Spatial variability of pesticide degradation in soil: mechanisms and implications

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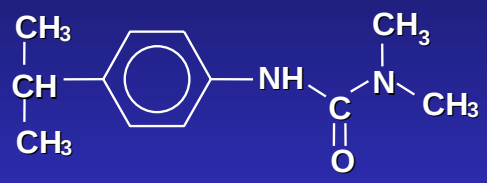
Pesticide degradation in the environment

Key questions

- How variable are pesticide degradation rates within individual fields?
- What are the mechanisms underlying within-field spatial variability of degradation rate?

Isoproturon
(3-(4-isopropylphenyl)-1,1-dimethylurea)



- Phenyl-urea herbicide
- used for control of weeds in cereal crops
- slowly degraded and moderately mobile in soil

Pesticides use in Great Britain (2003)

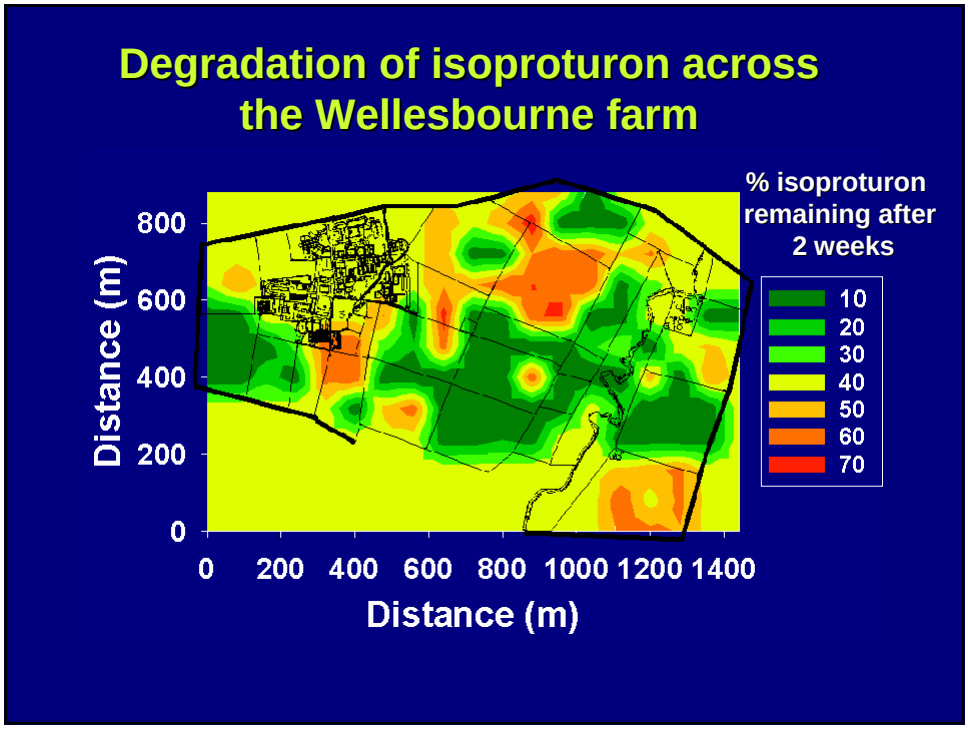
Use	Active ingredient	Area treated (10^3 ha)	Amount used (t)
Herbicide	Isoproturon	2,661	2,730
	Glyphosate	1,473	1,285
	All herbicides	*14,006*	*8,520*
Fungicide	Epoxiconazole	3,434	206
	Chlorothalonil	1,619	799
	All fungicides	*14,503*	*3,566*
Insecticide	Cypermethrin	2,105	51
	All insecticides	*3,809*	*434*

Pesticides most commonly exceeding 0.1μg l^{-1} in surface freshwater
(England and Wales, 2002)

