The Environmental Monitoring Network of Riegos del Alto Aragón (Spain)

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Abstract
This work presents the developed Network for irrigation return flows (IRFs) water quality control of *Riegos del Alto Aragón* Scheme, Spain. Water flows are measured and water sample are collected and analyzed for salinity, nutrients and pesticides. Results illustrating the state of the water quality of IRFs are presented. The collected database since 2005 is important for guiding present and future research on non-point pollution induced by intensive irrigation and establishing corrective measures. The results will be disseminated among farmers advancing the fertilization, irrigation, and manure management strategies that are considered more adequate to reduce the environmental effect of irrigation.
Keywords: Irrigation; Nitrogen; Pesticides; Phosphorus; Water quality.

1. Introduction

Irrigation in Spain accounts for 14% of the arable land and 50% of the final vegetal agrarian product (MAPAMA 2017) and is a key sector in the maintenance of population in rural areas, particularly in semi-arid areas like Aragón (Ruiz-Olano and Oliván-Villobas 2003). However, irrigation return flows (IRFs) contribute to water pollution by salts, nutrients (N and P) and pesticides. The General Community of Alto Aragon Irrigation Districts (RAA; 132,000 ha) is located in the NE region of Aragón (Spain), within the Ebro River Basin. Since 2002, some 1.1 Mha have been or are being modernized under the National Irrigation Modernization Plans in Spain, with around 67,000 ha modernized within RAA.

The prevalence of irrigation among water users in Spain points out the need to assess the environmental effect of irrigation on water quality, in order to preserve water quality and in compliance with the European Water Framework Directive —WFD— (EU 2000), The objectives of network presented herein are:

1. To establish the contribution of RAA to the pollutant loads in the Ebro River surface waters and determine the influence of factors such as crop patterns, irrigation systems and/or modernization and fertilization management on surface water quality.
2. To check the effect of the on-going or recently concluded modernization of the irrigation systems in RAA on water resources availability and water quality.
3. To provide an empirical basis for the development of agronomic/hydrologic models that can be used in the search of cropping and water management strategies for minimizing environmental effects of irrigation.
4. To help develop an approach to environmental quality standards based on pollutant loads emitted —not only concentrations.

2. Materials and Method

The General Community of RAA ordered a first study on the quality of IRFs in 2005 (RAA 2005) focused on flow, salts and nitrate. This study analyzed the evolution of water quality in 18 points in the RAA drainage network during 2005 (Fig. 1). In 2008, RAA appointed the CITA to establish a monitoring network for its drainage waters, selecting the monitoring stations from these 18 sampling points.

The development of the Network began in 2008 with the construction of the gauging station P-11 (Arroyo del Reguero) and continued throughout 2015, when the station at P-10 was incorporated.

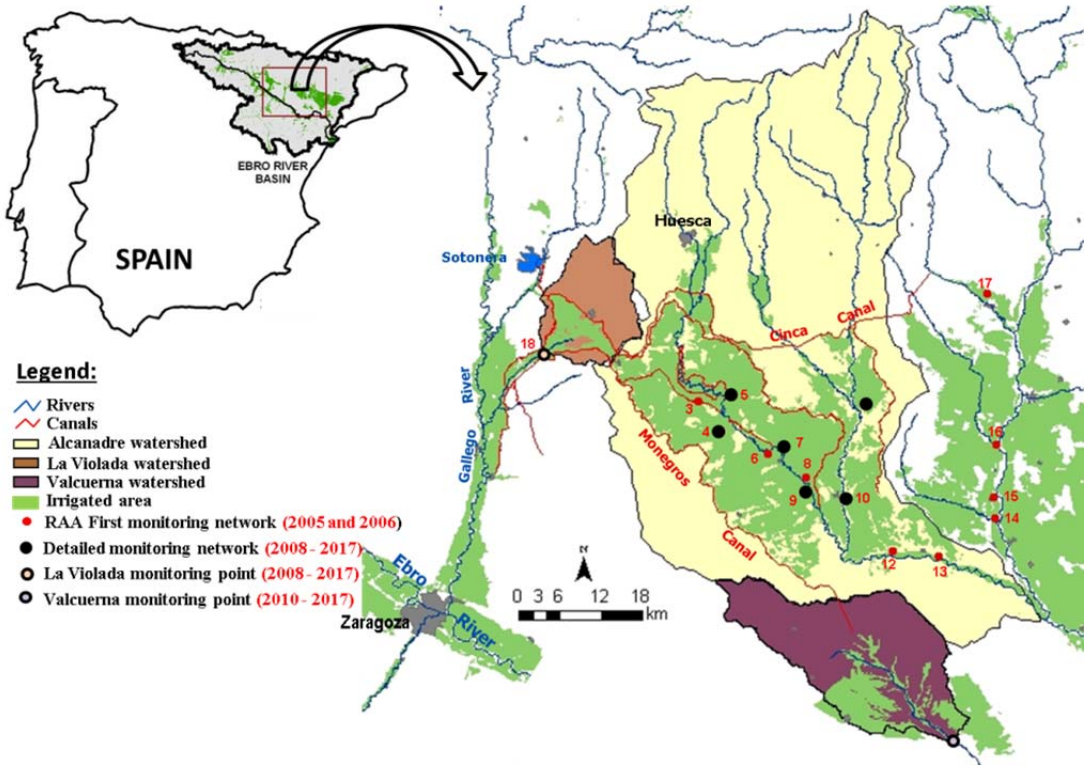

Figure 1. Location of the Riegos de Alto Aragón (RAA) environmental monitoring network.

