Littoral Benthic Macroinvertebrates and Their Correlation with the Chemical Composition of Water in theTbilisi Reservoir

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Abstract

Benthic macroinvertebrates are sensitive to any kind of changes in the aquatic environment. The distribution, taxonomic composition and relative abundance of benthic invertebrates are strongly affected by the availability and quality of feeding resource, sediment type, substrate and water quality. For this reasons benthic macroinvertebrates traditionally served as reliable bioindicators to detect and identify changes in water systems. The aim of the proposed study was to analyze taxonomic composition of the Tbilisi water reservoir littoral benthic macroinvertebrates and their relationship with chemical characteristics of water.

Tbilisi water reservoir (Tbilisi Sea) is located in the northern part of Tbilisi – N 41.75, E 44.85. Surface area is 11.6km^2, maximum depth – 43 m, average depth – 26.6 m, water volume - 300 million m^3. Filling of the reservoir started in 1951 by 11-km channel from the Iori River. Initially the reservoir was supplied only from Iori River. With time, the water level decreased significantly and its filling became possible only in 80-ies, after launching of Zhinvali Hydropower plant (N 42.09, E 44.45). Currently Tbilisi water reservoir is fed from the Iori River and mostly from the Aragvi River. Before filling the reservoir, there were three shallow saline lakes: Avchala (Kukia), Ilguniani and Avlabari lakes.

6 main benthic groups were determined during the research (2008, 2009): Oligochaeta, Ostracoda, Amphipoda, Chironimidae (Diptera), Ephemeroptera, Trichoptera, represented by different amounts depending on seasons. Presently the biomass of the benthic groups show drastic decline.

Among collected zoo material only Oligochaeta representatives were identified to the species level: 9 species were described. Correlation between these species and organic pollution was analyzed. Positive correlation with the organic pollution was detected in three cases: with *Nais psaudobtusa, Vejdovskyella intermediate*and *Chaetogaster Langi*. These 3 species were not recorded in the Tbilisi Water Reservoir in 1964. Negative correlation with the organic pollution was identified in five cases: *Dero obtusa*, *Uncinais uncinata*, *Amphichaeta leydigi*, *Limnodrilushoffmeisteri*, *Aulodrilus pluriseta*. None of them was detected in the samples after increase of permanganate oxidation and COD, although all five were detected in 1964. Comparison of the current results of complex hydrochemical and hydrobiological studies with the results of the similar studies carried out 40 years ago revealed eutrophication process in the reservoir.

Introduction

According to the EU adopted Water Framework Directive [1] the surface waters in Europe, must achieve a good ecological quality by the end of 2015. The priority areas for cooperation were agreed between the Georgian government and the European commission in the Country Strategy Paper 2007-2013 under the European Neighborhood and Partnership Instrument. The plan identifies priority actions for key environmental sectors including study of surface water bodies and their management [2]. EU Water Framework Directive implementation is envisaged in the Annex XXVI of the EU – Georgia Association Agreement, signed on 27th of June 2014 and ratified by the European parliament

on 18th of December 2014.Therefore, gathering information on the current conditions of water resources and planning their monitoring programs are of key importance [3-5].

Water reservoirs provide many benefits to society. The physical transformations in a lentic and lotic systems due to anthropogenic influences, significantly alters the physical [6, 7, 9], chemical [7, 8], and biological water characteristics [9-12]. Benthic macroinvertebrates represent one of the sensitive taxonomic groups to any kind of changes in the aquatic environment. The distribution, taxonomic composition and relative abundance of benthic invertebrates are strongly affected by the availability and quality of feeding resource, sediment type, substrate, and water quality [13-15]. For this reason benthic macroinvertebrates historically served as good bioindicators to detect and identify changes in water systems. Composition and distribution of macrobenthic community are used in ecological monitoring programs, and is an important ecological tool to describe spatial and temporal changes in water ecosystems [16-18].To use benthic animals in the assessment of temporal trends and changes in aquatic ecosystems, it is important to collect baseline information on the taxonomic composition and distribution of the species within a freshwater system and identify their correlation with the physical and chemical environment. The aim of the proposed study was to analyse taxonomic composition of benthic macroinvertebrates of the Tbilisi water reservoir and to identify their relationship with chemical characteristics of water.

