INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr III/1/2017, POLISH ACADEMY OF SCIENCES, Cracow Branch, pp. 907–922
Commission of Technical Rural Infrastructure

DOI: http://dx.medra.org/10.14597/infraeco.2017.3.1.070

EVALUATION OF WATER AND WASTEWATER INFRASTRUCTURE IN COMMUNES OF KUJAWSKO-POMORSKIE VOIVODESHIP

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Abstract

The paper assesses the development level of water and sewerage infrastructure in the Kujawsko-Pomorskie voivodeship in the period of 1999-2014. The analysis included the infrastructure in 144 communes. The outcome has ascertained large irregularity in water and sewerage network coverage saturation in particular years, especially in southern and eastern parts of the voivodeship. The growth dynamics of the sewerage network surpasses the water network growth in the analyzed period but still does not reach the development degree of the water system. The Kujawsko-Pomorskie voivodeship has the second densest water network in Poland. However, taking into account sewerage network density, it is ninth. Disproportion in both networks development degree is mitigated by building household sewage treatment plants, especially in the communes with lower population density, in which building sewerage network is too expensive. In 2014 two communes had no sewerage network at all and two others had that network very sparse (over 100 km of water network per 1 km of sewerage network). The most intense water and sewerage infrastructure development was recorded in 2007 and 2014, mainly in rural and urban-rural areas. It is related to increased expenditure on water and sewerage infrastructure within the Regional Operational Programme in the years 2004-2006 and 2007-2013.

Keywords: water supply network, sewerage network, water and sewerage management expenditures

INTRODUCTION

Water and sewerage management is one of the top priority tasks of the European Union (EU). When joining the European Community in 2004, Poland committed to adjust local laws to meet the requirements that the EU has set for all the member countries. Water and sewerage management requirements pertain mainly to water usage. Regardless the aim and scope, the water usage should fit the frameworks of the sustainable development and hence it may not cause deterioration of ecological state of waters and ecosystems dependent on them.

One of the factors of proper usage of water resources is appropriate state and mode of operation of the water and sewerage infrastructure (Boschek, 2002; Hummel and Lux, 2007; Bower, 2014; Pietrucha-Urbaniak *et al*., 2016). Accomplishment of that is possible through creation of new and modernization of the existing infrastructure (Wałęga *et al*., 2009; Pawełek and Woyciechowska, 2015). However, it requires appropriate funding of water and sewerage management and natural environment protection. The main causes for inappropriate infrastructure condition were negligence in the area of the environment protection as well as insufficient funding of putting in order the water and sewerage management. Only after joining the EU, there appeared a possibility for communes to raise greater funding for the infrastructure development (Kocur-Bera, 2011).

Water and sewerage infrastructure comprises the base for any business activity. According to many authors, infrastructure development level may decide of advantages or disadvantages of a given area and hence support or hamper its further development (Kropsz, 2003; Salamon and Krakowiak-Bal, 2013). Water and sewerage infrastructure condition in Poland is very diverse. It results from communes' financial capabilities and hence the amount of budgetary funds dedicated to that purpose. The number and scope of infrastructural investment depend on possibility to incur, proper exploitation and dedication of appropriate amount of funding necessary for them by municipalities (Krakowiak-Bal, 2008a). As a result, the condition and provisioning of water and sewerage equipment in Poland is far from sufficient (Kwapisz, 2002, 2005; Krakowiak-Bal, 2008b; Kłos, 2011; Piszczek, 2013).

THE AIM, MATERIAL AND METHODS OF THE STUDY

The aim of the study is the assessment of saturation degree and spatial diversity of selected components of the water and sewerage infrastructure in the communes of the Kujawsko-Pomorskie voivodeship in the years 1999-2014. The starting point was a selection of appropriate diagnostic parameters, which would illustrate water and sewerage infrastructure availability. It was decided that it would be best to use water and sewerage networks length, number of people using the networks and number of water and sewerage network connections. The data comes from the Data Bank of the Central Statistical Office. The selected data has been processed, which allowed using the indicator method. Network density indicator has been calculated with the formula:

$$W_g = \frac{L}{P} \tag{1}$$

where:

W_g – network density indicator (km·100 km^{-2})
L – length of water or sewerage network (km)
P – area of a commune (100 km^2)

The water and sewerage network density indicators express the network length related to 100 km^2 of area. Network equipment indicator has been described as water network length to 1 km of sewerage network length ratio. The indicator has been calculated with the following formula:

$$W_d = \frac{L_w}{L_k} \tag{2}$$

where:

W_d – network equipment indicator
L_w – water network length (km)
L_k – sewerage network length (km)

High value of the indicator shows low level of sewerage network funding, which in turn indicates large disproportion between water and sewerage networks. The results achieved for the three indicators have been presented in a form of cartograms with use of the ArcGis software utility. It allowed making an analysis of spatial diversity of selected elements of water and sewerage infrastructure in the communes of Kujawsko-Pomorskie voivodeship.

