Microbiological water quality of rivers in Serbia

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Introduction

In response to the growing pollution pressures to which freshwater ecosystems are exposed, water protection becomes one of the most important issues for the European Union (EU). Therefore, EU has established the Water Framework Directive (WFD, EC 2000) together with several other Directives (EC 1991ab, 1998) such as Urban Waste Water Treatment Directive, Nitrates Directive, Drinking Water Directive, etc., which represent the integrative legislative for the protection of all EU water resources (surface and ground waters). In the Republic of Serbia (RS) in the 2012 year, for the first time, surface water monitoring which was in the line with the WFD requirement was performed. This was preceded by the adoption of the Water Law of RS in 2010 (Official Gazette of the Republic of Serbia 30/10) together with other by-laws which are harmonized with the WFD. For the surface waters, in the RS, a total of 498 water bodies has been chosen for assessment (the latest number has been significantly increased by update in 2020), and for each of them, one sampling site is used for monitoring by the Status of the Surface Waters of RS (strategic document of Serbian Environmental Protection Agency 2018 related to development of monitoring within river basin management plans). About 69% of all water bodies in Serbia is represented by rivers, 28% are significantly altered water bodies and 3% artificial water bodies. Due to the lack of financial and human resources unevenness in the realization of monitoring program between years can be noticed and also unevenness in the spatial distribution of realized monitoring sites.

Water quality of the smaller water bodies which are not included in routine monitoring should not be neglected. Their impact on the major water courses could be significant, especially from the aspect of possible pollution hotspots which could be overseen due to lack of control. Considering that some of the indicated water bodies are used for other human related activities e.g. irrigation, knowledge of their microbiological quality is of high importance. Therefore a comprehensive survey is planned which will cover 100 sites situated at natural, altered and artificial water bodies not included in the monitoring program.

Indicator bacteria which are widely used in the assessment of the sanitary aspect of water quality belong to the group of coliforms. Coliform bacteria, primarily *Escherichia coli,* and intestinal enterococci are considered the basis of faecal pollution monitoring (Byamukama et al. 2005, Kirschner et al 2014). In the current study, *E. coli* was chosen as precise indicator of faecal pollution and the potential presence of pathogens.

