INVESTIGATIONS OF DEVELOPMENT SPECIFICS OF PHYTOPLANKTON COMMUNITY IN POLLUTED AREAS OF SYUNIK REGION

L. R. Hambaryan, L. G. Stepanyan, A. S. Mamyan

* Department of Ecology, Yerevan State University, 8 Charenc str., 0025, Yerevan, RA, e-mail: lus-ham@yandex.ru, phone: 095525746
** Institute of Hydroecology and Ichthyology of the Scientific Center of Zoology and Hydroecology of NAS RA, 7 P. Sevak str., 0014, Yerevan, RA, e-mail: a_mamyan@mail.ru, phone: 094394107

ABSTRACT

Ecological conditions of territories under pressures of pollution (agriculture, mining activity, urbanization) cause degradation of ecosystems. An example of ecologically adverse effect on an aquatic ecosystem is Voghchi River of Syunik region, where the mining activities conducted without being controlled in accordance with international environmental standards and with no consideration of the assessment of impact on environment.

Study of phytoplankton community of Voghchi River, revealed a large number of species - indicators of different types of pollution. The filamentous and large-forms of green and blue-green algae were dominating in phytoplankton. The development of these species demonstrates of heavy metal pollution on the river.

Research of phytoplankton of Voghchi River in 2014, showed that compared with years 2008-2009, the quantitative parameters of algae, especially their toxic forms, such as Phormidium, Microcystis, Aphanizomenon, Oscillatoria, Chroococcus and Anabaena, has increased.

Key words: phytoplankton community, heavy metal pollution, bio indicator, bio accumulator

INTRODUCTION

In recent years due to the active mining processes in Armenia the tailing areas and technological polluted areas were formed which have the problems of recovery and purification.

Biological indicators (bio indicators) may be defined as particular species or communities which by their presence provide information on the surrounding environment at a particular site.

Species composition can be related to ecological status in four main ways – seasonal succession, biodiversity, bio indicator species and determination of bioindices.

Microalgae are sensitive bio indicators for evaluation of different type of pollutions [3, 17].

The catchment area of the Vogchi River is situated in the south of the Republic of Armenia. The length of the river is 82 km and 56 km of which is in the territory of RA. The waters of the river are used for energy and irrigation purposes. The main tributaries of Vohchi River are Geghi and Artsvanik. The length of Geghi River is 30 km and the length of Artsvanik River is 17 km. The waters of the rivers are used for the industrial and irrigation purposes [5].

The mining and metallurgical industries are highly developed in the catchment basin of Vogchi River. For a long time, the sewer system have been in very bad conditions, the tailing storage facilities have been filled up with mining and metallurgical wastewaters, the biological water cleaning stations haven’t been working as a result of which wastewaters without a sufficient cleaning have been flowing into the aquatic ecosystems of the areas.

The biggest tailing storage of Armenia Artsvanik which contains Al, Fe, Cu, Mn, Mo and Geghanush storage are located in this area (Fig. 1). Geghanush tailing storage has first class of danger and contains Cu, Pb, Zn and Au [7].

All these have negative effects on the physicochemical and biological parameters of water, which especially influence on the phytoplankton community and change the quality and quantity of the compositions.

The present study was aimed at investigations of development specifics of phytoplankton community in polluted areas of Syunik region.

MATERIAL AND METHODS

The objects of this study were the Vogchi River and its tributaries - Geghi and Artsvanik Rivers (Fig. 2). Water samples were collected from 2008 to 2009 and in 2014.
During 2008 – 2009 the samples were taken from the follow stations:
1. Voghchci- before Qajaran town,
2. Voghchci- after Qajaran town,
3. Voghchci- before Kapan town,
4. Voghchci- after Kapan town,
5. Artsvanik - before Arcvanik tailings storage facility,
6. Artsvanik – River mouth Geghi- upstream
7. Geghi- River mouth
8. Geghi- River mouth

During 2014 the samples were taken from the follow stations:
• Voghchci -after Qajaran town
• Voghchci - after Kapan town
• Artsvanik – River mouth (after Artsvanik tailings storage facility
• Geghi- River mouth

The analyses of phytoplankton parameters were done by the standard methods accepted in hydrobiological studies. For the phytoplankton study, the 1 liter water sample taken from each site was fixed with 40% formaldehyde solution (0,4% final concentration) immediately and stored at a dark place. The further study was carried out under laboratory conditions [1].

The qualitative and quantitative analyses of phytoplankton were executed by a microscope in the Nageotte chamber (V=0,1 ml).

The species identification of planktonic algae was done by the determinants and the guides of freshwater systems [9, 11, 16, 21, 23].