Further part of the paper presents data related to number of water and sewerage networks connections leading to detached houses and to collective residence buildings. The indicator has been described as number of connections per 1 km^2 of commune area. In order to express water network availability, there has been used the number of inhabitants served by water and sewerage networks. The percentage indicator has been expressed with the following formula:

$$W_{ds} = \frac{M_s}{M_c} \cdot 100 \tag{3}$$

where:

W_{ds} – water network availability indicator (%)

M_s – number of commune inhabitants served by the water network (persons)
M_c – total number of commune inhabitants (persons)

Based on a spatial imaging of the indicators, there has been a comparative analysis of the above mentioned parameters conducted, i.e. availability and equipment of communes with water and sewerage networks.

The paper uses the data regarding the length of water and sewerage systems obtained from the Local Data Bank of the Central Statistical Office of Poland. Water and sewerage network density indicators, which express the network length related to 100 square km of surface, have been used. Equipment a given area with water and sewerage infrastructure has been described by the ratio of the water network length to 1 km of the sewerage network. There has been also acquired the data that regards to the number of water and sewerage connections to single – and multi-household buildings as well as the percentage of population that uses the water and sewerage networks.

The indicators have been presented for the period of 1999-2014 which allowed determination the degree of changes and average saturation of water and sewerage infrastructure in the reference to the 144 communes of the Kujawsko-Pomorskie voivodeship. Detailed analysis has been conducted for the 3 selected years, i.e. 1999, 2007 and 2014, which cover the periods before and after joining the EU by Poland.

STUDY RESULTS

According to the Local Data Bank of the Central Statistical Office of Poland, in 2014, the area of the Kujawsko-Pomorskie voivodeship was 17962 km^2 and it was inhabited by 2089992 people. The administrative division introduced on January 1st, 1999 has divided it into 23 districts and 144 communes, including 17 urban communes, 35 urban-rural communes and 92 rural communes. Average population density of the voivodeship is 116 people per square km. The main form of land cover is arable land, which comprises 55% of the total area.

The Kujawsko-Pomorskie voivodeship has relatively small annual water intake (average 119.5 m^3 per person) as compared to the average value for Poland (287.6 m^3 per person). The main water receiver is the water and sewerage management, which share in the total water intake fluctuated from 50.8% in 2001 to 44.6% in 2012 (Kubiak-Wójcicka and Piątkowski, 2015).

Total water network length in Poland in 1999 was 203466 km, of which 17747 km (or 8.2%) belonged to the Kujawsko-Pomorskie voivodeship. Within the 15 years, the network length increased by 43.7% in Poland and by 29.5% in the voivodeship. In the period of 1999-2014 in Kujawsko-Pomorskie voivodeship, the water network length increased in urban communes from 1621 km to

2028 km, in urban-rural communes – from 4936 to 6679 km and in rural communes – from 11190 to 14241 km (BDL GUS). The largest percent of the increase of water system length in urban-rural communes (by 35.3%) results from the development of house building in the sub-urban areas. The migration of city inhabitants to suburbs and to sub-urban communes contributed to faster pace of water system building and greater funding of water and sewerage management.

Along with the increase of water system length, the coefficients of water network density, of percentage of people using the network and of number of the connections per 1 km^2 have increased. In the period of 1999-2014, average water network density in Poland was 80.5 km per 100 km^2, and in the Kujawsko-Pomorskie voivodeship it was 114.3 km per 100 km^2, which is 41.9% more. Since 1999, the water network density has been steadily growing from 65.1 km per 100 km^2 to 82.2 km per 100 km^2 in 2007 and to 93.5 km per 100 km^2 in 2014. At the same period, in the Kujawsko-Pomorskie voivodeship, the water network density increased from 99 km per 100 km^2 (3rd place in Poland) to 115.7 km per 100 km^2 in 2007 and to 128 km per 100 km^2 (2nd place in Poland). Those values indicate that the water infrastructure of the voivodeship is growing steadily and ranks high within the country.

