



Valorization of agro-industrial wastes as organic amendments to reduce herbicide leaching into the soil

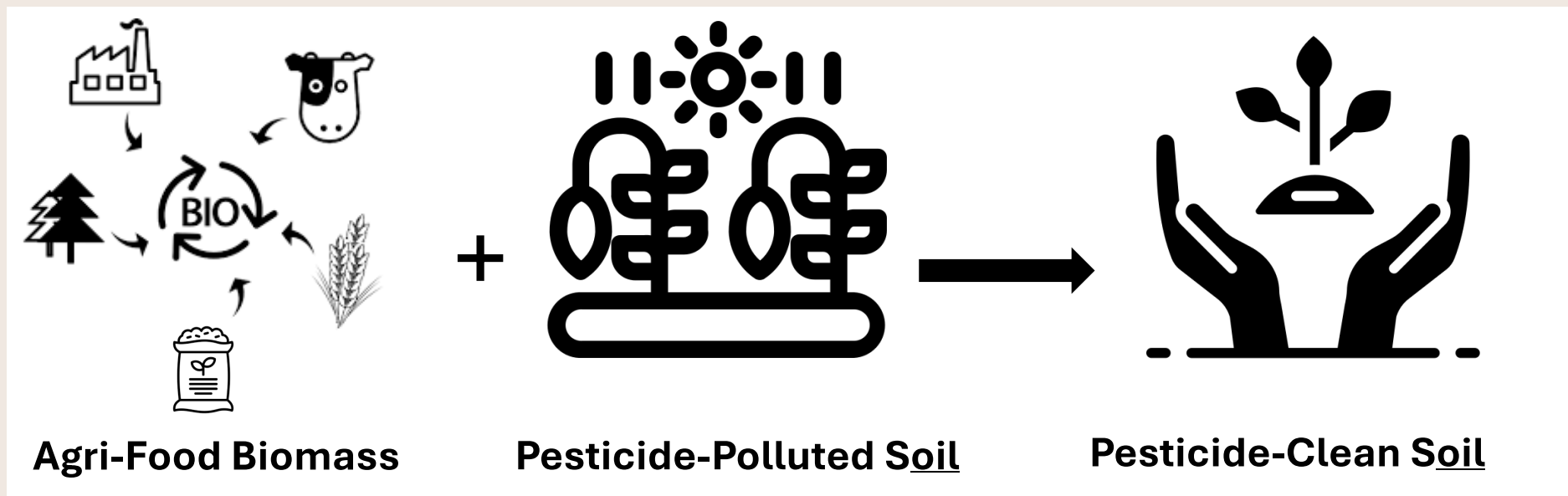
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INTRODUCTION

The widespread use of herbicides in intensive agriculture has increased concerns regarding soil and groundwater contamination. Herbicide mobility is influenced by several factors, including soil texture, organic matter content and pesticide physicochemical properties. The incorporation of organic amendments derived from agro-industrial wastes may enhance herbicide retention and reduce their transport through the soil profile while simultaneously promoting circular economy strategies.



The aim of this study was to **evaluate the effect of four agro-industrial wastes** (orange peel, spent brewers' grains, grape pomace, and gazpacho waste) **on the adsorption, dissipation and leaching behaviour of metobromuron and chlorbromuron** (phenylurea herbicides) in a semiarid soil.

MATERIALS & METHODS

Soil (S): gypsic-calcaric regosol (0.6% OM).

