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Problems of water supply to seaside localities of Poland

Abstract

Problems of water supply to seaside/resort localities are considered in the paper. The main task is to supply water of proper quality and amount at seasonal fluctuations in the demand. The paper focuses on the operation of water supply systems in the following localities of Central Pomerania: Mielno, Unieście, Mielenko, Sarbinowo, and Chłopy. They are main summer resorts of the region with typical fluctuation in population during the annual cycles affecting the amount of water supply. The atmospheric conditions, mainly temperature, generally affect the magnitude of water demand. The water-pipe system under consideration forms a very interesting technical solution for supplying both administration-industrial agglomeration, that is the municipal system, and localities lying in the seaside strip characteristic. The water intake is located in Mostowo which lies 19 km away from the main city centre of Koszalin.

Keywords: water-pipes, water intake, seaside localities, water distribution.

1. Introduction

During some recent years, there has been observed a distinct progress in improvement of water-pipe and sewage system exploitation together with continuous modernization of the technical infrastructure. There is observed an apparent tendency of process automation together with introducing control systems, in these also fuzzy control, in which the role of human being is directed mainly onto supervision of the working conditions and co-ordination of actions in every area of control. One of the most important problems in this area is continuous observation of water-works system and exchange of information between particular components of the system. Intensive actions are undertaken and developed in three directions:

- creation of computer data and information management
- quantitative and qualitative monitoring of technical and operational state of particular elements of water-pipe and sewage systems
- computer modelling.

The analysis of production and water input/consumption to/by receivers and a reliable prognosis of future water needs are essential elements of the programme of works concerning planning the modernization and extension of the water-pipe systems.

Since 1990 in Poland a decreasing trend in production and use of water practically in all water-pipe systems has been observed. The range and scale of this trend has been varying. The most important reasons of this decrease are: introducing a free market economy, increase in payment for water supply and sewage disposal, general installation of household water meters and limitations of water wastage/prodigality, considerable decrease in leakages through leaky sanitary equipment in the buildings and unreasonable excessive water use, rationalization of pressure in water-pipe networks, which, among others, significantly affects the failure frequency/mortality of pipes and their damage, decrease in wholesale water selling, reduction of leakages on the hot water dispatch/transfer, as well as a considerable drop (of 10-75%) of water usage by industry, mainly due to limitation and reduction in production and changes in technology. The decrease in consumption of municipal/tap water occurring in Poland since the beginning of 1990s in many towns and localities has not reached its bottom limit as yet. It is most probable that the water consumption rates will be undergoing further reduction to the level observed at present in Germany, and in Polish cities will reach on average about 120-125 dm^3 per day and inhabitant [1, 4, 5, 6]. It should be noted that due to reduction of water consumption, in numerous water networks, especially in settlement's distribution pipes, constant low velocities of water flow occur, time of water remain in network is extended. Thus the threat of water stagnation in some regions does appear. That situation favours settlings and sediments deposition inside pipes, which are mainly made of steel and/or cast iron, and it may favour the grow and development of bacterial gelly on the walls of pipes; in the end, it may lead to the secondary contamination of water and essentially complicate the processes of testing the hydraulic flow model parameters in the systems of water distribution. Counteraction treatment operations rely usually on:

- systematic effective rinsing and/or blow-off the pipes and removal of settings loosely bound with the basis/substrate; adequate efficiency of rinsing and sediments removal is obtained at the water flow velocity of about 1.8 m/s, which limits the range of diameters of the rinsed pipes
- cleaning or renovation of pipes
- improvement in the efficiency of water conditioning processes
- secondary local desinfection of the water used as an immediate medium.

2. Specificity of the seaside localities

2.1. Localization, landscape characteristics, and population

Mielno commune lies close to the seaside of the Baltic Sea on the Jamno Spit dividing Lake Jamno from the Baltic. The administration borders of Mielno commune is between the cities: Słupsk, Koszalin, and Kołobrzeg. The population of the Mielno commune is only 5000 inhabitants, whereas during summer season there are more than about 80 thousand guests/tourists arriving. The biggest locality is Mielno, which together with Uniescie forms one settlement, lying on the west Jamno Spit. Łazy are in the east of Mielno. West of Mielno there are villages like: Mielenko, Chłopy, Sarbinowo, and Gąski, former agricultural-fishermen colonies. The seaside beach spreads over the area of some dozen or so meters wide, built of white, clean, well rounded quartz sand.

