ASSESSMENT OF THE SANITARY-BACTERIOLOGICAL STATE OF THE ARPA AND YEGHEGIS RIVERS, ARMENIA

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Sanitary-bacteriological state of the Arpa and its tributary – Yeghegis rivers was assessed based on the bacteriological parameters (aerobic, coliform and *Escherichia coli* (*E. coli*) bacteria). Water sampling for the quantitative analysis of aerobic, coliform and *E. coli* bacteria was performed seasonally in May, July and November of 2016. The results of the study showed the deterioration of water sanitary-bacteriological state along the rivers. Fecal pollution degree in the midstream and downstream of the rivers may have posed serious pathogenic risks, in case of water used for recreational purposes.

Rivers – pollution – sanitary-bacteriological status – environmental risks

Բակտերիոլոգիական ցուցանիշների (աերոբ, կոլիֆորմ և *Escherichia coli* (*E. coli*) բակտերիաներ) հիման վրա գնահատվել է Արփա և դրա վտակ՝ Եղեգիս գետերի սանիտարաբակտերիոլոգիական վիճակը: Աերոբ, կոլիֆորմ և *E. coli* բակտերիաների քանակական անալիզի համար ջրանմուշառումներն իրականացվել են ըստ սեզոնների՝ 2016 թ. մայիս, հուլիս և նոյեմբեր ամիսներին: Ուսումնասիրության արդյունքները ցույց են տվել Արփա և Եղեգիս գետերի երկայնքով ջրի սանիտարաբակտերիոլոգիական վիճակի վատթարացում: Գետերի միջին և ստորին հոսանքներում ֆեկալ աղտոտվածության աստիճանը կարող էր առաջացնել լուրջ ախտածին ռիսկեր ռեկրեացիոն նպատակով ջրօգտագործման դեպքում:

Գետեր – աղտոտում – սանիտարաբակտերիոլոգիական վիճակ – Էկոլոգիական ռիսկեր

Дается оценка санитарно-бактериологического состояния реки Арпа и ее притока Ехегис по бактериологическим параметрам (аэробные, колиформные и *Escherichia coli* (*E. coli*) бактерии). Отбор проб воды для количественного анализа аэробных, колиформных и *E. coli* бактерий осуществлялся сезонно в мае, июле и ноябре 2016 года. Результаты исследования показали ухудшение санитарно-бактериологического состояния воды по течениям рек. Уровень фекального загрязнения в среднем и нижнем течениях рек может представлять серьезные патогенные риски в случае использования воды в рекреационных целях.

Реки – загрязнение – санитарно-бактериологический статус – экологические риски

The Arpa river catchment basin is situated in the southeastern part of Armenia. The Arpa river originated from south-east of Vardenis mountain is one of the major tributaries of the transboundary Araks river in the territory of Armenia. The river length is 126 km (in Armenia – 90 km), catchment basin – 2630 km². Yeghegis river (length – 47 km) is one of the main tributaries of the Arpa river. Due to the insufficient management of water resources and anthropogenic discharges in the Arpa river

catchment area, waste and wastewater mainly from household and agricultural activities may enter into surface water bodies and negatively affect the qualitative parameters of aquatic ecosystems, raising environmental risks [7]. Therefore, it's urgently required to assess the environmental quality of hydroecosystems in the Arpa river catchment area in the conditions of anthropogenic pressures.

Since bacterioplankton is very sensitive to anthropogenic pollution and responds rapidly to such an influence, it is considered to be a good indicator of water quality and have attracted considerable attention in recent years in a variety of water habitats [1, 6, 8]. Different taxa of these microscopic organisms may reflect the ecologo-sanitary state of water systems [4]. Therefore, in this study, planktonic bacteria were used for the characterization of water qualitative properties. The aim of the present study was to investigate and assess the sanitary-bacteriological state of the Arpa and Yeghegis rivers.

