The addition of chemical amendments to dairy cattle slurry for the control of soluble phosphorus (P) in runoff from grasslands

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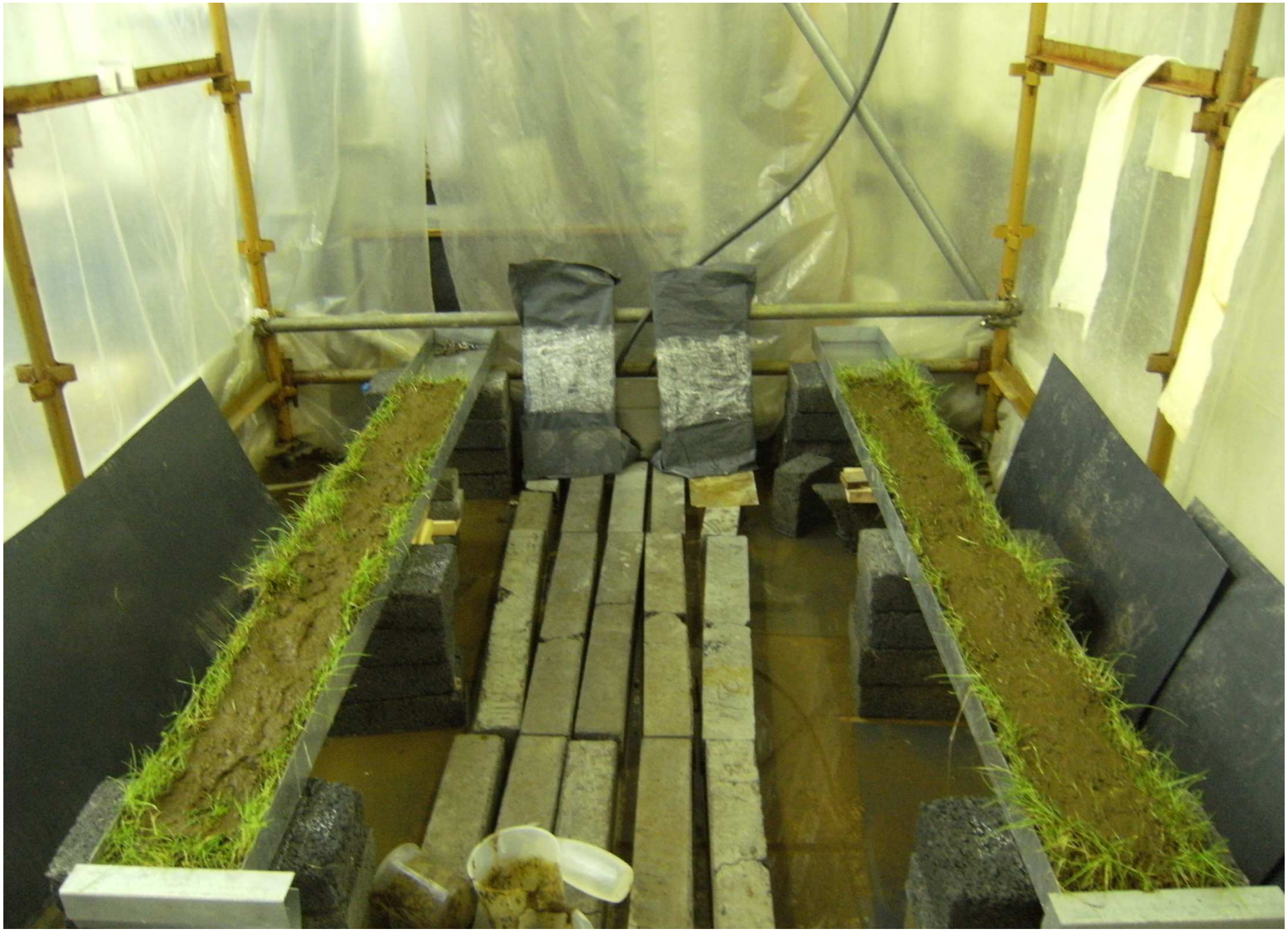


