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ASSESSMENT OF WATER SUPPLY AND WASTEWATER INFRASTRUCTURE DEVELOPMENT DYNAMICS IN POLAND IN THE YEARS 2003 – 2013

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Abstract

The paper presents an analysis of a chain index of water supply and wastewater infrastructure development dynamics in Poland in the years 2003-2013. The work aimed at determining the development index rate (relative growth) of water supply and sewage systems in Poland divided into 3 basic territorial units (rural, urban-rural and urban districts). Moreover, the paper describes the dynamics of changes concerning water consumption, share of population using water supplied by water supply systems, percentage of households possessing a bathroom and flush toilet and the share of population using sewage system during the analysed period. Conducted analyses used among others the chain index of dynamics to determine the rate of observed changes.

The analysis revealed the greatest rate of changes for the indices characterising sewage system and the share of population using the system and wastewater treatment plants. Despite the fact that rural areas were characterized by definitely the highest values of the rate of changes and chain index of changes dynamics, the differences between rural and urban areas concerning water supply and wastewater infrastructure in Poland are still considerable.

Keywords: infrastructure, water supply, sewage system

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INTRODUCTION

A high level of technical infrastructure development is an impulse for shaping the multifunctional rural development. The dependence is particularly perceivable in rural areas, where the access to technical infrastructure appliances determines the living conditions of local communities (Piszczek 2013). Regions with well-developed infrastructure are more attractive for settlement and development of business activities (Chojnicki and Czyż 2004). Regions with a large-scale modern infrastructure attract business activity, among others owing to possible decrease in the costs of new investments (Nijkamp 1986, Markowski 2007, Charlton and Vowels 2008, Churski 2008), however it does not prevent the opinions encountered in literature, that modern and extended technical infrastructure favours socio-economic peripheralization of a given area (Vickerman *et al*. 1999, Gorzelak 2009).

A diversification of the most necessary infrastructure facilities availability in individual regions of Poland has been observed for many years (Kwapisz 2005, Jarosz 2008, Jóźwiakowski *et al*. 2012, Perdał and Borowiczak 2012, Bergel *et al.* 2013, Salamon and Krakowiak-Bal 2013, Sikora *et al*. 2013, Mikołajczyk and Krajewski, 2014, Pawełek 2015, Pawełek 2016). Their high concentration in cities but low concentration in rural areas negatively affects development of the latter and living conditions of their communities (Gruszczyński 2001). Development of infrastructure has been analysed for many years in the approach of regional and national economic development. Z. Hellwig (1968) was the first to suggest a synthetic measure of development for comparing the level of economic development in selected countries. Analogous measures were presented, among others by Cieślak (1974), Bartosiewicz (1976), Strahl (1978), as well as by Zeliaś and Malina (1997), whereas these methods were compared among others by Krakowiak-Bal (2005).

Among the most important technical infrastructure facilities are water supply systems and sewage systems with the accompanying wastewater treatment plants. Longstanding neglect in the construction of sewage systems and wastewater treatment plants, particularly in rural areas of Poland was the source of deteriorating state of both surface and ground waters. By the end of 2003 as much as 10% of untreated municipal sewage and 28% of sewage subjected only to mechanical treatment was discharged directly to rivers and lakes. Only 29% of municipal sewage was subjected to biological treatment. At the time of the EU accession, availability of water supply and wastewater infrastructure differed considerably from the level in the West European countries. In 2003 wastewater treatment plants served only 57.4% of the population of Poland, whereas the average for the EU-15 was ca. 80%. Concentration of water supply system was 85.1% (MIiR 2014).This situation was due to the fact that development of water

supply system occupies a much higher position in the community's hierarchy of needs. Moreover, investments in sewage systems and wastewater treatment plants require higher outlays and are perceived by some of the local communities as additional financial burdens, but not as an element upgrading their living standards and limiting the natural environment degradation (Kłos 2011).

Poland's accession into the European Union required from our country fulfilling a number of requirements. The most difficult areas of negotiations cover the sector of agriculture and ecological policy concerning the state and quality of the natural environment in Poland. We managed to attain the longest transitional periods for water management in rural areas, in the first place regarding the water and wastewater management (Kłos 2011). In the EU Accession Treaty Poland undertook to fulfil the provisions of the Water Framework Directive (WFD) concerning provision of wastewater treatment plants and sanitation systems for the agglomerations of below 2000 Equivalent Number of Inhabitants (ENI) by 31 December 2015. Since the development of technical infrastructure is a costly process spread over time, efficient utilisation of both national and foreign external funding is particularly important (Kłos 2011).

