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Relationships between aquatic biotic communities and water quality in a tropical river–wetland system (Ecuador)

G. Alvarez-Mieles [a,b,c,*], K. Irvine [a], A.V. Griensven [a,d], M. Arias-Hidalgo [a,b], A. Torres [c], A.E. Mynett [a,b]

[a] UNESCO-IHE, Institute for Water Education, Department of Water Sciences and Engineering, PO Box 3015, 2601 DA Delft, The Netherlands
[b] Delft University of Technology, Faculty CiTG, PO Box 5048, 2600 GA Delft, The Netherlands
[c] Universidad de Guayaquil, Facultad de Ciencias Naturales, Av. Juan Tanca Marengo, Guayaquil, Ecuador
[d] Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium

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ABSTRACT

Many tropical wetlands threatened by land use changes, or modifications in hydrological regime require effective management policies and implementation to protect them. The Abras de Mantequilla wetland, located in the Guayas River Basin in Ecuador, is subject to two major environmental disturbances, i.e., short-term agriculture (rice, maize) on the land around the wetland and the effects of planned infrastructure works of the Baba dam in the upper catchment. Both activities are expected to be the main constraints for the future wetland health. The objective of this study was to provide an initial characterization of the biotic communities of the river and wetland habitats before the dam starts operating. Plankton, macroinvertebrates, fishes and associated physical and chemical variables were sampled at 12 sites during the wet season (February 2011).

Biotic metrics (abundance, taxa richness, diversity and evenness) were computed for the aquatic communities in the wetland and the river. A biotic index (Biological Monitoring Working Party-Colombia/adaptation) was applied to the macroinvertebrate community. Relationships between biotic and abiotic variables indicated nutrients, velocity and sediment type as main drivers. Cluster analysis grouped physico-chemical variables according to river or wetland sites. Similarities regarding the taxa composition among sites were explored with non-metric multidimensional scaling method (NMDS), showing clusters for ichthyoplankton and macroinvertebrates.

Higher densities of organisms were recorded in the wetland compared with the river. The wetland is an important area of breeding and reproduction for fish communities, with its lentic habitats promoting the development of high densities of ichthyoplankton. In order to achieve sustainable solutions for integrated river–wetland systems, management options should focus on maintaining natural variation in hydrodynamic conditions throughout the entire catchment, as well as implement good practices in agriculture and reforestation using native species. Local and national authorities should support continuous monitoring programmes, taking account of seasonal variation and of future impacts from flow reduction and nutrient enrichment.

* *Corresponding author at*: UNESCO-IHE, Institute for Water Education, Department of Water Sciences and Engineering, PO Box 3015, 2601 DA Delft, The Netherlands. Tel.: +31 15 2151821; fax: +31 15 2122921.
E-mail addresses: g.alvarezmieles@unesco-ihe.org, galvarezm6@hotmail.com (G. Alvarez-Mieles).
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1. Introduction

Wetlands associated with tropical rivers provide valuable habitats for a diverse and specialized flora and fauna, serve as important longitudinal and transversal corridors for dispersal of biota, and provide services at local and catchment scales. Hydrological, biogeochemical, socioeconomic and ecological functions of wetlands include water retention, flood control, water purification and provision of fisheries and forestry resources. Their ecological significance is expressed in terms of biodiversity, presence of rare species, habitat and productivity (Dudgeon et al., 2006; Gopal, 2009; Junk, 2002; Maltby, 2009; Ramsar, 2007).

Increasing impact from a range of pressures on tropical wetlands include water extraction for irrigation and human consumption, deforestation, agricultural intensification and fisheries exploitation. Increasing human populations generate changes in food production, leading to water deviation and decreasing wetland area. In severe cases, floodplain wetlands are drained with the extensive loss of biodiversity and natural functions. Land use changes affect species diversity and composition of both plants and animals. The impact of these activities is still poorly understood (Eppink et al., 2004; Ramsar, 2007).

