

Conference Proceedings

Cranfield Science for a Circular Economy. How to tackle the Water, Energy, Food nexus

16 June 2017

Cranfield University. School of Water, Energy and Environment



Organised by

SWEE Doctoral Communities

Water & Design, Environment & Agrifood, and Energy

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Capturing the value of the circular economy through reverse logistics

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The take-make-dispose economy is very risky for businesses and globe with finite resources. The projections of raw materials consumption is a major challenge for businesses to survive in the future. The scarcity of material drives the legislator and companies in the first place to adopt CE model to sustain themselves. A major enabler for CE model for businesses in term of material usage is reverse logistics where the companies optimize the use of material without compromising the future projection. In order to benefit the most from such a process such as RL to enable CE the companies must understand the requirements of adopting such a process. Here we will present a reverse logistics maturity model that will help the companies to first understand their RL structure and then tap on the potential areas for improvement with RLMM. The RLMM capture the RL components in three level of decision making Strategic-tactical-performance.

Is Geothermal Energy a sustainable solution for future generations?

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Cranfield University

Geothermal energy has been used for centuries as a source of energy (e.g. hot springs of the Ancient Roman bath in Bath, UK). The stored heat is mainly released by decay of natural radioisotopes within the earth core, reaching a heat flow of 47 TW (10^{12} Watt, unit of power). The annual rate of geothermal heat is about 1 500 EJ (10^{18} Joule, unit of energy) while the annual primary energy consumption worldwide represents one third of it, with 579 EJ in 2015. In 2010, it was estimated that the geothermal energy recovered worldwide for direct-use reached around 420 TJ/year, mainly represented by ground-source heat pumps (47 %), bathing and swimming (26 %), and buildings heating (15 %).

Geothermal energy can be used for electricity generation by producing high temperature fluids. In 2012, the power capacity reached 10.9 GW (10^9 W) with an estimated potential of 70 GW by 2050.

Despite the increasing development of geothermal power generation worldwide, the definitions of renewability or sustainability are still questioned in terms of time scale, relative to economics or energy availability. Throughout an overview of geothermal energy applications, current sustainability-based challenges will be described for targeting high potential geothermal resources with high efficiency rates. This talk will notably focus on recent studies on high energy systems near magmatic objects. These new prospects can increase significantly the amount of produced energy per units while decreasing investments with associated risks. Managing subsurface resources with adequate technology (e.g. re-injection, heat exchangers, cogeneration, etc.) need to be balanced in terms of economics and energy efficiency, to approach a virtuous circle in geothermal engineering.

Modelling innovative cooling technologies in Concentrating Solar Power – Hybrid cooling option

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Water consumption in conventional power generation systems is a topic of increasing interest, particularly for Concentrating Solar Power (CSP) where it is a constraint on the suitability of many sites, particularly in locations with high levels of solar insolation where aridity tends to be an issue. Therefore, wet cooling towers, which require large quantities of water, tends to be an unfavourable option in regions with high levels of solar insolation. The EU H2020 project Water Saving in Concentrating Solar Power (WASCOP) is investigating the potential of a number of innovative technologies to reduce water consumption in CSP where reductions of up to 90% are possible using dry cooling systems; however, this option leads to reductions in the overall plant efficiency. To assess the trade-off between the decrease in plant efficiency vs water requirements, a hybrid cooling system has been proposed that works with both dry and wet cooling systems in parallel. Both wet and dry cooling systems are used simultaneously and can reduce the negative impacts of each technology, but the optimal combination will vary according to the particular site conditions and the constraints imposed. A case study of a parallel hybrid cooling system is investigated to identify the potential for water saving and the impact on power production at different climate conditions. Results show that water consumption decreases by 37% if 50-50% dry-wet combination is used instead of 100% wet cooling system whereas the plant efficiency decreases by 1.7% (Figure 1). Moreover, this study aims on the development of a modelling approach for the whole-plant that uses multidimensional look-up tables generated using Thermoflex to show the thermodynamic performance of a CSP plant. The model is able to time-step through the ambient conditions of a Typical Meteorological Year (TMY) to generate an annual calculation of water consumption and power output.

Sampling of bioaerosols from composting sites using traditional and novel sampling techniques

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Composting is increasingly used as a sustainable waste treatment process; however, there has been a corresponding increase in the concern about bioaerosols. Studies have shown that composting facilities may release high concentrations of bioaerosols. Under prolonged or acute exposure conditions, bioaerosol has the potential to cause health risks to those living in and around composting facilities. Knowledge about the dispersal of bioaerosols from composting sites is still limited and further research is required before accurate assessment of bioaerosol dispersion can be made, in order to reduce the public exposure to bioaerosols.

Traditional sampling methods are labour intensive, costly and provide limited emission data, typically a snap shot of a single point in time. The Spectral Intensity Bioaerosol Sensor (SIBS) is a real time sensor providing data on particle concentration, fluorescence and size. The SIBS therefore has the potential to overcome many of the limitations of traditional sampling methods.

Three sampling visits have been made to a composting site to collect data about bioaerosol concentrations using the SIBS and the IOM (a conventional filter sampler). The objectives were to quantify and characterise the fluorescent particles from the composting facilities using the SIBS and to analyse how the SIBS data relates to data collected using traditional methods. This new analysis will help to place the SIBS data within the context of previous findings.

Analysis of the SIBS data shows how the emissions are released from the composting site. The fluctuation of emission concentration seen in the SIBS data explains the relationship between the composting operations and the emission concentration. This is information that is not possible to obtain using the IOM technique. The concentrations measure using the SIBS and the IOM are significantly different, which indicates the capability of the SIBS to detect more particles than the IOM and in more detail.

