

# Theoretical analysis of water demand for apartment buildings in Romania, Ukraine and Slovakia

Analiza teoretică a cererii de apă pentru clădirile cu apartamente din România, Ucraina și Slovacia

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**Abstract:** The design of new water supply networks as well as the reconstruction and modernization of the existing water supply networks is highly dependent on the calculated water demand for the urban population and its various needs. The aim of the paper is to make a comparison of urban water needs in Romania, Ukraine and Slovakia, considering different categories of consumption specific to apartment buildings. Using large diameters for the water supply network pipes will cause a decrease of the drinking water velocity, therefore the duration of stay in the water network will increase and chances for worsening the water quality will be higher. On the opposite, using small diameters for pipes will cause an increase of the water velocity, which will increase the head losses in the distribution network, causing significant energy demands for pumping. After presenting the technical legal framework concerning water demand calculation in Ukraine, Slovakia and Romania, a comparison was made for the selected apartment buildings and also for urban green areas watering. From the calculated results of total water demand it can be stated that the difference in water demand for the neighboring areas of Ukraine, Slovakia and Romania is significant.

**Keywords:** comparison; water demand; apartment building; urban green spaces watering.

**Rezumat:** Atât proiectarea noilor rețele de alimentare cu apă, precum și reabilitarea și modernizarea rețelelor existente depind în mare măsură de determinarea cantităților de apă potabilă pentru diversele nevoi ale populației urbane. Scopul lucrării este de a face o comparație între cerința de apă urbană din România, Ucraina și Slovacia, ținând cont de diferitele categorii de consum specifice clădirilor de apartamente. Utilizarea diametrelor mari pentru conductele rețelei de alimentare cu apă va determina scăderea vitezei apei, astfel că durata de stagnare în rețeaua de distribuție va crește și șansele de degradare a calității apei vor fi mai mari. Pe de altă parte, utilizarea unor diametre mai mici pentru conducte va determina o creștere a vitezei apei, ceea ce va duce la creșterea pierderilor de sarcină în rețeaua de distribuție și implicit la creșterea consumurilor de energie pentru pomparea apei. După prezentarea cadrului legislativ tehnic privind calculul cerinței urbane de apă în Ucraina, Slovacia și România, s-a făcut o comparație pentru clădirile de apartamente selectate, precum și pentru necesarul de apă pentru udarea spațiilor verzi urbane. Analizând rezultatele calculate ale cerinței totale de apă pentru zonele învecinate din Ucraina, Slovacia și România, se poate afirma că diferențele între cantitățile de apă rezultate sunt semnificative.

**Cuvinte cheie:** comparație; cerere de apă; clădiri cu apartamente; stropirea spațiilor verzi urbane.

## **1. Introduction**

During the last decades, human activity has produced unfortunately not only a global climate change, but also a significant reduction of the quantity and quality of drinking water sources. In some areas of the planet there is a large shortage of drinking water supplies [1]. In many countries, water losses in the distribution networks show alarming figures.

According to Roy [2], the US Environmental Protection Agency has recently been asking water companies to provide annual water quality reports to their consumers. Powell & Yurchenko [3] are presenting a dynamic picture of the development of private provision in urban drinking water. Privatisation versus remunicipalisation depend on the power balance configuration of the state, capital and society and it is a political decision.

Both the design of new and the reconstruction of existing water supply networks are based on estimating the drinking water demand. In particular, the value of demand of drinking water by the inhabitants (daily water consumption of the residential sector) and by the workers in industrial enterprises will have a strong influence on the determination of optimal diameters for the water pipes. Recently, Ukrainians are consuming less water than before from water supply networks, due to the increased tariffs for centralized water supply and sewerage. So, the vast majority of the existing water supply networks in Ukraine are designed for higher values of water flow in the pipes, which causes a decrease of the velocity of water, an increase of the duration of stay for water in the network and a deterioration of water quality. The oversized diameters of the pipes in the distribution network are the reason for the deterioration of the hydraulic performance of its functioning [4, 5].

Reduction of water consumption and rational use of water is one of the priority tasks of humanity today. A comparison of the existing norms of drinking water consumption in Ukraine (100-285 l/day per one inhabitant) with the previous ones (125-350 l/day per one inhabitant) indicates a decrease by about 25% [6, 7, 8].

