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DOI: 10.2478/sspjce-2013-0013

Analysis of Water Consumption Changes during two Decades

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Abstract

Water consumption depends on the consumers' habits, industrial companies and the nature of the activity, as well as on public users. Water consumption in Lithuania has decreased by more than three times over the past two decades. This was influenced by the changed consumers' habits, implemented water metering and increased water prices. But it has been analyzed little, how the dynamics of water consumption has been changing. This article examines the dynamics of water consumption variation over 20 years in one of Vilnius district. Variations of water consumption are analyzed in the article and the obtained results are compared with the parameters in the legal acts. Water consumption per night was analyzed in the article also, as these values could be fast and reliable assessment of water losses in network. The analysis of night water consumption was conducted and the recommended norm of night water consumption indicated.

Key words: water consumption, demand patterns, variation coefficient, water losses, night flows.

1 Introduction

The amount of water consumed by inhabitants per day changes, depending on the population, welfare, changes in financial or political system, city size, supplied water quality, water supply uniformity, pressure, water accounting and other factors [3, 5, 6].

Only groundwater is supplied by centralized water supply networks to inhabitants of Vilnius city, capital of Lithuania. By centralized water supply networks Vilnius inhabitants get water for almost 100 years. Over the years the rhythm of human life, which seems to have become much more intensive, and consumers' habits have been changing. However, there are no data on how the changes in the pattern of life and habits influence overall water consumption, and in particular water consumption dynamics. The fact that water consumption in Lithuania over 20 years decreased by a few times is clear, but whether water consumption variation of the users have changed, has not yet been more widely examined [2, 5].

Probable water losses in water supply network can be preliminary estimated according to water supplied to network at night time. Night flow usually is 10-20% of the average daily flow. Another relative index – the overnight water consumption should not exceed 2 litres for a flat (house) per hour [1, 4].

The aim of the article – is to analyse water consumption, its variation and to determine water consumption values at night in one district of Vilnius. Since there are no industrial companies and multi-storey residential buildings dominate in the district, it can be claimed that the obtained results reflect purely water consumption peculiarities of the inhabitants. Water consumption variation over the period of 20 years was analysed in the article.

2 Research object

Research object – is water supply network of Vilnius city district - Karoliniskes. Water supply network is operated by JSC "Vilniaus vandenys". The district was started to build in 1971. Apartment buildings (of 5, 9, 12 storeys) connected into 4–5 buildings blocks dominate. The apartment buildings account for more than 99.5% of all the buildings. The area of the district – is about 400 hectares, the population – about 30 000. The largest diameter of water supply lines – is 500 mm. Water is supplied from groundwater well-field through two boosting pump station and intermediate clean water tanks. It must be emphases that not only analyzed capital district is supplied by groundwater. At whole Lithuania only groundwater is used for centralized water supply, that's means all 100% consumer using only groundwater and surface water is not used at all.

3 Annual water consumption variation

At Fig.1 presents water consumption variation in Vilnius district Karoliniskes over a period of 20 years since 1991 to 2011.

