

MICROBIOLOGICAL ASSESSMENT OF FECAL CONTAMINATION  
IN THE RIVER WATERS OF THE VOGHJI RIVER CATCHMENT BASINA. L. VARAGYAN<sup>1</sup>, G. A. GEVORGYAN<sup>2\*\*</sup><sup>1</sup> Chair of Ecology and Nature Protection, YSU, Armenia<sup>2</sup> Scientific Center of Zoology and Hydroecology of NAS RA, Armenia

Quantitative parameters of total and fecal coliform, as well as *Escherichia coli* bacteria in the river waters of the Voghji River catchment basin were investigated to characterize fecal contamination in the investigated watershed basin. Water samples for microbial analyses were collected from the Voghji River and its Geghi, Norashenik and Vachagan tributaries in 2016, 2017 and 2020. The results of the study revealed the distribution, potential sources and environmental risks of fecal contamination in the Voghji River catchment basin.

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**Keywords:** rivers, fecal indicator bacteria, contamination, environmental hazards.

**Introduction.** Freshwater resources are endangered by pollution from natural processes and anthropogenic sources. Freshwater quality is essential not only for protecting aquatic ecosystems and hydrobionts, as well as human health, but also for ensuring economic and recreational value of waterbodies and, therefore, routinely monitored in any part of the world [1]. In this regard, fecal contamination is one of major water biological quality concerns. It has been shown there is a positive correlation between fecal contamination of water and the presence of pathogens in water [2]. Therefore, fecal contamination of water can pose serious public health problems and cause severe ecological and economic damages [3]. Fecal contamination of water originates from anthropogenic and zoogenic sources and is normally determined by the detection and quantitation of viable bacterial indicators such as, e.g., total and fecal coliforms, *Escherichia coli* [4].

Waste and wastewater management in the Voghji River catchment area (Armenia) is one of main environmental issues [5], which threatens surface waters with fecal contamination. All of this is also a threat for agricultural production and human health, since the waters are used for irrigation and can potentially transfer pathogens and infect agricultural crops. Therefore, the investigation of fecal contamination in the Voghji River catchment basin is very important in regard to the protection of the aquatic ecosystems and the environment.

The aim of the present study was to assess fecal contamination in the Voghji River catchment basin and identify its environmental risks.

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**Materials and Methods.** The Voghji River catchment area is located in the southern part of Armenia at an average altitude of 2420 *m* a.s.l. The catchment area is distinguished by a dense hydrographic network. The rivers are mainly short, fast-flowing and belong to the Araks River catchment basin. The longest river is the Voghji with a total length of 82 *km* (56 *km* in the territory of Armenia) [6].

Water sampling for quantitative analyses of total and fecal coliform (TC and FC) and *Escherichia coli* (EC) bacteria was done in 7 locations of the rivers in the Voghji River catchment basin as outlined in Table. River site V-1 is located in the area that does not have noticeable anthropogenic influences and was considered as reference for the river basin, while the other sites are at the risk of human impact. The samples were collected with sterile sample containers in July and September 2016, 2017 and 2020 and kept in a cool box under low-temperature conditions (4–8°C) during transportation. After reaching the laboratory of the Scientific Center of Zoology and Hydroecology of NAS RA (Armenia), the samples were analysed immediately under sterile conditions. TC and EC bacteria were incubated on nutrient medium (Compact Dry EC containing chromogenic enzyme substrate X-Gal, “R-Biopharm”, Germany) at 35°C for 24 *h*, while FC on nutrient plates (Compact Dry FC containing chromogenic enzyme substrate X-Gal, “R-Biopharm”) at 42°C for 24 *h*. The analyses were performed in triplicate, and the data, as obtained, were averaged.

