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DRINKING WATER' SAFETY PROBLEMS IN TBILISI

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Abstract

The safety of drinking and recreational water is a difficult and complex task of the water supply and environmental protection organizations of the World. At present, the problem has gone beyond the private interests of a single entity, as it includes, as a daily fulfillment of the population requirements and its health protection, as well as the countries' most important issues of security and sustainable economic development.

Problem urgency in Georgia has become over the last decades due to increment of diseases frequency and rates of infectious diseases of unknown origin, infants and young children mortality, reduction of population life expectancy etc. Taking into the consideration the water reservoirs poor ecological state, drinking water supply infrastructure current state, method and type of technology used in country for water disinfection, can be said that, neither medical scientists nor doctors, and most importantly, the health authorities have been paid no attention to the required level yet.

In the presented article the results of drinking water supply main reservoir of Tbilisi, so called "Tbilisi Sea" ecological state research are discussed. During the scientific survey particular attention has been paid to different kind of algae production in reservoir, polluting drinking water and causing its organoleptic characteristics changes, while the eutrophication process. For the latter' negative impact mitigation or elimination, the recommendations- methods and technical means are proposed.

Keywords: *water supply, reservoir, pollution, concentration, disease.*

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Introduction

Like in many other countries, in Georgia, the providing of potable water for the population and its protection is of utmost importance. However, recent threats of excessive nutrient inputs and future threat of global warming present a great challenge not only to watershed managers but to the entire population. The situation becomes especially troublesome in the last three decades. The majority of reservoirs water quality is deteriorated for recreation and water supply purposes. The carried out research is aimed for population diseases number reduction in Georgia, caused by different algae, existed in drinking water supply reservoirs, that produced in the result of nutrients high concentrations- mainly phosphorus and nitrogen in water, on an example of "Tbilisi Sea".

It is known, that the pollution of fresh water reservoirs due to natural and anthropogenic loading changes the water physicochemical characteristics (increased water temperature and turbidity, water color, odor and taste). The stage of eutrophication is related to the algal biomass or chlorophyll high concentrations. In the result of these phenomena on water surface floating substances are formed, the reservoir bottom is covered by uncharacteristic layers of sediment. The increased concentration of inorganic, organic and toxic substances causes oxygen content reduction. Latter changes environment active reaction, as well as the composition of bacteriological indicators. On the results

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the infection-spreading bacteria is formed. Such reservoirs, not only as drinking water source, but even for irrigation and fishery purposes are become worthless, if not hazardous. The World Health Organization estimates that 80% of the population diseases basically transmitted through the drinking water [1].

Reservoirs management for quality protection is hindered by limited knowledge of the factors of reservoir dynamics and water pollution. The state of this sphere in the World' developed countries has improved considerably in the past decades, scientific understanding of eutrophication has advanced to the point of providing predictive models, that have been used widely in managing of recreational lakes there, although these achievements are neither reflected nor implemented in current policies and practices of Health and Environment protection Ministries of Georgia.

Population growth together with increased food production caused sewage discharges and runoff from densely populated settlements and farms, used chemical fertilizers- nitrogen and phosphorus. Total impact of the latter and continuous contamination leads to: the ecosystem overloading, the sustainability violation, a useful biological products reduction and the water quality deterioration for drinking purpose [2].

During the eutrophication, high number of algae covers water surface as carpet, restricted the penetration of sunlight, resulting in the photosynthesis limitation. The latter prevents the growth of other algae and rooted aquatic plants to shallow depths. Besides, the algae often grow faster than water fleas consume them. Thus, a considerable amount of them will die. When the plants die they decompose due to bacteria and fungi activity. During this process oxygen is consumed and the nutrients are released together with carbon dioxide and energy. Phosphorus and ammonia may also be released into the water, further enriching it with nutrients.

Some particular type of algae, grown in highly nutrient enriched water bodies, blue-green algae or cyan bacteria, and so-called dinoflagellates, release in the water very powerful toxins which are poisonous at very low concentrations. Some of the toxins produce negative effects on the liver of life stock at minimal concentrations, but they can lead to the death of cattle and other animals even to humans when ingested in drinking water at higher concentrations. Under certain favorable conditions these organisms can develop in large quantities-(10^4-10^6 cells/l) of a single or coexisting nuisance species. Development and dissemination of massive harmful algae bloom (HAB) is observed in many lakes of Europe and USA, including the mountains ones of Switzerland, Sweden and Russia, which are located in the northern latitudes [2,3].