Using chemical and molecular markers for characterising aerosols from contrasting outdoor environments

Sonia Garcia Alcega

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Occupational activities involving high levels of biological material such as wastewater treatment plants (WWTP), biowaste facilities, animal farms and agriculture are of great concern for workers as respiratory diseases are potentially linked to continuous exposure to bioaerosols. Given the limitations of cell culturing techniques for bioaerosol studies, we explore the feasibility of using chemical and molecular markers such as microbial volatile organic compounds (MVOCs) and phospholipid fatty acids (PLFAs) to identify and quantify microorganisms in outdoor environments. For this purpose, air monitoring was conducted during 6h in three contrasting sites in the UK, a WWTP, a compost facility and a farm. The location with higher diversity and concentration of MVOCs and PLFAs corresponded to the compost facility and the location with the least to the farm, probably due to the low activity. Each location had different MVOCs and PLFAs profile patterns suggesting that chemical and molecular biomarkers are suitable for the characterisation of environmental air. The most predominant group of MVOCs in the WWTP were ketones (42%), in the compost facility were predominantly furans (41%) and in the farm there were 3 dominant MVOC groups: esters (23%), aldehydes (22%) and alkanes (28%). The farm only had PLFAs from fungal origin, whereas in the WWTP and the compost facility PLFAs from Gram positive and Gram negative bacteria as well as from fungi were identified.

Ecosystems and temporal scale in the Water-Food-Energy Nexus

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The potential for the global human footprint to compromise the security of water, food and energy resources cannot be understated. In response, the Water-Food-Energy (WFE) Nexus, a concept to aid the achievement of sustainable development (Hoff, 2011), has emerged. The WFE nexus scaffolds consideration of the interdependencies and trade-offs between these three pillars, operating compatibly with movement towards the circular economy.

Bidoglio and Brander, 2016, suggest a fourth pillar – ecosystem services (ES). These are the, often irreplaceable, services that ecosystems provide to sustain human life. Despite this, ES have been consistently undervalued in the decision-making process (Costanza et al., 1997; Dudgeon et al., 2006). Freshwater ecosystems, particularly, are known to contribute disproportionately to ES (Dudgeon et al., 2006).

Biotic components, dominating the evolution of lotic ecosystems, are used as indicators of river health and thus its ES capacity; macro-invertebrates are able to reveal both long-term temporal and spatial trends/changes. Being mid-food chain, their study has particular implications for higher-order species, such as fish (e.g. Garbe et al., 2016). There are clear (indirect) implications for both water and food.

Although subject to limited investigation, lag in ecological response to flow-disturbances (flood/drought) are observed in groundwater-fed rivers (see Boulton, 2003; Wright et al., 2004). This work, through a case-study, statistically modelled response of the macro-invertebrate bioindicator to flow (Visser et al., 2017). The consideration of lag appeared to enhance overall model performance ($R^2 > 0.6$). The results revealed that flows may have a lasting effect on ecological health (2-4 years). This suggests that current modelling efforts, and subsequent planning and management decisions, may underestimate the impact of flow disturbances upon the health of the lotic ecosystem. The need to consider a much broader temporal scale offers potentially essential input to an expanded WFE Nexus which acknowledges the key role of ES.

Reconciling competing demands for water – developing regional scale multi-sector collaborative approaches to water resources management

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Eastern England is the driest region in the UK and is expected to experience the largest population increase (5 million) over the next 25 years. It also contains the highest concentration of intensively productive agricultural and horticultural land, much of which is dependent on supplemental irrigation to deliver high quality, continuous supplies for premium produce to the major retailers and processors. A significant number of national and internationally protected aquatic ecosystems are also found in the region, creating conflict during drought periods between allocating water resources for environmental flows, public water supply and demands to produce food for a burgeoning population. Future climate projections are expected to result in increased aridity due to rising temperatures and evapotranspiration (ET) rates and increased seasonality in rainfall, with more frequent and intense periods of drought. In response to these multiple and inter-related water risks, a collaborative effort is underway to develop an integrated, multi-sector approach to reconcile competing demands for water. By combining future demand forecasting including climate change with a regional water resources simulator, a new approach to robust decision-making (RDM) has been developed. This enables stakeholders and decision makers to evaluate a range of future resource strategies in order to identify those that would be robust under a suite of plausible socio-economic futures. The approach includes the development of a series of performance metrics to enable trade-off analysis between competing sectors (e.g. agriculture, PWS, energy, environment) in order to identify appropriate supply-demand infrastructure measures to reduce the regions' vulnerability to future water scarcity.

A novel method for quantifying fat, oil and grease (FOG) in commercial kitchen wastewater

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Cranfield University

Discharges from food service establishments (FSEs) are a major source of fat, oil and grease (FOG) which cause blockages in sewer networks. Current management practices rely on physical separation in grease interceptors and/or bioaugmentation with bacterial products capable of enhancing natural microbial FOG degradation into benign end products. Evaluating treatment efficacy has been hindered by the inadequacy of current analytical methods for quantifying FOG in FSE wastewater owing to the presence of surfactants in detergents and protein from food residuals, which emulsify FOG and interfere in the extraction process. A reliable novel quantification method, based on the dairy industry Gerber milk fat determination method, has been developed which negates the impact of surfactants. Moreover the modified Gerber method allows free and emulsified oil to be quantified separately providing greater insight into FOG management strategies. FOG in dishwasher effluent was largely or completely emulsified, whilst potwash sink samples were dominated by free FOG floating on the surface. A test protocol was also developed to assess the efficacy of microbial FOG degradation and removal: environmental conditions and synthetic wastewater culture media were based on a comprehensive characterisation of FSE wastewaters. Kitchen wastewater comprises largely of food residues, thus providing bacteria with carbohydrates and proteins as alternative, potentially more easily degradable, organic substrates. Degradation and removal of the organic fractions were monitored in cultures of *Bacillus licheniformis* NCIMB 9375. The effects of cooperativity, saturation and inhibition were evaluated with enzyme kinetic models. Findings indicate that FOG removal does not start until bacterial populations enter the stationary phase, and is influenced by carbohydrate type and concentration; whilst proteinaceous material and carbohydrate supported bacterial growth.

