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Organic contaminants from sewage sludge to agricultural soil, edible crop parts and earthworms

Pierre-Adrien Rivier[1], Claire Coutris[1], Ivo Havranek[1], Hans Ragnar Norli[2], Erik Joner[1]

NIBIO Norwegian Institute of Bioeconomy Research,
[1]Division of Environment and Natural Resources
[2]Division of Biotechnology and Plant Health

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Sewage sludge use in agriculture

- ✓ Fertilizer and soil conditionner
  - ✓ Nutrient recovery, e.g. P, and lower need for chemical fertilization
  - ✓ Addition of organic matter to the soil reduces surface runoff, erosion and improves the water- and nutrient-holding capacity
  - ✓ Saving dumping site capacity and costs
- ✓ Undesirable organic and inorganic substances coming from domestic and industrial uses
- ✓ Regulations set limits for pathogens and heavy metals

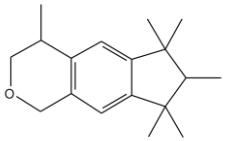
- ✓ Safe to grow plants in sludge amended soils?
  - ✓ Degradation in soil?
  - ✓ Transfer to edible crop parts?
  - ✓ Transfer to soil organisms?

Credit: Sustainable Traditions

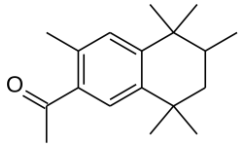
