Evaluation of the diffuse contamination in an agricultural soil treated with herbicides

José Martínez-Inigo, Gabriel Gascó, Araceli Pérez-Sanz, Carmen Lobo
Instituto Madrileno de Investigación Agraria y Alimentaria (IMIA)
Aptdo.127, 28800 Madrid, Spain
Phone: +34 918879472, Fax: +34 918879474, Email: mclobo@teleline.es

Introduction

Pesticide fate in soil represents an increasingly environmental concern [1]. Pesticides remain long-term in soil due to their stable chemical structure. They are exposed to sorption-desorption, surface runoff and leaching and can be taken up by plants and/or reach surface and groundwater. Consequently, pesticides are widely spread and their further xenobiotic action is extended in the ecosystem. Besides, pesticide physicochemical properties such as their half-life, solubility and sorption coefficient, soil and climate conditions directly determine pesticide mobility. Texture and organic matter content in the soil as well as rainfall regime mainly contribute to the transport of pesticides on the surface or through the soil profile. Finally, the agricultural management itself affects the pollution potentials of pesticides. Low effectiveness in the target action of pesticides occurs as a result of inappropriate dosing and application of pesticides and tillage and irrigation practices.

Propachlor and chlorthal are chlorinated herbicides commonly used to prevent weed germination in greenhouse seedbed soils. With the aim at a preliminary evaluation of the contamination risk through the soil profile, residual levels of herbicides and edaphic characteristics were analysed at different soil depths.

Materials and methods

Soil samples

Seedbed soils were sampled from two greenhouses (Villa del Prado, Central Spain). The soils were treated with the commercial formulation Ringo (C. Q. Massó) consisting of 35% propachlor and 35% chlorthal. A dose of 1g m^{-2} soil was applied in the irrigation water 3-4 days before seeding. Samples at different soil depths (0-15, 15-30, 30-60 and 60-90 cm) were collected in duplicate. Granulometric analysis was carried out according to Robinson pipette method [2]. Organic matter content was determined according to Walkey [3]. pH and electrical conductivity was measured in aqueous extract (soil:water = 1:2,5) [4].

Herbicide analyses

Propachlor (2-chloro-N-isopropylacetanilide) and chlorthal (2,3,5,6-tetrachloro-2, 5-cyclo-hexadiene-1, 4-dione) in 20g soil samples were extracted with ethyl acetate [5]. A Hewlett-Packard 5890 gas chromatograph equipped with an electron capture detector and automatic injector was used to determine the herbicide concentrations in the extracts. The column temperature was maintained at 60°C for 1 minute, then programmed at 15°C min^{-1} to 260°C, and held 1 minute.

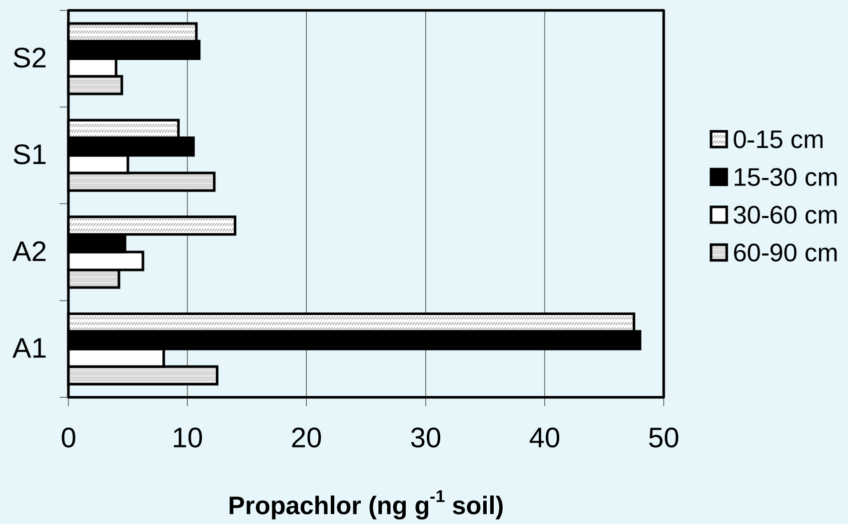
Results and discussion

The residual levels of propachlor and chlorthal were measured in seedbed soils 5 and 4 months after their application in greenhouse A and greenhouse S, respectively.

The persistence of the chlorinated herbicides was determined through the edaphic profile (figure 1). Soil characteristics were also analysed at different depths (Table 1).

