Characterisation of metal concentrations in treated municipal sludge in Ireland and impacts on runoff water quality following land application

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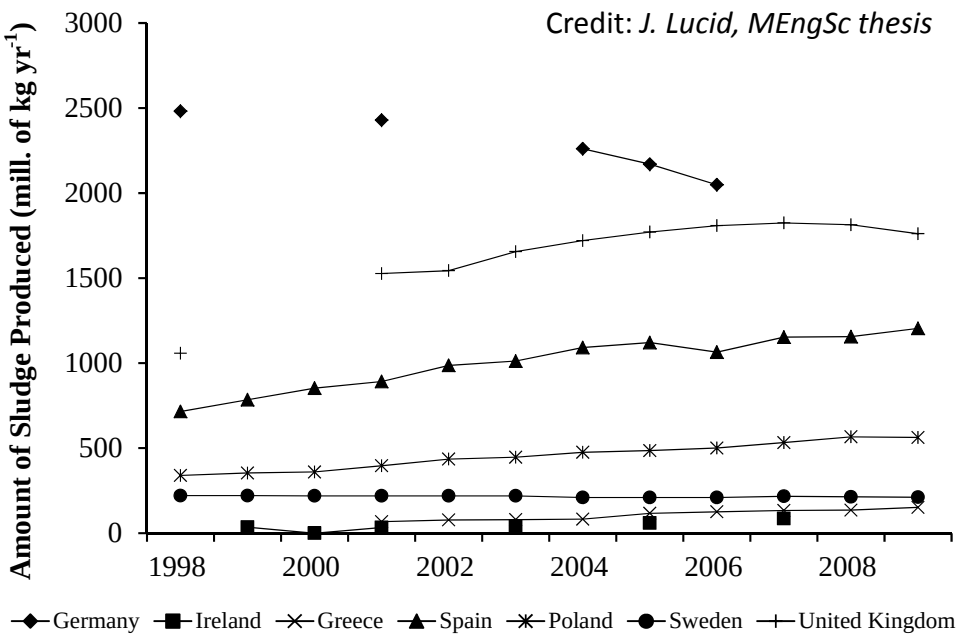
Background

- Production of untreated municipal sludge in the EU has increased from 5.5 million tonnes of dry matter (DM) in 1992 to ~ 10 million tonnes DM in 2010.
- EU legislation has forced those involved in sludge management to find alternative uses for sludge.
- Recycling to land is currently the most economical and beneficial way for sewage sludge management.



Background

- Municipal sewage sludge must be treated before land application.

- Treatment methods include:
  - Aerobic and anaerobic digestion
  - Thermal drying
  - Lime stabilisation
  - Composting

Background

- Benefits of recycling biosolids to grassland:
  - May be used as a soil conditioner, improving physical, chemical and biological properties
  - May reduce the possibility of soil erosion
  - A cheap alternative to commercial fertiliser

Background

- Drawbacks of recycling biosolids to grassland:
  - Nutrient, metal and suspended sediment losses may occur
  - Presence of 'emerging contaminants', such as pharmaceuticals
  - Presence of human enteric pathogens, as complete sterilisation is difficult to achieve
  - Metals may accumulate in soils and crops after repeated applications

Aims

(1) To examine if the metal content of treated sewage sludge ('biosolids') in Ireland exceeded permitted limit values and was affected by the treatment method, and

(2) if metals were present above regulated limits in runoff water following land application

Methodology – Metal characterisation

- Treated sludge was collected from 16 wastewater treatment plants (WWTPs) with population equivalents (PE) ranging up to approximately 2.3 million.

- Metals analysed using a handheld X-ray fluorescence (XRF) analyser

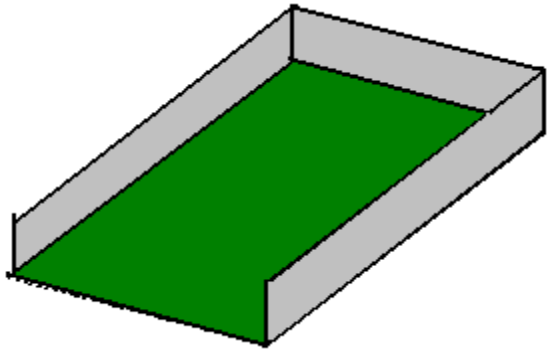
- **Metals examined:** Cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), molybdenum (Mo), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), tin (Sn), and zinc (Zn)

Methodology – Surface runoff experiment

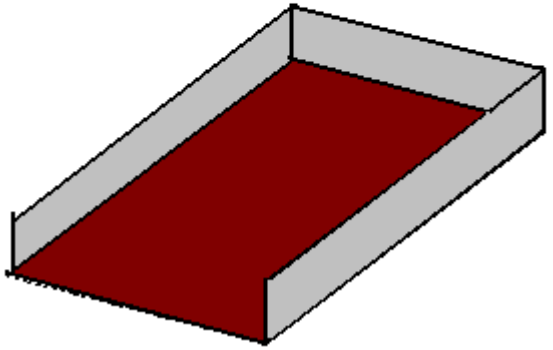
- Three types of biosolids, collected from the same WWTP, were applied to replicated (n=5) micro-plots:
  - anaerobically digested (AD)
  - lime stabilized (LS)
  - thermally dried (TD)

