therefore independent treatment and discharge systems are, and would have to be, implemented instead. In these areas wastewater utilization is to be realized by means of the growing number of onsite wastewater treatment systems.

Water supply and sewage systems are marked by complex network structure, capital-intensive nature and long time of exploitation. Though in recent years the systems, mainly in rural areas, have been intensely developed, more needs to be done to meet people's needs. In spite of significant improvements achieved in recent years, Poland will have great difficulty in meeting by 2015 the EU requirements related to adequate water supply and sewage infrastructure in rural areas.

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