Evaluation of the anthropogenic impact on surface water systems: case of Lower Arges Basin, Romania

Elfrida M. Carstea*, G. Pavelescu*, C. Ioja** and L. Cristescu*

* National Institute of R&D for Optoelectronics, Magurele, RO-077125, Romania
(E-mail: *frida@inoe.inoe.ro*; *gpavel@inoe.inoe.ro*; *cristescu@inoe.inoe.ro*)
** University of Bucharest, Centre for Environmental Research and Impact, Bucharest, Romania (E-mail: *cristi@portiledefier.ro*)

Abstract

Water Framework Directive states that all Europe Rivers must achieve good ecological status by 2015. This goal is much problematic in developing countries where cities are rapidly growing and authorities have to deal with new wastewater management problems. One such case is Arges Lower Basin which represents one of the most polluted areas of Romania due to the concentration of industrial, agricultural and household degradation sources carried along the stream. The major pollution source is Bucharest metropolitan area which, lacking a wastewater plant, releases the untreated water into the river. A complex study was performed in order to evaluate the influence of untreated wastewater on Arges river water quality. Samples collected from Arges River were analyzed using spectroscopic and standard techniques. The results showed a significant impact of urban sewage discharges on the river water quality. This urges the need to develop wastewater treatment facilities at the discharge points.

Keywords

Sewage; pollution; developing countries; quality; treatment

INTRODUCTION

European Union countries must achieve good ecological status for all rivers until 2015. This goal is more problematic in developing countries where cities are rapidly growing and authorities have to deal with new wastewater management problems. One of the most polluted areas from Romania is the Arges Lower Basin due to the fact that it collects large quantities of untreated waste from Bucharest metropolitan area. This large city (2.5 million inhabitants) lacks a wastewater treatment plant and the municipal waste is directly discharged into the river.

During the last decades, fluorescence spectroscopy has been intensely used in water river quality studies (Reynolds and Ahmad, 1997; Baker, 2002; Baker and Inverarity, 2004; Hudson et al., 2007). It is a rapid and sensitive technique that requires only small quantities of sample, without any preparation. Depending on the setup parameters, a sample can be measured in approximately one minute offering the spectral fingerprint for any type of water body. Due to its effectiveness, many researchers suggest using fluorescence spectroscopy as a surrogate technique for conventional water quality parameters, such as biochemical oxygen demand (Reynolds and Ahmad, 1997; Hudson et al., 2008).

The water quality indicator detected with fluorescence spectroscopy is dissolved organic matter, which is the ubiquitous fraction in water systems. The characteristic and quantity of dissolved organic matter helped in numerous studies (Baker, 2002; Baker and Inverarity, 2004; Wu et al., 2007) to identify the contaminant and easily quantify the degree of pollution. Dissolved organic matter comprises two principal fluorescence components: the microbial derived component and the terrestrial derived one. Protein-like fraction, microbial derived, indicates the bacterial and algal activity, while the humic-like component shows the quantity of degraded plant material present in the river (McKnight et al., 2001; Samios et al., 2007). These components are brought into the river system through soil leaching, surface run-off and point source pollution (Novotny, 2003; Goel, 2006).

The aim of this study was to evaluate the anthropogenic impact, mostly the urban influence, on the Arges Lower Basin. Therefore, the water quality analysis was performed using fluorescence spectroscopy and physical and chemical parameters (biochemical oxygen demand, pH, conductivity and turbidity) with standard procedures.

MATERIAL & METHODS

Four experimental campaigns had been performed in 2006 and 2007 collecting river samples from the Arges Lower Basin. In the lower basin, Arges River has two major tributaries: Sabar River with good ecological status and Dambovita River that crosses Bucharest and collects discharged municipal waste. In total, nine samples points had been established, as can be seen in figure 1. Six points were set on Arges Lower Basin: 1 – *Sabar* River, 2 – *Colibasi* on the Arges River before the confluence with Sabar, 3 – *Hotarele* after the confluence with Sabar, 4 – *Budesti* on Dambovita River before the confluence with Arges River, 5 – *Soldanu* on Arges after the confluence with Dambovita River and 6 – *Clatesti* before the Arges River flow into the Danube. Danube water was also sampled (7) in order to evaluate the quantity of contamination carried into the river. The last two sampling points (8 – named 1Dambov and 9 – named 2Dambov) were set on the Dambovita River while it crossed the Bucharest city.