According to the World statistics, in 40-50% of water environment eutrophication cases, different type of HAB is produced. These microorganisms' resistant toxic substances infect the nervous, immune, respiratory and digestive systems, which is often fatal ends. Unfortunately, there are not developed neither treatment methods, nor medicines for above mentioned toxin neutralization. According WHO' specialists and experts opinion, the most part of seemingly harmless algae mutates and has deadly impacts on living organisms [4,5]. There have been many incidents throughout the world in which outbreaks of human illness have been associated with the consumption of or contact with water affected by cyan bacteria. Children are particularly at risk because they generally consume a higher volume of water in proportion to their body weight compared to adults [6].

Although, phytoplankton has long been known to use organic nutrients in addition to inorganic ones, increasingly it has become recognized that they do so under natural conditions. Some species use organic nutrients for their nutritional requirements, others to supplement their use of inorganic nutrients, while still others may use organic compounds for their carbon demands as well. The chemical composition of dissolved organic matter exported from agricultural watersheds is not

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known, but can be said that enough quantity is taken up by reservoir plankton communities. The chemical composition and effects of dissolved organic matter on them vary depending on its source, plankton community composition and the season [7,8].

According to some scientist opinion one way to treat and disinfect surface waters where these algae grow and/or to prevent high concentration of organic matter is to use chlorine. Unfortunately this leads to the formation of compounds which may produce or induce cancer -a serious threat to the safety of drinking water supplies [9,10]. Nowadays, scientists are uniform in opinion, that chlorinated water is not good for drink. Before the evaporation, chlorine enters into reaction with other chemical and organic substances. In the result the new class of chemicals - organic chlorine substances- trihalomethanes, not left potable water, are formed. Some of them are the global eco toxicants, possessing powerful mutagen, immune depressant, carcinogenic etc. actions [9,10,11,12,13]. They are collected, both in human organism as well as in biosphere, including air, water, food etc. They poorly are split and collect, both in human organism as well as in a planet biosphere, including air, water, food etc. A doze irritating a skin is 0,0003 milligrams/kg of alive weight, lethal doze for these substances reaches LD_{-50} 0,07 mg /kg, that essentially less than similar size for some fighting poison gases, for example, for zoman, zarin and tabun (about 10-3 g/kg). The American Council of an Environment Quality has asserted that chlorinated water is very dangerous, and sometimes also is fatally dangerous to the human health. The risk of cancer development among people drinking chlorinated water, 2-5 times are higher, than among those who drinks not chlorine contained water. [1,11,13].

Doctor D. M. Price, the doctor of medicine, engaged in studying of dissolved in water chlorine influence, marks: «Cases of a cancer, cardiovascular diseases and senile aphrenia began to meet much more often after people have started chlorinated water drinking». Doctor A.T. Palin, the doctor of philosophy, in article "Chemistry and monitoring of modern chlorination" writes: «As a result of use of chlorine for destruction of pathogenic microorganisms in water, people suffer from arteriosclerosis, heart attacks and even die». Doctor N.V. Volker, approved, that chlorine is the most powerful injuring and killing agent of the present. It has prevented epidemic of one disease, but has created another -cardiovascular ones and a cancer. Doctor Martin Fox considers that as a result of chlorination in water are formed cancer generating substances. Francis T. Mayo, the head of an Environment Researches Municipal Center, said: «chlorine in potable water can promote occurrence of more dangerous diseases, than against what it is used. They even can develop in result seepage (absorption) chlorine through the skin that occurs during the taking a shower or a bath. Scientific researchers have connected chlorine and by-products of chlorination with a cancer of a bladder, a liver, a stomach, a direct and thick gut. Chlorine in water is a principal cause of high arterial pressure and an allergy».

In water-pool or in a bath flying organic products of chlorine evaporate from water, inhalation of these vapors (steam) can put not less harm, than the direct use of chlorinated water. Calculations show that the harm received in bath is equal to the harm received at the use of 2 l. chlorinated water a day. Thus, people which are frequently taking a shower, bath, or swimming in the pool, are in special dangers [1].

So, on the one hand, chlorine has released a civilization from constant danger of the diseases epidemics transmitted through water. On the other hand, the same chlorine creates in the water carcinogenic substances. Chlorine also promotes formation of water unpleasant smell and taste.

