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Katarzyna PIETRUCHA-URBANIK[1]
Agnieszka NIEMIEC[2]
Marek URBANIK[3]

STATE OF WATER SUPPLY INFRASTRUCTURE IN THE SUBCARPATHIAN CITIES

The characteristics of equipping the Subcarpathian province cities with water supply infrastructure was made on the basis of data collected from the Provincial Office, Statistical Office, reports submitted by water companies regarding the functioning of water supply infrastructure and literature data. The indicators characterizing water supply infrastructure were determined for the years 1995-2014. In the paper the indicators of equipping cities with water supply systems were presented. Also water consumption and changes in the length of the water supply network in the cities of the Subcarpathian Province were examined. The analysis shows that the water consumption for the years 1995-2014 decreased by almost 6 $m^3 \cdot year^{-1}$ per capita. The reason for such situation was the increasing price of water and the ecological awareness of the inhabitants of the Subcarpathian region. In the last year of the analysis the water supply system in urban areas of the Subcarpathian province was used by 95% of the population and, for comparison, in rural areas by 77% of the population. In the paper also changes in prices for water in the Subcarpathian region were shown, on the basis of data from the water tariffs in individual water companies. The important element of urban development is the technical infrastructure which reduces the investment costs. The determined indicators of equipping cities with water supply systems show an upward trend in the development of technical infrastructure. Based on the operational data from the water companies the failure rates in selected water supply networks were determined.

Keywords: water consumption, water supply, water price, the development of water supply infrastructure, water network failure

1. Introduction

The Polish accession to the European Union contributed to the systematic development of the technical infrastructure, which results in the increase of technical infrastructure level, especially in less developed areas, including small

[1] Autor do korespondencji / corresponding author: Katarzyna Pietrucha-Urbanik, Politechnika Rzeszowska, al. Powstańców Warszawy 6, 35-959 Rzeszów, tel. 17 8651703, kpiet@prz.edu.pl
[2] Agnieszka Niemiec, Politechnika Rzeszowska
[3] Marek Urbanik, Politechnika Rzeszowska

towns. In recent times the significant changes associated with the development of water supply infrastructure can be noticed, which had a significant impact on developing water supply network, what is indicated in numerous works [2-8].

People always seek to improve their living standards in different areas of life. Undoubtedly one of the factors contributing to the improvement of living standards is a level of development of water supply infrastructure. Access to tap water will not only increase living standards, but also contributes to the attractiveness of the property, the development of new investments in given region and excludes the additional costs of investment in technical infrastructure [10, 11]. Water supply through collective water supply system should meet certain requirements, related, among others, to the quality and the appropriate pressure of delivered water.

The Subcarpathian Province was established in 1999 under the act on a three-tier administrative division of the country, through connecting three provinces: Rzeszow, Przemysl and Krosno and parts of Tarnow and Tarnobrzeg provinces. Subcarpathian covers an area of 18,000 km^2, about 6% of Polish territory and is inhabited by 2,129 million people (approx. 5,53% of the Polish population). Cities are inhabited by 41.35% of the total population. The analysis of the age and material structure of water supply system, depending on the size of the water supply system in Subcarpathian, was presented in the paper [1]. The oldest water supply pipelines are located in cities with more than 20 thousand residents, most pipes are over 26 years old, while 80% of all pipes are less than 25 years old and are in cities with 5 to 10 thousand residents. In the construction of water pipes dominate material of PE and PVC, in the large cities appears grey cast iron, previously used for constructing water supply systems, constituting 51% of the mains and 18% of the distributional pipes [1].

Ensuring proper level of water supply infrastructure development is an important factor in economic development in accordance with applicable regulations.

2. Equipping cities of the Subcarpathian province with water supply networks

In recent years there has been a significant increase in the length of water supply network in individual cities of the Subcarpathian province. It is due to rapid expansion of cities and increasing living standards. The increase in the length of the water supply system in urban areas in the years 1995-2014 amounted to 182% and for the whole Subcarpathian to 196% (approx. 1300 km). As a point of reference it was assumed that in 1995 the total pipe length was 100%.

The characteristic values related to the degree of equipping cities with water supply networks, depending on the number of inhabitants, are presented in Table 1.

