Adding Value to Ash and Digestate (AVAnD).

Developing a Suite of Novel Land Conditioners and Plant Fertilisers from the Waste Streams of Biomass Energy Generation

Dr. Ben Herbert, Dr. Alfonso Lag-Brotons, Dr. Rachel Marshall and Prof. Kirk Semple

Resource Recovery from Waste Event Resource Recovery from Waste projects showcase

Leeds - 1 December 2016

Aims of project

This project aims to radically change the way in which biomass energy producers can support a circular economy.

This will be achieved through utilising bio-energy waste streams to develop soil conditioners and plant fertilisers, facilitating new ways to mesh commercial ideas with positive environmental benefits.

1) Assess the environmental impacts of applying a waste derived product to land
2) Optimize a novel soil conditioning material derived from mixtures of bio-energy waste (ash and digestate)
3) Close the nutrient cycle and ensure food security

Overall rationale

- Increase in anaerobic digestion (AD) and thermal conversion bio-energy generation
- Waste streams from these technologies (digestate and ash) typically have limited monetary value
- Potential for increased amounts to be applied to land
- Digestate and ash are rich in complementary nutrients, but currently of limited use
- Finite primary reserves of mineral fertilisers (phosphorus)
- Drivers:-
  - rising pressures on environmental resources
  - landfill taxes
  - waste-minimisation legislation
- Alternative options for waste reuse are increasingly being sought.

The Team

- *Lancaster University*
  - Prof Kirk T Semple
  - Dr Alfonso Luis Lag Brotons
  - Dr Rachel Marshall
  - Prof Nick Ostle
  - Prof John Quinton
  - Dr Ian Dodd
  - Dr Ben Surridge
  - Dr Farid Aiouache

- *Stopford Energy and Environment*
  - Dr Ben Herbert
  - Lois Hurst
- *The James Hutton Institute*
  - Dr Marc Stutter
  - Samia Richards
  - Lysa Avery
- *Aqua Enviro*
  - Dr David Thompkins
  - Andy Burguess