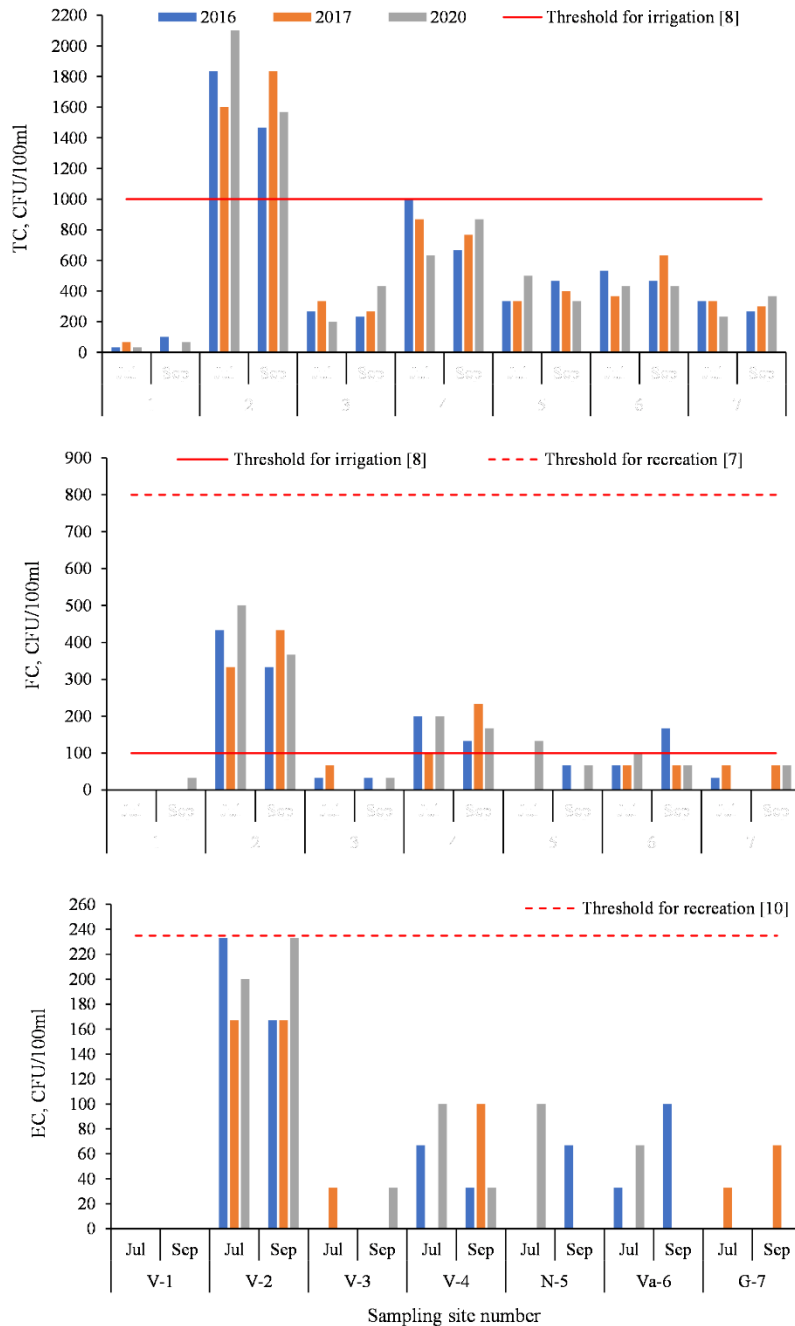
There are no Armenian microbial water quality standards, therefore, obtained results of TC, FC and EC concentrations were compared with foreign regulations and classification to assess fecal contamination in the river waters and its environmental risk potential [7–10].

