Hydromorphological effects of the renaturalization of an urban river: the Manzanares River in the city of Madrid (Spain)

Effets hydromorphologiques de la renaturalisation d'une rivière urbaine : la rivière Manzanares à Madrid (Espagne)

María Díaz-Redondo[1], Miguel Marchamalo[2], Felipe Morcillo[3]

[1] University of Lisbon, School of Civil Engineering, Lisboa, Portugal.
[2] Technical University of Madrid, Department of Land Morphology and Engineering, Madrid, Spain.
[3] Complutense University of Madrid, Faculty of Biological Sciences, Madrid, Spain.

RÉSUMÉ

Comme dans la plupart des rivières des grandes villes, la rivière Manzanares, dans la ville de Madrid, a été canalisée avec des murs en enrochement et murs de soutènement en pierre pour permettre un développement urbain intensif. De plus, neuf barrages ont été construits pour des raisons esthétiques afin de maintenir une vue sur une grande rivière. Au niveau écologique, les marges sont déconnectées du chenal par des structures artificielles, et la continuité longitudinale des écoulements, des sédiments et des espèces en amont et en aval, est fortement diminuée. L'ouverture des vannes urbaines, en mai 2016, a été le premier pas vers la renaturalisation de la rivière Manzanares dans la ville de Madrid. Les objectifs de renaturalisation comprennent le rétablissement de la fonction clé de la rivière en tant que corridor écologique (reliant les tronçons de la rivière en amont et en aval de la ville) et l'amélioration du paysage et de la valeur sociale de la rivière dans son contexte urbain. Les premiers effets écologiques de la reconnexion longitudinale de 7,5 km de rivière urbaine peuvent être quantifiés en termes de récupération partielle de la dynamique hydromorphologique. Premièrement, en éliminant la rétention d'eau, les profondeurs d'eau ont baissé d'environ 4 m en moyenne à 0,3 m, permettant des débits d'eau plus naturels, moins profonds et avec des vitesses différentes dans le chenal. Deuxièmement, des sédiments, principalement des sables, provenant des affluents en amont, pénètrent dans le système fluvial et se déposent dans la section canalisée, créant des barres latérales et des îlots. Le cas de la rivière Manzanares peut aider à comprendre comment une rivière urbaine peut évoluer avec une intervention non intensive axée sur le rétablissement de la dynamique naturelle.

ABSTRACT

As is the case of most rivers in large cities, the Manzanares River in the city of Madrid was channelized with rip-rap and stone walls to allow for intensive urban development. Moreover, nine small control dams were built for aesthetic reasons so as to maintain a view of a large river. At the ecological level, the margins were disconnected from the channel by artificial structures, and the longitudinal connection of flows, sediments and species between upper and lower sections was greatly diminished. The opening of the urban dam gates, in May 2016, has been the first step towards the renaturalization of the river. Renaturalization objectives include recovering the key function of the river as ecological corridor (connecting the river sections upstream and downstream of the city) and enhancing the landscape and social value of the river within its urban context. The first ecological effects of the longitudinal reconnection of 7.5 km of urban river can be assessed in terms of partial recovery of hydromorphological dynamics. Firstly, by eliminating water retention, water depths have lowered from around 4 m average to 0.3 m, allowing for more natural water flows, shallower and with different velocities within the channel. Secondly, sediments, mainly sands, from upstream tributaries are entering the fluvial system and are being deposited in the channelized section, creating lateral bars and islands. The case of the Manzanares River can help in understanding how an urban river can evolve with a non-intensive intervention focused on self-forming dynamics recovery.

