Drivers of water quality changes: Impact of the Common Agricultural Policy in the Guadalquivir river basin (south Spain)

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OBJETIVES

The 2003 Common Agricultural Policy (CAP) reform, which was in force in 2006, promoted a more market orientated and sustainable agriculture. The aim of this study is to determine the influence that this agricultural reform could have had on water quality of surface water bodies in the Guadalquivir River Basin (South Spain) over the period 1999-2009.

METHODS

Site and variables of study

Records of monthly nitrates (NO_3, mgL^{-1}) and suspended solids (SS, mgL^{-1}) for surface water.

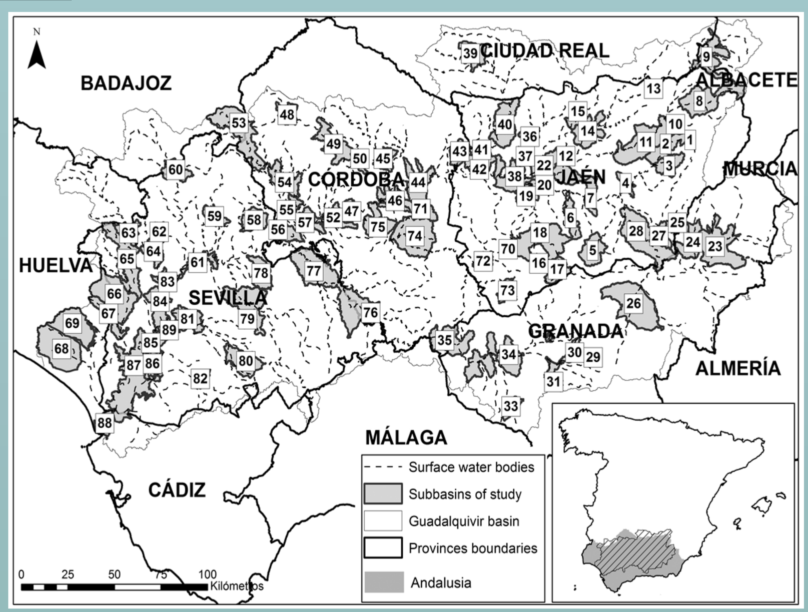

Figure 1. Subbasins under study

Time trend analysis

Linear ➡ Correction of autocorrelation but preserving the original trend

Kendall rank correlation coefficient

Quadratic ➡ $y = ax^2 + bx + \varepsilon$

y: percentile 50 (p50) and percentile 90 (p90) of the water quality parameter during the agricultural season

x: agricultural season

Subbasin characterization for each agricultural season (1999-2009):

Nitrates / Suspended solids

- **CLIMATE AND PHYSICAL ENVIRONMENT** → Precipitation, Slope
- **AGRICULTURAL STRUCTURE** → *Intensification*: **Biomass ha^{-1} of subbasin** for rainfed and irrigated crop systems; *Specialization*: **Shannon index**
- **URBAN STRUCTURE** → % urbanized areas
- **ECONOMIC AND POLICY INDICATORS** →
  - **Agricultural subsidies in € ha^{-1} of total agricultural area**
  - **% Coupled subsidy**
  - **Crop price index**
  - **Change agricultural policy reform in 2006/2007 agricultural season** (dummy)

Panel data analysis

Per **subbasin *i*** and **agricultural season *t***: $y_{it} = x'_{it}\beta + z_i'\alpha + \varepsilon_{it}$, where X_{it} is the ith observation on l explanatory variable, the $z_i'\alpha$ is the individual effect and ε_{it} is the error term. We deal with heteroskedasticity, cross sectional dependency and autocorrelation of residuals using Panel Corrected Standard Errors (PCSE).