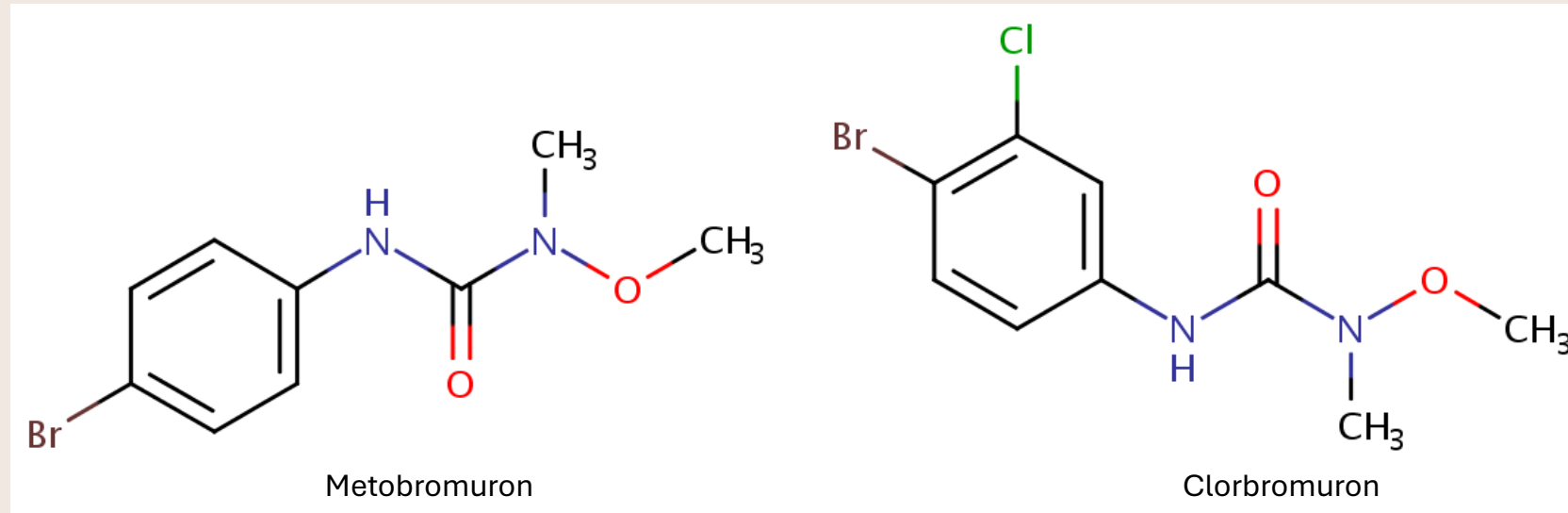
Amendments: orange peel (OP), spent brewers' grains (SG), gazpacho waste (GW) and grape pomace (GP).

Herbicides: metobromuron (MB) and chlorbromuron (CB).

Experimental set-up

- Determination of log K_{OC} values.** **Sorption** studies were carried out following Test No. 106: Adsorption - Desorption using a batch equilibrium method.
- Determination of herbicides DT_{50} .** **Degradation** tests were performed in aerobic and dark conditions for 60 days following the Test No 307: Aerobic and anaerobic transformation in soil.
- Calculation of different leaching indices.** **Leaching** experiment was assessed using disturbed soil columns in accordance with Test No. 312: Leaching in Soil Columns.

Soil samples were extracted with acetonitrile, and the separation, identification and quantification were carried out using a HPLC/PDA (Waters Corporation).



RESULTS & DISCUSSIONS

Adsorption of herbicides

Table 1. Log K_{OC} values calculated for herbicides in unamended and amended soils.

Soil	Log K_{OC}	
	Metobromuron	Chlorbromuron
S	1.9	2.5
S + OP	2.1	2.6
S + SG	2.2	2.7
S + GW	2.4	3.0
S + GP	2.4	2.9

Agro-industrial **amendments increased the adsorption of both herbicides**, particularly in soils amended with GW and GP. The increase in log K_{OC} values indicates a greater affinity for soil organic matter, which may reduce herbicide mobility and potential groundwater contamination.

Dissipation and Persistence

Table 2. Dissipation parameters obtained according to SFO kinetics for metobromuron and chlorbromuron in amended and unamended soils. Only DT_{50} (days) values are shown for clarity.

Soil	DT_{50}	
	Metobromuron	Chlorbromuron
S	56	95
S + OP	15	71
S + SG	11	18
S + GW	15	53
S + GP	16	33

Herbicide dissipation was accelerated in amended soils. MB persistence decreased from 56 days in the unamended soil to 11–16 days in amended soils, whereas CB DT_{50} values decreased from 95 to 18–71 days depending on the amendment applied. These results indicate that agro-industrial wastes may influence both sorption and degradation processes in soil.