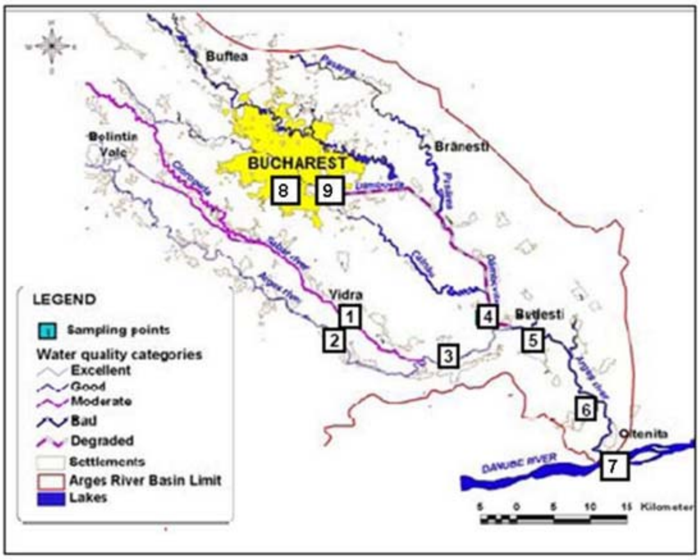

Figure 1: Sampling points on Arges River and tributaries.

Laser induced fluorescence measurements were performed with a Shamrock Spectrograph and ICCD Andor to record the spectra and a YAG-Nd laser was used (266 *nm)* as excitation source with 10 Hz frequency and 3-6 ns pulse duration. The spectrofluorometer FLS920 Edinburgh Instruments was also used to record fluorescence spectra. The measuring parameters were: excitation wavelength 265 nm, emission wavelength range 285 – 550 nm with steps of 1 nm, integration time 0.2 s. The standard biological (biochemical oxygen demand) and physical (pH, turbidity, conductivity) parameters were measured using conventional techniques.

RESULTS AND DISCUSSION

The water sampled at the strategically set collection points clearly evidenced the human impact on the water quality. The highest values for conductivity and turbidity were registered at Budesti sample, on Dambovita River, and the lowest at samples collected from points located before the Dambovita and Arges River confluence. The pH values ranged from 7 to 8.2 and no correlation with the other physical parameters was observed.

All four campaigns presented high quantities of organic matter at Budesti sample. In figure 2, the fluorescence emission spectrum for Budesti is presented, with the protein-like and humic-like fluorescence centres. Due to the fact that the protein-like component indicates the microbial activity, this fluorophore was used to quantify the degree of contamination with sewage water.

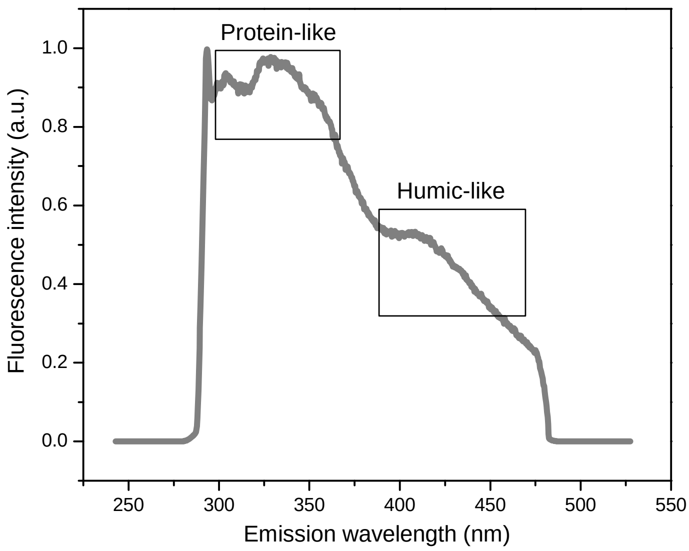

Figure 2: Fluorescence emission spectrum for Budesti sample. The protein-like and humic-like fluorescence centres are presented.

The maximum at 294 nm emission wavelength is the Raman peak, which represents the scattered light on water molecules, with a constant shift of $3290 cm^{-1}$ from excitation wavelength. Therefore, this peak was taken as reference and all fluorescence values were normalized to the Raman value.