Materials and methods

Tbilisi water reservoir is located in the northern part of Tbilisi (N 41.75, E 44.85), between Mt. Makhata and Outer (Gare) Kakheti upland. It belongs to Samgori irrigation system. Length of water reservoir is 11 km; width varies, with a maximum width of 2.5 km. Surface area is 11.6km^2, maximum depth – 43 m, average depth – 26.6 m, water volume - 300 million m^3. This large basin was filled artificially through 11-km channel from the Iori River in 1951 [19]. Initially the reservoir was supplied only from the Iori River. With time, the water level decreased significantly and its filling became possible only in 80-ies, after launching of Zhinvali Hydropower plant. Currently Tbilisi water reservoir is fed from the Iori River and mostly from the Aragvi River. Bottom of the reservoir is almost ideally flat, sloped southwards, with elevated banks. Before filling, there were three shallow saline lakes: Avchala (Kukia), Ilguniani and Avlabari lakes [19].

The first investigation of living forms of the reservoir date back 1952-1954 and were conducted by the Institute of Zoology; later in 1963-1964 more comprehensive study was conducted [19,20]; the benthic fauna of the point Telianiskhevi was studied separately [21] (Fig.1).

In 2008, 2009benthos samples, simultaneously with water samples were taken in the littoral zone of the Tbilisi water reservoir at preselected locations: point 1–Riv. Iori entrance to the reservoir (small lake); point 2 – Telianiskhevi, near to research station of the Institute of Zoology; point 3 – north-west part of the reservoir (Fig.1).

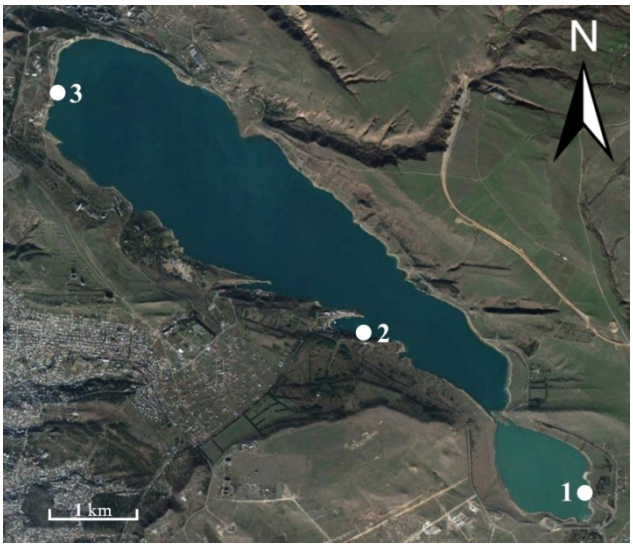

Fig. 1. 1 –Riv. Iori entrance to the reservoir (small lake), 2 – Telianiskhevi, near to research station of the Institute of Zoology, 3 – north-west part of the reservoir.

Benthos samples were taken by kick-net at the border zone of each station. Transect of minimum 10 m long were established at all three locations and samples were collected. Initial cleaning of the samples from the bottom sand and silt took place in situ; then the samples were placed in 4% formalin. Washing in water current and floating methods were used at the laboratory for cleaning the samples. Cleaned samples were sorted by Bogorov chamber under the microscope. Density (absolute number of individuals of each group) was calculated. Spring weight (0.5 mg accuracy) was used for specimen weighting.

Water samples for chemical investigation were taken for each sampling locality. Active hydrogen reaction (pH) and dissolved oxygen (DO) was measured by Extech instruments. Quantities of dissolved carbon dioxide and hydrogen sulphide were measured by titrimetry. Among the indicators of the general level of mineralization the hydrocarbonates, carbonates, sulfates, chlorides and water hardness were measured by titrimetry; potassium and sodium ions were measured by flame photometer; biogenic elements were measured by spectrum photometry method; bichromatic and permanganate oxidation by titrimetry; and biochemical oxygen demand (BOD) by Winkler's method [22, 23].