Presentation

- Objectives of study
- Introduction
- Work to date
  1. Agitator test
  2. Flume study (Rainfall simulation experiment)
- Discussion
- Conclusions

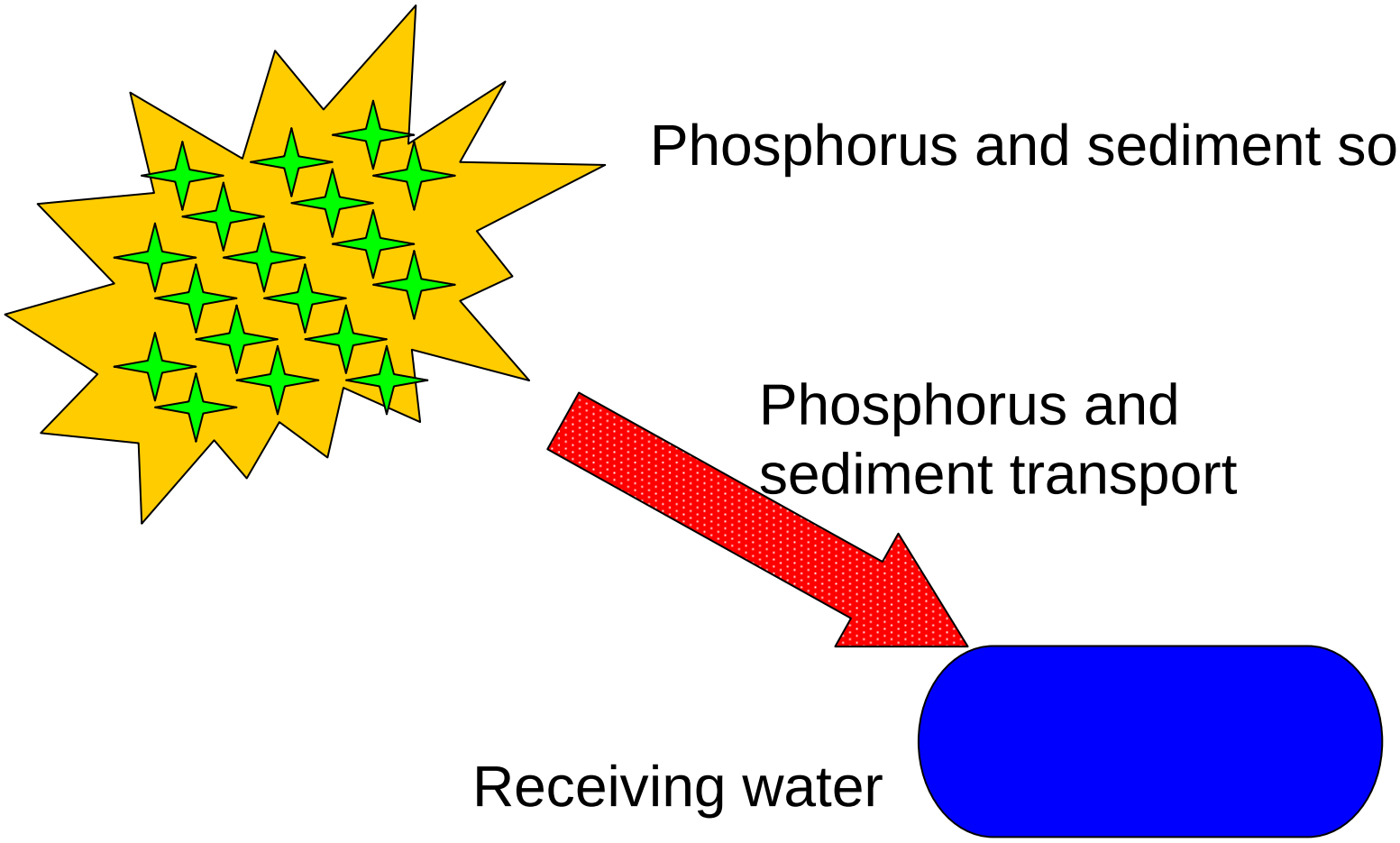
Objectives

- Identify amendments with potential to reduce P losses
- Examine effects of amendment of slurry prior to landspreading on:
    - •sediment and nutrient losses from grasslands
    - •availability of metals in the soil
    - •gaseous emissions from slurry
    - •availability of nutrients to plants

Landspreading

- Landspreading bound by the Good Agricultural Practice for Protection of Waters Regulations (S.I. No. 101 of 2009).
- Slurry is an excellent source of nutrients and landspreading is an effective way of disposing of a waste product.
- Nutrients may be lost to watercourses if applied in excess.
- Legalisation based on a source – pathway – receptor concept.

