THIACLOPRID LEACHING IN SOIL AS A CONSEQUENCE OF TREATED WASTEWATER REUSE FOR AGRICULTURAL PURPOSES

Smallwat11 3rd INTERNATIONAL CONGRESS

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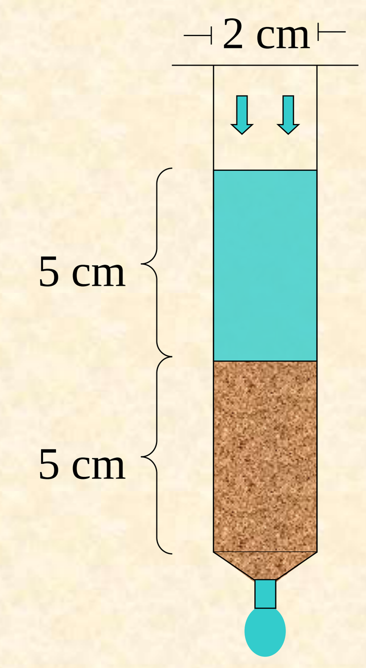
INTRODUCTION

Treated effluents from urban origin are being considered for land irrigation especially in countries with periodic water shortage. Irrigation with these effluents, apart from avoiding their disposal, can also provide organic matter and nutrients to soils of poor fertility such as those normally encountered in arid or semiarid areas. However, dissolved organic carbon (DOC) and salts, which are still present in wastewater even after treatment, may affect the leaching behaviour of contaminants applied to soil with agronomical purposes, such as pesticides, thus influencing their environmental fate.

The effect of irrigation with wastewater, and solutions containing DOC or salts, on the leaching of thiacloprid (THIAC), a neonicotinoid of medium polarity, was investigated in disturbed soil columns.

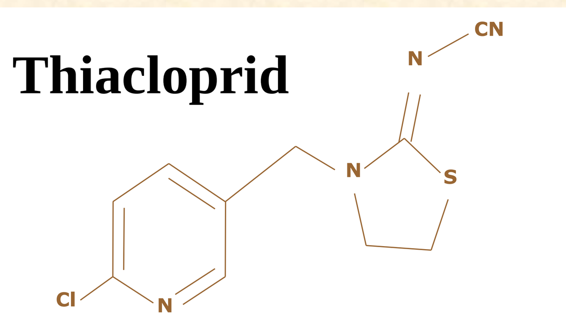
METHODS



Influent solutions:

- ✓ MQ water (MQ)
- ✓ Wastewater (WW) from municipal treatment plant
- ✓ 300 mg L^{-1} of organic carbon extracted from sewage sludge (DOC300)
- ✓ Ammonium sulfate 5 mM (SO_4^{2-})

Thiacloprid



Log K_{ow} 1.26
Water solubility 184 mg L^{-1}

Soil column (2 cm x 5 cm):
Calcareous Mediterranean silty loam soil
pH 8.1; CEC 7.9 $cmol_+$/kg;
OC 1.1%; $CaCO_3$ 25%; WHC 21%

Pesticide concentration in leachates was measured by HPLC-DAD at 245 nm, Cl^-, and A_{254}

RESULTS AND DISCUSSION

FIGURE 1. Experimental (points) and CXTFIT-fitted (lines) concentration breakthrough curves (BTCs) of THIAC under the influents tested