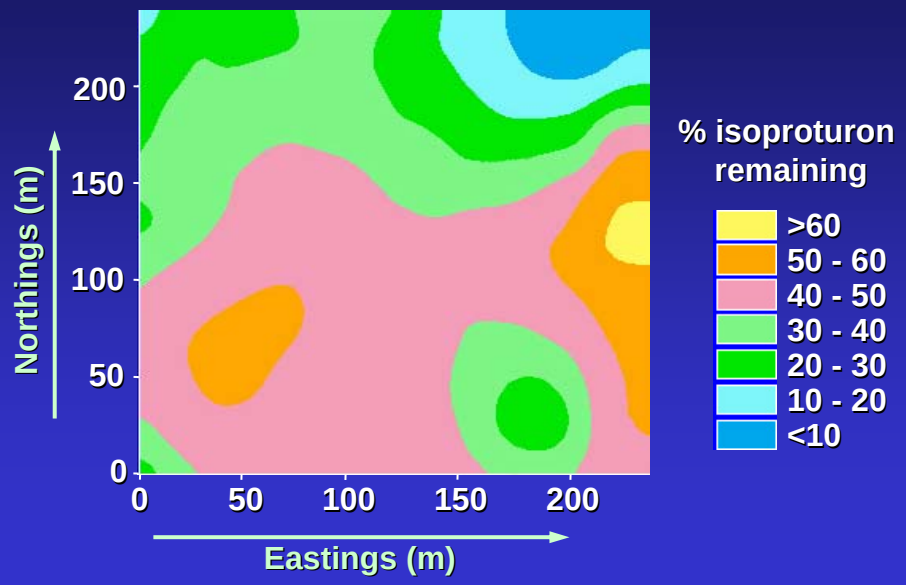
Pesticide	% samples >0.1μg l^{-1}
Isoproturon	10.4
Mecoprop	10.6
Diuron	11.5
MCPA	8.7
2,4 D	7.7

Degradation of isoproturon

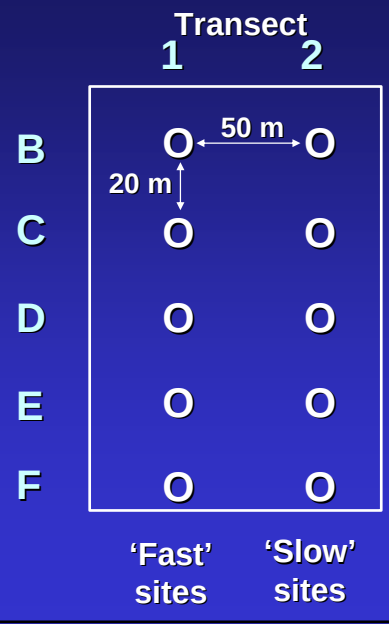
- Degradation is microbially mediated
- Considerable spatial variability in degradation rates between and within fields


Degradation of isoproturon across the Wellesbourne farm
% isoproturon remaining after 2 weeks
10
20
30
40
50
60
70
Distance (m)
800
600
400
200
0
0 200 400 600 800 1000 1200 1400
Distance (m)

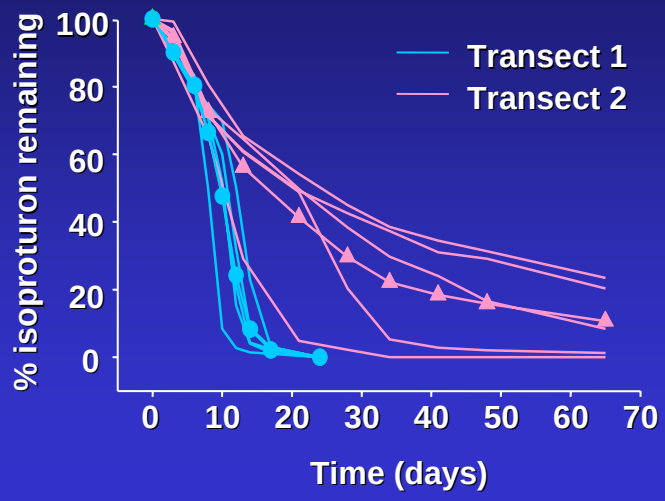
Isoproturon degradation in Deep Slade field after 21 days