Credit: Trade Effluent Service

Sewage sludge

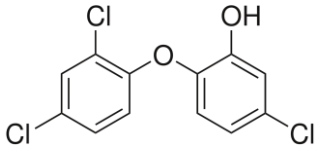
Galaxolide



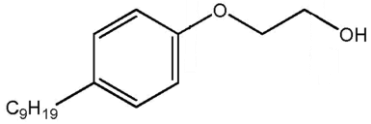
Tonalide



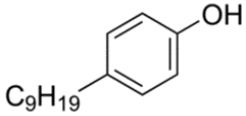
Triclosan

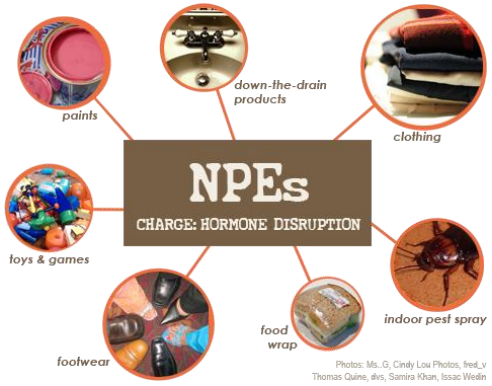


Nonylphenol-1-ethoxylate



Nonylphenol



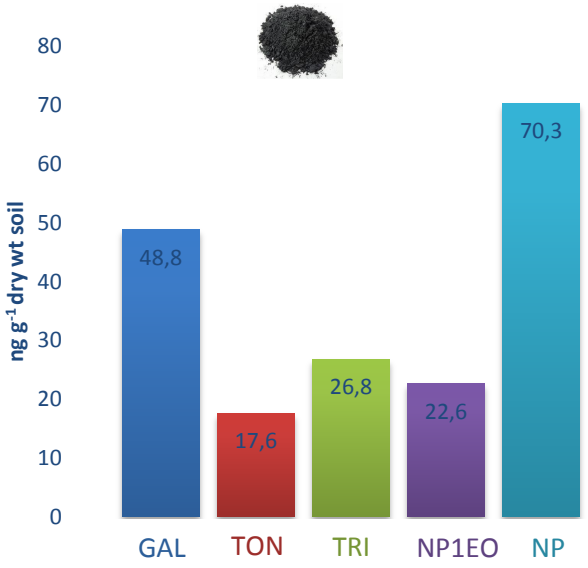


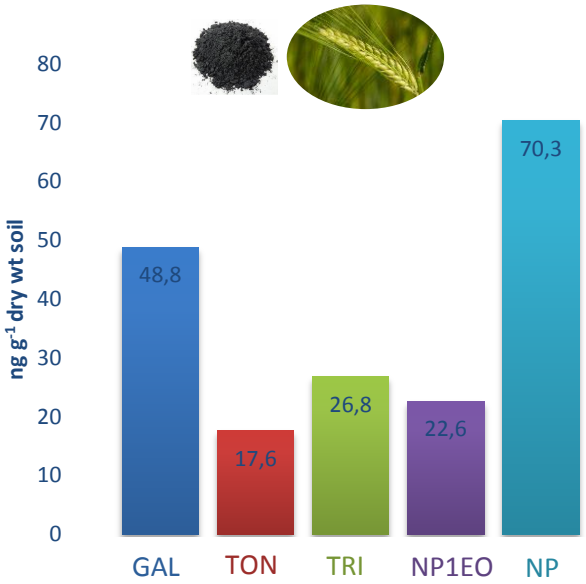
Experimental set-up

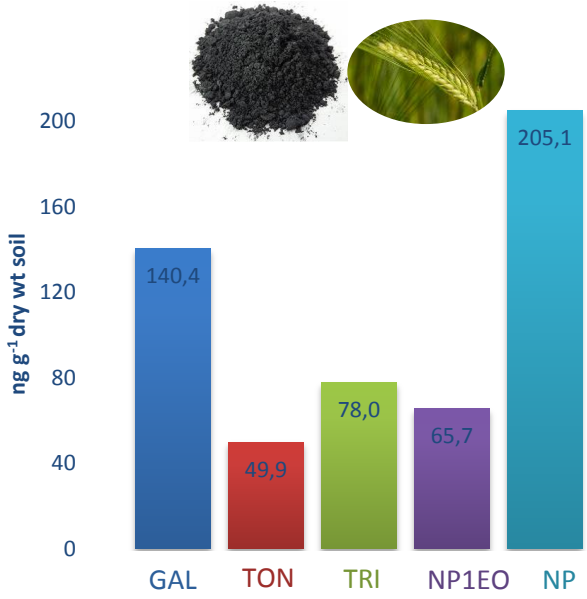
- ✓ Pot experiment on clay loam soil, with 3 sewage sludge dosed at 2 application levels: 20 and 60 t ha^{-1} (maximum permitted application rate and a rate 3 times higher)
- ✓ Sown with barley (25 plants per pot)
- ✓ 2 indigenous earthworms (*Aporrectodea caliginosa*) per pot
- ✓ Treatments without plants included to assess the effects of plant roots on degradation and bioaccumulation in earthworms
- ✓ The compounds of interest were analysed in soil, grains and earthworms after 3 months using QuEChERS extraction followed by GC-MS/MS analysis



Concentrations in soil at the beginning

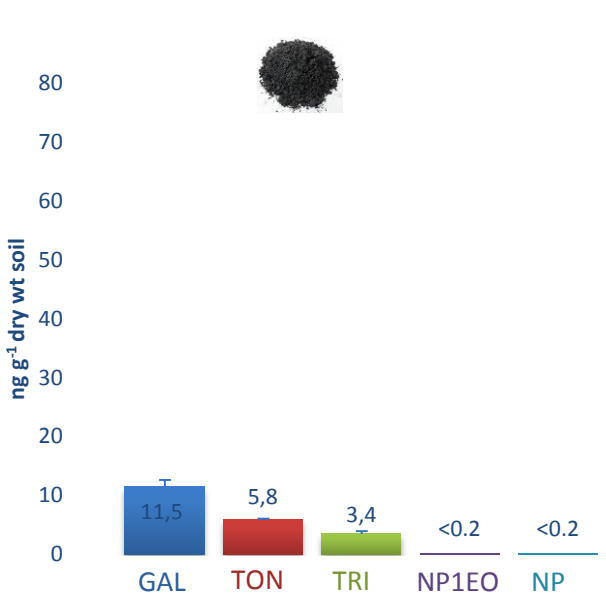


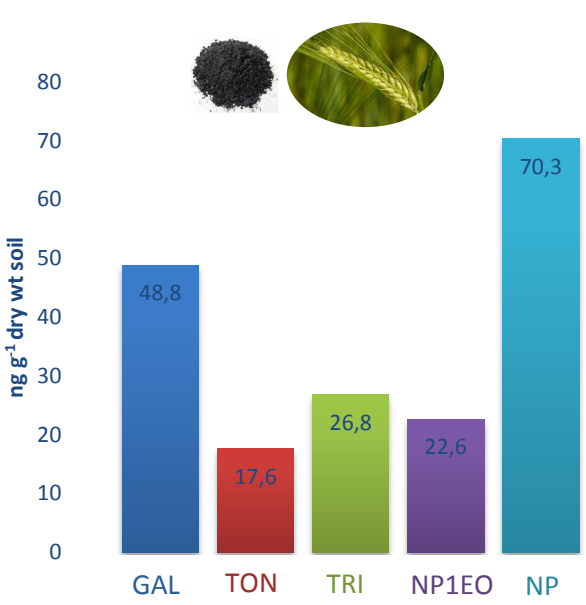


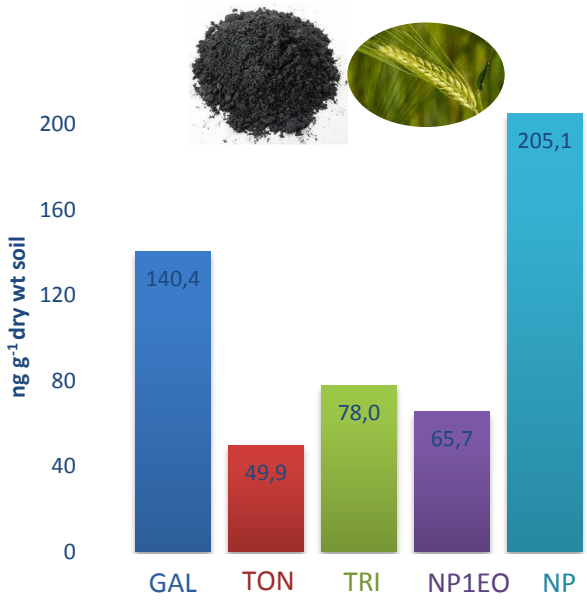


(Results Sludge A)