Recycling water, energy and food by anaerobic digestion

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Cranfield University

Food waste arising from domestic consumption behaviours and unconsumed food left over from retail, hospitality, has embodied calorific (methane) and crop nutrient (nitrogen, phosphorous and potassium) value and water therefore has high potential as a recyclable resource. Similarly, crop residues and other lower quality bio-waste such as vegetable peelings also have this potential. Subject to the costs of collection, sorting and processing, it is possible to extract the embodied water, energy and nutrients to provide resources, reducing primary production and distribution requirements. A key socio-technological solution is anaerobic digestion. This technology is available at a range of scales from household to full facility size, and is sustainable compared to conventional forms of energy production. Value from feedstocks, which would otherwise be added to landfill or incinerated, can be recovered through the production of biogas, digestate and water. Biogas can be used for the production of heat or electricity, whilst the remaining liquid digestate from the anaerobic digestion process can be separated for example using electro-coagulation to create solid fertilizer rich in nutrients and recycled water for reuse in the digestion process or irrigation. As with all socio-technological solutions, anaerobic digestion requires prioritisation and behaviour change as part of a set of potential solutions to improve water, energy and food sustainability. Although avoiding waste production and excessive use of natural resources has clearly higher priority, once waste is reduced to unavoidable levels (for example, arising from inedible parts of vegetables and fruit) then energy, water and nutrient recovery is the best alternative for a circular economy.

High-value compounds delivered from insects grown on waste

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In addition to increasing population, limited land and water, and increasing costs of fertilisers and energy, one of the biggest challenges of food production is wastage. Organic waste management is a complex issue involving social, economic and environmental aspects. About 30% of all produced food is wasted in pre- or post-consumption. Annually 250 billion litres of water and 300 million barrels of oil are used to produce 1.3 billion tons of food worth 750 million \$ that is never eaten (FAO, 2013). These materials can be upcycled to high-value products for animal and human consumption using insects. Insect larvae, in particular, or their components, have the potential to become prime ingredients in food and animal feed.

Essential fatty acids, minerals, vitamins and amino acids occurring in significant amounts in the larvae body, are susceptible to modification based on their feeding material, allowing process tailoring for specific compounds. In addition, co-extraction of high-value products, such as antimicrobial and antifungal agents or chitin, have the potential to significantly increase the cost efficiency of the overall process.

The aims of this study was to develop a close-loop system using mild conditions where *Hermetia illucens* larvae grown on organic waste, were extracted using a sustainable cascade process allowing the contemporary separation of proteins, lipids and chitin.

Hermetia illucens was chosen as most suitable candidate due to its non-pest status and its predisposition to process variety type of waste with high converting efficiency (up to 60%).

Preliminary results showed that larvae composition varies with age, mostly for the protein-lipids ratio and that different lipids can be fractionated at different stages of growth. In addition, the use of different extraction techniques at different growth stages, suggests that the process can be tailored to produce the best larvae type-product ration.



BEST ORAL PRESENTATION AWARD

Quantifying Soil Constraints to rice production

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Actual rice yields in particular locations generally fall short of potential yields dictated by genetic and agro-climatic factors, and it is important to understand the causes of such 'yield gaps' to prioritise research and target technologies. We develop digital soil assessment (DSA) methods for mapping soil constraints to crop production in areas where there is limited existing information. We use as a case study Punjab, northwest India, where soil salinity and alkalinity are important constraints. We modelled continuous depth functions of soil properties to 2 m depth using equal-area quadratic splines, and predicted electrical conductivity (ECe) and soil pH at set depth increments. We then used neural network models to derive the relationships between soil attributes (ECe and pH) and a suite of auxiliary variables, and determined the uncertainty in our estimates using Monte Carlo simulation methods. We then mapped soil constraints by combining the results of our digital soil mapping (DSM) with constraint variables based on the Fertility Capability Classification (FCC) system. We then modelled potential rice yield across the districts using the ORYZA2000 rice production model and agro-climatic data derived from MODIS land surface temperatures and meteorological stations. We determined yield gaps by comparing the potential yields with actual yields from Government regional production data. We overlaid maps of rice areas that are constrained with yield gaps. The results show that using an approach that considers the prediction uncertainties as inputs for DSA provide reliable digital soil constraint assessments especially in regions with limited legacy soil data. The use of 1km MODIS-derived LST in modelling of potential rice yield at every grid cell has significantly increased the yield gaps of rice in all the districts. Districts with the greatest concentration of soil constraints did not necessarily have the lowest yield gaps but rather had the smallest rice production areas, as production is concentrated away from the constrained sites.

Keywords: equal-area splines, neural networks, saline soils, calcareous soils, Monte Carlo Simulation, potential yields, yield gaps.

Spatially heterogeneous tillage and soil resilience

Iain Dummett

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The degradations of soils represents a threat to the sustainability of the global agrifood system. Soil biological communities have long been overlooked and undervalued with respect to their contribution to the generation of ecosystem services in the agricultural context. More recently, an acknowledgement that current agricultural practices in developed nations are not sustainable has highlighted the challenge of identifying practices which are complementary to soil biological communities and their potential for generating ecosystem services in support of crop growth. Sustainable tillage has emerged as one of a number of practices which can contribution to a more sustainable agricultural system in the UK. The research to be presented investigates the effects of strip tillage, a form of sustainable tillage, on soil health with a focus on the resilience of soil biological communities.