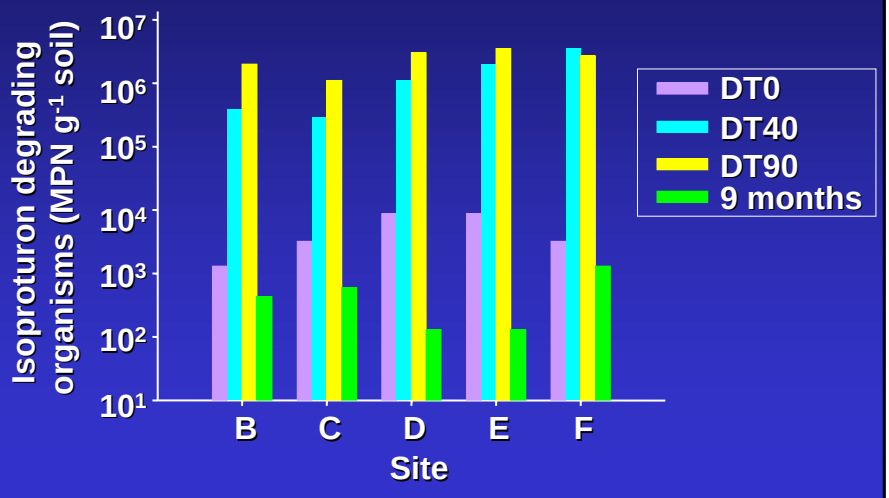
Sampling Pattern



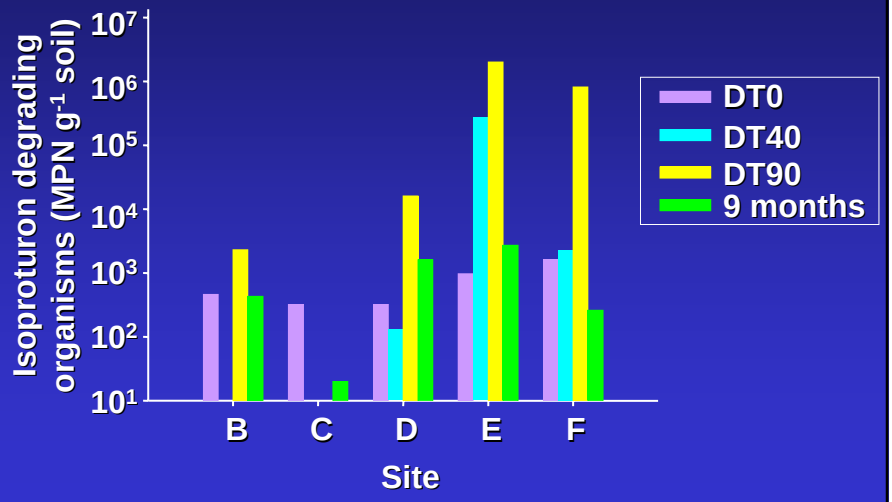
Degradation of isoproturon in soil from Deep Slade field



Dynamics of isoproturon degrading organisms a. Fast degrading sites



Dynamics of isoproturon degrading organisms
b. Slow degrading sites

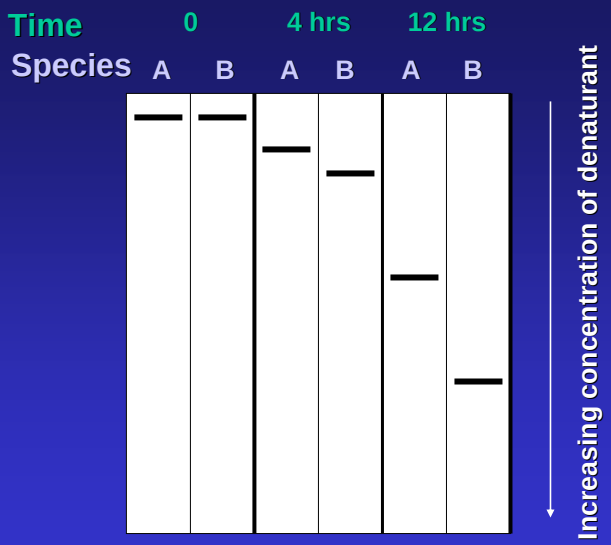


Denaturing Gradient Gel Electrophoresis (DGGE)

- PCR amplification of bacterial community 16S rRNA genes
- Separation on formamide / urea gradient gel

