Transport and attenuation of chloroacetanilides at the catchment scale

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Introduction

Chloroacetanilides are widely used as pre-emergent herbicides on corn and sugar beet. Surface runoff and erosion represent major processes of herbicide transport from agricultural land to aquatic ecosystems (Oliver et al., 2012). There is therefore a need to evaluate the transport and degradation pathways of chloroacetanilide herbicides at the catchment scale (Turner et al, 2006). The objectives of this study were i) to assess the temporal and spatial variability of S-metolachlor and acetochlor loads within the catchment, ii) to investigate their partitioning between the dissolved and particulate phases, and iii) to evaluate the in situ biodegradation of S-metolachlor. The latter objective was achieved by comparing the enantiomeric ratios (i.e. R vs. S-metolachlor) and the enrichment in ^{13}C of the non-degraded fraction of metolachlor in runoff water with those of the herbicide source.

Material and methods

A 47-ha agricultural catchment in Alsace (France), prone to frequent mudflows and a 77.2 m² beetroot plot located within the catchment was studied in terms of runoff, erosion, hydrochemistry and herbicides transport. Changes in the chloroacetanilide concentrations (using GC-MSMS) and their enantiomeric (using a chiral GC-MS) and carbon isotopic signatures (using a GC-C-IRMS) were quantified from March to August 2012.

Results and discussion

Nineteen rainfall events were monitored from 12 March to 15 August 2012, which totalled 335 mm. Among these events, 10 produced runoff of more than 10 m^3. Runoff coefficients on an event basis ranged from 0.04 to 57% (Fig. 1). A severe soil loss of 1006 t km^{-2} was observed during the study period.

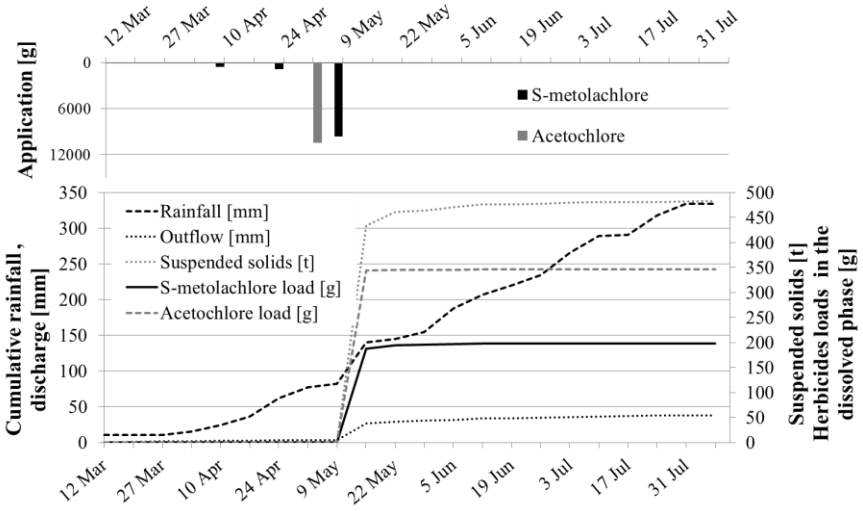

Figure 1. Cumulative suspended solids, chloroacetanilide loads in water and discharge at the catchment outlet together with cumulative rainfall and chloroacetanilide applications from 12 March to 15 August 2012.

Chloroacetanilide concentrations in runoff water reached a maximum of 65 µg L^{-1} and decreased from the application over time at the plot scale. A rainfall event on May 22 (40-year return period) represented more than 90% of the total exported load of chloroacetanilides at the catchment outlet (Fig.1). The export rate in the dissolved phase at the catchment scale was 1.8% and 3.3% for S-metolachlor and acetochlor, respectively. The enantiomeric and carbon isotopic signature varied over time (Fig. 2). Compared to the signature of the commercial product, mercantor gold®, enrichments in R-metolachlor (up to 37%) and in ^{13}C (up to 2.2 ‰) were observed. Chiral and carbon isotopic analysis presented the same trends, indicating the occurrence of chloroacetanilide degradation from their application to their transfer in runoff (Fig. 2).

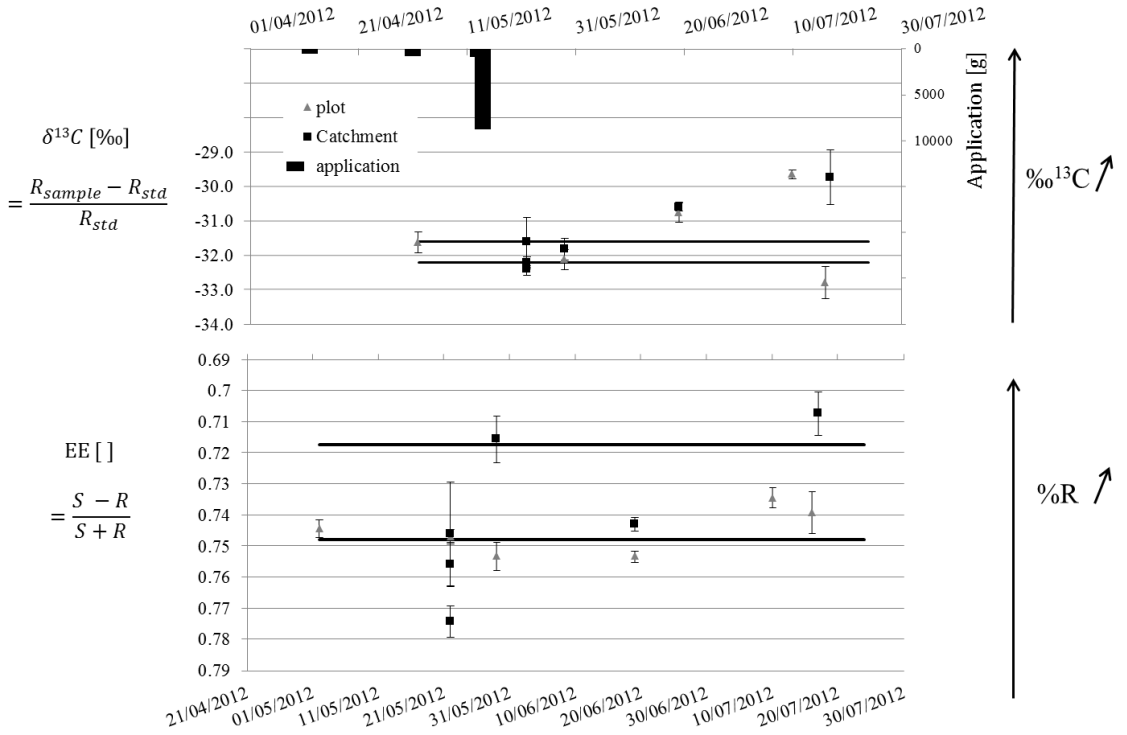

Figure 2. Enantiomeric excess (EE) and carbon isotopic composition (represented in $\delta^{13}C$ notation) in runoff water from May to July 2012 at the plot and catchment scales.

Conclusion

Results obtained provide quantitative field data for transport and attenuation of S-metolachlor and acetochlor in runoff. So far, this is the first investigation combining chiral and carbon isotopic analyses of chloroacetanilide herbicides at the catchment scale. We anticipate our results to be a starting point for better understanding and prediction of the transport of chloroacetanilides at the agricultural catchment scale.

References

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