Table 1. The average length of water supply network per one inhabitant in the cities of the Subcarpathian province in 2014

Tabela 1. Średnia długość sieci wodociągowej przypadającej na jednego mieszkańca w miastach województwa podkarpackiego w 2014 roku

Specification	Number of urban residents						Total
	poniżej 5000	5000-10000	10000-20000	20000-50000	50000-100000	powyżej 100000	
Total number of cities	20	14	7	6	3	1	51
Length of water supply network falling per one inhabitant, m·Mk^{-1}	0,21	0,95	1,7	2,03	3,52	5,54	2,33

With the increase of the water supply network length the number of connections to buildings also increases. In the last year the network length falling per capita amounted to 3,25 m·Mk^{-1}, whereas the length of the water supply system per unit area was 25,01 m·ha (Fig. 1).

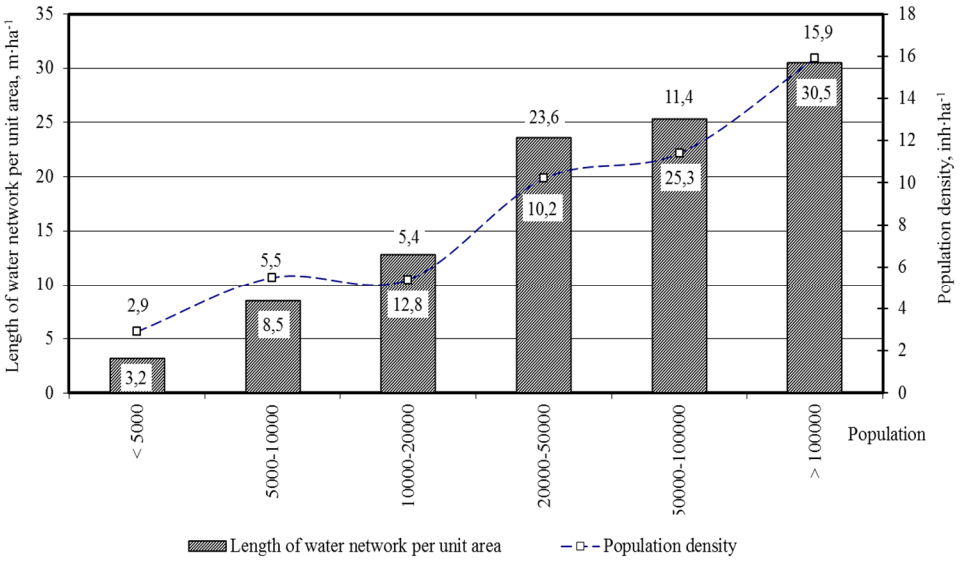

Fig. 1. Summary of the average length of water supply network per unit area and corresponding to it density of population in the cities of the Subcarpathian region in 2014

Rys. 1. Zestawienie średniej długości sieci wodociągowej przypadającej na jednostkę powierzchni oraz odpowiadającej im gęstości zaludnienia w miastach województwa podkarpackiego w 2014 roku

Both, the indicator of equipping with water supply network and the indicator of water use, are very useful in performing the analysis of prices and costs associated with the construction and the use of water supply network in cities with different numbers of inhabitants [3, 4]. The cities of with the longest length of the water distribution network in 2014 included: Rzeszów (536,9 km), Krosno (184,9 km), Tarnobrzeg (177 km), Mielec (170,3 km), Jasło (151,3 km), Przemyśl (149,7 km), Dębica (134,2 km), Nisko (104,2 km), Jarosław (103,6 km) and Sanok (100,1 km). For comparison, the cities with the shortest length of the water supply network included: Kołaczyce (4,1 km), Iwonicz Zdrój (4,4 km), Nowa Sarzyna (5,7 km), Lesko (6 km), Narol i Cieszanów (7,7 km), Dukla (9 km) oraz Oleszyce (9,1 km).

A clear indicator for describing the operation of water supply systems is the intensity of network load which can be determined as the average daily demand for water by the length of water supply network. In the cities of the Subcarpathian province it was 26,25 $m^3 \cdot d^{-1} \cdot km^{-1}$ (fall from 65,79 $m^3 \cdot d^{-1} \cdot km^{-1}$ in 1995), in comparison in rural areas it was 5,65 $m^3 \cdot d^{-1} \cdot km^{-1}$ (Fig. 2).