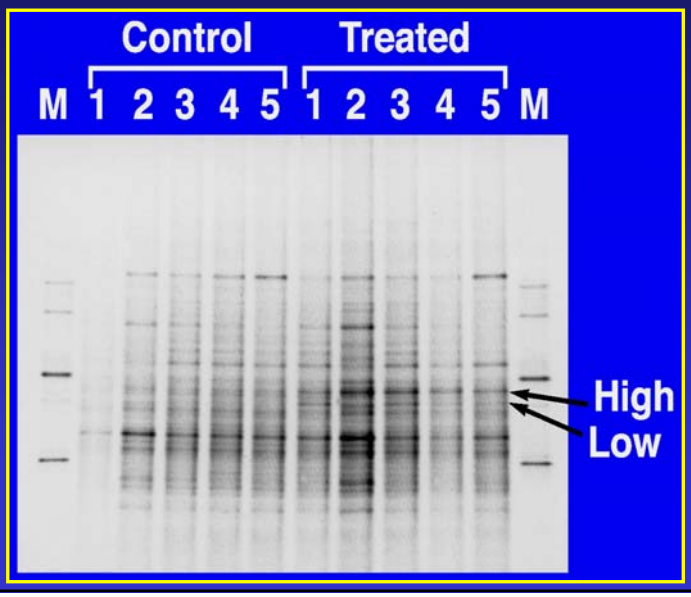
- Provides information on
  - microbial community structure
  - identity of organisms
  - non-culturable organisms

Denaturing gradient gel electrophoresis



Bacterial community DGGE profile from fast degrading sites

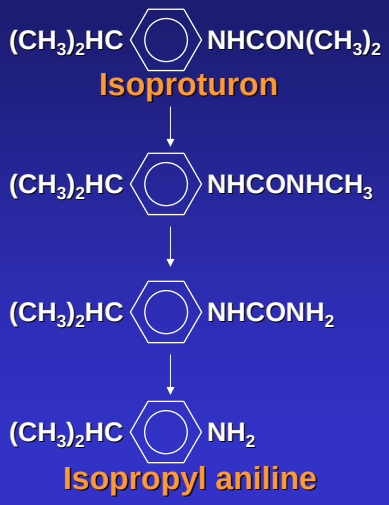
Muyzer (1993)
190 bp 16S rRNA fragment



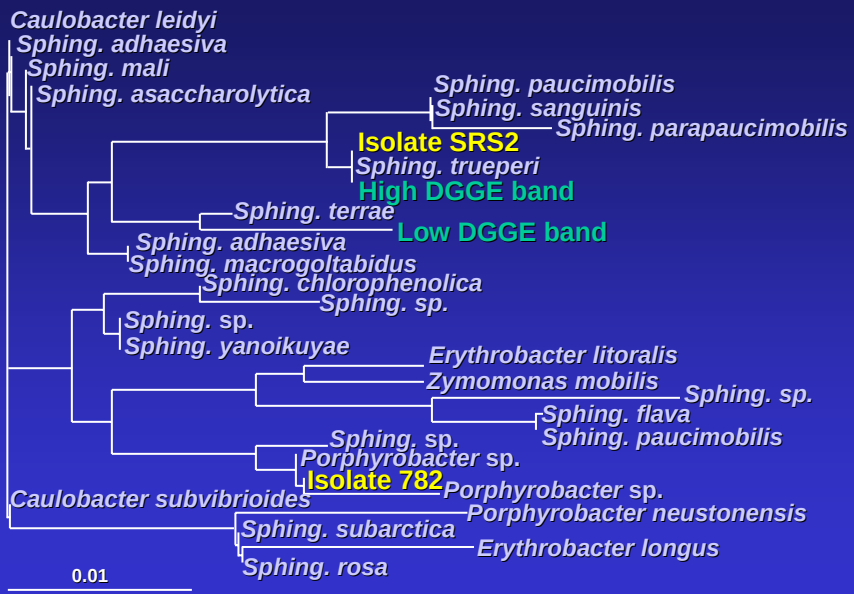
Isolation of isoproturon degrading bacteria

- Fast degrading soil inoculated into MSM plus IPU (MSI)
- After complete degradation, culture re-enriched into MSI
- Following complete degradation, spread onto MS-IPU agar
- Single colonies checked for degradation