RESULTS

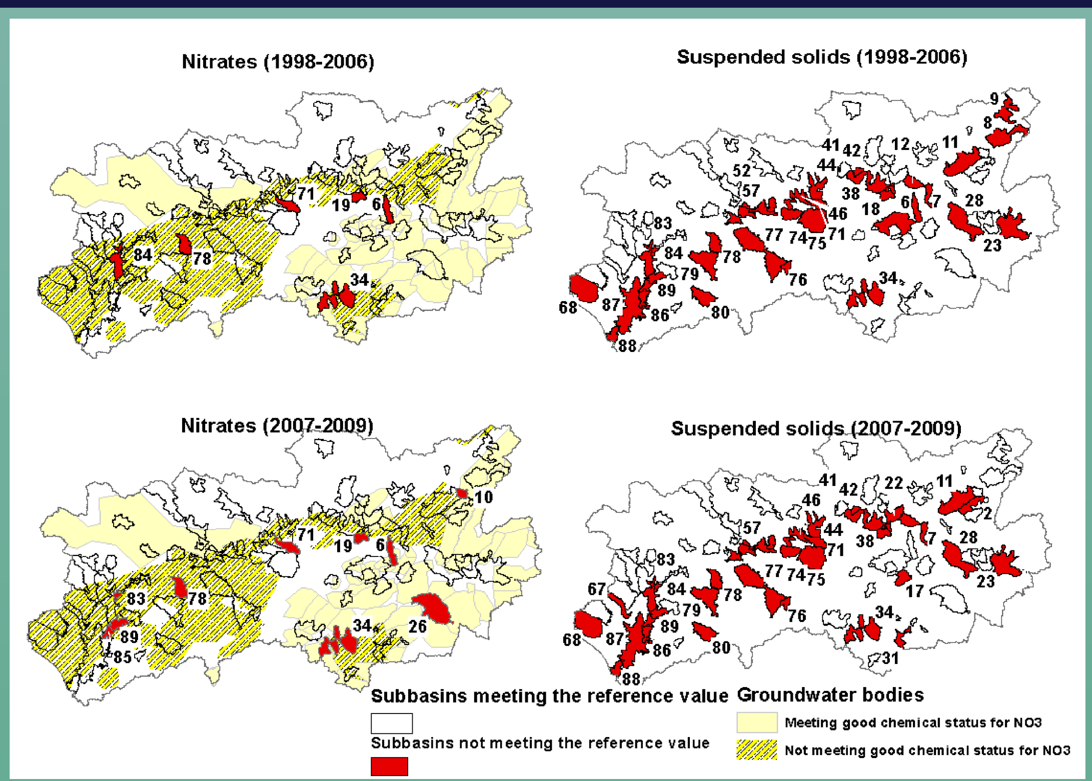

Figure 2. Subbasins whose annual median NO_3 and SS (mg L^{-1}) did not meet the good chemical status before (top) and after (bottom) the reform. Compliance of nitrates in groundwater bodies is also illustrated.

