Spatio-temporal dynamics of the aquatic vegetation on two sites of the Rhône River

Dynamique spatio-temporelle de la végétation aquatique sur deux sites du Rhône

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RÉSUMÉ

En milieu fluvial, le développement de la végétation aquatique est affecté par les conditions hydrologiques et hydrauliques ainsi que par l'effet rétroactif exercé par la végétation sur les paramètres physiques de l'environnement. La complexité des interactions entre la végétation et les conditions d'écoulement conduit à ce que le rôle joué par les conditions hydrologiques dans la dynamique de la végétation aquatique soit mal connu, particulièrement dans les rivières anthropisées où les conditions d'écoulements sont altérées. L'objectif de cette étude est ainsi d'analyser à partir de photographies aériennes l'effet des conditions hydrologiques sur la dynamique spatio-temporelle de la végétation aquatique. Cette étude a été réalisée sur deux secteurs du Rhône où la gestion des écoulements est différente : à Baix, le fleuve est court-circuité sur un tronçon de 8 km avec un débit réservé et des crues de moindre intensité, tandis qu'à Vienne, les conditions hydrologiques ne sont pas modifiées par le barrage de Vaugris. Pour les deux sites, la dynamique spatio-temporelle de la végétation aquatique est différente entre l'amont et l'aval des infrastructures (barrage et tronçon court-circuité). Néanmoins, à Vienne, la variabilité des conditions hydrologiques influence la dynamique de la végétation, alors que ça ne semble pas être le cas à Baix, probablement du fait de la régulation des débits.

ABSTRACT

In fluvial systems, the development of aquatic vegetation is affected by hydrological and hydraulic conditions as well as by the retroactive effect exerted by the vegetation on the physical parameters of the environment. Due to the complex interactions between the vegetation and flow conditions, the role played by hydrological conditions in the dynamics of aquatic vegetation remains largely unknown, particularly on anthropised rivers where flow conditions are altered. The aim of this study is to analyse from aerial images the effect of hydrological conditions on the spatio-temporal dynamics of aquatic vegetation. This study was realised on two sectors of the Rhône River where the flow management is different: in Baix, the river is bypassed on a 8 km reach with a regulated discharge and floods of lesser intensity, while in Vienne, the flow is not regulated by the Vaugris dam. For both sites, the spatio-temporal dynamics of the aquatic vegetation is different between the upstream and downstream of each of the infrastructures (dam and bypassed reach). Nonetheless, in Vienne, the variability of hydrological conditions influences the vegetation dynamics, while it does not seem to be the case in Baix, probably due to the flow regulation.

KEYWORDS

Dams, hydrological conditions, Rhône River, spatio-temporal dynamics submerged aquatic vegetation

1 INTRODUCTION

In fluvial systems, the development of aquatic plants is strongly influenced by flow conditions, both at a large scale by the set of flows over a defined time (i.e., hydrological conditions) and at a finer scale by the hydraulic conditions (Sand-Jensen et al., 1999; Tena et al., 2017). Flow conditions affect the growth of plants and can lead, in the case of a punctual increase of flows, to their breakage and / or uprooting (Bornette and Puijalon, 2011). Indirectly, hydrological conditions influence the recruitment, growth and survival of plants through the new mosaics of physical habitats that they constantly create. Reciprocally, aquatic plants influence the water velocities, the water depth and the sedimentation processes, hence favouring their own growth and survival downstream and within the stands, where the water velocities are reduced and the sediment particle size is finer (Sand-Jensen et al., 1999). Therefore, due to the complex interactions between the hydrological conditions and aquatic vegetation the role of hydrological conditions in the spatio-temporal dynamics of submerged aquatic vegetation remains largely unknown, particularly on anthropised rivers where flow conditions are altered. The aim of this study was to analyse the effect of hydrological conditions on the spatio-temporal dynamics of the aquatic vegetation in two developed sections of the Rhône River.

2 STUDY SITES AND METHODS

The study was carried out at two sites, Vienne and Baix, located on the Rhône River (Figure 1). These sites are geographically close but also present different flow conditions due to the different flow management. In Baix, the Rhône River is bypassed on an 8 km reach where the flow is regulated, while in Vienne, the Vaugris dam did not lead to flow regulation. On both sites, the submerged aquatic vegetation has been mapped every year between 2015 and 2019 from aerial images taken by Very Light Aircraft in September on a linear of 29.3 km and 16.7 km in Vienne and Baix, respectively. To analyse the spatio-temporal dynamics of the vegetation, both sites were divided into 20 reaches of equal length and 2 variables were calculated at the reach scale: the cover of the vegetation for each year and the change rate of the vegetation cover between two consecutive years. The formula used to calculate the change rate of the vegetation cover is *((AV t + 1 – AV)/ AV)*100*, *AV* corresponding to the area covered by the vegetation on a reach and *t* to the initial year, respectively. At the stand scale, the area of each stand per year was calculated. To analyse the effect of hydrological conditions on the vegetation dynamics, the years separating two images have been identified as years with high flows or years with low flows, depending on the number and the duration of high and low flow events (discharge ≥ 90th percentile and ≤ 10th percentile of the daily discharge chronicle 1980 - 2019, respectively), the mean discharge as well as the maximum discharge achieved. As the number of study years (n = 5) was too low to test the relationship between vegetation dynamics and hydrological conditions, we tested if the changes of the vegetation correspond to the differences of hydrological conditions among years, i.e., high flow *vs* low flow years.

