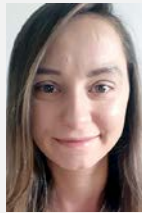


Water Quality and Water Consumption in Apartment Buildings in Slovakia



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In Slovakia, more than 1.7 million people live in apartment buildings. The contribution focuses on the hot and cold-water consumption and quality in apartment houses in Slovakia. The first part of the paper presents the results of a questionnaire survey about the quality of hot water in individual households. The second part consists of the analysis of the hot and cold-water consumption in several apartment buildings based on the experimental observation.

Key words: water quality, water consumption, potable water cold, potable water hot, questionnaire survey, experimental observation, apartment house

The requirements for the water consumption have changed in comparison to the last decades. Apartment buildings in Slovakia use the primary heat sources and old distribution networks with poor insulation, and it is therefore necessary to

analyse the issue of preparation and distribution of water in residential buildings. In apartment houses in Slovakia, in order to save energy, there are different thermal attenuations and shutdowns of energy supply for water heating. However, before such a measure is implemented, it would be useful to know how the quality of the supplied hot water will change, whether the residents of apartment building agree with the measure and how effective the measure is.

Water quality in apartment buildings in Slovakia

The first part of the contribution deals with the quality of hot water supply, which was reviewed on the basis of a questionnaire survey called “Opinions on the preparation and distribution system of hot water in Slovak households”, created on the Internet. The questionnaire evaluated the quality of the hot water in accordance with the subjective feeling of inhabitants.

The questionnaire was completed by 232 respondents living in an apartment house. In terms of age, 22% were

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students, 76% were working-age people and 2% were old-age pensioners [1]

Question 1: How is hot water prepared in your apartment building?

To the first question, 19% respondents stated that the hot water is in their apartment building prepared using a storage water heater, 5% has a plate heat exchanger, 2% combination of a plate heat exchanger and PWH accumulation in storage water heater, 69% did not know to answer (ordinary resident does not have access to the technical rooms) and 5% said otherwise. The graphical representation is shown in Figure 1.

Question 2: In What condition are pipes for water distribution in your apartment building?

To the question 2 answered 57% that the water pipes are in its original state, 24% answered that the pipe were renovated, and 19% did not know to answer.

Question 3: How are insulated pipes in the hot water distribution system of your apartment building?

To the third question, 23% respondents answered that pipes in their apartment houses are well insulated, 22% answered that the pipes are insulated with old felt insulation, 6% respondents thought pipes are not insulated, and 50% did not know to answer.

Question 4: What is the circulation of hot water in your apartment building?

To question 4 answered 50% of respondents that the circulation in their apartment house is uninterrupted, 19% thought it was shutting down at night, and 31% did not know to answer.

Question 5: What is the hot water supply in your apartment building?

To question 5 answered 70% that the hot water supply is continuous, 21% of respondents thought it was shutting down at night, and 9% did not know.

If the choice was made by the respondents, 64% would like the hot water supply to be uninterrupted. 36% of respondents would like the circulation and the source of hot water to be turned off overnight to save energy and money, although the hot water would not be available during the night.

Question 6: Do you think that the hot water in your apartment reaches a temperature of at least 45°C within 30 seconds after opening the water tap?

According to the Slovak rules, the supplier of hot water is obliged to provide the customer hot water with a temperature of 45°C within 30 seconds of opening the water tap.

77% of respondents answered that they obtain a hot water with the temperature at least 45°C and 23% of respondents answered they did not. Of all respondents living on the first to fourth floors, 19% respondents did not obtain hot water with required temperature, of all those living on the fifth to eighth floors is 21%, and of all those living on the 9th to 14th floors is 38%.

Question 7: How long will it take to get hot water at the desired temperature after opening the tap?

To the 7th question, 30% answered that they obtain hot water immediately, 47% of respondents takes hot water from 15 to 30 seconds, 18% thought it would take a minute, and 5% said that after more than a minute). The graphical representation is shown in Figure 2.

