Geophysical Research Abstracts
Vol. 18, EGU2016-13810, 2016
EGU General Assembly 2016

Salinity trends in the Ebro River (Spain)

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In the Ebro River Basin (Spain), the increase in water diversion for irrigation (following the increase in irrigated area) and the recovery of natural vegetation in the upper reaches, along with climate change have induced changes in the river flow and its associated salt loads. This study was supported by the Ebro River Basin Administration (CHE) and aimed to establish the trends in the salt concentrations and loads of the Ebro River at Tortosa (no 027, the extreme downstream gauging station).

The CHE databases from 1972-73 to 2011-12, including mean monthly flows (Q) and concentration readings (electrical conductivity converted to total dissolved solids –TDS– by regression) from monthly grab samples, have been used. The trends were established by (i) harmonic regression analysis; (ii) linear regression by month; and (iii) the non-parametric Mann-Kendall method. Additionally, (iv) the regressions of TDS on Q in the current and previous months were established, allowing for analyzing separately the trends in TDS linked to- (TDSq) and independent of- (TDSaj) the observed changes in flow. In all cases, the trends were analyzed for different periods within the full span 1973-2012 (1973 to 2012, 1981 to 2012, 1990-2012 and 2001-2012), trying to account for periods with sensibly similar patterns of land use change.

An increase in TDS was found for all the periods analyzed that was lower as shorter periods were used, suggesting that lower salinity changes might be taking place in the last years, possibly due to the reduction in the rate of irrigation development and to the on-going irrigation modernization process. The higher seasonal TDS increases were found in autumn and winter months and the increase in TDS was linked both to intrinsic changes in salinity (TDSaj) and to the observed decrease in flow (TDSq). On the other hand, the salt loads decreased, especially in autumn, as a result of the observed flow decrease.

These results are based on the observed evolution of flows and salinity in 1973-2012 and can only be extrapolated into the future if the drivers of this evolution (climate and land use changes) remain unchanged in the following years, what is uncertain. A more comprehensive methodology to estimate the effects of irrigation on water salinity has been developed based on a mass balance approach. Using actual data on volumes and concentrations of return flows observed in the basin (dependent on the actual salinity of soils and waters and the irrigation systems, among other factors), the return flows of the irrigated areas are aggregated to match the actual flows and loads observed in the Ebro River. Once this balance is satisfied, the effect of new irrigated areas, drainage water reuse, irrigation modernization, or climate change would be incorporated to the balance yielding salinity forecasts based on planned irrigation developments and modernization or climate change predictions. A priori, irrigation modernization would produce lower, more concentrated volumes of return flows with lower salt loads that would result in lower TDS concentrations in the Ebro River.