Many millions of US dollars are spent each year in the World, for the goal of drinking water general problems solution, among them for water supply reservoirs clearing and sanitation. Unfortunately there is no funding made from the government to solve this problem in Georgia yet, because the problem is not the properly studied and announced at necessary level [6].

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Ecological State of Tbilisi Drinking Water Reservoir

In Georgia there are 45 man-made reservoirs of different ages, sizes and profiles. Majority of them have been built for energetic and irrigation purposes, among them only four ones are multi use water bodies: Zhinvali-520 000 m^3, Sioni-325 000 m^3, Tbilisi sea 308 000 m^3 and Tavztskao-1,3 potable water supply, recreation and irrigation purposes.

Many other reservoirs, due to a combination of overuse a natural aging process, have become impaired, resulting in diminished ecological function, increased sedimentation and diffuse pollution sources, etc. Some important harmful microorganisms reside there during their life phases both in water and in sediments, due to pollution by both organic as well as inorganic contaminants, resulting in their eutrophication. Almost the similar process in "Tbilisi Sea" - (further reservoir), was launched long time ago, but no attention has been paid to this phenomena by that time, by water supply specialists and scientists. Over sixty years after reservoir built, water was only disinfected. Reservoir current state shows, that at more certain conditions revolutionary development of eutrophication is possible, which can cause irreparable damage to the water system and the vital problems to city water consumers, which can be remained without it for several weeks.

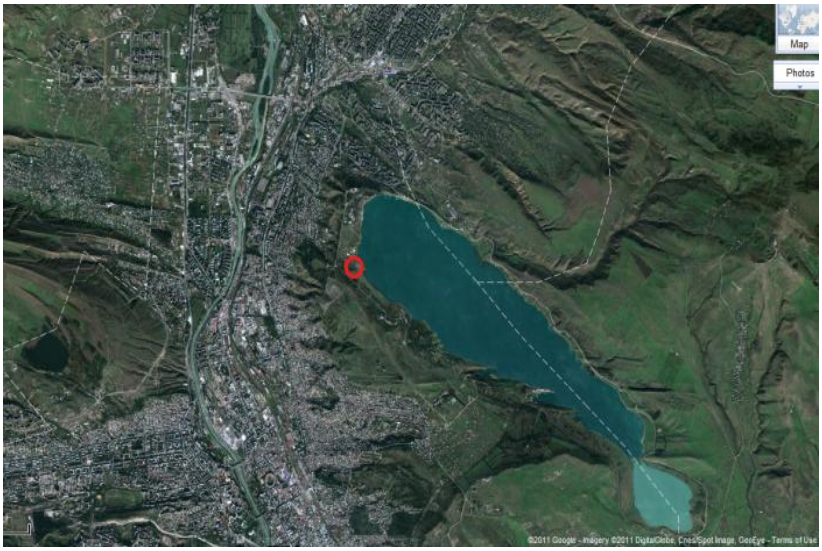

Photo # 1 "Tbilisi Sea" (reservoir)

The reservoir is located in the Northern-east part of Tbilisi city. It has an elongated shape from the Northern-west to Southern-east. Coastline length is 23.9 km., surface area - 11.8 km^2, total water volume is 308 and useful one- 155 million cubic meters respectively; mean depth is 26.6 m, maximal one- 45 m; maximal water level mark is 548 m, while the minimal one- 333 m. Reservoir' natural inflow is negligible. The reservoir is supplied by water, as from Zhinvali reservoir by gravity flow with discharge of Q = 12,5 m^3 / sec, out of which 12.0 m^3 /sec. considered the city's water supply, and 0.5 m^3 / sec. for Samgory agricultural land irrigation, as well as from Sioni' one, by the upper Samgori main channel, with water flow discharge of 6 m^3 / sec, out of which an average 2/3 is used for irrigation. The water rest volume, accumulated in the reservoir, is used for drinking purposes. Total quantity of main contaminants of Zhinvali and Sioni reservoirs, that nourish Tbilisi one is given in Table 1.