Concentrations in soil after 3 months







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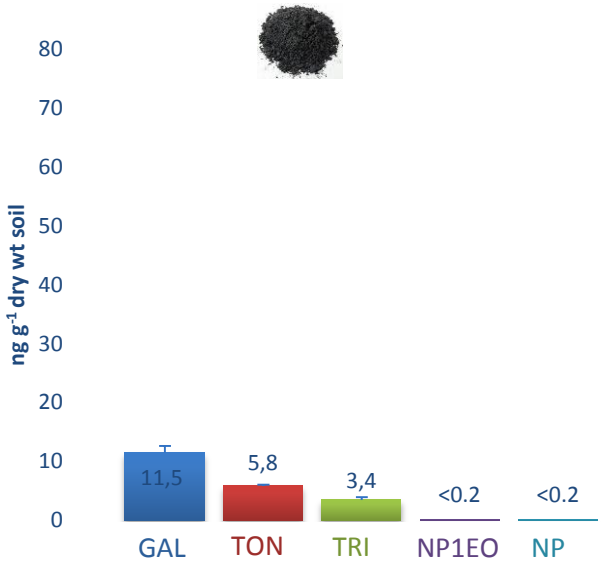

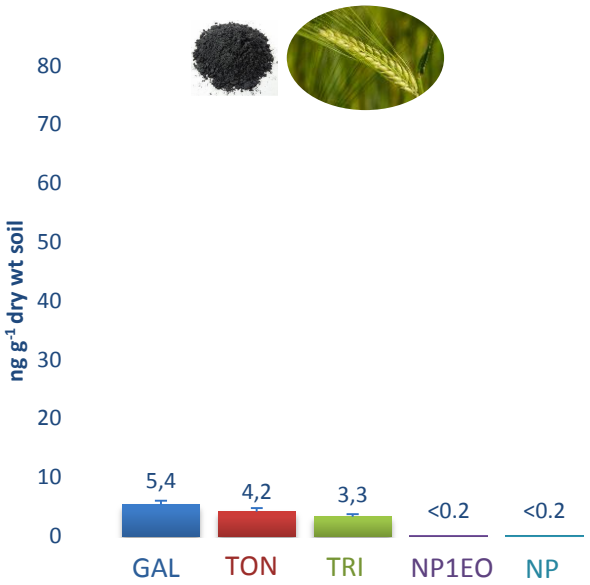

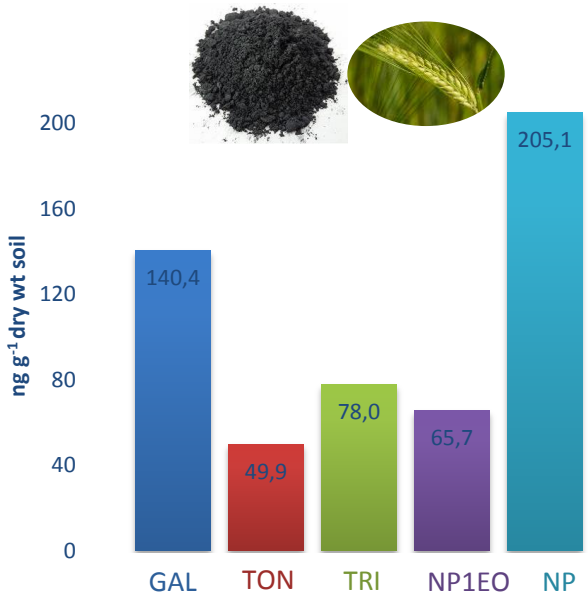

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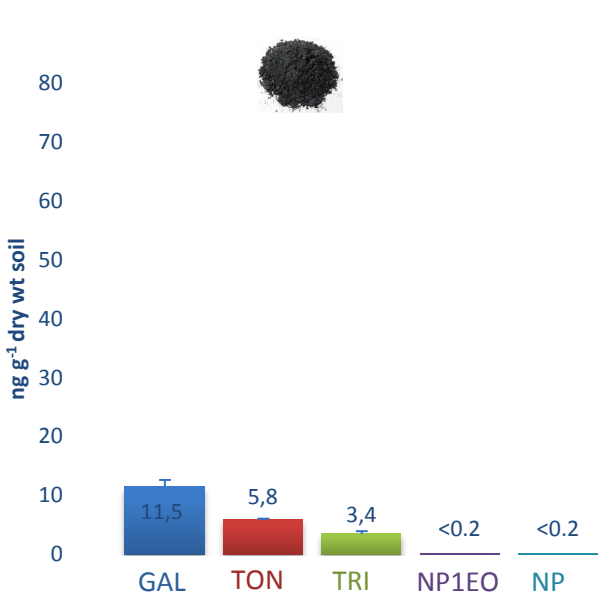
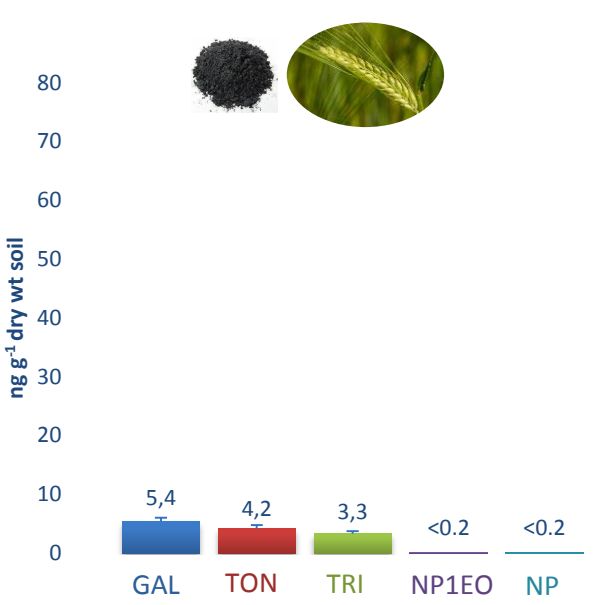
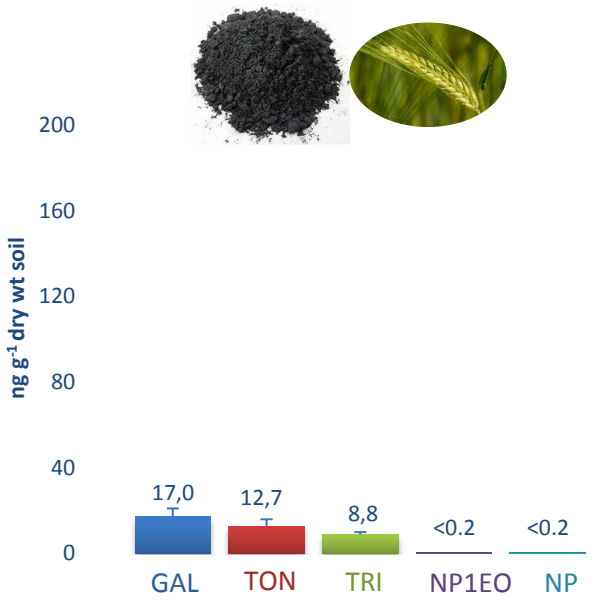