Spatial distribution of water network in the Kujawsko-Pomorskie voivodeship is diverse. The Fig. 1 presents the water network density in the communes in 1999, 2007 and 2014. In 1999, the most dense water network was recorded in urban communes, where the coefficient exceeded 200 km per 100 km^2. The towns with the highest in Poland value of the water network density coefficient include: Aleksandrów Kujawski (632.9 km per 100 km^2), Inowrocław (491.7 km per 100 km^2), Wąbrzeźno, Kowal, Chełmża, Ciechocinek and Radziejów (300-400 km per 100 km^2). In the rural communes, like Wielka Nieszawka, Śliwice, Solec Kujawski and Bobrowniki, the coefficient's value hasn't exceeded 30 km per 100 km^2. In 1999 as many as 18 communes of the voivodeship have exceeded the water network density recognized as large (above 200 km per 100 km^2) and 4 communes had that value exceptionally low, below 30 km per 100 km^2. The lowest water network density had the commune of Wielka Nieszawka (17 km per 100 km^2).

After Poland has joined the European Union, water network in rural and urban-rural areas has been significantly expanded and the building pace was much larger than in cities, which already had the water network well developed. Between 1999 and 2007 two more rural communes have reached 200 km per 100 km^2 of water network: Fabianki and Białe Błota. Those communes are located in direct proximity of large cities: Włocławek and Bydgoszcz, and hence comprise convenient locations for housing development for people which work in the cities. In 2007, the lowest density of water network was still recorded in the commune of Wielka Nieszawka (24.5 km per 100 km^2). This results directly from the land cover in that commune – over half of its area is covered by forests. The largest increase of water network density in the period of 1999-2007 was recorded in the following urban communes: Brodnica, Golub-Dobrzyń and Radziejów and in the following rural communes: Chrostkowo and Topólka.

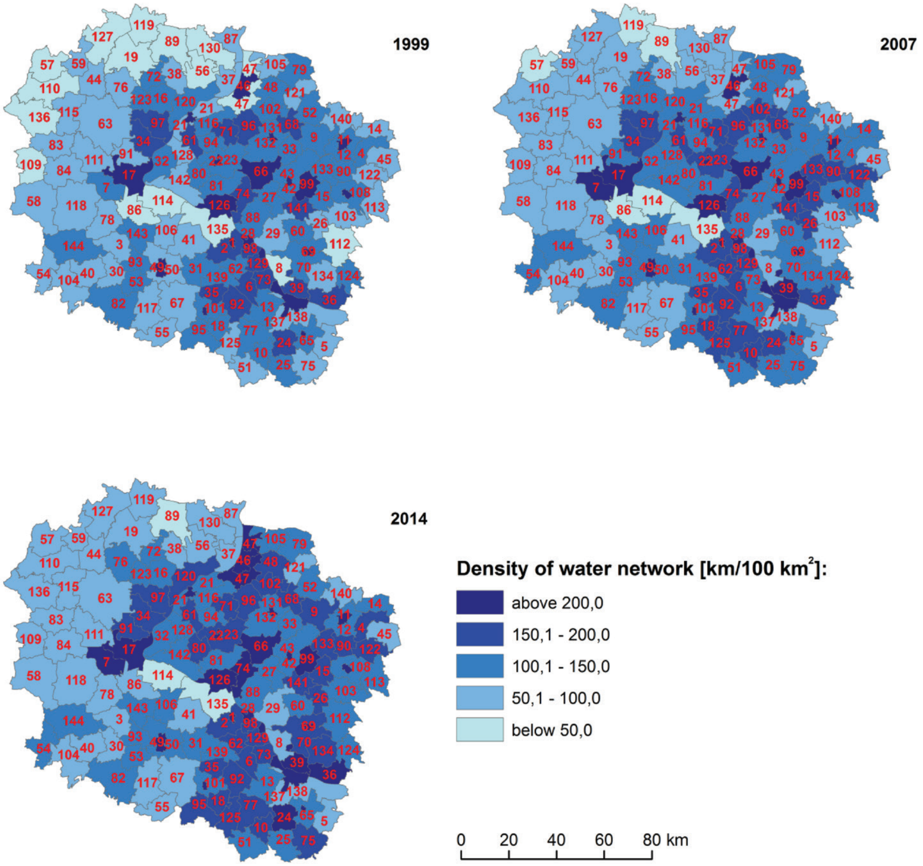

Figure 1. Density of water network in Kujawsko-Pomorskie voivodeship in 1999, 2007 and 2014 (own study on the basis of the BDL GUS)

