*INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH*
*INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS*

Nr IV/2/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1411–1421
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.2.104

# ANALYSIS OF RATE AND STRUCTURE OF WATER CONSUMPTION IN RURAL AREAS OF SELECTED COUNTIES OF THE KUYAVIAN-POMERANIAN VOIVODESHIP

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***Abstract***

Over recent years, the structure and rate of water consumption in Poland has exhibited significant changes. In urban areas has been observed a substantial decrease in water demand, whereas in rural areas the general trend has been the opposite. The aim of this work was to investigate the consequences of changes in area of water and sewage management in Bydgoski, Toruński and Włocławski counties, paying special attention to the rate and structure of water consumption. In this study were used data from the Central Statistical Office of Poland (GUS). The data included information concerning the length of waterworks system, and the rate and structure of water consumption in individual communes of the investigated counties. In 22 out of 28 examined units was recorded an increase of total and individual water consumption. Selected communes and rural areas have significant differences in rate and structure water consumption. The main cause of these changes are indicated to be an increase in population (migration from cities) accompanied by an expansion of waterworks.

**Keywords:** water consumption, waterworks system, Kuyavian-Pomeranian, rural areas

## INTRODUCTION

The aggregated water consumption in Poland since 1980/1990 exhibits a stable downward trajectory. This results from the decommissioning and

shutting down of many manufacturing facilities whose manufacturing processes were, in many cases, very water-intensive. The political transformation which began at the start of the ,90s caused not only significant changes in politics, but also lead to dramatic revisions in society and the economy (Hotloś, 2010). Free market economy principles were introduced and resulted in the freeing of prices of products and services, which had until then often been artificially reduced due to state subsidies. The case of water prices was similar, with cost depending only on number of inhabitants, not on actual consumption. The introduction of water meters significantly reduced water usage (Piasecki and Marszelewski, 2014).

The aforementioned downward trend of water consumption in structural terms varied considerably. In waterworks exploitation it was reduced by 36% and by slightly less (35%) in agriculture and forestry. The volume of water consumed for industrial purposes fell by 19% (Piasecki, 2014).

Over the last 25 years, the volumes of water consumed in rural and urban households have exhibited contrasting tendencies. As far back as 1990, urban households consumed 1,616 $hm^3$, which amounted to 84% of total consumption in Poland. Nowadays, this volume has been reduced to 791 $hm^3$. In the same period, in rural areas water consumption increased from 306 $hm^3$ to 399 $hm^3$. Rural water consumption currently contributes to over 33% of total water usage in Polish households.

Changes in rural infrastructure have been investigated by many researchers. They focused on rural areas from the national perspective (Gładysz, 1997; Pawełek, 2007), the individual voivodeship perspective (Dolata, 2008; Piszczek, 2013) and from the perspective of smaller administrative units (Gładysz, 2008; Krakowiak-Bal, 2008; Ogiołda and Kozaczek, 2013). This last seems to be very important because it enables a closer look at the changes which occurred in rural infrastructure. The aim of this paper was to assess the results of the aforementioned infrastructural development in terms of water consumption structure and quantity. Migration from rural to urban areas has been considered as a factor shaping and modifying water demand.

## RESEARCH AREA, MATERIAL AND METHODS

This study investigates rural areas of three districts (*Pol. powiat*): Bydgoski, Toruński and Włocławski, situated in the Kuyavian-Pomeranian Voivodeship. They were selected because of their closeness to the three biggest cities in this voivodeship, namely: Bydgoszcz, Toruń and Włocławek. Due to their location, these areas underwent the most dramatic changes in terms of infrastructure investments and population inflow. However, each area is idiosyncratic, and they differ environmentally, and in historical land usage.

Toruński and Bydgoski districts are situated in the central part of voivodeship, and in geographical terms they cover a large part of the Toruńska Basin. These districts have a common border, and their land area is respectively 1,230 and 1,395 km$^2$, of which rural areas account for 1,223 and 1,348 km$^2$ respectively. Bydgoski district has six municipalities and two boroughs. In the case of Toruń district, there are six rural municipalities and one borough, the city of Chełmża.

