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*Soil Research*

### Supplementary Material

#### **Degradation of conventional, biodegradable and oxo-degradable microplastics in a soil using a $\delta^{13}\text{C}$ technique**

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Properties of the soil used in the study; list of statistical significance (*p-value*) of cumulative CO<sub>2</sub> mineralized and mineralization rate of soil+plastic, soil and plastic (% of total plastic-C and mg kg<sup>-1</sup> soil basis), and priming effect; Mean residence time of labile and recalcitrant C and their proportions for plastics used in this study; FTIR absorption bands and assignments of original plastic samples used in this study; mineralization rate (per day) and cumulative CO<sub>2</sub>-C derived from plastic (total C), soil and soil+plastic treatments; ATR-FTIR spectra and scanning electron micrographs of original plastics and incubated plastics removed from soils after 77 and 185 days of soil incubation.

**This Supporting Information includes:**

**Table S1.** Properties of the soil used in the study.

**Table S2.** Statistical significance (*p-value*) of cumulative CO<sub>2</sub> mineralized and mineralization rate of soil+plastic, soil and plastic (% and mg kg<sup>-1</sup> soil basis) and priming effect.

**Table S3.** Mean residence time of labile and recalcitrant C and their proportions for bin liner, mulch film, F&V bag and straw in a soil.

**Table S4.** FTIR absorption bands and assignments of original plastic samples used in this study.

**Fig. S1.** Total CO<sub>2</sub>-C mineralization rate and cumulative total CO<sub>2</sub>-C mineralized from control soil and soil-plastic mixtures over a 185-day period.

**Fig. S2.** Plastic mineralization rate and cumulative proportion of CO<sub>2</sub>-C derived from plastic treatments over a 185-day incubation period.

**Fig. S3.** Scanning electron micrographs of original plastics and the samples removed after 77-day and 185-day of incubation in the soil.

**Fig. S4.** Soil organic C mineralization rate and cumulative soil organic C mineralized from soil-plastic mixtures over a 185-day incubation period.

**Table S1.** Properties of the soil used in the study.

<b>Properties</b>	<b>Value</b>
pH (1:5; soil:H <sub>2</sub> O)	5.47
Electrical conductivity (1:5; soil:H <sub>2</sub> O; mS/m)	4.27
Total C (%)	1.40
Total N (%)	0.55
Clay (%)	20.0
Silt (%)	8.7
Sand (%)	71.3
$\delta^{13}\text{C}$ (‰)	-15.24

**Table S2.** Statistical significance (*p*-value) of cumulative CO<sub>2</sub> mineralized and mineralization rate of soil+plastic, soil, plastic (% and mg CO<sub>2</sub>-C kg<sup>-1</sup> soil basis) and priming effect.

