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Review paper

PROBLEMS OF DRINKING WATER IN KAKHETI REGION

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ABSTRACT: The aim of this manuscript was to evaluate the drinking water resources of one of the most significant regions of Georgia-Kakheti and research the possibilities of their rational utilization taking into account the satisfaction of local population's demand on drinking water. In this connection we researched such components of water resources as, outputs of artesian springs, underground water flow of river Alazani, water resources formed on Kakheti municipal territories and qualitative data of water resources per capita. The artesian wells of river Alazani's subsoil waters are characterized, which are significant reserve of fresh water. It is underlined, that the outputs of the tributaries of river Alazani (especially the left ones) allow satisfying the population of Kakheti region with drinking water. The present condition of network of drinking water supply is also considered and the ways of their improvement. The recommendations are given for sustainable use of Alazani-Iori water resources according to the municipalities and possibilities of drinking water production satisfying international standards.

Key words: *drinking water, surface water, underground water, pollutants, contamination, well*

INTRODUCTION

Water covers about 70% of the earth, but only 3% of the world's water is fresh and two-thirds of that amount is tucked away in frozen glaciers or otherwise unavailable for our use. According to the World Health Organization (WHO) in 2015, 71% of the global population (5.2 billion people) used a safely managed drinking-water service (Gleick, 2004). Globally, about 2 billion people use a drinking water source contaminated with faeces. The polluted waters can transmit such diseases as diarrhoea, cholera, dysentery, typhoid and polio according to WHO. The contaminated drinking water is estimated to cause 502 000 diarrheal deaths each year. The clean fresh water is an essential ingredient of healthy human life, but 1.1 billion people lack access to water and 2.7 billion experiences water scarcity. Presently by 2025 half of world's population will live in water-stressed areas (Bouwer, 2002; Gleick, 2004). The World Economic Forum's Global Shapers Survey in 2017 enlisted food and water security on the 7th place among ten major problems facing the world today (Geladze et al., 2016). Taking into account all efforts we tried to analyse the present condition of utilization of drinking water resources in one of the largest and most important regions of Georgia, Kakheti and work out the priorities and recommendations of drinking water supply in future.

DISCUSSION AND RECOMMENDATIONS OF DRINKING WATER SUPPLY IN FUTURE

Georgia is characterized by considerable resources of underground fresh water, but presently they are utilized by less than 0.01%. Subterranean fresh waters have good composition (Sodium bicarbonate-chlorine waters against manganese background deficit) and are characterized by bacteriological purity (Makharadze and Geladze, 2015). In last period the drinking water business has been developing in Georgia intensively. Today such drinking water brands as "*Borjomis tskaro*", "*Bakuriani*", *"Natakhtari"*, *"Geva"* and some others are bottled in Georgia, but these companies have limited capacity and use only 20% of potential capacity in this business. They are working mostly in country's inner market. At the same time this business has much more potential and in case of proper management it can mitigate drinking water shortage in the world. The potential resources of Georgia's subterranean fresh waters exceed 6.5 ml/m^3 in 24 hours that is 2.3 billion m^3 in a year (Table 1). These waters satisfy the strictest requirements of the European and World Health Organization and 92% of them are accessible for use (Zhordania et al., 2008; Lomsadze et al., 2017). According to the 2014 general census of the population 318,583 people live in Kakheti today. There are eight municipalities (Akhmeta, Telavi, Sagarejo, Gurjaani, Kvareli, Lagodekhi, Signaghi and Dedoflistskaro), nine towns and 276 villages. The capital of the region is Telavi. On Kakheti's territory there are east Georgia's two big rivers water basins Iori and Alazani (Melikadze et al., 2014). The water collecting area of both is 10 524 km^2. In Kakheti region borders is included river Tusheti's Alazani basin with territory of 868.6 km^2. Rivers Iori and Alazani flow into the Mingechauri reservoir on Azerbaijan territory (Geledze et al., 2013). The drinking water is the number one problem in all eight Kakheti municipalities. In 2009 for solution of this problem was spent 16 million Lari.

