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Ecological Impacts of Channelization Modes on the Loire, Garonne And Elbe Rivers in Comparison

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Introduction

The Loire, Garonne and Elbe rivers have been engineered in different ways. A comparative study on the biological colonisation of the Loire and Garonne rivers has revealed different impacts of the different engineering scenarios on the structure and diversity of the chironomid communities. Especially, the harmful effects of embankments and intensive pumping of water for irrigation on the overall diversity of the Garonne River have been demonstrated. Based on these results we discuss the expected impacts of engineering management on the biodiversity of the Elbe.
The comparison of biodiversities in the Loire and Garonne rivers was done with monthly sampling of both benthic larvae and drifting pupal exuviae collected in the main channel and two side arms, respectively (Garcia and Laville 2000, 2001).

The Loire and the Garonne : different ways in past hydraulic engineering decisions and their actual consequences on the hydromorphology...

The Loire River

The Loire is a dynamic sandy river system with erosional and sedimentating areas, including wooded alluvial islands. It provides a variety of microhabitats, as boulders, gravel, stable and shifting sand bars, willow roots, woody debris, macrophytes and mud. Engineering works included:

- Construction of dikes, while preserving a 800-1000 m wide free fluvial corridor (Fig. 1)
- Only 2 electric power plants built in the upstream section
- Limited pumping for irrigation in the lower section

In consequence

- Preservation of different, interconnected channel types (Photos 1 & 2)
- Natural daily fluctuation of the water level (Fig. 2)
- Preservation of shifting bed dynamics (Photo 3)

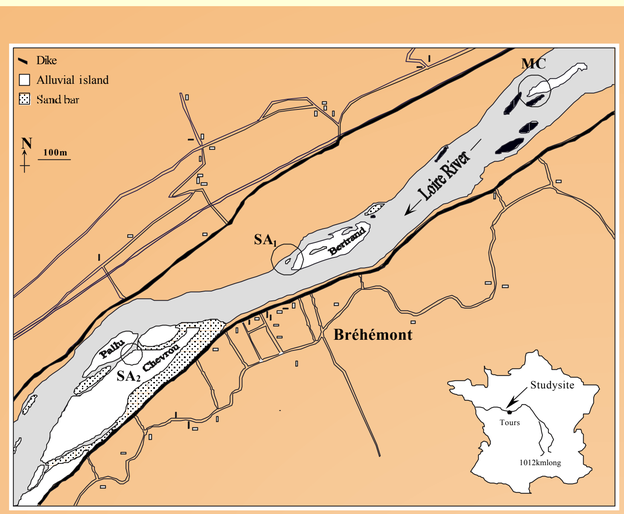

Fig. 1 : Map of the study sites showing dikes and sampling locations. MC : Main channel, SA_1 : Side Arm I, SA_2 : Side Arm II.

Photos 1 and 2: Views of the side arms SA_1 (left) and SA_2 (right).

Photo 3 : Dynamic sandbars (MC).

Photo 4: Embankment (MC).

Photos 5 and 6: Low flow discharge in disconnected side arms.

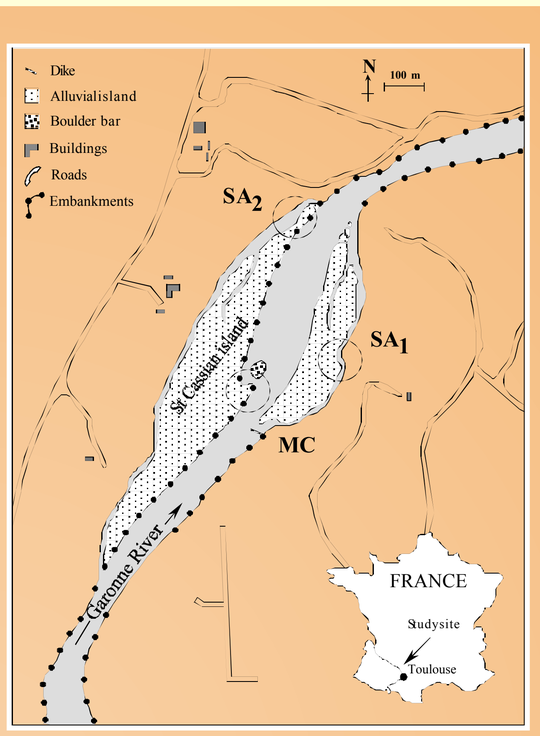

Fig. 3 : Map of the study site and sample area location. MC : Main channel, SA_1 : Side Arm I, SA_2 : Side Arm II.

The Garonne River

On the Garonne River, many hydraulic engineering works have been carried out to provide water for irrigation:

- Complete embankment of the main channel in 1958 (Photo 4)
- 19 electric power plants built in the upstream section
- Intensive pumping for irrigation in the lower section

In consequence

- Main channel fixed and disconnected from sidearms (Fig. 3)
- High daily water level fluctuation due to hydropower plant peaking (Fig. 4)
- Isolation and disappearence of side arms by aggradation (Photos 5 & 6)
- Homogenisation of the habitat conditions in the main channel by increasing current velocity (Table 1)

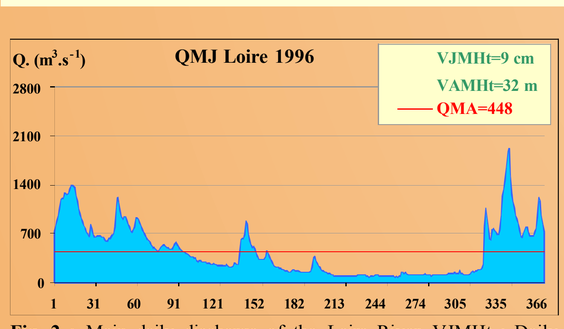

Fig. 2 : Main daily discharge of the Loire River. VJMHt : Daily cumulated variation of the water level. VAMHt : Annual cumulated variation of the water level. QMA: Mean annual discharge ($m^3 s^{-1}$).