Currently, the stations P-4, P-5, P-9, and P-11 are registering flows continuously and sampling for water quality daily by use of automatic samplers; while in stations P-7 and P-10, flows are measured and samples are collected monthly. The monitoring network in RAA is completed by two other stations (Violada and Valcuerna) (Fig. 1). All samples are analyzed for salinity, nitrate and phosphorus (total and dissolved); and some of them are also controlled for pesticides.

3. Results and discussion

This work generated important information in this network. Some results illustrating the state of the water quality of irrigation returns flows are presented (Fig. 2). Regarding mean concentration values (NIS, IS and HY), there were differences for each analyzed variable between control points. The EC showed values always above the FAO limit of 0.7 dS/m for unrestricted use for irrigation. For nitrates, mean annual concentrations were low at P4, P5 and P7 and very high at P10 and P11 (exceeding the upper permissible limit of 50 mg/L for human consumption water). The concentrations of DP were always very high at P4 and P11, therefore posing a high risk of degradation of the quality of receiving water bodies.

On the other hand, the volume of water supplied in each area and the drained surface make that the higher concentrations do not correspond often to high pollutant loads per hectare.

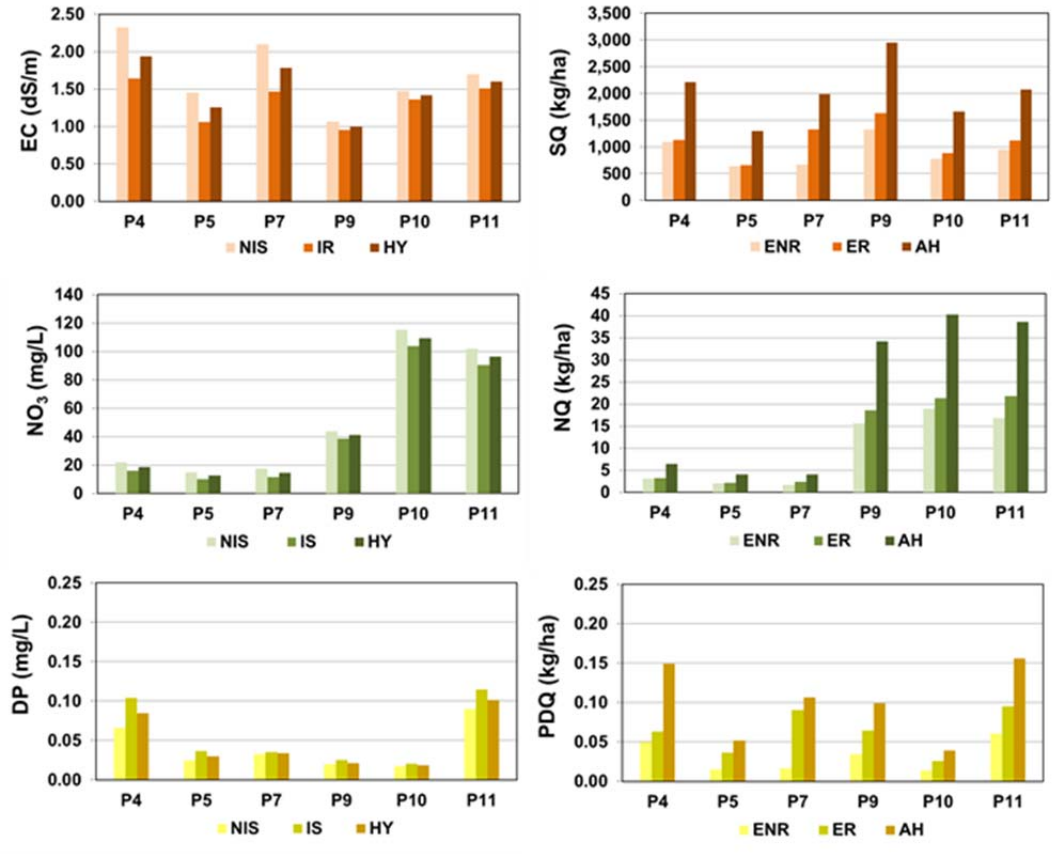

Figure 2. Electric conductivity (EC), nitrate (NO_3) and dissolved phosphorus (DP) mean concentrations *vs.* corresponding exported mass per unit area (SQ, NQ and PDQ) at P4, P5, P7, P9, P10 and P11 monitoring point. Data includes no irrigation season (NIS), irrigation season (IS) and hydrologic year (HY).

4. Conclusion

The establishment of a monitoring network for IRFs by the General Community of RAA shows that the stakeholders are assuming their role in preserving water quality and complying with the environmental standards in the WFD. The collected database is indispensable for guiding future research and establishing corrective measures. Some works will follow from the information collected in this network:

- The use of models offers the chance to propose managing strategies (in irrigation, fertilization and crop management) that may lead to reduced pollutant outputs once they are properly calibrated in irrigated basins. The modeling works at basin scale already initiated in Violada (Cavero et al. 2011) and P-11 (Dechmi and Skhiri 2013) will be continued with a better characterization of soil properties (Jiménez-Aguirre et al. 2017) and the use of crop model DSSAT.
- One of the main outcomes of the modeling process will be the proposal of ***Management Plans*** directed at reducing pollutant loads from the irrigated areas.
- Finally, the results will be disseminated among farmers by means of talks and short notes (prepared by CGRAA) advancing the fertilization, irrigation, and manure management strategies that are deemed more adequate to reduce the environmental effect of irrigation.

5. Acknowledgments

The Environmental Monitoring Network has been implemented by the *Comunidad General de Riegos del Alto Aragón*. This work was funded by *La Caixa* and the General Community

of Alto Aragon Irrigation Districts through collaboration protocols, and by the Spanish Ministry of Economy and Competitiveness and the European Regional Development Fund (ERDF) through the research grants AGL2010-21681-C03-03 and AGL2013-48728-C2-2-R.

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