Preservation of biodiversity in rivers and their associated riparian areas is related with human society and socioeconomic activities in complex ways (Décamps, 2011; Ramírez et al., 2008). Wetlands are key elements of a river basin and wetland management affects river basin services. The importance of integrating wetlands into river basin management has been increasingly recognized (Ramsar, 2007). However, appropriate monitoring is essential for effective management. Monitoring programmes require clear objectives, careful selection of measured variables, and a clear justification for monitoring frequencies (Irvine, 2004, 2009). Increasingly, biological variables are used in addition to physical and chemical characteristics. Biological criteria can represent the status of a river reach or wetland over a longer period of time than chemical data (Simon, 2000).

The aim of this paper is to evaluate the current ecological status and the ecological management of the Abras de Mantequilla wetland in relation to the ongoing and planned developments in the surrounding river system. This is done by the assessment of the diversity and abundance of the aquatic biotic communities and their relationships with abiotic factors. Such information provides an initial component in understanding the river–wetland system that can lead to support wetland stakeholders (local communities, experts and government authorities) in developing monitoring activities and environmental management plans for the wetland and upstream areas.

2. Case study

The Guayas River Basin is located in the Coastal Region of Ecuador (Los Ríos Province) (Fig. 1). Agriculture, fisheries and hydropower are the main economic activities in the basin. Agriculture is based on banana plantations, rice, maize, African palm and cacao. Two hydro-electrical projects are located in the upper catchment. These, along with point and non-point sources of pollution (sewage, agriculture) and change in land uses are the main environmental pressures.

The Abras de Mantequilla wetland (56000 ha), declared a RAMSAR site in 2000, is located in the center of Guayas River Basin. The wetland consists of branching water courses surrounded by elevations of 5–10 m (Quevedo, 2008). It is part of the Chojampe sub-basin. Strong interactions between the wetland and the Nuevo River lead to flooding during the wet season (January–May), when water depth in the wetland increases due to the flow of the Nuevo River through Estero Boquerón (Fig. 1), and when the rainfall run-off from the Chojampe sub-basin drains into the wetland. The Chojampe sub-basin contributes approximately 30% of the water, and the Nuevo River around 70%. During the dry season (July–November), the water level in the wetland decreases drastically, and water remains only in the deep central channels, reducing the inundated area to 10% compared with the wet season (Arias-Hidalgo et al., 2013).

Current land uses around the wetland and hydropower projects in the upper catchment are expected to be the main constraints for the future health of the wetland. The original forest coverage is less than 3% due to the land conversion to agriculture in the last decades. Agriculture in the immediate area of the wetland consists of short term crops (rice, maize) with intensive use of fertilizers. The Baba hydroelectric project, located in the upper catchment of Quevedo-Vinces River started the filling of its reservoir in middle 2011, and is expected to start operations in 2013. The dam may cause a 43% reduction in the flow of Vinces River and, consequently, a decrease in the flow of the Nuevo River (Arias-Hidalgo et al., 2013).

3. Materials and methods

3.1. *Field sampling and laboratory work*

Sampling sites were selected according to a spatial distribution representing the main hydrological features of the wetland and connected river. Samples were collected from lentic sites with low velocities (0.1–0.3 m/s), and lotic sites with velocities >0.5 m/s. Lentic sites (S1, S2, S3b, S3c, S5, S6, S7) are located in the wetland area. The wetland was divided in three sections: upper (S5, S6); middle (S1, S2); and low (S7, S3b, S3c). Lotic sites (S11, S4, S3a) correspond to the inflow (Nuevo River-Estero Boquerón). S3a is located at the mouth of the wetland and S11 close to Vinces River. S13 correspond to the outflow (downstream section of Nuevo River). S9 is located at the North of the wetland corresponding to the rainfall run-off (drainage Chojampe sub-basin) (Fig. 1).

A total of 39 physico-chemical variables were measured in the water column and sediments. Biotic sampling included phytoplankton, zooplankton, ichthyoplankton, macroinvertebrates and fishes. The variables were selected to describe a range of abiotic and biotic characteristics as a first sweep overview of variables of potential use for long term monitoring to support management.