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ESTIMATION OF ACTUAL CONSUMPTION OF WATER BY TBILISI POPULATION

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Abstract: *Tbilisi water supply and sanitation project considers rehabilitation of water supply system, based on the results of the pilot project, carried out in the scope of the project preparation activities and aimed estimation of actual consumption of water by Tbilisi population, evaluation of leakages from domestic sector, transmission mains and distribution network.*

Bulk and combined water meters were installed at the selected main and distribution network and, finally, leakages per km of transmission main and distribution network was calculated.

The studies have shown that:

- *High pressures on connections cause increase in amount of leakages per capita (L/per capita/day);*
- *Leakages increase the, risk of damages to buildings.*
- *Decrease in amount of leakages from transmission mains and distribution network would reduce production of water and subsequently cost of power energy used by pumping stations.*

Results of the pilot project will be used by international and local consultants in order to identify future investment projects for water supply rehabilitation, which would improve supply of water to the population of Tbilisi.

Key words: *water supply of Tbilisi, leakages, water resources per capita, water losses, flow meters, water meters.*

1. INTRODUCTION

Water supply system of Tbilisi, comparing to other cities of Georgia, is a complex of complicated engineering plants. Supply of water is carried out from Aragvi river valley (ground water), Zhinvali reservoir on Aragvi River and Tbilisi Sea (surface water). Main consumers of water are divided into the following categories: population, industrial enterprises and public (budget) organisations. Based on TWSU information 428 million m^3 of water is to be produced in 1998, out of which 320 million m^3 is to be sold. 400 million m^3 is supplied to the distribution network. The difference between production and supply, 28 million m^3/year is used in treatment plants and production fields [1].

800 L/day is used per capita of population in Tbilisi, though some districts are supplied with water several hours per day (defined schedule). The water supply schedule is often violated, because of power supply cut offs to pumping stations and irrational use of water resources. 45% of supplied water to the consumers is unaccounted for water, including leakages.

Considering all above - mentioned rational use of water resources, reduction of leakages and losses from distribution network and reduction of consumption is highly important.

Tbilisi water - supply and sanitation project considers rehabilitation of water - supply system, based on the results of the pilot project carried out in the scope of the project preparation activities. The pilot project aimed estimation of actual consumption of water by Tbilisi population, evaluation of leakages from domestic sector, transmission mains and distribution network.

Phase I of the pilot project aimed estimation of actual water production, leakages from distribution network and domestic households: Phase II of the pilot project considered assessment of actual water consumption and leakages in domestic sector using installed water meters. Initial objective of the phase III activities was estimation of leakages from transmission mains and distribution network, extrapolation of received information for the whole city. Afterwards, it was decided to include estimation of leakages from budget organisations and industrial enterprises as well.

86 water meters and manometers were installed on connections to residential buildings located in different parts of Tbilisi. 8 meters were installed at connections to public organisations, a bulk water meter was installed at transmission main. 4 combined water meters - at industrial enterprises and 4 combined meters - at distribution network. Thus, in total 103 water meters was installed during the pilot implementation.

Results of the pilot project will be used by international and local consultants in order to identify future investment projects for water - supply rehabilitation, which would improve supply of water to the population of Tbilisi.

2. THE BODY OF THE ARTICLE

The pilot project aimed assessment of actual consumption of water and leakages from transmission mains, outside and indoor distribution network, extrapolation of received information for the whole city and estimation of average water consumption per capita per day (per hour, per second) using installed water meters.

Water supplying in Tbilisi is distributed among 10 administrative districts. Typical buildings surveyed during the pilot project are located in different districts, and they were selected considering their water - supply schedules, pressures, social and economic factors of the population. In total 103 water meters were installed on connections to different categories of consumers. By installing bulk and combined water meters at a selected transmission main and distribution network, we estimated water leakages and consumption per day. Special maps were drafted to present selected buildings and installed water meters.

The information collected during the pilot was extrapolated for the whole Tbilisi, using several elements of mathematics statistical theories.

Two groups of factors can be applied, as reasons for inefficient operation of water supply system. The first group consists of factors, which are very difficult, or almost impossible to eliminate:

1. The topography and different elevations of the city - it is built, as a narrow line (2-4 km) along the Mtkvari River stretched for about 40-45 km from North-West to South- East. At the same time 80-85% of the whole water is supplied from one side, North-West, Aragvi river valley. The difference in the city elevations is 300 meters, but if we take into consideration, that surrounding villages receive the water from the same source, than the difference is more, than 1000 meters, that is why in spite of the fact the city network is zoned (4 zones and satellites) the number of pumping stations is much higher, than acceptable norms and the leakages are higher, than acceptable.

2. The climate is hot and dry, during the summer time the amount of water consumption is increasing dramatically, due to the watering of the yards, streets, plants, walls and roofs, cooling of food and fruits, which causes the increase of day/night usage ratio, than the norm.