Restoring Soil Health and Productivity of A Degraded Soil: Impact on Crop Yield

Benedict Unagwu

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Degraded soils are associated with declining soil organic matter, low nutrient status and low crop productivity. Low agricultural productivity is a major threat to achieving global food security hence improving the productivity of degraded soils is key achieving to sustainable food production. This study investigated the effects of 4 soil amendments (mushroom compost, MC; PAS-100 compost, PAS; Anaerobic digestate solid waste, AD_SW; and Poultry manure, PM), applied at 10 t ha⁻¹ and 30 t ha⁻¹ on the physical, chemical and biological SQIs of a degraded sandy loam soil. The treatments were arranged in a completely randomized design in a greenhouse and replicated four times. The soil and organic amendments were thoroughly mixed and incubated for two weeks. Thereafter, maize, Zea mays, (Severus variety) was planted. Composite 3-point soil samples were taken from each treatment replicate at post-harvest (POH) for analysis. The following soil SQIs were analysed: pH, soil organic matter (SOM), Olsen P, available K, total oxides of nitrate (TON), ammonium-N, microbial biomass carbon (MBC), and bulk density. The data generated were subjected to analysis of variance (ANOVA) followed by post-hoc Fisher LSD analysis at 5% probability level. The results revealed that the organic amendments at any application rates had remarkable improvements ($p < 0.05$) on the SQIs. For instance, the Olsen P increased from 33 mg kg⁻¹ (baseline result) to 121 mg kg⁻¹(POH result). Similarly, the SOM increased from 2.33% to 3.74%, MBC (71.6 – 431 mg kg⁻¹); TOC (0.25 -9.89 mg kg⁻¹) and available K (87.3 – 1600 mg kg⁻¹) as compared with the control (un-amended soil). Application of PM, PAS, AD_SW and MC at 30 t ha⁻¹ best improved the soil physical, chemical and biological soil conditions and significantly increased maize yield.

Reusing wastewater for the irrigation of food crops in drylands

Alban Echchelh

Cranfield University

Water scarcity severely affects drylands threatening their food security, whereas, the oil and gas industry produces significant and increasing volumes of wastewater that could be reused for agricultural irrigation in these regions. The literature review that we carried out shows that there is potentially sufficient water to irrigate about 150 000–300 000 ha/year of cropland in arid and semi-arid areas. The quality of oil and gas wastewater is often a limiting factor for the reuse in irrigation as it can lead to soil salinisation, sodification, and heavy metals build-up. Although the inappropriate use of oil and gas wastewater in irrigation could be damaging for the soil, the agricultural sector in dry areas is often prone to challenges in soil salinity.

The next objectives of the research will be to model the effect of irrigation with oil and gas wastewater on soil salinity, sodicity and crop yield in different climates and soils typical of drylands. In addition, the effect of mitigation measures such as water treatment, soil amendments and crop rotation will be modelled in order to identify the best practices to control salinity and sodicity risks. The cost of using oil and gas effluents in irrigation will be compared to alternative irrigation water in drylands. Finally different irrigation scenarios will be compared in order to assess their agro-economic sustainability, the developed framework will be applied to case studies.

In short, this research approaches a recent aspect of the energy-water-food nexus: The opportunities and challenges behind the reuse of abundant oil and gas effluents for irrigation in hydrocarbon-rich but water-scarce and food-unsecured drylands.

Effect of acclimatisation of *Aspergillus flavus* strains on aflatoxins contamination and colonisation of pistachio nuts

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Pistachio nuts can be contaminated by *Aspergillus flavus* under warm and humid conditions. This can result in contaminate with aflatoxin B₁ (AFB₁), classified as a class 1a carcinogen. There have been no studies on the impact that acclimatisation of *A. flavus* to elevated CO₂ may have on colonisation and aflatoxin B₁ contamination. Thus the objectives of this study were to examine whether acclimatisation to 1000 ppm elevated CO₂ of *A. flavus* strains AB3 and AB10 (5 generations) affected AFB₁ production and mycelial growth under interacting Climate Change conditions and compare this with non-acclimatised cultures. The results of this study showed that acclimatisation influenced growth of one strain while there was no significant effect on another strain when colonising pistachio nuts. For AFB₁, the production was significantly stimulated after ten days colonisation after acclimatisation for one strain, while there was no significant increase for the other strain. This suggests that there may be intra-strain differences in effects of acclimatisation and this could influence mycotoxin contamination of such commodities as mixed population of contaminant fungi often occurs. More studies are needed on the acclimatisation of fungal pathogens and their effect on crops under Climate Change scenarios to obtain more accurate data on implications for mycotoxins contamination of economically important commodities.

Maximizing the value of trade wastes

Olivia Berzal

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Trade wastes, wastewaters generated from industrial or production processes, are diverse, complex and in many cases contain toxic compounds. The selection of suitable treatment technology for these wastes then requires a detailed understanding of their characteristics and expert knowledge of the technologies available. The high organic load from most trade wastes fulfils the demands of biological treatments. Aerobic and anaerobic treatments are the division of biological treatments depending on the need for oxygen for the micro-organisms. The main advantage of anaerobic digestion over aerobic treatment is the production of biogas, which can be used for energy production. This technology combined with a membrane can provide greater effluent quality in which case water recycling can be considered. Alternatively, trade wastes can also be used as a substrate in biological nutrient removal treatment of municipal wastewater. The application of these technologies may be limited depending on the complexity and toxicity of the wastes to be treated. It is then critical to understand what parameters may affect the performance of the treatment technologies. However, the limiting parameter and corresponding values reported in the literature differ widely. Therefore, there is a need to study the impact of waste characteristics on each technology before selecting a treatment route. The aim of this project is to build a decision support tool to match trade wastes to suitable treatment options. Ultimately, this tool will help water companies to choose the most appropriate technology for the treatment of a specific waste as well as to optimise the potential for resource recovery. Anaerobic digestion, anaerobic membrane bioreactor and biological nutrient removal technologies will be the focus of this study and the tool. Trade waste composition and technology limitations will be studied experimentally and the results will be a cost-benefit analysis to match each trade waste to one of the treatment options. At this stage of the project, current knowledge on trade waste characteristics and the limitations of the selected technologies is used to develop the structure of the tool.