## **2. Aim**

The aim of the paper is to make a comparison of urban water needs in Romania, Ukraine and Slovakia for different categories of consumption specific to apartment buildings.

## **3. Method**

During this research we have compared the legislative requirements in Romania, Ukraine and Slovakia in terms of water needs. Accordingly, a calculation of the water demand for the selected apartment building was carried out. Finally, a comparison was made.

## **4. Results**

### **4.1 Analysis of legislative requirements**

The values of the estimated daily water demand (average per year) for different consumers of the three countries are given in Table 1.

Table 1

## Average specific water demand for apartment buildings

Type	Apartment building description	Average specific water demand for apartment buildings per one person (litres/day)		
		Ukraine [6,7]	Slovak Republic [9]	Romania [10]
1	Apartments that are connected to the public water supply and are equipped with shower	100–110	100	100-120
	Apartments that are connected to the public water supply, are equipped with shower and have gas supply	120–135		
2	Apartments that have local hot water preparation and are equipped with bathtub	150–170	135	
	Apartments that have local hot water preparation and are equipped with bathtub and gas water heaters	210–235		
3	Apartments that have central heating and central hot water preparation and are equipped with bathtub	230–260	145	150-180
	Apartments that have central heating and central hot water preparation and are equipped with a bathtub longer than 1500 mm	250–285		

The daily drinking water demand indicated in Table 1 is in a certain range of values because the territory of Ukraine according to climatic conditions is divided into IV districts [11]. For this paper and further calculations (comparison of Romanian, Ukrainian and Slovak legislative framework), the north-western architectural and construction climatic region of Ukraine (district I) has been selected.

In Slovakia, following the [9], the water demand can be reduced by 25% if consumers live in a building that is not connected to the public sewerage network. For apartments in a building with over- standard sanitary equipment (for example a swimming pool), the water demand is increased by 15%.

The analysis of Table 1 shows that (taking into account the architectural, structural and climatic regionalization of the territory of Ukraine), the daily Ukrainian water demand (averaged per year) is exceeding the Slovakian demand by: up to 35% - for residential buildings with water supply and sewerage without bathtubs; from 11% to 74% - for buildings with local hot water heaters; from 59% to 96.5% - for buildings with central hot water supply.

The Romanian Standard 1343-1/2006 does not take into account the bathroom equipment (showers/bathtubs), therefore only two types of apartments will be considered, based on the hot water preparation mode (local or centralized). In the case of local hot water preparation, Romanian values of the daily water demand are close to Slovakian ones, but in the case of centralized hot water preparation, Romanian values are slightly higher (up to 24%).

Table 2

Type of consumption	Water daily demand (liters/(m <sup>2</sup> .day))		
	Ukraine [6]	Slovakia [9]	Romania [10]
Urban green spaces watering	3 – 6	1	1.5 – 2.5

Table 2 shows that the water daily demand for urban green areas watering is 3 to 6 times bigger in Ukraine than in Slovakia. In Romania, the water daily demand for urban green areas watering (average value) is still 2 times bigger than in Slovakia.

#### 4.2 Theoretical comparison of the selected apartment building

For the comparison it was selected an apartment building with 110 occupants, situated in a town with 95,000 inhabitants.

The average specific water demand was calculated for the three types of apartment buildings. Water consumption for firefighting was not considered in any of these examples.

The first type of apartment building is considering apartments that are connected to the public water supply including apartments with shower and with gas supply.

The second type of apartment building is considering apartments that have local hot water preparation, bathtub and gas water heaters.

The third type of apartment building is considering apartments that have central heating and central hot water preparation and bathtub longer than 1500 mm.

The results of calculating the daily consumption of drinking water for every type of apartment building are shown in Table 3.

In Slovakia, the average daily water demand for the apartment building of the first type is about 22% lower than in Ukraine, for the second type is about 40% lower than in Ukraine and for the third type is about 46% lower than in Ukraine.

Romania's values are higher than in Slovakia (for type 2 about 23% higher and for type 3 about 63% higher), but lower than in Ukraine (for type 2 about 26% lower and for type 3 about 12% lower).

Table 3.