Włocławski district is located in southern part of the voivodeship and the total area of this district is 1,474 km$^2$ (rural areas 1,454 km$^2$). It consists of 13 municipalities, including 8 rural and 5 urban-rural. Due to the favourable natural conditions, chiefly fertile soils (so called black earth/chernozem) the land-use pattern is dominated by farmland (fig. 1).


**Figure 1.** Area of research

Analysis was performed based on statistical data from the Local Data Bank (*Pol. Bank Danych Lokalnych)* and Central Statistical Office (*Pol. Główny Urząd Statystyczny)*. They included information on waterworks network length, volume and structure of water consumption in individual municipalities covering the period 1998–2013. Additionally, data on the populations using waterworks and individual household water consumption in the years 2002–2013 was used. The research procedure employed standard statistical measures and selected indices. Analysis of process intensity was performed based on measures calculated with relation to: population (water consumption per capita) and area (waterworks saturation).

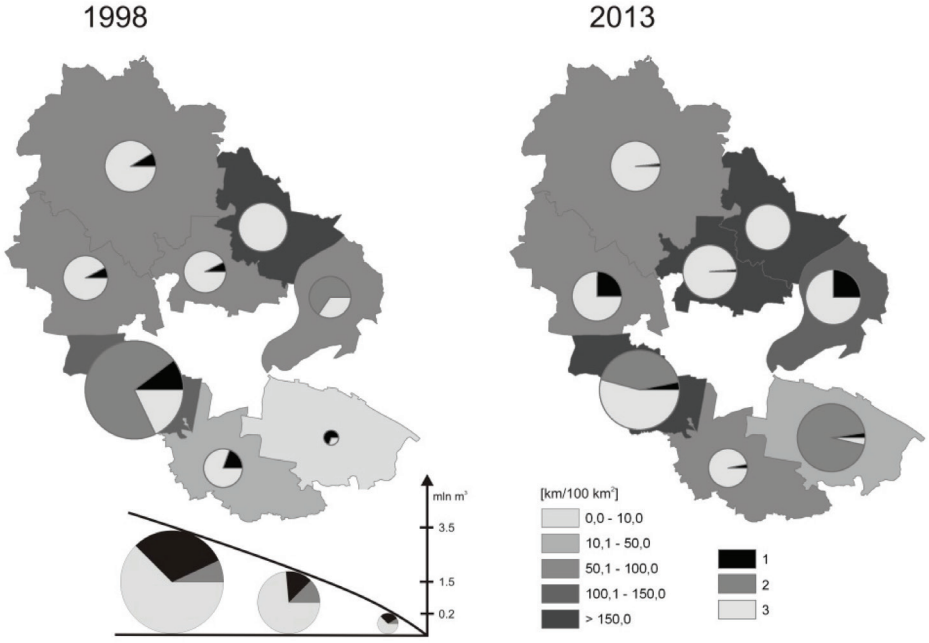
In order to visualise the obtained results, a choropleth cartographic method was applied. This enabled the simultaneous presentation of the values of several variables: volume and structure of water consumption, and waterworks saturation. The important advantage of this method is the possibility to perform a spatial quantitative analysis which facilitates the noticing of relationships between variables.

## RESULTS

Over the years 1998–2013, a 40% increase in total annual water consumption has been observed in all investigated municipalities. However, in the case of the whole voivodeship, the water consumption has fallen by 27%. The biggest growth in consumed water (over 86%) was observed in municipalities and rural areas of the Toruński district. In the case of the Bydgoski and Włocławski districts, this increase was significantly smaller, and amounted to 16% and 18% respectively. It is important to note that individual communes and rural areas exhibited different dynamics of change and volume of consumed water. In 6 of the 28 analysed territorial units, a decrease in water consumption was observed. The highest was recorded in the Białe Błota municipality (692 $hm^3$) and resulted from reduced water demand in agriculture. In the remaining areas, the increasing water consumption was driven mainly by the picking up demand for communal purposes.

Within individual municipalities and rural areas, significant changes and variation in consumed water structure were observed. In the vast majority of territorial units, the share of industry and agriculture in water consumption has decreased in favour of waterworks network exploitation. In municipalities and rural areas of the Bydgoski district, with the exception to Solec Kujawski municipality, water consumption is driven mainly by household demand. It is worth noticing that, in the cases of Sicienko and Dąbrowa Chełmnińska, industry still plays significant role in water consumption, whereas in Białe Błota and Solec

Kujawski municipality it is agriculture which creates a large portion of water demand (fig. 2).