Legend:
Commune names according to the numbering and commune types: (1) – urban communes; (2) – rural communes; (3) – urban-rural communes:
1 – Aleksandrów Kujawski (1), 2 – Aleksandrów Kujawski (2), 3 – Barcin (3), 4 – Bartniczka (2), 5 – Baruchowo (2), 6 – Bądkowo (2), 7 – Białe Błota (2), 8 – Bobrowniki (2), 9 – Bobrowo (2), 10 – Boniewo (2), 11 – Brodnica (1), 12 – Brodnica (2), 13 – Brześć Kujawski (3), 14 – Brzozie (2), 15 – Brzuze (2), 16 – Bukowiec (2), 17 – Bydgoszcz (1), 18 – Bytoń (2), 19 – Cekcyn (2), 20 – Chełmno (1), 21 – Chełmno (2), 22 – Chełmża (1), 23 – Chełmża (2), 24 – Choceń (2), 25 – Chodecz (2), 26. Chrostkowo (2), 27 – Ciechocin (2), 28 – Ciechocinek (1), 29 – Czernikowo (2), 30 – Dąbrowa (2), 31 – Dąbrowa Biskupia (2), 32 – Dąbrowa Chełmińska (2), 33 – Dębowa Łąka (2), 34 – Dobrcz (2), 35 – Dobre (2), 36 – Dobrzyń nad Wisłą (3), 37 – Dragacz (2), 38 – Drzycim (2), 39 – Fabianki (2), 40 – Gąsawa (2), 41 – Gniewkowo (3), 42 – Golub-Dobrzyń

(1), 43 – Goub-Dobrzyń (2), 44 – Gostycyn (2), 45 – Górzno (3), 46 – Grudziądz (1), 47 – Grudziądz (2), 48 – Gruta (2), 49 – Inowrocław (1), 50 – Inowrocław (2), 51 – Izbica Kujawska (3), 52 – Jabłonowo Pomorskie (3), 53 – Janikowo (3), 54 – Janowiec Wielkopolski (3), 55 – Jeziora Wielkie (2), 56 – Jeżewo (2), 57 – Kamień Krajeński (3), 58 – Kcynia (3), 59 – Kęsowo (2), 60 – Kijewo Królewskie (2), 61 – Kikół (2), 62 – Koneck (2), 63 – Koronowo (3), 64 – Kowal (1), 65 – Kowal (2), 66 – Kowalewo Pomorskie (3), 67 – Kruszwica (3), 68 – Książki (2), 69 – Lipno (1), 70 – Lipno (2), 71 – Lisewo (2), 72 – Lniano (2), 73 – Lubanie (2), 74 – Lubicz (2), 75 – Lubień Kujawski (3), 76 – Lubiewo (2), 77 – Lubraniec (3), 78 – Łabiszyn (3), 79 – Łasin (3), 80 – Łubianka (2), 81 – Łysomice (2), 82 – Mogilno (3), 83 – Mrocza (3), 84 – Nakło nad Notecią (3), 85 – Nieszawa (1), 86 – Nowa Wieś Wielka (2), 87 – Nowe (3), 88 – Obrowo (2), 89 – Osie (2), 90 – Osiek (2), 91 – Osielsko (2), 92 – Osięciny (2), 93 – Pakość (3), 94 – Papowo Biskupie (2), 95 – Piotrków Kujawski (3), 96 – Płużnica (2), 97 – Pruszcz (2), 98 – Raciążek (2), 99 – Radomin (2), 100 – Radziejów (1), 101 – Radziejów (2), 102 – Radzyń Chełmiński (3), 103 – Rogowo (2), 104 – Rogowo (2), 105 – Rogóźno (2), 106 – Rojewo (2), 107 – Rypin (1), 108 – Rypin (2), 109 – Sadki (2), 110 – Sępólno Krajeńskie (3), 111 – Sicienko (1), 112 – Skępe (3), 113 – Skrwilno (2), 114 – Solec Kujawski (2), 115 – Sośno (2), 116 – Stolno (2), 117 – Strzelno (3), 118 – Szubin (3), 119 – Śliwice (2), 120 – Świecie (3), 121 – Świecie nad Osą (2), 122 – Świedziebnia (2), 123 – Świekatowo (2), 124 – Tłuchowo (2), 125 – Topólka (2), 126 – Toruń (1), 127 – Tuchola (3), 128 – Unisław (2), 129 – Waganiec (2), 130 – Warlubie (2), 131 – Wąbrzeźno (1), 132 – Wąbrzeźno (2), 133 – Wąpielsk (2), 134 – Wielgie (2), 135 – Wielka Nieszawka (2), 136 – Więcbork (3), 137 – Włocławek (1), 138 – Włocławek (2), 139 – Zakrzewo (2), 140 – Zbiczno (2), 141 – Zbójno (2), 142 – Zławieś Wielka (2), 143 – Złotniki Kujawskie (2), 144 – Żnin (3)

