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Changing size and structure of water consumption in Poland in the late twentieth and early twentyfirst century

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Abstract. Since the early 1990s the downward trend of water consumption has been observed in Poland, which also applies to urban areas. The paper presents the analysis of changes in water consumption in Poland in the years 1990-2012. The study takes into account the structure of water consumption as well as its diversity in urban and rural areas. Moreover, the dynamic pace of development of water supply infrastructure and increase of its accessibility for rural residents is indicated. As a result of the study it was revealed the total amount of water consumed in Poland was reduced by 24%. The biggest, almost 36 percent drop, occurred in the operation of the water supply system (35.9%) as well as agriculture and forestry (35%). Water consumption in production decreased by about 19%. There was a significant difference between the structure and the trend of changes in water consumption in rural and urban areas. In the countryside the largest share in the structure of water consumption was taken by production and irrigation, and in cities - production and households.

Moreover, a drop by 20% was recorded in specific total water consumption, and it was stressed that in the cities it was more than twice as high (46%). In the case of rural areas, this indicator value increased by 15%. In addition, the main factors determining the decrease in water consumption were identified, which included, among others, the liquidation of many industrial plants as a result of political transformation and the introduction of a general system of water consumption metering (water meters).

In conclusion, from the ecological point of view, a significant reduction in water consumption in Poland should be considered beneficial. At the same time, it needs paying attention to the economic and technological effects of the drop in water consumption.

Keywords: water supply, water resources, water consumption, water consumption per capita.

Introduction

Water is the main chemical component of living organisms conditioning their existence. It is a basic element of life for which man was unable to come up with a substitute. Therefore, such an important issue is the access to clean drinking water. It is believed that countries with water resources below 2000 m³/M may have difficulty meeting the needs of the population, and the countries with the resources below 1000 m³/M as having deep water deficit [1].

In Poland, the water resources per capita average 1580 m³, but this figure decreases to about 1000 m³ in the years of low total precipitation. As the effect of this, Poland's water resources are almost three times lower than the European average (4560 m³/M) and about 4.5 times lower than the world average (7300 m³/M) [2].

A very important issue is the amount of water taken from the aquatic ecosystem, because after it has been used a large part of it will be returned to the environment. Therefore, the derivative of the amount of the volume of water drawn from the ecosystem is the resulting amount of wastewater. Each aquatic ecosystem can take a certain amount of wastewater without major damage. However, exceeding the capacity of the ecosystem related to its ability to the self-cleaning effect, often damages it irreversibly [3]. For these reasons the relation between the water intake and its resources determined on the basis of the water exploitation index seems important. In the case of Poland, the size of this index is unfavourable and is 15-20%. But the biggest problem of water management in Poland is not water quantity, but significant precipitation variability and extreme hydrological phenomena. It is most felt by agriculture, which results in crop failures [4, 5].

This paper analyses the structure and size of water consumption in Poland in the years 1990-2012. The study takes into account differences in water consumption in urban and rural areas. In addition, the development of water supply infrastructure and its availability to the residents was specified.

Materials and methods

The analyses were based on the data from the Yearbook of Environmental Protection issued by the Polish Central Statistical Office (GUS) and the Local Data Bank of GUS [6, 7]. They included information on the size and structure of water consumption and the number of people using the water supply network. The data on the length of said network in order to determine the dynamics of its development was also used. Furthermore, examining the diversity of water consumption in rural and urban areas in Poland it was also considered that a significant transformation in the place of residence of the population has taken place.

On the basis of these data on the population and the size and structure of water consumption in Poland the following indicators were calculated:

specific total water consumption:

$$I_{total} = \frac{C_{total}}{M \cdot 365} \tag{1}$$

where: I_{total} – specific total water consumption,

 C_{total} – total water consumption,

M – number of citizens of Poland.

specific water consumption in households (urban and rural areas):

$$I_{hc} = \frac{C_{hc}}{M_c \cdot 365} \text{ or } I_{hv} = \frac{C_{hv}}{M_v \cdot 365}$$
 (2)

where: I_{hc} , I_{hv} – specific water consumption in households (urban and rural areas),

 C_{hc} , C_{hv} – water consumption in households (urban and rural areas),

M_c, M_v – number of inhabitants (urban and rural areas)

In addition, the chain rate of change dynamics of water consumption in urban and rural areas and the aforementioned length of the water supply system were calculated. Denoting the studied phenomenon as y_i , the average chain rate of growth takes the following form:

$$\bar{i} = n_{-1} \frac{y_1}{y_0} \cdot \frac{y_2}{y_1} \cdot \frac{y_3}{y_2} \cdot \dots \cdot \frac{y_n}{y_{n-1}}$$
(3)

