1. INTRODUCTION

A circular economy for nutrients will become increasingly necessary for food security in the UK and Europe and land application of organic wastes will have a central and critical role and also divert biodegradable waste from landfill disposal. The high-energy requirement of N fertiliser manufacturing and approaching peak P production emphasise the need to expand recycling of biowastes to land.

Organic wastes are complex, varied and variable materials and therefore represent a significant resource management challenge. Understanding these properties and the soil-plant interactions of biowastes, nutrients and contaminants is vital to innovative and creative systems to improve nutrient supply, whilst minimising contaminant availability and impacts.

2. AIMS AND OBJECTIVES

The principal aim is to maximise the use of biowastes as nutrient resources for long-term food security in the UK, whilst ensuring food safety and environmental and soil sustainability. A further aim is to protect, support and enhance Ecosystem Services (eg. soil infiltration, long term nutrient/carbon storage, pollutant attenuation). The specific objectives will be defined during the NERC Catalyst Grant and will be focused within the areas presented in Boxes 4-9.

3. APPROACH

The research programme benefits from a collaborative and integrated strategy that combines the expertise of four leading institutions on biowaste treatment optimisation, soil physicochemical and biological interactions, agronomic properties and environmental impact (Figure 2). This presents unique opportunities to manipulate treatment processes to maximise the process, nutrient value and other properties while minimising environmental risk.

4. MECHANICAL BIOLOGICAL TREATMENT

Although not currently applied to land in the UK, compost like output (CLO) from mechanical biological treatment (MBT) represents a potentially significant nutrient resource. We aim to determine mass balances and flows of nutrients (N, P, K, S, Mg), and of target contaminants during MBT, and strategies to optimise use of CLO as a nutrient resource.

4. ANAEROBIC DIGESTION

Anaerobic digestion has a critical role for effective nutrient management of biowastes. We will develop treatment processes to manipulate nutrient availability and maximise contaminant destruction. A key area is digestion technologies for wastes with rich nutrient and energy contents, e.g. poultry and meat industry wastes, that challenge standard AD technologies. Further obj-45-3ec-45-3es are to generate digestate with a range of stabilities for agronomic assessment (Box 9), and N_{15} labelled digestate for investigation of N behaviour in soil (Box 7).

5. COMBUSTION RESIDUES

Research on combustion residues (biomass/Energy-from-Waste/SRF) will focus on determination of the nutrient composition and chemical forms present, and investigate processes to improve agronomic properties of the residues (by improving nutrient /reducing contaminant availability) and/or nutrient recovery.

6. AGRONOMIC PROPERTIES

A programme of laboratory studies and controlled environment experiments will determine the fertiliser replacement value (N, P, K, S, Mg) of a selection of wastes including untreated and treated wastes using materials generated in 3-5, and soils and wastes sourced with the assistance of our Industrial Partners (Box 10). The impact of waste application on soil physical/chemical properties (i.e. WHC, porosity, density, water infiltration, aggregation, CEC, EC) will also be investigated.

7. SOIL NUTRIENT TRANSFORMATIONS

State of the art techniques will be applied to examine the fundamental interactions of wastes with soil to improve and inform the management of these nutrient resources. Key areas include mass balances of nutrients (N, P, K, S) in waste-amended soil (N_{15} labelled digestates will be produced by UoS for N transformation studies), physical and chemical fractionation of N, P and S in waste-amended soils, and biochemical/microbial ecology constraints on mineralisation of waste-derived nutrients.

8. SOIL HEALTH AND THE ENVIRONMENT

The interactions of waste with soil will be examined at a fundamental chemical and microbiological level to investigate potential impacts on soil microbial health, relationships between waste metal content and soil ecology, the behaviour and significance to human health and the environment of selected organic contaminants (PAHs, CPs and PFCs) potentially transferred to soils in wastes, and the transfer and fate of plant pathogens.

9. CLIMATE CHANGE IMPACTS

There is potentially a strong link between GHG emissions (N_{2}O and CH_{4}) from biowaste amended soil and biowaste stability. We will quantify the significance of this mechanism by investigating the interactions between biowaste organic matter stability and nutrient availability, soil physical properties, and environmental conditions. Land spreading activities may also achieve C sequestration, therefore rates of C decomposition will be measured to inform the C offset attributed to land application of biowastes.

10. INDUSTRIAL PARTNERS

The research will be achieved with the support of our partners: Agrivet; AnDigestion; Anglian Water; Environment Agency; Defra; Marches Biogas; Thames Water; Yorkshire Water; WRAP.