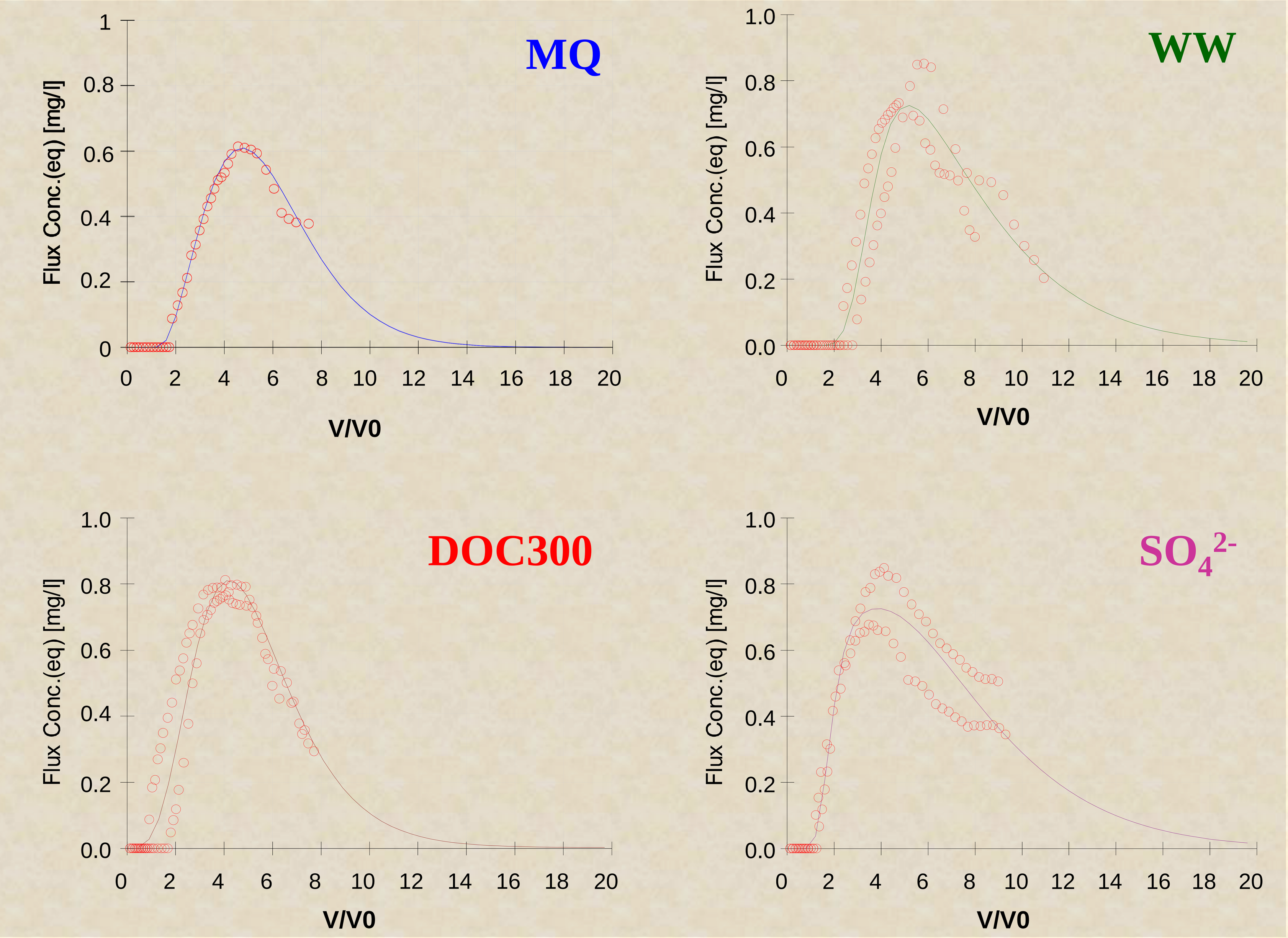


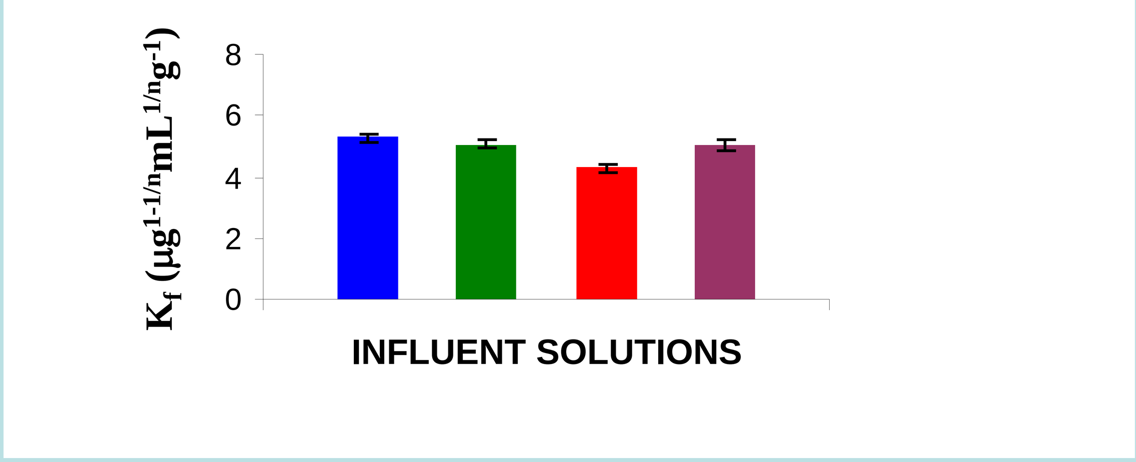
TABLE 1. Soil column parameters for the different influent solutions (in brackets standard errors)

