RIVER BASINS NETWORK
WFD AND AGRICULTURE

GOBIERNO DE ESPAÑA | MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO | CONFEDERACIÓN HIDROGRÁFICA DEL EBRO

Workshop
River Basin Network on Water Framework Directive & Agriculture

Water Quality and Irrigation Return Flows: concepts and facts

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cita | GOBIERNO DE ARAGON, Departamento de Industria e Innovación

Zaragoza, 26 January 2012

Research Group “Irrigation, Agronomy and the Environment”

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http://www.eead.csic.es

Unidad de Suelos y Riegos
Centro de Investigación y Tecnología Agroalimentaria, Diputación General de Aragón

Grupo de Riego, Agronomía y Medio Ambiente
Departamento de Suelo y Agua, Estación Experimental de Aula Dei, CSIC

Zaragoza (Spain)

General objective

Generate scientific and technological information in the “soil-water-crop-atmosphere” interface leading to more competitive, efficient and sustainable agricultural systems, with emphasis on irrigation, agronomy and the environment, and with a research-applied focus.

Personnel – Total

Year 2011

Permanent researchers	12
Temporary researchers	4
Technicians	19
Students	18
TOTAL	53

Largest group in Spain working on irrigation and the environment

Priority lines

1- Sustainable use of water and soil resources

2- Environmental impact of agricultural activities

3- Crop agronomy

Priority works

1- Diagnosis and improvement of irrigation management.

2- Impact of irrigated agriculture on soil and water quality (“off-site” diffuse pollution).

3- Response of crops to abiotic stresses (water, salinity).

4- Nitrogen fertilization and nitrate leaching control. Optimization of pig-slurry applications.

5- Agronomic applications of remote sensing.

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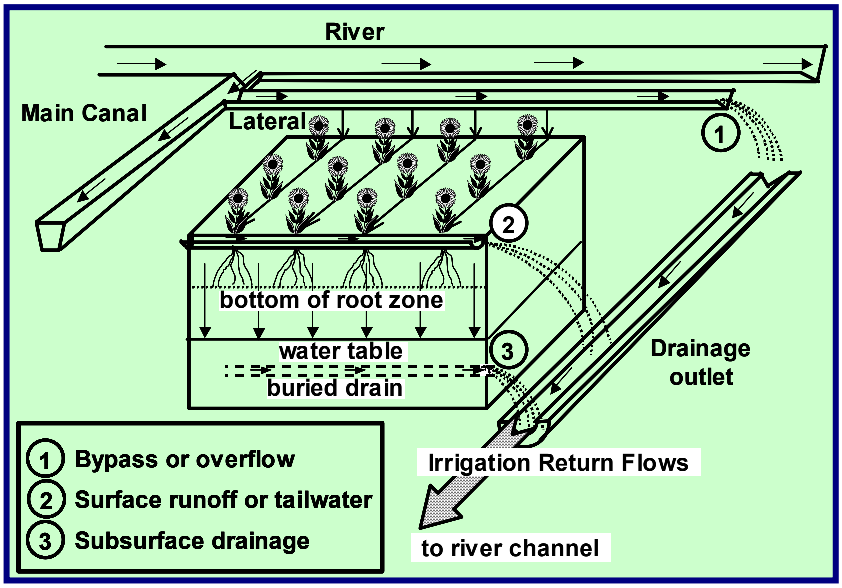
Main components of Irrigation Return Flows (IRF)



Main quality parameters of the IRF components and expected quality changes in relation to the quality of irrigation water

