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Review

Potential application of macroinvertebrates indices in bioassessment of Mexican streams

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ABSTRACT

Biomonitoring of surface waters using benthic macroinvertebrates is a common practice in developed countries. However, the use of biomonitoring metrics as part of regular monitoring programs in developing countries is scarce. This study is aimed at identifying the macroinvertebrate-based monitoring approaches which can be potentially applied to assess the ecological status of Mexican streams, and to provide guidelines and practical tools to implement such approaches. In this study, a total of 35 biomonitoring metrics were selected, divided into the following classes: 5 metrics of richness, 11 metrics to list the macroinvertebrates organisms (enumeration metrics), 6 diversity and similarity indices, 7 biotic indices, 5 functional feeding metrics and 1 multimetric approach. This selection was made using the a posteriori approach. Characteristics such as: sensitivity, ecological relevance, representativity, feasibility, metric interpretation, performance, and geographical suitability were also taken into consideration during the selection process. A description of the sampling and analytical procedures necessary to compute the selected metrics are also described. We provide an inventory of macroinvertebrate metrics that could be used in Mexico and nearby areas. However, further work is required to determine the accuracy and performance of these metrics for ecological assessment of Mexican streams.

Contents

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1. Introduction

In developing countries freshwater pollution aggravated by an increasing demand of water is a critical problem. The combination of rapid population growth and of industrialization and urbanization processes has increased the pressure placed on water resources and acutely reduced the supply of quality water. The surface waters of urbanized developing countries can be affected by a wide range of anthropogenic waste. This waste makes water inadequate for drinking, threatens aquatic biodiversity (Vörösmarty et al., 2010), increases the frequency of waterborne diseases (Schwarzenbach et al., 2010), and diminishes the related social and economic benefits (Hazilla and Kopp, 1990). Given these consequences, and for an appropriate management of water resources, efficient and inexpensive tools for surface water quality assessment need to be implemented.

The assessment of surface water quality is predominantly conducted by measuring physical and chemical parameters (e.g., stream flow, pH, nitrate, biochemical oxygen demand (BOD_5)). Although these parameters provide precise information about water pollution (USEPA, 2013), some of these require expensive laboratory analyses.

Instead, biomonitoring can be implemented. One important benefit of biomonitoring is the ability of organisms to integrate their responses over space and time, thus providing an insight into environmental conditions prior to the sample being collected. The use of biological organisms as indicators of water pollution level is cost-effective (Alba-Tercedor, 1996) and is an attractive alternative for developing countries where the expertise and technological and economic resources are limited (Resh, 2007; Thorne and Williams, 1997).

1.1. General interest of biological monitoring

Mexico's geographical location and climatic and topographic diversity enable the presence of great biodiversity (Conabio, 1998). Such biodiversity is also characterized by a high degree of endemism (e.g., endemic fish species – Mercado-Silva et al., 2002; Dominguez-Dominguez et al., 2008). However, biodiversity is currently threatened by human activities, leading to ecosystem deterioration or to the extinction of biota, often making biodiversity one of the factors used in biomonitoring tools. The importance of biomonitoring is justified by the need to know the current state of aquatic ecosystems to design appropriate conservative and protective actions.

The continuous degradation of surface waters due to various causes – such as anthropogenic activities (industry, farms, agriculture and urban wastes), the destruction of habitats, invasions by alien species and altered water flow regimes – sparks the interest to change the monitoring and management of streams from a regulatory approach to a holistic ecosystem approach (Pinto et al., 2009). Biotic communities present changes in their structure, composition and behavior when the physical, chemical or biological attributes of a river are altered. Therefore, aquatic ecosystems are increasingly monitored by observing the overall responses of a biocenosis able to integrate all the stressors undergone by the ecosystem over space and time. In this manner, biological monitoring has become an effective tool to assess water quality and aquatic ecosystem integrity (Barbour et al., 1999; Markert et al., 1999).

Usually, biomonitoring tools concern only a part of biocenosis, e.g., fish. Their application implies the knowledge of biological organisms currently present in a geographical site and includes a listing of these organisms. They provide information about the current health status of aquatic ecosystems. Such information is crucial to implement appropriate restorative, protective and preventive actions.

1.2. Biological organisms in biomonitoring

With regard to the biomonitoring of lotic systems, the metrics based on periphyton, benthic macroinvertebrates and fish communities are the most frequently used (Li et al., 2010). Metrics based on periphyton and fish communities are good indicators of habitat/hydro-morphological alterations. However macroinvertebrate-based metrics have a better response when enrichment of pollutants (like NO_3) is the main stressor affecting stream integrity (Johnson et al., 2006).

We have focused on macroinvertebrate-based metrics because macroinvertebrates present different advantages (Bonada et al., 2006; Rosenberg and Resh, 1993), including:

- their benthic nature, which allows a spatial analysis of pollutants;
- their relatively long life cycles, which allow environmental changes to be followed over long periods of time (they provide evidence of conditions for the last 6 months), contrary to diatoms that can reflect environmental changes for the previous 2 months;
- their sensitivity to different types of chemical and/or hydromorphological alterations;
- their abundance and diversity: the large number of species produces a range of responses to a wide variety of disturbances;
- they are easy to identify at the family level (at this level of identification they provide, in general, enough information of alteration level), compared to periphyton;
- sampling is easy to implement and requires few people, and equipment is relatively inexpensive; compared to sampling fish;
- and their ubiquitous occurrence.

1.3. Use of biomonitoring tools in Mexico

The biological assessment of aquatic ecosystems using macroinvertebrates has historically been carried out in developed countries (Cairns and Pratt, 1993). The available metrics cover a broad spectrum of techniques going from simple enumeration and community descriptors (see review: Metcalfe, 1989) to more sophisticated