<0.2 % $[NP]_{start}$

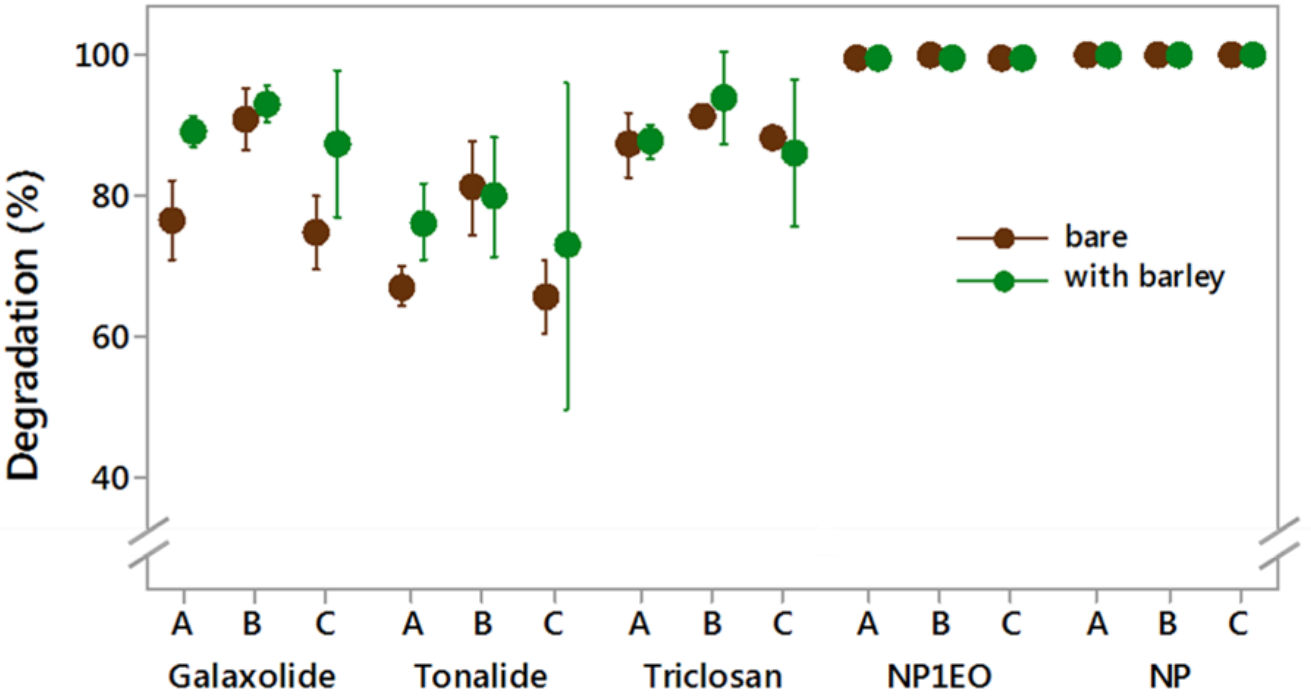
<0.6 % $[NP1EO]_{start}$

6-14 % $[TRI]_{start}$

7-25 % $[GAL]_{start}$

17-34 % $[TON]_{start}$

Degradation in soil



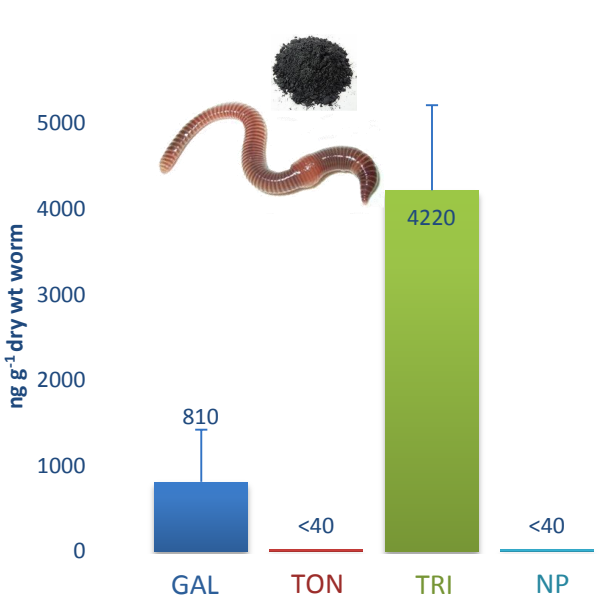
Higher degradation in planted soil

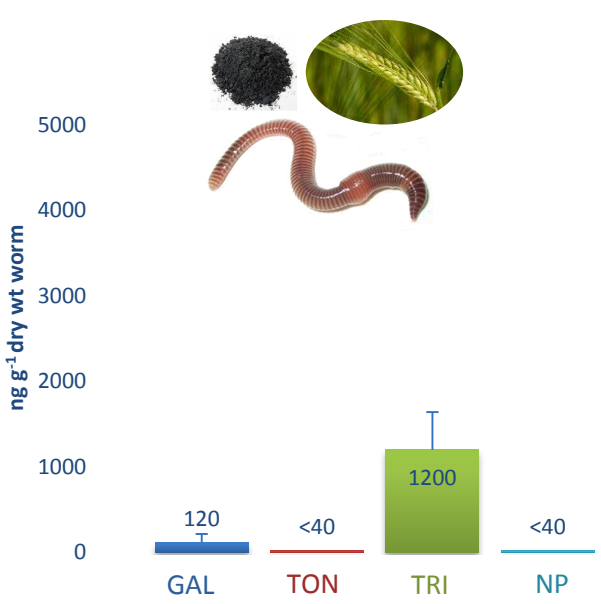
Similar degradation with and without barley, no effect of plant roots on degradation