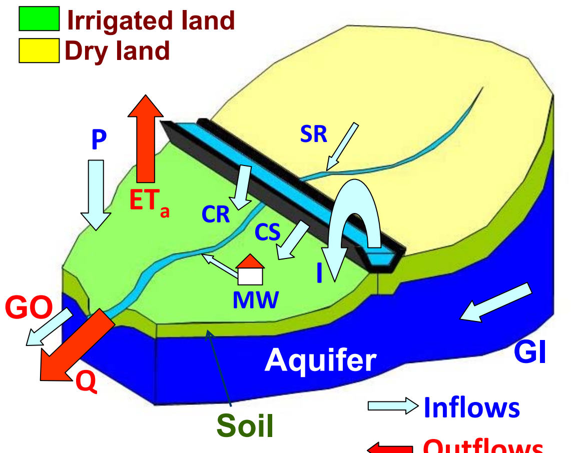
Quality parameters	Components of IRF		
	Bypass	Tailwaters	Drainage
General quality degradation	0	+	++
Salinity	0	0, +	++
Nitrogen	0	0, +, ++	+, ++
Phosphorous	0, +	++	0, -, +
Biological oxigen demand	0	+, 0	0, -, --
Sediments	0, +, -	++	--
Pesticides	0	++	0, -, +
Trace elements	0	0, +	0, -, +
Phatogens	0	0, +	-, --

0: Negligible degradation
+, ++: Moderate, High degradation (evapoconcentration, agrochemicals, erosion, mineral dissolution…)
-, - - : Moderate, High amelioration (filtration, fixation, microbial degradation, mineral precipitation…)

Water inflows and outflows at irrigation district level

Inflows

- I = Irrigation
- P = Precipitation
- CR = Canal Releases
- CS = Canal Seepages
- SR = Surface Runoff
- MW = Municipal Wastes
- GI = Groundwater Inflows



Outflows

- Q = Surface outflow
- ETa = Actual crop evapotranspiration
- GO = Groundwater Outflow

Irrigation Return Flows (IRF)
Q – CR – SR – MW – % GI + % GO

Monitoring of quantity and quality of irrigation return flows

Gauging and water quality station

Continuous water level recorder

Automatic water sampler

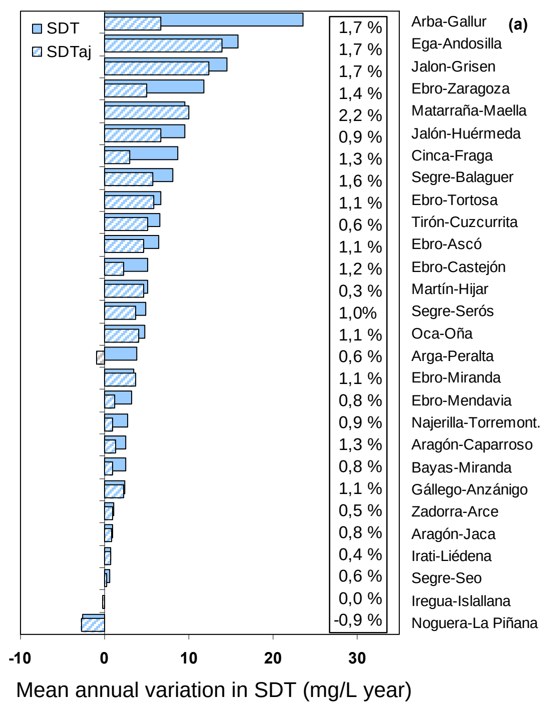
Why IRF are important within the European WFD?

Because the load of contaminants (i.e., volume of IRF and contaminant concentrations) largely determine the quality (i.e. the concentration of contaminants) in the receiving water bodies (rivers)

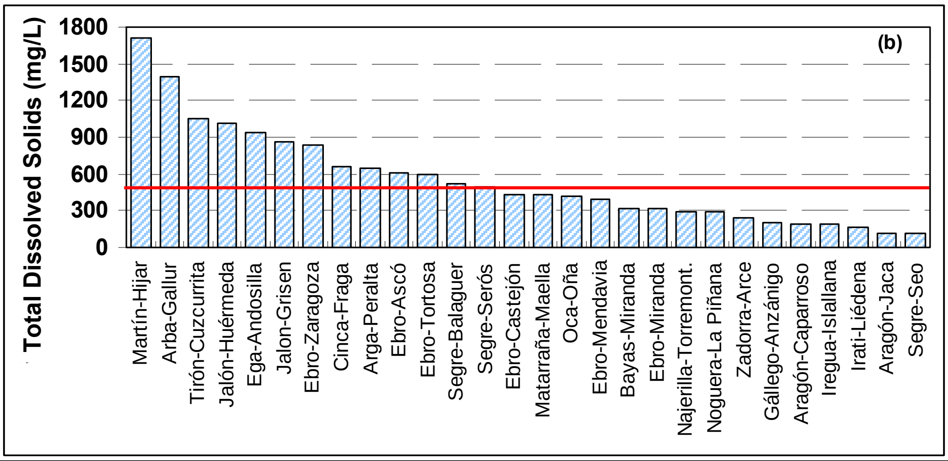
Hence, salt and nitrate concentrations is a relevant and increasing problem in many rivers of the Ebro Basin…