Results

Macroinvertebrates: following zoo-benthic groups were found in 2008: Oligochaeta, Ostracoda, Amphipoda, Chironimidae (Diptera), Ephemeroptera, Trichoptera. Summer samples were dominated by Trichoptera and Chironomidae – 43.48% and 36.96% respectively, followed by Ephemeroptera (10.87%),Oligochaeta(4.35%), Amphipoda (3.26%) and Ostarcoda (1.09%), while benthic fauna of autumn samples was mainly composed by Chironimidae (67.50%) and Trichoptera (24.17%), followed by insignificant amount of Ephemeroptera (4.17%), Amphipoda (3.33%) andOstracoda (0.83%). Oligochaeta were not detected in the autumn samples.

Only 3 groups of benthic fauna were registered in spring 2009 dominated by Oligochaeta (63.16%), followed by Chironomidae (26.32%) and Amphipoda (10.53%). In summer and autumn 2009 benthic macroinvertebrates had following composition: Oligochaeta, Ostracoda, Amphipoda and Chironomidae.The dominant group for both seasons of the year was Chironomidae 32.55% (in summer) and 76.58% (in autumn) respectively. In summer samples Chironomidae were followed by

Ostracoda (25.94%), Oligochaetaand Amphipoda (20.75% each group), while in autumn samples Chironomidae were followed by Oligochaeta (9.01%), Ostracoda (8.11%) and Amphipoda (6.31%). Trichoptera and Ephemeroptera were not registered in 2009 (Fig. 2).

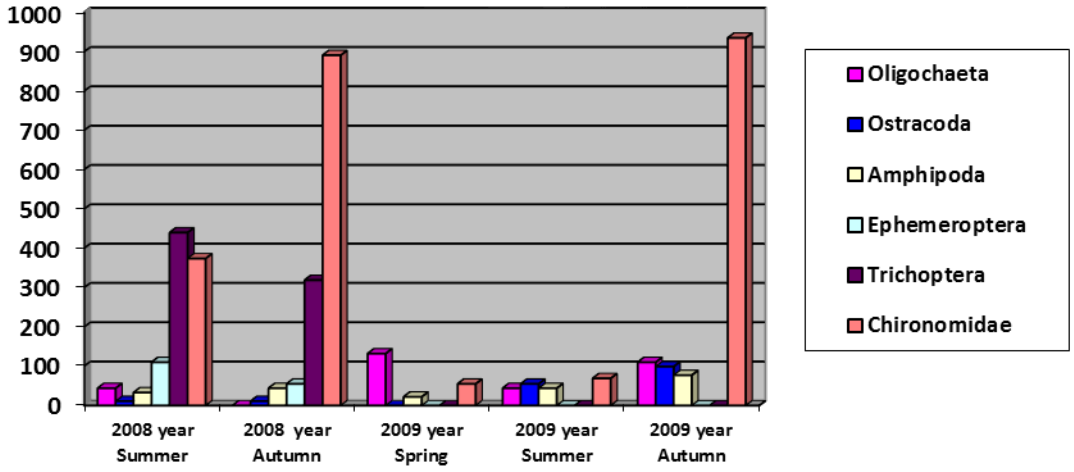

Fig.2. Quantitative chart of the benthic macroinvertabrates in 2007 and 2009.

Annual biomass of benthos in 2008 equals to 1304 mg/g², whilein 2009, equals513 mg/g².

Ologochaeta was the only group which was identified to the species level: 9 species were identified - *Vejdovskyella intermedia* (Bretscher, 1896); *Nais pardalis* Piguet,1906; *Nais simplex* Piguet, 1906; *Nais pseudobtusa* Piguet,1906; *Ophidonais serpentina* (Muller,1773); *Chaetogaster langi* Bretscher, 1896; *Aulodrilus pigueti* Kowalewski,1914; *Limnodrilus claparedeanus* Ratzel, 1868 and *Tubifex tubifex* (Muller, 1774). *Vejdovskyella intermedia* (Bretscher, 1896) was first registered in 2001 [21]. 11 species of Oligochaeta were registered in 2001 there. *Amphichaeta leydigi* and *Enchytraus* sp. were not found in our recent samples. The Enchytraeidae family is common in water with high content of oxygen [24, 25].

Trichoptera and Ephemeroptera were registered only in the samples from the point Telianiskhevi.

According to classification of the natural waters by O.A. Aliokin [22] the analyzed

Water belongs the hydrocarbonate class, calcium group, type II (HCO_3^-<Ca^{2+} +Mg^{2+}< HCO_3^- +SO_4^{2-}). In each sample 16 chemical parameters were measured.