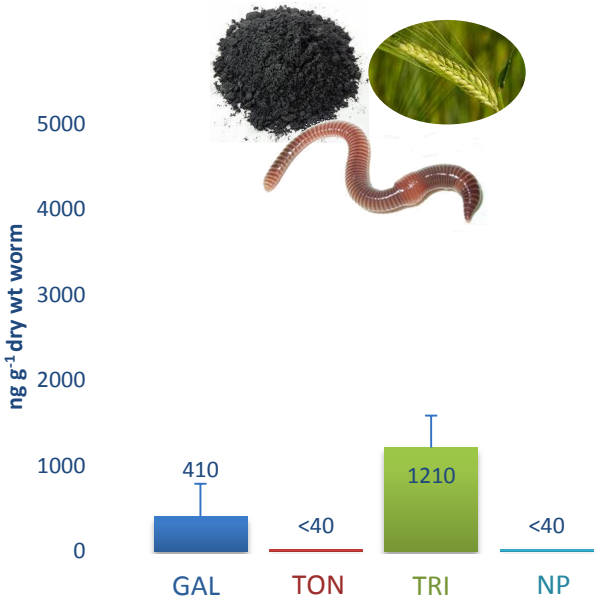
Limited/no transfer to barley grains

	Galaxolide	Tonalide	Triclosan	NP1EO	NP
	Concentrations in ng g^{-1} dry wt grain				
Sludge	*LOQ = 0.2 ng g^{-1}*		*LOQ = 2 ng g^{-1}*		
A (60 t ha^{-1})	0.5 ± 0.3	0.9 ± 0.1	7.5 ± 0.9	<LOQ	<LOQ
B (60 t ha^{-1})	<LOQ	<LOQ	4.5 ± 2.0	<LOQ	<LOQ
A (60 t ha^{-1})	<LOQ	<LOQ	5.6 ± 2.3	<LOQ	<LOQ