Salinity tendencies (SDT = total dissolved solids in mg/L) in 28 rivers of the Ebro Basin based on 1975-2008 data. The percent SDT increase over the mean SDT is also shown.

Several of the most problematic rivers collect the IRF of important irrigation districts…

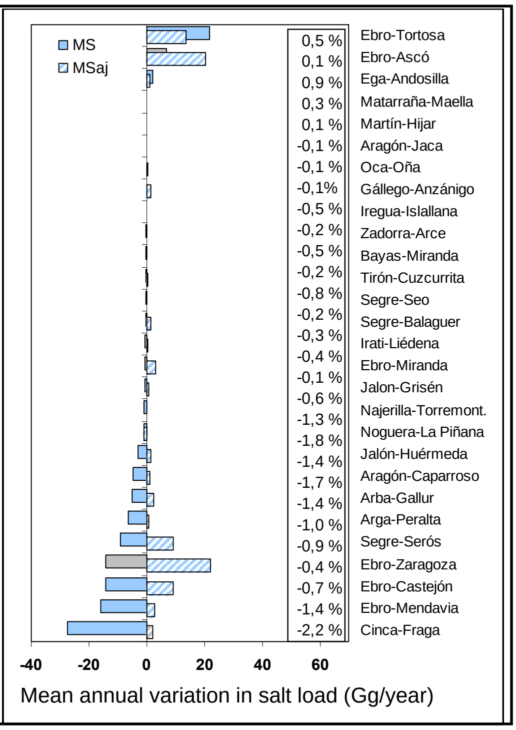


Mean 1975-2008 salt concentrations (Total Dissolved Solids) in 28 rivers of the Ebro Basin. The red line at 450 mg/L indicates the FAO threshold value above which waters are moderately restricted for irrigation purposes of salt-sensitive crops



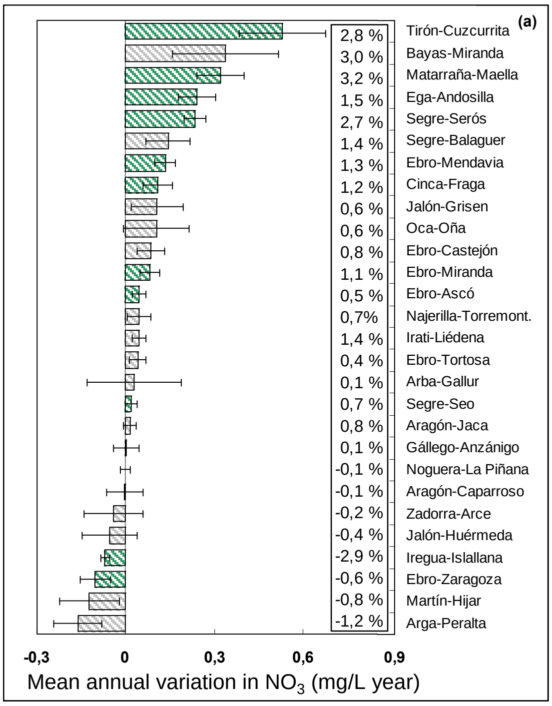
Salt load tendencies (MS, Gg) in 28 rivers of the Ebro Basin based on 1975-2008 data. The percent MS variation over the mean MS is also shown.