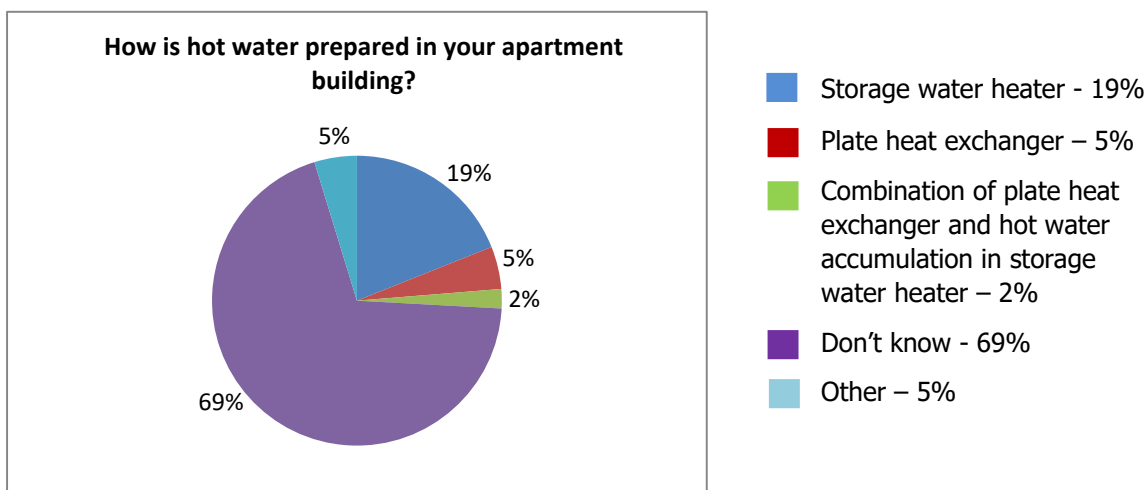


Figure 1. How is hot water prepared in your apartment building?

Question 8: How satisfied are you with the temperature of the hot water supplied?

To the eighth question, 45% of respondents answered that they are very satisfied with the temperature of obtained hot water, 50% are satisfied, 3% are dissatisfied and 2% are very dissatisfied. The graphical representation is shown in the Figure 3.

Question 9: How satisfied are you with the quality of the hot water supplied?

To the ninth question, 34% answered that they are very satisfied with the quality of obtained hot water, 60% are satisfied, 6% are dissatisfied and no one was very dissatisfied. The graphical representation is shown in the Figure 4.

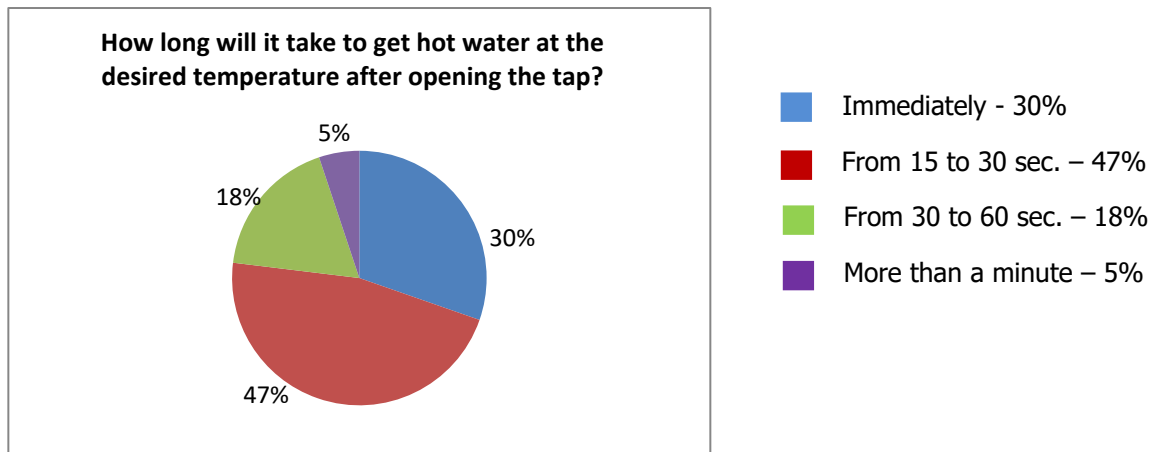


Figure 2. How long will it take to get hot water at the desired temperature?