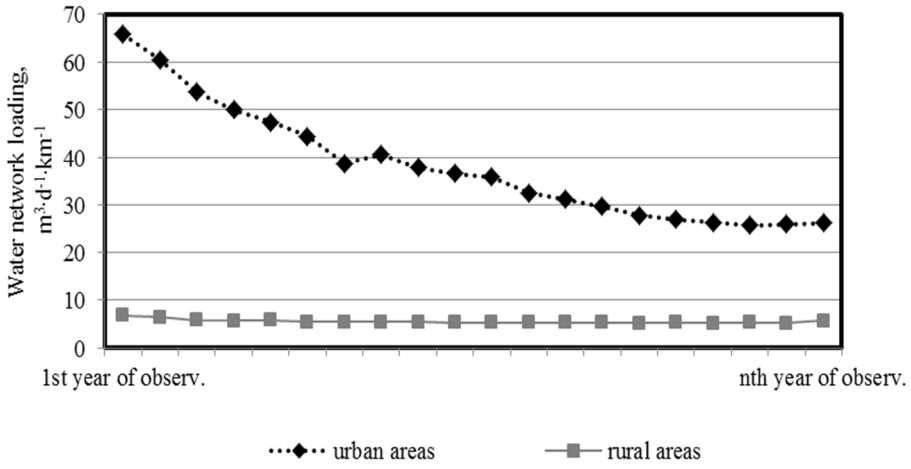

Fig. 2. Summary of the intensity of water network load in rural areas and in the cities in the years 1995-2014

Rys. 2. Zestawienie intensywności obciążenia sieci wodociągowej na obszarach wiejskich oraz w miastach w latach 1995-2014

Analysis of the dependence between number of inhabitants per 1 km of water supply network in the cities of the Subcarpathian region and the intensity of the network load showed an obvious correlation of 60%, confirming that the more residents the higher indicator of the intensity. By using this dependence, the level of water losses in the water supply system can be specified and the assessment of state of water supply in the given city compared to similar water supply systems, can be made.

3. Water consumption in the cities in the Subcarpathian region

The greatest impact on water consumption in households had the number of residents. Over the years, this dependence has changed depending on the equipping households with water facilities, such as dishwashers, washing machines, fittings. In recent years, a significant decrease in water consumption, caused by the increase of water price and the use of water saving equipment, is noticed. The average consumption of water in cities varied at the level 20,04-27,2 $m^3 \cdot M^{-1} \cdot rok^{-1}$. Such fluctuations in the levels of water consumption in cities are caused by rising prices of water and increasing operating costs of the whole water network. Habits of residents vary from year to year, which also results in fluctuations in the value of indicators of water consumed by residents for the living purpose. Changeability of the water consumption is also affected by other factors not directly related to human activities, such as seasons, holidays and temperature differences.

Different values of the indicators showing the use of water supply network in the cities of the Subcarpathian province are one of the causes of differentiated prices for water in rural areas and in the cities. The analysis shows that in the cities with a population of more than 100 000, the water consumption is significantly lower than in the small towns of less than 5 thousand residents (20 cities with an average water consumption per capita of 25,73 $m^3 \cdot M^{-1} \cdot rok^{-1}$). For the 14 cities with a population from 5 to 10 thousand, the average water consumption was 20,56 $m^3 \cdot M^{-1} \cdot rok^{-1}$.