*Coordinates of sampling sites in the Voghji River catchment basin*

Sampling site number	N/Lat	E/Long	River site location
V-1	39°09'26.9"	46°06'47.4"	Voghji River site located upstream of Kajaran Town
V-2	39°09'01.8"	46°11'34.3"	Voghji River site located downstream of Kajaran Town
V-3	39°13'27.7"	46°20'19.4"	Voghji River site located upstream of Kapan Town
V-4	39°11'52.5"	46°28'05.4"	Voghji River site located downstream of Kapan Town
N-5	39°11'54.9"	46°28'02.8"	Norashenik River site located near the river mouth
Va-6	39°11'53.5"	46°23'43.8"	Vachagan River site in Kapan town
G-7	39°11'58.3"	46°15'31.8"	Geghi River site located near the river mouth

**Results and Discussion.** The results of the study of TC, FC and EC abundance in the river waters of the Voghji River catchment basin are given in Figure. The Figure shows spatially heterogeneous distribution of the quantitative parameters of the investigated coliforms in the area. In comparison to reference concentrations, elevated values were observed in all investigated sites. The highest quantitative parameters of coliforms were registered in river site V-2 followed by sites V-4, Va-6, N-5, G-7, and V-3. TC abundance recorded in sites V-2, V-4, Va-6, and N-5 during whole investigation period exceeded the highest value registered in reference site V-1 by about 15–21, 6–10, 4–6, and 2–5 times, respectively, while sites G-7 and V-3 showed TC concentrations exceeding the highest registered reference value by around 2–4 times. FC concentrations observed in sites V-2, V-4, and Va-6 during whole study period exceeded the highest registered reference value by approximately

10–15, 3–7, and 2–5 times, accordingly. The highest registered reference concentration was also exceeded in other sites, but occasionally and by up to 3 times. Although EC was not found in reference site during whole investigation period, however, it was almost always present in sites V-2 and V-4 and occasionally registered also in other sites.



Quantitative parameters of the investigated coliforms in the Voghji River catchment basin.

Fecal contamination degree was estimated based on classification given in [9]. According to TC concentrations, river site V-2 was moderately fecal-contaminated. Such contamination may have posed environmental risks in the case of water used for irrigation purposes (see Figure). River site V-4 showed slight fecal-contamination, which reached even the threshold level for irrigation use of water. These contaminations of Voghji River sites V-2 and V-4 located downstream of Kajaran and Kapan towns, respectively, can be explained by the impact of urban household discharges. River site Va-6 was mainly sufficiently clean and very rarely showed slight fecal contamination. River sites V-3, N-5, and G-7 were characterized by sufficiently clean water.

The quantitative parameters of FC in sites V-2 and V-4 also indicated fecal contamination-based environmental hazards in the case of water used for irrigation. According to FC concentrations, contamination-based environmental risks were rarely posed also from sites N-5 and Va-6. The abundance of FC in the river waters was lower than the threshold values for recreational use, which indicates that the adverse effects of fecal contamination on human health in the case of water used for recreational purposes were negligible.

Although the quantitative parameters of EC didn't indicate fecal contamination-based environmental hazards, however the bacterial concentrations in site V-2 were occasionally very close to the threshold value for recreation use of water.

**Conclusion.** Microbial investigations conducted in the Voghji River catchment basin indicated fecal contamination in the river ecosystems, which was mainly environmentally problematic in Voghji River sites affected by urban (Kajaran and Kapan towns) household discharges. Such contamination may pose environmental risks in the case of river water use for irrigation purpose. The results presented can be very helpful for environmental managers in contamination and river basin management for the future.

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#### REFERENCES

1. Sekar R., Jin X., et al. Fecal Contamination and High Nutrient Levels Pollute the Watersheds of Wujiang, China. *Water* **13** (2021), 457.  
<https://doi.org/10.3390/w13040457>
2. Tallon P., Magajna B., et al. Microbial Indicators of Fecal Contamination in Water: A Current Perspective. *Wat. Air and Soil Poll.* **166** (2005), 139–166.  
<https://doi.org/10.1007/s11270-005-7905-4>
3. Weller D.L., Murphy C.M., et al. Land Use, Weather, and Water Quality Factors Associated with Fecal Contamination of Northeastern Streams That Span an Urban-Rural Gradient. *Front. Water* **3** (2022), 741676.  
<https://doi.org/10.3389/frwa.2021.741676>
4. Paruch L., Paruch A.M., et al. Faecal Pollution Affects Abundance and Diversity of Aquatic Microbial Community in Anthro-Zoogenically Influenced Lotic Ecosystems. *Sci. Rep.* **9** (2019), 19469.  
<https://doi.org/10.1038/s41598-019-56058-x>