The European Union funds have always played and still play an important role in financing investments in the construction and modernisation of sewage system and wastewater treatment plants. Funds were allocated for this goal from SAPARD Programme and subsequently in 2004-2005 from the Sectorial Operational Programme – Restructuring and modernisation of food sector and rural development and from the Integrated Agricultural Development Programme, which among others assumed improvement of living conditions in rural areas. Finally, in the years 2007-2013 financial support for modernisation of technical infrastructure facilities, including water supply and wastewater systems was provided within one of the measures of the Operational Programme Infrastructure and Environment. About 15% of all EU funding over the analysed period was spent on implementation of projects focused on the environmental protection and preventing natural hazards. In the years 2004-2012 the number municipal sewage treatment plants in Poland grew to 430, whereas over 250 facilities were modernised. The number of cities served by sewage treatment plants increased from 840 in 2001 to 903 in 2012 (CSO 2013).

The proportion of the EU funds in the financing of plumbing investments in Poland reached 20%. District budgets have the highest share in the financing of this type of investments, because they fulfil the requirement of investing their own funds in financial engineering of the investments realised with the aid of external funds. However, the share is different (about 40%) depending on the currently functioning programme and opportunities for funding acquisition (Kłos 2011). On the other hand, the proportion of funds from the National Fund for Environmental Protection and Water Management, provincial, county and

district funds for environmental protection and water management remains on a constant level, constituting c.a.1/3 of the total committed funding.

The period of Poland's accession into the EU caused many positive changes in water management and development of sewage systems in the country. However, there is no data in the literature about how the development of water supply and wastewater system translates into actual improvement of the inhabitants' life, i.e. whether, for example providing a water supply or sewage system for 100% of the district inhabitants causes that 100% of the local communities would use it. The literature of the subject lacks information to what extent a greater number of population using water supply or sewage system led to a growth in the number of households equipped with bathrooms or flush toilets.

The paper aimed at an analysis of the dynamics of changes in the concentration of water supply and sewage systems in Poland during the 2003-2013 period considering the rate of these changes in various types of territorial units (urban or rural district and urban-rural district), as well as the analysis of the rate of changes for other selected indices characterising plumbing infrastructure in Polish households.

MATERIALS AND METHODS

Data obtained from the Central Statistical Office and Local Data Bank were used in the paper. The data characterise the quantitative status of water supply and wastewater infrastructure in each Polish commune (municipality). The information obtained for the analysis refers to all years over the 2003-2013 period. 8 indices computed in the paper were compiled in two groups (Table 1). The first indices group (W1 and W2) characterises the concentration of water supply and wastewater infrastructure. The second group of indices (W3-W8) characterises the living standards of the inhabitants and provides information about the actual utilisation of infrastructural resources by the community.

For each of the indices a chain index of changes dynamics ($i_{n/n-1}$) was computed for the changes which occurred between 2003 and 2013 (the base year was always the one preceding the assessed one) and the rate of changes index (fixed base relative growth) ($i_{n/1}$) – where the base year for the whole period was 2003). The computed values were expressed in percent.

$$\bar{i}_{n/n-1} = \frac{y_n}{y_{n-1}} \cdot 100$$

$$\bar{i}_{n/1} = \frac{y_n}{y_1} \cdot 100$$

Table 1. List of analysed indices characterising water and wastewater infrastructure and its utilisation

No.	Name	Unit
Group 1 –indices characterising concentration of infrastructure		
W1	Concentration of water supply system per 100 km^2 of the area	km·100 km^2
W2	Concentration of sewage system per 100 km^2 of the area	km·100 km^2
Group 1 – indices characterising living standards of population		
W3	Share of population using water supply system	%
W4	Share of population using sewage system	%
W5	Share of population using wastewater treatment plants	%
W6	Share of apartments with bathrooms	%
W7	Share of apartments with flush toilet	%
W8	Water consumption per inhabitant	m^3·(pers·year)$^{-1}$

Moreover, mean annual rate of changes ($\overline{T}$) was determined for each analysed index according to the dependence (Zeliaś 2000),

$$\overline{T} = \left(\bar{i} - 1\right) \cdot 100$$

Where:

$$\bar{i} = \sqrt[n-1]{\frac{y_1}{y_0} \cdot \frac{y_2}{y_1} \cdot \frac{y_3}{y_2} \cdots \frac{y_n}{y_{n-1}}}$$

Where:

$\bar{i}$ – mean chain index of the investigated dynamics,

- y_o – value of the investigated phenomenon in the base year,
- y_1 – value of the investigated phenomenon in subsequent years.

All changes were determined separately for urban districts, rural districts and urban-rural districts.