Courtesy: Dr. L. Xiao



Chemical amendment of slurry

- Metals in amendments bind with P to form less soluble compounds
  - alum (aluminium sulphate)
  - PAC (poly-aluminium chloride)
  - burnt lime ($Ca(OH)_2$)
  - ferrous chloride ($FeCl_2$)
  - fly ash
  - flue gas-desulphurisation by-product (FGD)
  - Alum-based water treatment residuals (Al-WTR)

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Background -chemical amendment of slurry

- Alum is used extensively in the USA to treat poultry litter

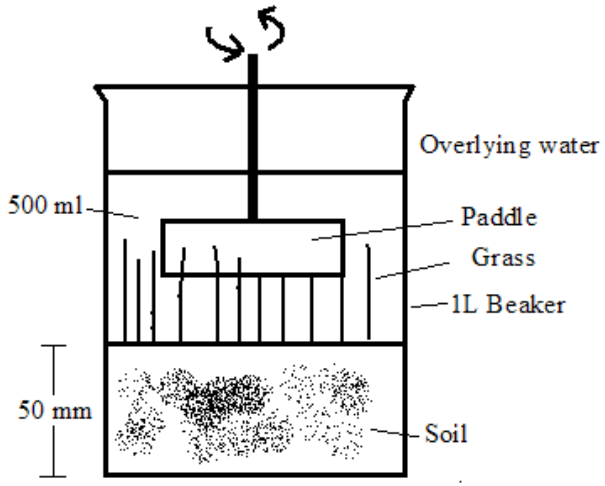
- Moore et al. (2007) reported that alum-treated poultry litter resulted in:
  - lower P losses via overland flow and leaching
  - higher fescue yields due to increased levels of N available to plants as a result of reduced NH_3 losses
  - aluminium uptake by forage and Al runoff from the plots were not affected by treatment

Work to date

1. Agitator test
   - To identify potential amendments, suitable application rates, and estimate costs associated with each treatment

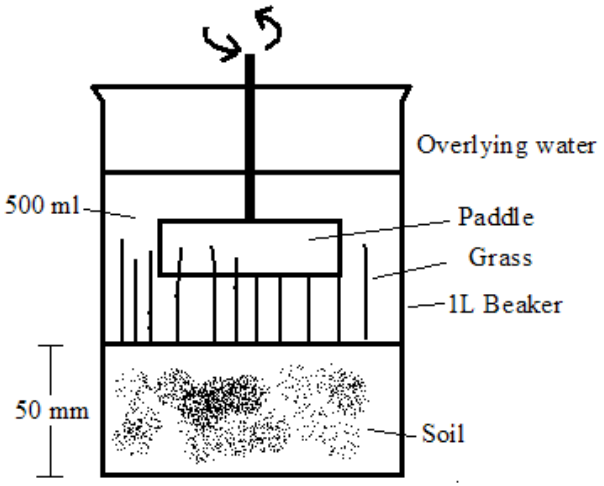
2. Flume experiment
   - Examine best amendments

1.Agitator test



- Investigate the release of P from soil to surface water
- Grassed soils collected from site in aluminium cores
- Transferred to 1-L glass beaker
- Amended with slurry or amended slurry
- Saturated with deionised water
- Submerged in 500-ml water
- Paddle rotated at 20 rpm and samples taken 0.5,1,2,4,8, and 24 hours
- This rotational speed corresponded with a tangential velocity of 0.034 m/s at the perimeter of the paddle