With the increase in the development of water supply infrastructure in the Subcarpathian province cities the water consumption decreased. One of the reasons of such situation is the water price. Many cities explains the increases in water price by the significant investment of the infrastructure. The Constitutional Tribunal ordered the Members of the Polish Parliament to clarify the calculation for water charges. Considering the water price, Rzeszów, the largest city of Subcarpathian, ranks at the seventh place in the whole country, with a gross price of 4,28 $zł \cdot m^{-3}$. While the detailed analysis showed that in the last year of analysis the highest water prices are, among others, in the following cities in the Subcarpathian province: Rudnik nad Sanem - 9,59 $zł \cdot m^{-3}$, Zagórz - 8,95 $zł \cdot m^{-3}$, Sieniawa – 8,59 $zł \cdot m^{-3}$, Kańczuga - 8,56 $zł \cdot m^{-3}$, Cieszanów - 7,73 $zł \cdot m^{-3}$, Pruchnik - 7,59 $zł \cdot m^{-3}$, Iwonicz Zdrój, Narol - 6,59 $zł \cdot m^{-3}$, Dynów - 6,65 $zł \cdot m^{-3}$, Radymno - 6,59 $zł \cdot m^{-3}$. In turn, the lowest prices occur in Lubaczów (2,25 $zł \cdot m^{-3}$), StalowaWola (2,37 $zł \cdot m^{-3}$), Sokołów Małopolski (2,75 $zł \cdot m^{-3}$), Ropczyce (2,83 $zł \cdot m^{-3}$), Leżajsk (2,93 $zł \cdot m^{-3}$), Mielec (3,25 $zł \cdot m^{-3}$), Błażowa (3,26 $zł \cdot m^{-3}$), Lesko (3,45 $zł \cdot m^{-3}$), Jasło (3,55 $zł \cdot m^{-3}$), Dębica (3,62 $zł \cdot m^{-3}$). The water consumption in big cities is influenced by the water price, in small towns with up to 5,000 residents the price of cold water per $1m^3$ is higher than the price of water in cities with over 100 000 inhabitants, which is presented in Table 2.

Table 2. The average net price per 1m^3 of water in the cities of the Subcarpathian province in 2014
Tabela 2. Średnia cena netto za 1m^3 wody w miastach województwa podkarpackiego w 2014 roku

Specification	Number of urban residents						Total
	poniżej 5000	5000-10000	10000-20000	20000-50000	50000-100000	powyżej 100000	
Total number of cities	20	14	7	6	3	1	51
Średnia cena za wodę (netto), zł·m^{-3}	5,81	4,49	3,11	4,20	2,40	3,96	4,00

Water consumption for various purposes in the cities of the Subcarpathian province varies throughout the period of analysis, which in case of individual sectors of the economy is due to economical water and sewage management in industrial plants, so the introduction of closed water circuits, the recession of the economy and the closure of unprofitable (often water-absorbing) industrial plants, as well as the environmental protection requirements, which force the industrial plants to use the environment friendly technology. The water consumption for industry underwent fluctuations throughout the analysed period, in the last year of analysis it amounted to 19302 dam^3·a^{-1} (the average increase of 22% compared to the first year of the analysis). Similar situation occurred in the case of water used for agriculture and forestry, despite large fluctuations in water consumption, the average increase in the last year of analysis was 40% and the water consumption in 2014 amounted to 42222 dam^3·a^{-1}. On the other hand, the consumption of water for the operation of the water supply network has fallen to value of 60627,2 dam^3·a^{-1}, a decrease of 17%.

4. Percentage of people with access to water supply network in the cities of the Subcarpathian province

With the increase in population, urbanization and fast economic development the demand for water increases. In the last year of analysis the indicator of the access to water supply network was 96.8%. There was a significant increase in number of people who use the water supply system in comparison to 1995 when the indicator was 84%. The cities where almost 100% of people have the access to water supply network are: Przecław, Brzostek, Lubaczów, Nowa Dęba. In Sieniawa, Głogów Małopolski, Iwonicz-Zdrój, Łańcut, the access to the water supply network had 99,95%. The cities with the smallest number of the population having access to water supply network were: Dynów (44,01%), Rymanów (4,48%), Jedlicze (54,49%), Radymno (58,64%), Rudnik on San (67,23%), Nisko (77,73%), Strzyżów (78,29%). Providing the residents safe water for con-

sumption is not an easy process and requires a large involvement of operators in the efficient management and, among others, the renovation of old water pipes. The reason for the connection to a public municipal water supply system even the smallest households, that often have individual underground water well, can be depletion of small water sources which can often be caused by weather conditions or improving the material conditions of the residents. More and more new housing estates and houses are being built in the outskirts of cities, which affects the need to build new water supply networks.