Table 1. Resources of Kakheti underground fresh waters (Geledze et al., 2013)

Basin/spring	Output, m^3/day
Alazani	938 200
Lagodekhi-Signaghi	129 000
Bursa	92 600
Napareuli	29 600

From foothills of river Alazani's left bank outflow approximately 25 artesian springs. Among them the biggest is *Afenis tskaro* with summer-autumn output of 220-250 litter/sec amount of water, then comes *Fatmasuri tskaro* with 188 litter/sec output. It outflows near Kvareli village. The output of *Dumasturi tskaro* (Pankisi gorge) is 27-105 liter/sec. To big output springs can be added: *Tsivi tskaro* (village Zinobiani) with output of 72-110 litter/sec, *Sakrdis tskaro* (village Shakriani) 50-59 litter/sec, *Munis tskaro* 55-74 litter/sec and *Chantliskuris tskaro* 55-74 liter/sec (Geledze et al., 2013). From right bank of river Alazani's east side (Dedoflistskaro municipality), outflows many kart springs with output of 1-litter/sec. The condition of water formation facilitates the supplement of river Alazani by underground waters. From Shakriani to Tchiauri the underground flow is 43-45% of the annual volume of water. The part of underground flow in river Alazani's basin is high: 40-50% in upper part and more than 50% in river Didkveri basin. The total flow of Alazani's left bank is 500-866 mm (river Chelta's basin). The right bank of river Alazani is comparatively poor by underground waters: in river Kisiskhevi's basin their part in annual total flow is 23% (155 mm), in river Cheremiskhevi's basin 38% (82 mm). River Iori's basin is comparatively much poorer. In the upper part of river Iori's water basin, subterranean water flow is 38.7% of the annual amount and its absolute meanings 270 mm. At about equal heights, river Alazani's right bank subterranean flow is 678 mm that is 49.5% of annual amount (Chartliskhevi-Khizabavri). In the middle parts of the rivers Iori and Alazani are two trustworthy groups: the first is at 15 km from Sagarejo, with the total output of springs of 100 litter/sec and the second at Iori's right bank at village Duzagram. The total output of both is 350 litter/sec. These waters are of good quality. Generally Kakheti's water resources are formed by surface flow, underground flow, reservoirs and other sources (Table 2).

Table 2. Kakheti water resources, million m^3

River	Basin area, km^2	River flow	Surface flow	Underground flow	Reservoirs	Others
Alazani	6.700	3.109	1.825	1.284	505	
Iori	3.824	805	458	347		
Total	10.524	3.914	2.283	1.631	505	10
Kakheti water resources altogether	4.429 million m^3					

Iori and Alazani's total water flow is 88.4% from all water resources of Kakheti.