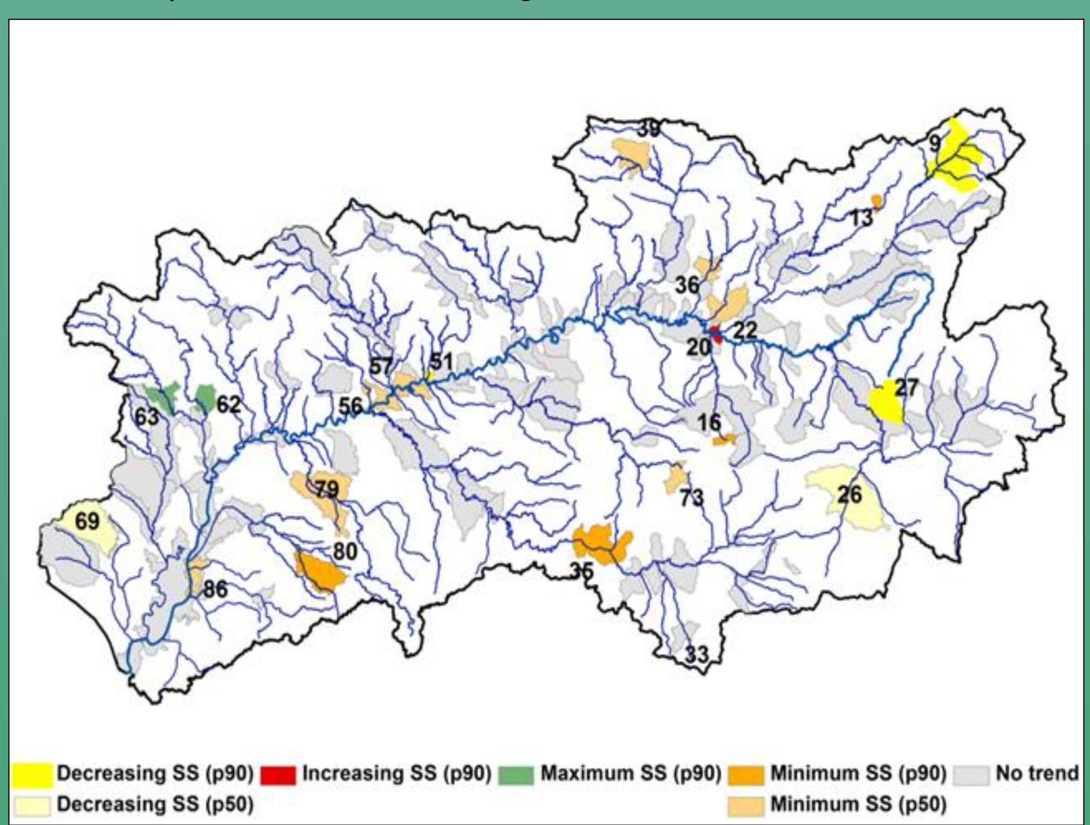

Figure 3. Subbasins spatial distribution for annual suspended solids (SS) trends (mg L^{-1}), differentiating percentiles 50 (p50) and 90 (p90).