<b>Plastics</b>	<b>Day 1</b>	<b>Day 4</b>	<b>Day 9</b>	<b>Day 23</b>	<b>Day 43</b>	<b>Day 77</b>	<b>Day 126</b>	<b>Day 185</b>
<b>Total mineralization rate (soil+plastic; mg CO<sub>2</sub>-C kg<sup>-1</sup> soil day<sup>-1</sup>)</b>								
Bin liner / Control soil	<0.0001	<0.0001	0.1643	0.9501	0.9939	0.9962	0.9180	1.0000
Bin liner / F&V bag	<0.0001	<0.0001	0.0117	0.6432	0.9710	0.9990	0.9983	1.0000
Bin liner / Mulch film	<0.0001	<0.0001	0.3055	0.6654	0.9999	0.9999	0.9975	1.0000
Bin liner / Straw	0.9930	<0.0001	0.7482	0.8165	0.9871	0.9987	0.9310	1.0000
Control soil / F&V bag	<0.0001	0.1142	0.8307	0.9643	0.9995	1.0000	0.9824	1.0000
Control soil / Mulch film	<0.0001	0.9980	0.9968	0.9704	0.9816	0.9996	0.9859	1.0000
Control soil / Straw	<0.0001	0.6643	0.8102	0.9964	1.0000	1.0000	1.0000	1.0000
F&V bag / Mulch film	<0.0001	0.0620	0.6331	1.0000	0.9400	1.0000	1.0000	1.0000
F&V bag / Straw	0.0001	0.7904	0.2160	0.9982	0.9999	1.0000	0.9870	1.0000
Mulch film / Straw	<0.0001	0.4746	0.9441	0.9988	0.9679	1.0000	0.9896	1.0000
<b>Plastic mineralization rate (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil day<sup>-1</sup>)</b>								
Bin liner / F&V bag	<0.0001	<0.0001	0.3306	0.8833	0.9681	0.9729	0.9205	0.9998
Bin liner / Mulch film	<0.0001	<0.0001	0.9993	0.9884	0.8515	0.9987	0.9996	1.0000
Bin liner / Straw	<0.0001	<0.0001	0.4113	0.8706	0.9740	0.9630	0.9303	1.0000
Mulch film / F&V bag	<0.0001	0.9991	0.4000	0.7184	0.5916	0.9370	0.8801	0.9999
F&V bag / Straw	0.7989	0.9863	0.9988	1.0000	1.0000	1.0000	1.0000	1.0000
Mulch film / Straw	0.0011	0.9633	0.4893	0.7018	0.6129	0.9210	0.8921	1.0000
<b>Soil mineralization rate (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil day<sup>-1</sup>)</b>								
Bin liner / F&V bag	<0.0001	<0.0001	0.0179	0.5887	0.9533	0.9993	0.9998	1.0000
Bin liner / Mulch film	0.0231	<0.0001	0.1618	0.3710	0.9987	0.9955	0.9772	1.0000
Bin liner / Straw	<0.0001	<0.0001	0.8744	0.7958	0.9787	0.9993	0.9112	1.0000
Mulch film / F&V bag	<0.0001	0.0183	0.7734	0.9825	0.9825	0.9995	0.9885	1.0000
F&V bag / Straw	<0.0001	0.6692	0.1040	0.9850	0.9992	1.0000	0.9391	1.0000
Mulch film / Straw	<0.0001	0.1964	0.5144	0.8888	0.9949	0.9995	0.9941	1.0000
<b>Plastic mineralization rate (%)</b>								
Bin liner / F&V bag	<.0001	<.0001	0.2428	0.8355	0.9500	0.9553	0.8840	0.9998
Bin liner / Mulch film	<.0001	<.0001	0.9869	0.9964	0.8872	0.9998	1.0000	1.0000

Bin liner / Straw	<.0001	<.0001	0.2867	0.8251	0.9553	0.9463	0.8921	0.9999
Mulch film / F&V bag	<.0001	0.9885	0.4116	0.7182	0.5929	0.9323	0.8770	0.9999
F&V bag / Straw	0.9335	0.9951	0.9996	1.0000	1.0000	1.0000	1.0000	1.0000
Mulch film / Straw	<0.0001	0.9432	0.4719	0.7062	0.6065	0.9208	0.8851	1.0000
<b>Cumulative total C (soil+plastic; mg CO<sub>2</sub>-C kg<sup>-1</sup> soil)</b>								
Bin liner / Control soil	0.0008	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / F&V bag	0.8574	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Mulch film	0.1243	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Straw	1.0000	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Control soil / F&V bag	0.0126	0.0007	0.0053	0.2803	0.7252	0.3353	<0.0001	<0.0001
Control soil / Mulch film	0.3705	0.4671	0.2971	0.9953	0.1427	0.0075	<0.0001	<0.0001
Control soil / Straw	0.0007	0.0005	<0.0001	0.0002	0.0004	<0.0001	0.0001	<0.0001
F&V bag / Mulch film	0.5763	0.0366	0.4235	0.4755	0.7716	0.3825	0.5412	0.4021
F&V bag / Straw	0.8899	0.9984	0.1866	0.0377	0.0103	0.0162	0.7930	0.8178
Mulch film / Straw	0.1316	0.0203	0.0018	0.0002	0.1665	0.5143	0.0867	0.0458
<b>Cumulative plastic C (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil)</b>								
Bin liner / F&V bag	0.0036	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Mulch film	0.0129	<0.0001	<0.0001	<0.0001	0.0013	0.0054	0.0189	0.0187
Bin liner / Straw	0.0026	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mulch film / F&V bag	0.9445	0.9315	0.4743	0.0208	<0.0001	<0.0001	<0.0001	<0.0001
F&V bag / Straw	0.9996	1.0000	0.9999	1.0000	0.9997	0.9997	0.9999	0.9873
Mulch film / Straw	0.9681	0.9279	0.5129	0.0195	<0.0001	<0.0001	<0.0001	<0.0001
<b>Cumulative soil C (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil)</b>								
Bin liner / F&V bag	0.1929	0.0211	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Mulch film	0.8640	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Straw	0.0074	0.0579	0.0043	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mulch film / F&V bag	0.0337	<0.0001	0.0010	<0.0001	0.0058	0.0003	<0.0001	<0.0001
F&V bag / Straw	0.5519	0.9678	0.0075	0.0002	<0.0001	<0.0001	0.2856	0.2166
Mulch film / Straw	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<b>Cumulative plastic C (%)</b>								
Bin liner / F&V bag	0.0021	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

