Spatio-temporal variability in stream flow status: Candelaro river case study

A.M. De Girolamo, A. Calabrese, G. Pappagallo, G. Santese, A. Lo Porto
Water Research Institute, National Research Council of Italy
annamaria.degirolamo@ba.irsa.cnr.it

Francesc Gallart
Institute of Environmental Assessment and Water Research (IDÆA), CSIC

Narcis Prat
Dept. Ecologia, Univ. Barcelona

Jochen Froebrich
Centre for Water and Climate (CWK) Integrated Water Resources Management
Wageningen UR - Alterra

Abstract: The spatio-temporal variability of the flow status of the Candelaro river and its tributaries was assessed in order to analyze the hydrological regime and to provide some information to assist the determination of the ecological quality as required by the European Water Framework Directive. Different types of flow were defined for this temporary river and a flow status frequency method was used to analyse the occurrence along the year of the different flow conditions. Daily streamflow data recorded in some gauging stations were used and the results were verified through field observations of flow status. Based on the results, maps were developed representing the spatial distribution of the different flow types along the year.
Keywords: Temporary river, Water Framework Directive, Hydrological regime.

1. Introduction

The European Water Framework Directive (WFD) constitutes a new view of water resources management in Europe, based mainly upon ecological elements, its final objective is achieving at least “good chemical and ecological quality status” of water bodies. To attain good ecological status, aquatic systems must not significant depart from reference “natural” conditions. Information describing stream hydrological regime are of the major importance for implementation of WFD, since it may be responsible for the ecological status. The analysis of the hydrological regime is particularly relevant for the intermittent rivers since it varies on spatial and temporal scale depending on precipitation patterns and is severely disturbed by flash floods. Many definitions of non permanent rivers can be found in the literature (Svec et al., 2005) and in the WFD implementation process some EU countries have developed a definition of these water bodies based on the number of days per year during which water is flowing in the river. In 2008, Italy differs these stream types, and in 2009-2010 gives the criteria for the monitoring activities, but it doesn’t include the timing of samplings. Frequency and

timing of samplings are crucial points for temporary rivers because the quantitative flow status determines the river biological communities. Streams with long dry periods can have a reduced fauna compared with permanent but their ecological status can be "good" even if the flow is scarce and only pools remain along the river network. In this framework, the main objective of the present paper is to analyse the spatio-temporal variability of the flow status of the Candelaro river and its tributaries in order to classify the hydrological regime and to provide some information to assist the determination of the water ecological quality.

2. Materials and Methods

2.1 Study area

The Candelaro river basin is located in the Puglia region in southern Italy (Figure 1). The basin is characterised by a mean elevation of 300 m above sea level, ranging from 0 m to 1142 m. The drainage area is about 2200 km^2 and the main river course has a length of 67 km. The soils are related to the lithology and generally show a texture varying from sandy-clay-loam to clay-loam or clay. The average annual precipitation in the catchment in the period from 1986 to 2001 was 579 mm. The rainfall is mostly concentrated in autumn and winter, it is unevenly distributed and often occurs with high intensities of short duration. The stream flow regime changes rapidly and follows the precipitation regime closely.

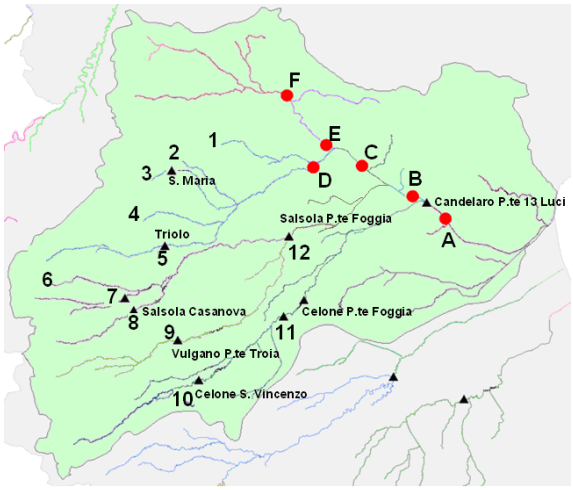

Figure 1: Candelaro river basin. River bodies identified by Puglia Region, streamflow gauging stations (triangles), simulated streamflow (red points).

2.2 Methods

In 2010, the Puglia region authority provided a river characterization based on the use of abiotic indicators, following the System B of the WFD and the national Decree 131/2008. Seven river types were identified in the Candelaro river basin which in turn were differentiated in 14 river bodies according to anthropogenic pressures.

For each river body we have analyzed the streamflow at reach scale as proposed within the MIRAGE Project[1] (Gallart et al., 2010). Five classes of flow were identified as relevant to aquatic life: *dry* (if most of the reach is dry), *disconnected pools* (when the flow is scarce only isolated pools appear along the channel), *connected pools* (when there are a lot of pools connected by a slow flow), *riffles* (if the flow is continuous) and *floods*. The monthly frequency of occurrence of these flow statuses were evaluated. In order to do this, it was necessary to fix the thresholds of streamflow between one class and another. At a first analysis these flow values can be determined on the basis of the Flow Duration Curves (FDC), but field observation are necessary to verify the thresholds between disconnected pools and connected pools and between connected pools and riffles. The monthly frequency of each flow status was calculated on measured monthly flows, when available (from 1965 to 1996), or on simulated values. The hydrological model "SWAT" was used to simulate streamflows from 1990 to 2009.