3. It is very difficult and economically not sound to use the technical water in Tbilisi.

The second group consists of reasons, which can be eliminated.

1. The usage of bad quality, or damaged sanitary equipment, which causes a big amount of leakages inside the buildings, at the same time closing equipment is almost not functioning at all in the external networks and yards, which cause additional leakages. This factor is not accounted at all

in the whole balance of water – supply, because it occurs after installed water meters. Thus, it is counted as the water consumed.

2. On the industrial plants it is virtually non-existent the contemporary systems of multiple usage of the same water, as a result almost clean water is disposed to the sewage.

3. The public sanitary units are equipped with outdated facilities, which consume water 15-20 times higher, than the norm.

4. The potable water is used for the watering of the streets and public gardens and parks.

5. The zoning of the water supply system in the city needs exact definition of the borders of each zone, because in the most cases on these borders high pressures are being created. Pressure gauges are not installed, though this equipment could facilitate the normal distribution of pressures.

6. The measuring of the water supplied and sold is not reliable due to the poor quality of water meters.

7. The technical conditions of external and internal distribution network (deteriorated pipes, damaged reinforcement, damages in the network etc.).

Pilot project work plan for three phases was prepared considering these factors.

During the phase I Tbilisi water supply schemes were prepared for 10 selected residental buildings. Sanitary technical equipment was evaluated in the buildings, leakages were measured and cost of repairs assessed. Average leakage in selected buildings was 0,2 - 0,4 m^3/day per capita. Phase I of the pilot project can be considered, as a preparation phase, as during this phase 86 apartment buildings, located in different districts of the city, were selected, at connections of which water meters were installed afterwards. A map was prepared, as showing location of all selected buildings. Pressures were measured in the network and maps were prepared according to the results of manometer reading.

According to the work plan of phase II of the pilot project, daily meter reading was carried out on connections. After data processing, meter reading analyses and extrapolation of pilot data for the whole city, average consumption of water by domestic sector was identified; consumption equals - 960 L/per capita/day, while leakage is 29,38% out of water supplied i.e. 282 L/per capita/day. Analyses of received information showed identity of leakages during day and night hours, which can be explained by increase of pressures in the network at night.

Phase III work plan considered estimation of leakages from water transmission mains and distribution network. Bulk and combined water meters were installed at the selected main and distribution network and, finally, leakages per km of transmission main and distribution network was calculated. Bulk water meter (Ø = 500mm) was installed on the transmission main (Ø = 600mm) out

flowing from Samgory water treatment plant, which supplies water to 10 block of buildings in III Massive settlement, Samgory district. Total amount of population living in the selected area equals 16535 residents. Meters were read at selected hours at day and night. Night leakages from the main equal 800 m^3. Supply of water to all connections to the main was stopped, in order to assess leakages from the main during the day time.

Similar experiments were carried out on Sulkhan Saba Street, Mtatsminda district and I block of Didi Digomi, Saburtalo district. Leakages from distribution network was identified in block No 10 of III Massive settlement, where combined water meters (Ø = 150/30mm) were installed at all connections.

Water meters were also installed at connections to selected industrial enterprises and public organisations. These organisations are located in different districts of Tbilisi. Using water meters their consumption and leakages were assessed. As it is known, leakages also occur during damages on the network. Approximate leakage per damage was calculated considering number of damages per year and diameter of pipes in the network.

Regular meter and manometer reading was carried out on connections to the selected buildings, aimed to identify average consumption and leakages.

Water meters were installed in specially built manholes and in basements of selected buildings.

The works implemented under the pilot project classified existing problems of water supply into two groups. Leakages are considered, as one of the problems, which can be eliminated. Works aimed evaluation of sanitary technical equipment in selected households. By extrapolating pilot data for the whole city, leakages are assessed to equal 0.2 - 4 m^3/per capita/day [2].

Statistical analyses [3] of collected information using water meters installed at 86 buildings connections, allowed us to identify average consumption per capita per day, which is 960 L. Furthermore, average leakage in domestic sector was calculated: 29,38% out of the water supplying (282 L/per capita/day). Leakages at night and during the day time are practically equal, because of pressure increases at night.

Leakages from transmission mains and distribution network were also assessed. Analyses of the results showed, that leakage per km of transmission main is about 0,186 L/sec, and 0,5 L/sec of water (40 L/per capita/day) is leaking from distribution network.

According to analyses of amount of damages on the network, 43m^3/day is leaking per damage. Furthermore, amount of leakages increase per year, the increase is about 4.5 - 5%, which is caused by deteriorated pipelines.

Average leakage from industrial enterprises is about 39-40% out of the water supplying. 37-42% of water supplied to public organisations is lost or leaking (see Tables 1, 2, 3 and Figures 1, 2) for combined register of leakages and, losses.