Concentrations in earthworms after 3 months







(Results Sludge A)

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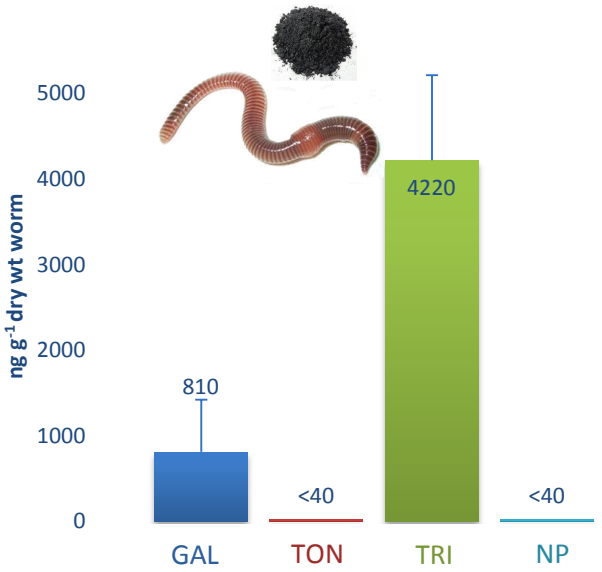
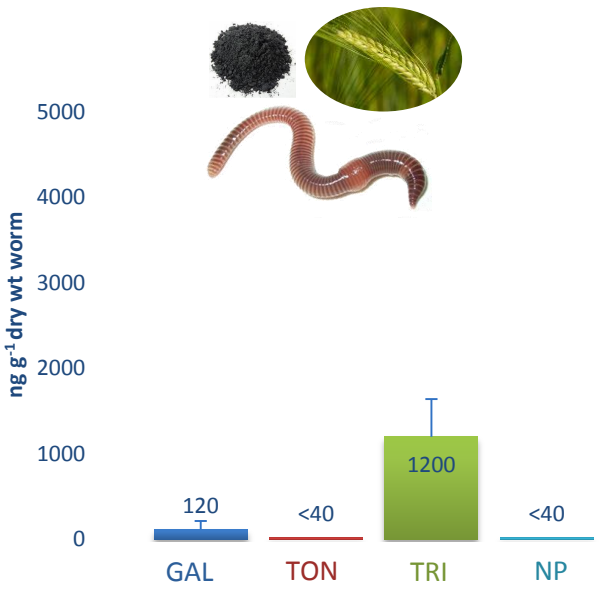
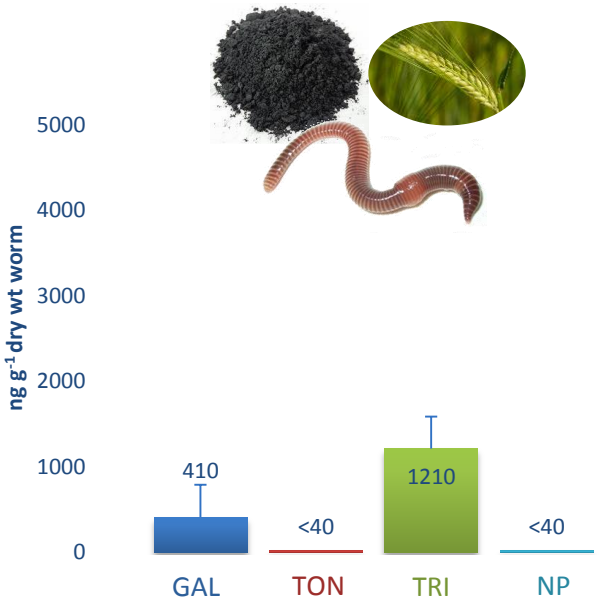
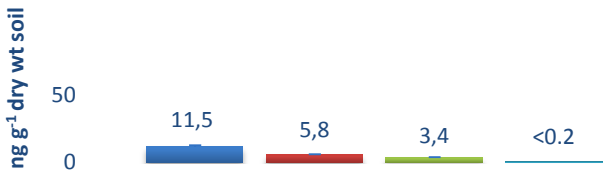
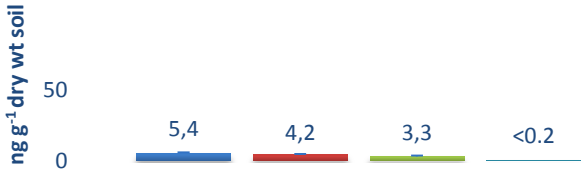