1.Agitator test



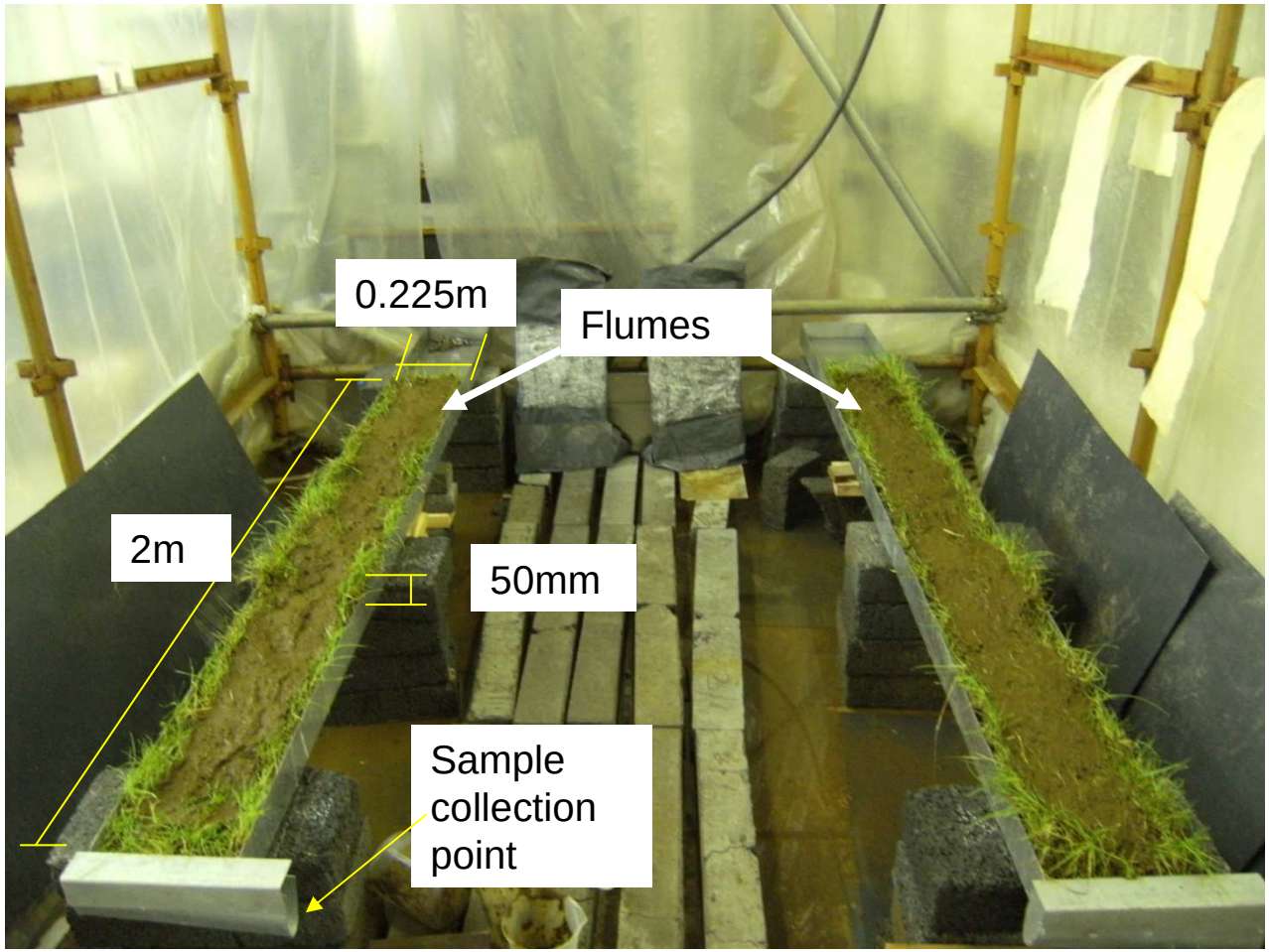
Cost analysis

- Cost of chemical amendments was estimated based on:
  - cost of chemical
  - chemical delivery
  - addition of chemical to slurry
  - volume increases due to addition of water
  - volume increases during slurry agitation
  - and slurry spreading costs
- Teagasc estimates that the cost of land spreading slurry is € 2.1/ ton slurry