Herbicides applied in the water irrigation at the initial dose of 2 µg g^{-1}soil were significantly reduced after 4-5 months. Nevertheless, residual amounts of chlorthal and propachlor accounted up to 178 and 116 ng g^{-1} soil, respectively. In the greenhouse A, the highest concentrations of both herbicides were found at 0-15 and 15-30 cm depth, whereas just between 10% and 14% of propachlor and 4% and 7% of chlorthal remained at 60-90 cm depth. In contrast, up to 33% of propachlor and 51% of chlorthal reached the soil layer between 60 and 90 cm depth in the greenhouse S. In general, tillage soil layers (0-15 and 15-30 cm depth) with considerable contents of organic matter

(Table 1) retained most of the residual herbicides. However, distinct pattern of herbicide distribution in depth was found between the greenhouses (Figure 1). Major mobilisation of herbicides towards deep soil layers was observed in the greenhouse S. Propachlor was relatively uniformly distributed through the edaphic profile in S1 while chlorthal



was accumulated at 60-90 cm in S2. The fact that no significant differences in the seedbed seedbed soil characteristics were found (Table 1) suggested that variations in the irrigation practice directly affect the herbicide lixiviation. An irregular irrigation most likely caused a distinct difference in the herbicide application that led to the significantly different total amounts in the two samples of soil from the greenhouse A (Figure 1).

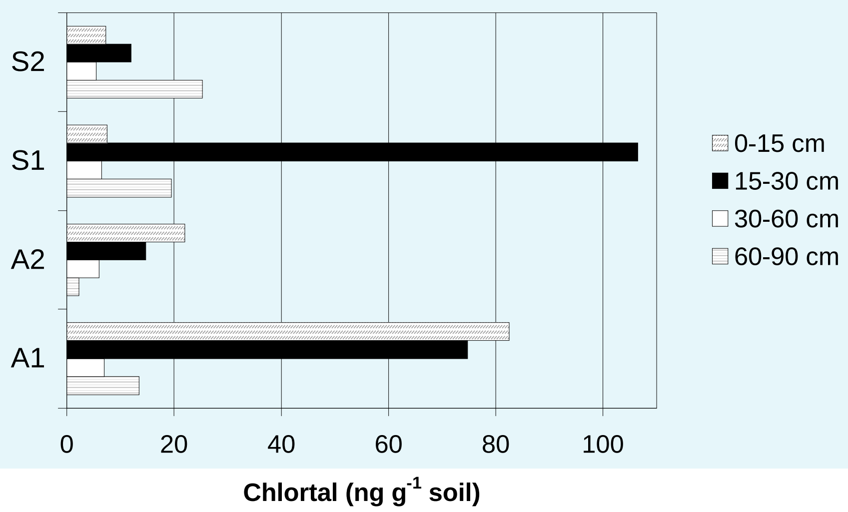


Figure 1. Residual levels of propachlor and chlorthal through the soil profile 5 months and 4 months after herbicide application in the greenhouse A (samples A1 and A2) and greenhouse S (samples S1 and S2), respectively.

Table 1. Edaphic properties analysed through the greenhouse seedbed soil profiles. A1 and A2: samples from the greenhouse A. S1 and S2: samples from the greenhouse S. Average values are presented. In all cases the standard error was ≤10%.

soil sample	depth	organic matter %	clay %	sand %	Silt %	pH	conductivity µmh/cm
A1	0-15 cm	1.81	7.0	73.9	19.1	6.0	262
	15-30 cm	0.84	5.1	69.1	25.8	5.6	259
	30-60 cm	0.30	8.0	65.0	27.0	5.7	179
	60-90 cm	0.27	6.5	67.9	25.6	6.6	175
A2	0-15 cm	1.85	7.8	71.1	21.1	6.3	234
	15-30 cm	1.11	3.8	73.3	22.9	6.4	336
	30-60 cm	0.46	7.8	65.0	27.2	6.7	250
	60-90 cm	0.36	5.6	78.0	16.4	6.7	221
S1	0-15 cm	1.03	7.1	76.7	16.2	6.3	339
	15-30 cm	1.26	6.9	70.4	22.7	6.0	323
	30-60 cm	0.35	6.6	71.2	22.2	6.0	223
	60-90 cm	0.70	6.4	76.7	16.9	6.3	230
S2	0-15 cm	2.26	7.3	75.7	17.0	5.7	322
	15-30 cm	1.96	6.7	75.3	18.0	5.8	249
	30-60 cm	0.48	6.4	74.6	19.0	5.2	164
	60-90 cm	0.43	8.3	71.0	20.7	5.4	181

The mobility of both propachlor and chlorthal beyond superficial soil layers enhanced the risk of diffuse contamination towards groundwater. In a preliminary estimation, water from a shallow well near greenhouses was analysed. Chlorthal was not detected and propachlor level of 41 µg l^{-1} was notably below the lifetime health advisory level (90 µg l^{-1})[6].

In conclusion, at the recommended dose, chlorinated herbicides applied by irrigation to seedbed soils are mainly remained at the superficial layers. In the 4-5 months period propachlor and chlorthal were mostly degraded. However, residual levels in the deep layers indicated a risk of contamination through the soil profile.

References

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