Using the average chain rate of growth the average rate of change (\overline{r}) of water consumption in the analysed period was determined:

$$\overline{T} = (\overline{i} - 1) \cdot 100 [\%] \tag{4}$$

Results and discussion

Since the early 1990s the downward trend of water consumption has been observed in Poland (Fig. 1). In the years 1990-2012 a decrease in total water consumption was approximately 24%. The biggest, almost 36 percent drop, occurred in the exploitation of the water supply system (35.9%) as well as agriculture and forestry (35%). Water consumption in production decreased by about 19%. Despite a significant decrease in water consumption for many years its structure was not subject to significant change. About 75% of the water is consumed in production, 15% for municipal purposes, and only 10% for irrigation.



Fig. 1. Water consumption by the national economy sectors in Poland: 1990-2012. Explanations: 1 – total, 2 – production, 3 – irrigation and forestry, 4 – exploitation of the water supply network.

The decrease in water consumption observed in Poland was caused by many factors. One of the most important was the change in the industrial sector. The socio-economic transformation that took place in Poland in the late 1980s and 1990s forced the closure of many unprofitable plants. At the same time they were often water-intensive plants.

In the case of households, an important factor limiting the water consumption was widespread metering of consumption of tap water and a significant increase in its price. In addition, in the analysed period water wastage was significantly reduced by installing good quality equipment and the modernisation of canals and sanitation.

Analysing the share of rural and urban areas in the total water consumption in Poland, a big change was recorded (Fig. 2). In 1990, in Poland the vast majority of water was consumed in the cities (over 65%). Currently, more than half of the water is consumed in rural areas (about 55%), and only 45% in cities. For these reasons, an extremely different nature of the changes of the tested element in both areas should be stressed. Before the early twenty-first century the water consumption in rural areas showed insignificant multidirectional changes. It was not until after 2000 that there has been a clear upward trend.



Fig. 2. Urban and rural areas in total water consumption. Explanations: 1 - urban areas, 2 - rural areas.

Water consumption in urban areas was decreasing steadily since the early 1990s. A slight increase was recorded only in 2006-2007. This slight deviation from that trend was mainly due to an extremely low precipitation in that period. It should be noted that in the last two years of the research period, the share of urban and rural areas in the total water consumption in Poland stabilised and remained unchanged.

In rural areas in the years 1990-2012 water was mainly consumed for production and irrigation. Households accounted for only a few percent of the total water consumption. However, the average annual growth rate of water consumption in the case of households was the largest and amounted to more than 2%. As a result, the volume of water consumed for this purpose increased throughout the study period by more than 152%. The relatively smaller increase in water consumption was recorded in production - by 38% - with an average annual growth rate of 1.5%.

| Table 1. | |
|----------|--|
|----------|--|

| Lp. | Area | Dynamics of changes in the various sources of water consumption | | | Average annual rate of change | | |
|-----|--------|---|------------|-------------|-------------------------------|------------|------------|
| | | Production | Irrigation | Households | Production | Irrigation | Households |
| | | | | % | | | |
| | | | | 1990 – 2012 | | | |
| 1 | Poland | -18.8 | -34.9 | -37.6 | -0.9 | -1.9 | -2.1 |
| 2 | Rural | 38.1 | 50.0 | 152.7 | 1.5 | -2.1 | 1.9 |
| 3 | Urban | -45.0 | 93.8 | -50.2 | -2.7 | 3.1 | -3.1 |

Dynamics and the average annual rate of change in water consumption

The reason for such a significant increase in the amount of water consumed by households was an increase in the availability of water supply infrastructure in rural areas and counter-urbanisation phenomenon observed in Poland since the late 1990s. The result of this process in recent years is an increasing number of rural residents, with decreasing urban population. The dynamic development of water supply infrastructure, including the transmission network, occurred since the early 1990s (Fig. 3).



Fig. 3. Length of the water supply network in Poland in the years 1990-2012, broken down into urban and rural areas. Explanations: 1 – Poland, 2 – rural areas, 3 – urban areas.

As a result of the investment the total length of the water supply network increased by 163 354.8 km and a number of new intakes and water treatment plants were built. For comparison, during this period in the cities a little more than 26 500 km of water supply network were completed. The average annual growth rate of the water supply network in rural areas amounted to 6%, while only 3% in urban areas.

Increased water consumption for production purposes in rural areas was mainly due to the transfer of many industries and services to suburban areas where business costs are much lower. Additional incentives were often special economic zones created in rural areas. Within them, the companies were entitled to additional discounts and incentives.