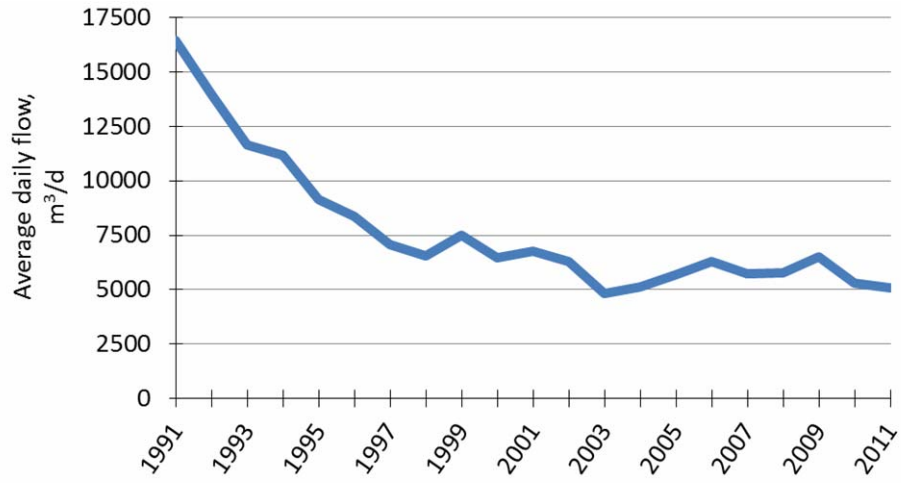

Figure 1: Annual water demand variation in 1991-2011

An obvious decrease in water demand is seen when analyzing data of water consumption over 20 years. The graph presents the average amount of water per day each year. When analyzing average annual water flow, it was found that water demand decreased by about 3.5 times. Presented data show that water consumption in the district decreased by about 2.5 times from 1991 to 1998. Later until 2003, consumption decreased slightly. For about 10 years already, water consumption is stabilized and changes little. Maximum average annual water demand was in 1991 – about 16442 m^3/d, and minimum in 2003 ~ 4815 m^3/d.

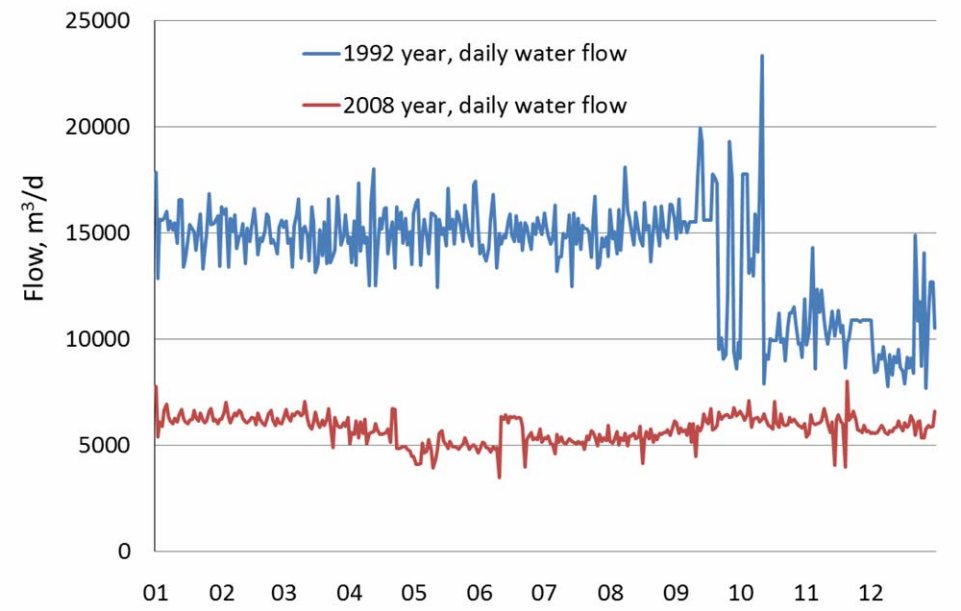

Figure 2: Comparison of water consumption in 1992 and 2008

Water consumption differs depending on the season of the year. According to the data of the last decade, it was established that minimum water consumption is in the summer. It could be based on the fact that multi-storey buildings dominate in the district and part of the population spends more time in gardens or are away in the summer. In multi-storey districts, as opposed to individual homes, water is not almost used for watering.

Figure 2 show the comparison of water needs in 1992 and 2008. During the 16 year period water consumption decreased 2.5 times. In 1992 average daily water need was approximately 14000 m^3/d, but in 2008 it decreased to 5700 m3/d. Changes of water consumption in second half of 1992 was led by the country blockade from former Soviet Union. During this time water supply was restricted due to lack of energy resources. Given figure shows how political actions effects water consumption and welfare of the people. After the country blockade in the middle of 1993 water consumption increased again. However the analysis of 20 year period shows that water consumption decreased few times.

There are several main reasons why water consumption decreased. One of the main reasons is installation of water meters in the flats of apartment houses. Currently 98% of all flats of apartment houses have water meters by which the payment for the consumed water is done.