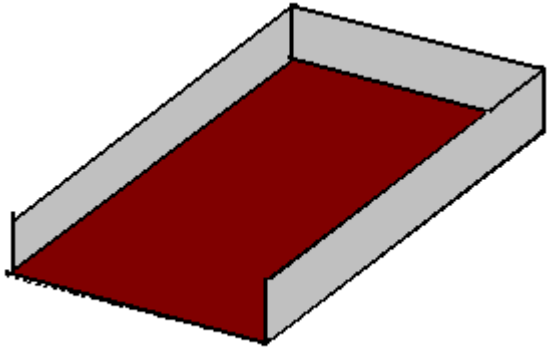
- A grass-only micro-plot was used as the study control.

Methodology – Surface runoff experiment



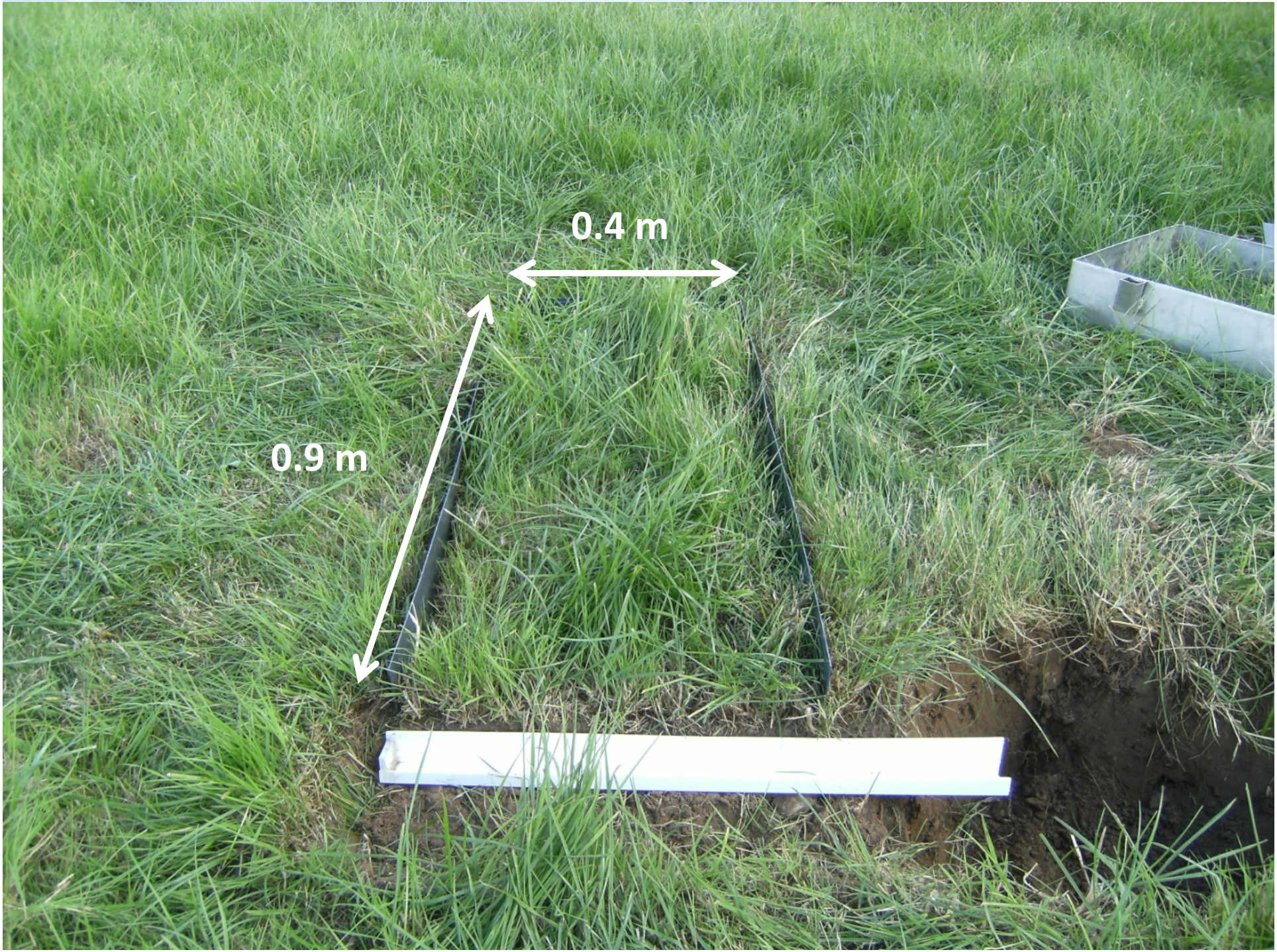
Plot isolated using PVC sheeting (50 mm below soil surface)





