Inter-annual evolution of habitat conditions in restored former channels: example of the Rhône river

Evolution inter-annuelle des conditions d'habitat dans d'anciens chenaux fluviaux restaurés : retours d'expérience sur le fleuve Rhône

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RÉSUMÉ

Au cours des deux derniers siècles, certaines activités humaines et infrastructures (*i.e.* endiguement, construction de barrages, etc) ont altéré la connectivité entre le chenal principal du Rhône et les écosystèmes riverains. Les habitats des milieux périfluviaux, et plus particulièrement les chenaux secondaires et les bras morts, sont aujourd'hui condamnés à disparaître sans la mise en œuvre de mesures curatives**.** Afin de proposer des actions de gestion adaptées et durables, il est nécessaire de mieux comprendre le fonctionnement de ces milieux. Cette communication a pour but de fournir une typologie physique de 18 anciens chenaux fluviaux restaurés à partir (i) d'une analyse de l'évolution des conditions granulométriques de leur fond, puis (ii) d'une évaluation quantitative de leur connectivité hydrologique latérale (eaux superficielles) prenant en compte la variabilité de niveaux des plans d'eau (fréquence d'un niveau donné, vitesse d'élévation entre différents niveaux), et la caractérisation de la dynamique des évènements débordants (durée et intensité des évènements). Les résultats indiquent qu'une grande diversité de trajectoires physiques persiste dans l'espace et le temps entre les sites. Les bras restaurés présentent un large éventail de fonctionnements hydrologiques et hydrauliques. Le régime hydrologique des chenaux secondaires (débit de connexion faible) est soit identique soit très similaire à celui du chenal principal, tandis que les bras morts présentent des degrés variables de connectivité latérale. Ils possèdent un comportement hydrologique plus complexe qui dépend principalement de multiples niveaux de connexion avec le chenal principal.

ABSTRACT

Over the last two centuries human actions (*i.e.* embankment, damming, etc.) have altered the connectivity between the main channel of the Rhône river and riverine ecosystems. Slackwater habitats of the river, especially secondary channels and backwaters are ineluctably doomed to disappear without curative actions. Furthermore there is a strong need to better understand the functioning of these environments in order to propose appropriate and suitable management actions. This talk aims to provide a physical typology based on (i) an analysis of grain size evolution and (ii) a quantitative assessment of lateral hydrological connectivity (superficial water) in term of water level variability (frequency of a given level, flashiness between different levels of water), determination of overbank flow dynamics (duration and intensity of such flow events). Results indicate that a high diversity of physical trajectories persists both in space and time amongst sites. Restored former channels have a wide range of hydrological and hydraulic functioning. The hydrological regime of the secondary channels (low overflowing discharge) is either identical or very similar to that of the main channel, while the backwaters experience varying stages of hydrological connectivity. They exhibit more complex hydrological behaviour which mainly depends on multiple stage-dependent connections to the main channel.

KEYWORDS

Floodplain rehabilitation, habitat conditions, hydrological flow pulse, lateral hydrological connectivity.

1 THE RHONE RIVER

1.1 A strongly regulated river: consequences for floodplain ecosystems

Human actions (*i.e.* embankment, damming, etc.) have altered the connectivity between the main channel and riverine ecosystems. Slackwater habitats of the Rhône, especially secondary channels and backwaters, are ineluctably doomed to disappear without curative human actions, while they are considered are considered as hotspots of biodiversity (*e.g.* Bornette et al. 1998).

1.2 An ambitious restoration program

A major restoration plan has been initiated in 1998. It consists in two main actions: firstly to increase minimum flow in by-passed reaches of the hydroelectric schemes and secondly to restore some preselected former channels. The channel sediments were dredged, either locally or over the entire channel length. Furthermore, the upstream or downstream alluvial plug was removed in 10 floodplain channels to reconnect them to the main channel.

1.3 Aim of this talk

This talk focuses upon 18 restored former channels which have been restored between 1999 and 2006 along four different bypassed sections of the Rhône River between Seyssel and Lyon. It aims to provide a physical typology of habitat conditions evolution through time based on an analysis of grain size characteristic changes (i) and a quantitative assessment of hydrological connectivity (*i.e.* surface water connections and flow dynamics).

2 MATERIAL AND METHODS

2.1 Grain size of deposited sediments

Sediment grain size is based on five fine sediment samples per former channel. They are longitudinally performed and as far as possible equally spaced along the centerline of each channel. Samples were collected with an Eckman grab and were analyzed using a laser granulometer. Changes in habitat conditions are determined through the evolution of average median grain size and median grain size variability within each of the sites.

2.2 Hydrological / hydraulic dynamics analysis

We used stage-discharge relations derived from limnimetric series, topographic data and flow duration curves (FDC) to analyze the hydrological identity of each restored former channel. Segmented linear regressions have been applied to establish stage-discharge statistical relationships and to identify significant breakpoints in the trend. The meaning of the breakpoints was interpreted from a DEM (2 m of resolution, precision of 20 cm in z, provided by the IGN) in combination with numerical hydraulic modeling.

3 RESULTS

3.1 Post-restoration evolution of grain size

Figure n°1 highlights three main types of grain size responses to restoration. Secondary channels have locally sandy deposits, but the grain size pattern adjusts quickly to new hydraulic conditions. Periodically scoured channels by flood constitute an intermediate situation involving complex temporal trajectories which differ between channels. Pure backwaters are characterized by very fine overbank deposits, homogeneous in grain size and associated with low inter-annual variability.