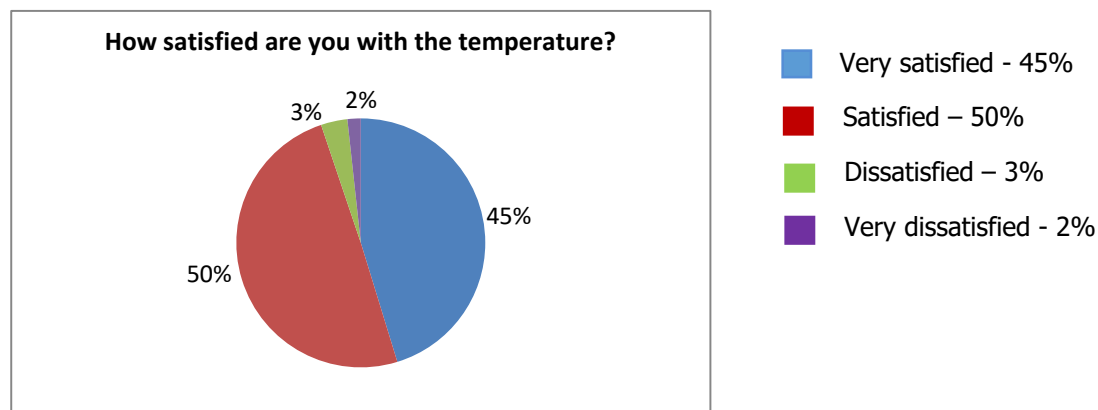


Figure 3. How satisfied are you with the temperature of the hot water supplied?

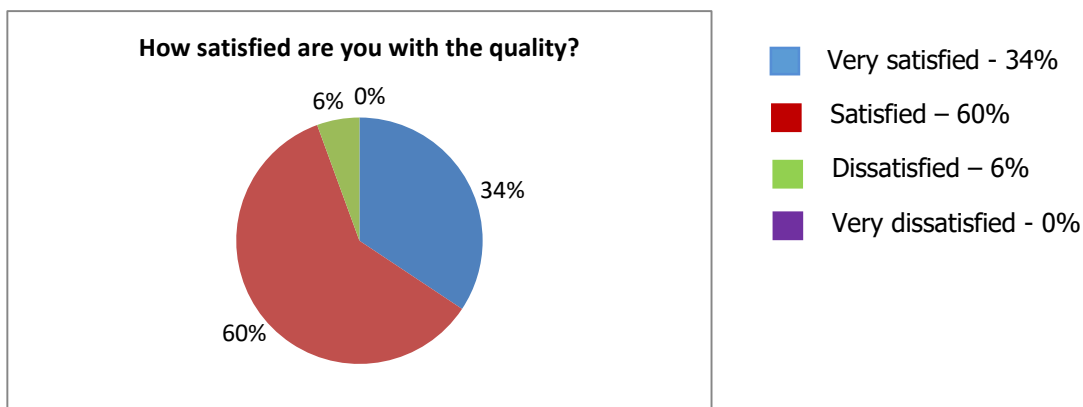


Figure 4. How satisfied are you with the quality of the hot water supplied?

Question 10: How satisfied are you with the price you pay for the consumed hot water?

To the question 10 answered 4% of respondents that with the price of hot water they are very satisfied, 62% are satisfied, 28% are dissatisfied and 6% are very dissatisfied.

The survey showed that most of the residents of apartment buildings are satisfied with the temperature, quality and price of the hot water. The preparation of hot water is usually uninterrupted. Most residents think their hot water will reach temperature 45°C in a relatively short time. Of those inhabitants, where the temperature does not reach 45°C, the majority lives in 9th to 14th floor, which confirm that **the quality of supplied hot water decreases with the distance of the apartment from the heat source** [1].

