Efficiency of a farm biobed in a Mediterranean climate

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Introduction

On-farm biopurification systems for the treatment of pesticide-contaminated wastewater are now found all over the world. The first type, called a biobed, was a hole in the ground filled with a mixture of soil, peat and wood chips developed in Sweden in 1997 (Castillo et al., 2008). However, the best solution in terms of efficiency and durability of substrates in other environments, such as in a Mediterranean climate, has still to be defined.

Material and methods

A lined biobed was built at the University Experimental Farm in Legnaro (PD) using a mixture of wheat straw and wood chips as organic material to assess efficiency and microbial community evolution. Two herbicides (terbuthylazine: TERB and metolachlor: METO) were applied at the beginning of the season from 2009 to 2012 at high concentration to simulate a worst-case scenario. Leached water was sampled every month from spring to autumn and, at the end of 2012, the substrate was also sampled.

To determine herbicide concentration in soil, samples of 20 g were shaken for 1 hour with 60 ml of 9:1 methanol:0.1 N HCl followed by centrifugation. The supernatants were filtered, evaporated in a rotary evaporator, re-dissolved in 50 ml of HCl, cleaned by solid phase extraction and re-dissolved in methanol. To determine herbicide concentration in water, 1 liter samples were filtered at 0.45 μm pore size, cleaned by solid phase extraction and re-dissolved in methanol. The analyses were performed by LC-MS.

To determine microbial community evolution two approaches were used: 1) ARISA (Amplified Ribosomal Intergenic Spacer Analysis) to test the extent of PCR-detectable biodiversity of bacterial and fungal assemblages in both untreated and treated substrate and 2) a newly-patented device (Fertimeter) that reports soil microbial activities of cellulolysis and proteolysis as functions of the extent of degradation of cotton or silk fibres buried in the soil for fixed lengths of time and measured by residual dynamometric resistance to breakage. The measures were repeated monthly for two years.

Results

In general each sampling season showed a similar trend with the highest concentration found in leached water a few days after the herbicide application and a reduction in concentration at the end of the year.

Low herbicide concentrations were found in leached water at the end of each season, with the highest values varying from 4.7 to 17 μg l⁻¹ for METO and TERB respectively in 2011.

METO and TERB were also found in the profile at the end of 2012; their concentrations were about 30 μg l⁻¹.
ARISA tests showed no evidence of biobed-related impact in terms of taxa richness, Simpson or Shannon diversity index, with values that were in line with those occurring in agricultural soils of the same region.

The biobed, notwithstanding its use, did not appear to depress functional microbial activities in comparison to cropped soils. An active season-dependent level of degradation was observed with peaks of 40-50% occurring between late May and June. Interestingly, during the brief peak period, soil microorganisms were observed to experience a non-limiting availability of soil nitrogen and phosphorus. This condition did not occur earlier or later in the year.

Table 1. Degradation of the fertimeter cotton fiber in 2012.

<table>
<thead>
<tr>
<th>Sampling day</th>
<th>CONTROL %</th>
<th>NITROGEN %</th>
<th>PHOSPHORUS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/03/2012</td>
<td>1.90 (±0.57)</td>
<td>16.50 (±1.16)</td>
<td>5.79 (±1.32)</td>
</tr>
<tr>
<td>16/04/2012</td>
<td>8.01 (±1.16)</td>
<td>18.46 (±2.91)</td>
<td>13.06 (±2.58)</td>
</tr>
<tr>
<td>25/05/2012</td>
<td>21.58 (±11.47)</td>
<td>34.69 (±5.90)</td>
<td>27.78 (±3.87)</td>
</tr>
<tr>
<td>20/06/2012</td>
<td>42.99 (±6.68)</td>
<td>45.26 (±8.17)</td>
<td>40.79 (±9.85)</td>
</tr>
<tr>
<td>23/07/2012</td>
<td>3.69 (±1.76)</td>
<td>22.71 (±1.62)</td>
<td>16.87 (±2.80)</td>
</tr>
<tr>
<td>29/08/2012</td>
<td>13.99 (±3.53)</td>
<td>28.32 (±2.21)</td>
<td>24.20 (±4.69)</td>
</tr>
<tr>
<td>17/09/2012</td>
<td>4.12 (±2.12)</td>
<td>21.19 (±2.62)</td>
<td>17.99 (±2.26)</td>
</tr>
<tr>
<td>19/10/2012</td>
<td>3.69 (±2.17)</td>
<td>16.88 (±1.65)</td>
<td>14.88 (±3.21)</td>
</tr>
</tbody>
</table>

Conclusion

Notwithstanding its use, the biobed did not appear to depress functional microbial activities in comparison to cropped soils. After four years the farm biobed still showed good performances.

References