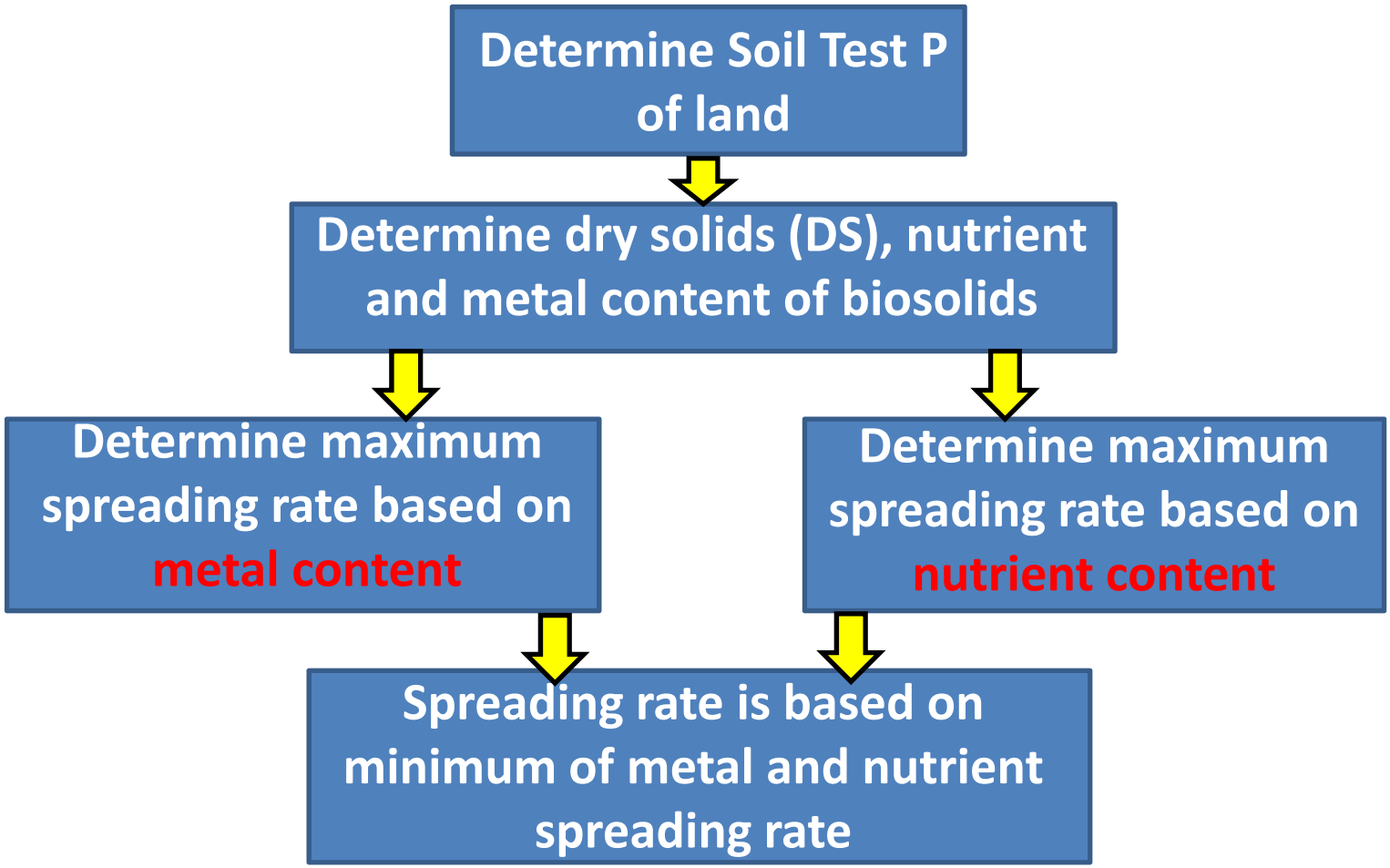
Rainfall simulators used to apply rain 24, 48, 360 hr after application date

Target Intensity 10.5 mm hr^{-1}


0.4 m
0.9 m

Methodology – Surface runoff experiment

Biosolids Application Regime (after Lucid et al., 2013. Wat, Air, Soil Poll 224: 1464)