2.2. Water intake in Mostowo

The intake is placed in the valley of the River Radew distanced about 18 km south-east of Koszalin, in Manowo commune. There are 36 drilled wells arranged along Lake Rosnowo, serving to supply water. The distance between terminal holes is over 5.5 km. The wells are spaced at the distance of about 300 m one from another and their depths are (30-70) m. The water is intaken by abyssal/borehole pumps and forced with pipes of diameter (150-500) mm to the water main. To avoid a water hammer, there is a counter-impact chamber built on a cast-iron pipe DN 1000 [1, 2, 3, 5, 6]

2.3. Characteristics of water-pipes

Koszalin and Mielno commune are supplied with water from two underground intakes: in Koszalin at Rzeczna Street and in Mostowo. Basic elements of Koszalin water-pipe system are: water intake in Mostowo, intake and water treatment station at Rzeczna Street in Koszalin, transit water-pipe Mostowo-Koszalin

DN 800 and DN 1000, transit water-pipe Koszalin-Mielno-Sarbinowo-Unieście (Fig. 1) as well as water main and distributive network.

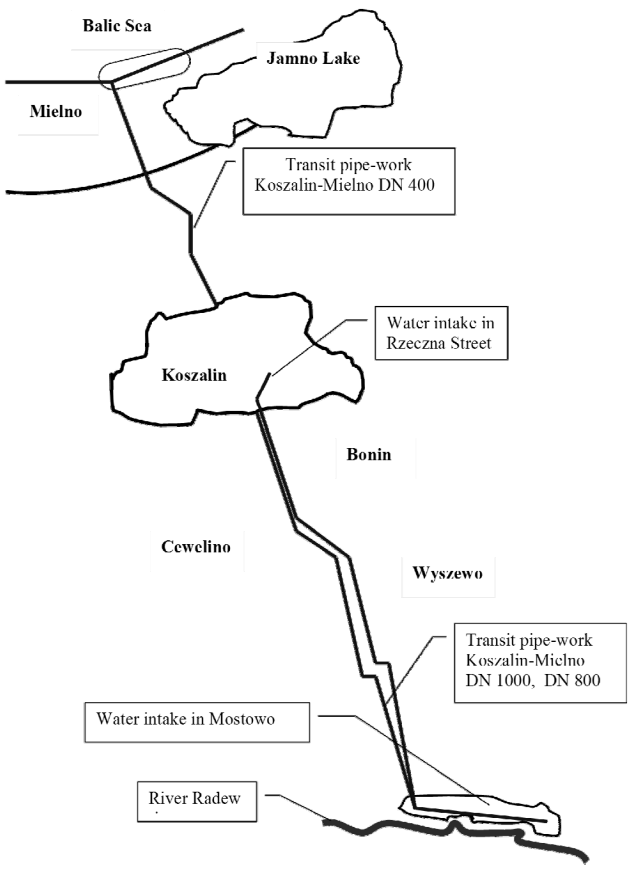

Fig. 1. Transit pipe-work Mostowo-Koszalin-Mielno

2.4. Transit pipe-work Mostowo-Koszalin DN 800 and DN 1000

The water from the intake Mostowo is conducted to Koszalin by two transit lines. The pipe-work DN 800 is made of 19430 m long cast iron pipes to connect the municipal network in the region of Rzeczna Street. The second transit line DN 1000 is made of 24800 m long cast iron pipes. In Kretomino, this pipe-work turns to west and crosses the newly built settlement of houses "Raduszka" supplying it with water. Then at Połczyńska Street in Koszalin, the pipe-work enters the reduction chamber to reduce the diameter down to 600. The pipe-works are interconnected between each other with 5 lacings serving to preserve and supply with water Koszalin city and the seaside sites and premises.