Negative salt load tendencies due to negative tendencies in flow volumes

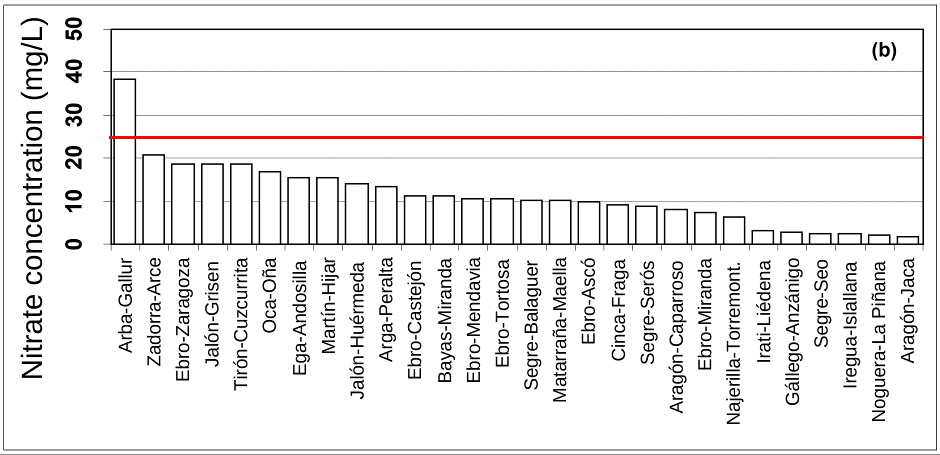


Nitrate tendencies (NO_3, mg/L) in 28 rivers of the Ebro Basin based on 1980-2008 data. The percent NO_3 increase over the mean NO_3 is also shown.

Several of the most problematic rivers collect the IRF of important irrigation districts… but disposal of pig slurry is also an important factor in some rivers

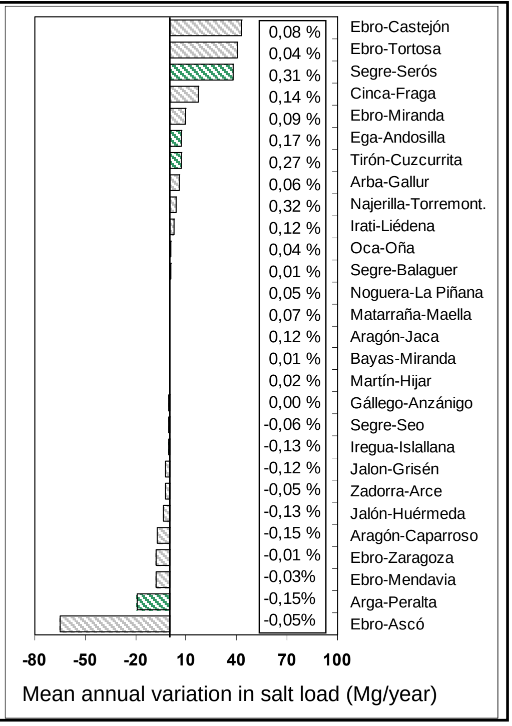


Mean 1980-2008 nitrate concentrations in 28 rivers of the Ebro Basin. The red line at 25 mg/L indicates the Nitrate threshold Directive above which waters are moderately contaminated by Nitrate



Nitrate load tendencies (NO_3, Mg) in 28 rivers of the Ebro Basin based on 1980-2008 data. The percent NO_3 load increase over the mean NO_3 load is also shown.