Phosphorus and ammonia removal through Ion Exchange process

Samuela Guida

Cranfield University

Readily accessible sources for nutrients such as phosphorus (P) and nitrogen (N) are becoming depleted or energetically unfeasible thus leading to a demand for alternative solutions. Recycling nutrients through sustainable methods could be the only reasonable option for energetic and economic reasons. Traditional wastewater treatment technologies remove nutrients by a combination of biological and chemical processes that are well established and perform to the required discharge contents. However, traditional flowsheets offer very limited options for achieving very tight consents as well as nutrient recovery. Ion exchange (IEX) process is a hybrid removal/recovery technique: there is full control of the effluent quality and the nutrient are selectively removed and concentrated in the regenerant from where they can be recovered as valuable products. Although the use of chemical regenerants could be identified as prohibitive, the possibility to obtain marketable products increases the process' economic feasibility. In my project, I will focus on the use of ion exchangers to remove phosphorus and ammonia from wastewater. For the ammonia removal IEX, MesoLite will be used. This manufactured material is produced by chemical modification of clay minerals and other aluminium-bearing materials to produce a predominately tetrahedrally coordinated Al^{3+} ion enhancing the number of exchange sites. On the other hand, the phosphorus will be removed using the HAIX media, where ferric oxide nanoparticles have been embedded to provide very selective uptake of P. The N recovery will be obtained using a liquid-liquid membrane process producing ammonium sulfate, which is a valuable fertiliser. The P can be separated and recovered from the used brine NaOH as a calcium phosphate precipitate by addition of hydrated lime to the regenerant. The product can then be recovered by filtration or centrifugation; this enables restoring the NaOH brine regenerative capability that can be re-used multiple times.

Volatile fingerprinting of potato rots during cold storage

María Gutiérrez-Pozo

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Potato crop is one of the fourth main food crop in the world after maize, rice and wheat, feeding a big part of the global population each year. It is a fat-free food that contains proteins, vitamins and minerals. Potato tuber is very versatile because it can be consumed as fresh, frozen, fried or even dehydrated. Half of the potato crop is sold as fresh product for immediate use, while the rest is stored for up to 10 months. That is the reason why potato storage is essential for the production process. The storage is a dynamic situation, due to crops respiration and its interactions with the environment. Storage conditions must have the capability to react to changes by the optimization of the conditions during the store and the quality maintenance throughout the whole storage period. The main environmental conditions that must be controlled are temperature (8-10oC) and relative humidity (95-100%). A well ventilation control is essential, limited control can create an optimal environment for fungal and bacterial growth, therefore potato spoilage and generation of waste. Nowadays potato storage diseases are acquiring more and more importance due to the increased tendency in the pre-process potato market, which strict requirement is a perfect skin finished without any kind of blemish. A quick, non-destructive and real-time detection would be optimum. When potato tubers are infected by a pathogen, there have been related the released of some Volatile Organic Compounds (VOCs). The aim of my PhD is the identification of potato rots VOC-biomarkers for the development of a low-cost, compact and sensitive multi-species trace gas sensor for the early detection of potato diseases under commercial storage conditions. Also gain a deep understanding of the ecophysiology of important potato pathogens for the development or improvement of new control systems.

3-Minutes Thesis Competition

Improving air quality monitoring in developing countries for better public health and higher quality of life (Ghana case study)

Collins Gameli Hodoli, Prof. Fred Coulon and Dr. Iq Mead

Cranfield University

Ghana being an emerging economic powerhouse in the Sub-Saharan African region, rapid industrialization and urbanization integrated with high demands for energy, food and water imposes pressure on the environment to sustain the increasing population. This requires appropriate policies on environmental resources management to control and mitigate adverse impacts. One of these areas is air quality monitoring but this is primarily difficult to undertake in Ghana because traditional air quality monitoring equipment are expensive to purchase and maintain. There is also lack of governmental support, limited infrastructure and resources as well as expertise with current technical know-how. Other contributory factors include heterogeneity of the Ghanaian environment coupled with poor participation of stakeholders and the media, prevalence of ad hoc awareness raising and capabilities for delivering air quality monitoring strategies which is characteristic of Sub-Saharan Africa.

In order to understand and characterise the sources of selected/scheduled key pollutant species and develop appropriate mitigation strategies and implement environmental guidelines, air quality monitoring must be routine on long-term basis. Relatively low-cost emerging cutting edge sensing technologies are capable of collecting fast, reliable, real-time and onsite data. These simplified remote sensing and environmental technologies have the potential to provide us with data in infrastructure deficient and complex environments such as Ghana at a relatively low-cost as compared to the traditional air quality monitoring equipment. These sensors are robust, operate on low-power and useful in setting up high-density networks for air quality monitoring and suitable for the Ghanaian case study.



BEST 3-MINUTES THESIS COMPETITION AWARD

Application of Microbubbles and Nanobubbles in Drinking Water Treatment

Alexander John

Cranfield University

Within the water industry there is a drive to reduce cost and increase the efficiency of drinking water and wastewater treatment. One technology that has shown promise in this area is the generation of microbubbles and nanobubbles.

Owing to a smaller size, their surface area to volume ratio and internal pressure are much higher than bubbles produced through conventional treatment methods. The potential avenues for implementation include aeration, dissolved air flotation and advanced oxidation processes. Previous work within wastewater has shown that the properties of microbubbles and nanobubbles, an increased surface area to volume ratio and increased internal pressure, result in a faster rate of reaction and a higher rate of mass transfer which leads to a faster, more efficient treatment.

