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COMPARATIVE INVESTIGATION OF THE RIVER PHYTOPLANKTON OF THE DEBED RIVER CATCHMENT BASIN'S MINING AND NON-MINING AREAS

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Phytoplankton quantitative and qualitative parameters in the Kachachkut, Alaverdi (Lalvar), Akhtala and Shnogh rivers of the Debed river catchment basin were investigated in 2017. Comparative analysis of the river phytoplankton composition of mining and non-mining areas showed comparatively low phytoplankton diversity in the Alaverdi, Akhtala and Shnogh rivers being at the risk of mining impact. Phytoplankton community in the risky sites, especially in the Alaverdi and Akhtala rivers was stressed.

Rivers – phytoplankton – mining activity – risks

2017 թ. կատարվել է Դեբեդ գետի ջրահավաք ավազանի Կաճաճկուտ, Ալավերդի (Լալվար), Ախթալա և Շնող գետերի ֆիտոպլանկտոնի քանակական և որակական ցուցանիշների ուսումնասիրություն: Յանքարդյունաբերական և ոչ հանքարդյունաբերական տարածքների ֆիտոպլանկտոնային կազմի համեմատական վերլուծությունը ցույց է տվել ֆիտոպլանկտոնի համեմատաբար աղքատ բազմազանություն հանքարդյունաբերության ազդեցության ռիսկայնություն ունեցող Ալավերդի, Ախթալա և Շնող գետերում: Ֆիտոպլանկտոնային համակեցությունը ռիսկային հատվածներում, մասնավորապես՝ Ալավերդի և Ախթալա գետերում գտնվում էր ճնշված վիճակում:

Գետեր – ֆիտոպլանկտոն – հանքարդյունաբերական գործունեություն – ռիսկեր

В 2017 году были исследованы количественные и качественные параметры фитопланктона в реках Качачкут, Алаверди (Лалвар), Ахтала, Шног, водосборного бассейна р. Дебед. Сравнительный анализ состава фитопланктона горнодобывающих и негорнодобывающих территорий показал сравнительно низкое разнообразие фитопланктона в реках Алаверди, Ахтала и Шног, подвергающихся риску воздействия горнодобывающей промышленности. Сообщество фитопланктона на рискованных участках, особенно в реках Алаверди и Ахтала, были в стрессовом состоянии.

Реки – фитопланктон – горнодобывающая деятельность – риски

The Debed river catchment area is situated in Lori Marz (administrative district) located in the north of the Republic of Armenia. This area is considered one of industrial centers in Armenia where mining and metallurgical industries are highly developed.

Giving priority to the development of economic sphere, the possible environmental effects of metallurgical industrial activities have been ignored or little attention has been paid. The insufficient management of discharges induced by mining activities in the Debed river catchment area has become a serious threat to aquatic ecosystems and biocommunities. Water in contact with mine deposits often contains large amounts of pollutants such as heavy metals. This can have a devastating impact on surrounding aquatic environments [11]. There are many studies on the hydrobiological effects of mining activities. Investigations carried out by different authors showed that metallurgical industrial activities affecting different types of water bodies caused the loss of the diversity of benthic and planktonic communities [10, 11, 14, 15, 18, 19]. Planktonic algae are microscopic plants living in the aquatic environments. They are vital primary producers for both marine and freshwater ecosystems. Algae are frequently found in polluted and unpolluted water and reflect the average ecological condition of the water environments. Their growth is influenced by many different processes ranging from physical, chemical to biological and ecological processes and more [13]. The impact of mining industrial activities on algal growth can be expressed by the violation of the processes of photosynthesis, respiratory metabolism, secondary metabolite synthesis [5]. The aim of the present study was to conduct the comparative analysis of the river phytoplankton composition of the Debed river catchment basin's mining and non-mining areas.

Materials and methods. Phytoplankton community in the Kachachkut, Alaverdi (Lalvar), Akhtala and Shnogh rivers of the Debed river catchment basin was investigated. Phytoplankton samples were taken from the risky (Alaverdi, Akhtala and Shnogh) and non-risky (Kachachkut) river sites of the Debed river catchment area in April, July and September of 2017 (tab. 1).