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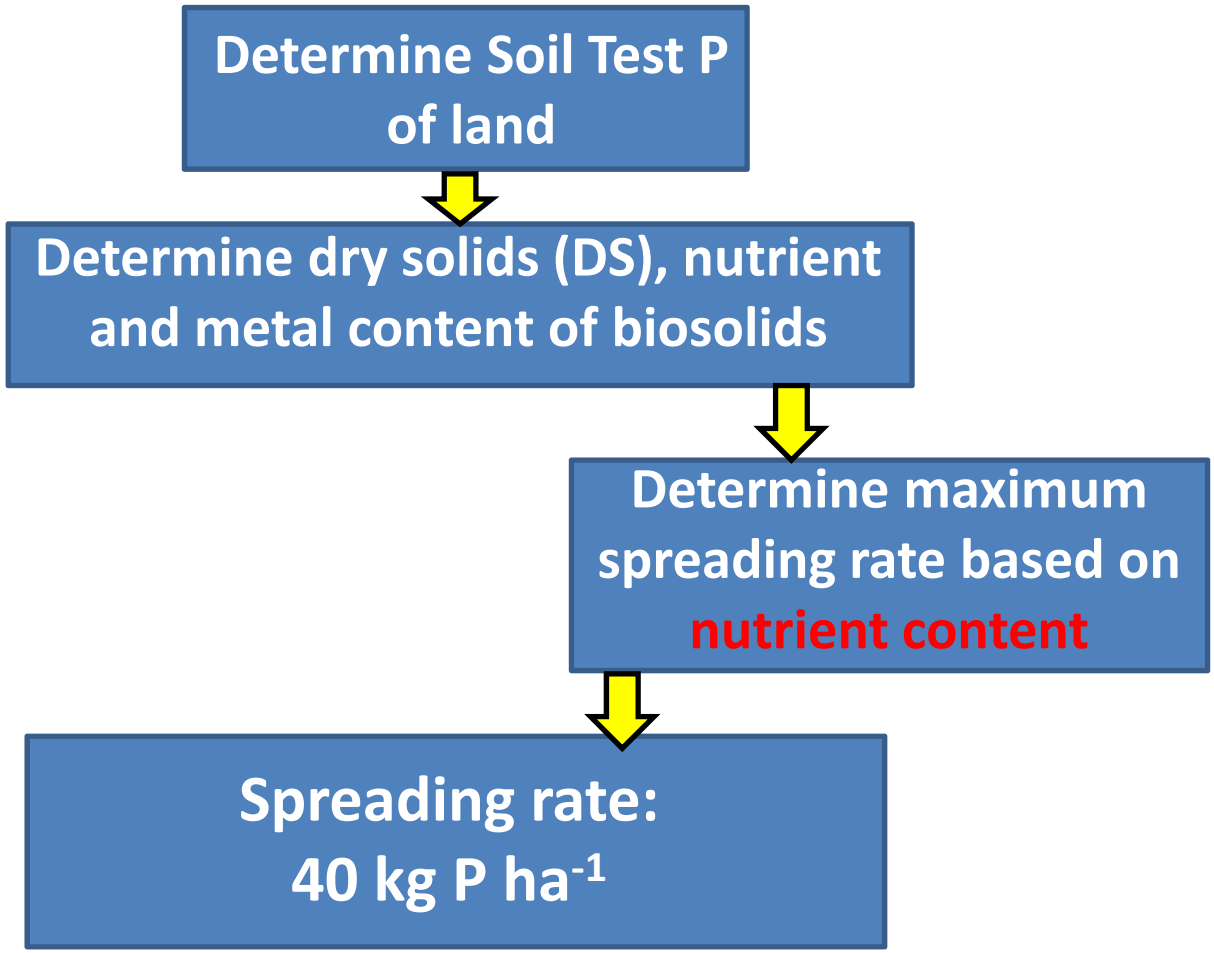
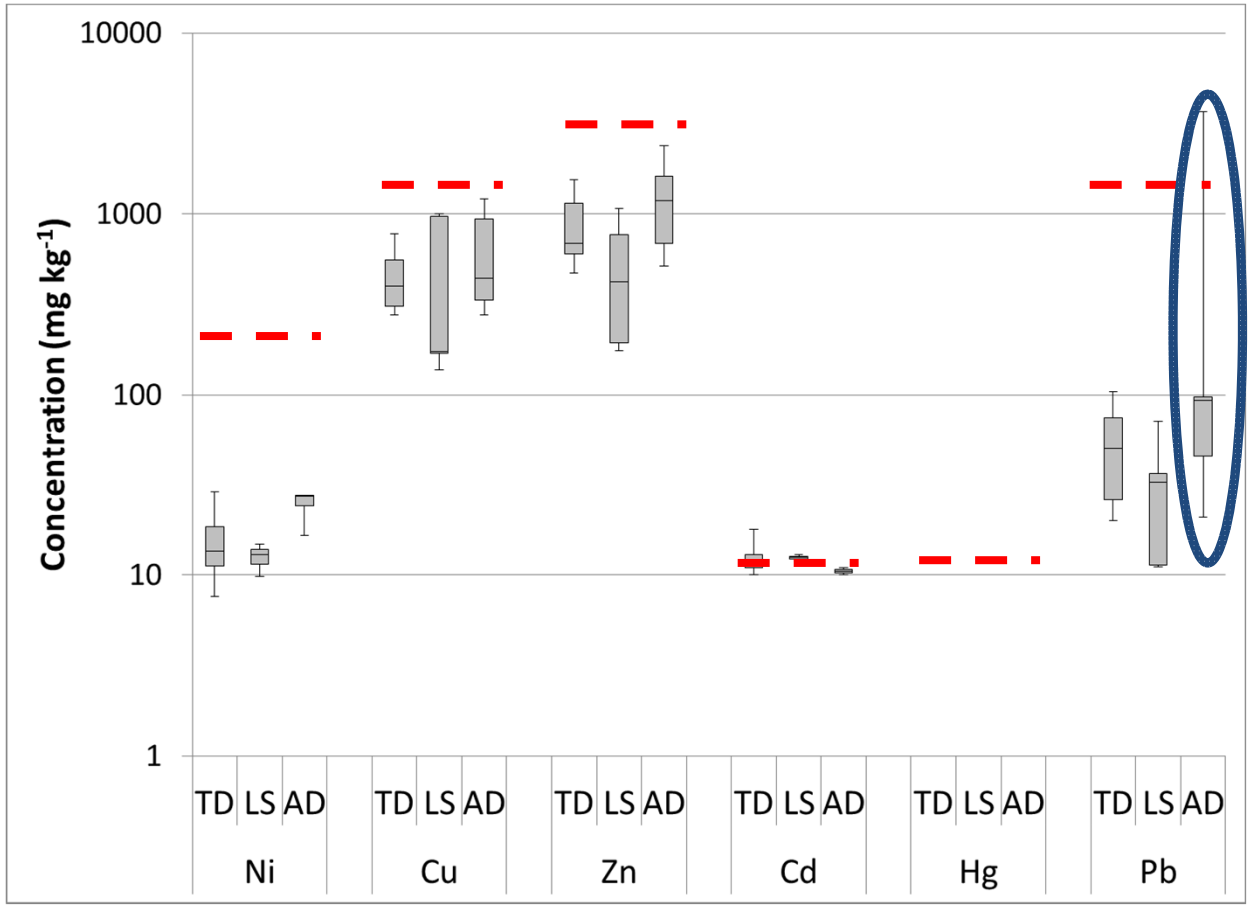