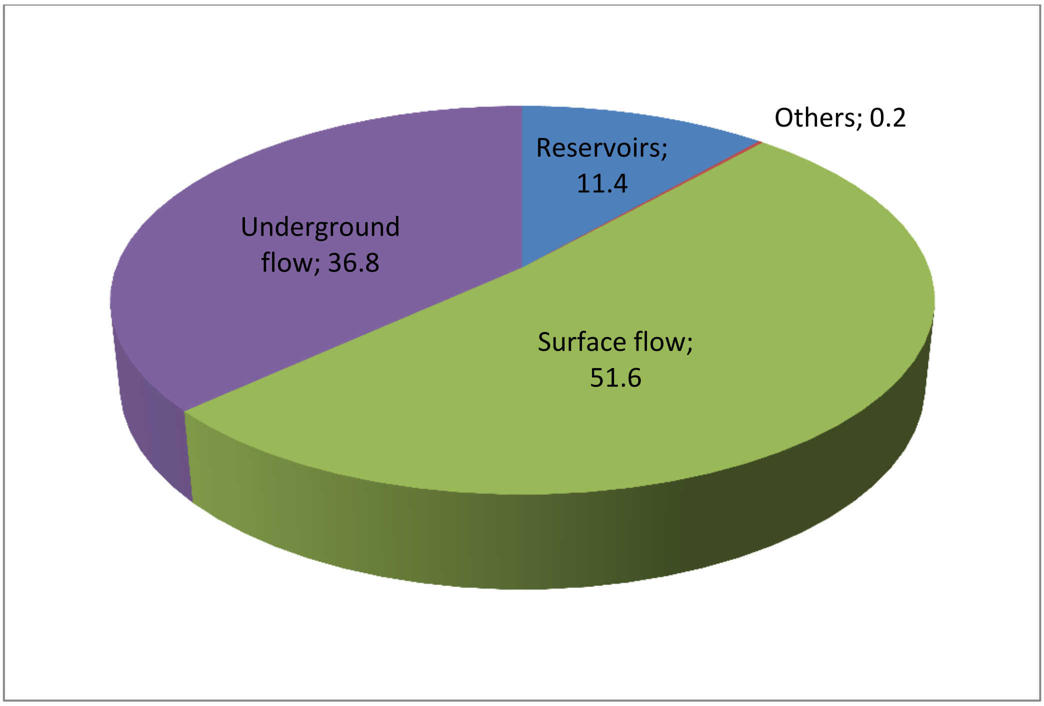

Figure 1. Kakheti water resources distribution %

Among Kakheti municipalities Akhmeta is notable by water resources formed at the place (0.9 km^3). In Signaghi municipality this index is the least 0.07 km^3. By water resources per capita Akhmeta municipality is characterized by more amount 28 606 thousand m^3 in a year i.e. 78.3 m^3 in 24 hours. In Signaghi municipality water resources per capita is 2 337 thousand m^3 in a year, i.e. 6 402 m^3 in 24 hours and it is on 12.23 times lesser than in Akhmeta municipality. In Dedoflistskaro municipality water resources formed at the place are 51 mm. Water resources per capita here are 6 126 thousand m^3 in a year, i.e. 16 783 m^3 in 24 hours and it is 2.6 times more than in Signaghi municipality. Water flow from outside areas by municipalities is: Akhmeta-1.36 km^3, Sagarejo 0.30 km^3, Signaghi 0.28 km^3 and Dedoflistskaro 0.16 km^3 (Figure 2).