3. Results

Figure 2 shows the FDC (a) and the frequency of occurrence of the five streamflow classes (b) of the Celone river (gauge 10 in Figure 1). It shows a seasonal hydrological regime. Here, dry conditions generally occur from May to December; floods are frequent from January to March, and disconnected pools can take place from April to December.

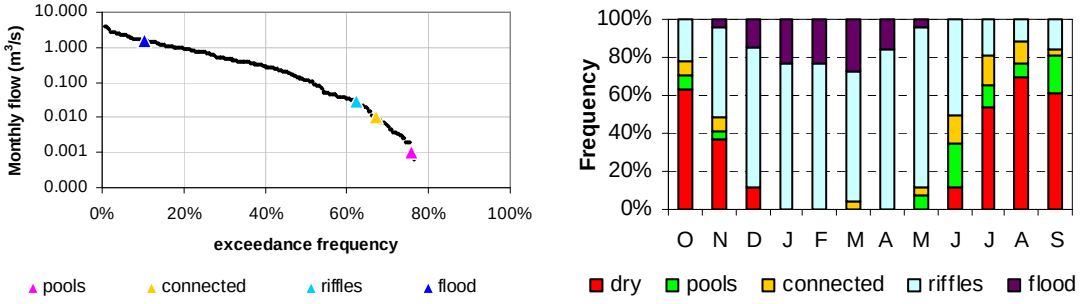

Figure 2: (a) Flow Duration Curve of the Celone S. Vincenzo gauging station (85 km^2). The triangles represent the thresholds identified between two different statuses. (b) Flow status frequency graph of the Celone river.

All the streams located in the mountainous part of the basin are quite natural; they show the same streamflow regime (gauging stations N. 6, 7, 8, 9, 10, in Figure 1). In this area biological samplings should be scheduled before June because after this month dry conditions can take over.

On the ground level of the basin the situation is different. The few natural reaches (1, 2, 3, 4 in figure 1) can be affected by dry conditions, as well as by isolated pools, also in the winter season. On the contrary, the main channel, which is heavily modified, shows a regime very far from its natural conditions (gauging stations A, B, C, D, F in Figure 1). Many waste water treatment plants discharge their sewages into the river, consequently the low flow regime is completely altered and it never reaches dry

[1] European Community's Seventh Framework Programme (FP7/2007-2011). MIRAGE Project (211735)

conditions. For the same reason, the downstream reaches of Salsola river show a dry status period shorter than that recorded in headwater streams. The Celone river, which is one of the main tributaries of the Candelaro, shows in its downstream reaches a very long dry period, from April to February. This is mainly due to a reservoir, built in 1996, that alters the natural regime of the river.
In 2010, monitoring activities were carried out along all over the river network. During the wettest period (January) continuous flow was recorded all over the streams, while during the driest period (September) only the 7% of the river network presented a continuous flow. Figure 3 shows a map representing the flow statuses during the driest period.

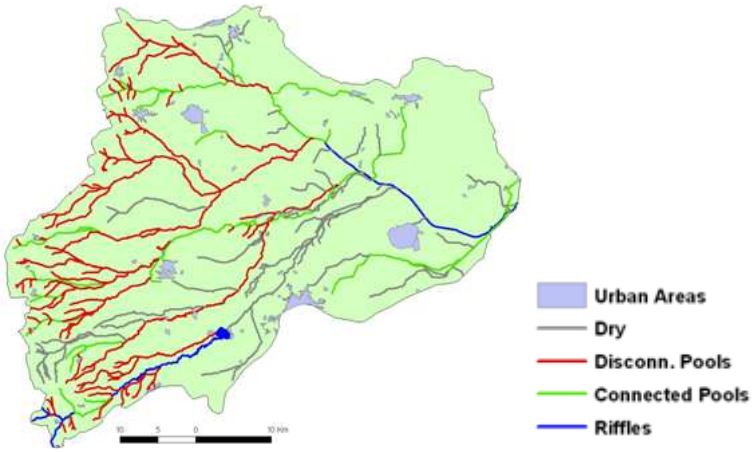

Figure 3: Flow status recorded during the driest period in the Candelaro river basin.

4. Concluding remarks

Flows are highly variable both in space and time in the Candelaro river basin. Dry and disconnected pools statuses are very frequent and their duration varies both year to year and from reach to reach. Hence, biological samplings have to be scheduled taking into account the flow statuses at reach scale. A new method has been used to describe streamflow regime at reach scale. The results achieved show that the flow status frequency graphs can really provide useful information in order to evaluate ecological water quality in temporary rivers.

References

Gallart, F., Prat N. et al., (2011 in revision). Analyzing stream reach flow status frequency to assist the determination of ecological quality in temporary streams, Aquatic Sciences.

Svec, J.R., Kolka, R.K., Stringer, J.W. (2005). Defining perennial, intermittent, and ephemeral channels in Eastern Kentucky: Application to Forestry best management practices. Forest Ecology and Management, 214. 170-182.