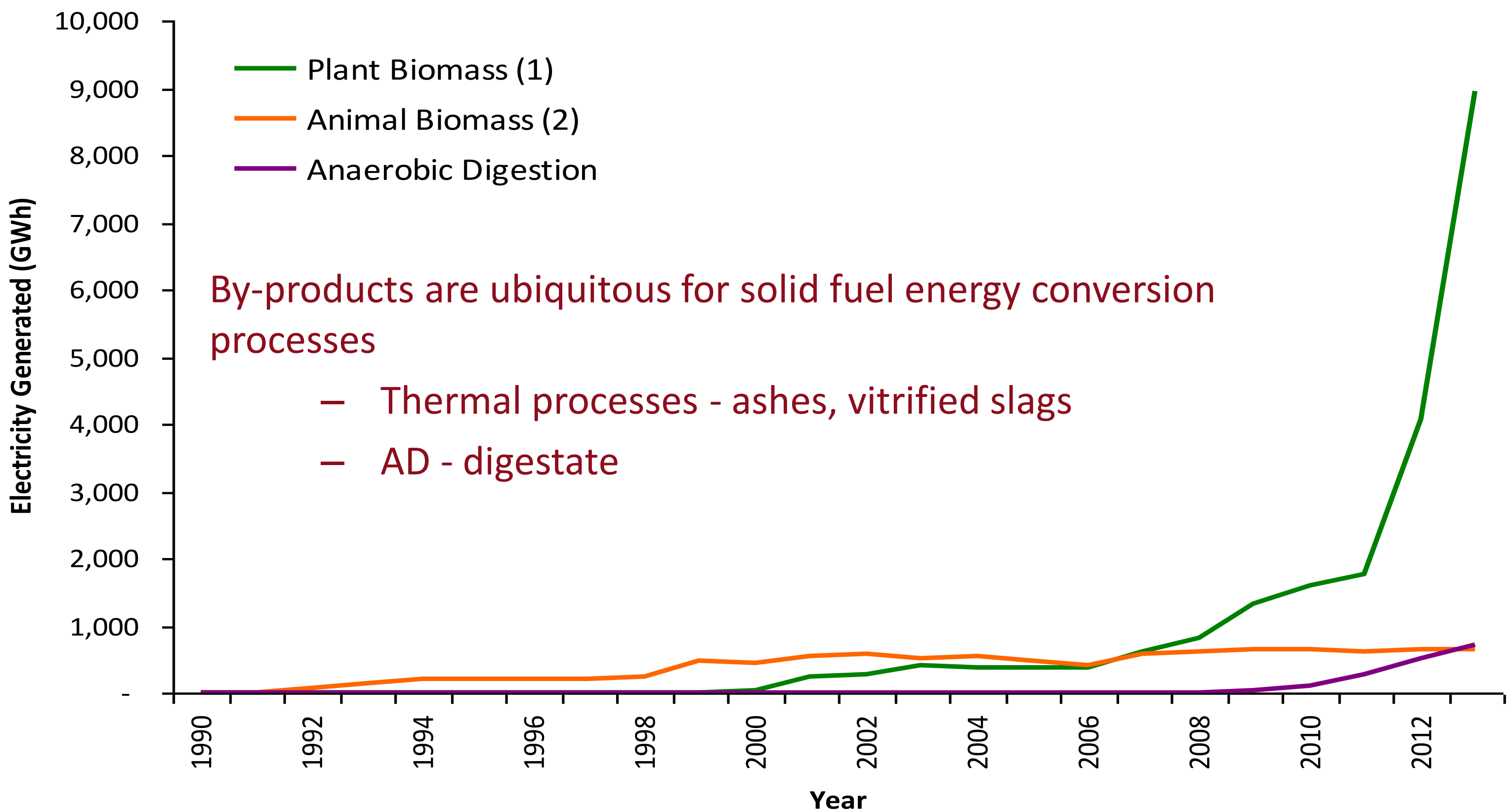
Partners & Steering committee

NERC RRfW funding – Catalyst Phase

- Stopford Energy & Environment – 2012 Proof of Concept
- Catalyst Phase 2013 - £77,496.
- Database of those working in sector
- Two workshops to the sector on the background and development of the project
  - identification of key issues/areas requiring research
  - a consortium to take project forward
- Position paper published in *Environment International*
  - Matthew J. Riding, Ben M.J. Herbert, Lois Ricketts, Ian Dodd, Nick Ostle, Kirk T. Semple. 2015. Harmonising conflicts between science, regulation, perception and environmental impact: The case of soil conditioners from bioenergy. *Environment International* 75, 52–67
- Writing and submission of full grant proposal to NERC
  - Funded £856,484 (2015-18)

Project overview

An energy-industry problem



By-products are ubiquitous for solid fuel energy conversion processes

- Thermal processes - ashes, vitrified slags
- AD - digestate

Source; Digest of UK energy statistics (DUKES) 2014
(1) Includes the use of straw combustion and short rotation coppice energy crops.
(2) Includes the use of poultry litter and meat & bone.

Why Ash?

- Ash contains inorganic minerals; potassium, phosphorus, calcium and magnesium are particularly abundant
- Plants require these minerals for nutrition
- Ash is a cost to most operators; £80/T to landfill
  - Estimated £50M annually

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Why Digestate?

- Digestate provides nitrogen, organic matter, trace nutrients etc
- Known difficulties
    - Quality and consistency
    - Dewatering
- Closing the Loop

Masses of ash…

- 50 operating dedicated biomass plants in 2013[1]
  - Total electrical output 1849MW
- 620,000 TPA ash
- 174 Olympic swimming pools worth of ash…

- A further 300MW under construction
- 3,600MW awaiting construction
  - Potential for 2,000,000 TPA

(1) Renewable Energy Planning Database (REPD), excluding small-scale domestic installations

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…and digestate

- Currently 152 operating AD units in the UK
- 88 of which are "waste-fed"
  - Operational capacity of 6.3M TPA
  - Estimated mass of digestate ~6.3M TPA
  - 2,500 Olympic sized swimming pools

- So how do we turn these wastes into an economic benefit?

Conventional fertilisers

- Highly formulated, consistent product
- Supply N, P, K
- 100% phosphate, 30% of potash and almost 90% of sulphur is imported to the UK.