During the subsequent 7 years, further expansion of water network has been recorded in the Kujawsko-Pomorskie voivodeship. In 2014, the largest values of the water network density coefficient (above 200 km per 100 km^2) has been recorded in 25 communes, of which the following urban communes have exceeded the value of 500 km per 100 km^2: Inowrocław, Aleksandrów Kujawski, Golub-Dobrzyń and Chełmża. Among rural communes, the largest value of the coefficient have the communes located around the largest cities: Bydgoszcz, Toruń, Włocławek and Grudziądz. On the other end, there are two communes, which did not expand their water network: Wielka Nieszawka and Osie. It is because their land cover comprise mainly forests and the building density is very low. Among the urban-rural communes, the coefficient's value in 2014 was the largest in Dobrzyń nad Wisłą (220 km per 100 km^2), Piotrków Kujawski, Świecie and Lubień Kujawski (150-200 km per 100 km^2), and among the rural communes, the coefficient's value was the largest in Fabianki, Radomin (250-300 km per 100 km^2), Grudziądz, Białe Błota, Choceń and Lubicz (200-250 km per 100 km^2). The largest increase of water network density between 2007 and 2014 was recorded in urban commune of Golub-Dobrzyń and in rural commune of Grudziądz. Taking into account the period of 1999-2014 however, the greatest rate of water network saturation increase was recorded in urban communes of Brodnica, Golub-Dobrzyń and Chełmża. In the areas of rural and urban-rural communes, the increase of water network density was definitely lower throughout the analyzed period. The communes with the highest rate of water network increase at rural areas include Grudziądz and Chrostkowo, and at urban-rural areas – Lubień Kujawski. The communes that deserve attention are those in which the water network density remained almost unchanged throughout the analyzed 15-year period. Those are: rural commune Bądkowo and urban commune Nieszawa. In those communes, the water network coefficient was high and its values were respectively 184 and 225 km per 100 km^2.

Along with the increase of water network length, the number of connections and the number of people using it have been increasing. In the years 1999-2014, the number of water network connections in Poland increased by 44.3% and in the Kujawsko-Pomorskie voivodeship – by 33.9%. The largest increase has been recorded in rural communes and the smallest – in cities.

Systematic expansion of water network resulted also in an increase of number of connections per 1 km^2. In 2014, the largest values of that coefficient among urban communes were recorded in Aleksandrów Kujawski (294 per km^2) and among rural communes, in: Białe Błota, Lubicz, Osielsko, Fabianki and Raciążek (above 22 per 1 km^2). Among the urban-rural communes, the coefficient reached the largest values in the communes of Nakło nad Notecią, Świecie and Pakość (18-22 per 1 km^2). The increase of connections number is especially visible in the communes neighboring large cities. A good example of that is the city of Bydgoszcz with surrounding communes of Osielsko, Białe Błota and Nowa Wieś Wielka, which are the city's residential base with majority of detached houses. In the proximity of Toruń, such a role is played by the commune of Lubicz and for Włocławek it is the commune of Fabianki. The smallest values of the coefficient has been recorded in the communes of Sośno, Wielka Nieszawka and Osie (less than 6 per 1 km^2), which results from natural conditions (large forests, floodplains).

Together with the water network's length and water network's connections number increase, the number of people using the network also increases. Based on the data from Central Statistical Office of Poland available since 2002, average percent of people in Poland using water network on that year was 85% and in 2014 – 92%. Both in 2002 and 2014, the Kujawsko-Pomorskie voivodeship belonged to the group of regions with the largest percentage of people using water network (above 90%). Within the Kujawsko-Pomorskie voivodeship itself, the percentage of people using water network is diverse. In 2002, in as many as 24 urban communes and 7 urban-rural communes, the percentage of people using water network did not exceed 75%. The most people were using water network in the southern part of the region, in the proximity of Bydgoszcz and in the towns and cities like Inowrocław, Wąbrzeźno, Janikowo, Włocławek, Bydgoszcz, Radziejów, Aleksandrów Kujawski, Ciechocinek, Chełmża and Rypin. In 2014 in turn, all the communes have exceeded 75% of people using water network, and in 98 communes, the indicator reached 95-100%. Therefore, it must be recognized that the degree of water infrastructure furnishing for the people is high.

An important part of technical infrastructure is sewerage network. In 1999, total length of sewerage network in Poland was 46752.3 km and in 2014 it has tripled (up to 142876 km). The pace of sewerage network length increase was higher than in case of the water network. In the Kujawsko-Pomorskie voivodeship, the length of the sewerage network has also tripled throughout the analyzed 15 years. The fastest pace of the network expansion was observed in rural areas (from 637 km in 1999 to 3519 km in 2014) and in urban-rural areas (from 615 to 1818 km). In the cities the increase was 84.3% (from 1252 km to 2310 km). Together with sewerage network length increase, its density, the number of connections and the percentage of people using it have also increased. In 1999, sewerage network density in Poland was 15 km per 100 km^2 and in the Kujawsko-Pomorskie voivodeship – 14 km per 100 km^2. In 2014, the numbers were respectively 46 and 43 km per 100 km^2.