Table 1 : Hydromorphological characteristics of the study sites (1996, river kilometres are from the source).

	LOIRE (River km 794)			GARONNE (River km 290)		
Width of the Main Channel (m)	Min : 123		Max : 537	Min : 75		Max : 164
Distance between the dikes (m)	Min : 688		Max : 1056	Min : 75		Max : 164
Mean annual discharge ($m^3 s^{-1}$)	481			178		
Current velocity (m s^{-1})	**Min**	**Max**	**Average ± SEM**	**Min**	**Max**	**Average ± SEM**
Main Channel	0.05	0.51	0.36 ± 0.02	0.03	0.88	0.51 ± 0.04
Side Arm I	0.00	0.24	0.05 ± 0.02	0.03	0.55	0.25 ± 0.13
Side Arm II	0.00	0.24	0.04 ± 0.01	0.00	0.03	0.02 ± 0.01

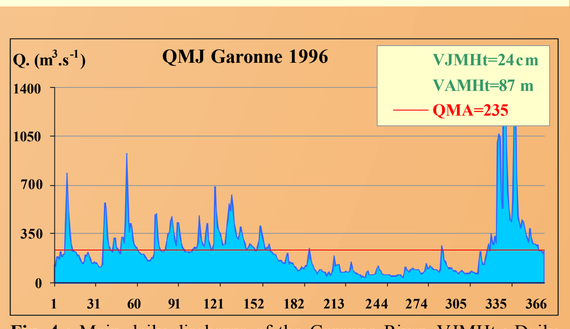

Fig. 4 : Main daily discharge of the Garonne River. VJMHt : Daily cumulated variation of the water level. VAMHt : Annual cumulated variation of the water level. QMA: Mean annual discharge ($m^3 s^{-1}$).

… and on the total diversity.

Table 2 : Chironomid diversity recorded in the side arms (R = Species richness, N = Number of specimens). Rare species: abundance < 5 specimens per study site.

	LOIRE			GARONNE		
	R	**N**	**R/LogN**	**R**	**N**	**R/LogN**
All species						
Side Arm I	93	4 606	25.4	89	5 861	23.6
Side Arm II	87	2 519	26.3	86	3 935	23.9
Rare species						
Side Arm I	23	2 472	6.8	21	8 124	5.4
Side Arm II	21	2 848	6.1	15	3 613	4.2

Table 3 : Chironomid diversity (R/LogN) recorded for each substrate type of the main channel.

	Roots	**Wood**	**Macrophytes**	**Mud**	**Boulders**	**Gravel**	**Sand**
Loire	13.1	12.3	12.0	10.7	10.4	8.9	7.8
Garonne	11.5	10.7	11.5	11.6	8.8	9.3	-

Fig. 5 : Compared species richness in the main channels of the Loire and the Garonne rivers.

The lower section of the Loire River still possesses considerable fluvial dynamics which favours a high biodiversity. Conversely, artificial stabilization of banks and irrigation management in the Garonne River have resulted in a modification of the fauna:

- Strong loss of the diversity in the main channel (Fig. 5).
- Simplification of the structure of the chironomid community by the dominance of four small, rheophilous and "r" type reproductive strategy species: *Cricotopus bicinctus*, *Orthocladius rivicola*, *Rheocricotopus chalybeatus* and *Synorthocladius semivirens*.
- Loss of the diversity in the sidearms (Table 2).

The decrease in diversity appears mainly due to the disappearance of the most diversely colonised microhabitats like roots, woody debris or macrophytes (Table 3). These results show that the preservation of shore heterogeneity and standing water areas are essential to maintain biodiversity in rivers.

Which hydraulic engineering scenario for the Elbe River?

The measures of river engineering on the Elbe to promote navigation, especially embankment and historic construction of groyne structures perpendicular to the flow (Photo 7), partially exert similar ecological impacts as on the Garonne: alteration of the shore structure, loss of connection with side arms, disturbance of shoreline habitats by ship waves action and increase of flow velocity in the middle of the channel. Hence, the present impacts of the Elbe management on the macroinvertebrate fauna are similar as on the Garonne: disappearance of specialised species and decrease in overall biodiversity.
An alternative way for shore protection, if navigation is thought to persist, is to build groyne structures parallel to the river shore, as now done near Wittenberg (Photo 8). The construction of such kind of alternative groyne structures would create standing waters at the margin of the main channel which are regularly flooded. This will allow the renewal of habitat dynamics and the persistence of natural shores protected from ship waves action. The expected ecological consequences are the colonisation by frequent and rare species and finally an increase of the overall biodiversity.

Photo 7: Perpendicular groynes near Wittenberge.

Photo 8: Parallel groyne near Wittenberg, an alternative way for shore protection.

Photo 9: Natural sidearm of the Elbe.

References: Garcia X.F. & Laville H. (2000). First inventory and faunistic particularities of the Chironomid population from a 6th order section of the sandy river Loire (France). Arch. Hydrobiol. 147(4), 465-484.
Garcia X.F. & Laville H. (2001). Importance of floodplain waters for the conservation of chironomid (Diptera) biodiversity in a 6th order section of the Garonne River (France). Annls. Limnol. 37(1), 35-47.