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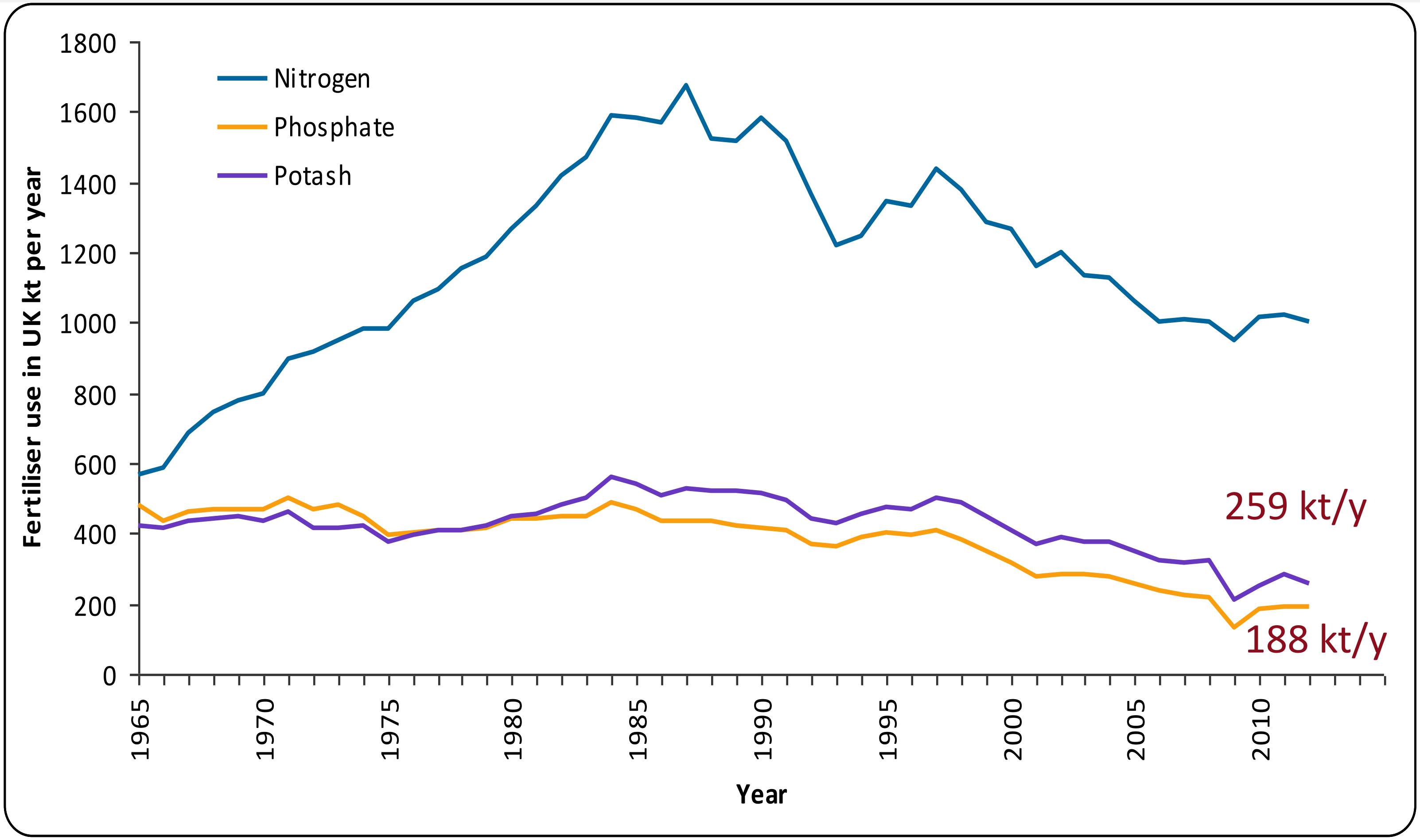
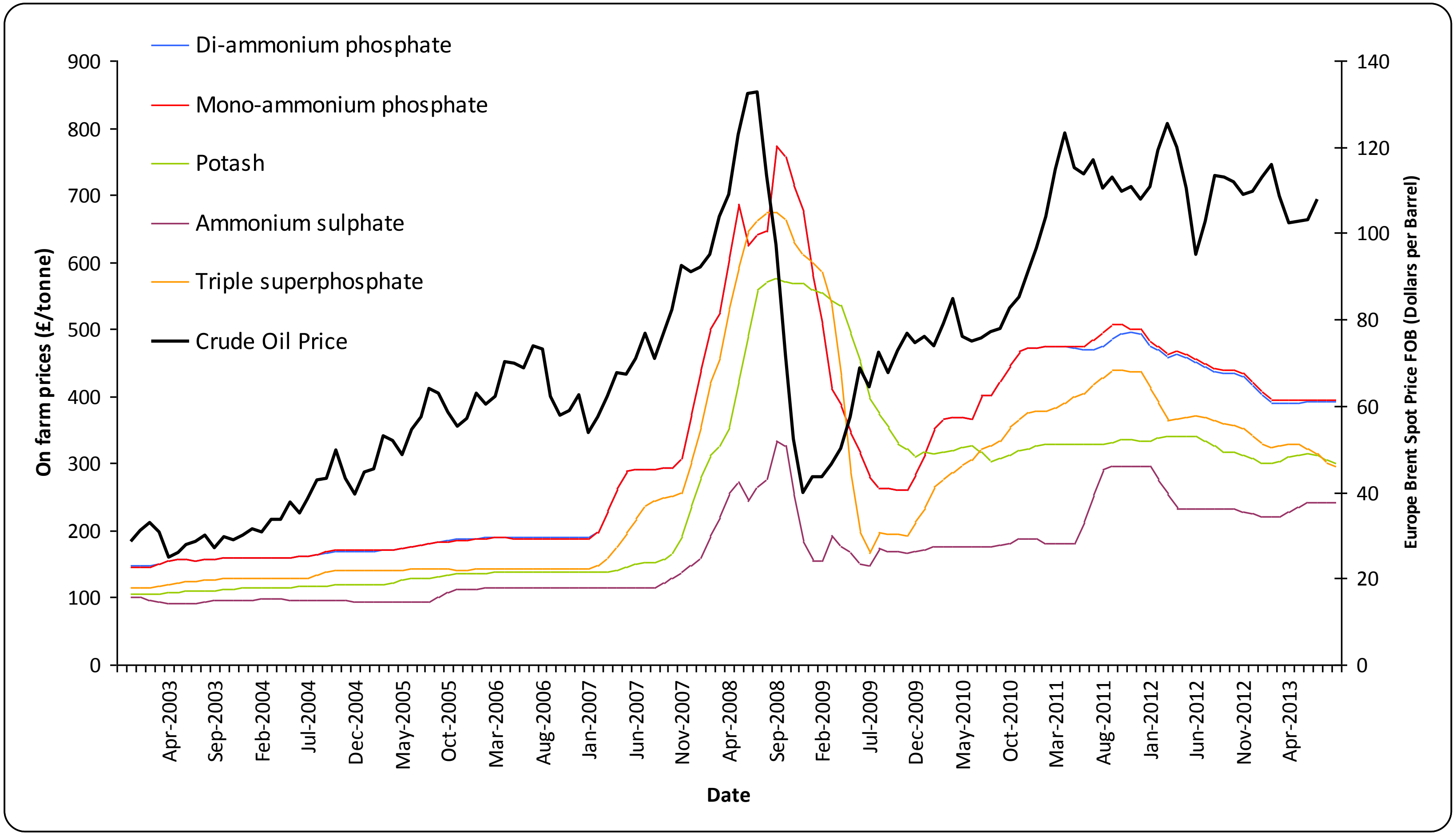
UK Fertiliser Use