The fluorescence intensities of the protein-like fraction are presented in figure 3a for the samples collected along the Arges River flow and in figure 3b for samples collected along Dambovita River. The samples collected at Colibasi, Sabar and Hotarele (Fig. 3a) showed very low fluorescence intensities for the protein-like component, which represents a minor contribution from the nearby farms. Meanwhile, Budesti sample exhibited high fluorescence intensities for the protein-like fraction, due to the large input with sewage wastewater from Bucharest households into Dambovita River. The intensity of the protein-like fluorescence started to decrease at the next location, Soldanu, until Arges River flow into the Danube, showing the effects of the autopurification process (dilution).

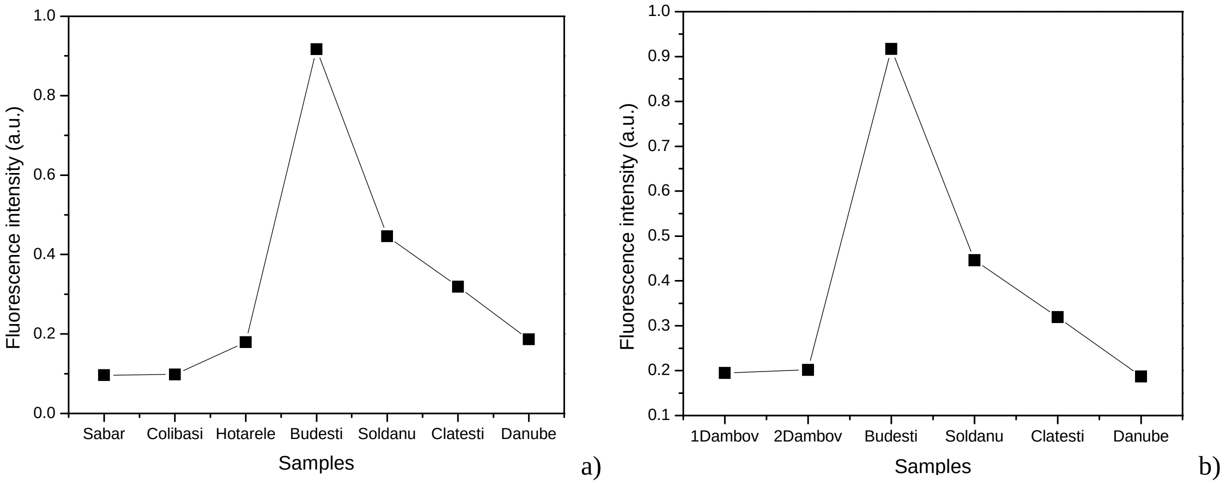

Figure 3: Fluorescence intensity maxima for the protein-like component measured at samples collected from Arges (a) and Dambovita (b) Rivers.

The two samples, named 1Dambov and 2Dambov (fig. 3b), collected from Dambovita River in Bucharest before sewage discharge, showed low protein-like fluorescence intensities. The significant increse of microbian pollution was detected in Budesti location, proving that the major source of pollution for Dambovita and Arges Rivers is the Bucharest municipal wastewater.

An hourly variation was observed in the organic matter fluorescence intensity depending on the quantity of sewage water released into the river. The variation can be seen in figure 4. The protein-like component measured at Budesti sample presented the highest values in the morning (7 AM) and in the afternoon (6 PM) and the lowest values before noon (11 AM). This trend was determined by the increase in human activity at 7 AM and 6 PM in the Bucharest metropolitan area. The humic-like component followed the same behaviour and this could probably be explained by the fact that the municipal waste, once released into the river, increased the debit carriyng along higher quantities of soil and degraded plant matter. Therefore, the quantity of humic substances, in this case, was proportional to the quantity of water discharged into the river.

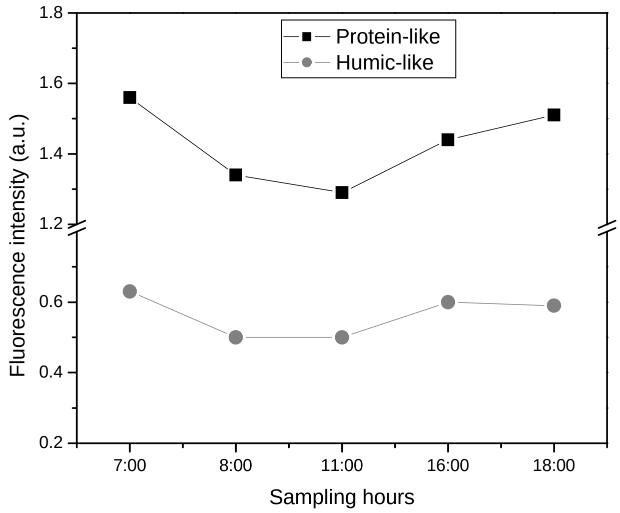

Figure 4: Fluorescence intensity maxima for the protein-like component measured for Budesti sample at hourly frequency.

