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Nitrogen and salt loads in the irrigation return flows of the Ebro River Basin (Spain)

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The conservation of the quality of surface waters demanded by the European Water Framework Directive requires, among others, an assessment of the irrigation-induced pollution. The contribution of the irrigation return flows (IRF) to the pollution of the receiving water bodies is given by its pollutant load, since this load determines the quality status or pollutant concentration in these water bodies.

The aim of this work was to quantify the annual nitrogen and salt loads in the IRF of four irrigated catchments within the Ebro River Basin: Violada (2006-10), Alcanadre (2008-10), Valcuerna (2010), and Clamor Amarga (2010). The daily flow (Q), salt (EC) and nitrate concentration (NO_3) were measured in the drainage outlets of each basin. The net irrigation-induced salt and nitrogen loads were obtained from these measurements after discounting the salt and nitrogen inputs from outside the catchments and the non-irrigated areas. The N-fertilizer applications were obtained from farmer surveys and animal farming statistical sources.

Irrigation water salinity was very low in all catchments (EC < 0.4 dS/m), but IRF salinity was very high in Valcuerna (7.9 dS/m) with underlain saline lutites, high to moderate in Clamor (2.6 dS/m) and Violada (2.1 dS/m) with gypsum-rich soils, and low in Alcanadre (1.0 dS/m) due to dilution in the inefficient traditional flood-irrigation system. Annual salt loads were highest in Valcuerna (11.9 Mg/ha) and lowest in Alcanadre (3.6 Mg/ha) and Clamor (3.3 Mg/ha). Salt load was also high in flood-irrigated Violada (10.3 Mg/ha), but dropped to 2.6 Mg/ha after its modernization to sprinkler irrigation (in 2008-09).

N-fertilizer applications ranged from 221 kg/ha in the corn-dominated Valcuerna in 2010 to 63 kg/ha in 2008 in Violada, when farmers barely applied fertilizers due to the irrigation modernization works in progress that year. The highest N applications derived from pig slurry applications by farmers that used their lands as disposal sites for their farm residues. The highest NO_3 concentrations (mean of 113 mg/L) and annual N loads (mean of 38 kg/ha) were found in Valcuerna, the most intense corn sprinkler-irrigated catchment. The lowest NO_3 concentrations (21 mg/L; 5 times lower than Valcuerna) were measured in the Alcanadre flood-irrigated catchment. In contrast, Alcanadre N loads (21 kg/ha) were only about two times lower than in Valcuerna, due to the higher IRF volumes in Alcanadre (353 mm versus 132 mm in Valcuerna). Irrigation modernization in Violada decreased N loads from 20 to 5 kg N/ha (four times lower) due to the sharp reduction of IRF while maintaining NO_3 concentration around 20 mg/L. The only significant contribution of ammonium (17% to the total N load of 13 hg/ha) was found in Clamor, the catchment with highest agro-industrial development.

Overall, IRF salt and nitrate concentrations tended to increase and salt and nitrate loads tended to decrease in modernized sprinkler irrigation catchments, but the presence of soluble minerals, the applied inorganic and especially organic N, and the cropping patterns also played a significant role in this behaviour.