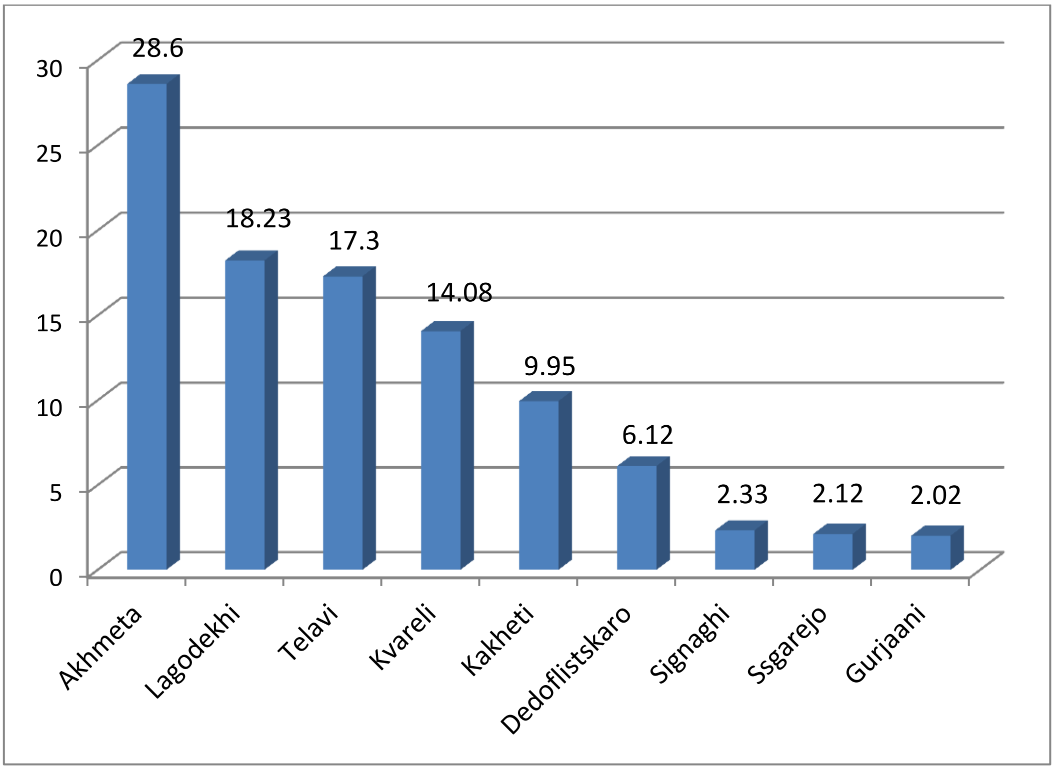

Figure 2. Distribution of water resources of Kakheti per capita according to the Municipalities (1000 m^3)

Distribution of Kakheti underground fresh natural water resources according to the municipalities and water collecting rivers is given in Table 3. The comparative analysis of Kakheti underground fresh water natural resources with the same indices of Georgia's other regions show us that by amount of water resources they are after Abkhazeti (10 264 millon m^3/day), Samegrelo-Svaneti (9 382 million m^3/day) and Imereti (6 448 million m^3/day). At the same time fresh water natural resources are spread unevenly among Kakheti municipalities. This unevenness determines different provision level and deficit of drinking water. The flat lands of river Alazani are artesian basin of considerable fresh water reserves. Besides, the outputs of Alazani's tributaries (especially the left ones) allow the population of Kakheti region to be fully supplied by drinking water. Beside from Kakheti municipalities only Signaghi and Lagodekhi are supplied by 24 hour schedule today. The others have drinking water by different schedule. The same situation is in most villages of the region (Lomsadze et al., 2016).

Table 3. Distribution of Kakheti fresh underground natural water resources according to the municipalities and water collecting rivers

Municipality	Water collecting river	Natural resources, ml.m³/day	Prognostic exploitation resource, ml.m³/day	Demand on drinking/communal water, ml.m³/day	Deficiency (-), excess (+) water resources ml.m³/day
Akhmeta	North Caucasus Alazani	0.318			
	Tushetiis Alazani	0.529			
	Alazali river	1.372			
Akhmeta total	-	2.219	1.109	0.029584	+1.079416
Telavi	Alazani	0.660			
Total	-	o.660	0.330	0.063791	+0.266209
Kvareli	Alazani	0.411			
Total	-	0.411	0.205	0.032526	+0.172474
Gurjaaqni	Alazani	0.515			
Total	-	0.515	0.257	0.046256	+0.210744
Lagodekhi	Alazani	0.411			
Total	-	0.411	0.205	0.028044	+0.176956
Sagarejo	Iori	0.279			
Total	-	0.279	0.139	0.039727	+0.099273
Signaghi	Alazani,	0.104			
	Iori	0,172			
Total	-	0.276	0.138	0,026937	+0.027225
Dedoflistska-ro	Alazani, Iori	0.096			
Total	-	0.096	0.048	0.020775	+0.00645
Kakheti total	-	4.867	2.431		