The viability of microbubbles and nanobubbles in drinking water treatment processes has not been fully confirmed. A particular problem in the treatment of drinking water that could benefit from the application of microbubbles and nanobubbles is the removal of pesticides. Regulations for the amount of pesticide allowable in drinking water are strict and there are considerable practical difficulties in meeting these legislative limits due to their resistance to conventional treatment. This research project looks at the application of microbubbles and nanobubbles in the treatment of drinking water with a focus on the removal of pesticides using ozone.

Minimising Disinfection by Products

Erin Losty

Cranfield University

There are over 600 known Disinfection by-products (DBPs), THMs (Trihalomethanes) and HAAs (Haloacetic acids) are the most abundant, and are usually used as an indicator for formation of total DBP mixture. The discovery of nitrogenous, brominated and iodinated DBPs, although present at lower concentrations, have shown to be more cytotoxic and genotoxic than their more prevalent counterparts. In 2011, WHO stated, by keeping THMs and HAAs below the guideline values, this will provide adequate control of all DBPs, despite the fact that 45-50% of the total organic halide concentration, representing the halogenated DBP mixture, is unidentified. This partially defined mixture is therefore characterised by its THM and HAA components, and is assumed these can act as a proxy for the composition and toxicity for the whole mixture.

Understanding the relationship between the control pathway and DBP formation is key to giving an insight to their occurrence and exposure. NOM (Natural organic matter) in raw waters act as precursors to the formation of DBPs through the treatment and disinfection process. NOM is a highly complex mixture, its variable and unpredictable nature can make it difficult to predict the DBPs formed. Because of this, the toxicity and exposure to DBPs is also difficult to predict. Little is known about components of the mixture, their interaction and hence their toxicity. Therefore, risk assessment of human exposure becomes difficult to assess.

Analytical methods for the determination of 35 DBPs from 10 categories were used to determine DBPs giving a better understanding of the composition of the DBP mixture. Coagulation, Ion exchange, Advanced oxidation processes and Nanofiltration treatments were also performed on four different water sources. Similarities and correlations between DBPs with aggregated water sources may suggest some universal indicators within water sources and give a better understanding of the DBP as a whole mixture.

Potential biological control agents from strains isolated from gm and non-gm brazilian maize for control of *Aspergillus Flavus* and aflatoxin B₁ production

Alessandra Marcon Gasperini

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Contamination of maize by *Aspergillus flavus* and the production of aflatoxins imposes an extensive socio-economic cost. Among the measures studied to reduce the risk of mycotoxins, biocontrol has been considered a promising technology for sustainable agriculture. A potential option for *A. flavus* management in the field has largely been focused on the use of atoxigenic isolates of *A. flavus* which may be able to compete with the toxigenic strains by displacing them and reducing aflatoxin B₁ (AFB₁) contamination. Thus, the aim of this work was to identify potential biological control agents isolated from distinct Brazilian GM/non-GM maize cultivars for control of AFB₁. The control of AFB₁ production using different initial inoculum ratios of 4 atoxigenic strains of *A. flavus* (AFL-) isolated from Brazilian GM/non-GM maize with 3 different toxigenic *A. flavus* strains was examined. The mixtures of spores of the strains were spread-plated on maize meal agars using a GM maize cultivar (P30F53F) and its respective non-GM isogenic (P30F53) cultivar as substrates. The AFB₁ content was evaluated by HPLC-FLD after 7 and 14 days of incubation. All the AFL- strains were able to reduce the AFB₁ production in both 0.98 and 0.95 a_w treatments after 7 and 14 days at 30°C. The ratios of 50:50 and 25:75 of AFL⁺:AFL⁻ were not statistically different at 0.95 a_w and the overall relative reduction of AFB₁ at the end of the incubation period was 46%-100%. There was no difference in the results obtained using GM and non-GM maize as a nutritional matrix in terms of AFB₁ production or the relative amounts of control achieved. These results are a good method for effective screening of candidates for in vivo assays.

Effect of Upstream Gas Injector type and distance on two phase flow structure and behaviours of a multiphase flowmeter

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This study investigated the effect of three different types of gas injectors and two different injection distances on co-current horizontal to vertical upward air–water two-phase flow into a Venturi multiphase flow meter. The test loop has a horizontal length of 27 m with a blindtee and, on top of it, a vertical Venturi multiphase flow meter (VMPFM) was implemented. Measurements were taken by using conductivity ring probes (installed 0.43 m upstream of the blindtee), and the Wire Mesh Sensor (WMS) (installed between the blindtee and the Venturi inlet). Pressures at the key locations along the flow loop are also measured. The nominal air and water superficial velocities used for the study are in the range 0.5 - 4.5 m/s and 0.2 – 1 m/s, respectively. In order to find out the influence of gas injecting manners on the flow structures the void fractions in the horizontal section and VMPFM inlet were analysed, and the Venturi differential pressure signals were characterised.

It was found that the void fraction distribution obtained from the WMS shows a typical centre peaked void distribution that increased with increase in air superficial velocity, the void fraction related to the 290D upstream gas injection point was lower than that to the 100D upstream gas injection point, while the void fraction's Probability Density Function distributions of the three injection types, were similar. The characterizations of Venturi differential pressure drop signals with the aid of root mean square (RMS) show that the gas injecting methods did NOT have significant influence on the differential pressure signal behaviours, while the upstream gas injection distances DID have.