The assessment of similarity in the species composition of phytoplankton community was performed by the Sorensen index [19].

\[ K = \frac{2j}{(a+b)} \]
Where “a” and “b” are the numbers of species in samples “a” and “b”, respectively, and j is the number of species shared by two samples; K is the quotient of similarity and ranges between 0 and 1.

Shannon–Wiener or biodiversity index of algae from different sections was calculated. This index was determined on a scale from 0 to 4, with 4 being the highest level of biodiversity and 0 indicating the near-complete or complete absence of algae.

\[ H' = -\sum_{i=1}^{R} p_i \ln p_i \]

Where \( H' \) is the index of species diversity, \( p_i \) is the ratio of the number of species of the taxonomic group to the total number of species in the community [14].

RESULTS AND DISCUSSION

Three groups of algae such as Bacillariophyta, Chlorophyta and Cyanophyta were registered during the study of phytoplankton community in the Voghchi, Artsvanik and Geghi Rivers from 2008 to 2009. The species of Euglenophytas in a small quantity were registered in the Voghchi River in 2014.

During the study diatoms dominated by quality and blue-green algae dominated by quantity. An exception was only in Geghi River, where diatomic algae dominated by quantity and quality. The qualitative domination of blue-green algae is not typical for the rivers of Armenia [8, 12, 13, 20]. Probably due to the heavy metal pressing the blue-green algae have qualitative domination in the catchment basin of Voghchi River as blue-green algae are more tolerant to heavy metals. For example, it is known from literature, that blue-green algae belonging to the genera of Oscillatoria and Phormidium are more resistant to zinc and copper [24].

During the study of Voghchi River catchment basin from 2008 to 2009 40 species of algae were recorded from which 30 species were Bacillariophyta, 5 species were Chlorophyta and 5 species were Cyanophyta. During the study of Voghchi River in 2014 80 species of algae were investigated from which 53 species were Bacillariophyta, 13 species were Chlorophyta, 12 species were Cyanophyta.

The increase of variety of algae in 2014 occurred due to the heavy metal tolerant species. The heavy metal tolerant species such as Chroococcus turgidus, Spirulina sp. as well as Phormidium and Oscillatoria genera were recorded in high quantitative indices. The algae species Scenedesmus acutus, Chlorella vulgaris, Euglena piciformis, E. polymorpha and Phacus longicauda well known from the literature as a heavy metal tolerant species [2-4, 6] were investigated in the River.

Quantitatively the blue-green algae dominated in Voghchi and Artsvanik Rivers from 2008 to 2009 (Fig. 3). The maximum quantity of Cyanophyta - 252000 cell/l and its biomass - 0.6 g/m³ were recorded in Voghchi River in Station 2 in September of 2008. The highest quantity - 156000 cell/l and biomass - 0.5 g/m³ of blue-green algae were recorded in Artsvanik River in April in of 2009. In both rivers the dominated species was Aphanothece cathrata. Domination of blue-green algae might occur by the influence of wastewaters from urban mining, metallurgical and domestic activities. During the study of phytoplankton community of Voghchi River in 2014 species of Cyanophyta group were dominated. The maximum quantity of blue-green algae (2148000 cell/l) and biomass (14.9 g/m³) were recorded in Station 4 in July of 2014. Spirulina sp. and Anaebaena spiroidea species had high quantitative indices. The species such as Microcystis aeruginosa, Chroococcus turgidus, Phormidium foveolarum, Ph. retzii, Oscillatoria subtilissima, Aphanothece cathrata were registered in Voghchi River. Chroococcus turgidus and Spirulina sp. are known as bioindicators of heavy metal pollution and bio accumulators of Cu and Mn [2-4, 6] were registered in Voghchi River as well. Euglena piciformis, E. polymorpha and Phacus longigauda from Euglenophytas also known as the bioindicators of heavy metal pollution [3] were found in the river.

The growth of phytoplankton community decreased in Artsvanik River in 2014 (Fig. 4). Only two species of blue-green algae: Aphanothece cathrata and Microcystis aeruginosa with very low quantity (32000 cell/l) and biomass (0.07 g/m³) were registerd in the river.

---

**Fig. 3.** Percentage of major groups of phytoplankton of Voghchi, Artsvanik and Geghi Rivers in terms of quantity, from 2008 to 2009.
Diatomic algae dominated in Geghi River from 2008 to 2009 and in 2014. The highest quantity (696000 cell/l) and biomass (4.6 g/m³) of diatoms were registered in April of 2009 and 456 000 cell/l by quantity and 1.5 g/m³ by biomass in July of 2014. The main species of diatom investigated in the river were *Cocconeis placentula*, *Fragilaria capucina* and *Cymbella ventricosa*.