The sewerage system in Kakheti municipalities is not developed. It more or less functions well in towns (primarily in Telavi and Signaghi). In Lagodekhi and Akhmeta only 50% of the population can use the sewerage system. The main problem of this situation is in absence or amortized old purifying plants. The most part of Kakheti villages are supplied by self-flowing and artesian wells. The most problematic are Signaghi and Sagarejo municipalities. In rest of the municipalities 90% are satisfied by water supply by this or other way. In 2012, 39% from all finances in this field were spent on creation and restoration of old water supplying systems and only 2% on rehabilitation of sewerage systems (Lomsadze et al., 2017). The waters of Alazani and its tributaries are mostly contaminated by organic and biogenic substances influx from unpurified sewerage systems, legal or illegal dust-holes, agricultural lands, drainage and sewage waters. Priorities in this field in future must be: development of sewerage and water purifying systems; working out strategic plans of town development; effective supervision on control and inspection agencies; organization of dust-holes and special grounds for waste products; providing the local population by real information about drinking water condition; enhancing consciousness of the local population concerning waste products management; for security of drinking water supply of the population it is necessary to rehabilitate the amortized pipelines network and headwater systems; for improvement of water supplying of regional population it is necessary to reconstruct or rehabilitate existing water subways and drainage systems; to reduce water losses and purposeless, wasteful use of drinking water the appropriate sanctions must be imposed, along with instalment of water meters; malfunction water purifying and sewerage systems in towns and villages mast be rehabilitated. For improvement of water resources utilization of Alazani-Iori water collecting basin we recommend:

1. Dedoflistskaro presently is supplied by water from "*Djvaris Tskaro*". Its output is 3.5 liter/sec. The second spring *"Dedoflistskaro"*, which located in north-west part of the town, is piped in concrete well, with volume of 210 m^3. From that well on 7 meter distance is located water-tower which supplies the population of the town with water. The *"Dedoflistskaro"* water spring is adjoined with cracked lime bedrocks and by composition belongs to hydrocarbon-chlorine, calcium-magnesium type of waters. The springs output is 2.5 litter/sec. As above mentioned two water springs didn't satisfy the town's demand on water, the horizontal water drainage gallery was built in 3 kilometer's distance of the town, with capacity of 5 litter/sec. So, today, Dedoflistskaro is getting 11 litter/sec volume of water. But town's demand is 14.5 litter/sec. and this difference can be satisfied by constructing a new water-power station which is planned on Lagodekhi's municipal territory, or drilling new bore-holes in Alazani's right bank on alluvial sedimentary rocks.

2. Gurjaani is supplied from river Alazani's water filtrate base. At the 12 kilometre's distance from Gurjaani on Alazani's right terraces is built water-power plant. Presently, from this plant is taken 35 litter/sec water that doesn't satisfy Gurjaani's demand which is 70 litter/sec. In future this demand can be satisfied by reconstruction of existing power plant and constructing a new pipeline. The stratums of water-saturate level are so high, that at the simultaneous work of all pumps, water level is no less than 0.3 m. The construction of a new, more powerful pumps and new 300 mm. pipeline will allow the water supply of 60-70 litter/sec. It will guarantee the demand on water not only today but in future too, as natural water resources are much more, from 0.6 m^3/sec to 3.9 m^3/sec.

3. Telavi is supplied on base of water springs: *"Tbili Tsklebi"*, *"Bursis Tskaroebi"* and *"Naqalaqaris Tskaroebi"*. The *"Tbili Tskaroebis"* water outputs are located on south of the town on 4 km. distance. Its total output is 3 litter/sec. For satisfaction of increased demand on water in 1959-1960 the new water power stations have been built. On 13 km. distance from Telavi to south-west, near Telavi-Gombori road, on the right bank of the river Turdo, there are natural outputs of the spring *"Bursis Tskaroebi"* where two horizontal galleries are built. The total capacity of both is 18 litter/sec up of the river Turdo's flow at 2.8 km. distance, the *"Naqalaqaris Tskaroebis"* natural outputs are put into pipes. It's capacity is 5-8 litter/sec. On different places of town Telavi's territory, there are many water outputs with the total capacity of 25 litter/sec but as these outputs are located on places with dense population and exposed to bacterial contamination, their use as drinking water sauce is not recommended. The total capacity

of Telavi water power plants is 41 litter/sec and it is not enough for satisfaction of town's demand on drinking and communal water. For solving this problem must be used river Alazani's flood lands terrace underground waters, near Shakriani bridge place. It will give us the possibility of getting 100 litter/sec additional amount of water and will satisfy the population demand on water not only today, but in future too.