Results

Amendment	Rate	Cost €/t	% P reduction
Alum	1.22:1 Al:P	6.5	94
PAC	1.22:1 Al:P	8.5	92
$Ca(OH)_2$	10:1 Ca:P	8	81
$FeCl_2$	2:1 Fe:P	5.7	88
WTR	156 kg/m^3	3.4	71
Fly ash	300 kg/m^3	14.3	72
FGD	150 kg/m^3	6.3	72

2.Material and methods -Flume study



Slurry: Total phosphorus 1450mg/l; Dry matter 9.2%

Soil and slurry collected from farm in Athenry, Co Galway (Morgan's P: 6 mg/l)

Intact sample taken from site and trimmed before being put in the flumes

Slope approximately **5°**

Tests conducted in triplicate

To date **alum** and **lime** have been examined in flume experiments

Slurry applied at **33m^3/ha**

Amendment rate based on stoichiometric ratio of metal-to-total phosphorus

Alum applied at **1.1:1 Al:TP**

Lime applied at **10:1 Ca:TP**

Rainfall simulation experiments

Intensity **11.5 ± 1mm/hr**

Each rainfall event ran for 1 hr duration

t=0 hr Pack flumes, then saturate and allow to drain and reach approx. field capacity

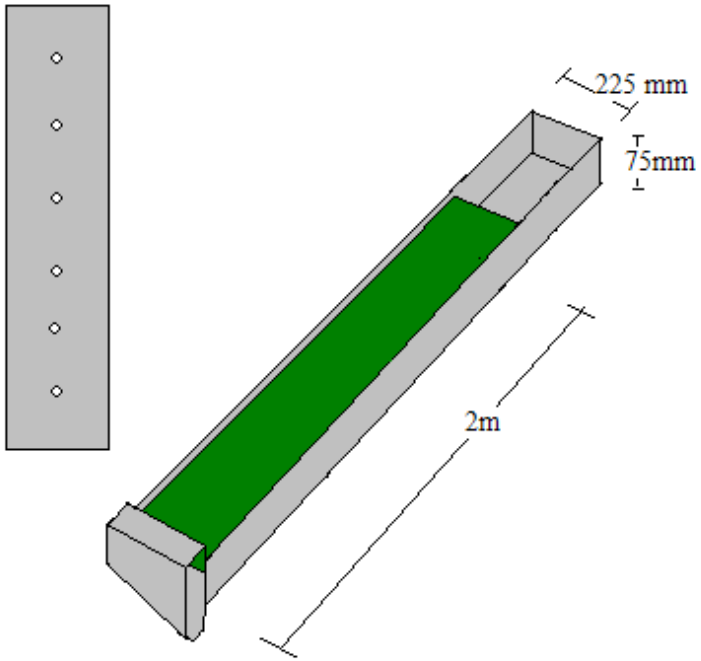
t=24 hr Apply slurry/ amended slurry

t=96 hr **1st rainfall event**

t=98 hr **2nd rainfall event** (Allow to drain between rainfall events 2 and 3)