Standard B class mechanic water meters were used in the flats, these water meters haven't been changed for 10 years and meters are naturally worn out. B class water meters have low sensitivity level (minimal recording flow is only 30 l/h). The hardness of the water in the country is medium. So for these reasons the sediments forms on the axis and imperials of the meters, it leads to decrease of the measurement accuracy. It is defined that average difference between main water meter of the apartment house and the sum of all water meters in the flats is about 20%. This amount of water is apparent water losses. However it is obvious that this water was consumed, but wasn't metered because of inaccurate measuring devices and possibility to make influence on measurement data. However this amount of water is evaluated by water supply companies during the determination of the water price and it increases the price of the water for all customers. The installation of the water meters was motivated by fact that each consumer pays only for individually used amount of water, but water is used not only in the flat, but also for the other needs. This situation is a disagreement in legal procedures, because formally the water supply limits at an apartment houses is water meter at inlet pipe, however the residents pays only for water amount used in their flat.

Another main reason for reduction of water consumption was increased water price. 2011 year average price for water supply in Lithuania is about 0.8 Euro for 1 m^3. And average price for sewerage and wastewater treatment in Lithuania was about 1.1 Euro for 1 m^3. In 2010 price for water meters and meters replacement cost was included in water tariff, for this reason water meters will be changed in every flat every 4 years in the future.

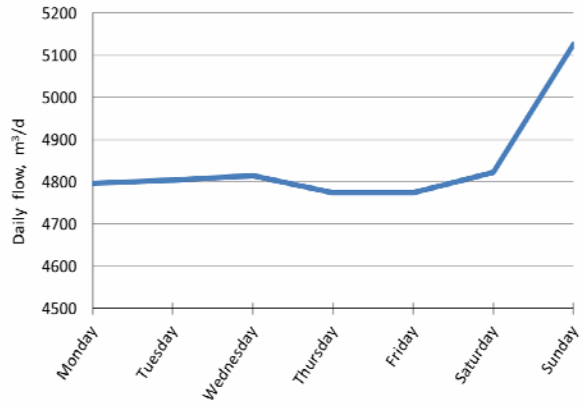

Figure 3: Water demand during the week

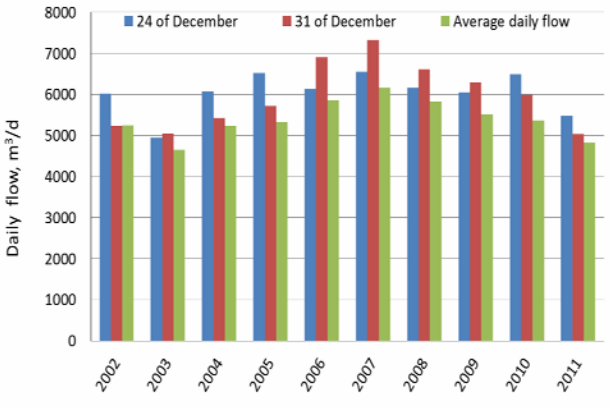

Figure 4: Comparison of water demand

Amount of water used per day is different in respect to the week. Fig. 3 presents the analysis of the average water flow per day in the days of the week. Minimum water demand per day is on Thursday and Friday, while maximum – on Sunday. Water demand on Sunday increases by about 8% in comparison to Thursday and Friday.

Water consumption on weekends is higher than on weekdays. However, maximum water demand is on holidays: December 24 and 31. Fig. 4 presents comparison of water demand over the period of 10 years on holidays (December 24 and 31) with average water demand per day of the respective years. On holidays water demand increases significantly – up to 20% in comparison to the average water demand per day.