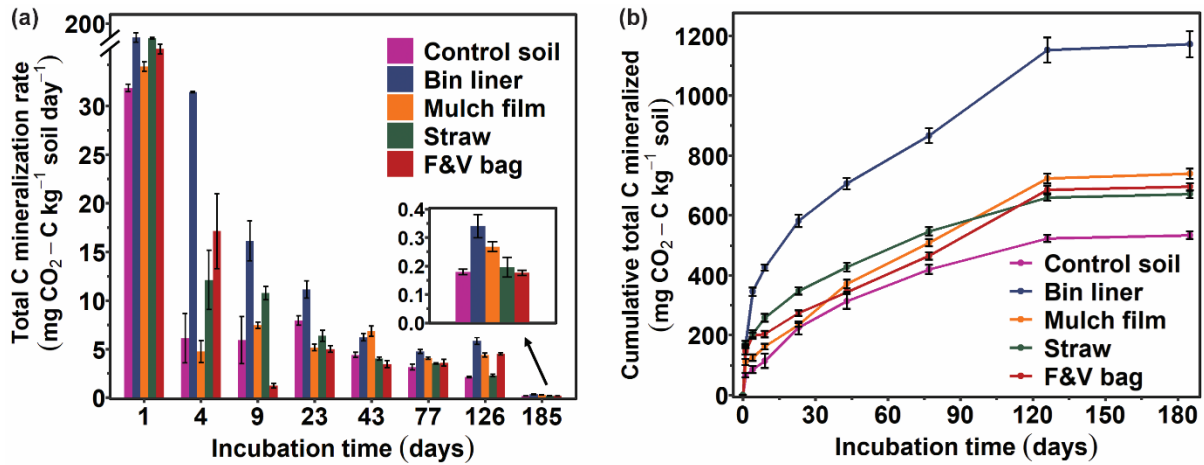
Bin liner / Mulch film	0.0081	<0.0001	<0.0001	<0.0001	0.0001	0.0004	0.0004	0.0004
Bin liner / Straw	0.0012	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mulch film / F&V bag	0.9363	0.9036	0.4665	0.0262	<0.0001	<0.0001	<0.0001	<0.0001
F&V bag / Straw	0.9999	1.0000	1.0000	1.0000	1.0000	0.9999	1.0000	0.9974
Mulch film / Straw	0.9529	0.8990	0.4866	0.0239	<0.0001	<0.0001	<0.0001	<0.0001
<b>Priming effect (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil)</b>								
Bin liner / F&V bag	0.1929	0.0211	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Mulch film	0.8640	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bin liner / Straw	0.0074	0.0579	0.0043	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mulch film / F&V bag	0.0337	<0.0001	0.0010	<0.0001	0.0058	0.0003	<0.0001	<0.0001
F&V bag / Straw	0.5519	0.9678	0.0075	0.0002	<0.0001	<0.0001	0.2856	0.2166
Mulch film / Straw	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

**Table S3.** Mean residence time of labile and recalcitrant C and their proportions for bin liner, mulch film, F&V bag and straw in a soil.