Results

Results

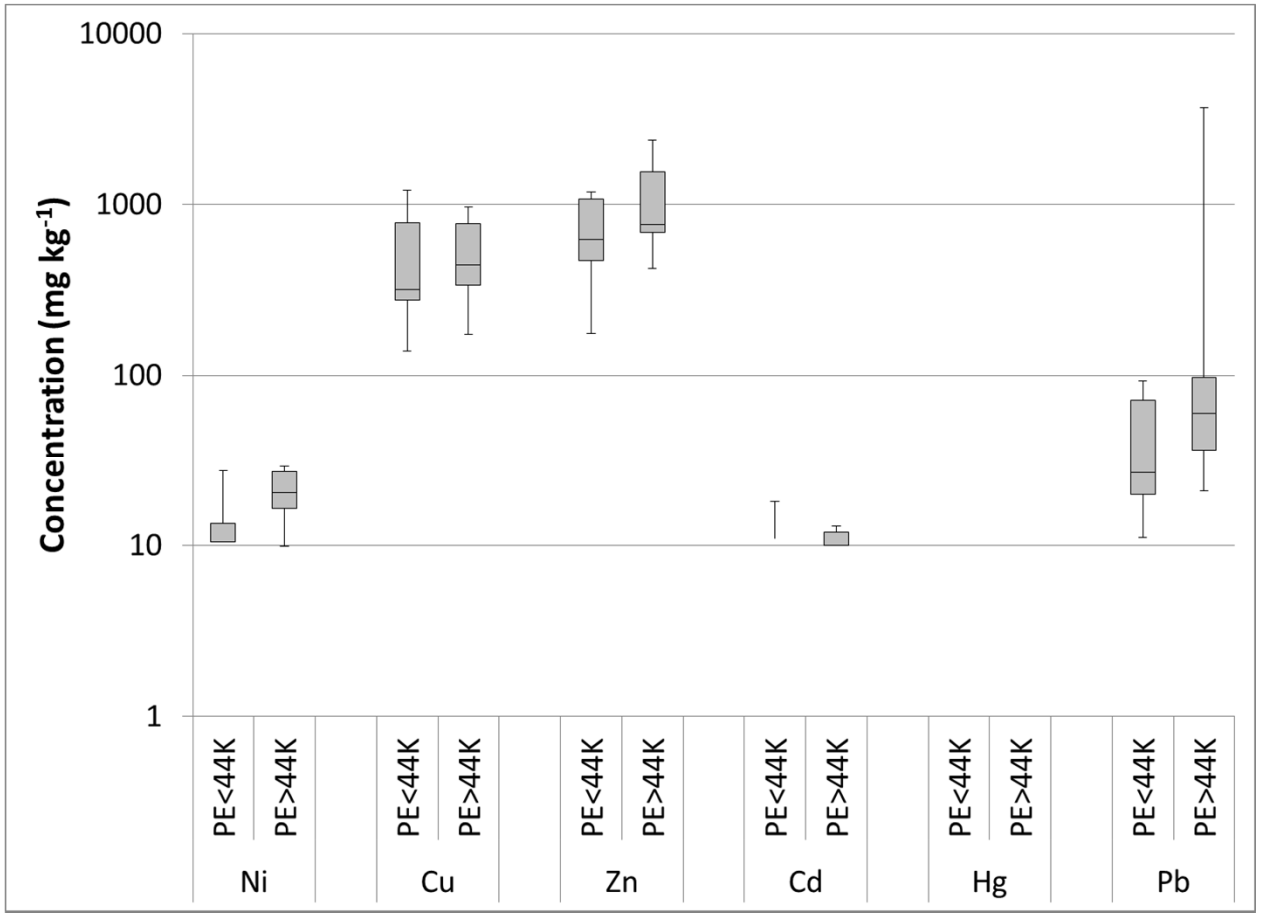
Characterization of 16 WWTP's biosolids



Limit values for metal concentrations in sludge for use in agriculture

Results

Characterization of 16 WWTP's biosolids