t=123 hr **3rd rainfall event**

Rainfall simulation experiments



Suspended sediment and phosphorus analysis

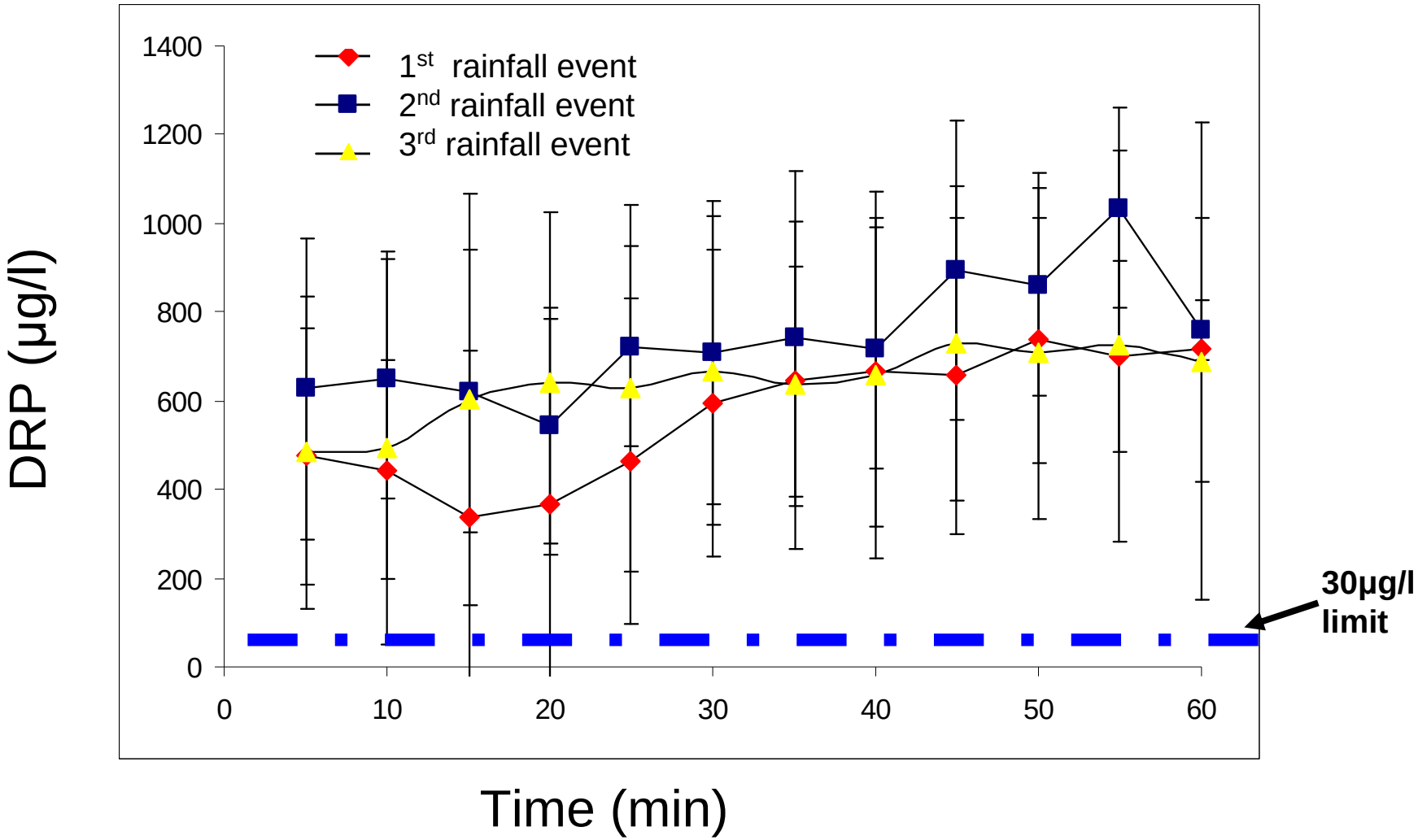
- Suspended sediment (**SS**)
- Dissolved reactive phosphorus (**DRP**)
- Total phosphorus (**TP**)
- Total dissolved phosphorus (**TDP**)
- Particulate phosphorus (**TP** – **TDP** = **PP**)