Samples and sites

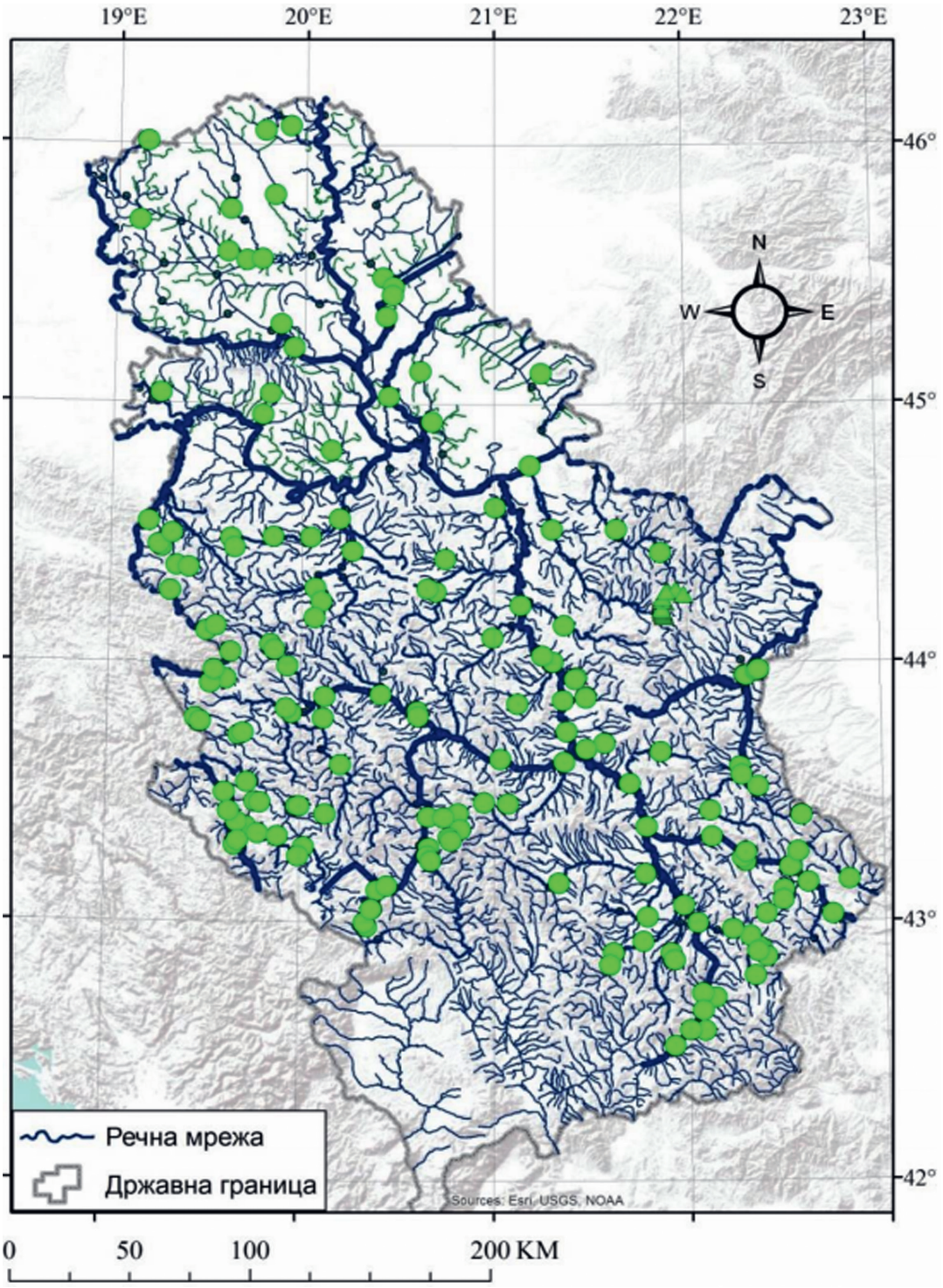
Water samples were collected in 2019 from 40 sites. An overview of all 100 sampling sites planned for the survey is indicated in figure 1.

Methodology

Water samples were collected in 500 ml sterile glass bottles approximately 30 cm below the water surface. Samples were stored in dark at 4 °C and transferred to the laboratory where samples were processed within 6 h of sampling. Quantification of *E. coli* was performed by Colilert Quanti-Tray 2000 system, which provides a Most Probable Number (MPN) result, based on a colour change/fluorescence in 97 tray compartments of the IDEXX tray. Powdered reagent Colilert-18 was used for cultivation following the instructions of the manufacturer. Trays were incubated at 37 °C for at least 18 h. For the assessment of the water quality based on *E. coli* numbers, a classification scheme developed for the Danube River was used (Kirschner et al. 2009).

Results and discussion

The results of the survey based on 40% of processed samples are summarized in figure 1. According to the numbers of *E. coli* in samples, 18% of the samples were characterized by a low level of pollution while 25% were moderately polluted. It is alarming that 57% of the investigated sites were found to be under the high influence of faecal pollution, thus belonging to the class of critical (25%) and strong pollution (32%). As expected, most of the sites where critical or strong pollution was recorded were located near settlements or cities where communal waters are discharged without any previous treatment. Among the investigated waterbodies, we have also selected a few irrigation channels used in agricultural areas. Most of these showed a moderate or critical degree of pollution. There are rural settlements near these sites, and detected faecal pollution most likely originates from the wastewaters of households or farms. In addi-