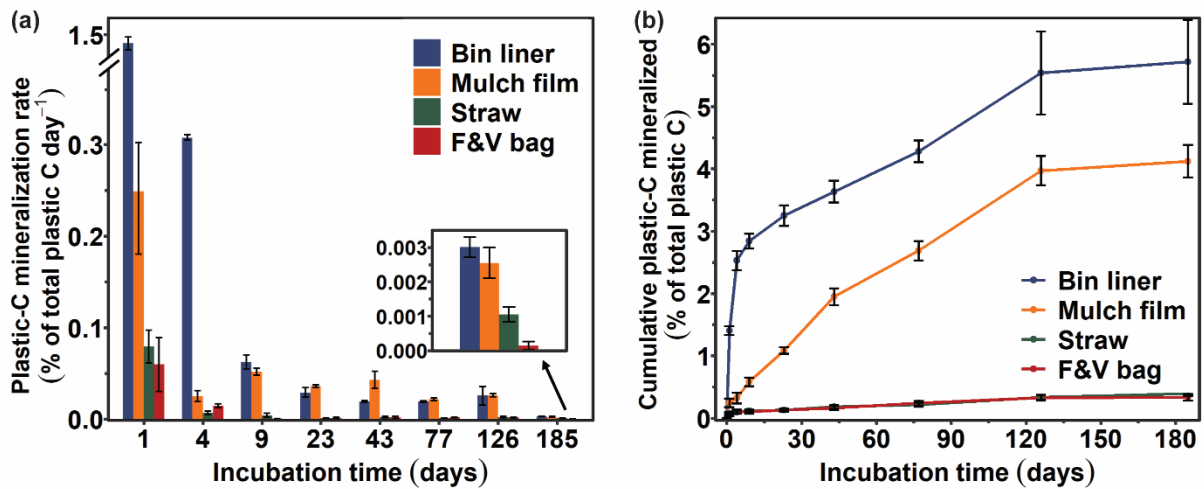
Plastic	Mean residence time		Proportion (%)		Residual standard error
	Labile C (day)	Recalcitrant C (year)	Labile C	Recalcitrant C	
Bin liner	1.66	14.96	2.84	97.16	0.29
Mulch film	0.01	0.00	4.72	95.28	0.19
Straw	0.69	162.91	0.10	99.9	0.01
F&V bag	1.37	193.26	0.10	99.9	0.03

**Table S4.** FTIR absorption bands and assignments of original plastic samples used in this study.

Plastics (composition)	Absorption band (cm <sup>-1</sup> )	Assignment
Biodegradable bin liner and mulch film plastics (PBAT & starch)	727	CH <sub>2</sub> stretch
	873	=C=H out-plane bend of benzene ring
	1017	C-O stretch; CH in-plane bend
	1102	CH <sub>2</sub> -OH stretch; C-O stretch
	1267	C-O symmetric stretch
	1409	CH <sub>2</sub> in-plane bend
	1454	CH <sub>2</sub> deformation
	1711	C=O stretch of ester groups
	2874	CH <sub>2</sub> stretch
	2956	CH <sub>3</sub> stretch
	3000-3600	OH- stretch
Oxo-biodegradable straw (PP mixed with Reverte™)	809	C-CH stretch; CH <sub>2</sub> rock; C-C stretch
	841	C-CH <sub>3</sub> stretch; CH <sub>2</sub> rock
	899	CH <sub>3</sub> rock; CH bend
	973	CH <sub>3</sub> rock; C-C stretch
	998	CH <sub>3</sub> rock; CH <sub>3</sub> bend; CH bend
	1167	C-C stretch; CH <sub>3</sub> rock; CH bend
	1375	CH <sub>3</sub> bend
	1456	CH <sub>2</sub> bend
	2838	CH <sub>2</sub> symmetrical stretch
	2917	CH <sub>2</sub> asymmetrical stretch
2949	CH <sub>3</sub> asymmetrical stretch	
Conventional F&V bag (HDPE)	718	CH <sub>2</sub> rock
	1471	CH <sub>2</sub> band
	2847	CH <sub>2</sub> symmetric stretch
	2914	CH <sub>2</sub> asymmetric stretch