Degradation of isoproturon by isolates SRS2 and 782



16S rRNA from DGGE bands and isolates



Soil factors influencing microbial activity

Soil Properties

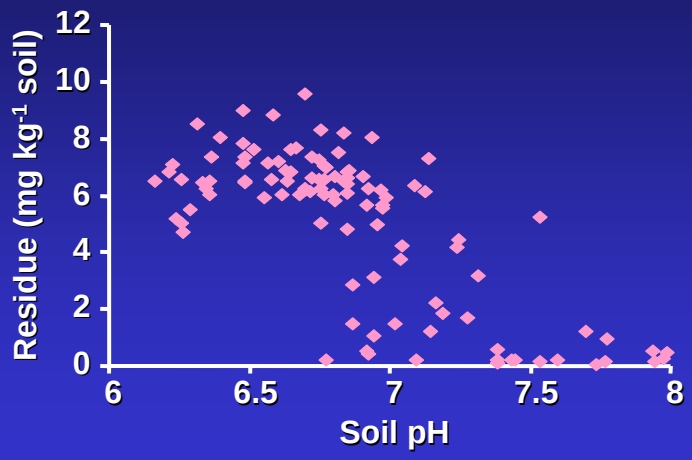
Organic matter
pH
Nutrient status
Mineralogy

Environment

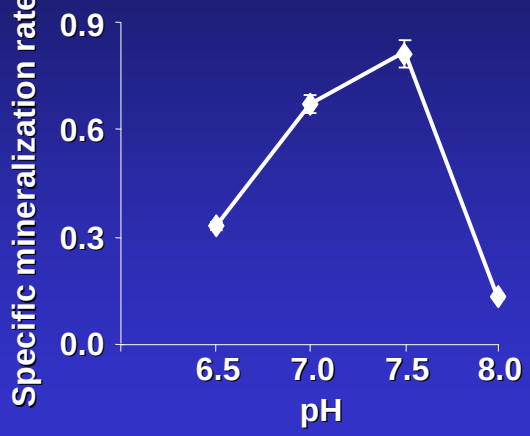
Temperature
Moisture content
Aeration

Pesticide degradation

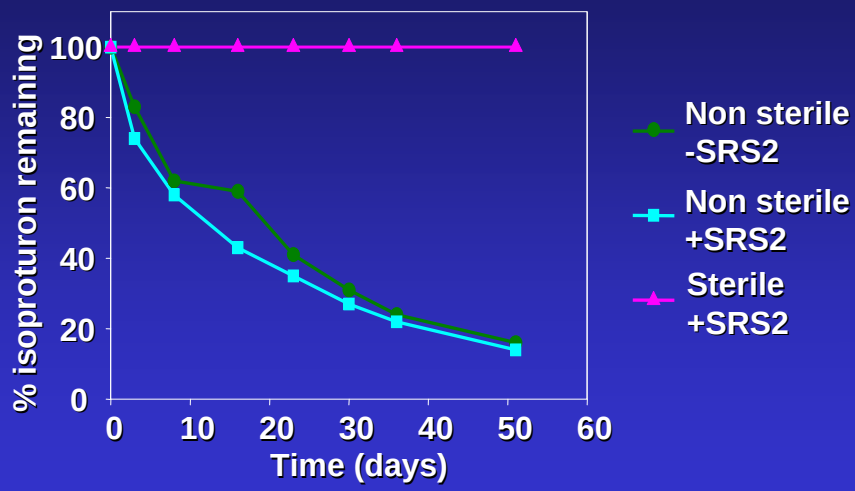
Relationship between isoproturon degradation and soil pH



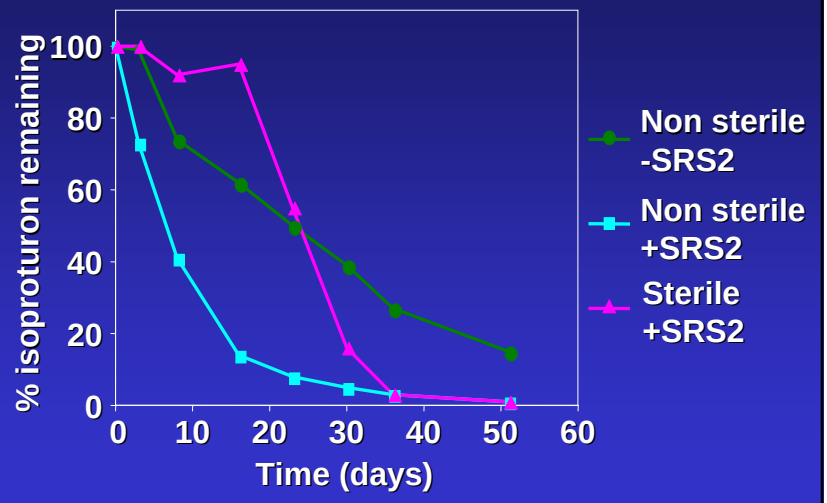
Degradation of isoproturon by SRS2 in pure culture