Concentrations of metals in accordance with median PE (44,000) of WWTPs examined.

Results

Characterization of 16 WWTP's biosolids

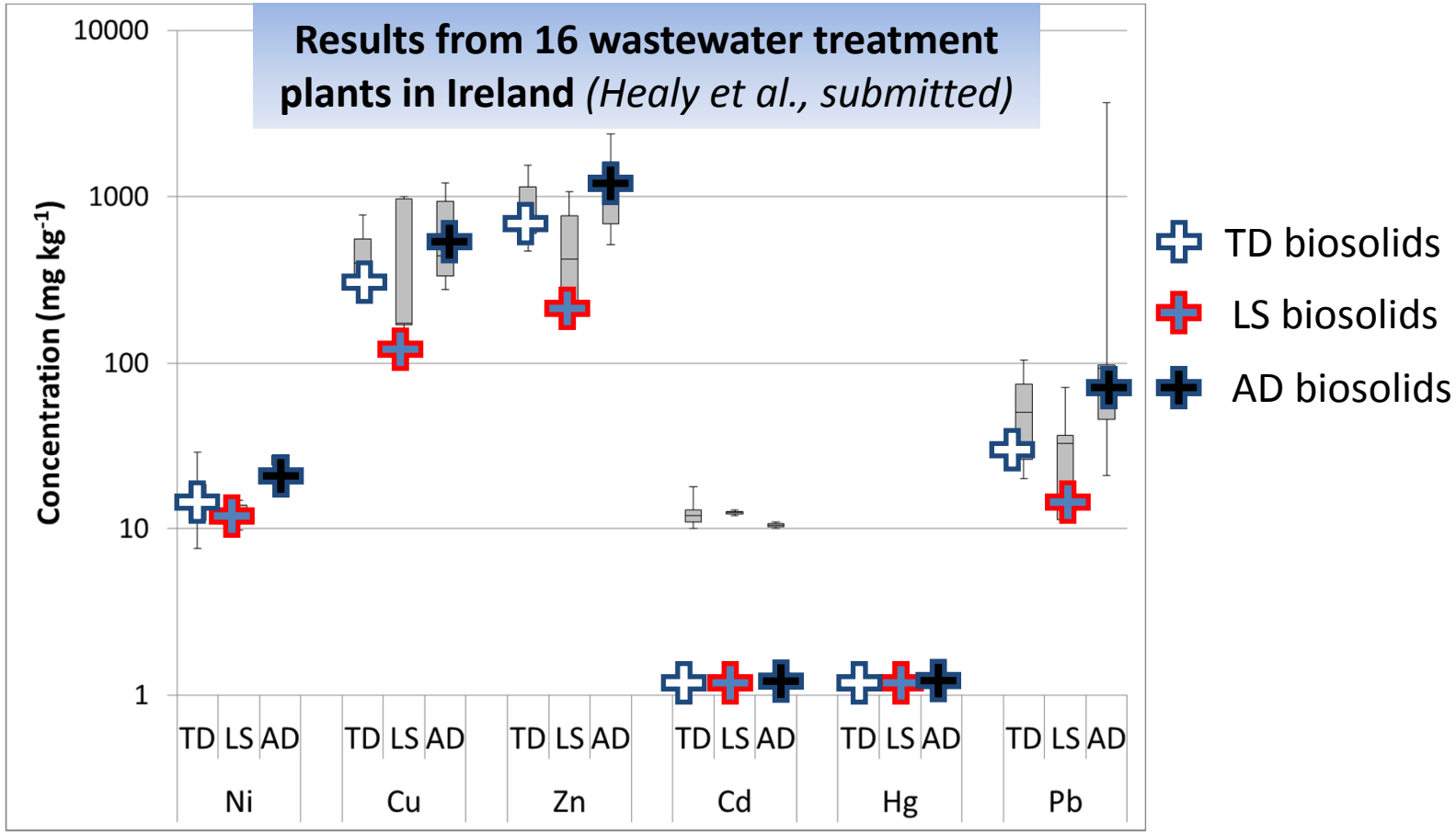
Concentrations (mg kg^{-1}) of <u>unlegislated metals</u> (in the EU) in the treated sludge