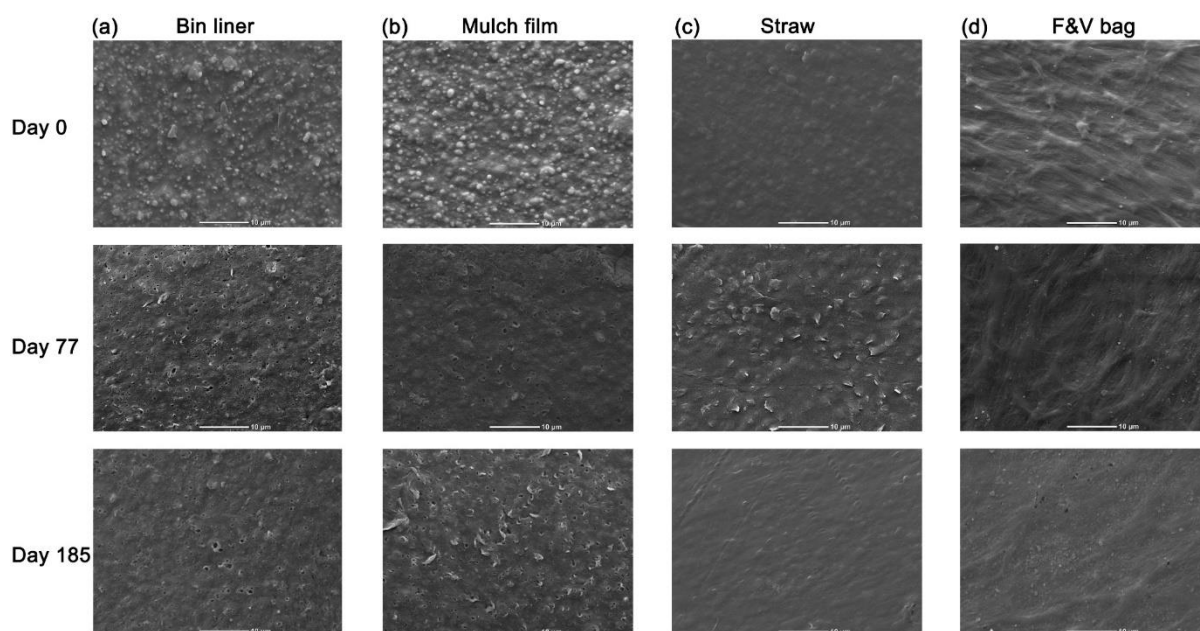


**Fig. S1.** (a) Total CO<sub>2</sub>-C mineralization rate (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil day<sup>-1</sup>) and (b) cumulative total CO<sub>2</sub>-C mineralized (mg CO<sub>2</sub>-C kg<sup>-1</sup> soil) from control soil and soil-plastic mixtures incubated at 37±1 °C over a 185-day period. Error bars represent ± standard errors of the mean (n=3).

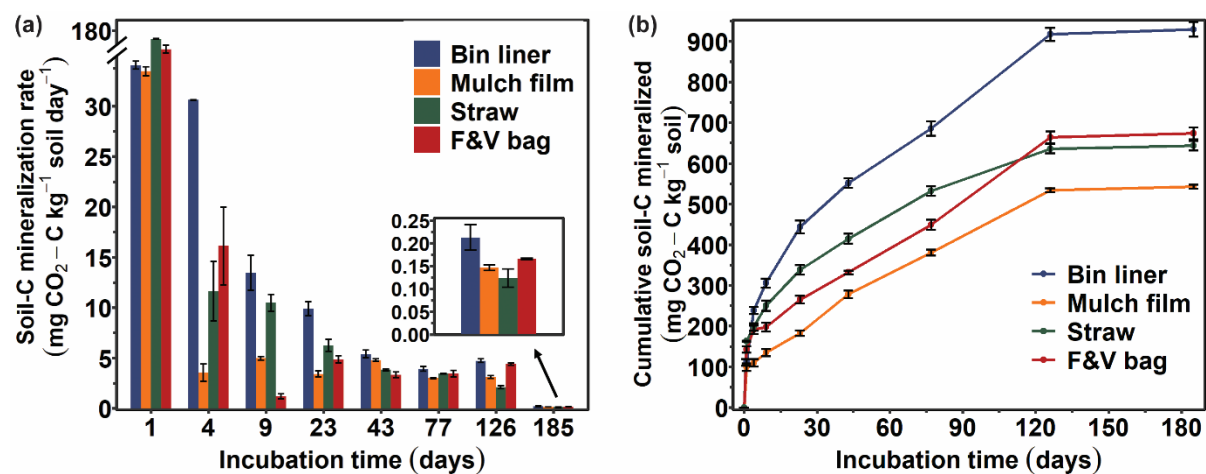


**Fig. S2.** (a) Plastic C mineralization rate (% of total plastic C day<sup>-1</sup>) and (b) cumulative CO<sub>2</sub>-C mineralized (% of total plastic C) from plastic treatments over a 185-day incubation period. Error bars represent ± standard errors of the mean (n=3).





**Fig. S3.** Scanning electron micrographs of original plastics and the samples removed after 77-day and 185-day of incubation in the soil at  $37\pm 1$  °C: (a) bin liner, (b) mulch film, (c) straw and (d) F&V bag.



**Fig. S4.** (a) Soil organic C mineralization rate ( $\text{mg CO}_2\text{-C kg}^{-1}\text{ soil day}^{-1}$ ) and (b) cumulative soil organic C mineralized ( $\text{mg CO}_2\text{-C kg}^{-1}\text{ soil}$ ) from soil-plastic mixtures incubated at  $37\pm 1$  °C over a 185-day incubation period. Error bars represent  $\pm$  standard errors of the mean ( $n=3$ ).