Degradation of isoproturon by SRS2 in pH 6.5 soil



Degradation of isoproturon by SRS2 in pH 7.5 soil



Further questions

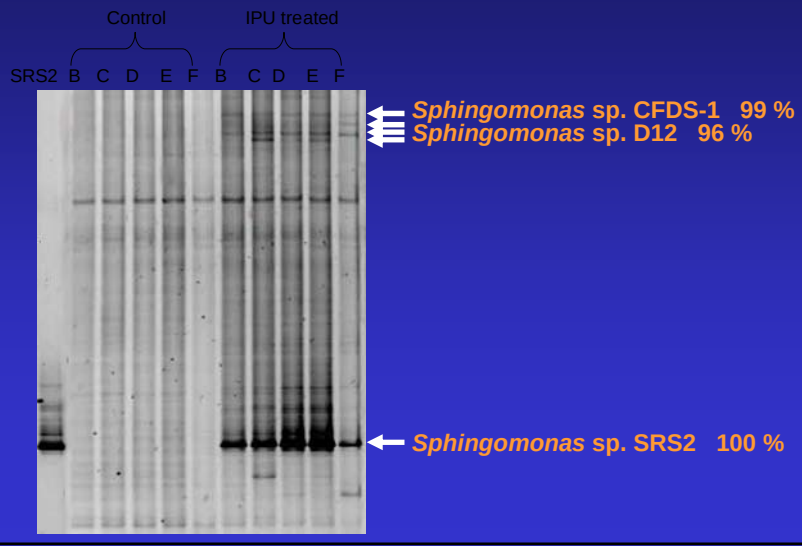
- What is responsible for isoproturon degradation at low pH sites?
- Does isolate 782 play a role in degradation?

16S PCR DGGE using *Sphingomonas* sp. specific primers

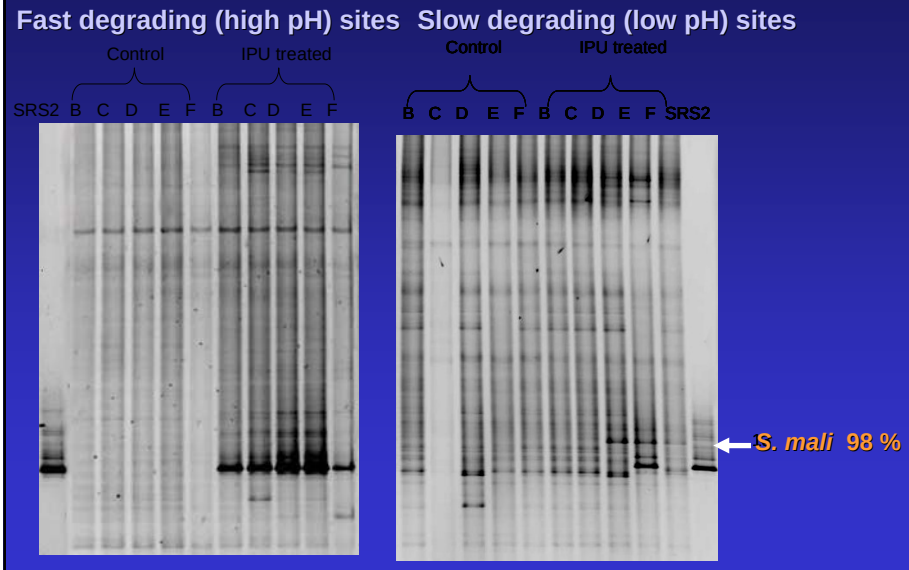
- Leys et al (2004) AEM 70, 1944-1955
- 360 bp fragment
- separation on 20-60 % urea/formamide gradient

Sphingomonas sp. DGGE community profile at isoproturon DT90

Fast degrading (high pH) sites



Sphingomonas sp. DGGE community profile at isoproturon DT90



Conclusions

- Strains isolated using enrichment procedures may not represent those acting *in situ*
- Diverse closely related strains can adapt to degrade IPU within a single field
- Spatial variability in IPU catabolism is the result of interaction between pH and degradative *Sphingomonas* spp

Acknowledgements

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