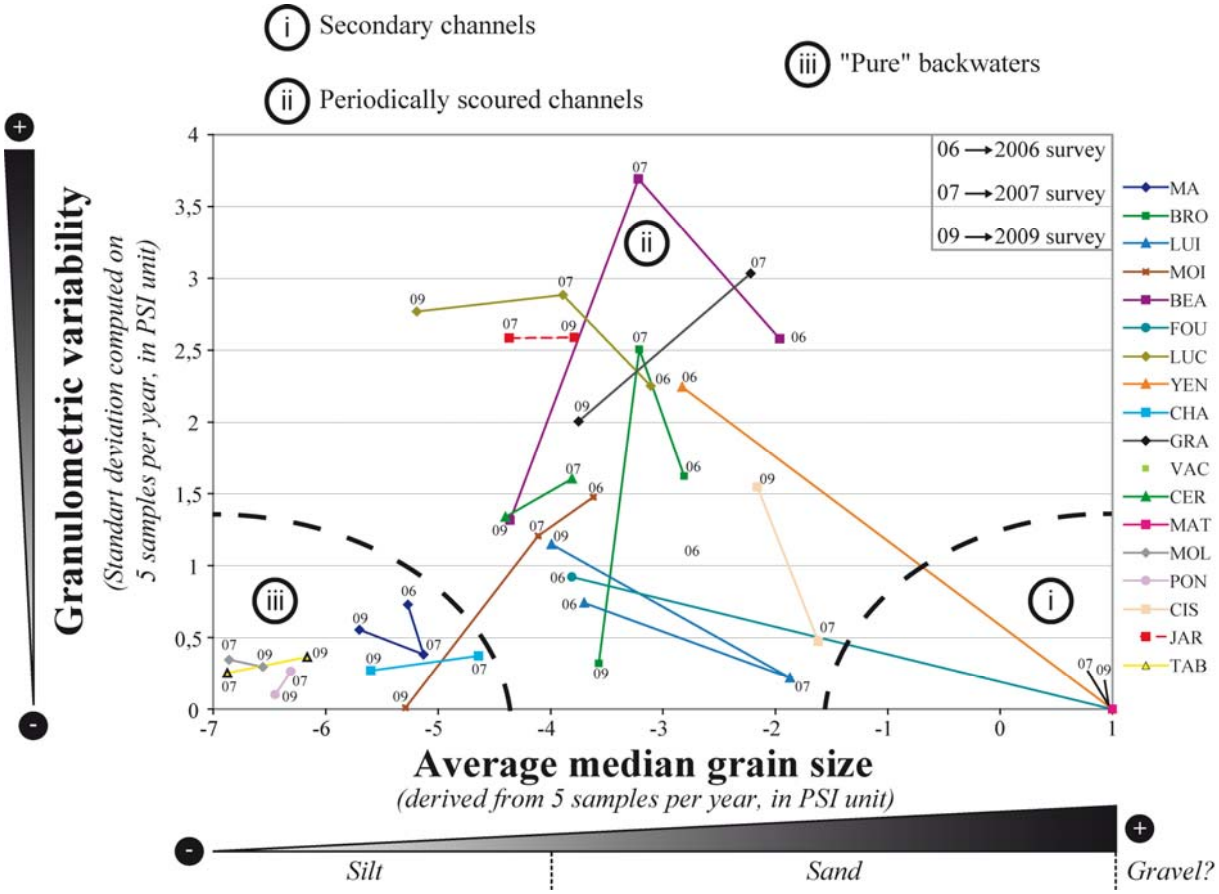

Figure n°1: Evolution of grain size characteristics in restored former channels.

3.2 Quantitative assessment of lateral hydrological connectivity

Water level variability (frequency of a given level, flashiness between different levels of water), overbank flow dynamics (duration of such flow events) are analyzed for each former channel. On an other hand we linked the average shear stress (N/m2) at the time of the overflowing and the frequency of the mean daily overflowing discharge (d/year) to asses connection intensity. The combination of all these metrics allow us to provide the "hydrological identity" of each restored former channel.

4 CONCLUSIONS

Results indicate that a high diversity of physical trajectories persists both in space and time amongst site, which validates one of the main objectives of the project (Amoros, 2001). Restored former channels have therefore a wide range of hydrological functioning. The hydrological regime of the secondary channels (low overflowing discharge) is either identical or very similar to that of the main channel, while the backwaters experience varying stages of hydrological connectivity. They exhibit more complex hydrological behaviour which mainly depends on multiple stage-dependent connections to the main channel.

Further investigations have to be realized concerning the role of hydro-morphological dynamics as an important structuring factor of biological communities in order to predict biological responses (invertebrates, ichtyofauna, macrophytes) according to modifications of hydromorphological features.

LIST OF REFERENCES

Amoros C. (2001). *The Concept of Habitat Diversity Between and Within Ecosystems Applied to River Side-Arm Restoration.* Environmental Management 28(6), 805–817.

Bornette G., Amoros C., Lamouroux, N. (1998). *Aquatic plant diversity in riverine wetlands: The role of connectivity*. Freshwater Biol., 39, 267–283.