Type of apartment building	Number of occupants in house	Daily water consumption for one occupant (l/(day.pers.))	Unaccounted consumption		Coefficient of daily non-uniformly consumption		Daily water consumption (m <sup>3</sup> /day)		
			%	$\gamma_i$	$K_{max}$	$K_{min}$	Minimum	Average	Maximum
<b>Ukraine</b>									
1	110	120	10	1.1	1.2	0.8	11.62	14.52	17.42
2	110	210	10	1.1	1.2	0.8	20.33	25.41	30.49
3	110	250	10	1.1	1.2	0.8	24.20	30.25	36.30
<b>Slovakia</b>									
1	110	100	-	-	1.3	0.75	8.25	11.28	14.30
2	110	135	-	-	1.3	0.75	11.14	15.22	19.31
3	110	145	-	-	1.3	0.75	11.96	16.35	20.74
<b>Romania</b>									
1	110	110	15	1.15	1.4	1.3	18.09	18.79	19.48
2	110	110	15	1.15	1.4	1.3	18.09	18.79	19.48
3	110	165	15	1.15	1.35	1.20	25.05	26.61	28.18

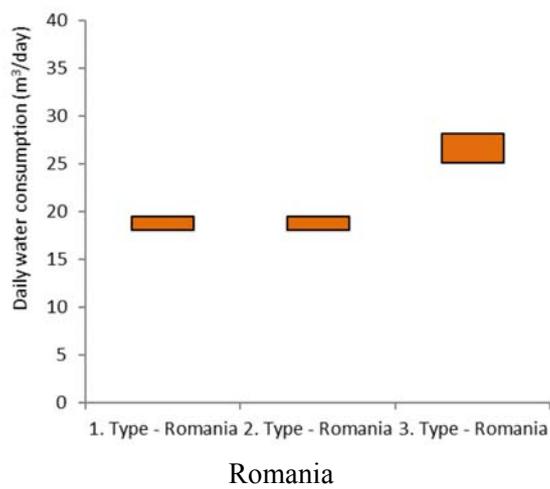
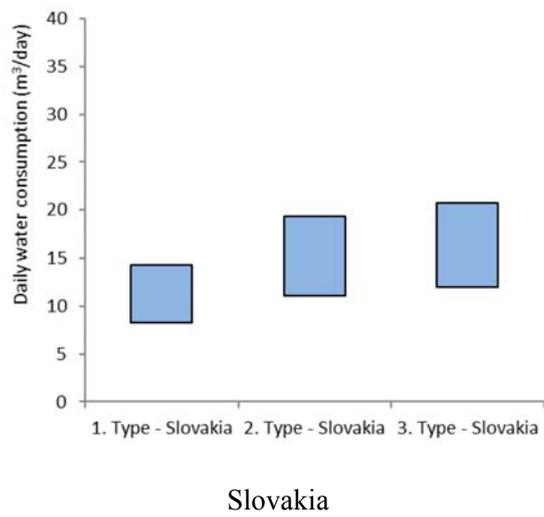
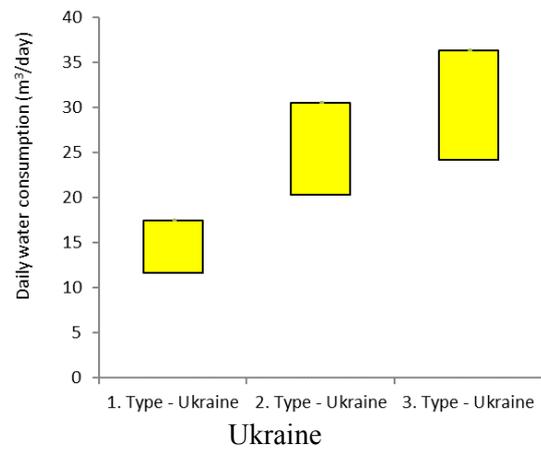


Figure 1. Comparison of the daily water demand in Ukraine, Slovakia and Romania

Similarly, it was calculated the daily demand for watering the urban green spaces in Ukraine, Slovakia and Romania according to the legislative framework. The green area considered was 5000 m<sup>2</sup>. The results are presented in Table 4.

Table 4.