RESULTS

In the years 2003-2013 a considerable increment of the length of active water supply system was observed in Poland, which increased by 23.8% reaching 287.6 thousand km. During the 2003-2013 period the greatest increase in the waterworks length was registered in Mazowieckie province (by 12.05 thousand km), whereas in relative terms in Warmińsko-Mazurskie province (by 44.6%). The lowest increment of water supply system was noted in Opolskie province

(growth by 10.7%), Wielkopolskie (13%) and Łódzkie (13.65). The best developed water supply networks are in Śląskie province (166 km ·100km^{-1}), Kujawsko-Pomorskie (126), Łódzkie (123), Malopolskie (121) and Mazowieckie (119). The smallest density of water supply system characterizes Zachodnio-Pomorskie (46) and Lubuskie (48) province.

Table 2 shows compiled results of analyses of changes dynamics for individual indices. Cities have the best developed water supply networks, however a mean annual rate of changes over the investigated period was almost the same for rural areas, cities and urban-rural areas, which was also presented in Figure 1. Figure 1 illustrates the changes of the chain index of changes dynamics in concentration of water supply system in the years 2003-2013.

The index more important than the length of water supply network is the percentage of the total number of population using the network. This index increased from 85.6% by the end of 2003 to 88.3% in 2013. The highest percentage of population use water supply system in Opolskie province (94.6%), whereas the lowest in Podkarpackie (76%) and Malopolskie (76%), despite a well-developed network. The greatest dynamics of the rate of changes concerning this index characterized rural areas, whereas the smallest changes were noted in cities (the share of inhabitants using water supply systems in the analysed cities increased only by 2%), which resulted from the potential present in this area.

It is also worth noticing that during the analysed period a decline by about 7% in water consumption per a statistical inhabitant of Poland happened. However, the declining tendency concerns mainly city dwellers (-10.7%). A statistical rural dweller increased water consumption during the analysed period by 17.7%. Water consumption by the inhabitants of urban-rural districts did not change.

In 2013 the total length of sewage system in the area of Poland was 132.9 thousand km and was by 93% longer than in 2003. Nevertheless, this length does not constitute even 50% of the active water supply network length. Still in many places water supply systems are functioning without sewage systems, whereas sewage system without a collective wastewater treatment plant is a common case (Kłos 2011).

The highest concentration of sewage system is registered in Śląskie, Podkarpackie and Malopolskie provinces (average for Poland is 45km ·100km^{-1}, whereas the highest increase in sewage system in relation to the length of the network in 2003 was registered in Opolskie, Świętokrzyskie, Podkarpackie and Malopolskie provinces. Concerning this index, the highest value of dynamics of changes and mean annual rate of changes was reached for each type of the territorial unit (Tab. 1). Dynamics of the rate of changes in the concentration of sewage system in the individual regions of Poland is strongly correlated with the percentage of population using sewage system (r=0.87) and using sewage treatment plant (r=0.82). There is an apparent polarization between the city-country arrangement in this respect, which was also mentioned by Perdał and Borowiec (2012).

Table 2. Dynamics of changes of selected indices characterizing water supply and wastewater infrastructure in 2003-2013

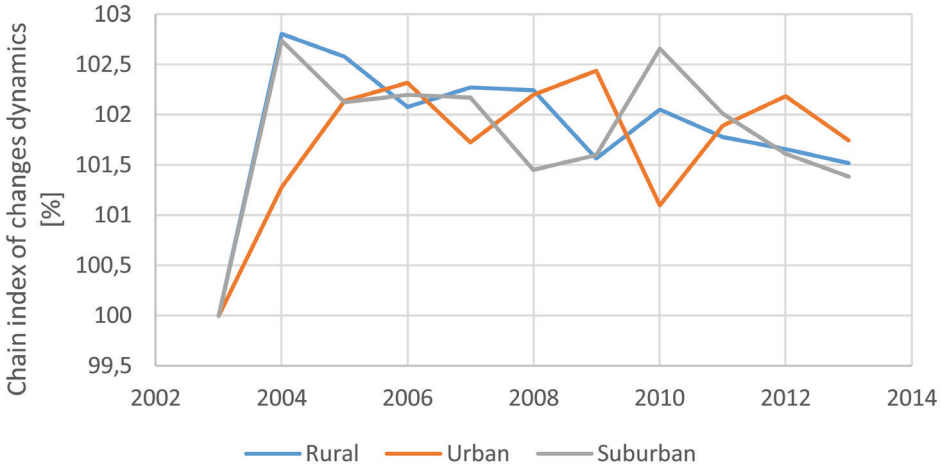
Parametr	Rural areas			Urban areas			Suburban areas		
	Unit value in 2013	$\bar{i}_{n/1}$	$\overline{T}$	Unit value in 2013	$\bar{i}_{n/1}$	$\overline{T}$	Unit value in 2013	$\bar{i}_{n/1}$	$\overline{T}$
W1	95.68	122.55	2.05	339.64	120.72	1.90	91.82	121.83	1.99
W2	37.37	248.00	9.51	320.55	141.00	3.50	40.86	201.90	7.28
W3	76.74	108.66	0.83	93.47	101.92	0.19	83.86	104.27	0.42
W4	29.78	184.80	6.33	83.13	108.62	0.83	50.04	125.37	2.29
W5	34.93	197.62	7.05	90.09	108.41	0.81	56.63	132.41	2.85
W6	79.74	110.33	0.99	94.27	104.29	0.42	87.01	107.06	0.68
W7	83.65	118.21	1.69	96.33	103.99	0.39	90.45	110.77	1.03
W8	27.82	117.72	1.64	30.88	89.27	-1.13	27.38	99.86	-0.01