Negative salt load tendencies due to negative tendencies in flow volumes



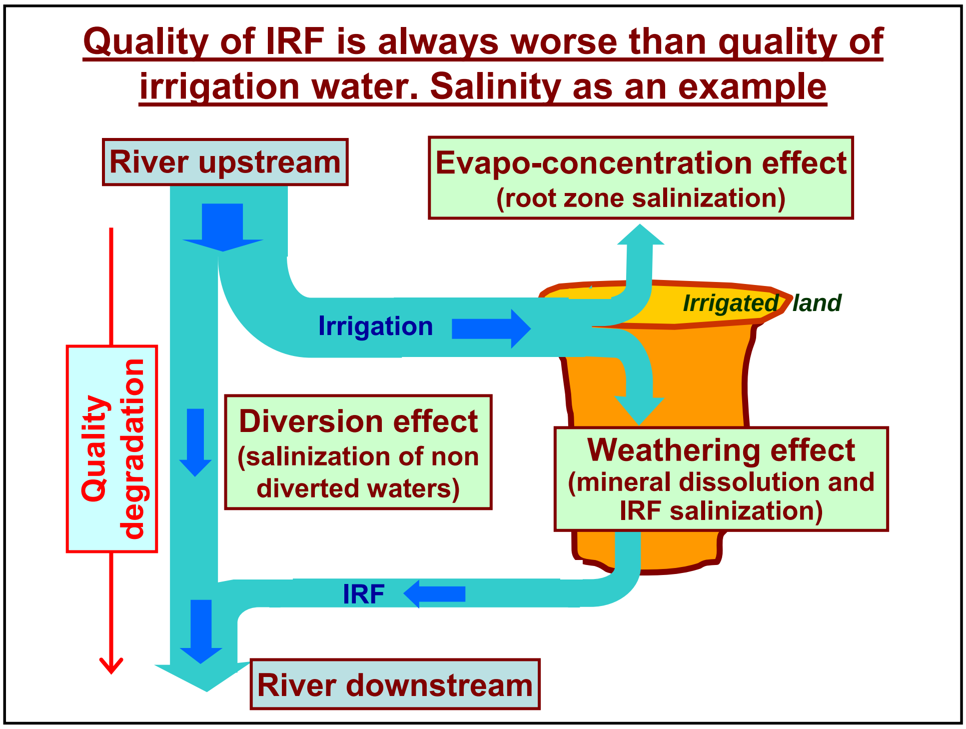
Summary of conclusions

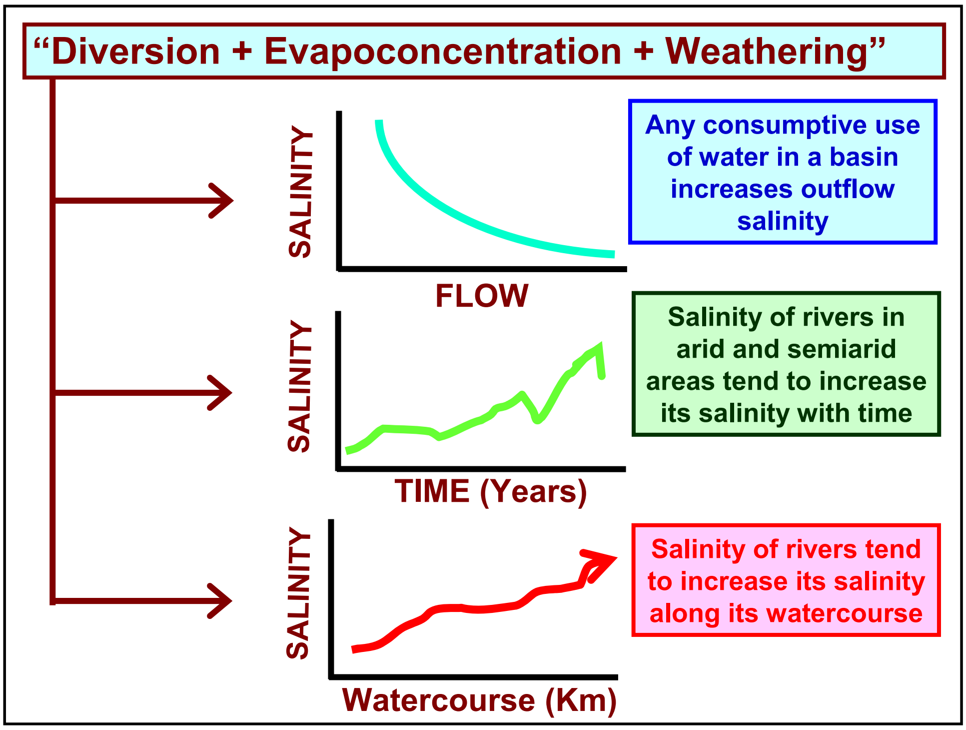
1- Positive tendencies in salt concentrations in 93% of rivers based on 1975-2008 data.