Table 1. Water Chemical characteristics of Tbilisi reservoir

Parameters	2008 Spring	2008 Autumn	2009 Summer	2009 Spring	2009 Autumn
pH	8,57	8,3	9	8,6	8,28
HCO_3^- (mg/l)	170,8	146,4	158,6	207,4	146,4
NO_2^- (mg/l)	0,002	0,003	0,002	0,005	0,01
NO_3^- (mg/l)	0,088	0,26	0,08	0,2	0,1
NH_4^+(mg/l)	<0,04	0,04	0,04	0,15	0,3
SO_4^{2-} (mg/l)	80	54	50	50	10

Cl^- (mg/l)	8,51	2,84	19,87	12,2	9,93
Ca^{2+} (mg/l)	52,44	34,2	56,8	52,8	38,4
Mg^{2+}(mg/l)	4,61	14,45	4,37	14,06	12,14
$Na^+ + K^+$(mg/l)	-	20,93	22,54	22,08	3,22
DO (mg/l)	12,2	7,78	8,38	12,48	6,72
BOD(mg O_2/l)	3,6	0,81	1,09	3,7	1,15
Permanganate-Ox (mg/l)	9,6	8	17,94	24	9,28
COD(mg O/l)	24	20	45	60	23,2
TOC (mg/l)	9	7,5	16,875	22,5	8,7
TDS (mg/l)	197,36	298,82	357,16	418,54	243,39

Active water reaction (pH) in all cases was alkaline, withrange - 8.3-9.0. In spring, pH increased up to 8.57-9.0due to increase of viability of phytoplankton, together with the intensification of photosynthesis,while inautumn pH decreasedto 8.28-8.3. When pH was low the abundance of *Chironomidae* increased, while abundance of Trichoptera, Ephemeroptera and Ostracoda decreased; the Trichoptera case was the most explicit.

During the study period dissolved oxygen varied from 6.72 to 12.48 g/L. Daily and annual dynamics of oxygen is not limited to phytoplankton activity, because its photosynthetic impact is insignificant.

Among biogenic elements, content of $N–NH_4^+$ in the water samples varies from 0.04 to 0.3 mg/L; $N–NO_2^-$ – from 0.002 mg/L to 0.01 mg/L; $N–NO_3^-$ – from 0.088 mg/L to 0.26 mg/L. By season, water hardness (content of Ca^{2+}, Mg^{2+} ions) is quite stable. A total suspended solid matter (TDS) varies within 197.36-418.54 mg/L.

Discussion

We compared obtained chemical and hydrobiological data with the previously existing data [19, 20]. The comparison demonstrated that the highest biomass was registered in 1953 – 2309 mg/g², drastic decline of benthos biomass took place in 2009 (Fig.3).

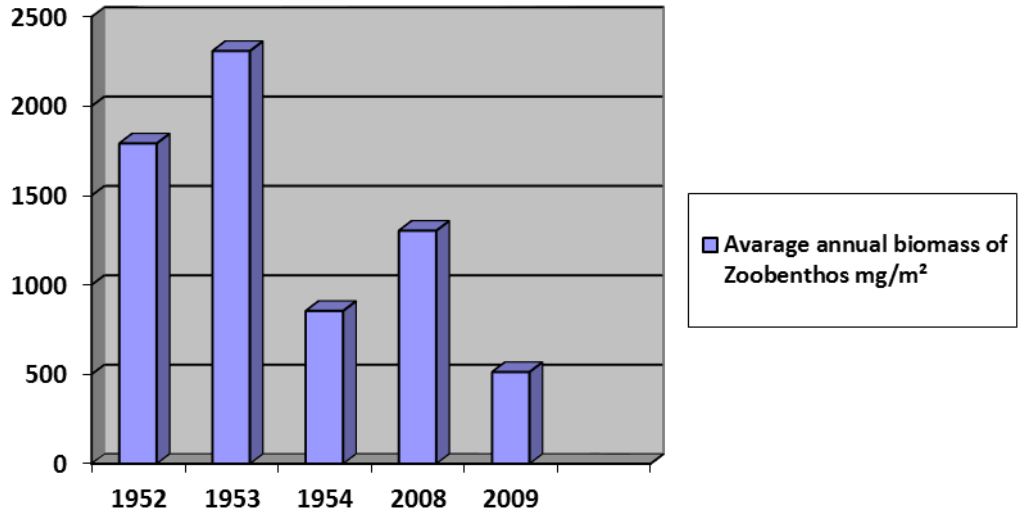

Fig. 3. Zoo benthos anual biomass in 1952, 1953,1954, 2007, 2009.