ISSN 1512-1461

Table 1.Total quantity of main contaminants of Zhinvali and Sioni reservoirs

#	*Parameters in kg.*	*Zhinvali reservoir*	*Sioni reservoir*
1	Floating pollutant	1 956	990
2	Dry residual	1 065	547,4
3	Organic substances	214 974	107 490
4	Nitrogen total	47 024	23 360
5	Phosphates	5 820	2 910
6	Potassium	15 820	7 725
7	Chlorines	140	69,1
8	BOD	90 254	45 127
9	COD	26 1064	130 532
10	Fe total	7,7	3,9
11	E.coli 10^6 units/l.	2,35	1,18

During the research carried out, throughout the period of 2013-2014. Particular attention was paid to phytoplankton and HABs' development processes, because mainly they determine changes of water organoleptic indicators and impact on water safety. Such an approach is explained by the fact, that most of water pollution indicators partly meet the WHO requirements [1]. In summer season, when water consumption reached its highest level, the most densely populated districts of Tbilisi, reservoir water' major users, basically were complained to unpleasant odor and taste of drinking water, the main reason of which was different algae existence in the water.

Water sampling, handling and storage, chemical, biological and bacteriological examinations were carried out according to standard sampling technique described in ISO 5667-3 and ISO 5667-4 for lakes and reservoirs [14,15]. The laboratory analysis of reservoir water samples quality has shown that: water sometimes belongs to very polluted, sometimes to bacteriological clean category, coli-index mostly was not exceed 1000 units / l, but in certain cases it reached high value equals to 24000/50000 units / l. The existence of nitrites in natural surface waters at value of 0,005mg/l, demonstrates its fecal contamination. Nitrate quantity did not exceed- 5,8 mg/l. Phosphates values were ranged in 0,04-0,05 mg/l. See table 2.

Tabl. 2 Results of laboratory analysis of reservoirs water

№	Paramrs / Sampl. objects	DO mg/l	Oxid satur ation %	Permanga nate oxid- On 0_2 mg/l	Bichrom. oxid- On 0_2 mg/l	NH_3 mg/l	Nitrites mg/l	Nitrates mg/l	Phosphates mg/l	Oil products mg/l	Phenols mg/l	BOD mg/l	E.coli units/l
1	2	3	4	5	6	7	8	9	10	11	12	13	14
2	Zhinvali reservoir	8,2-13,4	> 100 –	0.8-3,0	1.,8-14,3	0,00	0,00	0,3-1,6	0,04	0,00-0,002	0,00	1,0-7,3	2400

ISSN 1512-1461

3	Tbilisi reservoir	8,0-12,0	95-100	1,0-2,9	2,5-17,1	0,00	0,005	1,4--5,8	0,04-0,05	0,01	0,00	1,8-8,1	24000 /50000
3	Sioni reservoir	7,1-8,5	100	1,0-4,3	1,7-21,9	0,01	0-0,03	0,3-0,6	0,05	0,01	0,005	1,5-2,7	2400

The examination of the algological samples from reservoir shown that the total number of 95 taxis were identified out of 7 divisions, presented in Tbilisi reservoir. The main algae are: 1. Blue-greens – ***Cyanobacteria***; 2. Greens - ***Cylorophyceae***; 3. Diatoms - ***Diatomeae***; 4. Desmines - ***Desmidiales***; 5. Pyrrophita - ***Peridineae***; 6. Volvokses- ***Volvocales***; 7. Eugilines - ***Euglenineae***. They cover water' surface and float along the coastline at width of 15-85 m.
The observation, made in the spring, has shown that mainly the diatomaceous algae (***Melosira, Asterionella, Fragilaria da Naviculaceae***) were developed and spread. The number of cells per liter was varied between 40 to 165 thousand units.

During observations were revealed some other types of algae, including toxic one, presented by Anabeana. In spring its number was at quantity of 1000-3 500 cells/l. but in summer – concentration was increased approximately twice, depending on distance from water inflow point and wind direction respectively.

From our point of view, the presence of these algae in water was the main reason of its unpleasant odor and taste, and one of the key problems of drinking water poor quality. The Tbilisi reservoir water generally has the soil and fish odor and taste. For the aim of water odor and taste elimination generally more quantity of chlorine (double doze) is used. That is why in such cases- in mid-spring and summer, water had white color, chlorine odor and taste. Unfortunately this leads to the formation of compounds which may produce or induce cancer- a serious threat to the safety of drinking water supplies [10].

Concerning to other pollution sources of reservoir, it is very important to say, that close to it the communal waste dump place is located, where for the waste disinfection chlorine powder is used. During the stormy winds period, the chlorine-content waste burning products and the chlorine powder itself, as smog are propagated over the reservoir, particles of which deposited in water.