2- Positive tendencies in Nitrate concentrations in 29% of rivers based on 1980-2008 data… but in 68% of rivers based on 1975-2008 data.

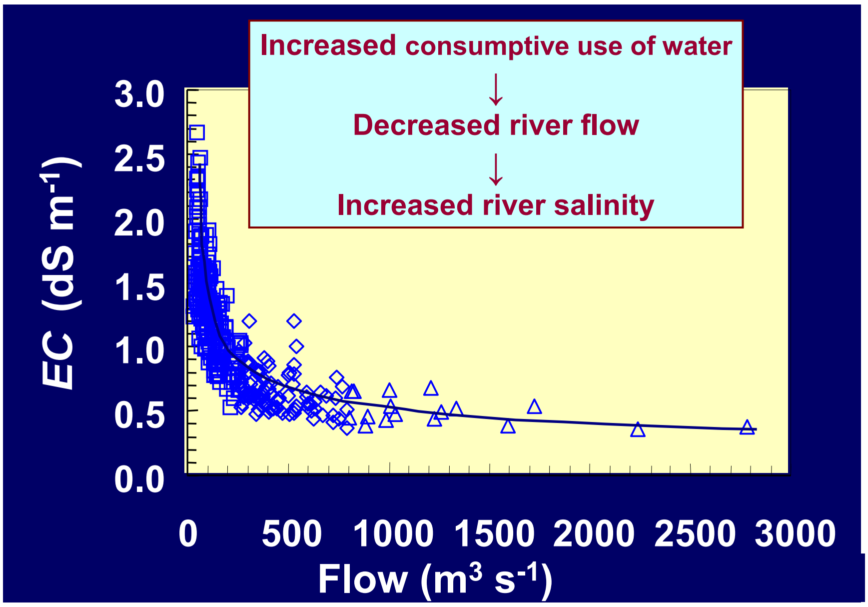
3- Negative tendencies in flow volumes in 82% of rivers based on 1975-2008 data.

4- Non significant salt and nitrate load tendencies in most rivers due to positive concentrations and negative flow tendencies.


Quality of IRF is always worse than quality of irrigation water. Salinity as an example
River upstream
Evapo-concentration effect
(root zone salinization)
Irrigated land
Irrigation
Quality degradation
Diversion effect
(salinization of non diverted waters)
Weathering effect
(mineral dissolution and IRF salinization)
IRF
River downstream


"Diversion + Evapoconcentration + Weathering"
SALINITY
FLOW
Any consumptive use of water in a basin increases outflow salinity
SALINITY
TIME (Years)
Salinity of rivers in arid and semiarid areas tend to increase its salinity with time
SALINITY
Watercourse (Km)
Salinity of rivers tend to increase its salinity along its watercourse

The Ebro river at Zaragoza as an example



Threshold water quality values for human consumption

Substance	Threshold (mg/L)	Substance	Threshold (mg/L)
Arsenic	0.01	Mercury	0.001
Boron	0.5	Molybdenum	0.07
Cadmium	0.005	Nickel	0.02
Copper	1.3	Nitrate	50
Chromium	0.10	Nitrite	3.0
Lead	0.015	Selenium	0.01
Manganese	0.05	Uranium	0.002