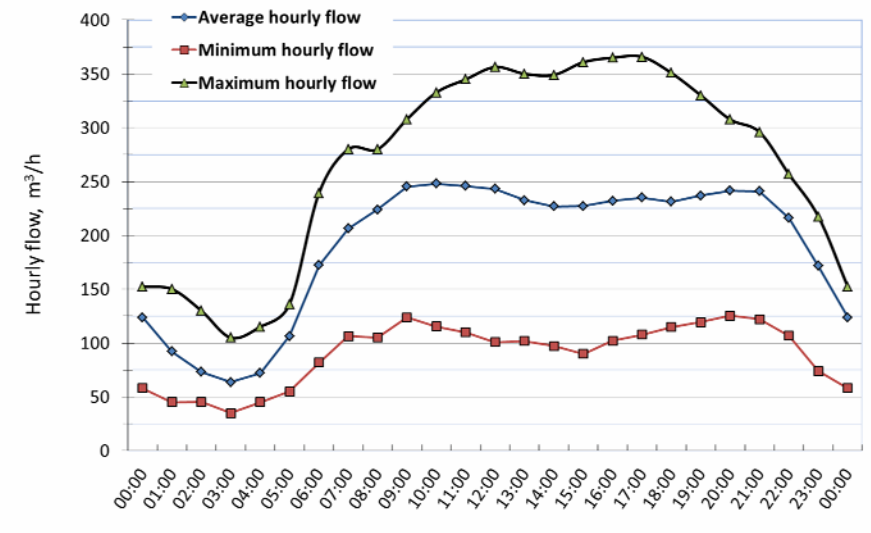

Figure 5: Average, maximum and minimum hourly water demand per day

Water consumption changes not only per year, but also per day. Fig. 5 presents average, maximum and minimum hourly water consumption during 2011-2012. Average water demand per day is 191 m^3/h. Minimum water consumption is at 3 a.m. – about 30 m^3/h. Maximum water consumption is at 5 p.m. – about 365 m^3/h.

4 Pattern of variation coefficients

Average water demand in a city (district) is an important indicator, but is rarely used in practical life because all the water supply engineering equipment should be selected by evaluating differences in water consumption, and has to work reliably under maximum water demand. Water consumption varies both in respect of the day and the week, as well as in respect of the year. In order to describe variations in water consumption, daily or hourly coefficients are used.

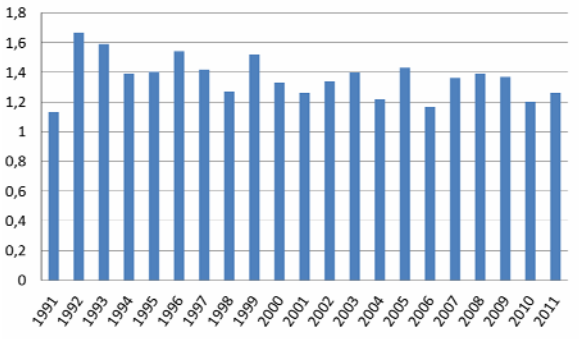

Figure 6: Change of the maximum daily variation coefficients

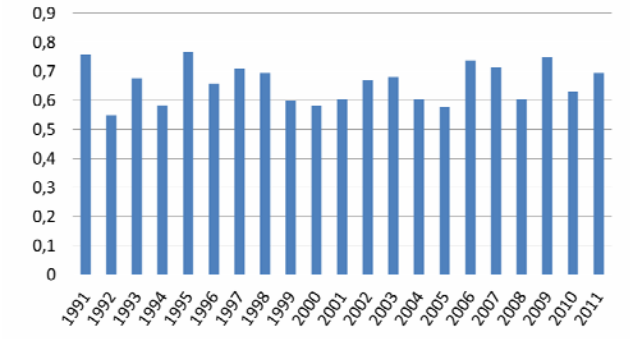

Figure 7: Change of the minimum daily variation coefficients

Water consumption variation coefficients are widely used in design practice [4, 5], as they assess water variation and respectively pumps and pipelines sizes are selected. The daily and hourly variation coefficient was calculated.

Fig. 6 and Fig. 7 presents maximum and minimum daily variations coefficients of difference for the years 1991-2011. Despite the fact that water consumption decreased by about 3.5 times, payment procedure for water consumption had been changing, water metering was installed in almost all flats, what is more, water consumers‘ habits had been changing, but it can be said that the nature of water consumption had remained similar over all 20 years.

The calculated average daily water consumption variation coefficient value is 1.36. The maximum determined variation coefficients per day are slightly higher than those indicated in designing rules (1.20-1.25), but basically is similar.