5. Failure frequency of water supply network

In the figures 3-4 the number of failures that occurred in the distributional pipes were summarized, referring the number of failures to the length of the water network [9]. Eight water supply systems were distinguished in Subcarpathian Province with different population: 6 thousand residents (a), 47 thousand residents (b), 47 thousand residents (c), 67 thousand residents (d), 181 thousand residents (e), 40 thousand residents (f), 113 thousand residents (g) (the available data concern only distribution network), 18 thousand residents (h), 62 thousand residents (i).

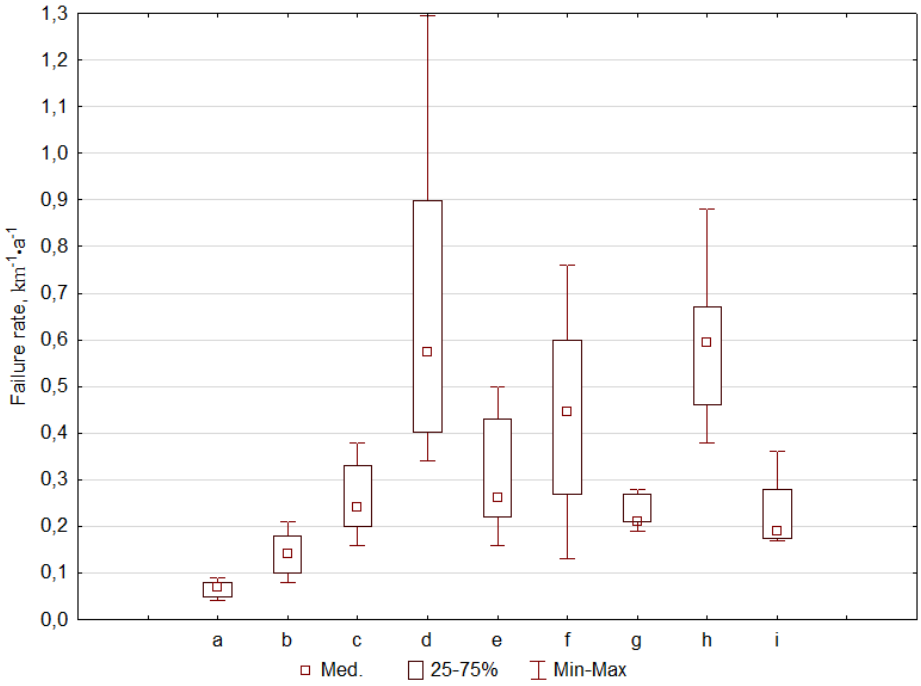

Fig. 3. The failure rate for the distribution network λ_R

Rys. 3. Zestawienie wskaźnika intensywności uszkodzeń dla przewodów rozdzielczych λ_R