In 1999, the largest density of sewerage network in the Kujawsko-Pomorskie voivodeship had 15 urban communes with the coefficient's values above 50 km per 100 km^2, among others, in Aleksandrów Kujawski (621 km per 100 km^2) and Inowrocław (350 km per 100 km^2). At the same time, in 23 out of 144 communes in the region there was no sewerage network at all, and in 50 rural and 19 urban-rural communes, the coefficient was less than 10 km per 100 km^2. In 2007, 6 rural communes only had no sewerage network and in 7 rural communes the coefficient exceeded 50 km per 100 km^2. In 2014, in 14 rural and 7 urban-rural communes had sewerage network density greater than 50 km per 100 km^2, mainly in central and northern parts of the region. Only in Chrostkowo and Topólka there was no sewerage network at all. In 2014, among rural communes, the coefficient values were the largest in Osielsko and Świekatowo (100-130 km per 100 km^2), and among urban-rural ones – in Żnin, Świecie, Janikowo, Mrocza, Tuchola and Kruszwica (500-100 km per 100 km^2) – Fig. 2.

Similarly to the water network case, the increase of sewerage network length resulted in larger number of connections and larger percentage of people using the network. In 2002, the percentages of people using sewerage network in Poland and in the Kujawsko-Pomorskie voivodeship were respectively 56.7% and 59.2%. In 2002, the percentage of people using sewerage network exceeded 80% in 9 cities of the region only, and in as many as 49 rural communes that number did not exceed 20%. In 5 communes, people were not using sewerage network at all (Topólka, Raciążek, Chrostkowo, Boniewo, Aleksandrów Kujawski) because there was no sewerage network there. During the subsequent years, the number of people using sewerage network was systematically growing. In 2014, the largest percentage of people using sewerage network had rural communes Osielsko and Wielka Nieszawka (97%), Kęsowo and Papowo Biskupie (80-85%), and among urban-rural communes there were Świecie, Tuchola and Solec Kujawski (80-90%). In towns in turn, the largest percentage was recorded in Kowal, Brodnica and Rypin (above 95%).

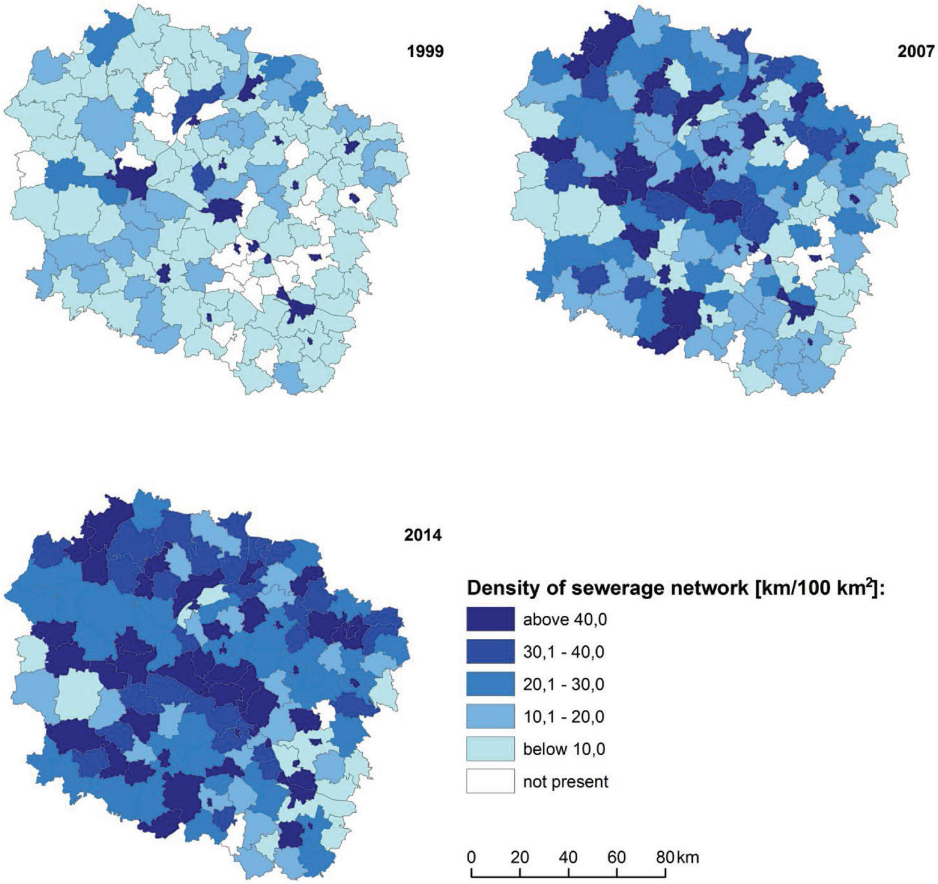

Figure 2. Density of sewerage network in Kujawsko-Pomorskie voivodeship in 1999, 2007 and 2014 (own study based on the BDL GUS)