The Sorensen similarity index was estimated for the Voghchi, Artsvanik and Geghi Rivers from 2008 to 2009. Comparison was done between Stations 1 and 2, 3 and 4, 1 and 4 for Voghchi River, between Stations 5 and 6 for Artsvanik River and between Stations 7 and 8 for Geghi River.

The value of Sorensen indices was very low in Voghchi River, which certify that the species composition of phytoplankton community was changed under the impact of the cities Kapan and Qajaran (Table 1).

**Table 1.** Values of the Sorensen similarity indices in the sampling sites of Voghchi River, 2008-2009.

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Years</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 before Qajaran town - after Qajaran town</td>
<td>0.25</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>3-4 before Kapan town - after Kapan town</td>
<td>0.57</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>1-4 before Qajaran town - after Kapan town</td>
<td>0.2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>5-6 before Artsvanik tailings storage facility - after Artsvanik tailings storage facility</td>
<td>0.5</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>7-8 Geghi upstream - Geghi River mouth</td>
<td>0.66</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>

Low value of Sorensen indices was registered in Artsvanik River which certifies that the species composition of phytoplankton community was changed under the impact of the tailings storage facility of Artsvanik.

High value of Sorensen indices was observed for Geghi River which may be due to the river morphological characteristics (flow velocity, length of the river, the river turbidity), and due to the relatively weak influence of anthropogenic pressure (Table 1).

Shannon–Wiener or biodiversity index of algae from different sections was calculated from 2008 to 2009, 2014. According to the Shannon–Wiener index the diversity of algae decreased after the anthropogenic impact zone (after towns and tailing storage facility of Artsvanik) which proves unfavorable conditions of algal growth. Low value of Shannon–Wiener indices was observed after the tailing storage facility of Artsvanik, which and relatively high value of Shannon–Wiener indices was observed in Geghi River during the study period (Table 2).

**Table 2.** Values of Shannon–Wiener indices of algae for Voghchi, Artsvanik and Geghi Rivers, 2008-2009.

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2008</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>0</td>
<td>1,25</td>
<td>1,21</td>
<td>1,94</td>
<td>1,91</td>
<td>1,06</td>
<td>1,07</td>
<td>1,23</td>
</tr>
<tr>
<td>Autumn</td>
<td>0,84</td>
<td>0,71</td>
<td>1,33</td>
<td>1,06</td>
<td>1,25</td>
<td>0,39</td>
<td>0,65</td>
<td>2,27</td>
</tr>
<tr>
<td><strong>2009</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>1,80</td>
<td>1,40</td>
<td>-</td>
<td>2,27</td>
<td>2,69</td>
<td>1,20</td>
<td>2,10</td>
<td>2,15</td>
</tr>
<tr>
<td>Autumn</td>
<td>0,98</td>
<td>0,53</td>
<td>1,32</td>
<td>1,45</td>
<td>0,68</td>
<td>0,51</td>
<td>1,41</td>
<td>1,34</td>
</tr>
<tr>
<td><strong>2014</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>-</td>
<td>0,42</td>
<td>-</td>
<td>1,40</td>
<td>-</td>
<td>0,30</td>
<td>-</td>
<td>2,0</td>
</tr>
</tbody>
</table>
CONCLUSIONS

The investigations done 2008-2009 and in 2014 revealed quantitative and qualitative changes in the species composition of phytoplankton community in the catchment basin of Voghchi River which is not typical for the other rivers of Armenia. The investigations revealed that in conditions of the mining activities in Voghchi River and in its tributaries heavy metal tolerant species dominated in phytoplankton community. The bioaccumulator species such as *Scenedesmus acutus*, *Chlorella vulgaris*, *Euglena piciformis*, *E. polymorpha* and *Phacus longicauda* were investigated in the river (Fig. 5).

![Species](image)

*Fig. 5. Some species of algae in the phytoplankton community in Voghchi River catchment basin.*

The assessment of changes in the species composition of phytoplankton community performed by the Sorensen and Shannon-Winner indices showed that the biodiversity of microalgae was poor which revealed that the catchment basin of Voghchi River is in ecologically pressed conditions.

REFERENCES


[24] Online: https://books.google.am/books?id=kvsPo4Et5xcC&pg=PA106&lpg=PA106&dq=blue+green+algae+heavy+metals&source=bl&ots=swg234FyVYZ&sig=0AD4ohSFst5FRki08mi2FFyQOE&hl=ru&sa=X&ei=kMFQVciwPuGRsiD6g9zDQw&ved=0CGQ6AEwCQ#v=onepage&q=blue%20green%20algae%20heavy%20metals&f=false