Future hunger: the way forward

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Degraded soils are associated with declining soil organic matter, low nutrient status and low crop productivity. Low agricultural productivity is a major threat to achieving global food security hence improving the productivity of degraded soils is key achieving to sustainable food production. This study investigated the effects of 4 soil amendments (mushroom compost, MC; PAS-100 compost, PAS; Anaerobic digestate solid waste, AD_SW; and Poultry manure, PM), applied at 10 t ha⁻¹ and 30 t ha⁻¹ on the physical, chemical and biological SQIs of a degraded sandy loam soil. The treatments were arranged in a completely randomized design in a greenhouse and replicated four times. The soil and organic amendments were thoroughly mixed and incubated for two weeks. Thereafter, maize, Zea mays, (Severus variety) was planted. Composite 3-point soil samples were taken from each treatment replicate at post-harvest (POH) for analysis. The following soil SQIs were analysed: pH, soil organic matter (SOM), Olsen P, available K, total oxides of nitrate (TON), ammonium-N, microbial biomass carbon (MBC), and bulk density. The data generated were subjected to analysis of variance (ANOVA) followed by post-hoc Fisher LSD analysis at 5% probability level. The results revealed that the organic amendments at any application rates had remarkable improvements ($p < 0.05$) on the SQIs. For instance, the Olsen P increased from 33 mg kg⁻¹ (baseline result) to 121 mg kg⁻¹(POH result). Similarly, the SOM increased from 2.33% to 3.74%, MBC (71.6 – 431 mg kg⁻¹); TOC (0.25 -9.89 mg kg⁻¹) and available K (87.3 – 1600 mg kg⁻¹) as compared with the control (un-amended soil). Application of PM, PAS, AD_SW and MC at 30 t ha⁻¹ best improved the soil physical, chemical and biological soil conditions and significantly increased maize yield.

A holistic modular power management framework to achieve resilience operation of microgrid including electric vehicles

Mohammed Alkhafaji, Prof Patrick C.K. Luk, Dr John Economou

Cranfield University

The electricity become essential in our life whereas the electricity network has a major impact on our life style. Due to several changes in the nature of the elements of the electricity network such as integrating renewable energy, electrified transportation sector, and change the nature of load from single direction to bidirectional bring many challenges to the existing electrical system that increase the possibility of electricity congestion. Therefore, development the exciting electricity system to an automated system focusing on reconstructed the distribution network to microgrid network becomes important to ensure process electricity to the end users. The study presents a holistic approach from three levels, which are MGO, CSO, and EVO, to manage and control power flow of microgrid network regarding balancing the supply of the distributed generates and EVs with electric demand. The EVs are powered by both battery and supercapacitors. It is demonstrated the multidisciplinary problem of managing and controlling energy and power indecomposable in such a way that three major processes and the links between them can be identified. This paper illustrates the modular structure of managing power flow of microgrid that consists of thirteen various distributed generators, loads, and EVs. Each EV is connected to the microgrid and has multiple energy resources. The paper describes two optimisation formulations to manage the microgrid and EVs operation respectively. The objective function of the microgrid management used MIQP optimisation formulation to control and to schedule the operation of the distributed generators, EVs and the electrical demand to avoid possible over loading or network degradation. The objective function of the EVs management used a MILP optimisation formulation to control the power flow from battery and supercapacitors of the EV with microgrid. The analogies presented in this paper explicate and demonstrate the problem as a chronological systematic implementation framework.

Solute and matric potential effects on growth and ochratoxin A production by *Penicillium verrucosum* and *Aspergillus westerdijkiae* contaminating wheat and coffee

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Ochratoxin A (OTA) contamination of wheat and coffee is caused by *P. verrucosum* and *A. westerdijkiae*. These fungi usually survive in soil and on crop debris and colonise cereals and coffee respectively, during harvesting and storage. There is thus interest in understanding the relationship between key environmental factors which influence growth and mycotoxin production. This study has examined the effect of interacting conditions of water stress x temperature on growth and OTA production by strains of these two fungal species. The effect of non-ionic, ionic and matric stress on growth was compared at different temperatures. The impact on relative amounts of OTA which was produced on a conducive Yeast Extract Sucrose medium (YES) and on wheat-based medium was examined for *P. verrucosum*. This showed that there were significant differences in the relative tolerance of solute and matric potentials for these two fungi. The minimum water activity (a_w) for growth in glycerol-amended medium was 0.90, for ionic solute (NaCl) 0.86, and for matric stress was 0.86. The optimum a_w x temperature conditions for OTA production on non-ionic amended media by *P. verrucosum* was at 0.98 a_w and 25°C. For *A. westerdijkiae* this was also 0.98 a_w and 25°C. Studies are in progress to better understand the molecular basis for the differences between these types of water stress. Studies are also being carried out to screen different natural preservatives to control growth and OTA production by these two species in wheat and coffee. Climate change impacts on contamination will also be investigated in due course.

Energy demand and solar data analysis for efficient solar PV systems

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Solar energy is one of the most abundant energy resources on the earth capable of providing the world energy demand if properly harnessed. The tremendous rise in global energy demand has spurred researches into the use of solar energy for energy supply. The utilization of solar energy to economically meet the world's increasing energy demand depends on two factors: availability of solar energy resource and appropriate technology to harness it. This study will evaluate the performance of systems for the utilization of solar energy in a particular location, knowledge of the available solar energy at the location is imperative. This paper therefore presents the energy analysis of a village in the North-East Nigeria and the solar data analysis for an efficient solar Photo Voltaic System for energy supply. The total energy demand for the village including schools, hospitals, markets, garage etc. is 1 MW. The average solar irradiance for North-Eastern Nigeria which lies between latitude 11.90 and longitude 13.10 for over a period of ten years is 409.15 W/m². The average sunshine hours for the area under study is 11hours 50 minutes. It is obvious that the utilization of solar energy in North-Eastern Nigeria is economically and technologically viable.