Fertiliser prices

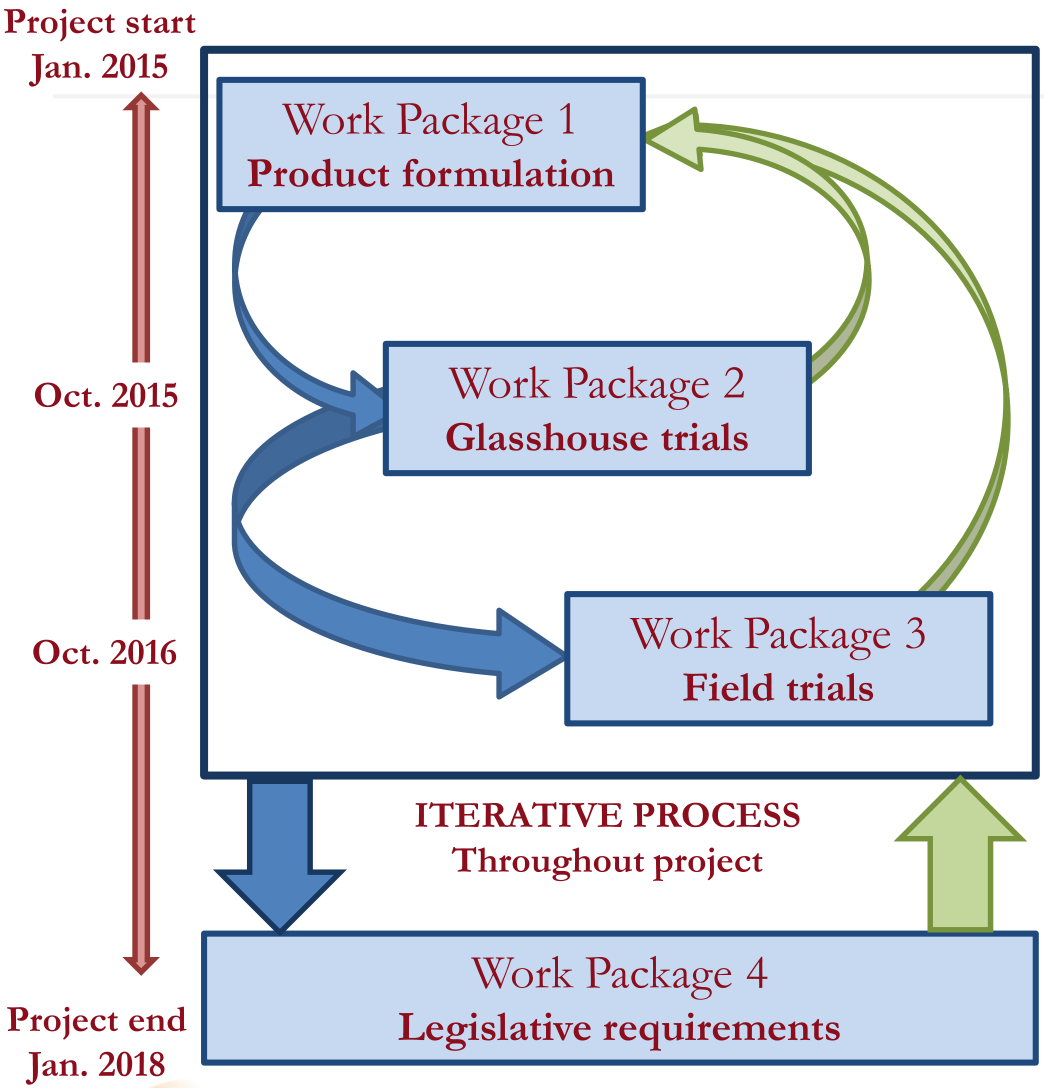


Our project

- NERC funded Resource Recovery from Waste project
- Develop soil conditioners and fertilisers from ash and digestate
- Assess the environmental impact and any detrimental effects of using the products

Challenges?

Ashes and digestates	Conventional fertilisers
Highly variable composition	Consistent and reliable
Problematic form for use and storage	Concentrated, stable forms
Restrictive (but necessary) regulations	Well established regulatory framework
Scepticism among users	Trusted
Readily available	Energy intensive to product Diminishing availability
Low cost	Expensive to buy



Characterisation of selected ash/digestate and selection of blends for WP2

Assessment of ash, digestate & blend impact on soil quality and crop growth

As for WP2, but with most promising blends. Additionally, further ecosystems impacts considered (i.e. GHG emisions).