Materials and methods. The objects of the study were the Arpa and its tributary – Yeghegis rivers. Bacteriological (aerobic, coliform and *Escherichia coli* (*E. coli*) bacteria) investigations were carried out in 5 river sites (3 points in Arpa, and 2 points in Yeghegis) (tab. 1). Water samples for the quantitative analysis of aerobic, coliform and *E. coli* bacteria were collected seasonally in May, July and November of 2016. The samples taken by sterile sample containers were kept in a cool box in low temperature conditions during the transportation to the laboratory and were analysed immediately after reaching the laboratory. The quantitative analysis of aerobic, coliform and *E. coli* bacteria was implemented by the RIDA COUNT medium sheets (coated with ready-to-use culture medium). 1 ml water sample was added to the medium sheet and incubated at 35°C for 24–48 hours. Then the bacterial colonies grown on the medium sheet were counted. The experiments were performed under sterile conditions.

The ecologo-sanitary state of the rivers was assessed according to the ecologo-sanitary quality classification accepted in the CIS (Commonwealth of Independent States) countries (based on coliform bacteria count) and the *E. coli* bacteria criteria set by the U.S. Kansas Department of Health and Environment [2, 10].

Table 1. Coordinates of rivers investigated site

Sampling site number	N/Lat	E/Long	River site location
1	39°52'17.4"	45°42'54.9"	Arpa river upstream
2	39°41'33.0"	45°27'06.6"	Arpa river midstream
3	39°43'31.9"	45°11'22.6"	Arpa river downstream
4	39°54'09.1"	45°29'41.9"	Yeghegis river upstream
5	39°46'12.4"	45°18'31.0"	Yeghegis river downstream

Results and Discussion. The results of the study showed that total planktonic bacteria count according to the Arpa and Yeghegis rivers flow increased (fig. 1). It's known that elevated organic matter concentration in aquatic ecosystems leads to an adequate increase in planktonic bacteria count [1, 5, 6]. All of this indicated that the Arpa and Yeghegis rivers flowing through urban and rural areas were exposed to organic pollution induced by irregular household and agricultural discharges as a result of which bacterial count from the upstream of the Arpa and Yeghegis rivers to the downstream increased gradually. Seasonal changes in planktonic bacteria count were mainly conditioned by the thermal regimes of the rivers (Fig. 1). It's known that increased water temperature may lead to microbial activation and organic matter level (through decreasing dissolved oxygen concentration) increase causing an increase in planktonic bacteria count [6].
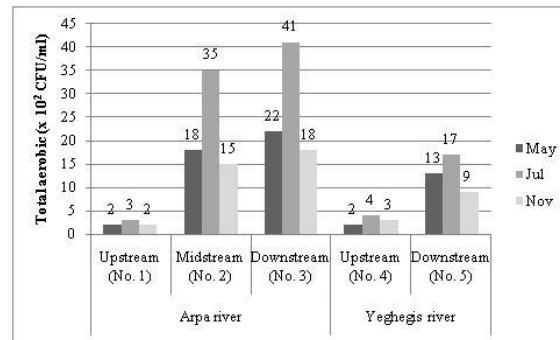
Fig 1. Aerobic bacteria count in the Arpa and Yeghegis rivers (CFU – colony-forming unit).

The same picture of changes in planktonic bacteria count along the rivers was also observed in case of coliform bacteria and coliform group species – *E. coli* (figs. 2 and 3). Worldwide coliform and *E. coli* bacteria are used as the indicators of fecal contamination and hence, the possible presence of disease causing organisms [1, 6, 9]. They are always present in the digestive tracts of animals and humans and are found in their waste [6]. All of this allows to conclude that an increase in coliform and *E. coli* bacteria count according to the rivers flow was mainly conditioned by the impact of waste and wastewater resulted from urban and rural household and cattle breeding activities in the Arpa river catchment area (figs. 2 and 3).
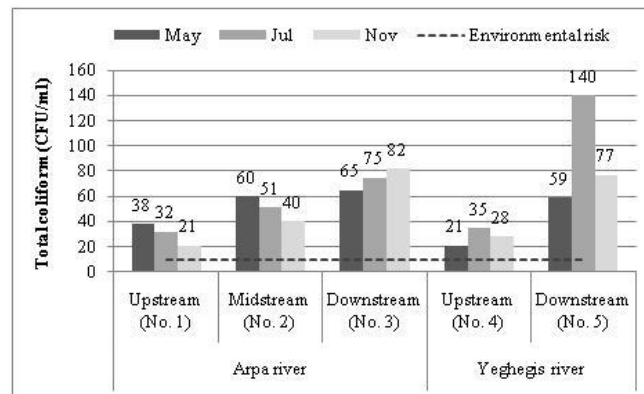

