

Ecology / Écologie

Impact of the longitudinal and seasonal changes of the water quality on the benthic macroinvertebrate assemblages of the Andorran streams

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Received 21 February 2005; accepted 20 September 2005

Available online 28 October 2005

Presented by Henri Décamps

Abstract

The ecological quality of the Andorran streams was assessed in 1998–1999, based on the survey of the water chemistry and the benthic macroinvertebrate assemblages. Two types of modification of the water quality were observed in the Andorran rivers: (i) a progressive degradation along the longitudinal gradient with a chronic degradation in the lower water courses; (ii) a seasonal modification in the mid-elevation sites. Two responses of the benthic macroinvertebrate assemblages to these disturbances were observed: an extreme simplification of the composition and a change of the trophic structure of the assemblages in the more impacted sites. **To cite this article:** *Y. Younes-Baraillé et al., C. R. Biologies 328 (2005).*

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Résumé

Effet des modifications longitudinales et saisonnières de la qualité des eaux sur les communautés d'invertébrés benthiques dans les rivières andorranes. Une étude de la qualité écologique des rivières andorranes, basée sur le suivi de la composition physicochimique de l'eau et l'évolution spatio-temporelle des communautés de macroinvertébrés benthiques a été menée en 1998–1999. Deux types de modification de la qualité de l'eau ont été observées dans les rivières andorranes : (i) une dégradation progressive vers l'aval aboutissant à une pollution chronique dans la zone aval des cours d'eau ; (ii) des perturbations saisonnières dans les sites de moyenne vallée. Deux réponses des communautés de macro-invertébrés benthiques à ces perturbations ont été observées : une extrême simplification de la composition et une modification de la structure trophique de ces communautés dans les sites les plus perturbés. **Pour citer cet article :** *Y. Younes-Baraillé et al., C. R. Biologies 328 (2005).*

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Keywords: Mountain streams; Water chemistry; Disturbance; Biological indices

Mots-clés : Torrents de montagne ; Physicochimie de l'eau ; Perturbation ; Indices biologiques

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1. Introduction

Mountain hydrographic systems are characterized by steep slopes and low water temperatures. Compared to lowland rivers, the impact of sporadic pollutions on the benthic fauna in mountain streams follows a different pattern, mainly because dissolved oxygen is not a limiting factor. Moreover, pollution is usually rapidly washed downstream and diluted by tributary supplies [1].

Several works have been carried out on the impact of man-induced disturbances on benthic macrofauna in alpine streams, i.e. in the Austrian torrents [2,3], and in the Pyrenees [4], however few specifically on the seasonal impact of tourism. In 1975, Lafont [5] studied the impact of the wastewater discharge from the ski stations on streams of the French Alps and Jura Mountains. In Andorra, two studies were conducted on the higher course of the Ariège River to assess the impact of the ski activities and the impact of the sewage treatment plant of the city Pas de la Case on Diatoms [6], and on Chironomid populations [7]. Prat et al. [8,9] conducted an extensive survey of the physicochemical composition of the Andorran streams with special attention to eutrophication processes. Data on the ecology of the Plecoptera and the Ephemeroptera and on the factors determining the distribution of some Diptera within the Andorran hydrographic network are also available [10,11].

The Andorran economy is mainly based on the seasonal tourism, ski in winter and mountain hiking in summer. The permanent population of Andorra, mainly urban, is of 65 877 inhabitants (population census 2000). However, the Andorran population is characterized by a regular increase (4.3% between 1990 and 2000) and a strong seasonal variability (11 million tourists in 2000; source: tourist information of Andorra). In winter, the frequentation of the snow sport stations generates an increase in wastewater discharges (about 336 438 tourists in February 1999 at the city Pas de la Case, corresponding to the maximum number tourists for the period of winter school holidays) and in summer, mountain hiking, hydrothermal curing and commercial tourism due to the duty free zone status of Andorra also strongly increase the production of wastewater (644 267 tourists in August at Pas de la Case in 1999, corresponding to the maximum number tourists for the summer period, and 179 508 tourists in November at Pas de la Case in 1999, corresponding to the minimum number tourists for the other periods). As a consequence, the ecological functioning of the Andorran rivers is disturbed.

This study aims to describe the longitudinal and seasonal changes of the water chemistry composition of the

Andorran streams and to identify the impacts of these changes on the benthic macroinvertebrate assemblages. Results are discussed taking into consideration the seasonal tourism activities.

2. Methods

2.1. Studied sites

Andorra is a small landlocked country between France and Spain (Fig. 1). Its altitude ranges between 840 m and 2946 m. The Andorran hydrographic network is organized around two main rivers located on the Spanish slope: the Riu Valira d'Orient and the Riu Valira Del Nord (Fig. 1). The first crosses Andorra from east to west, the second from north to south. They join in Andorra la Vieilla, the main city of Andorra, and become the Riu Gran Valira, a tributary of the Rio Segre (Ebro's catchment). Twelve out of the 13 sampling sites were located on this hydrographic unit. The site of Pas de la Case is atypical, because located on the Pyrenees French slope on the Riu Arieja and downstream the first wastewater treatment plant built in Andorra. Geographical and morphological characteristics of the studied sites are given in Table 1 with additional information about the type of anthropogenic impact affecting each site. Sites located in the upper course of the streams are exposed to ski activities. Most of the sites located in the mid and low courses of the streams are exposed to the discharge of domestic sewages (cities, ski resorts and camping areas) and to mechanical disturbances caused by the development of the tourism infrastructures.

2.2. Data collection

Nine physicochemical variables (temperature, pH, conductivity, COD, BOD, nitrate, nitrite, ammonium and phosphate) were measured weekly from September 1998 to December 1999 by the Medi-Ambient Department of Andorra. Except for temperature, measured in situ, the other physicochemical analyses were conducted at the laboratory according to a normalized protocol.

The benthic macroinvertebrates were sampled in autumn 1998, winter 1998/1999, summer 1999 and autumn 1999 in each sampling sites. At each site, eight subsamples were taken using a Surber net (200 μm mesh size, sampling area of 1/20 m^2), according to the microhabitat diversity). All the collected specimens were counted and the family level was retained for this study.

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