5. Varagyan A.L. Chemical and Microbiological Investigation of Organic Contamination in the River Ecosystems of the Voghji River Catchment Basin. *Biolog. J. Armenia* **70** (2018), 108–112 (in Armenian).
6. Gevorgyan G.A. *Ecological Assessment of the Voghji and Meghriget Rivers and Their Catchment Basins*. PhD Thesis. Yerevan (2011) (in Armenian).
7. Arizona Department of Environmental Quality (ADEQ). *Total Maximum Daily Load For: Oak Creek-Slide Rock State Park parameters: Escherichia coliform (Open File Report 09-08)*. USA, AZ, Phoenix, ADEQ (1999).
8. Canadian Council of Ministers of the Environment (CCME). *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*. In: *Canadian Environmental Quality Guidelines*. Canada, Manitoba, Winnipeg, CCME Publications (1999).
9. Romanenko V.D., Oksiyuk O.P., et al. *Ecological Assessment of the Impact of Hydraulic Engineering Construction on Aquatic Objects*. Kiev, Naukova Dumka (1990) (in Russian).
10. U.S. Environmental Protection Agency (EPA). *Bacterial Water Quality Standards for Recreational Waters (Freshwater and Marine Waters) (EPA-823-R-03-008)*. Washington, DC, USEPA (2003).

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ՈՂՋԻ ԳԵՏԻ ՋՐԱՀԱՎԱԹ ԱՎԱԶԱՆԻ ԳԵՏԱԶՐԵՐԻ ՖԵԿԱԼ  
ԱՂՏՈՏՎԱԾՈՒԹՅԱՆ ՄԻԿՐՈԿԵՆՍԱԲԱՆԱԿԱՆ ԳՆԱՀԱՏՈՒՄ

Ուսումնասիրվել են Ողջի գետի ջրահավաք ավազանի գետաջրերում ընդհանուր և ֆեկալ կոլիֆորմ, ինչպես նաև *Escherichia coli* բակտերիաների քանակական ցուցանիշները՝ հետազոտված ջրահավաք ավազանում ֆեկալ աղտոտվածության բնութագրման համար: Մանրէաբանական անալիզների համար ջրանմուշները վերցվել են Ողջի գետից և դրա Գեղի, Նորաշենիկ և Վաչագան վտակներից 2016, 2017 և 2020 թթ.: Հետազոտության արդյունքներով բացահայտվել են Ողջի գետի ջրահավաք ավազանում ֆեկալ աղտոտվածության բաշխվածությունը, հնարավոր աղբյուրները և միջավայրային ռիսկերը:

А. Л. ВАРАГЯН, Г. А. ГЕВОРГЯН

МИКРОБИОЛОГИЧЕСКАЯ ОЦЕНКА ФЕКАЛЬНОЙ ЗАГРЯЗНЕННОСТИ  
РЕЧНЫХ ВОД БАССЕЙНА РЕКИ ВОХЧИ

Для характеристики фекального загрязнения водосборного бассейна р. Вохчи, исследованы количественные показатели общих и фекальных колиформ, а также бактерий *Escherichia coli* в речных водах исследуемого водосборного бассейна. Пробы воды для микробного анализа были отобраны из реки Вохчи и ее притоков Гехи, Норашеник и Вачаган в 2016, 2017 и 2020 гг. Результаты исследования выявили распространение, потенциальные источники и экологические риски фекального загрязнения водосборного бассейна р. Вохчи.