The course of changes in the amount of water consumed in urban areas had, as already mentioned, a different nature than in rural areas. The largest decrease was observed in the use of water for municipal purposes (50%) and slightly lower on manufacturing (44%). Average annual rate of change in both cases was negative and amounted to 3.1 and 2.7%, respectively.

What is interesting is an increase in the amount of water used for irrigation, which relates mainly to green areas, in particular parks, squares and lawns. A large part of water is also consumed on watering gardens and allotments, which continue to operate in many cities in Poland (Fig. 4). The average annual increase in water consumption for this purpose amounted to 3.1%.



Fig. 4. Structure of water consumption in urban (A) and rural areas (B) in the years 1990-2012. Explanations: 1 – total, 2 – production purposes; 3 – irrigation and forestry; 4 – exploitation of the water supply network.

The structure of water consumption in urban areas is now dominated by production purposes (about 75%). The remainder of the water is consumed mainly for municipal aims (24%). During the studied period this structure did not change much. In the case of rural areas the share of production in water consumption significantly increased, while the share of irrigation decreased. It should be emphasised, however, that in the volume of water consumption for this purpose significant differences in individual years are observed.

This is mainly due to changing weather conditions occurring in Poland, especially precipitation totals.

Until the mid-1990s, the specific total water consumption in Polish cities was higher than the national average. In subsequent years, a systematic decrease in water consumption in urban areas caused a reduction in the value of this indicator. It is now much lower than the average for Poland. In rural areas, the opposite trend was observed (Fig. 5).



Fig. 5. Specific water consumption: total (A) and in households (B). Symbols: 1 – Poland, 2 – urban areas, 3 – rural areas.

A similar situation occurred in the case of the indicator describing the specific water consumption in households. Within 23 years this indicator for urban areas fell twice from 187 to 93 m³ per day. In 1990, the difference between specific water consumption in rural and urban areas was more than three-fold. Currently, it is only 23 m³ per day.

Conclusions

The analysis found a significant decrease in total water consumption in Poland in the years 1990-2012. The decline referred to all sources of water consumption and, as a result, its structure remained largely unchanged. The key factors determining the decrease in water consumption were highlighted; they included, among others, liquidation of many industrial plants as a result of political transformation and the introduction of a common system of metering of water consumption (water meters).

There was a significant difference between the structure and the trend of changes in water consumption in rural and urban areas. In rural areas the largest share in the structure of water consumption was recorded in production and irrigation, while in cities – in production and households. In both areas, the opposite trend of changes in the amount of water used was observed. In urban areas, this figure decreased, while in rural areas – the opposite – it increased. The main causes of these changes were highlighted, which included increasing attractiveness of suburban areas for investment, the development of water supply infrastructure in the country and progressive counter-urbanisation.

Examining the total specific water consumption in Poland, its 20% decline was recorded; in urban areas the level of decline was more than twice as large (46%). In the case of rural areas, the indicator value increased by 15%. The main reason for this was an increase in water consumption for production purposes, which resulted from the transfer of a significant number of businesses from the city centers to suburban areas. In addition, analysing the indicator of the specific water consumption by households, the attention was drawn to the tendency to decrease the differences between urban and rural areas.

To summarise the observed changes in the size of water consumption in Poland, what should be emphasised is their significance both in the economic and natural sphere. From an ecological point of view, these changes should be considered beneficial. However, from the point of view of water supply, especially in larger cities, the observed changes can be a significant problem. Constantly decreasing water consumption caused difficulties in forecasting water demand, and hence the collection and disposal of wastewater.

The consequence of this is that the newly-built water and sewage networks in Polish cities appear to be in many cases too large in relation to the current demand. This results in an increase in fixed costs in the provision of water supply and sanitation. This directly translates into an increase in specific costs and charges for these services.

Undoubtedly, however, limited water resources in Poland and the large variability of their occurrence in time and space make it necessary for rational water management. Therefore, the decrease in water consumption in large part should be identified with a reduction in human pressure on the environment.

Bibliography

^{1.} Iwanicka Z. Efficient use of water in urban areas Polish, (in Polish) / Z. Iwanicka. – 2007. – [Electronic resource] – Access mode : (http://suw.biblos.pk.edu.pl/resources/i3/i3/i8/i6/r3386/IwanickaZ_Racjonalizacja Zuzycia.pdf).