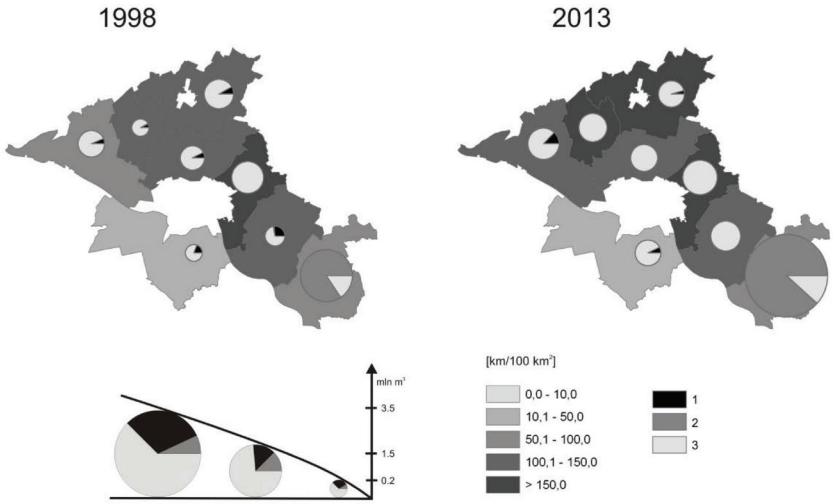



Source: own elaboration based on CSO data

**Figure 2**. Rate and structure of water consumption together with waterworks system saturation in communes and rural areas of Bydgoszcz County. Where: 1 – industry, 2 – agriculture and forestry, 3 – operation of waterworks system.

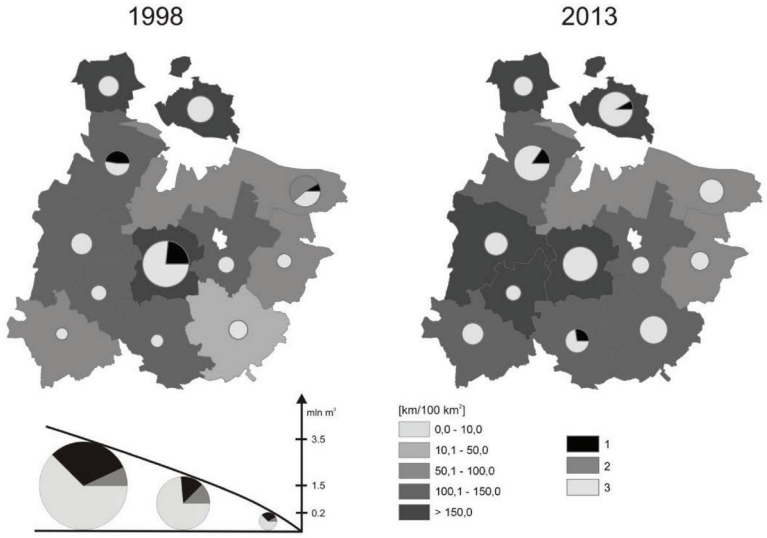
In the analyzed territorial units of Toruński and Włocławski district, the observed changes in water consumption structure were similar to those in the Bydgoski district. In almost all municipalities and rural areas, over 90% of consumed water comes from waterworks (fig. 3 and 4), with one exception – Czernikowo municipality – where water demand is mainly created by agriculture.

One of the main reasons why the water consumption is picking up so rapidly is an increase in population. The highest population growth was observed in these three districts (fig. 5). Population migration from major cities to suburban areas is common in Poland (Szymańska and Hołowiecka, 2000; Szymańska and Biegańska, 2011). One may therefore suppose that similar changes in water consumption occur in other suburban areas of Polish cities.