2.5. Transit pipe-work Koszalin-Mielno DN 400 and DN 350

This is the pipe-work connecting all of the seaside localities from Mielno to Dobieslawiec. It is made of 10355 m long asbestos-cement pipes. It consists of two lines of conduits distanced (1-3) m arranged in parallel. A part of the pipe-work, made of PVC, of 400 dia from Strzezenica-Mielno is 1627 m long, whereas the second line of this pipe-work of 350 dia is 2035 m long. Both pipe-works are interconnected between each other with three lacings/"bandeaus" by means of PE pipes of 400 dia with in-ground shutter DN 400 serving to preserve water supply to the seaside strip.

2.6. Water main and distribution networks

The pipe-work connecting seaside localities from Mielno to Strzezenica is made of PVC and asbestos-cement pipes, the length of those interconnecting Mscice-Mielno is 4990 m. All pipes of diameter 250 mm within the localities are counted as the municipal water main network, but below 250 mm in dia, as the distribution network. Conduits of diameter to 300 mm are simultaneously distribution pipes. With the extension and development of new settlements in the seaside localities, the water-pipe network is constantly expanded.

3. Water requirements in the seaside localities

The water requirement changes during the year in the seaside localities. These changes are affected by touristic needs in the summer time. Analyzing the monthly water distributions in the years 1998-2006 for Mielno, the highest increase in the water supply is noted in the summer months, that is July and August (Fig. 2). The weather conditions and the affluence of tourists play a basic role. The least water consumption is observed in early spring and winter time. In 1998, the least water consumption was in February and September, in 1999 in February, March, April and November, and in the years 2000-2006 in January, February, and March. It depends on the character of a locality as there are no tourists at those times[1, 2, 3].

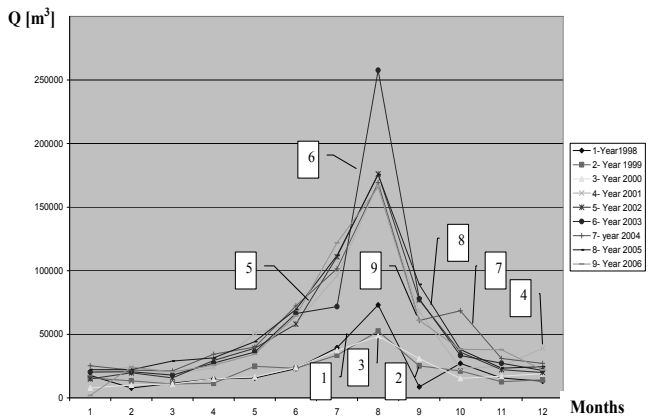

Fig. 2. Monthly fluctuations in water consumption in Mielno

Fig. 3 shows the monthly changes in water distribution for Unieście in the years 1998-2006.

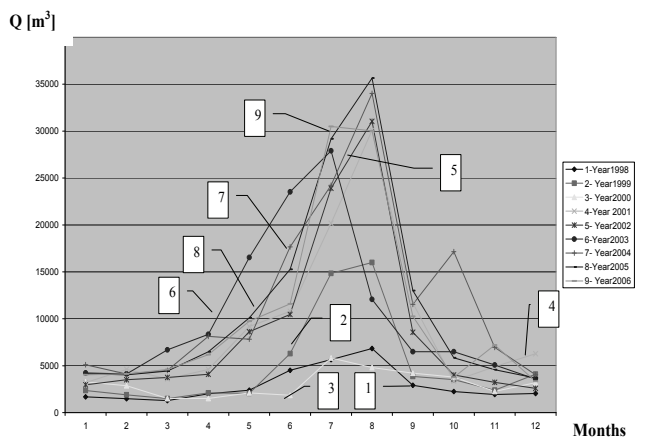

Fig. 3. Monthly fluctuations in water consumption in Uniescie

There is some regularity observed in Fig. 3 in water consumption, with the highest water demand in summer time. The highest water demand was in July and August, and the least consumption in 1998 was in January, February, March and November. In 1999, the least demand was in February, March, and in the years 2000-2006 in January, and March.