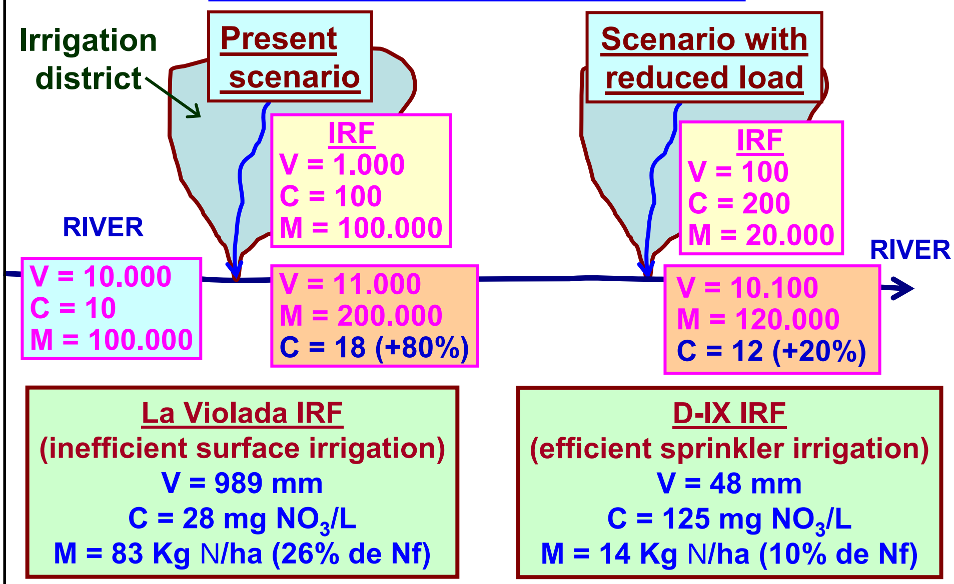
Conclusion

Substance concentrations determine the water suitability for its different uses

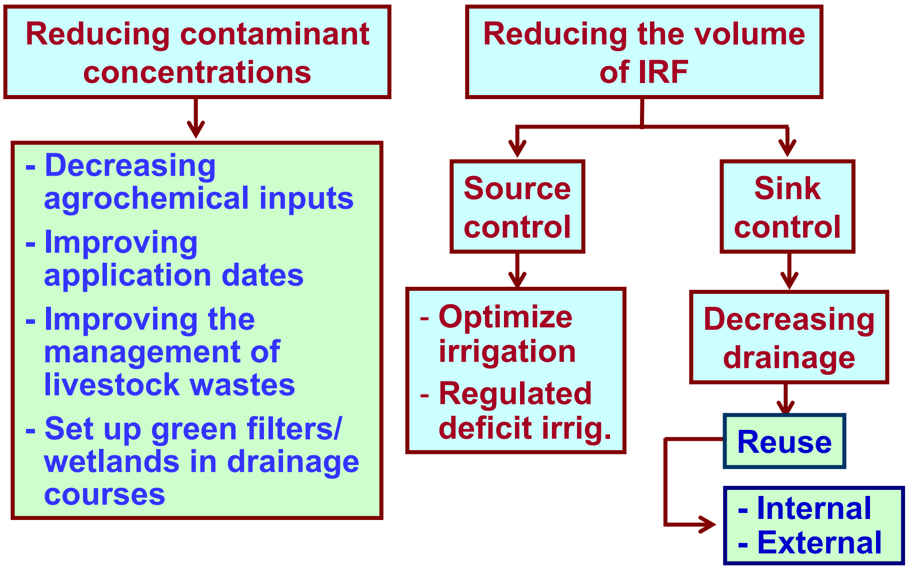
But…

- The load of contaminants in the irrigation return flows (IRF) determines the concentration of contaminants in the receiving water bodies
- Hence, diffuse pollution induced by irrigated agriculture should be quantified in terms of IRF contaminant loads, not in terms of contaminant concentrations
- **Load is the critical variable for the assessment of irrigation pollution**
- Approach taken by USA EPA (TMDL), but not by the European Water Framework Directive…

Irrigation diffuse pollution: load is the critical variable



How to minimize contaminant loads in IRF?
(Load = Concentration x Volume)



Emergency Plan for Irrigation Modernization in Spain (MARM, 2006)

River water quality will increase because:

1- The volume of good quality waters non diverted for irrigation will increase in the rivers

2- The load of contaminants will decrease in IRF

… even though the concentration of contaminants in IRF will/could increase

RECOREBRO: Ebro River Basin Network for the assessment of irrigation-induced pollution