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Resource use and management

The last peri-urban rivers of the Mexico Basin: establishment of potential reference conditions through the evaluation of ecological quality and biological indicators

Los últimos ríos periurbanos de la cuenca de México: establecimiento de las condiciones de referencia potenciales a través de su calidad ecológica e indicadores biológicos

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Abstract

In assessing the health of rivers, the standardization of environmental and biological information as a baseline is essential in order to determine the set of conditions that are closest to the natural state of ecosystems. This is the case especially in peri-urban rivers where anthropogenic transformations occur rapidly and constantly. The objective of this work was to determine hydromorphological, physicochemical and biological parameters in 10 mountain rivers of the Mexico Basin, in order to establish a network of potential reference conditions and to validate the regional ecological quality. The potential reference conditions in this study are defined as oligotrophic water bodies with well-oxygenated concentrations and low ion concentrations. These conditions were recorded in 4 sub-basins with high hydromorphological quality. These results were corroborated through a base assembly composed of the macroinvertebrate families Baetide, Chrironomidae, Dugesiidae, Heptageniidae, Limnephilidae, Tipulidae and the class Arachnida (Acarina). The algal community was represented by *Nostoc parmelioides*, *Placoma regulare*, *Batrachospermum gelatinosum*, *Paralemanea mexicana*, *Draparnaldia mutabilis*, *Prasiola mexicana* and *Vaucheria bursata*. The major disturbances were structural changes in the riverbed that affect the structure and function of rivers.

Keywords: Reference sites network; Ecological quality; Benthic macroinvertebrates; Macroscopic algae; Hydromorphology

Resumen

El establecimiento de líneas base de información biológica y ambiental son fundamentales para la determinación de la salud actual de los ríos y las condiciones que se acercan a su naturalidad, en especial en sistemas periurbanos donde la transformación antrópica es rápida y constante. El objetivo del estudio fue evaluar un conjunto de parámetros hidromorfológicos, fisicoquímicos y biológicos en 10 ríos de montaña de la cuenca de México, para reconocer las características que definen las condiciones de referencia potenciales y el estatus de calidad ecológica en la región. Las condiciones de referencia potenciales fueron definidas por aguas oligotróficas, bien oxigenadas y de baja concentración iónica, condiciones registradas en 4 subcuencas que mantienen características hidromorfológicas naturales. Estos resultados fueron corroborados a través del ensamble base de macroinvertebrados, integrado por las familias Baetide, Chironomidae, Dugesiidae, Heptageniidae, Limnephilidae, Tipulidae y la clase

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Arachnida (Acarina). La comunidad algal característica estuvo representada por las especies resilentes *Nostoc parmelioides*, *Placoma regulare*, *Batrachospermum gelatinosum*, *Paralemanea mexicana*, *Draparnaldia mutabilis*, *Prasiola mexicana* y *Vaucheria bursata.* Las alteraciones más importantes son modificaciones estructurales del caudal que afectan la estructura y función de los ríos.

Palabras clave: Red sitios de referencia; Calidad ecológica; Macroinvertebrados bentónicos; Algas macroscópicas; Hidromorfología

Introduction

The study of aquatic resources associated with large urban centers is of vital importance, because they provide 3 of the most important ecosystem services related to human well-being: water purification and provision, retention of biodiversity in terrestrial ecosystems, and regional climatic regulation (Niemelä et al., 2010). In this sense, aquatic ecosystems have a great influence on the cultural and economic aspects of the local human communities, mainly because they are subject to a broad array of public policies and strategies aiming to manage the aquatic resources through the construction of dams, diversion of waterways, generation of power, and extraction of *in situ* water (Perló & González, 2005). Some of these structural interventions are physical stressors that alter the ecosystem, including the associations within the biological communities (Caro-Borrero, Carmona-Jiménez, González-Martínez & Mazari-Hiriart, 2015). Physical alteration of ecosystems can have an even greater impact than some alterations in water chemistry; even though local regulations are based on chemical parameters assessment (Acosta, Ríos, Rieradevall, & Prat, 2009; Caroni, van de Bund, Clarke, & Johnson, 2013).

The Metropolitan Area of the Mexico Basin has grown exponentially during the past 6 decades. Mechanisms employed to supply water to this area are based mainly on extraction of deep water from the aquifer and importation of water from neighboring basins (Perló & González, 2005). Currently, the aquifer is overexploited and water importation is a complex and expensive process for the city. An alternative management program designed to preserve the aquatic ecosystems, as well as to provide an adequate supply and distribution of water in the region should be based on a comprehensive and sustainable approach toward the surface water resources (Legorreta, 2009). This will necessitate assessment of the health of the rivers to determine the set of conditions that most closely resemble the natural state; this requires a record of chemical, physical and biological parameters at several sites with similar physical features that represent the least disturbed conditions and provide an estimate of the natural variability in biological conditions and habitat quality (Acosta et al., 2009; Cortés, Hughes, Rodríguez-Pereira, & Pinto-Varandas, 2013). Furthermore, information about biological communities could be translated into indicators of hydrological ecosystem function (Caro-Borrero, Carmona-Jiménez, & Mazari-Hiriart, 2015).

The ecological reference conditions are outlined as an environment with few anthropogenic pressures and minimal ecological impacts, and are not necessarily representative of pristine environments (Wallin, Wiederholm, & Johnson, 2003). In this sense, the greatest challenge in the selection of sites to determine the reference conditions is finding an approach that allows unification of a range of criteria to be combined in its characterization. The breadth of the concept and the freedom in the selection of parameters and assessment methods limit the comparison of results and the potential setting of regional patterns (Pardo et al., 2012). This highlights the need for intercalibration based on local characteristics of ecosystems in order to facilitate determination of the evaluation criteria and thresholds for rejection or acceptance of the parameters measured (Pardo et al., 2012).

The final step is the validation of physicochemical data through the composition of the biological community, a complex task in regions where pristine ecosystems are practically nonexistent; consequently, a biological baseline has been established in places already affected by human activity (Friberg et al., 2011). Also, the methods based on community analysis that have been used to assess ecological quality have been applied mainly in developed countries, where environmental research is detailed and available, and biodiversity parameters are sufficiently precise and incorporated within ecological responses (Nijboer & Verdonschot, 2004). In Mexico, insufficient study of the criteria for evaluation of ecological quality has impeded establishment of a network of potential reference sites.

The objective of this study was to evaluate a set of parameters, including hydromorphological, physicochemical and biological information about the mountain rivers of the Mexico Basin, in order to define the ecological quality at a regional scale and to establish a baseline that will allow reference conditions to be formulated.

Materials and methods

The Mexico Basin (Fig. 1) lies in the morphotectonic region of the Trans-Mexican Volcanic Belt at 19°00′–19°40′ N, 98°30′–99°30′ W and has a total surface area of 9,600 km^2, of which 5,518 km^2 are mountain ranges that rise above 2,400 m asl. (Ferrusquía-Villafranca, 1998; Legorreta, 2009). The climate of the region is sub-moist and temperate (annual median temperature 13.4 °C, annual median precipitation between 1,200 and 1,500 mm), with abundant rains from June to October and a dry season from November to May (García, 2004). Its geological traits consist of rock pockets alternating with andesitic to basaltic lavas (Ferrusquía-Villafranca, 1998), above which forests of *Abies religiosa*, *Pinus hartwegii* and *Quercus* spp. grow in the upper area of the watershed, with mixed forests in the middle and lower areas (Ávila-Akerberg, 2010). Thirty sites were selected, representing 10 sub-basins with perennial