Leaching behaviour

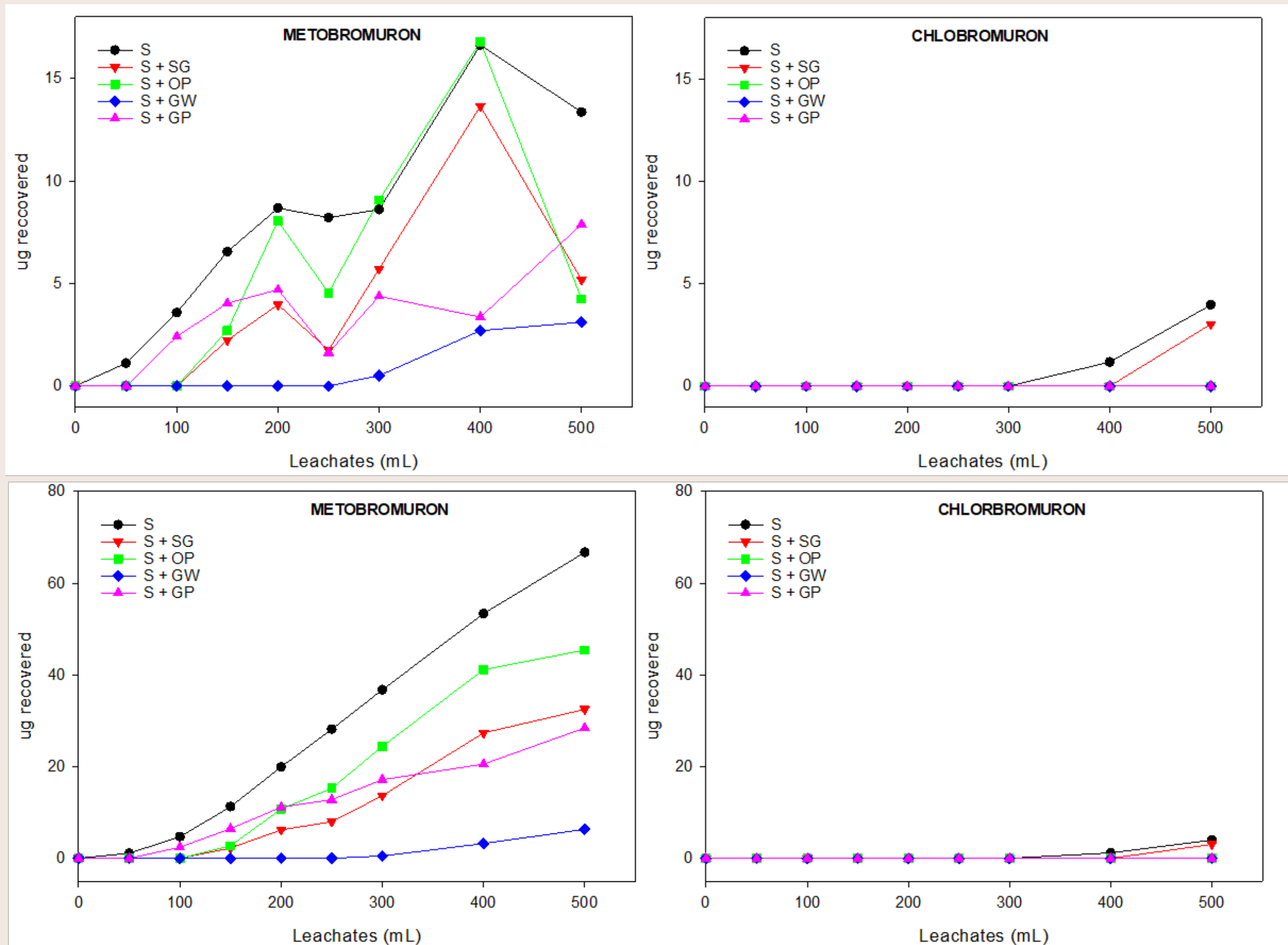


Fig 1. Relative (top) and cumulative (bottom) breakthrough curves (BTCs) of herbicides applied to soil columns in amended and unamended soils.

The **incorporation of agro-industrial wastes significantly reduced MB leaching** through the soil columns, particularly in soils amended with GW and GP. **In contrast, CB showed limited downward movement** and remained largely retained within the soil profile.