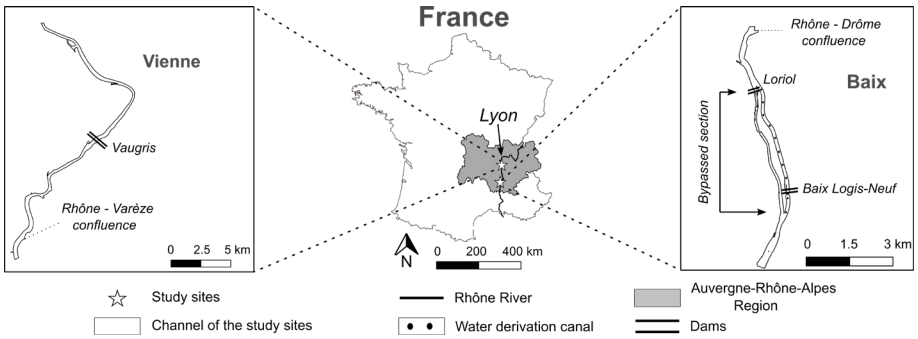

Figure 1: Location of the study sites.

3 RESULTS AND MAIN CONCLUSIONS

Three out of the five years studied have been identified as years with high flows (2015, 2016 and 2018) and two as years with low flows (2017 and 2019). The most severe flood happened in January 2018, corresponding to a return period of 10 and 6 years in Vienne and Baix, respectively. On both sites, a difference in vegetation cover was observed upstream and downstream of each of the infrastructures (dam and bypassed section): in Vienne, a higher cover was observed on reaches downstream of the Vaugris dam than on the upstream ones and, in Baix, a lower cover was observed on reaches located within and downstream of the bypassed section than those located upstream. From a temporal view, this difference is also observed as the variability of the change rate is lower on

reaches located downstream of the Vaugris dam in Vienne and on reaches located upstream of the bypassed section in Baix (Figure 2). Both infrastructures may thus have a different effect on the environmental parameters influencing the dynamics of the vegetation as its development is favoured downstream of the Vaugris dam in Vienne while it is favoured upstream of the bypassed section in Baix. While the development of the vegetation can be promoted when these infrastructures induce a reduction of water depth and velocity and a warming of the water, it can be limited when they favour a high concentration of suspended materials as well as when the regulation of flow leads to the dewatering of a portion of the channel (Bornette and Puijalon, 2011; Tena et al., 2017).

The temporal dynamics of the vegetation cover differs between both sites. Indeed, the change rate of the vegetation cover follows our hypothesis, with negative values the years with high flows (2016 and 2018) and positive values the years with low flows (2017 and 2019), except for Baix where the rate is null or negative in 2019 (Figure 2). The particularity of 2019 can also be observed, to a lesser extent, in Vienne where the change rate in 2019 is lower than the one of 2017 while the hydrological conditions of these years are similar. We thus suppose that the differences observed for the year 2019 are due to the flood of 2018 that overall reduced the growth of the vegetation (i.e., through sediment scouring), with a higher impact in Baix.

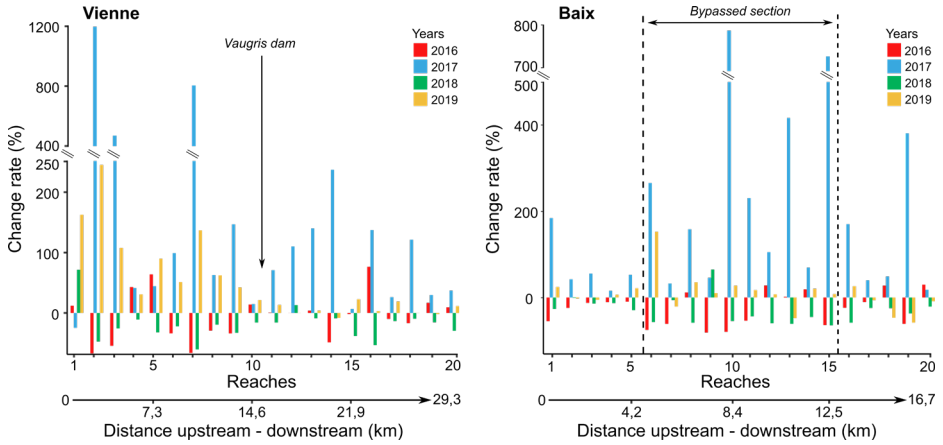

Figure 2: Change rate of the vegetation per reach between two consecutive years. On the abscissa axis, the reaches are ordered according to their location along the upstream – downstream gradient. The location of the Vaugris dam is shown by the vertical arrow and the bypassed section is delineated by the vertical dashed lines.

Finally, in accordance with the dynamics of the vegetation cover, the area of stands differs according to hydrological conditions in Vienne but not in Baix. However, conversely to what we expected, the stands are larger the years with high flows (2015, 2016 and 2018) than those with low flows (2017 and 2019). These results, combined with the positive values of the change rate the years with low flows, raise the question of how low flow years can contribute to the vegetation dynamics by providing new habitats available for colonization in Vienne.

To conclude, this study demonstrates that the spatio-temporal dynamics of the vegetation is influenced by infrastructures on both sites. Moreover, on the non-regulated site (Vienne), the dynamics of aquatic vegetation are influenced by hydrological conditions, while it is less clear on the regulated site (Baix), probably due to the flow regulation. Additional data are nonetheless needed to better understand on which environmental parameters, particularly relating to the sediment, water depth and velocity, these infrastructures act, explaining thus their effect on vegetation dynamics. These data, combined with the results of this study, may help stakeholders to better anticipate the effects of flow regulations and restoration works on vegetation dynamics, particularly in Baix in the context of reactivation of fluvial margins.

LIST OF REFERENCES

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