Over the period of 20 years values of the minimum daily water variation coefficient ranged from 0.55 to 0.76, with an average value – 0.66. Obtained values comply with standard design values. Having carried out the research, it was found that the nature of water consumption has not changed over 20 years.

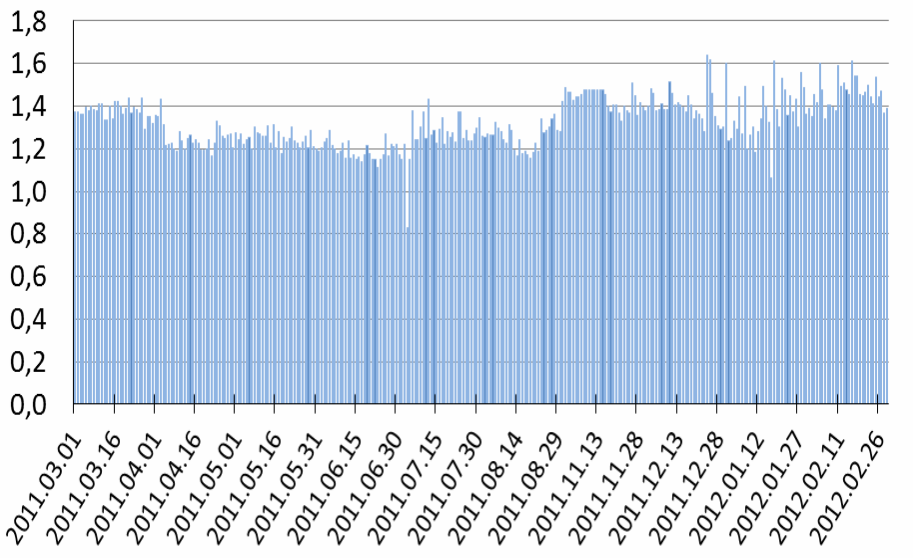

Figure 8: Maximum hourly variation coefficients

Average maximum hourly water consumption variation coefficient over the analysed period was 1.36 (see Fig. 8), and average minimum hourly variation coefficient over the analysed period was 0.46.

Water consumption pattern left the same during whole 20 years period. Clear that total amount of water was reduced few times, but water consumption pattern left the same. This could argue by water consumption variations coefficients. All data presented in this article indicate no statistically approved differences over analysed time period. But it shall be noted, that article dealing with purely domestic district only.

5 Night flow measurements

When analyzing water supply network efficiency one of the main criteria are water losses in the network. Water loss reduction is one of the major work areas of water supply companies. Water losses in Vilnius water supply system vary in the interval 15-20%. Most applicable method to determine water losses is establish district metering area (DMA) and night flow measurements [8]. Analysed city district was considered as DMA and night measurements were analysed in the study. Flow and pressure data have been collected at the DMA input section, during a leak detection survey carried out during an analysis. Data in this article presents only night flows in order be in relation with data presented above in the article.

Figure 9 presents flow variation at 3 a.m. in one of the Vilnius districts. It was established that minimum night flow is about 20 m^3/h, but such a low water flow was only about 15% a year. Sometimes night water flow reached as much as 300 m^3/h, which clearly indicates water losses and pipe fractures.