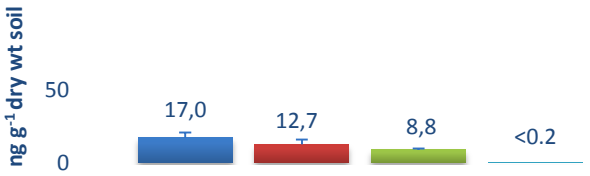




Bioaccumulation Factor (BAF) = $[worm]_{final}/[sludge\ amended\ soil]_{final}$







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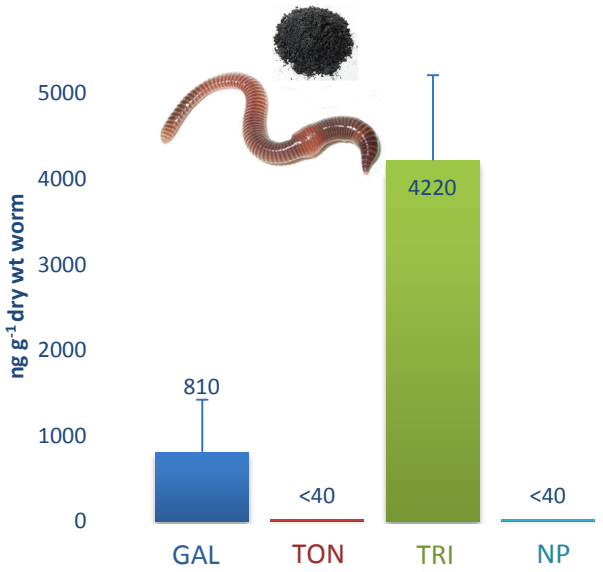
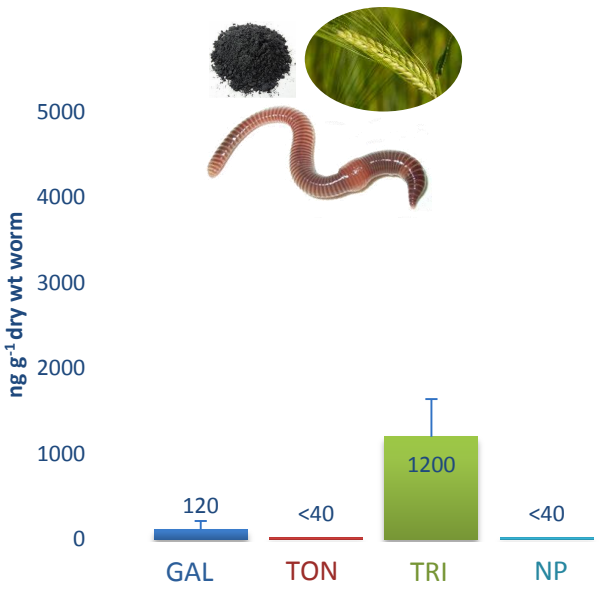
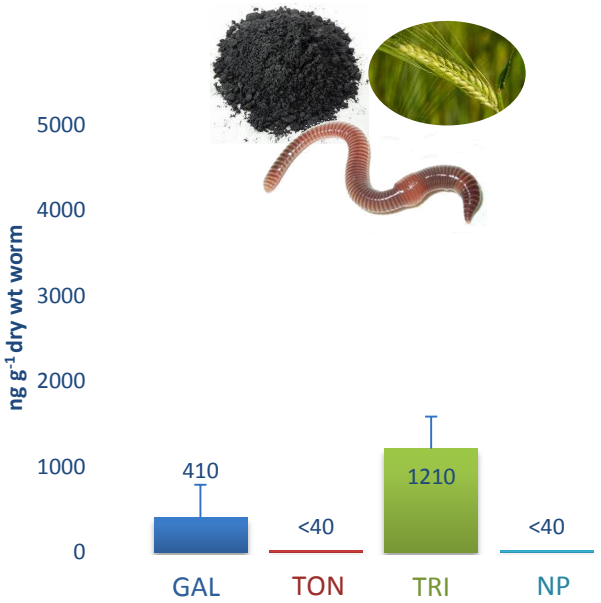






BAF = 68 (17-119)

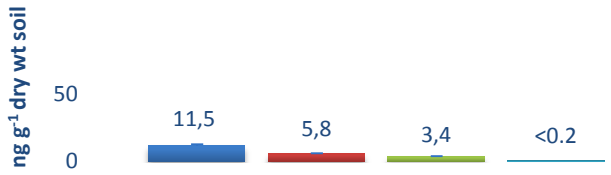
BAF = 1221 (1061-1381)

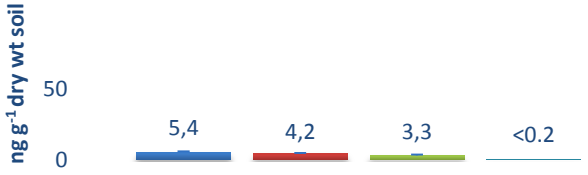
BAF = 24 (5-42)