Analysis revealed a correlation of certain species oligochaetes with the water pollution by organic matter (table 2). Thus some of the identified species of oligochaetes could be regarded as potential indicators of water pollution.

Table 2. The species of Oligochaetes distributed in the Tbilisi Reservoir and their correlation with the Chemical Oxygen Demand (COD).

№	Species of Oligochaeta	1964		2008		2009		Relation to COD mg O/l
		species in sample	COD mg O/l	species in sample	COD mg O/l	species in sample	COD mg O/l	
1	*Ophydonais serpentina* (Muller,1773)	⊕	**7.6-9**	⊕	**20-24**	⊕	**23.2-60**	⊗
2	*Nais pardalis* Piguet,1906	⊕		⊕		⊕		⊗
3	*Nais simplex* Piguet,1906	⊕		⊕		⊕		⊗
4	*Nais pseudobtusa* Piguet,1906	∅		⊕		⊕		**(+)**
5	*Uncinais uncinata* Oersted,1842	⊕		∅		∅		**(-)**
6	*Vejdovskyella intermedia* Bretscher, 1896	∅		⊕		⊕		**(+)**
7	*Dero obtuse* Udekem, 1855	⊕		∅		∅		**(-)**
8	*Aulodrilus pigueti* Kowalewski,1914	⊕		⊕		⊕		⊗
9	*Aulodrilus pluriseta* Piguet,1906	⊕		∅		∅		**(-)**
10	*Chaetogaster langi* Bretscher, 1896	∅		⊕		⊕		**(+)**
11	*Limnodrilus hoffmeisteri* Claparede, 1862	⊕		∅		∅		**(-)**
12	*Limnodrilus claparedeanus* Ratzel, 1868	⊕		⊕		⊕		⊗
13	*Amphichaeta leydigi* Tauber,1879	⊕		∅		∅		**(-)**
14	*Tubifex tubifex* (Muller,1774)	⊕		⊕		⊕		⊗

⊕ - Species presentin the sample. ∅ - Species absent in the sample.(+) – positive correlation to COD, (-)– Negative correlation to COD,(⊗)No correlation.

COD comprised 7.6-9mg O/L, in the data of 1964, while in 2008-2009 this number increased up to 20.0-60.0 mg O/L. Positive correlation with the organic pollution was detected in 3 cases; *Nais*

psaudobtusa, *Vejdovskyella intermedia* and *Chaetogaster langi*. These 3 species were not recorded in the Tbilisi Water Reservoir in 1964, while in 2008-2009 they were detected. Negative correlation with the organic pollution was identified for five species: *Dero obtusa*, *Uncinais uncinata*, *Amphichaeta leydigi*, *Limnodrilushoffmeisteri*, *Aulodrilus pluriseta;* none of them were detected in the samples after increase of permanganate oxidation and COD, although all five were detected in 1964. No such correlation was detected for other species.

Comparison of the results of complex hydrochemical and hydrobiological studies with the results of similar studies 40 years ago allows us to evaluate current condition of the water quality in the Tbilisi Reservoir. Since 60-ies of 20th century content of chemical oxygen demand (COD) increased significantly -more than 3 to 6 times, yet, COD content in the analysed water is not too high. Increase of COD is characteristic for eutrophication process. It is important to continue sampling and sample analysis for father comprehensive study.

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სანაპირო ზოლის ბენთოსის მაკროუხერხემლოები და მათი კავშირი წყლის ქიმიურ მაჩვენებლებთან, თბილისის წყალსაცავი

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ჟ. შუბითიძე, მ. გიოშვილი

რ ე ზ ი უ მ ე

ბენთოსური მაკროუხერხემლოები წყლის გარემოში ნებისმიერი ცვლილებების მიმართ მგრძნობიარე ტაქსონომიურ ჯგუფს წარმოადგენს.