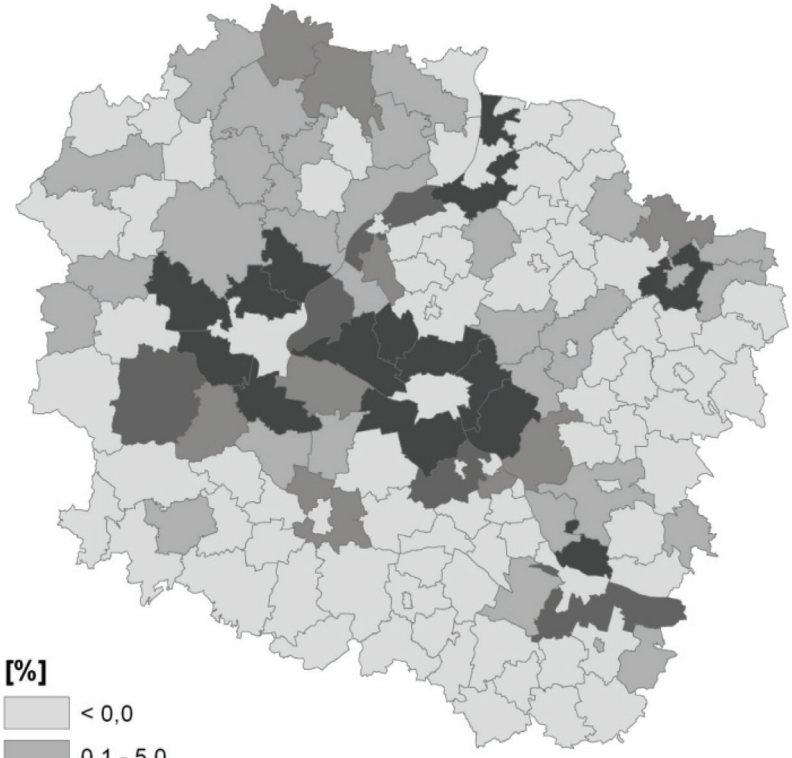

Source: own elaboration based on CSO data

**Figure 3**. Rate and structure of water consumption together with waterworks system saturation in communes and rural areas of Toruń County. Where: 1 – industry, 2 – agriculture and forestry, 3 – operation of waterworks system.




Source: own elaboration based on CSO data

**Figure 4**. Rate and structure of water consumption together with waterworks system saturation in communes and rural areas of Włocławek County. Where: 1 – industry, 2 – agriculture and forestry, 3 – operation of waterworks system.




Source: own elaboration based on CSO data

**Figure 5**. Population percentage gain in communes of the Kuyavian-Pomeranian Voivodeship

An increase in water consumption was observed not only in total amount, but also *per capita* (table 1). Similar upward trend was also observed in other rural areas in Poland (Pawełek et al. 2015, Orzechowska 2011). According to CSO data since the year 2002 on can notice a systematic growth in water consumption, however its value is significantly lower than in analyzed rural communes. Please note that a contrary tendency was observed in Toruń, Bydgoszcz and Włocławek, as well as in other Polish cities (Piasecki and Jurasz 2015). Due to continuous population inflow into the analysed municipalities and rural areas, the increasing water consumption should pertain.

**Table 1**. Specific water consumption in communes and rural areas of Bydgoszcz, Toruń and Włocławek districts

| Territorial unit | Per capita water usage ($m^3$) | | | Territorial unit | Per capita water usage ($m^3$) | | |
|---|---|---|---|---|---|---|---|
| | 2002 | 2008 | 2013 | | 2002 | 2008 | 2013 |
| Kujawsko-Pomorskie – village | 28.3 | 32.0 | 32.9 | Obrowo | 26.8 | 24.2 | 26.3 |
| Bydgoski district – communes and rural areas | | | | Wielka Nieszawka | 47.8 | 63.2 | 49.9 |
| Białe Błota | 32.5 | 38.4 | 29.9 | Zławieś Wielka | 18.1 | 36.4 | 32.1 |
| Dąbrowa Chełmińska | 22.6 | 30.7 | 31.1 | Włocławski district – communes and rural areas | | | |
| Dobrcz | 39.2 | 44.1 | 40.1 | Baruchowo | 23.7 | 25.4 | 39.1 |
| Koronowo – obszar wiejski | 31.0 | 36.2 | 37.1 | Boniewo | 19.0 | 25.8 | 26.6 |
| Nowa Wieś Wielka | 20.2 | 29.6 | 27.0 | Brześć Kujawski | 23.3 | 28.1 | 34.9 |
| Osielsko | 32.2 | 42.6 | 43.7 | Choceń | 50.4 | 53.3 | 57.3 |
| Sicienko | 28.4 | 34.4 | 34.5 | Chodecz | 13.3 | 18.9 | 23.6 |
| Solec Kujawski | 37.0 | 30.9 | 31.1 | Fabianki | 30.5 | 36.5 | 38.4 |
| Toruński district – communes and rural areas | | | | Izbica Kujawska | 14.4 | 25.0 | 30.8 |
| Chełmża | 39.6 | 38.1 | 30.6 | Kowal | 26.1 | 26.6 | 28.9 |
| Czernikowo | 29.8 | 28.8 | 32.0 | Lubanie | 58.9 | 33.9 | 32.1 |
| Lubicz | 36.0 | 35.2 | 27.3 | Lubień Kujawski | 16.7 | 18.5 | 38.8 |
| Łubianka | 32.6 | 45.1 | 56.9 | Lubraniec | 25.6 | 24.0 | 32.2 |
| Łysomice | 33.8 | 42.2 | 36.5 | Włocławek | 23.2 | 33.0 | 29.4 |