Gathering of evidences to permit application to land ("End of Waste")

Workpackage 1 Update:

Feedstock characterisation and Blend formulation

Characterisation of waste streams

Digestates(n=6)

Ash fractions (n=6)

+

Selection criteria

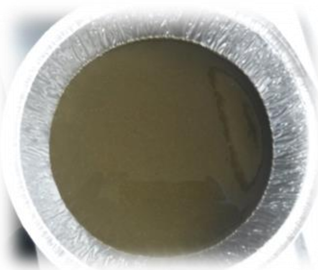
- Low levels of heavy metals and organic pollutants
- Comparing digestates with low and high levels of available N and P
- Comparing bottom ash versus fly ash

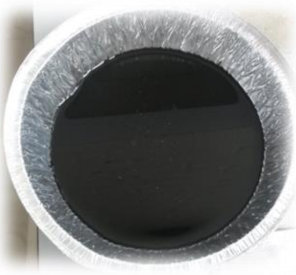
=

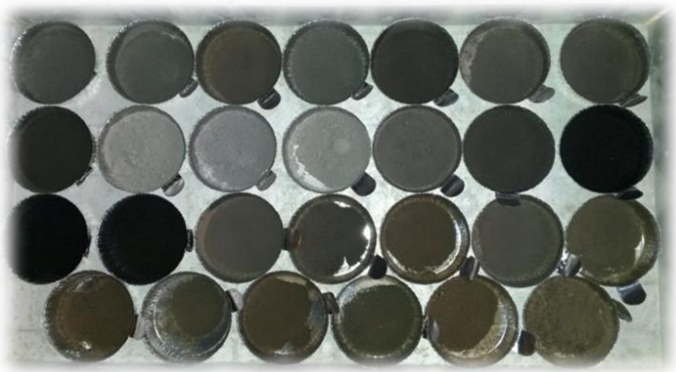
Product formulation

Blend AA, Blend AB

Blend BA, Blend BB







• WP1: Interactions between the wastes

Laboratory Trials to test unknown potential for:

- *NH_3 loss (Completed at Lancaster Univeristy)*
- *Changes in P-speciation (Ongoing at Lancaster University and JHI)*
- *Dewatering and blend stability (Ongoing at Aqua Enviro)*
- *Pathogen reduction (Ongoing at JHI)*

WP2 - Greenhouse trials –
Design and results so far

Potential fertilisation Treatment	Code	Levels (n)
Control	C	1
Organic Nitrogen control (Urea)	C_{ON}	1
N (Urea)-P-K	C_{NPK}	1
Ash	A	2
Nitrogen (Urea) ash control	A_N	2
Digestate	D	2
Blends	D+A	4
Total		**13**

Overarching Factors

- Planted/Unplanted (n=2)
- Soil type (n=2) [Neutral Loam and Acidic Sandy]
- Plant type (n=1) [winter wheat]

Experiment split in two experiments on soil type (2x2)

WP2 - Greenhouse trials – Design and results so far

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DURATION

Six weeks
(From 29/10/15 to 17/12/15)

pH, EC
Water holding capacity
Total C, N, P and K (before)
Plant available N, P and K
Total & available elements

During growth
Plant growth measurements including germination, water use efficiency

At the end
Shoot fresh and dry weight
Tissue mineral composition
Tiller number (branching) in wheat

VARIABLES

Assessed at the start (t=0) and the end of the experiment (t=6 weeks)

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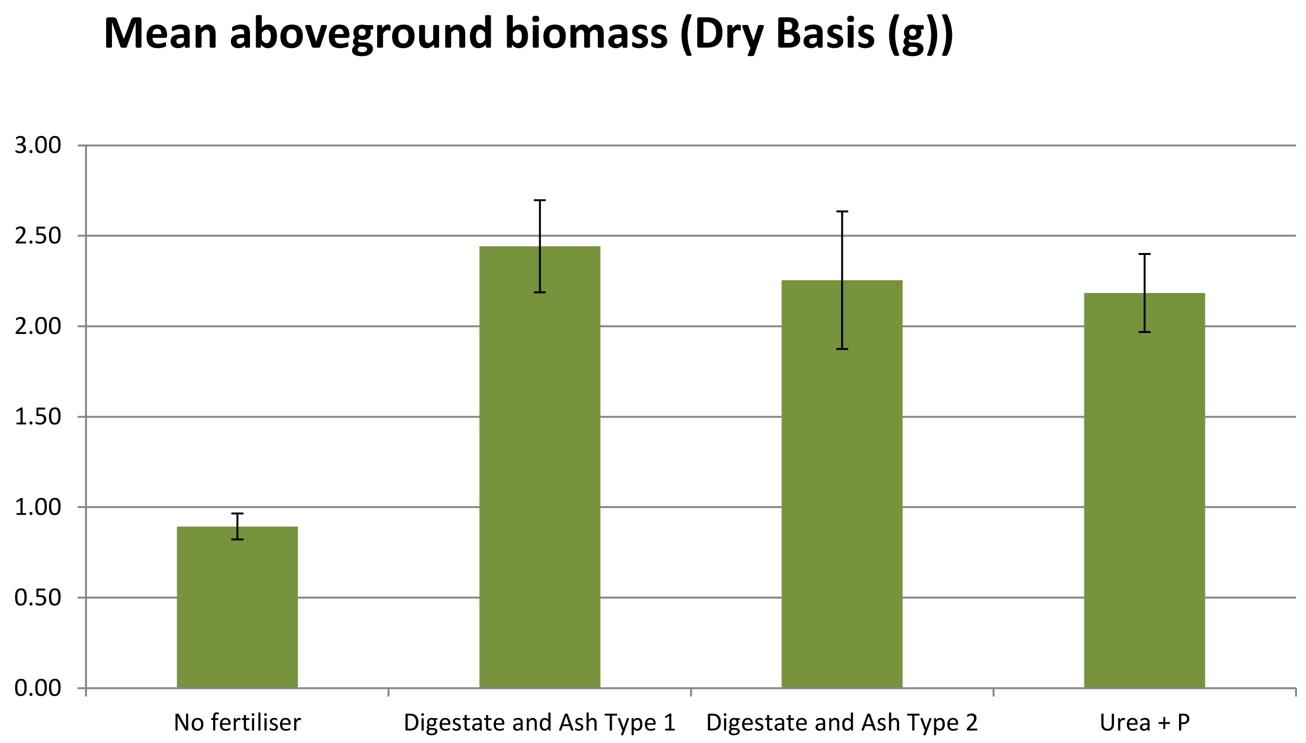
WP2 - Greenhouse trials –
Design and results so far