3. CONCLUSION

High pressures on connections cause increase in amount of leakages per capita (L/per capita/day);

Leakages increase the risk of damages to buildings.

Decrease in amount of leakages from transmission mains and distribution network would reduce production of water and subsequently cost of power energy used by pumping stations.

RECOMMENDATIONS

Improvement of conditions of sanitary technical equipment in buildings would reduce consumption and leakages up to 70-80%;

Installation pressure regulators and pressure gauges on distribution network and connections to buildings would reduce actual consumption and leakages;

Maintenance of distribution network and change of highly deteriorated parts of it would reduce amount of leakages;

Installation of bulk water meters at transmission mains to measure total production and supply and distribute consumption between categories on consumers;

Installation of water meters on connections to all consumers would allow supervision of consumption and reduce actual consumption;

Further analyses of water consumption is recommended, as it is affected by many factors.

Table I. Combined register of water leakages and losses

General information	
Population (1000)	N = 986.1 *
Territory km^2	F = 350
Total length of the network km^2	L = 3321.8
Supply of water million m^3/year	428**

	Main Consumero f water (Types of Consum-ers)	Consumption and leakage in Tbilisi													
		Population			Industry***			Public organisations			Mains and dis-trict. network			Damages on the network		
		Consumption (L/per capita/day)	Leakage (L/per capita/day)	Leakage %	Consumption (L/per capita/day)	Leakage (L/per capita/day)	Leakage %	Consumption (L/per capita/day)	Leakage (L/per capita/day)	Leakage %	Leakage from mains (L/1 km/sec.)	Leakage from dist. network (L/1 km/sec)	Leakage per km (L/per capita/day)	Leakage per damage m3/day	Leakage per capita per damage (m3)	Leakage (million m3/year)
1	Population	960	282	29.38								.				
2	Industrial Enterprise				217	84.63	39									
3	Public or-ganisation							191	92.5	48						
4	Mains and distr. net-work										0.185	0.5	40	.		
5	Damages												•	43	3I	
6	Techno-logical use											'				28

*Source of information on population: relevant services of Tbilisi Municipality, 1997

**Total amount of water supplied to Tbilisi - 428 million m^3/year

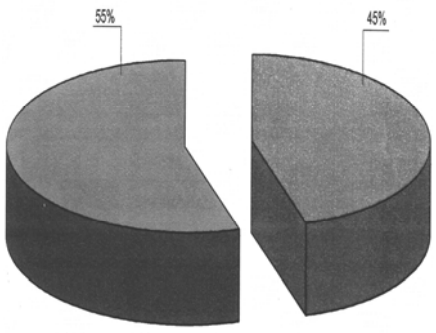
***Data on consumption and leakages from industrial enterprises is approximate, because of small amount of selected enterprises

Table 2. Leakages in domestic sector

N	Water supply groups	Supply hours per day	Leakages L/day/per capita	Water supply 0/0 (considering territory)	No of Population	Leakages (%)	
						1000m^3/day	mil.m^3/year
1.	"A"	24	282	62.5	616.3	173.8	63.44
2.	"B"	16	188	10.5	103.5	19.5	7.1
3.	"C"	8	94	26.7	263.3	24.8	9.03
Total					986.1	218.1	79.57

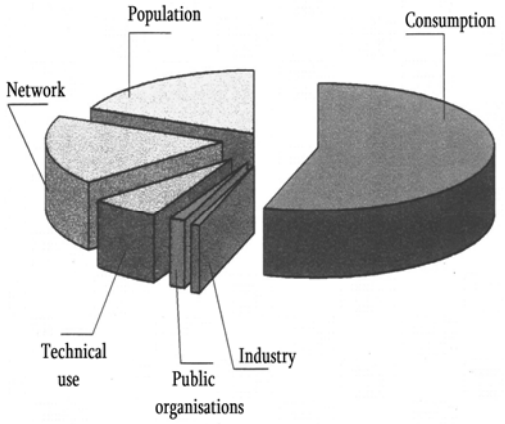
Table 3. Water lost and leakages

N	Consumer, pipes	Leakage Q, mil. m^3/year	Leakage % from total leakages
1.	Population	79.57	41.31
2.	Industry	3.31	1.72
3.	Public Organizations	5.73	2.98
4.	Mains & network	45	23.36
5.	Damages in the network	31	16.09
6.			



Total	Consumption	Leakages
100%	55%	45

Figure 1. Distribution of leakages in Tbilisi water supply network (considering type of supply)



%	Categories	Mln. m^3/per year
18.81	Population	79.57
17.75	Network	75.97
6.54	Technical use	28.00
1.33	Public organisations	5.73
0.77	industry	3.31

Figure 2. Structure of water leakages and loses according to each categories of consumers

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