Table 1. Coordinates of rivers investigated site

River site location	N/Lat	E/Long
Kachachkut river mouth	41°04'55.2"	44°37'07.2"
Alaverdi river mouth	41°05'56.8"	44°39'28.8"
Akhtala river site located near the river mouth	41°08'57.3"	44°46'56.0"
Shnogh river site located near the mouth	41°09'04.1"	44°49'49.3"

A 1-liter water sample taken from each site was preserved with 40% formaldehyde solution (0.4% final concentration) and stored in a dark place. Further study was carried out under laboratory conditions. The fixed phytoplankton samples were settled in a dark space for 10–12 days, and then the volume of the experimental samples was decreased from 1000 ml to 100 ml by a siphon (50 μm). Repeating the same process for the second time, the volume of the experimental samples was reduced to 10 ml [3]. The qualitative and quantitative analyses of phytoplankton were executed under a microscope (XSZ-107BN-C) using Nageotte chamber. Taxonomic groups of phytoplankton were identified by using the keys/determinants of freshwater systems [6, 7, 9, 20, 21]. The diversity status of phytoplankton community in the river ecosystems was assessed by Shannon-Wiener diversity index [16]. The comparative analysis of the phytoplankton species composition of the investigated rivers was performed by Sorensen similarity index [17].

Results and Discussion. During the investigation period, 31 species from the groups Bacillariophyta (diatom algae), Cyanophyta (blue-green algae), Chlorophyta (green algae) and Euglenophyta (euglenoids) were registered in the Kachachkut river (tab. 2). Diatoms were a quantitatively and qualitatively dominant group, which is typical for mountainous rivers (tab. 2, fig. 1). This is explained by the fact that diatoms, compared to green and blue-green algae, are well adapted for river biotopes (due to certain adaptive mechanisms) and can survive in unstable hydrological conditions of rivers [1].

Table 1. Number of phytoplankton species registered in the investigated rivers during the investigation period

Rivers	Phytoplankton groups				
	Bacillariophyta	Cyanophyta	Chlorophyta	Euglenophyta	Total
Kachachkut	24	4	1	2	31
Alaverdi	8	4	NR	NR	12
Akhtala	8	4	NR	1	13
Shnogh	14	3	1	NR	18

NR – not registered

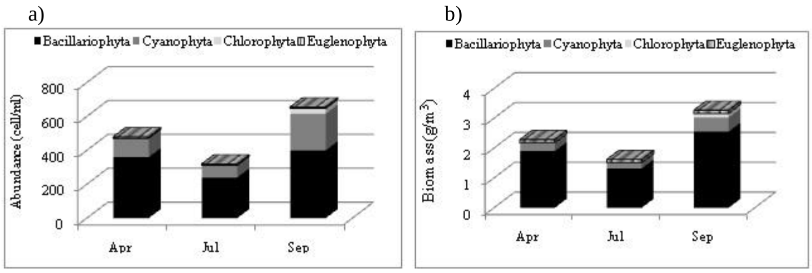

Fig.1. Quantitative parameters of phytoplankton in the Kachachkut river

The Alaverdi river was characterized by comparatively low phytoplankton diversity (12 species) (tab.1). The results of the study of phytoplankton community in the Alaverdi river showed that the picture of phytoplankton development was significantly different from the regularities of phytoplankton development in other Armenian rivers [1, 2, 4, 8]. Only diatom and blue-green algae were recorded, and blue-green algae had a big quantitative advantage during whole period of the investigation (fig. 2). Such dominancy of blue-green algae in the river phytoplankton community was also registered in the southern mining areas of Armenia, especially in highly polluted sites which indicated about high tolerance of this algal group to heavy metal pollution [12]. All of this allows to conclude about heavy metal pollution and phytoplankton community stress in the Alaverdi river.

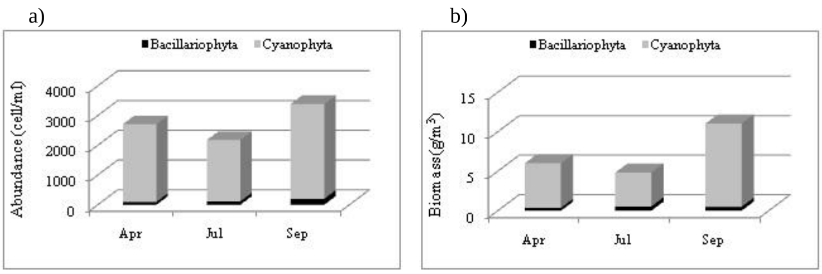

Fig.2. Quantitative parameters of phytoplankton in the Alaverdi river

During the investigation period, 13 species from the groups Bacillariophyta, Cyanophyta and Euglenophyta were recorded in the Akhtala river (tab. 1). Diatoms were a qualitatively dominant group, however blue-green algae had a big quantitative advantage (tab. 1, fig. 3). Despite high quantitative values, the phytoplankton community in the Akhtala river was stressed, and the quantitative composition was mainly conditioned by blue-green algae (fig. 3).