- 2. Grabowska M. Water-related barriers in the economic development of Poland / M. Grabowska // Socio-Economic Problems and the State. 2010. No 1(3). P. 55-61.
- Kuczyński W. Water Supply in Poland in Relation to the Global Situation / W. Kuczyński, W. Żuchowicki // Annual Set The Environment Protection. – 2010. – No 12. – P. 419–465.
- 4. Pierzgalski E. Measures for soil water control in Poland / E. Pierzgalski, J. Jeznach //Journal of Water and Land Development. 2006. Vol. 10. P. 79–89.
- Water-related threats / Z. W. Kundziewicz, M. Zalewski, A. Kędziora, E. Pierzgalski // Nuka. 2010. No (4). P. 87–96.
- 6. Statistical information and elaborations environment yearbooks 1990-2013, Central Statistical Office, Warsaw.
- 7. Local Data Bank of GUS. [Electronic resource] Access mode : (http://www.stat.gov.pl/bdl/app/strona.html?p_name=indeks).

Аннотация. А. Пиасэцки, В. Маршэльэвски Количественные и структурные изменения в потреблении воды в Польше на переломе XIX –XX вв. С начала 90-х годов в Польше наблюдается тенденция к понижению потребления воды, которая в значительной степени актуальна и для городских территорий. В предлагаемой работе проанализировано потребление воды в Польше за период 1990–2012 гг. В исследовании учтены как общая структура потребления, так и ее особенности на городских и деревенских территориях. Кроме того, в работе обращается внимание на динамическое развитие водопроводной инфраструктуры и рост ее доступности для населения деревни. В результате проведенного исследования было констатировано понижение потребления воды в Польше на 24%. Самое большое, почти 36-процентное, падение произошло в области эксплуатации водопроводной сети (35,9%), а также в сельском хозяйстве и лесопромышленности (35%). Потребление воды в области производства уменьшилось на около 19%. Выявлены существенные различия между структурой и тенденциями в потреблении воды на городских и деревенских территориях. В деревне самую большую долю в структуре потребления составляли производство и оросительные системы, а в городах – производство и домашние хозяйства.

В работе обращается внимание на понижение удельного итогового потребления воды на 20%, причем подчеркивается, что по городам оно было более чем в два раза больше (46%). В случае деревенских территорий этот указатель вырос на 15%. Кроме того были определены главные факторы, влияющие на понижение потребления воды, к которым относятся, в частности, закрытие многих промышленных предприятий в результате социально-политической трансформации и введение всеобщей системы измерения потребления воды (счетчики воды).

Итогом проведенного исследования является утверждение о том, что с точки зрения экологии существенное понижение потребления воды в Польше следует признать положительным явлением, причем следует обратить внимание также на его экономические и технологические последствия.

Ключевые слова: снабжение водой, водные ресурсы, потребление воды, поголовное потребление воды.

Анотація. А. Піасецкі, В. Маршельевскі Кількісні та структурні зміни в споживанні води в Польщі на переломі XIX -XX ст. З початку 90 - х років у Польщі спостерігається тенденція до зниження споживання води, яка значною мірою актуальна і для міських територій. У пропонованій роботі проаналізовано споживання води у Польщі за період 1990-2012 рр.. У дослідженні враховані як загальна структура споживання, так і її особливості на міських і сільських територіях. Крім того, в роботі звертається увага на динамічний розвиток водопровідної інфраструктури та зростання її доступності для населення села. У результаті проведеного дослідження було констатовано зниження споживання води в Польщі на 24 %. Найбільше, майже 36 -відсоткове падіння сталося в галузі експлуатації водопровідної мережі (35,9 %), а також в сільському господарстві і лісопромисловості (35 %). Споживання води в області виробництва зменшилася на близько 19%. Виявлено суттєві відмінності між структурою і тенденціями в споживанні води на міських і сільських аструктурою і тенденціями в споживанні води на міських і сільських аструктурою і тенденціями в споживанні води на міських і сільських а територіях. У селі найбільшу частку в структурою і тенденціями в иробництво і зрошувальні системи, а в містах - виробництво і домашні господарства.

У роботі звертається увага на пониження питомої підсумкового споживання води на 20 %, причому підкреслюється, що по містах воно було більш ніж в два рази більше (46 %). У разі сільських територій цей покажчик зріс на 15 %. Крім того були визначені головні чинники, що впливають на зниження споживання води, до яких належать, зокрема, закриття багатьох промислових підприємств в результаті соціально-політичної трансформації та запровадження загальної системи виміру споживання води (лічильники води).

Підсумком проведеного дослідження є твердження про т, що з точки зору екології істотне зниження споживання води в Польщі слід визнати позитивним явищем, причому слід звернути увагу також на його економічні та технологічні наслідки.

Ключові слова: постачання водою, водні ресурси, споживання води, поголовне споживання води.

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