Distribution and leaching risk assessment

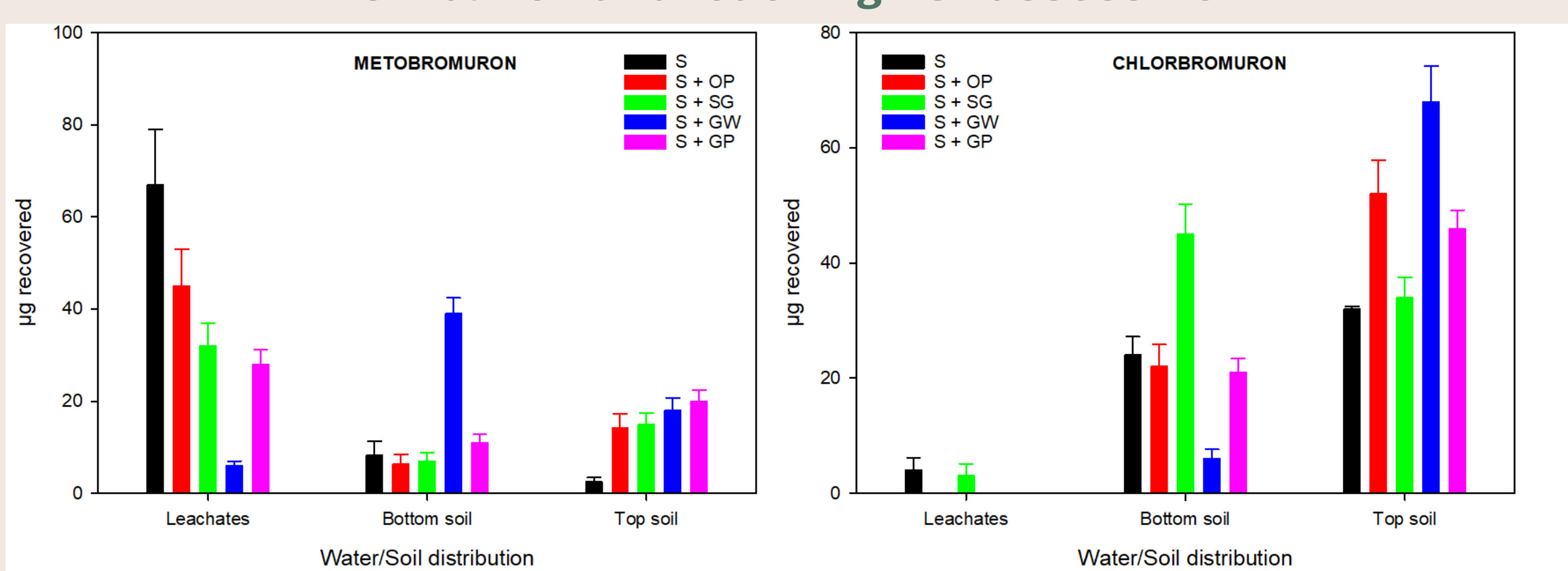


Fig 2. Distribution of herbicides in soil and total leachates in unamended and amended soils.

The **incorporation of agro-industrial wastes markedly affected herbicide distribution between soil and leachates**. MB recovery in leachates decreased from 65 % in the unamended soil to 44 % and 6 % in soils amended with OP and GW, respectively. In contrast, CB was predominantly retained in the upper soil layer, indicating a limited transport under the experimental conditions.

The experimental results were consistent with the leaching indices calculated from sorption and dissipation data. Most indices classified MB as mobile in the unamended soil, whereas **amendment application generally shifted its classification towards lower mobility**. For CB, the majority of indices indicated low mobility or transition behaviour, **confirming its reduced leaching potential in amended soils**.

CONCLUSIONS

The **incorporation of agro-industrial wastes increased herbicide adsorption, reduced persistence and significantly decreased leaching through the soil profile**. Among the evaluated materials, **grape pomace and gazpacho waste produced the strongest effects**. These findings support the valorization of agro-industrial wastes as sustainable amendments for groundwater protection while contributing to more sustainable waste management practices.

References:

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