Increase of the length of sewerage network resulted in a larger number of connections. The number of sewerage network connections in Poland and in the Kujawsko-Pomorskie voivodeship increased in the period of 1999-2014, respectively by 181% (from 1035403 to 2912618) and by 135.3% (from 61698 to 145197). The pace of the increase of connections number per 1 km^2 was larger in the rural area (by 368%) than in the cities (71%) and urban-rural communes (135%). In 1999, in as many as 23 rural communes, there were no sewerage connections due to lack of sewerage network, and in 58 rural and 15 urban-rural communes there were less than 2 connections per 1 km^2. The largest number of sewerage network connections was recorded in 15 urban communes, like Brodnica or Inowrocław (150 connections per 1 km^2) and the following urban-rural communes: Świecie and Tuchola (8 connections per 1 km^2). Over the next 15 years, sewerage network length has grown rapidly, as well as the number of sewerage network connections, mainly in rural areas. In 2014, as many communes as 9 rural (Osielsko, Białe Błota, Łysomice, Nowa Wieś Wielka, Lubicz, Złotniki Kujawskie, Choceń, Łubianka, Fabianki) and 4 urban-rural ones (Świecie, Tuchola, Solec Kujawski, Nakło nad Notecią) the number of sewerage network connections reached 10-20 per 1 km^2. The largest increase of the number of sewerage network connections per 1 km^2 was recorded in rural communes Wielgie, Dąbrowa Chełmińska and Choceń.

Detailed analysis of water and sewerage networks indicates major diversity in the development of water and sewerage infrastructure. Sewerage network development fell behind the systematic and long lasting expansion of water network. Hence, significant discrepancies in both networks development are apparent, and that has been presented with use of the coefficient of water network length per 1 km of sewerage network length. In 1999, in Poland and in the Kujawsko-Pomorskie voivodeship, there were respectively 4.4 and 7.1 kilometers of water network per 1 km of sewerage network. In rural communes, that coefficient reached 17.6 and in the cities it was 1.2. In the period 1999-2014, the matters improved significantly because in 2014 the coefficient's value in Poland and in the Kujawsko-Pomorskie voivodeship fell to respectively 2.0 and 3.0 km of water network per 1 km of sewerage network, and in rural areas – to 4.0. In 1999, in as many as 23 rural communes, mainly in the eastern part of the region, the coefficient was high. The situation was the worst in the rural communes of Wielgie, Radziejów, Bobrowo and Rojewo, in which there was 200 km of water network per 1 km of sewerage network. The most balanced development of water and sewerage infrastructure was in urban-rural communes of Tuchola and Solec Kujawski and in rural communes of Wielka Nieszawka and Nowa Wieś Wielka. Over the next years, the relation between water and sewerage networks' length has improved, especially in rural communes, in which the situation was the worst in 1999.

The highest indicator value has been recorded in the commune of Wielgie – 363 km water network per 1 km of sewerage network in 1999. In later years the matter has improved significantly because in 2007 the indicator's value was only 26.3 and in 2014 – 10.4. Similar situation was observed in the commune of Radziejów, in which the indicator of water network length per 1 km of sewerage network was 271 in 1999 and 275 in 2007. Significant improvement took place later in 2014, when the indicator value was 11.8. The indicator value decreased because of large funding dedicated to building of water and sewerage infrastructure.

In 2014, it was the worst in rural communes of Chełmno and Lipno, in which there was 100-150 km of water network per 1 km of sewerage network – Fig. 3.

