The role of high flow events on sediment transport and deposition on vegetated bars of the Isere River

Impact des crues fréquentes sur le transport sédimentaire et le dépôt sur des bancs végétalisés de l'Isère

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RÉSUMÉ

Les lits de nombreuses rivières alpines sont sujets à l'installation de végétation à cause de l'altération de leur régime hydro-sédimentaire. Ceci augmente les risques d'inondation, est néfaste pour la biodiversité, et tend à stabiliser la morphologie fluviale. Manipuler l'hydrologie pourrait être une option de gestion pour limiter l'installation de la végétation. Dans ce contexte, nous cherchons à caractériser l'impact des crues fréquentes sur la mobilité sédimentaire et sur la végétation au cours de ses premiers stades de développement. Notre site d'étude est l'Isère, une rivière alpine très impactée par les activités humaines. Nous avons suivi trois bancs entre avril et septembre 2014. La mobilité des sédiments grossiers a été caractérisée par des placettes peintes. L'évolution de la végétation et des dépôts de sédiments fins a été suivie sur cinq à dix placettes de 25 m² par banc, à l'aide de photos verticales régulières. La période de mesure a été caractérisée par des crues mineures, dont le temps d'occurrence moyen ne dépasse pas six mois. Certains évènements ont été marqués par des très fortes concentrations en sédiments fins (jusqu'à 40 g/l), qui ont été à l'origine de dépôts sur les placettes de suivi. On a observé très peu de mobilité des sédiments grossiers, ce qui peut expliquer le fait que ces crues n'ont pas été capables de détruire la végétation. Nos résultats préliminaires tendent à montrer que pour entretenir la végétation à travers la manipulation de l'hydrologie, des débits supérieurs à ceux observés au cours de la saison 2014 doivent être lâchés.

ABSTRACT

Vegetation encroachment is common in alpine rivers in which sediment and hydrological regimes have been modified by human activities. This encroachment increases flood risks, has negative impacts on biodiversity, and tends to stabilize river morphology. Managing hydrology in a way that would limit vegetation development on river bars might be an interesting option for river management. In this context, we aim at understanding the impact of frequent high flow events on sediment mobility and vegetation in its first development stages. Our study focuses on the Isere River, a highly managed gravel-bed river flowing on the western side of the Alps. We monitored three bars between April and September 2014. Coarse sediment mobility was regularly assessed using painted plots. Vegetation evolution and fine sediment deposition were monitored on five to ten 25 m² plots per bar, using repeated vertical photographs. The measurement period was characterized by only minor high flow events, with an average occurrence time of up to 6 months. Very high suspended sediment concentrations occurred occasionally (up to 40 g/l) which resulted in measurable sediment deposition within our plots. Very little coarse sediment mobility was observed, and as a result no vegetation was removed. Our preliminary results highlight the need for flows higher than those observed in 2014 to be released in order to manage vegetation through hydrology.

KEY WORDS

Flushing flows, fluvial dynamics, Isère River, sediment transport and deposition, riparian vegetation

INTRODUCTION

Many Alpine river beds have been recently subjected to vegetation encroachment on river bars, due to anthropogenic modifications of sediment and flow regimes. Vegetation impacts sediment transport and deposition pattern, thereby changing fluvial dynamics. Indeed, vegetation decreases flow velocity and increases sediment cohesion. Both effects tend to stabilize river morphology, which promotes further vegetation development on river bars. This has negative impacts on biodiversity and increases flood risks.

Our aim is to understand whether flushing flows could be a mean for preventing or slowing vegetation colonization of river bars. Specifically, we are interested in understanding the impact of relatively small floods on sediment transport and deposition patterns on partly vegetated bars. We are also looking at the consequences of such floods on early stages of vegetation development, when physical processes have most influence (Corenblit et al., 2007). We present here the first results of a field monitoring campaign which took place in the spring and summer 2014.

1 METHODS

1.1 Study site

Our study site is the Isère River, between the towns of Albertville and Montmélian (figure 1). This left-bank tributary of the Rhône River is located in South Eastern France, on the western side of the Alps. Within this reach the Isère River has one major tributary, the Arc River.

The hydrological regime is pluvio-nival, with higher flows due to snow melt in spring and summer. The Isere is characteristic of many Alpine Rivers and human impacts with (1) embankments constructed nearly 150 years ago, (2) massive sediment extractions between the 1950s and the 1980s, and (3) alteration of mean and high flows due to dams and flow diversions for hydroelectricity production. The studied reach has been subjected to vegetation encroachment since the late 1980s.

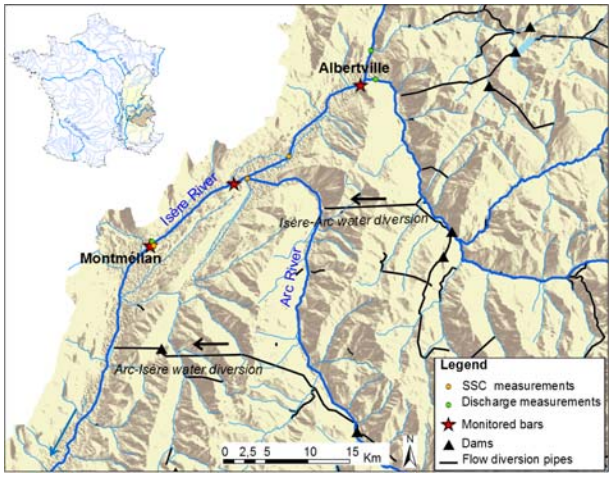

Figure 1. Location of Isère watershed, study reach, and monitored bars. Discharge and SSC measurement sites are also presented, as well as hydropower dams and flow diversion pipes.