Metal analysis of runoff

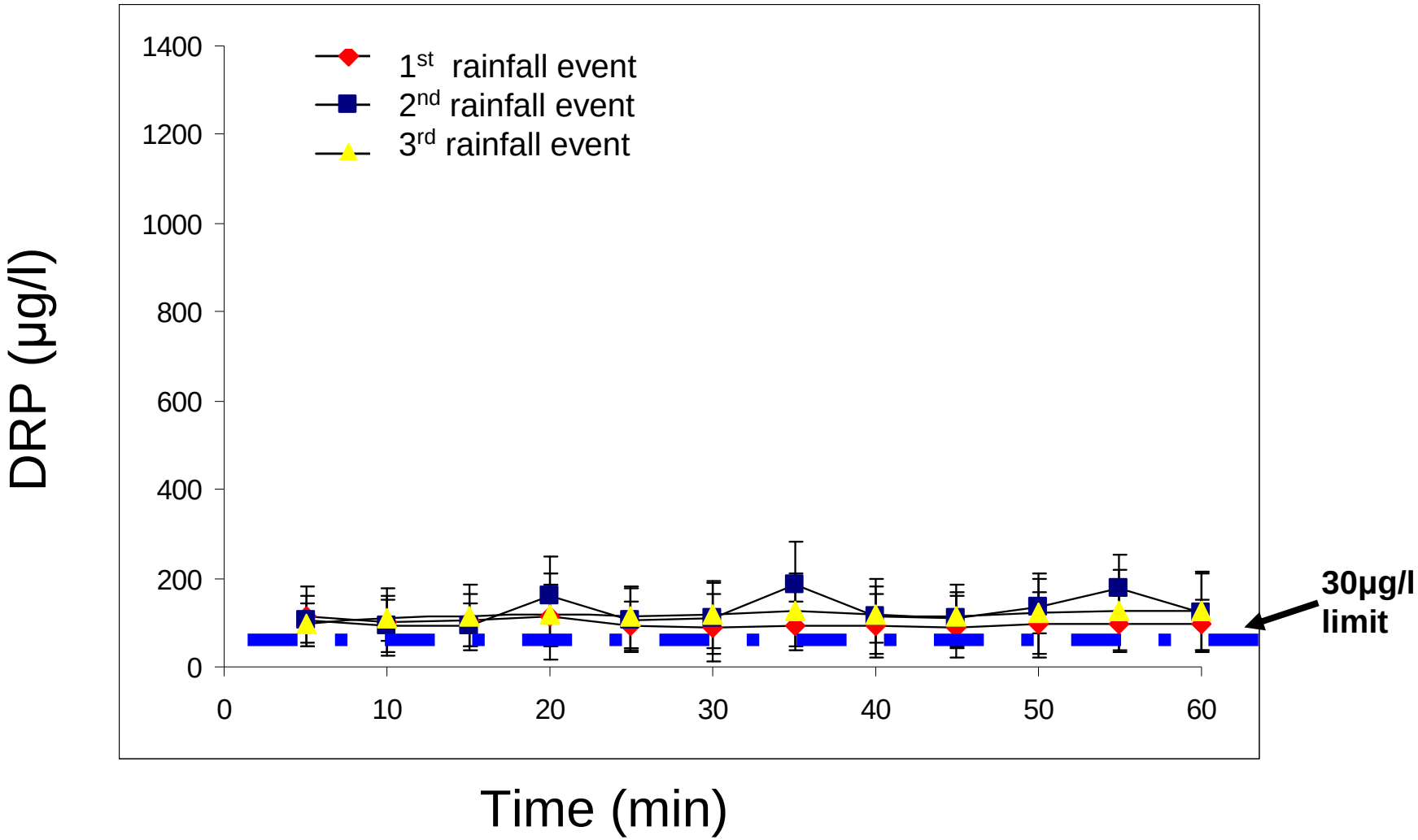
- Runoff samples analysed for following metals: Al, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, V and Zn

- Neither alum nor lime-amended slurry exceeded drinking water extraction limits (75/440/EEC) for these metals