WP2 - Greenhouse trials –
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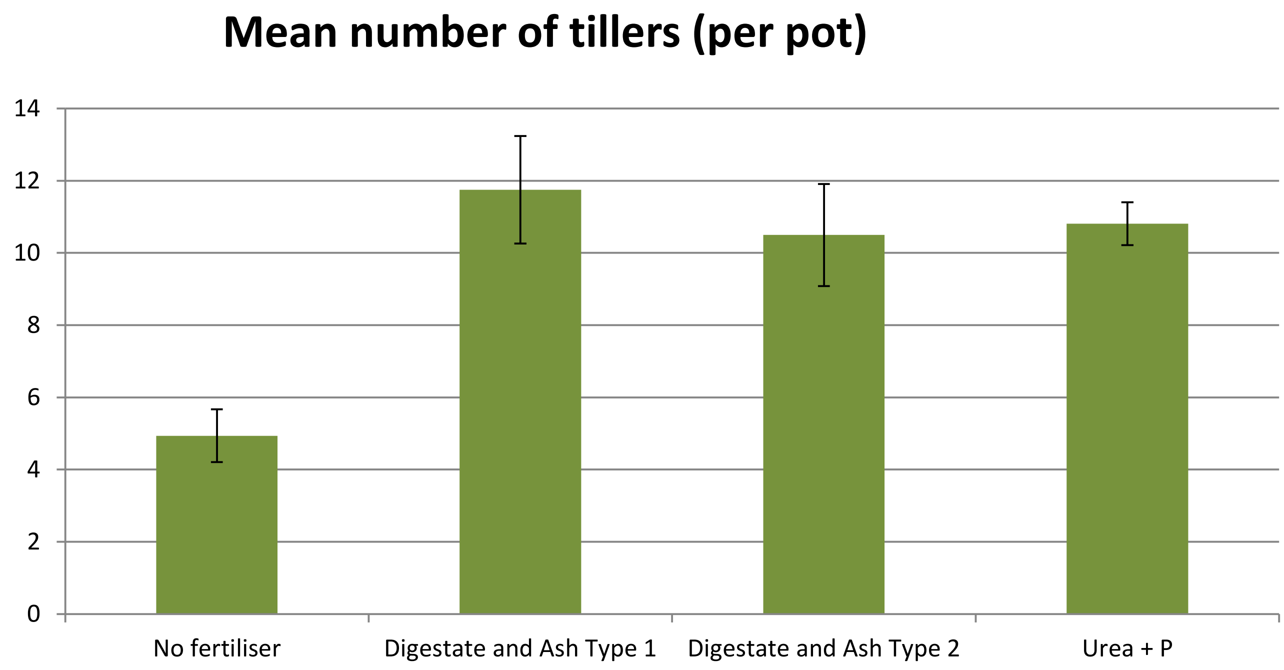

WP3 – Experimental design

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Overarching Factors

Planted species (n=2) Winter wheat + spring wheat

Fert. Treatments (n=7) 120/60 kg/ha (N-P2O5) for whole cycle.

60/63 kg/ha (N-P2O5) as basal dressing initially.

Remaining N (57 kg/ha) – *Inorganic top up (Urea- fertirrigation)*

Fertilisation treatment	Code	Levels (n)	Replicates (n)
Control	C	1	7
Conventional/Inorganic fertiliser (fixed target)	U+P	1	7
Ash with Urea	U + A1	1	7
Digestate	D1, D2	2	7
Blends	D1A1/D2A1	2	7
Total		**7**	**49**

Exp. description:

Location: Myerscough Agricultural College; Lee farm (polytunnel)

Crop: Wheat (winter)

Management: Conventional (fertilization and crop).