The phytoplankton was extremely stressed especially in September when partly decomposed colonies and detritus were registered, and the recorded species were small sized and morphologically modified. Unfavorable conditions for phytoplankton growth may have been conditioned by high level of heavy metal pollution induced by mining activities in the river catchment area.

a) b)

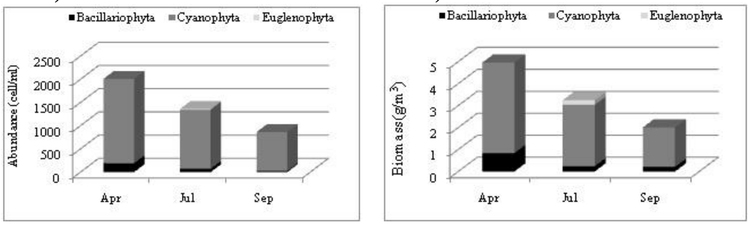

Fig.3. Quantitative parameters of phytoplankton in the Akhtala river

18 diatom, green and blue-green algae species were recorded in the Shnogh river during the investigation period (tab. 1). Diatoms were a quantitatively and qualitatively dominant group (tab.1, fig. 4).

a) b)

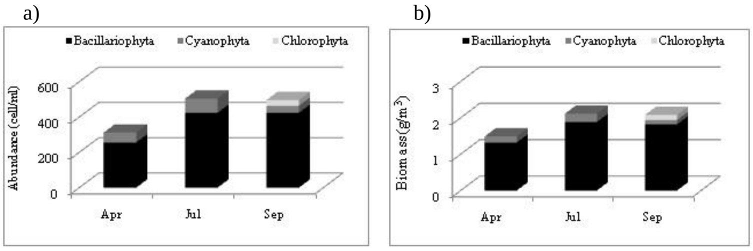

Fig.4. Quantitative parameters of phytoplankton in the Shnogh river

The river phytoplankton diversity status, expressed as Shannon-Wiener diversity index, is presented in fig. 5. The investigated river ecosystems can be ranked according to phytoplankton diversity decreasing order as follows: Kachachkut-Shnogh-Akhtala-Alaverdi. The richest phytoplankton diversity was registered in the Kachachkut river, and the lowest diversity – in the Alaverdi river, where, according to the results of our previous investigations, the ecosystem was highly polluted with heavy metals resulted from mining activities [11]. Compared to the algal diversity in the Kachachkut river not being at the risk of mining impact, the slight loss of phytoplankton diversity in the Shnogh river, and the significant diversity loss in the Alaverdi and Akhtala rivers are explained by the impact of mining activities in the river catchment basins (fig. 5).

The Sorensen similarity index values for phytoplankton in the investigated rivers showed that firstly Akhtala and Alaverdi, and secondary Alaverdi and Shnogh were the most similar rivers according to the phytoplankton species composition (tab. 3). All of this indicated about the similarity of living conditions in the rivers being at the risk of mining impact.

Thus, the comparative investigation of the river phytoplankton composition of the Debed river catchment basin's mining and non-mining areas showed that the Alaverdi, Akhtala and Shnogh rivers located in the risky territories were characterized by comparatively low phytoplankton diversity which was probably conditioned by the impact of mining activities in the river catchment areas.

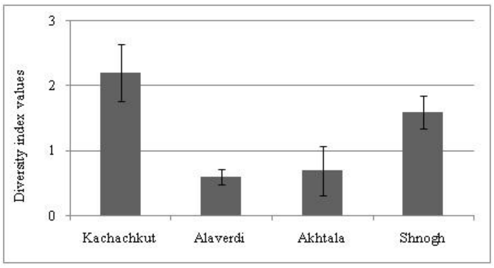

Fig.5. Mean values of Shannon-Wiener diversity index for phytoplankton in the investigated rivers

Table 3. Sorensen similarity index values for phytoplankton in the investigated rivers

	Kachachkut	Alaverdi	Akhtala	Shnogh
Kachachkut	-			
Alaverdi	0.32	-		
Akhtala	0.36	0.64	-	
Shnogh	0.49	0.53	0.51	-

The results of the study indicated phytoplankton community stress in the Akhtala and Alaverdi rivers being at high risk of the impact of Alaverdi copper smelter (including tailing damp) and Akhtala mountain enrichment combine (including tailing damp) activities [11]. In general, it can be noted that the metabolic progress of phytoplankton cenosis being at the risk of the mining impact occurred on the account of the ecological regression of the community.

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