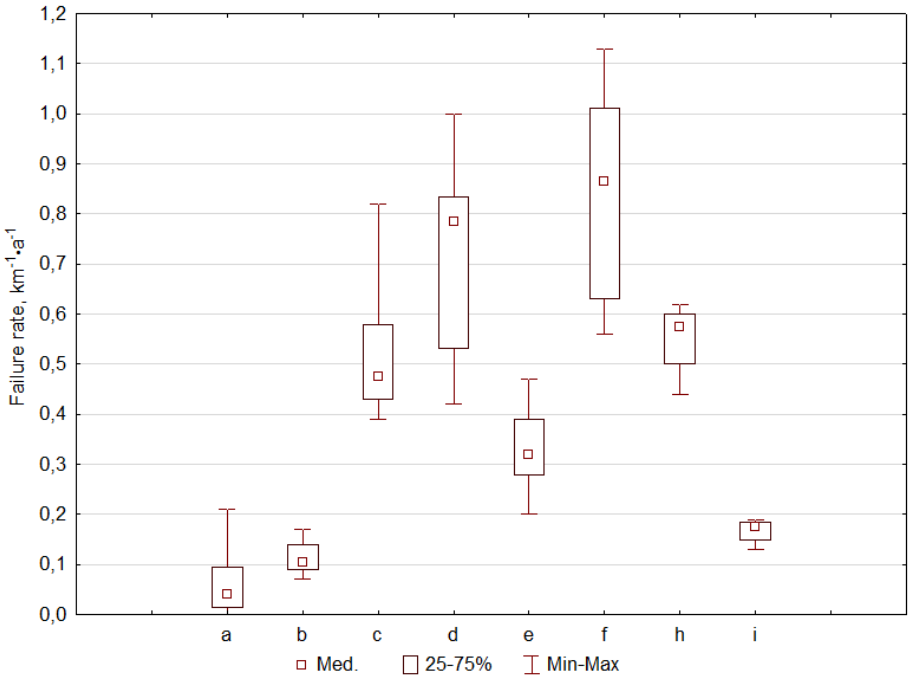

Fig. 4. The failure rate for the water connections λ_P

Rys. 4. Zestawienie wskaźnika intensywności uszkodzeń dla przyłączy wodociągowych λ_P

The values of failure rates for distributional pipes λ_R slightly differ from the criteria values proposed in the studies [12]. For water supply connections the failure rates are at a satisfactory level. The detailed analysis of failures showed that the failure rate for water supply connections show a downward trend. In the last year of analysis in selected cities the values of failure rates for the distribution network were as following: 0,16 $km^{-1} \cdot a^{-1}$ (e), 0,38 $km^{-1} \cdot a^{-1}$ (c), 0,375 $km^{-1} \cdot a^{-1}$ (d), 0,19 $km^{-1} \cdot a^{-1}$ (f), 0,18 $km^{-1} \cdot a^{-1}$ (e) and remained at a satisfactory level.

6. Conclusion

The decrease in water consumption was mainly due to the rising price of water, as well as increasing environmental awareness of people, who, for several years, pay more attention to the ecology. Lower water consumption makes it difficult to conduct the forecasting of water supply. However, in order to reduce the consequences of changes in water quality in the network, due to extension of the time of water flow, the companies take various countermeasures, including, among others, the rinsing of water supply network. Larger water consumption for rinsing the water supply system contributes to the increase in production costs and charges for water services.

The rapid development of water supply infrastructure in the Subcarpathian region encourages investors to make new investments. The significant expansion of water supply infrastructure in the cities of the Subcarpathian province occurs due to the connecting the adjacent areas to the cities and the expansion of existing cities or building the new ones, so connecting the new buildings to the water supply network.

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STAN INFRASTRUKTURY WODOCIĄGOWEJ MIAST WOJEWÓDZTWA PODKARPACKIEGO

S t r e s z c z e n i e

W pracy przedstawiono charakterystykę wyposażenia miast województwa podkarpackiego w infrastrukturę wodociągową, sporządzoną na podstawie analizy danych zebranych z Urzędu Wojewódzkiego, Banku Danych Lokalnych Urzędu Statystycznego, sprawozdań składanych przez przedsiębiorstwa wodociągowe dotyczących funkcjonowania infrastruktury wodociągowej oraz danych literaturowych. Wyznaczono wskaźniki charakteryzujące infrastrukturę wodociągową dla lat 1995-2014. W pracy omówiono wskaźniki zwodociągowania województwa podkarpackiego. Dokonano również analizy zużycia wody oraz zmian długości sieci wodociągowej w miastach województwa podkarpackiego. Z przeprowadzonej analizy wynika, że zużycie wody na przestrzeni lat 1995-2014 spadło o niemal 6 $m^3 \cdot rok^{-1}$ na jednego mieszkańca. Na przyczynę takiej sytuacji miała rosnąca cena za wodę oraz świadomość ekologiczna mieszkańców województwa podkarpackiego. W ostatnim roku analizy z sieci wodociągowej na terenie miast województwa podkarpackiego korzystało ponad 95% mieszkańców w miastach, a dla porównania 77% procent na obszarach wiejskich. W pracy przedstawiono również analizę zmian cen za wodę na terenie województwa podkarpackiego na podstawie danych pochodzących z taryf opłat za wodę w poszczególnych przedsiębiorstwach wodociągowych. Ważnym elementem rozwoju miast jest uzbrojenie w infrastrukturę techniczną, co wpływa na obniżenie kosztów realizacji inwestycji. Wyznaczone wskaźniki zwodociągowania miast województwa podkarpackiego wykazują tendencję wzrostową w zakresie rozwoju infrastruktury technicznej.

Słowa kluczowe: zużycie wody, wodociągi, cena wody, rozwój infrastruktury wodociągowej

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