Source: own elaboration based on CSO data

This phenomenon would not be possible without adequate development of water infrastructure, which of course varied across regions, and was mainly dependent on population density, inflow of new inhabitants, and landscape. The data draws attention to the fact that, in several municipalities, waterworks saturation exceeded 150 km per 100 $km^2$. For rural areas it is a significant value, comparable to the waterworks density of Toruń and Bydgoszcz in 1990s.

Analysis of changes in volume and structure of water consumption in rural areas seems to be very important due to the limited availability of fresh water, and future reclamation of sewage. It is crucial to know how much water is derived from a given ecosystem, because a major part of this water will return to it. Each ecosystem can absorb a certain amount of pollution without major damage. However, exceeding the self-purifying capacity leads to its deterioration, often irreversible (Kuczyński and Żuchowicki, 2010). Therefore, it is very important

that the development of sewage treatment plants and infrastructure keep pace with waterworks expansion.

As has previously been mentioned, the waterworks infrastructure has been significantly expanded in investigated municipalities and rural areas. Similar development was observed in terms of sewage networks. However there are some shortcomings; simply juxtaposing the number of population served by waterworks (86.7%) and those by sewage infrastructure (44.3%) exposes an obvious underinvestment. In rural areas, this situation results from dispersed settlements, which leads to the lack of economic justification for such projects. Equally frequently, these underinvestment result from technical constraints, which occur in areas of variable landscape (Kłos, 2013). The simple solution is to utilise individual wastewater treatment plants. In the analysed municipalities and rural areas this approach has been applied, and resulted in an over two-fold increase in the number of individual sewage treatment plants over the years 2008–2013 (from 1,936 to 5,713). The greatest increase was observed in rural areas of the Włocławski district (347%), whereas the smallest was in the Toruński district (119%).

A detailed analysis of water consumption changes is needed not only from an environmental perspective, but also because it has measurable economic benefits. This refers mainly to the waterworks companies, which in order to appropriately manage their infrastructure and to rationalise their maintenance costs, have to conduct a similar analysis.

## SUMMARY

Over the years 1998–2013, water consumption within the Toruński, Bydgoski and Włocławski district municipalities has increased by 40%. It has been suggested that there exist significant differences between those territorial units when it comes to water consumption structure and volume. The main reason for the observed changes lies in population inflow and dynamic development of waterworks infrastructure. In result in the majority of rural communes and areas over 90% of consumed water comes from waterworks.

The growth in terms of total and *per capita* water consumption will probably continue, due to the still-growing population. Indicated transformations in the area of infrastructure and water consumption seems to be especially interesting, mainly from the perspective of changes observed in urban areas. The increasing importance of water consumption on rural areas leads to greater spatial distribution of its consumers, which enforces faster development of the waterworks network. In several rural communes the waterworks saturation significantly exceeded 150 kilometers per 100 km$^2$. This process may potentially be harmful

to the environment if sewage infrastructure (on average 44.3% of population is connected and is using sewage infrastructure) is not created concurrently.

A correct diagnosis of dependencies and tendencies in water consumption in rural areas provides an opportunity to minimise pressure on the natural environment. Additionally, it enables correct planning of water and wastewater infrastructure, whilst considering socio-economic factors.

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Received: 04.02.2016
Accepted: 14.06.2016