Metal	Anaerobic digestion		Lime stabilisation		Thermal drying	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
As	<LOD		<LOD		<LOD	
Se	3	2	3	1	2	1
Sr	162	61	183			
Mo	5	2	4			
Ag	11	2	11			
Sn	55	57	23	4	23	5
Sb	20	5	17	3	17	4
Cr	51	43	25	15	16	12

Antimony (Sb) is substantially higher than in non-polluted soils (0.53 mg kg^{-1})

Results

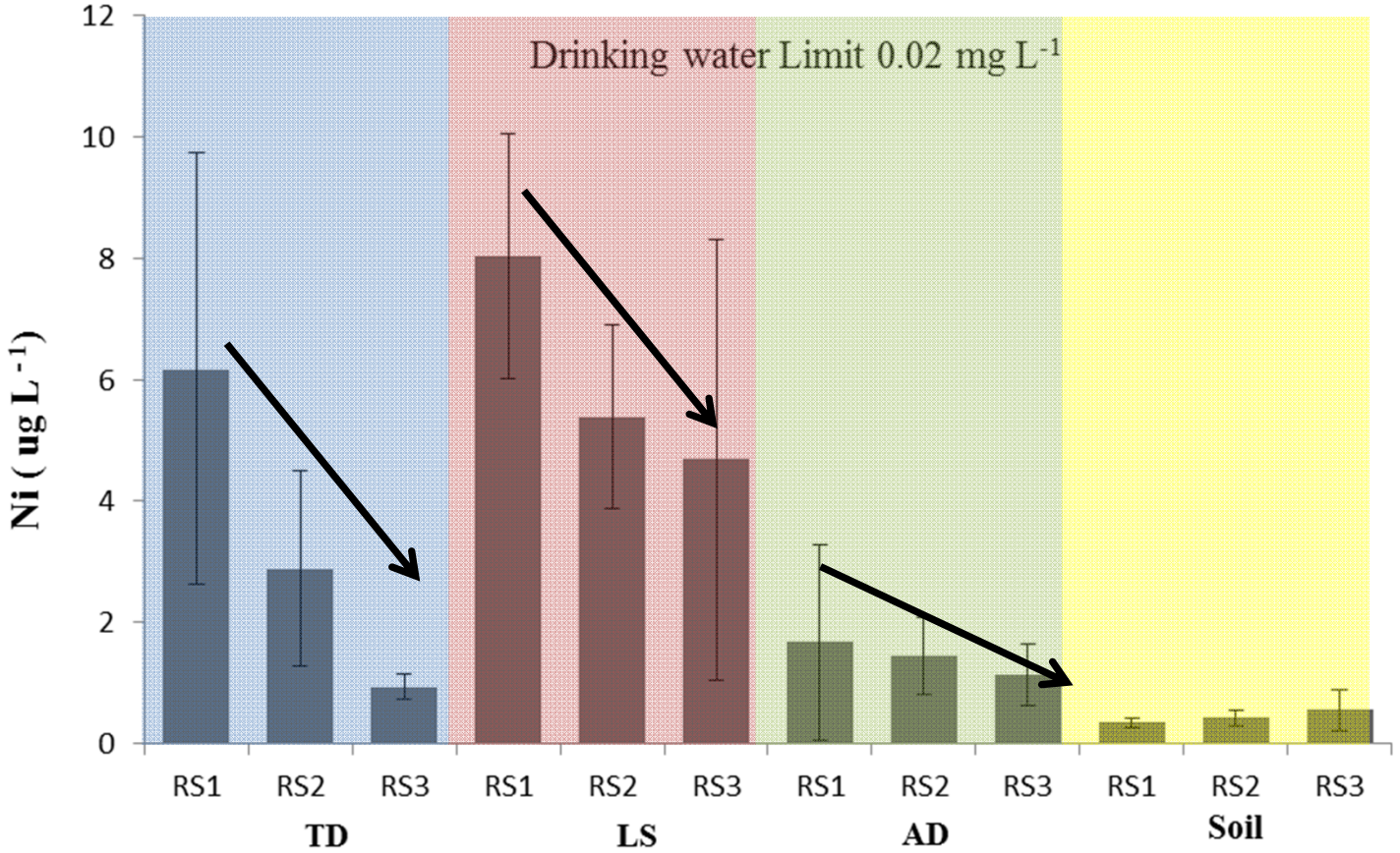
Metal loss in runoff



Results

Metal loss in runoff

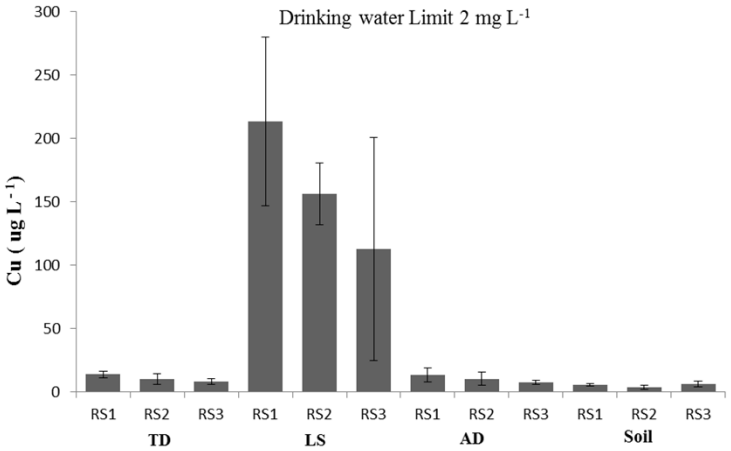
RS1 = 24 hr after application
RS2 = 48 hr after application
RS3 = 360 hr after application