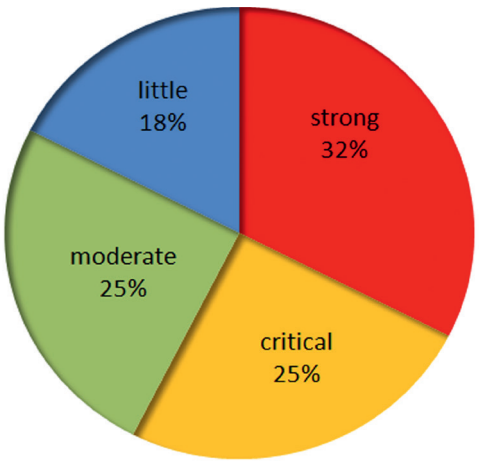


Figure 1: Above: Map of all 100 sampling sites (green dots) which will be addressed in the survey, 40 sites were used for microbiological analyses; grey lines: catchment limits. Pie chart: Distribution of the samples within different classes of pollution based on E. coli numbers.

tion, these channels are characterized by poor water flow, which results in the persistence of faecal pollution. On the other hand, sites on mountain streams and sites located upstream of populated areas showed the expected low or moderate pollution.

Conclusions

The survey is still in progress and the data obtained from the remaining sites is needed to provide a full insight into the status quo regarding the level of faecal contamination of water bodies in Serbia. Based on the samples processed so far, the seriousness of the situation is more than evident. In further research, the origin of faecal pollution at impacted sites will be traced using quantitative PCR - based assays for the analysis of general-, human- or animal-associated genetic Bacteroidetes faecal markers.

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Improving water quality for nature, humans and the Black Sea – the launch of the IDES project funded by the Danube Transnational Programme

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25 partners of ten countries along the Danube (Germany, Austria, Romania, Hungary, Slovenia, Slovakia, Bulgaria, Serbia, Croatia and Moldavia) join forces in the EU-funded project IDES to improve water quality in the Danube River and its tributaries by integrative floodplain management based on Ecosystem Services. Synergies instead of trade-offs, identified by an impartial evaluation tool, will foster the implementation of water quality management for a better environment both for nature and humans.

Background

National governments have committed themselves to the aim of reducing the nutrient loads transported by the Danube in order to ensure and enhance the ecological status of the Danube. The challenge of reducing the eutrophication of the Danube and its tributaries, and thus of the Black Sea, can only be met by transnational basin-wide cooperation. Diffuse pathways clearly dominate overall emissions, with rural emissions as major source. Emissions differ extremely between regions, but every region is affected: e.g. Germany and Slovenia produce the highest area-specific N emissions in the basin, Serbia generates the highest area-specific P emission rates (ICPDR 2015). Near-natural floodplains or buffer strips have high potential to reduce nutrient pollution, small but specific areas of them may even contribute significantly to reducing the nutrient inputs and to increasing the nutrient retention rates (Gericke et al. 2020). However, floodplains are subject to multiple human uses which strongly affect the water quality of rivers. Water quality management faces immense competition with other interests in floodplains (e.g. land use, fishery, navigation, flood retention), thus leading to very slow progress in implementation. So far, these uses have been managed sectorally (e.g. water management, nature conservation, agriculture), rarely regarding water quality or interactions between sectors. The ongoing project Danube Floodplain (Rîndasu-Beuran 2019) links attempts to improve flood retention and restoration, while water quality is not yet in focus. IDES project aims to add water quality targets to this effort and improve water quality by developing integrative floodplain management based on ecosystem services.

Ecosystems offer many services to human well-being (MA 2005). Along rivers and floodplains, nature provides manifold services, for instance flood protection, nutrient retention, drinking water, food and fibre production, habitats for biodiversity and possibilities for recreation, heritage or education (Grizetti et al. 2015). Degraded floodplains, in contrast, are not able to offer these goods or only in strongly reduced amounts. Taking into account all relevant ecosystem services, a multi-functional and sustainable water