KEYWORDS

Urban rivers, fluvial processes, Manzanares River, erosion, sedimentation

1 INTRODUCTION

Until the early 20th century, the Manzanares River in the city of Madrid was a shallow river, surrounded by thickets, with an important amount of sands that accumulated in lateral bars and central islands. Despite this, the river was frequented by the population as a place of recreation, sands were extracted from its channel, and wash-houses and bathhouses were distributed along its banks. Throughout the 20th century, the population grew and the areas near the river banks were urbanized, the river was channelized and nine dams were built with the aim of creating a series of separate ponds, giving it an aesthetic view more typical of the large Central European rivers. The Manzanares River gradually lost its river banks, its islands, its fauna, and was transformed into a channel without any ecological value and overlooked by society.

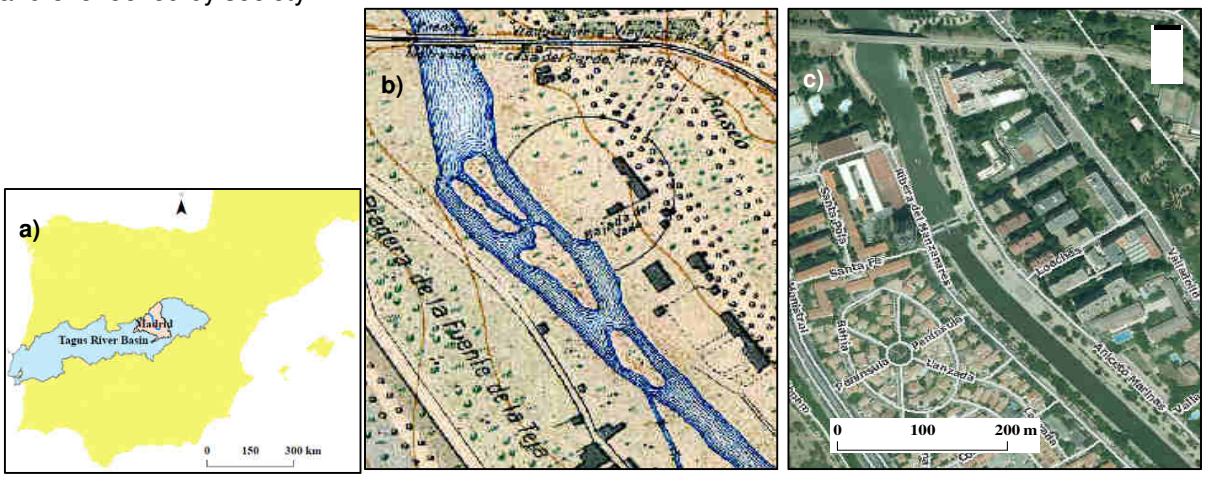

Figure 1. Location (a) and historical change of the Manzanares River in Madrid: 1900 map (b) and 2014 aerial photograph (c). Source: *http//ldehistoricamadrid.cchs.csic.es*

As many other urban river segments (Petts, 2007), this section of the Manzanares River was declared as a Heavily Modified Water body (Tajo River Basin Management Plan 2015-2021). Therefore, the recovery of urban rivers, as many other heavily modified rivers, is not only a necessity but an obligation (Gumiero *et al*., 2005). There is a requirement to comply with the EU Water Framework Directive ("prevent deterioration, improve and restore the state of water bodies and ensure that they are in good chemical and ecological status") as well as with the National Water Legislation (“Protect, improve and regenerate all surface water bodies in order to achieve a good status”)

As part of the Renaturalization initiative by the Madrid City Council, the opening of urban dam gates in 2016 has already allowed for partial hydromorphological recovery. The present study aims at evaluating this initial natural dynamics recovery through geomorphological metrics.

2 METHODS

Aerial photographs representing the previous situation (autumn 2014) and the months following the opening of urban dam gates (spring 2016, autumn 2016) have been digitalized. In addition, a fieldwork on spring 2017 has been incorporated. The geomorphological analysis focuses on the evolution of islands and bars. Metrics include areas (m2) for both and shoreline length as the sum of perimeters (m) in contact with water, i.e. island perimeter and only the length of bars that is in contact with water. On the other hand, we also calculate ratios of areas and shoreline lengths per patch (island or bar). All these metrics are an indication of habitat quality and availability (Tockner & Standford, 2002).