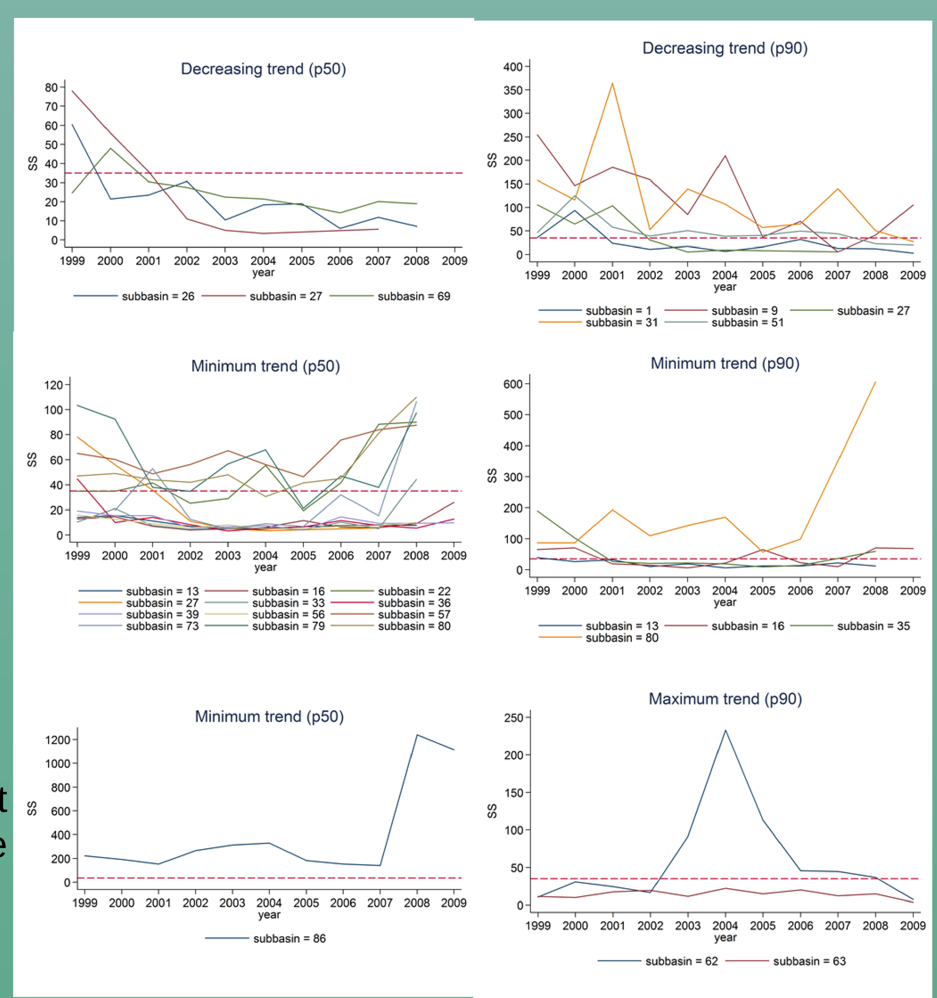

Figure 4.. Suspended solids trends (mg L^{-1}) for percentiles 50 (p50) and 90 (p90) per subbasin over the study period. The reference value of 35 mg L^{-1} is visualized when observations exceed it..

Most of the subbasins do not exhibit statistically significant trends for both NO_3 and SS, neither for lineal nor quadratic equations. Despite the acute SS concentrations in the basin, only five subbasins present an improvement trend. Subbasins showing a U-shaped trend for SS are heterogeneously spread throughout the watershed (Figures 3 and 4).

In the panel data analysis we found that growing *agriculture intensification* and *subsidies to irrigated land* cause greater NO_3 concentrations (Table 1). Larger NO_3 p50 concentrations occur with lower percentage of coupled subsidy, since subbasins with smaller percentage of coupled subsidy include more extension of crops not entitled to receive subsidies (vegetables and citrus trees). Greater SS concentrations are associated with larger *biomass* and *subsidies to irrigated areas*. After 2006, the extreme values of suspended solids decreased, although the median values increased, since soil erosion in olive orchards became worse due to expansion on soils with steeper slopes.

variable		Lagged NO_3	Lagged SS	Precip.	Slope	Biomass rainfed	Biomass irrigated	% urban areas	% Coupled subsidy	Subsidies rainfed	Subsidies irrigated	Change agric. reform	Intercept	No. Obs.	R^2
NO_3	p50	0.579***		0.0589*	-0.102***	0.179***	0.212***		-0.0779*		0.0582*			777	0.78
	p90	0.503***		0.103***	-0.100***	0.168***	0.190***	0.0351*			0.0833**	0.200**		777	0.75
SS	p50		0.564***		-0.0868***	0.103***	0.213***			0.0194*	0.0276**	0.147***	-0.0352***	804	0.68
	p90		0.290**		-0.105***	0.207***	0.257***				0.0906***	-0.275**		786	0.58

* p<0.05, ** p<0.01, *** p<0.001

Table 1. Panel data regressions for nitrates (NO_3) and suspended solids (SS) for both percentiles 50 (p50) and 90 (p90).

CONCLUSIONS

The general high concentration of suspended solids throughout the watershed is highlighting a worrying water deterioration process in surface water, because of an inappropriate land use and agricultural management in the region. The agricultural intensification in terms of biomass production per unit of subbasin causes greater concentrations of both water quality indicators throughout the watershed. The implications of intensification on water quality are particularly significant in areas where olives and semi intensive crops predominate. CAP has evolved according to economic conditions, but the agricultural policy reform did not help to alleviate the nitrate and suspended solids concentrations in surface water bodies of Guadalquivir River Basin. In accordance with our study, after the agricultural reform and with lower values of coupled subsides, farmers have oriented their productions towards the market, probably worsening the environmental conditions of the basin.