We monitored three bars during the spring and summer 2014, located on figure 1. Both upstream sites were cleared of vegetation and fine sediments by mechanical intervention in 2008 and 2012 respectively.

1.2 Field measurements

The initial configuration of the bars was assessed in terms of vegetation distribution, topography, and surface sediment size. In order to understand the impact of high flow events on sediment transport and deposition related to the first stages of vegetation development, we monitored hydrology, and measured sediment mobility and vegetation cover throughout spring and summer 2014.

Sediment transport and vegetation dynamics associated with high flow events at the bar scale were monitored on 25 m² plots distributed across each of the bars. This plot size was chosen in order to capture vegetation dynamics even in sparsely vegetated areas. They were monitored regularly using vertical photographs taken with the help of a 6 m telescopic mast (example shown on figure 2). Thus their evolution is known at the flood event timescale. These photographs are used to quantify the evolution of fine sediment distribution on the plot through time. In order to assess coarse sediment mobility, 1 m² plots were spray-painted within the 25 m² plots. Their sediment size distribution was assessed before and after floods through digital imagery (Chung and Chang, 2013). Concerning vegetation, the photographs show the surface growth of vegetation and enables identification of the different species that are present (both herbaceous and woody species). This allows us to determine whether specific high flow events are able to destroy vegetation of given characteristics in different regions of the river bar.

2 RESULTS AND DISCUSSION

Several high flow events occurred during the spring and summer 2014, but none had an average occurrence time superior to 6 months. Some events were characterized by very high suspended sediment concentrations (SSC), up to 40 g/l. Two flushing flow operations occurred in the upstream basin, with an amplitude similar to that of natural flows of this season.

The photographs are still being analyzed; however some interesting trends have emerged. First, this season has been marked by a strong tendency for deposition of fine sediments, despite some observations of re-suspension at the event time scale. Sediment deposition patterns seem to be strongly linked with suspended sediment concentration during high flows. Vegetation in its first development stages (less than 1 year old) seems to have almost no impact on sediment deposition, in contrast with what a previous study observed on the Isere River for later stages of vegetation development (Allain-Jegou, 2002). Second, coarse sediment mobility was very low in most of the monitored plots. Finally, no vegetation was removed by any high flow event that occurred during the season.

Figure 2 and table 1 illustrate the evolution of a typical 25 m² plot between July 16th and August 6th2014. Three high flow events occurred during this time, each with an average occurrence time of 4 months, with SSC reaching 40 g/l. This led to significant fine sediment deposition (+20% of plot area), but no vegetation was removed.

In terms of river management, flushing flows had no impact on vegetation removal, while they did lead to fine sediment deposition on the bars. Our preliminary results suggest that in order to be efficient in terms of vegetation removal, artificial floods must have higher magnitudes.

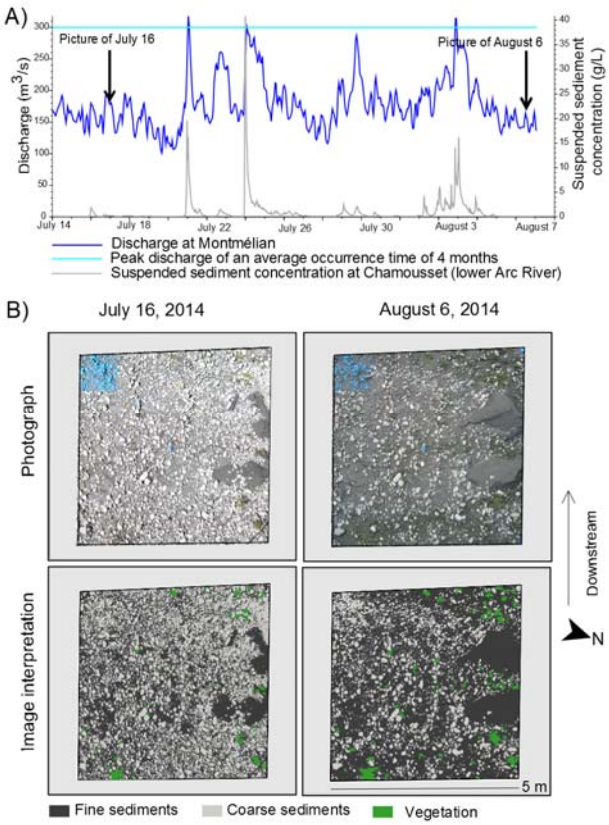

Figure 2. Example of evolution of a 25m² plot before and after three minor high flow events. A) hydrology and fine sediment concentration between July 16th and August 6th 2014, and B) photographs and occupation analyses of 25 m² plot at these two dates

Table 1. Surface occupation of plot shown of figure 2.

	July 16th 2014	August 6th 2014
Number of vegetation individuals	140	150
Surface occupied by vegetation	0,43 m² 1,7%	0,78 m² 3,2%
Surface occupied by fine sediments	12,72 m² 52,5%	17,69 m² 73,0%
Surface occupied by coarse sediments	11,08 m² 45,7%	5,75 m² 23,7%
Coarse sediment mobility		None

3 CONCLUSION

We have seen that a spring and summer season with no significant high flow events led to sediment deposition and vegetation development of bars of the Isère River. Our results suggest that even during the first stages of vegetation development, frequent floods are not able to remove vegetation. This is likely due to insufficient coarse sediment mobility.

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