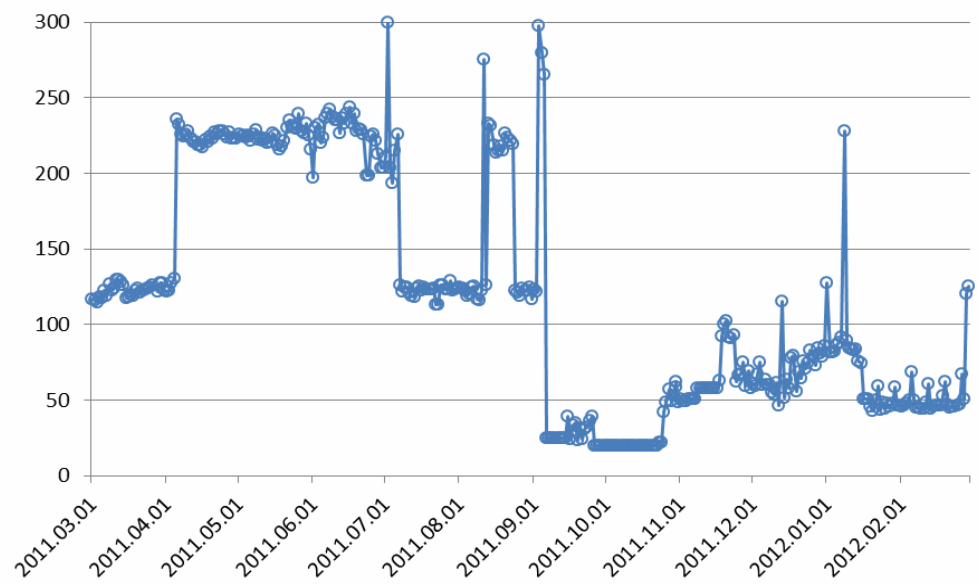

Figure 9: Night measurements data (at 3 a.m.)

Calculated night water consumption is about 1.8 litres per hour per flat. Presented measurement data is before an active water leakage reduction programme was started. Target level is 0.8 l/h/flat, obtains from direct flow measurement at the inlet of blockhouses. Flow measurement at blockhouses shows real night water consumption, as excludes water leakage from pipelines outside houses. These data shows that more than half water are lost during the night in the district. Reduction of water losses without active leakage program is impossible, as water did not appear on surface and not becomes visible. It has been calculated that night water consumption is about 10% of the average water consumption.

6 Conclusions

1. Over 20 years water consumption in Vilnius district – Karoliniskes decreased about 3.5 times, which was influenced by population decrease, increased water prices, financial situation in the country and implementation of water metering.
2. Domestic water consumption pattern has a little variation during two decades. Estimated average maximum daily variation coefficient is 1.36.
3. In a district of apartment houses minimum water demand is in the summer, because part of the inhabitants spends more time in gardens or is on holidays.
4. Maximum water consumption is at weekends and holidays – and can be up to 20% higher than the average annual demand per day.
5. The maximum water consumption in Karoliniskes district is at 5 p.m., the minimum at 3 a.m.
6. Calculated water consumption during night is 1.8 litres/h/flat. However real water consumption at blockhouses is 0.8 litres/h/flat. More than half water is lost during the night in pipelines, and only active water leakage reduction programme could reduce a water losses.

References

[1] Thornton, J., Sturm R. & Kunkel G. (2008). *Water Loss Control*. (2nd ed.). McGraw-Hill Companies.

[2] Burrows, R., Crowder G. S. & Zhang J. (2000). Utilization of network modelling in the operation management of water distribution systems. *Urban Water*. 2, 83-95. DOI: 10.1016/S1462-0758(00)00046-7.

[3] Dube, E. & Van Der Zaag P. (2003). Analysing water use patterns for demand management: the case of the city of Masvingo, Zimbabwe. *Physics and Chemistry of the Earth*. 28, 805-815. DOI: 10.1016/j.pce.2003.08.004.

[4] Obradovic, D. (2000). Modeling of demand and losses in real-life water distribution systems. *Urban Water*. 2, 131-139. DOI: 10.1016/S1462-0758(00)00051-0.

[5] Trifunovic, N. (2006). *Introduction to Urban Water Distribution*. Taylor & Francis/Balkema.

[6] Tinker, S. C., Moe C. L., Klein M., Uber J., Amirtharajah A., Singer P. & Tolbert P. E. (2009). Drinking water residence time in distribution networks and emergency department visits for gastrointestinal illnes in Metro Atlanta, Georgija. *Journal of Water and Health.* 7 (2), 332-343. DOI: 10.2166/wh.2009.022.

[7] Chung, G., Lansey K., Blowers P., Brooks P., Ela W., Stewart S. & Wilson P. (2008). A general water supply planning model. *Environmental Modelling & Software.* 23 (7), 893-905. DOI: 10.1016/j.envsoft.2007.10.002.

[8] Covas, D. I., Jacob A. C. & Ramos H. M. (2008). Water losses' assessment in an urban water network. *Water Practice & Technology*. 3 (3). DOI: 10.2166/wpt.2008.061.