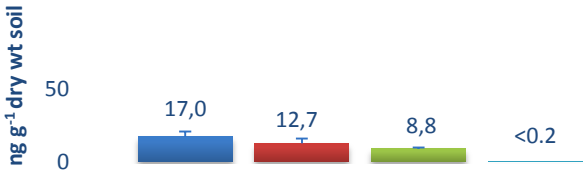
BAF = 364 (229-498)

BAF = 26 (1-51)

BAF = 137 (96-178)

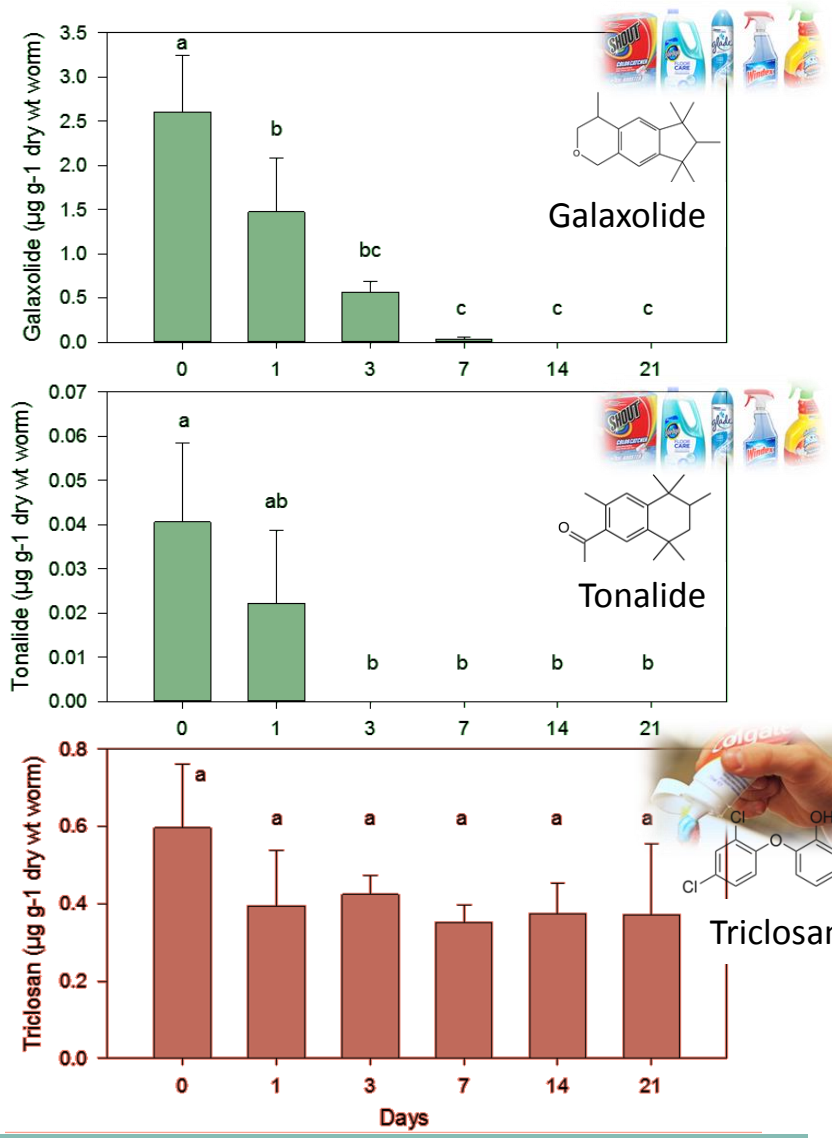




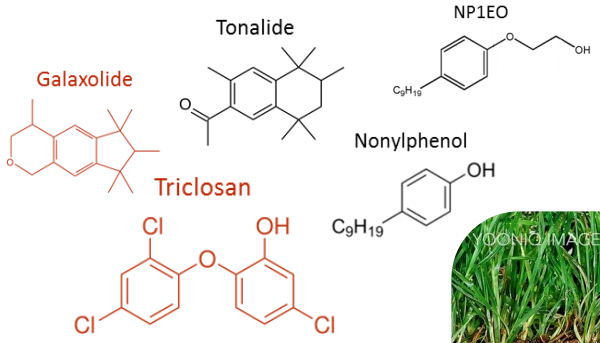


Excretion of galaxolide, tonalide and triclosan by earthworms

Persistence in earthworms:
triclosan >> galaxolide > tonalide



Summary



- ✓ Important degradation in soil after 3 months
  No effect of the rhizosphere on degradation – except for galaxolide
- ✓ Limited/no transfer to the edible plant parts
- ✓ High transfer of galaxolide, very high transfer of triclosan to earthworms
  Bioaccumulation 2-9 times higher in bare soil
- ✓ Use of sewage sludge on agricultural soil?

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Thank you for your attention!

Acknowledgements:

The Research Council of Norway