The annual water consumption in the typical seaside localities of Central Pomerania in the years 1998-2007 is presented in Fig. 4.

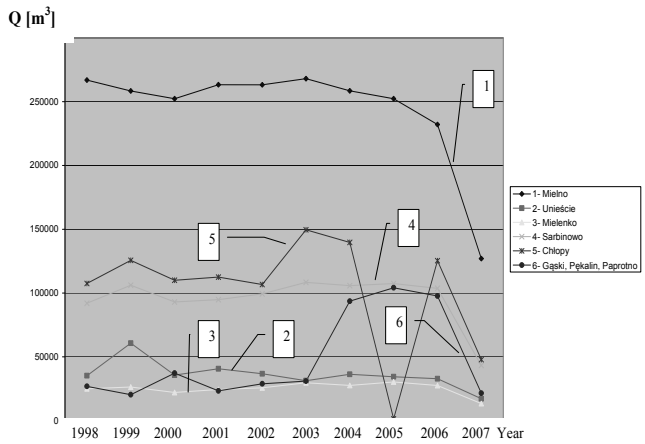

Fig. 4. Annual water consumption in the seaside localities of Central Pomerania in 1998-2007

The characteristic feature observed is the continuous increase in water demand in Mielno, the locality of the highest developed infrastructure, whereas in smaller localities of Central Pomerania the water consumption has not changed or even has decreased, like in Łazy. In some seaside localities (Gąski, Pękalin, Paprotno), with a large number of tent camping fields, the water consumption has been less than e.g. in Sarbinowo where camping sites, with better sanitary equipment/fittings, are exploited and more tourists come [1, 2, 3].

4. Summary and conclusion

The fundamental exploitation principle of a water-pipe system is keeping the continuous water inflow to the network and the access of receivers at proper pressure, good quality, and amount of water. To fulfill these rules, it is necessary to keep water-pipes, fittings, installations and appliances in full readiness and performance through their systematic survey, making all required conservatory works, damage removal and minor inspections. It is also important to make analyses of network operation in view of getting necessary system pressure, as well as testing the quality of water delivered to receivers [3, 4, 6, 7, 8].

Final solutions, modernization, and optimization of a water requirement system should be preceded by complete hydraulic calculations when taking into account all factors conditioning the effects of the operational system. In design of water-pipe systems, all expected factors of the water requirement system should be considered. These factors are water supply and water distribution conditions, as well as mutual interactions with each of the elements in the system during its simultaneous operation. Efficient operation of a water-pipe network should be supplied with technical documentation and servicing instruction/manual of installations and structures.

There was performed the analysis concerning the amount of water distribution, when taking into consideration the following factors:

- change of permanent population, x_1
- change of seasonal/incoming population, x_2
- average twenty-four hour temperature, x_3
- amount of precipitation, x_4
- wind power, x_5
- insolation, x_6
- cloud cover, x_7.

All these higher presented atmospheric conditions affect considerably the way of behavior and spending time in the vacation localities, and with these the water consumption. The methods of linear multiple polynomial regression and Student's t-test were used for the analysis of the effect of atmospheric conditions, permanent and seasonal population:

$$y = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_7 x_7$$

where:

y - amount of water consumption;
b_j - coefficient of linear regression, for $j = 1, 2, \ldots, k$; here $k = 7$.

The significance of the effect was found in the case of the following factors:

- seasonal population
- temperature
- wind power
- cloud cover.

In the paper an attempt has been made to reveal the effect of selected factors on the amount of water distribution in the seaside summer resort localities of the Polish coast as well as in the agglomeration of administrative-industrial character. It should be stressed that, from the technical viewpoint, one should conform to the basic rule that the maximum twenty-four hour requirements have to be fulfilled also under non-normal operational conditions even at the expense of the diminished/ minimum pipework output/capacity. This type of solution of the problem ensures existing of surplus during the whole operation period as the water-pipe is designed to serve for the period of several decades. In the light of experience during many recent years in Poland, specifically in the seaside localities, where a distinct drop in water demand occurs seasonally, a versatile analysis of all the factors is of great importance [3, 4, 6, 7, 8].

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