Water Quality Indicators in River Basins—A Portuguese Case Study (Northern Portugal)

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Abstract

The objective of this work is the identification of the main contamination sources in the Vizela river watershed and the potential effects on water quality. The physico-chemical parameters temperature, pH, Total Dissolved Solids (TDS), electrical conductivity (EC), redox potential (Eh), chloride, fluoride, bromide, nitrite, nitrate, sulphate, and phosphate water contents were analysed. The microbiological parameters *Escherichia coli* and intestinal *enterococci* were monitored over the time. The obtained results indicate that the water located downstream the Vizela river is the most contaminated, although there has been an improvement in the water quality over the time. The microbiological contents are higher than parametric Portuguese values defined for human consumption, and often also for the parametric values defined for recreation water activities. As a preventive and monitoring measure, it is recommended to monitor the various physico-chemical and microbiological parameters in water points, with a spatial and temporal regular and constant monitoring.

Keywords

Surface water • Industrial activity • Nitrites • Contamination • Monitoring

1 Introduction

Water quality in a watershed is one of the most relevant issue. Meeting water quality goals to sustain environmental quality in a large scale, multi-state water system is a challenge (Fernandez and McGarvey 2019). The increase in population over the last decades, as well as the occurrence of water stress areas, constitutes an important source of contamination for surface and groundwater (Negm et al. 2020). Water quality in a watershed is mainly controlled by anthropogenic activities and natural processes, which may be directly or indirectly influenced by the surface activities (Pratt and Chang 2012; Ai et al. 2015; Vasconcelos 2015; Belabed et al. 2017).

The industrial activities concentrated in the Valley of Ave river and the proliferation of energy production units have intensified the sources of contamination, mainly industrial and domestic ones. To recover the natural conditions of the Ave River, in 1999, a regional programme "*Vale de Ave's depollution system*" was implemented. However, after the application of this project, the ecological status of the river did not go beyond the classification of "poor quality", according to the Portuguese Environment Agency (Rong et al. 2019). The objective of this work is the identification of local and diffuse contamination sources located in the Vizela River, aiming to improve the river water quality.

2 Study Area

The Ave river is in the North of Portugal, inserted in the Portuguese Hydrographic Region (RH2)—River Cávado, Ave and Leça (Agência Portuguesa do Ambiente 2015). It is about 98 km long. Along with its main tributaries, East River (right bank) and Vizela River on the left bank, it occupies an area of about 240 km^2 (Soares et al. 1999).

The textile industry and agricultural activities are the principal activities. In the study area, the total annual rainfall is over 1400 mm, with the highest temperature in June (19.9 ºC) and the lowest one in November (11.5 ºC) (Brás 2018).