4. Kvareli is supplied by drinking and communal water from following springs: 1. filtrates of river Duruji; 2. Artesian spring *"Fatmasuri"* and 3. river Bursa's open flow. The capacity of water power plant is 20-25 litter/sec. If we add *"Fatmasuri"* spring water it will make altogether 60 litter/sec but the present demand of Kvareli on drinking and communal water is much more. It can be satisfied by filtrates of river Alazani. This water is characterized by good quality. Its mineralization is 0.2 g/litter. By chemical composition it belongs to hydrocarbon calcium-magnesium type of waters. The construction of new pump tower is just going on with capacity of 80 litter/sec and after beginning of its exploitation Kvareli's demand on drinking and communal water will be satisfied.

5. Sagarejo is supplied by river Tvaltkhevi's underground waters. The water tower is located on 2 km. distance from the town and is the horizontal gallery of 18 m. length. From the gallery the water influx into collecting well and then by means of 150 mm steel pipeline into 400 m^3 volume reservoir. After chlorination the water from reservoir is supplied to the upper part of the town, which is higher than the reservoir and by gravity flow to south, lower part of the town. The water tower's average capacity is 20 litter/sec. In 1958 the additional horizontal gallery was built of 80 m length. This gallery is on 25 m lower than water tower and is built vertically to river Tvaltkhevi flow. The water from the gallery by 200 mm pipeline is supplied to 400 m^3 reservoir. The gallery's capacity is 17 litter/sec. Sagarejo's demand on drinking and communal water is 137 litter/sec. For satisfaction of this demand it is recommended to use artesian underground waters which are acceptable by quantitative, as well as, qualitative points of view.

In Iori-Alazani water basin, as well as, in other parts of Georgia, agricultural water supply is based on small village water ways, or separate wells, which serve limited number of villages. These water ways are much behind than large, cooperated water ways, by water quality, as well as, by cost price of 1 m^3 of water. Iori-Alazani basin agricultural water supply is characterized by dense population. Towns and villages are located very close to each other. So, separation of agricultural water ways isn't reasonable. The schemes of water ways better to be developed in complexly for all natural zones and regions. On base of our research we can conclude that agricultural water supply of Iori-Alazani basin must be developed in future by construction of cooperated large water way systems, which will cover the whole territory of villages and cattle-breeding farms, including towns and enterprises. For such example can be Signaghi water ways that supply Signaghi and Lagodekhi municipalities, the most part of Dedoflistskaro municipality and part of Gurjaani and Kvareli municipalities. The project of west part of Kakhiti cooperated water way has already been worked out and after beginning of its exploitation all villages and town population will be satisfied by water. The control of used water for agricultural supply today is made only by existed water ways, but most part of the population doesn't have their own water ways, so used water isn't registered. Water supply per capita in this region is 578 litter/sec that includes 75 to 80% of communal water sector. These standards are very high and come nearer to town population standards on water use. In Kakheti region we consider the most reasonable in future the construction of group waterways and transmission of water from more secured regions to less secure ones. If we want to estimate human influence on environment we must know the whole amount and quality of water in the whole region. Presently in Alazani water basin there is only one hydrological monitoring station. The amount and quality of water is checked only at one place (Shakriani) near Telavi. At last we must note that the obtained materials about Iori-Alazani water basin don't give us the exact picture of water components and amount of water and its quality, because of absence of perfect data base. Thus, it is necessary to increase the number of hydrological monitoring stations and data base.

CONCLUSIONS

Kakheti region is rich by water resources, including drinking water. But presently the problem is the supplying hypsometrically higher located municipalities by water. This problem can be solved by means of pumping plants. For solution of other problems we recommend: water supplying and sewerage systems rehabilitation and new constructions; supplying of populated areas with these systems; construction of water purifying systems which will secure chemical and bacteriological control of influx waters; estimation of amount of drinking water; organization of drinking water bottling; improvement of drinking water quality according to international standards; enhancement of peoples self-consciousness concerning water objects contamination; systematic monitoring of drinking water quality by modern laboratories; development of centralized water supplying systems for all settlements by means of transmitting water from water secure regions to lesser secure ones.

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