INFLUENT SOLUTION	R^2	MSE x 10^2	D x 10^2	β	ω	μ (min^{-1})	R
MQ	0.993	0.040	0.390	0.47 (0.02)	6.49 (0.91)	3.83 (0.05)	7
WW	0.900	0.866	0.076	0.46 (0.03)	4.70 (0.50)	3.25 (0.07)	7
DOC300	0.917	0.828	0.002	0.16 (0.09)	7.95 (0.24)	3.22 (0.07)	5
SO_4^{2-}	0.901	0.797	0.100	0.27 (0.02)	4.76 (0.24)	3.06 (0.04)	6

MSE: mean standard error; D: dispersion coefficient; β: mobile water partitioning coefficient; ω: mass transfer coefficient; μ: first order degradation rate; R: retardation factor.

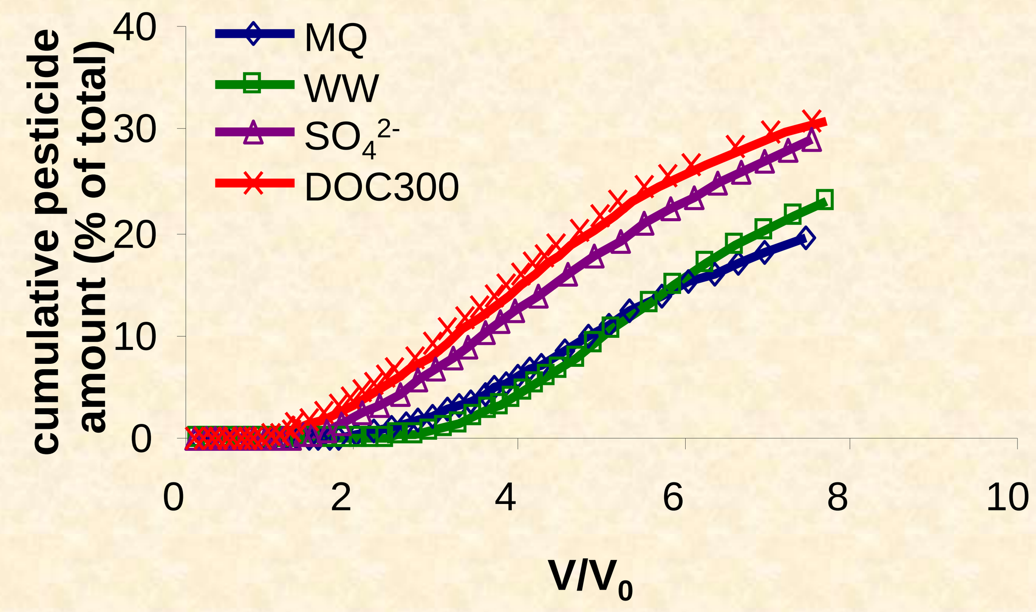
- ➢ The mobile water fraction was in all cases <50%, therefore stagnant water occurs. BTCs appear asymmetrical in shape shifted to the right. This tailing phenomenon is normally attributed to non-equilibrium sorption due to time-dependent interactions between the pesticide and the soil components *(Rodríguez-Cruz et al., 2011)*.
- ➢ The peak maxima of the different infiltrated solutions are ranged as DOC300<SO_4^{2-}<WW=MQ and are delayed with respect to the tracer peak (Cl^-) as corresponds to a moderately retained compound. This behaviour correlates well with pesticide retention by soil from batch assays *(Figure 3)*.
- ➢ The low ω values (lower than 10) indicate that THIAC mass transfer is likely governed by the mobile phase velocity (convective transport).
- ➢ Values of μ are an indication of a slight THIAC degradation in the liquid phase.

FIGURE 3. Freundlich sorption constants of THIAC in soil with the different solutions



DOC300 leaches the highest amount of THIAC (31%) and MQ the lowest (19%). THIAC is less retained on this soil in the presence of DOC300 *(Figure 3)*, due either to enhanced solubilization in the flowing solution or displacement of pesticide retained on soil by DOC. Similar results have been also reported in the leaching of imidacloprid, another neonicotinoid insecticide *(Flores-Céspedes et al., 2002)*. However, the effect of DOC on pesticide mobility is complex and depends on DOC origin as well as on soil and pesticide properties (*Ding et al., 2011*).