Five water points were selected and analysed, between July and October 2018, in the Vizela river watershed. The water points are spatially distributed from the Vizela river source (point V5) to the confluence with Ave river (point
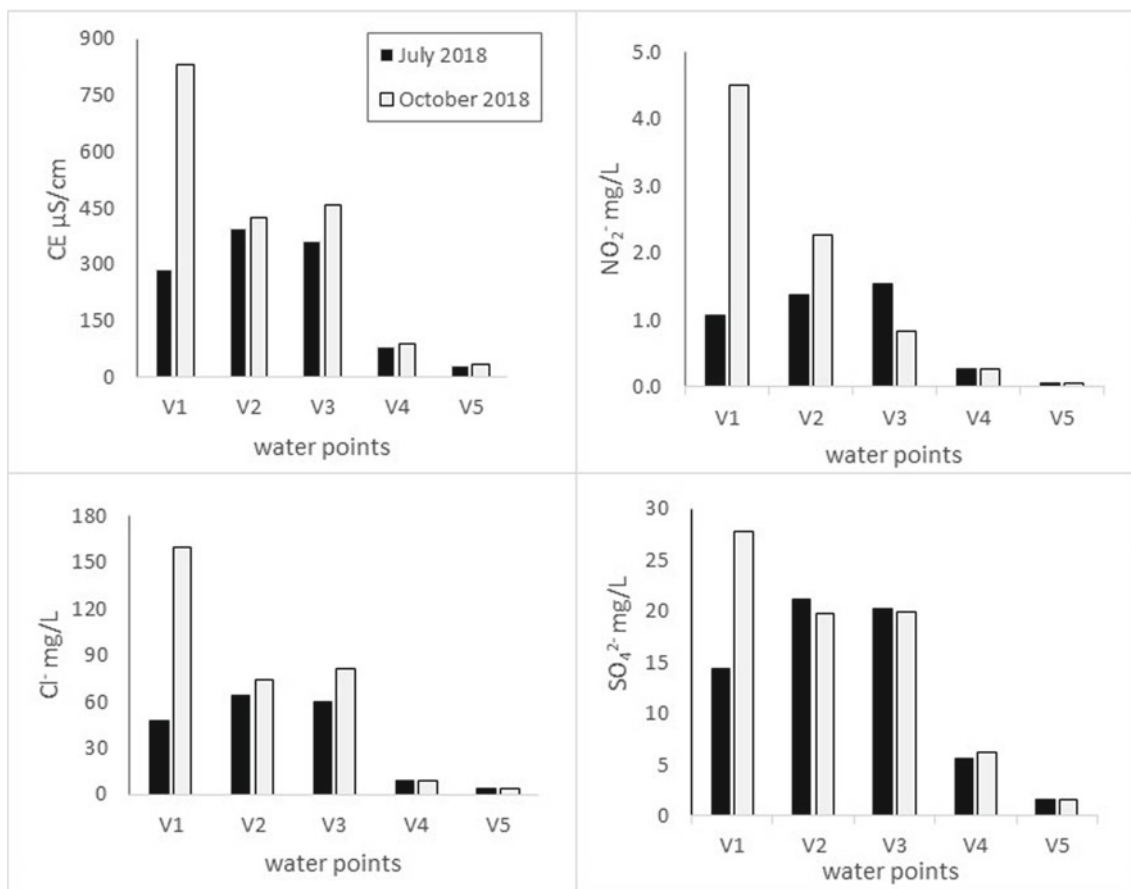
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Fig. 1 Seasonal variation of water from the Vizela river

V1). The physico–chemical parameters: electrical conductivity (EC), temperature, pH, Eh, and Total Dissolved Solids (TDS) were determined in situ, and selected anions were determined by ion chromatography at the University of Minho (Braga, Portugal). The microbiological parameters (*Escherichia coli* and intestinal Enterococci) were determined between 2012–2017 (Câmara Municipal de Vizela 2018).

3 Results and Discussion

Water temperature is an indicator of water quality and will affect dissolved oxygen and pH values. The highest temperature value was obtained in September (V1 = 22º C), while the lowest one in October 2018 (V5 = 18.2º C). The pH value ranged between 6.9–7.9, without a significant temporal variation. Total dissolved solids (TDS) varied between 423 mg/L (point V1) and 18 mg/L (point V5), with a similar variation in electrical conductivity (EC; Fig. 1). In October, the highest TDS and EC values were obtained. The highest chloride water content was detected in October, although in the water points V4 and V5, no significant

temporal variation was observed. The water sample V1 had a maximum content of 160.1 mg/L Cl^-, with a significant temporal variation (Fig. 1).

Nitrite water content was higher in October than in July, except for water point V3. The water content showed a maximum of 4.5 mg/L NO_2^- (point V1) and a minimum of 0.050 mg/L NO_2^- (point V5). The water from V1, V2, and V3 were unsuitable for human consumption because NO_2^- content was above the Portuguese parametric value (0.5 mg/L) (Brás 2018). The highest SO_4^{2-} water content was observed in October (points V1 and V4) and the lowest one in water from V5 (Fig. 1). The microbiological parameters showed the occurrence of *Escherichia coli* above the parametric value for recreation activities (Diário da República: 2007).

4 Conclusions

The obtained results show that water downstream the Vizela river is the most contaminated, although there has been an improvement in water quality in the river watershed over time, mainly since the creation of the regional programme, in

1999. Otherwise, upstream water presents the lowest contents in most of the analysed parameters, because it is closer to the natural spring of the Vizela river. Water contamination increases with distance from the source of the Vizela River. The microbiological parameters, represented by *E. coli* and intestinal Enterococci water content, were higher than parametric Portuguese legisled values indicated for human consumption and is also above the parametric value defined for recreation activities. The monitoring of water physico-chemical and microbiological parameters is strongly recommended in the Vizela river watershed including a spatial and temporal water network.

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