Irrigation: Well watered (≈80% pot WHC). Drip irrigation based on crop requirements

Soil type (n=1): Myerscough field

3. WP3 – Experimental design

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Randomised blocked design (7x7)

49 mesocosms. Nov16 – July17

Moisture sensors (ML2X Thetaprobes)

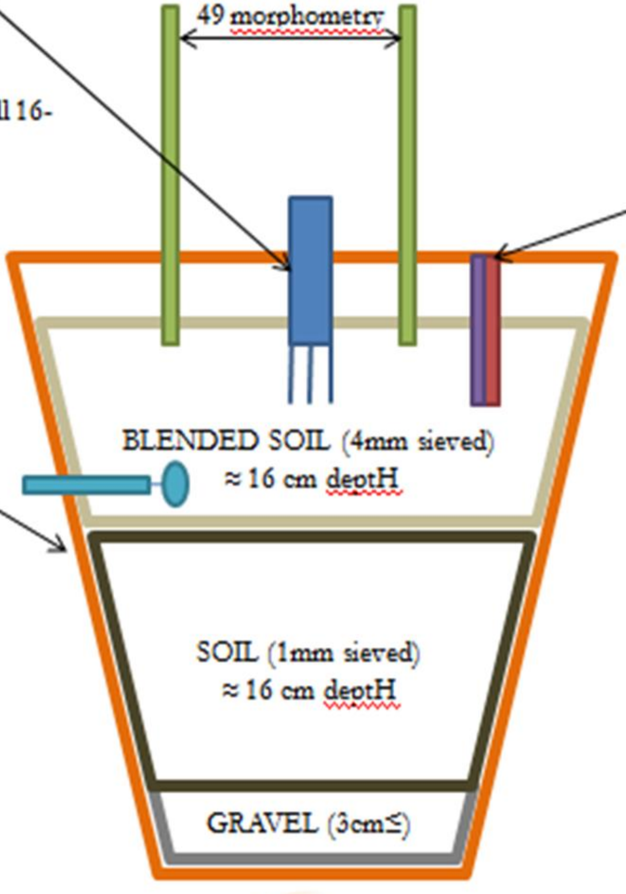
28 sensors (7 treatments x 4 replicates)
Monitor well water conditions (Check)
Probes buried 10 cm into the soil (rods till 16-18 cm)

Wheat plants

2 per pot?
4-5 samples elemental analyses
49 morphometry

PRS probes

Grant application (30 ud)
Passive sampling
3 treatments monitored (4 replicates)

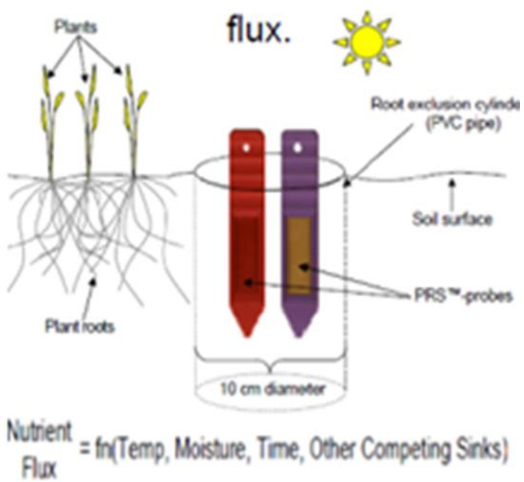


Rhizon-samplers

Pore Water sampling

Cost to be determined.

Matching GHG samplings and total number of experimental units (4-5 replicates per treatment, total 28-35)



4. Case studies – AVAnD project

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IMPACTS

Impact Highlights

- Government Chief Scientist's Annual Report – Case Study
- Publications
- Nuffield Foundation
- Undergraduate Teaching
- Farmers Forum
- IP Protection
- Licensing and Assignment Options
- Market Testing
- Business Planning

Intellectual Property

- Patent application
- Licensing
- Spin-out
- Assignment

In the News

Potential

It builds on research originally conducted by one of the partners, Stopford Energy and Environment Ltd consultancy, which investigated using a mixture of digestates – the waste left over after material has been through an anaerobic digester – and ash, from burnt biomass, as an alternative to existing fertilisers.