3 RESULTS AND CONCLUSIONS

Before the opening of gates (autumn 2014), the urban stretch merely consisted of a series of impoundments with no dynamics at all (Table I). After the opening of gates, results show that sedimentation is taking place in the form of islands and bars. The increase in number, area and shoreline length of islands and bars is remarkable straight after the gate opening (spring 2016) and a few months later (autumn 2016).

We can also appreciate that area and shoreline length almost double from spring to autumn 2016, although the following year (spring 2017) this rise has slowed down. The trend in the number of patches shows a more constant increase in the three time steps after the gate opening.

Table I. Evolution of island and bar number, areas and shoreline length before (autumn 2014) and after the gate opening of urban dams.

	Autumn 2014	Spring 2016	Autumn 2016	Spring 2017
Area (m^2)				
Islands	61	12,199	16,764	19,419
Bars	0	15,917	26,862	30,445
Total island & bar area	**61**	**28,116**	**43,626**	**49,864**
Shoreline length (m)				
Islands	48	3,920	6,137	7,434
Bars (contact with water)	0	1,877	3,811	4,312
Total shoreline length	**48**	**5,797**	**9,948**	**11,746**
Patches (units)				
Number of islands	2	123	145	157
Number of bars	0	42	67	74
Total number of patches	**2**	**165**	**212**	**231**

Therefore, ratios of shoreline length and area per patch (island and/or bar) indicate that, at the beginning, sedimentation produces many small and medium-sized patches (Figure 2). Later on, patches do not grow significantly in number but, instead, become larger in size.

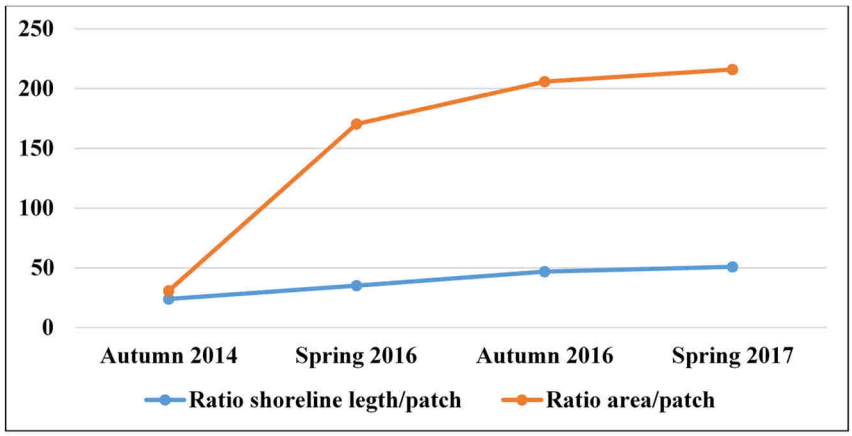

Figure 2. Ratios of shoreline length and area per patch (island and/or bar).

In a short period of time, the evolution of fluvial dynamics has been spectacular. The rapid creation of bars and islands entails an increase in natural zones of terrestrial/aquatic transition (shoreline length) that can be temporarily colonized by different types of animals and plants.

As a conclusion, we have to acknowledge that the barrier removal and consequent partial recovery of natural dynamics in an urban stretch can lead to the improvement of the river ecological corridor function and, overall, of the ecological potential as required by the WFD.

LIST OF REFERENCES

Gumiero, B., Mant, J., Hein, T., Elso, J., & Boz, B. (2013). Linking the restoration of rivers and riparian zones/wetlands in Europe: Sharing knowledge through case studies. *Ecological Engineering*, 56, 36–50.

Petts, J., (2007). Learning about learning: lessons from public engagement and deliberation on urban river restoration. *Geographical Journal,* 173, 300-311.

Tockner K. & Stanford J. A. (2002). Riverine flood plains: present state and future trends. *Environmental Conservation, 29*, 308–330.