ბენთოსური მაკროუხერხემლოების განაწილება, ტაქსონომიური შემადგენლობა და სიმჭიდროვე მკაცრადარის დამოკიდებული საკვები რესურსების ხელმისაწვდომობასა და ხარისხსზე, ფსკერის ტიპზე, სუბსტრატზე და წყლის ხარისხსზე. ამის გამო ბენთოსური მაკროუხერხემლოები ისტორიულად ცნობილია, როგორც კარგი ინდიკატორები წყლის ეკოსისტემაში მიმდინარე ცვლილებების აღმოსაჩენად.

წარმოდგენილი კლევის მიზანი იყო თბილისის წყალსაცავის სანაპირო ზოლის ბენთოსური მაკროუხერხემლოების ტაქსონომიური შემადგენლობის შესწავლა და მისი კავშირი ქიმიურ მაჩვენებლებთან. თბილისის წყალსაცავი თბილისის ჩრდილოეთით მდებარეობს (N 41.75, E 44.85). ზედაპირის ფართობი 11.6კმ^2 –ია, მაქსიმალური სიღრმე – 43 მ, საშუალო – 26.6 მ, წყლის მოცულობა - 300 მლნ. მ^3. წყალსაცავის შევსევბა 1951 წელს დაიწყო, 11 კმ-იანი არხით მდ. იორიდან. თავდაპირველად წყალსაცავი მარაგდებოდა მხოლოდ მდინარე იორიდან, დროთა განმავლობაში წყლის დონე მკვეთრად შემცირდა და წყალსაცავის შევსება მხოლოდ ჟინვალის ჰესის (N 42.09, E 44.45) ამუშავების შემდეგ გახდა შესაძლებელი, 80-იან წლებში. ამჟამად თბილისის წყალსაცავი მარაგდება მდინარე იორისგან და მეტწილადმდინარე არაგვისგან. შევსებამდე წყალსაცავის ადგილას იყო მხოლოდ 3 პატარა თხელწყლიანიმლაშე ტბა: ავჭალა (კუკია), ილგუნიანი და ავლაბრის ტბები.

კვლევის განმავლობაში (2008, 2009 წწ) სეზონების მიხედვით, განსხვავებული თანაფარდობით 6 მთავარი ბენთოსური ჯგუფი იქნა რეგისტრირებული: *Oligochaeta, Ostracoda, Amphipoda, Chironimidae (Diptera), Ephemeroptera, Trichoptera*. ბენთოსური ორგანიზმების ბიომასის გამოთვლის შედეგად დადგინდა მისი მკვეთრი შემცირება წარსულის მონაცემებთან შედარებით.

მოპოვებული ჯგუფებიდან სახეობის დონემდე მხოლოდ ოლიგოქეტების ჯგუფი იქნა შესწავლილი. შეგროვებული მასალის კვლევის შედეგად გამოირკვა ოლიგოქეტების 9 სახეობა. გაანალიზებული იქნა ორგანულ დაბინძურებასთან ოლიგოქეტების კორელაცია. დადებითი კორელაცია გამოვლინდა 3 სახეობის შემთხვევაში, ესენია: *Nais psaudobtusa, Vejdovskyella intermedia and Chaetogaster langi*, აღსანიშნავია, რომ აღნიშნული სახეობები გასული წლების კვლევებში არ იყო დაფიქსირებული. უარყოფითი კორელაცია გამომჟღავნდა 5 სახეობის შემთხვევაში,

ესენია: *Dero obtusa, Uncinais uncinata, Amphichaeta leydigi, Limnodrilushoffmeisteri, Aulodrilus pluriseta,* კვლევის პერიოდში, წყალში პერმანგანატული დაჟანგულობის და ჟანგბადის ქიმიური მოხმარების მაღალი მაჩვენებლების შეთხვევაში არცერთი მათგანი არ დაფიქსირებულა.

მიღებული შედეგების შედარებამ 40 წლის წინანდელ მსგავს ჰიდრობიოლოგიურ და ჰიდროქიმიურ კვლევევის მაჩვენებლებთან აჩვენა, რომ წყალსაცავში მიმდინარეობს ეუტროფიკაციის პროცესი.