Events

Stopford Energy & Environment
Land conditioners and pl
fertilisers from biomass e
generation by-produ
Lois Ricketts
ADBA R&D Forum, Southampton
Lancaster Environment Centre
Think Energy, Think Environment, Think Engin
ADBA R&D FORUM
14-15 APR 2015
UNIVERSITY OF SOUTHAMPTON
OFFICIAL EVENT GUIDE
ADBA
Organised by
In partnership with
WESTMINSTER FOOD & NUTRITION FORUM
Growing The UK Nutrient Platform
AIM: To establish a cross-sector UK Nutrient Platform for all stakeholders with interests in sustainable nutrient use and recycling, nutrient management and security and environmental impact.
Royal Society of Chemistry | Burlington House | London
In November 2014, the concept of a UK Nutrient Platform was introduced at a successful event in Leeds.
This second event will be an opportunity to meet other stakeholders and participants and to define organisation, funding, objectives & actions.
Register your interest
To be on the mailing list for this and other UK Nutrient Platform events, please mail the event manager at: info@link2energy.co.uk.
More details and full programme to follow.
Please note—if you did not attend the first event in Leeds, don't let that put you off participating in this or future events. You are welcome to attend.
Save the date:
29th April 2015
09:30 - 16:30
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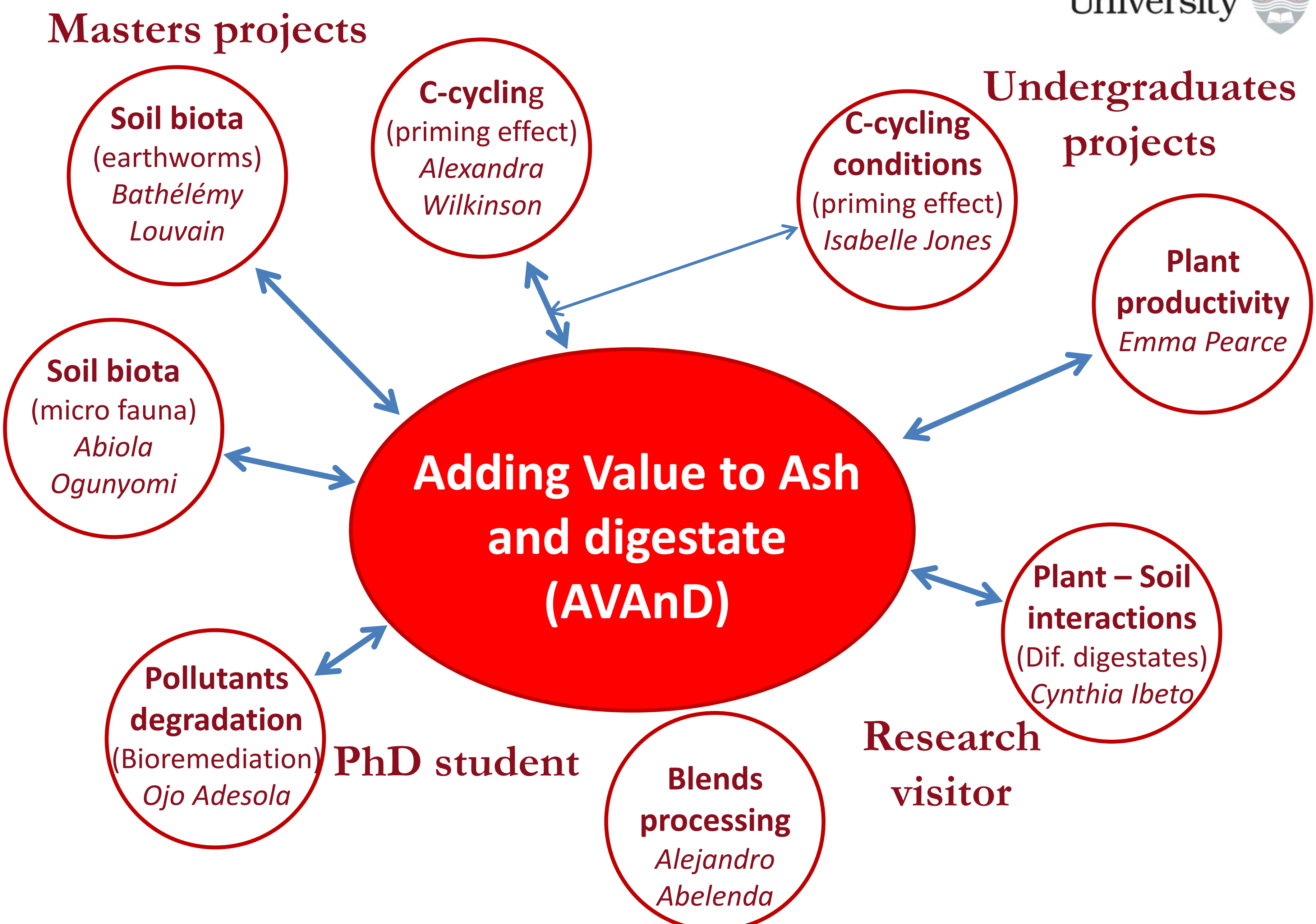
Renewable chemicals from waste – securing the molecular value from waste streams
20 November 2015, London, United Kingdom

Students projects



The vision

- Widespread adoption of this technology
- A sustainable substitute for conventional chemical fertilizers
- Reduction in the carbon footprint of the agrochemical industry
- Underpin the long-term commercial viability of the biomass to energy sector by monetising sector derived waste streams
- Utilisation of growing waste streams of biomass by-products to promote the growth of crops
- Close the production loop for biomass to energy generation enabling a cradle to grave approach

Outcomes

- A sustainable substitute for conventional chemical fertilizers
- Significant reductions in the carbon footprint of the agrochemical industry.
- Closing of the production loop for biomass to energy generation enabling a cradle to cradle approach.

Thanks for listening

Lancaster University

aqua enviro limited

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The James Hutton Institute