Daily water demand for watering the urban green spaces

Type of consumption	Watering area (ha)	Water demand (l/m <sup>2</sup> )	Number of watering during the day (-)	Daily water demand for watering (m <sup>3</sup> /day)		
				Minimum	Average	Maximum
<b>Ukraine</b>						
Urban green spaces watering	0.5	3	1	0	15	15
<b>Slovakia</b>						
Urban green spaces watering	0.5	1	1	0	5	5
<b>Romania</b>						
Urban green spaces watering	0.5	1.5 - 2.5	1	7.5	10	12.5

In Slovakia, the average daily water demand for watering of urban green areas is about 67% lower than in Ukraine. In Romania, the average daily water demand for watering of urban green areas is about 33% lower than in Ukraine.

The total daily water demand from water supply networks for apartment buildings of third type (including watering of 5000 m<sup>2</sup> green area around this building) is shown in Table 5.

Table 5.

Total daily water demand for the third type of apartment building

Type of consumption	Total daily water demand (m <sup>3</sup> /day)		
	Minimum	Average	Maximum
<b>Ukraine</b>			
Type 3 apartment building	24.20	30.25	36.30
Watering of urban green areas	0.00	15.00	15.00
Total:	24.20	45.25	51.30
<b>Slovakia</b>			
Type 3 apartment building	11.96	16.35	20.74
Watering of urban green areas	0.00	5.00	5.00
Total:	11.96	21.35	25.74
<b>Romania</b>			
Type 3 apartment building	25.05	26.61	28.18
Watering of urban green areas	7.50	10.00	12.50
Total:	32.55	36.61	40.68

In our case, the average water demand for watering of green areas is about 1/3 of the average total water requirement in Ukraine, 23.4% in Slovakia, respectively 27.3% in Romania. For a better representation of water needs for all three countries, data are presented in Figure 2, where we can see that for this selected apartment building, the maximum water demand in Slovakia is about the same as the minimum water demand in Ukraine. Romania’s average total water demand is about the same as in Ukraine, but the amplitude between minimum and maximum values is much smaller than in Ukraine.

From the calculated results of total water demand shown in Figure 2 and map in Figure 3, it can be stated that the difference in water demand for neighboring areas of Ukraine, Slovakia and Romania is significant and perhaps unjustified.

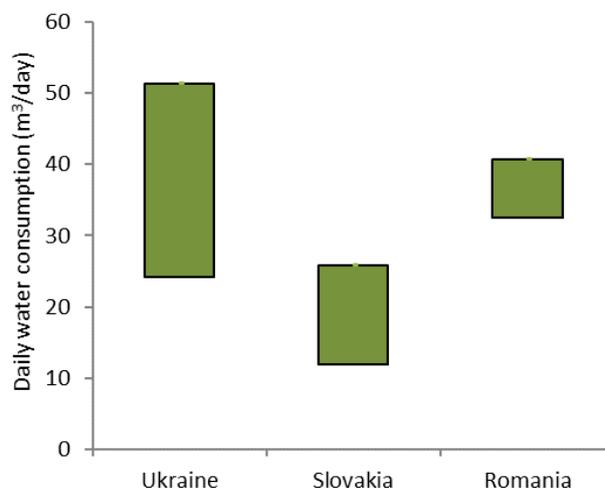


Figure 2. Comparison of the total average daily water demand in Ukraine, Slovakia and Romania



Figure 3. Neighboring countries Ukraine, Slovakia and Romania on the map  
(Source: [www.google.com/maps](http://www.google.com/maps))

## 5. Conclusions

From the analysis of drinking water demand in Ukraine, Slovakia and Romania we noticed important differences between Ukraine and Slovakia. For the selected apartment building with 110 occupants, situated in a town with 95,000 inhabitants, in the case of Type 3 apartments (central heating and central hot water preparation and bathtub longer than 1500 mm), the average daily water demand in Slovakia was about 46% lower than in Ukraine. The average water demand for watering of green areas is about 1/3 of the average total water requirement in Ukraine, 23.4% in Slovakia, respectively 27.3% in Romania. The maximum water demand in Slovakia is about the same as the minimum water demand in Ukraine. Romania's average total water demand is about the same as in Ukraine, but the amplitude between minimum and maximum values is much smaller than in Ukraine.

From the calculated results of water demand it can be stated that the difference in water demand for neighboring areas of Ukraine, Slovakia and Romania is significant. From a practical point of view, the reduction of water consumption standards in Ukraine will reduce the diameters of water supply networks and, consequently, substantially reduce the amount of pipe materials necessary for water supply systems and save raw materials and energy resources.

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