Unfortunately, in Georgia there are not neither HABs' toxins, nor THMs' detecting laboratories. All above said, contributes to the deterioration of drinking as well as recreational waters quality, making them unsuitable for consumption and unacceptable in view of health protection standards.

The problem with HAB development in other reservoirs, among them of recreational ones, almost reached alarming proportions. With the goal of recreational and drinking water quality improvement by the way of algae number reduction, among the available methods of ecosystem management, some technical and technological solutions, acceptable for the country's budget, were selected: Bio-manipulation; Biochemical, Mechanical, and Aeration methods.

ISSN 1512-1461

General Recommendations for Reservoirs Water Quality Improvement in Georgia

With the goal of fresh water quality improvement, according to international standards requirements, it is necessary to implement the following measures:
1. The independent expert ecologists group, equipped with the modern measuring technologies, has to be established, which will carry out continuous monitoring and control over water quality, both of the reservoir as well as of its nourishing sources;
2. Taking into the consideration changed environmental conditions, for all such reservoirs sanitary protected zones boundaries have to be revised and new ones have to be developed. Strict control has to be carried out over the execution of sanitary protection zones requirements;
3. On the basis of new data and calculated forecast, the study of the water system stability during evolution process has to be conducted, with the goal to provide no more deviations than allowed ones;
4. Within the opportunities and requirements, all kinds of complex microbiological, sanitation, physical and chemical criteria of the water quality have to be determined;
5. Appropriate governmental body has to be carried out an implementation of environmentally safe measures of water resources integrated management, including the protection of freshwater ecosystems and the living resources. For this goal the freshwater and coastal ecosystems' resources management strategy has to be developed immediately;
6. In order to improve the protection and maintenance of water resources have to be tightened the requirements against polluters and the severity of sanctions even by increasing of penalties;
7. The relevant government agencies have to: conduct control over the sanitary and preventive measures of industrial facilities, encourage the construction of water treatment facilities, equipped with the modern, clean, safe technologies, their development and implementation in country, design and operation of landfills on the basis of reliable meteorological, hydro-geological and environmental expertise results;
8. The Ministries of Health and Environment protection have to develop the research programme of polluted water negative impact on human health, with the goal of drinking and recreational water reservoirs protection by the way of scientifically proved measures implementation;
9. Method of drinking water disinfection as well as sewage one by the chlorination, has to be changed by the method using hypo (sodium hypo chloride), as more effective and harmless substance, that does not impact on water ecosystems' biodiversity and living organisms' development ability;
10. In the country big cities has to begin the implementation of an environmental culture. Using the mass media, public health and civil society organizations have to provide population with the information, that directed to drinking and recreational water quality improvement;
11. The water sanitary items teaching in country' primary schools, has to be introduced. Pupils have to be explained a connection between their health and clean water, between clean water supplies and its cost for the population.

Conclusions

- Over the last decades in Georgia increase the frequency and number of infectious, cardiovascular and cancer diseases, significant part of which, presumably caused by polluted drinking water. Actually, in country there is no the clearing construction, that dumped water would answer WHO specifications;
-Though many agricultural complexes in Georgia are not operated any more, but manure and fertilizers huge weights, continuing waters pollution, in the result of which in almost all recreational and drinking water supply reservoirs, the eutrophication processes of different rate are observed. Among them in Tbilisi reservoir which water has the soil and fish odor and taste, caused by algae;

ISSN 1512-1461

-Degraded water quality from increased nutrient pollution promotes the development and persistence of many HABs and is one reason for their expansion in water bodies. The composition-not just the total quantity-of the nutrient impacts HABs. Both chronic and episodic nutrient delivery promotes HAB development;
-Recently developed tools and techniques, removing the algae from water bodies are not available in country. Also there are neither HABs prediction methods nor their toxins and trihalometans determining laboratories in Georgia. That is why in the scientific reports and articles, connected with the reservoirs ecological state, only poor information can be found.
-In lots of countries different kind of methods and technologies are used for algae removal from water body, but for GWP the chlorination is the cheapest and consequently most profitable way for water disinfection, unpleasant odor and taste neutralization that is harmful for our citizens' health. Unfortunately the health and environment protection governmental bodies have paid no attention to this problem at a required level yet.

In the submitted material we only have tried to designate a problem in general with the goal to attract attention of governmental bodies responsible for our population health safety. Meanwhile, it is much deeper and complex, that needs to carry out more serious scientific researches, by group of experts in sphere of water ecology and health protection, that have to be funded by Georgian government.

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