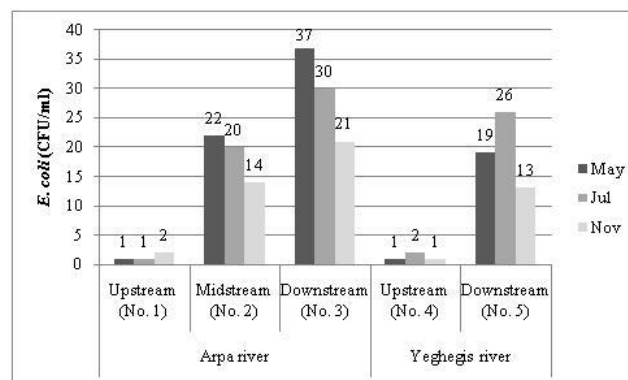**Fig. 2.** Coliform bacteria count in the Arpa and Yeghegis rivers.

Fig. 3. *E. coli* bacteria count in the Arpa and Yeghegis rivers.

If a large number of coliform bacteria ($\geq$ 1000 CFU/100 ml) are found in water, it is possible that pathogenic (disease causing) organisms are also present in the water, and the water may become dangerous even for recreational uses [3]. The results of the study showed that according to the coliform bacteria count, environmental risks may have been posed from all the investigated sites, in case of river water used for recreational purposes (fig. 2). Based on the quantitative parameters of coliform bacteria, the ecologo-sanitary quality of the waters of the Arpa and Yeghegis rivers was assessed and is presented in tab. 2.

Table 2. Ecologo-sanitary quality of the waters of the Arpa and Yeghegis rivers according to coliform bacteria count

Sampling site number	Fecal pollution degree		
	May	Jul	Nov
1			
2			
3			
4			
5			

According to the *E. coli* bacteria criteria set by the U.S. Kansas Department of Health and Environment, waters are divided into three categories: class A – public swimming area; class B – publicly accessible water bodies; class C – no public access [10]. The results of the *E. coli* bacteria study showed that the waters in the upstream (sampling site Nos. 1 and 4) of the rivers belonged to class A and were safe for recreational use. Low or safe level of *E. coli* bacteria in the sampling site Nos. 1 and 4 indicated that the sources of coliform bacteria in the upstream of the Arpa and Yeghegis rivers were probably environmental (coliforms of non-fecal origin), and therefore, these sites can be considered safe for recreational uses. Nevertheless, the waters in the midstream (sampling site No 2) and downstream (sampling site Nos. 3 and 5) of the rivers belonged to class C, and the public access into these water bodies was unallowable (tab. 3).

Table 3. Geometric mean values of *E. coli* bacteria count in the Arpa and Yeghegis rivers

Sampling site number	*E. coli* bacteria count (CFU/100ml)			
	July	Environmental risk categories and values		
		Class A	Class B	Class C
1	132			
2	1494			
3	2361	160	262	427
4	143			
5	1917			

Based on the results of the aerobic, coliform and *E. coli* bacteria study, it's possible to state that the deterioration of water sanitary-bacteriological state according to the Arpa and Yeghegis rivers flow was registered which may have been conditioned by organic and fecal pollution caused by urban and rural household and agricultural

activities in the Arpa river catchment area. According to the coliform and *E. coli* bacteria count, fecal pollution degree in the midstream and downstream of the river ecosystems may have posed serious pathogenic risks, in case of water used for recreational purposes.

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