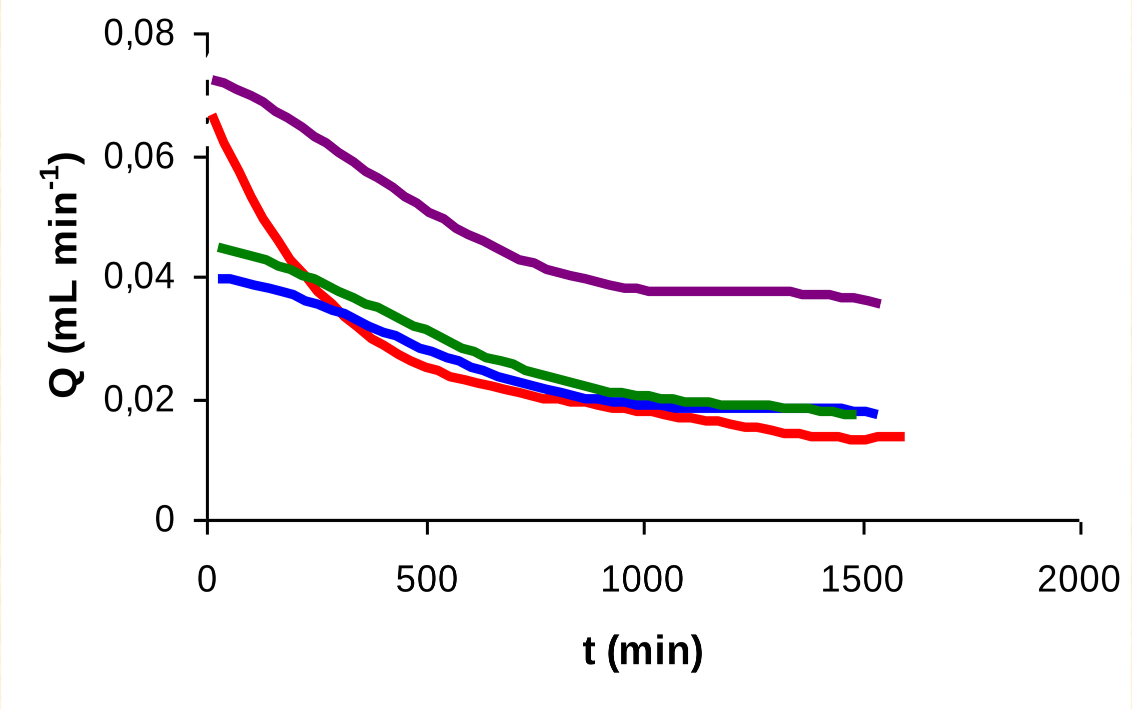
FIGURE 2. Cumulative THIAC amount leached (μg) with different influents



CONCLUSIONS

- ✓ High concentrations of DOC in influent solutions enhance the mobility of THIAC by solubilization or displacement of pesticide retained on soil.
- ✓ When SO_4^{2-} solutions are used, the potential of THIAC leaching is also increased, likely due to release of DOC trapped in soil carbonates.
- ✓ Therefore, an increase in the amount of DOC and salts in wastewater composition may pose a potential hazard of groundwater contamination by promoted leaching of THIAC.

FIGURE 4. Elution flux variation with time



Differences were found in elution flux (Q) *(Figure 4)*. The total infiltrated volume ranged as SO_4^{2-} ≈ 2 x WW ≈ DOC300 ≈ MQ. This could explain the high amount of pesticide leached when SO_4^{2-} was employed (29%) with respect to MQ *(Figure 2)*. Additionally SO_4^{2-} has been reported to dissolve soil carbonates from calcareous soils releasing the DOC retained in carbonates (*Rodríguez-Liébana et al., 2011*). When using this salt as influent, an enhancement of DOC from soil occurred as shown by the higher A_{254} with respect to MQ.

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Proyecto cofinanciado por FEDER

Thanks to the support of the Spanish Ministry of Science and Innovation (CGL2007-60355). EMASAGRA is thanked for providing treated WW and sludges. J.A.R. acknowledges the C.S.I.C. for a JAE-predoctoral fellowship.