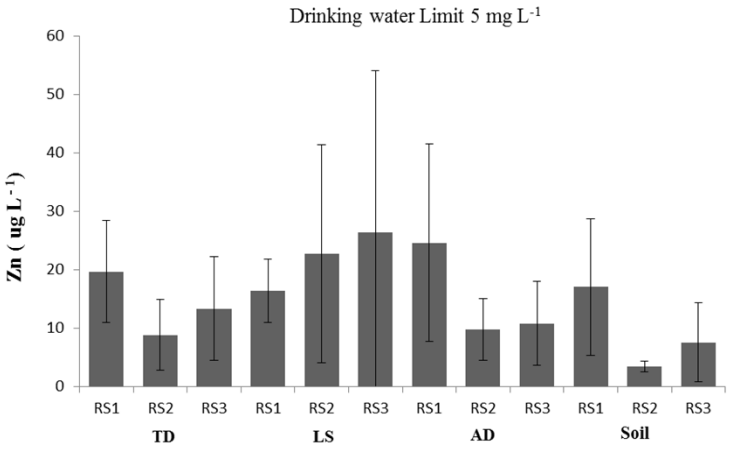


Results

Metal loss in runoff

Regulated parameter	Drinking water limit (mg L^{-1})	Runoff in excess of drinking water limit
Nickel (Ni)	0.005	No
Copper (Cu)	2	No
Zinc (Zn)	5	No
Cadmium (Cd)	0.005	No
Lead (Pb)	0.015	No





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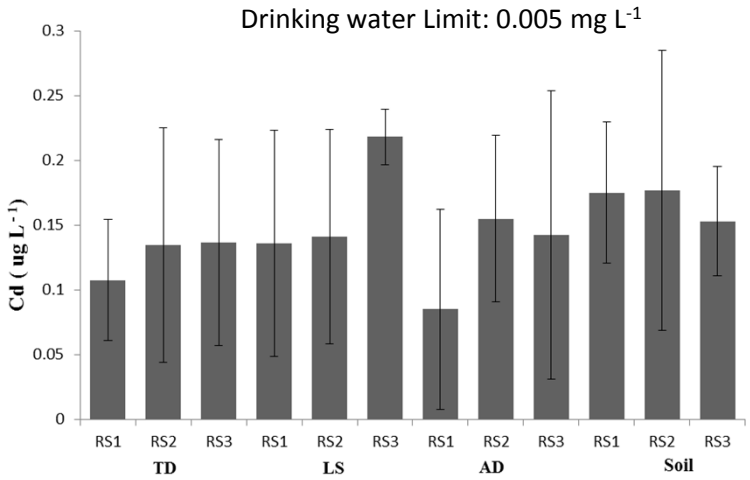

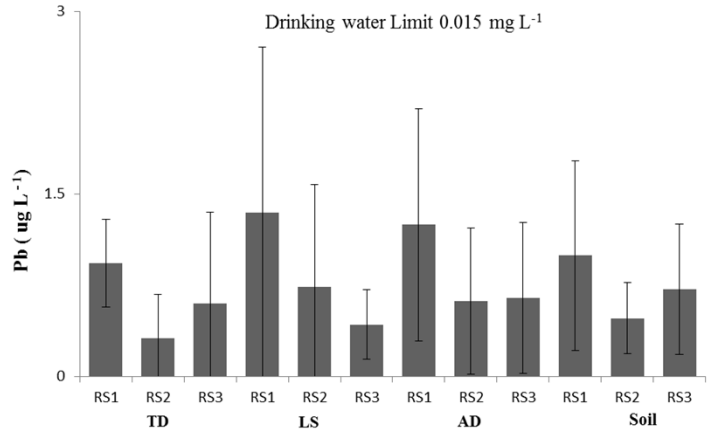

Conclusions

On the basis of these survey of metals in WWTP sludge:

- Legislated metals were below the limits for use in agriculture.
- Some unlegislated metals (antimony) was high. Therefore, unlegislated metals may be applied without regulation.

On the basis of these micro-plot experiments:

- The metal parameters in surface runoff were below EU regulatory limits
- Loss in runoff is a 'worst case' scenario (no buffer zones)

A final important caveat…

- Pharmaceutical testing of biocides, present in most biosolids, is ongoing, and may be decisive

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