Water consumption in apartment buildings in Slovakia

The second part of contribution is dedicated to the hot and cold-water consumption in apartment buildings in Slovakia. The evaluation of water consumption is based on the experimental measurement of daily water consumption per the resident which was done in three selected apartment buildings. The aim of the measurement was to analyse the consumption of hot and cold-water and set the daily water abstraction peaks. Measurements were done for selected rising pipe of cold and hot water for:

- apartment building “A” located in Bratislava (capital city of Slovakia), hot and cold-water supply to 12 flats for 30 inhabitants, measured period: 08/2016 → 10/2016;
- apartment building “B” located in Bratislava (capital city of Slovakia), hot and cold-water supply to 9 flats for 14 inhabitants, measured period: 12/2016 → 02/2017
- apartment building “C” located in Prešov (city in the east of Slovakia), hot and cold-water supply to 12 flats for 27 inhabitants, measured period: 09/2017 → 11/2017.

Measured values were a flow of hot and cold-water and its temperature on the interval of 3 seconds. On the basis of the measured values, the daily average water abstraction was determined. The measuring system was located in the front of the rising pipe of the hot and cold-water [2].

Cold-water Flows and temperature in apartment buildings

In **Figure 5** daily maximum, average and minimum value of the cold-water flow rate in litres per minute in individual apartment houses A, B and C are figured. The average flow rate for apartment house “A” was 25.4 litres per minute, for the apartment building “B” it was 23.3 litres per minute and for the apartment house “C” the average cold-water flow was 23.6 litres per minute.

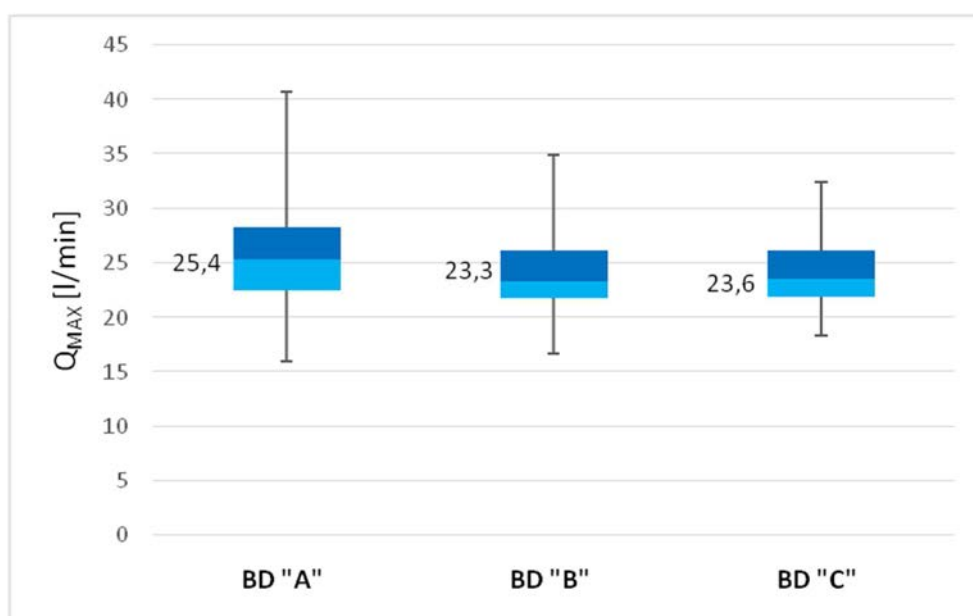


Figure 5. Behaviour of cold-water flows in apartment buildings A, B, C in measured periods.
 Q_{MAX} = flow rates of cold-water (litres per minute), BD = apartment building.

Concerning to the temperature, the cold-water temperature in apartment building “C” was around 10°C all the time, in the apartment building house “B” the measured average temperature of cold-water was 15°C and in the apartment building “A” the temperature of cold-water was mostly above 18.5°C, which is inadequate from the hygiene point of view.

Hot water flows and temperature in apartment buildings

The Figure 6 shows the daily maximum, average and minimum of hot water flow in litres per minute. The average hot water flow rate for apartment building “A” was 21.1 litres per minute, for apartment building “B” 24.0 litres per minute and for apartment building “C” 23.9 litres per minute.

The temperature of hot water in apartment building “A” was from 53°C to 57°C. In residential building “B” the temperature was from 55°C to 57°C and in the building “C” the temperature was from 46°C to 48°C throughout the measured period.

From the measured data of cold and hot water flows, the average **daily water consumption** during the day were determined. An overview of the results of cold and hot water consumption in apartment buildings A, B, C is given in Table 1.