The organic matter varied also at seasonal scale, with different responses for the protein-like and humic-like fractions, as can be seen in figure 5 for Budesti sample. The protein-like component presented the highest values in spring and the lowest in autumn. In winter and summer, approximately the same values were detected. However, more research is needed to establish if this is a general yearly trend and, if so, the cause of this trend has to be determined. A different behaviour was observed at the humic-like fluorescence; similar values were recorded in autumn and spring, higher than those registered in winter and summer. The increased precipitation quantities in spring and autumn probably generated higher quantities of humic substances.

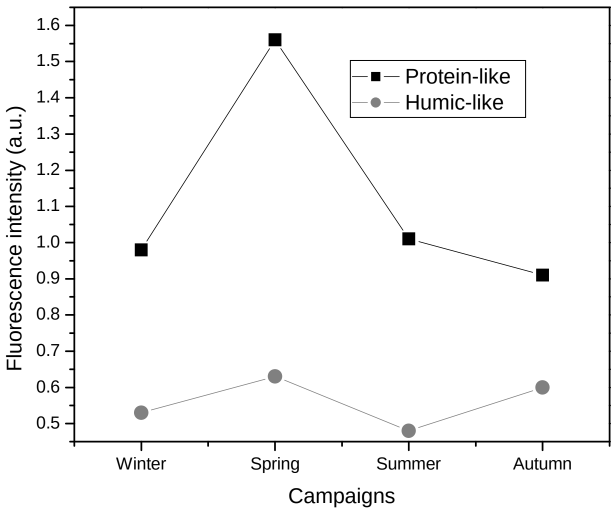

Figure 5: Seasonal variation of the protein-like fluorescence for Budesti sample.

In order to obtain further water quality information biochemical oxygen demand was also measured. The results are presented in figure 6 in comparison with the fluorescence intensity of the protein-like component. A correlation factor of 0.92 was obtained, higher values being recorded for Budesti sample, which decreased gradually for Soldanu and Clatesti samples. Sabar, Colibasi and Hotarele samples showed low biochemical oxygen demand values, similar with the fluorescence results.

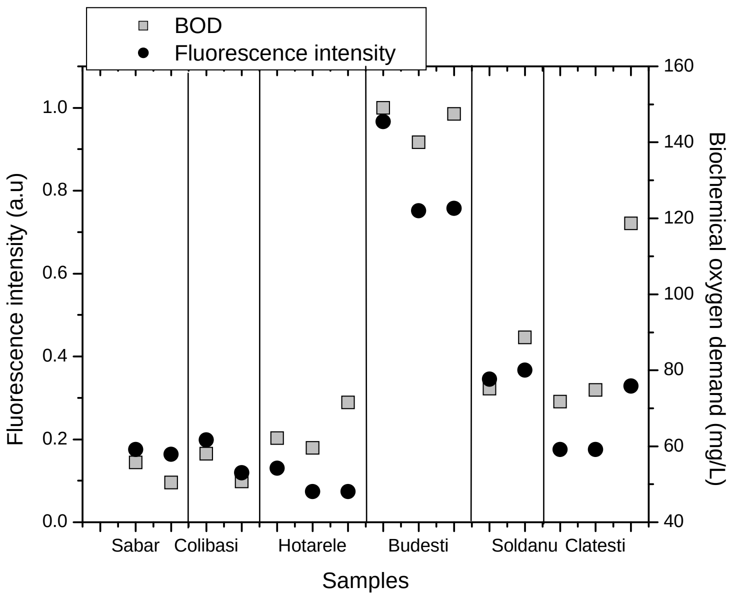

Figure 6: Biochemical oxygen demand results in comparison with protein-like fluorescence intensity.

CONCLUSIONS

Organic matter fluorescence intensity and biochemical oxygen demand were analysed in order to evidence the anthropogenic impact on the river water quality, specifically the Lower Arges Basin. The results revealed the significant contamination with wastewater discharged from Bucharest, especially at Budesti. After the Dambovita River confluence with Arges, the river started to be less contaminated due to the autopurification process. An hourly organic matter trend was detected due to the increased human activity in morning and afternoon hours. These results underline the need to develop wastewater treatment facilities at the discharge points.

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