Source: Own study

Figures 1 and 2 present the dynamics of changes of water supply and wastewater infrastructure concentration in the years 2003-2013 divided into territorial units. It is impossible to indicate which of the district types were developing the fastest – concerning water supply system during the analysed period, whereas rural areas revealed the highest dynamics concerning the concentration of sewage system over the whole analysed period. Intensive development of sewage systems, particularly in rural and urban-rural areas is caused by the necessity to eliminate the outcomes of many-year neglect concerning sewage systems and wastewater treatment plants, but is also determined by huge financial outlays on this sector of technical infrastructure. The problem of uneven development of water supply and sewage systems and growing polarization between the rural and urban areas concerning the dynamics of changes in water and sewage system was already discussed in the paper by Krakowiak-Bal (2009), basing on the data from the pre-accession period.

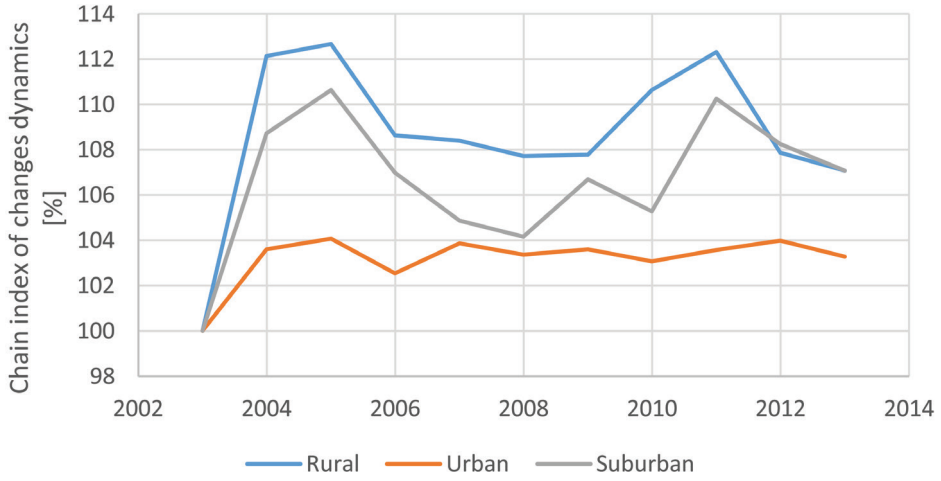
During the analysed period the percentage of population using sewage system increased from 56.9% to 64.3%, however in 2013 the highest level of the discussed index (over 77%) was registered in Pomorskie and Zachodniopomorskie provinces, whereas the lowest in Lubelskie (49.7%) and Świętokrzyskie (52.5%). In the years 2003-2013 the highest percentage of population started using sewage system in Podkarpackie province (increase by 15.7%), Opolskie (11.9%) and Świętokrzyskie (10.5%), i.e. in the provinces where sewage system increased most. Analysis of the correlation index confirmed a significant dependences between the increase in sewage system length and growth of the

population number using sewage system (r=0.72). A considerable gap between rural and urban areas still exists in terms of the discussed indices characterizing wastewater infrastructure (Tab. 2).



Source: Own study

Figure 1. Chain index of changes dynamics in water supply network concentration



Source: Own study

Figure 2. Chain index of changes dynamics in sewage system concentration

It is worth noticing that irrespective of the kind of territorial unit, Polish households possess bathrooms and toilets with flush toilet bowl (over 79%), whereas the rate of changes concerning these facilities is positive and strongly correlated (r=0.98).

CONCLUSIONS

1. The rate of changes and chain indices of changes dynamics assume the highest values for rural areas which during the studied period most heavily invested in the development of particularly sewage system in result of many-year neglect in this respect.
2. The highest values of chain index of changes dynamics were registered for sewage system concentration (W2).
3. The lowest values of chain index of changes dynamics were observed for the percentage of people using water supply system (W3). The low value resulted from relatively high values of the index itself, which made difficult obtaining high values of dynamics index.
4. Analysis of correlation index confirmed a significant dependence between the increase in sewage system length and increase in the number of population using sewage system and wastewater treatment plant (over 0.8).
5. Water consumption in Poland per one inhabitant decreased during the studied period. However, rural inhabitants differ from this trend (increase by 17.7%).

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