From the measured results it is obvious that the **total water consumption of cold and hot water is from 68 to 92 litres per person per day**. The average values of water consumption per inhabitant were calculated from the results of experimental measurements of the flow rate

Table 1. Comparison of daily consumption of cold and hot water in apartment buildings.

Identification	Number of inhabitants	Water consumption litre / (person.day)		Total water consumption litre / (person.day)
		Cold-water	Hot water	
Apartment building “A”	30	38.25	32.36	70.61
Apartment building “B”	14	37.26	31.28	68.54
Apartment building “C”	27	42.01	49.48	91.76

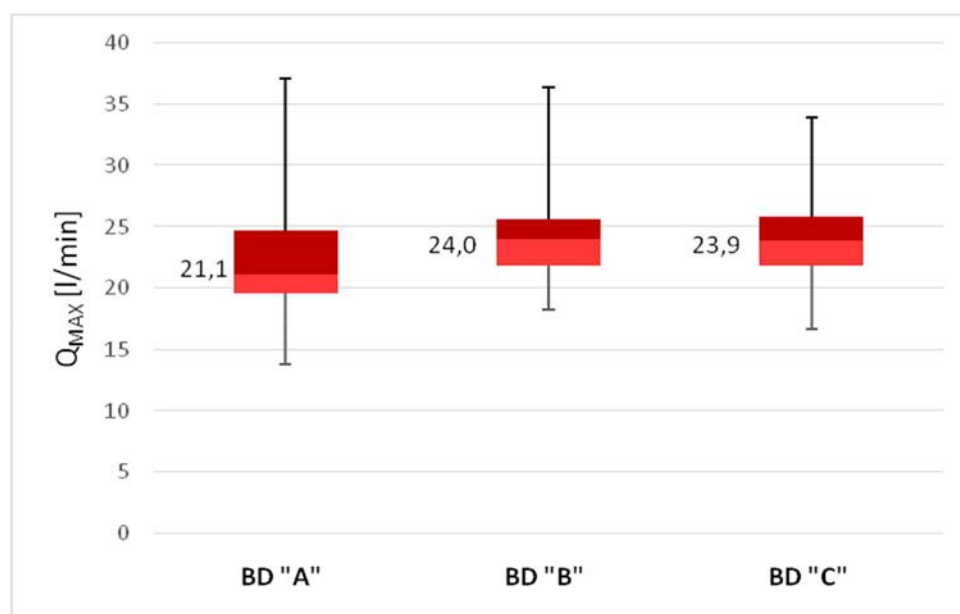


Figure 6. Behaviour of hot water flows in apartment buildings in measured periods.
 Q_{MAX} = flow rates of hot water (litres per minute), BD = apartment building.

and volume of supply cold and hot water. According to Slovak regulation, there is a specific water demand for the residential buildings of *135 to 145 litres per person per day*, while *real data show that water consumption is less than 100 litres per person per day*. It would be appropriate to make adjustments in Slovak regulations in the future [2].

Conclusion

Experimental measurement of water consumption in apartment houses in Slovakia showed that the total consumption of cold and hot water for one inhabitant ranges from 68 to 92 litres per person. The values for specific water demand in Slovak designing rules for the residential buildings are oversized by about 30%. The hot and cold-water consumption peaks are always at maximum in the morning and evening both during the weekend and during the week. Weekends confirm the increased consumption of cold and hot water, as the residents of apartment buildings are in the apartment building at this time [2].

The questionnaire survey showed that residents of single-family houses, who have to take care of the hot water system themselves, are much more interested in the hot water preparation and distribution issues than residents of apartment buildings. Overall, men are more interested in this issue than women, which confirms the fact that it is men who care about the technical operation of the household. In terms of age, pensioners are the most interested in their hot water system, followed by people of working age [1].

As for the quality of cold-water, several researches done in the Department of Building Services in the Slovak University of Technology showed that in some apartment buildings in Slovakia, there is a problem with keeping the temperature of cold-water below the recommended limit of 15°C. In experimental measurements, the temperature of cold-water in the range of 18 to 20°C was measured in some apartment buildings which must be prevented by high-quality of insulation of water pipes. ■

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