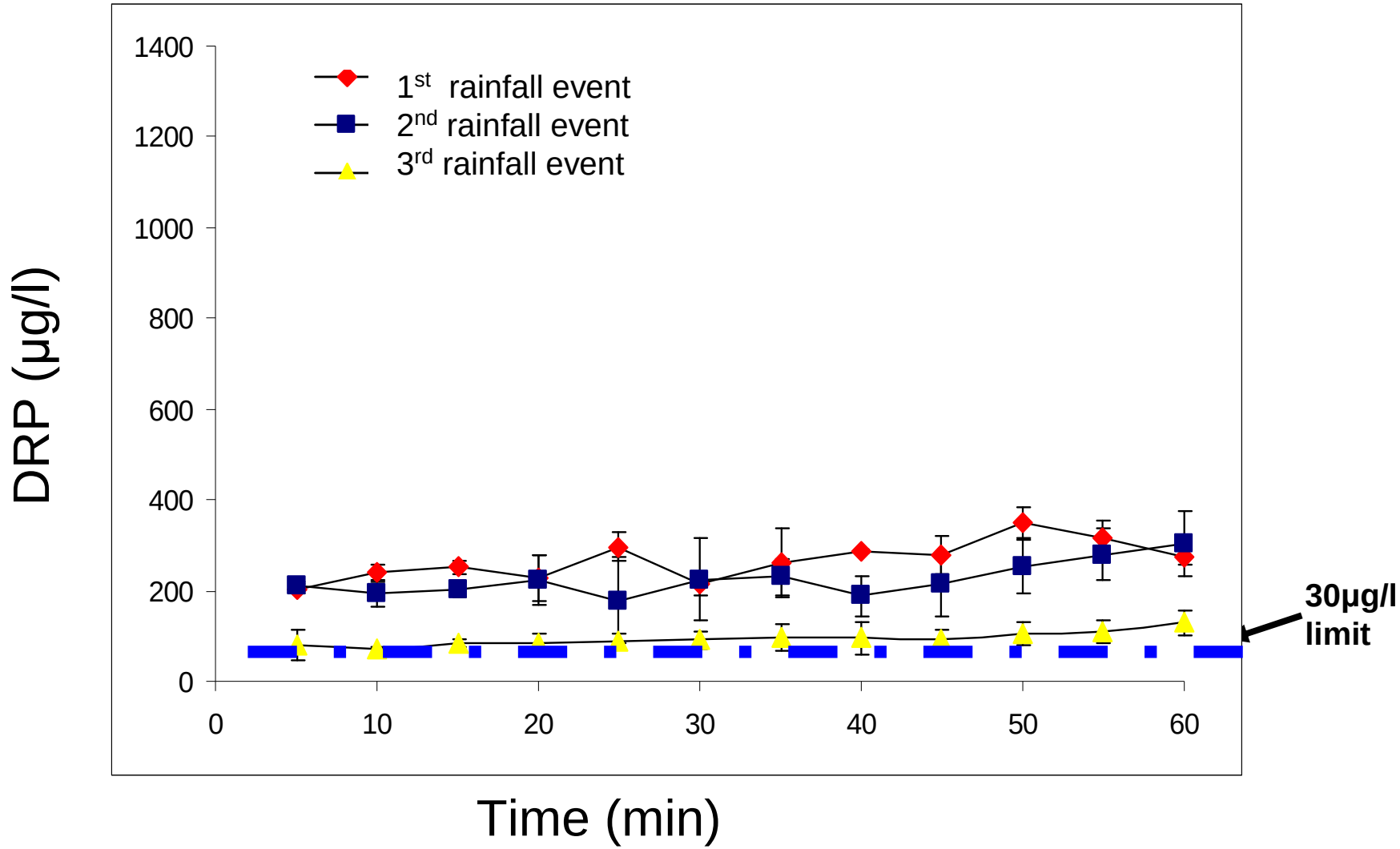
Slurry only (study control)



Alum-treated slurry



Lime-treated slurry



Average Reductions

Treatment (rate)	Average percentage reduction in flow-weighted mean concentrations (FWMC) compared to slurry-only control				
	SS	TP	PP	TDP	DRP
Alum (1.1:1 Al:P) 38.5 kg Alum/tonne slurry	86	93	95	90	83
Burnt lime (10:1 Ca:P) 27.6 kg lime/tonne slurry	78	82	88	53	69

Discussion

- Chemical amendments are expensive
- Phosphorus sorbing materials (PSMs) such as Al-WTR are cheaper and may have potential to reduce P losses
- Higher application rates of PSMs are needed to achieve the same reduction in P as chemicals such as alum
- Potential for adverse effects on gaseous emissions
- Long-term effects on soil need to be examined

Conclusions

- There is potential for the use of amendments to control P losses from dairy cattle slurry

- Further work:
  - Field study in Johnstown Castle
  - Nutrient and metal availability
  - Gaseous emissions from amended slurry

Acknowledgments

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