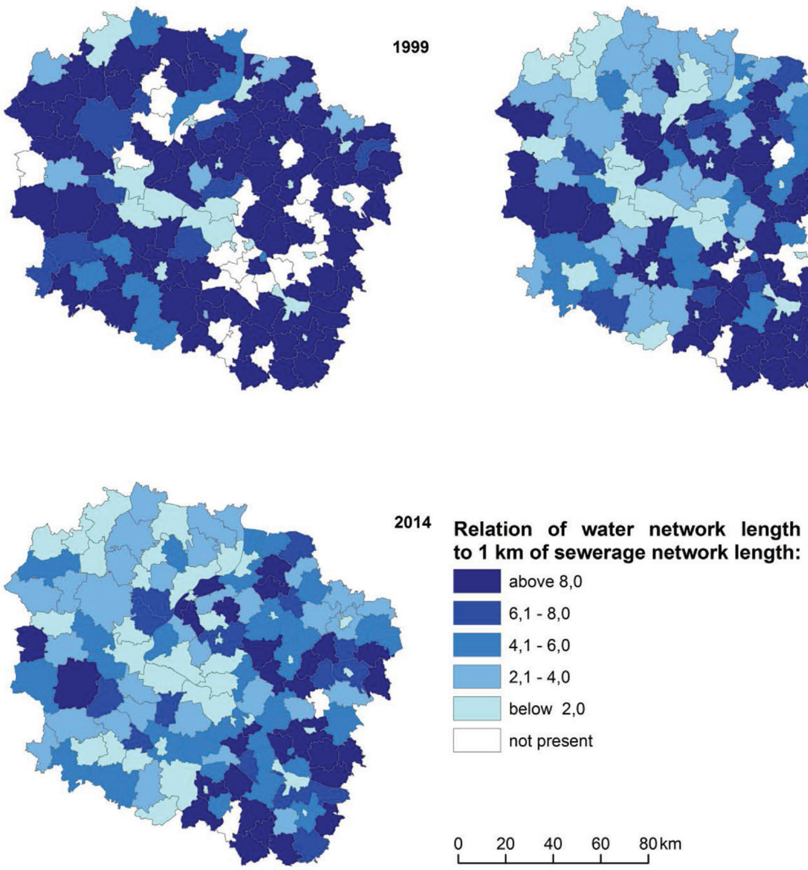

Figure 3. Relation of water network length to 1 km of sewerage network length in the Kujawsko-Pomorskie voivodeship in 1999, 2007 and 2014 (own study based on the BDL GUS)

The largest infrastructure demands result from the necessity to regulate water and sewerage management, not only in the Kujawsko-Pomorskie voivodeship but in the other regions too (Magiera-Braś, 2006; Woźniak and Sikora, 2007; Krakowiak-Bal, 2008b; Sikora *et al.,* 2013; Salamon *et al.,* 2016).

In the period of 1999-2014, in the Kujawsko-Pomorskie voivodeship, water network length was systematically growing, mainly in rural areas, in central and western part of the region. Together with expansion of water network, the number of connections as well as percentage of people using the network have increased.

Water and sewerage network development was funded as a part of the Regional Operational Programme in years 2004-2006 and 2007-2013. Particular attention was put on investments in water and sewerage infrastructure and natural environment protection in rural areas (Rural Development Programme).

Since Poland has accessed the European Union, thanks to increased funding of water and sewerage management, there has been found significant increase of sewerage network in the areas of dense housing and increase of the fraction of people using sewerage network. Nevertheless, there is still a substantial gap between urban and rural areas in the scope of sewerage infrastructure (Malinowski *et al.* 2016).

Despite significant extension of the sewerage network in the last 15 years, its density degree is still not satisfactory. Excessive cost makes sewerage network extension impossible in the communes with low population density. In those areas, there are built household sewage treatment plants, which comprise a cheaper alternative to sewerage network. As indicated by Hyski (2011), the number of such treatment plants in the Kujawsko-Pomorskie voivodeship is the second largest in Poland.

In the light of achieved results, it seems that it is necessary to continue investments, which are dedicated to rural areas in south-eastern part of the region. In the areas of small residential density, the local authorities should consider possibilities to subsidize construction of household sewage treatment plants. Average annual cost of such a plant is lower than gathering liquid sewage in hermetic tanks (Karolinczak *et al.,* 2015) or using sewerage network. As stated by Faust *et al*. (2015), the future issue of the sewerage infrastructure aging and its maintenance costs will have significant influence on water prices and hence may have an influence on household water usage volume (March Corbella and Sauri Pujol, 2009).

CONCLUSIONS

Based on the analysis, it must be stated that:

- Water network density in Kujawsko-Pomorskie voivodeship has been and still is higher than the country's average (2nd place among 16 regions)
- The dynamics of sewerage network growth throughout the analyzed 15 years was higher than that of water network. However, the current state is still far from satisfactory. The sewerage network density coefficient in Kujawsko-Pomorskie voivodeship is similar to Poland's average value, which in 2014 put the region on 9th place out of 16. The largest increase was recorded in rural and urban-rural communes. The

communes with lower population density turn to building household sewage treatment plants.

- The largest discrepancies between water and sewerage networks development levels occur in the communes located in south-eastern part of the voivodeship. In 2014, only 2 communes in Kujawsko-Pomorskie voivodeship had no sewerage network.

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Received: 28.02.2017
Accepted: 23.06.2017