Core loss analysis of a ferrite interior permanent magnet motor

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This paper presents the impact of rotor design parameters of a ferrite interior permanent magnet (IPM) on the core losses. The losses are calculated for a model of a spoke type configuration including the higher order harmonics. Two-dimensional finite element software (2D FEM simulations) is employed to analyse and solve the models of the machines. Ferrite IPMs with one-, two-, and three-layer configurations are considered. The influence of the PM poles dimensions and locations on the core losses is comprehensively investigated and discussed. Comparison between these configurations is carried out to reveal the influence of the number of layers.

Power Control and Fault Analysis of VSC-based Multiterminal HVDC of Offshore Windfarms

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Cranfield University

High voltage DC transmission is gaining more attention since it has no reactive power considerations, it can transmit power over long distances together with the advancement of power electronic devices and the reduced costs for such systems have resulted in increased popularity.

With advent of voltage sourced converter (VSC) constructing DC networks in a multiterminal high direct current (MTDC) becomes more convenient way and easier to implement. In this project a three terminal MTDC network was proposed based on a series connection of diode rectifiers and VSC to perform a multiterminal system to save the cost of using VSC alone and to achieve the controllability of using diode rectifier alone. To assess the performance of the proposed configuration under various operating conditions such as, for example, faults and normal operational conditions, a universal model was designed and then implemented using MATLAB/Simulink software. A detailed fault analysis was carried out to evaluate the proposed topology under DC faults such as pole-to-pole and pole-to-ground, and AC side fault, which in turn can be either symmetrical or unsymmetrical fault. The unsymmetrical AC fault requires a modification of the control system (dual control strategy/reconfigurable control) by taking into account the negative sequence component of the current, and this requires a separation of the dq current and voltage into a positive sequence dq current and negative sequence dq current. The separation of the components can be implemented using many methods such as delayed signal cancelation (DSC) or by using the notch filter. The proposed model shows an improved performance after fault clearance in terms of current overshoot and the time required for the system to return to its steady state conditions.

Reusing wastewater for the irrigation of food crops in drylands

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Water scarcity severely affects drylands threatening their food security, whereas, the oil and gas industry produces significant and increasing volumes of wastewater that could be reused for agricultural irrigation in these regions. The literature review that we carried out shows that there is potentially sufficient water to irrigate about 150 000–300 000 ha/year of cropland in arid and semi-arid areas. The quality of oil and gas wastewater is often a limiting factor for the reuse in irrigation as it can lead to soil salinisation, sodification, and heavy metals build-up. Although the inappropriate use of oil and gas wastewater in irrigation could be damaging for the soil, the agricultural sector in dry areas is often prone to challenges in soil salinity.

The next objectives of the research will be to model the effect of irrigation with oil and gas wastewater on soil salinity, sodicity and crop yield in different climates and soils typical of drylands. In addition, the effect of mitigation measures such as water treatment, soil amendments and crop rotation will be modelled in order to identify the best practices to control salinity and sodicity risks. The cost of using oil and gas effluents in irrigation will be compared to alternative irrigation water in drylands. Finally different irrigation scenarios will be compared in order to assess their agro-economic sustainability, the developed framework will be applied to case studies.

In short, this research approaches a recent aspect of the energy-water-food nexus: The opportunities and challenges behind the reuse of abundant oil and gas effluents for irrigation in hydrocarbon-rich but water-scarce and food-unsecured drylands.

Investigation of Nanoparticle Deposition and Fluid PH Level Effects on Surface/Liquid Ionic Interaction

Ali Naser

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The sustained growth in energy consumption worldwide continues to raise concerns over the difficulties of its supply. While constructing new power plants may be a solution for such problem, improving the systems efficiency of existing ones would be beneficial in terms of reducing such acceleration in demands. One of the area that requires special attention is the piping systems (PS) that host the heat transfer fluid (HTF). A large amount of energy is required to circulate the HTF and overcome the pressure losses caused by the surface-fluid interaction along the PS. Such obstacles can be reduced by modifying the characteristics of the surface of the PS and/ or HTF.

This research focuses on studying the effect of surface-fluid ionic bounding's and surface topography on the wettability of the surface by using nanocoating technique and alternating the HTF PH levels with a view to reducing the pressure losses and hence, the power required to move the HTF. A sample of Aluminum (Al) was selected as a substrate with deionised water (DIW) of different PH acting as the HTF's. The sample was nanocoated with Al using physical vapor deposition (PVD) process to fabricate Al film of 100 nm. Microstructures of the sample before and after coating were observed using an atomic force microscopy (AFM) and a high speed video camera was used to examine the influence of surface topography on the HTF's droplets through their contact angles with the substrates surfaces. The results showed that the contact angle between the HTF's and the substrate was mainly effected by the ionic bounding interaction which was increased/decreased by changing the PH levels of the fluid. It also revealed that, while nanocoating had decreased the surface roughness up to 50%, it highly promoted the ionic bounding mechanism. Such findings can be adopted to enhance the efficiency of the PS in power plants.

Optimizing the location of distributed generators in microgrid based on voltage stability analysis

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Cranfield University

The increasing number of electric vehicles (EVs) and distributed generators (DGs) within the microgrid demands a high-level management to control power flow between them and the voltage stability and angle stability. This paper presents a holistic approach from three levels to manage and control the power flow of a microgrid regarding balancing the supply of the various DGs and EVs with electric demands. The EVs are powered by battery and supercapacitors whereas the powertrain of EVs is connected during parking to the microgrid through modified H-bridge multilevel inverter. This paper demonstrates the multidisciplinary problem of managing and control energy and power in such a way that three major processes and the links between them can be identified. The system implementation has been designed as a unified systematic framework where the power management decomposes into modular blocks in chronological executions. The execution of the framework proceeds to demonstrate a reconstruction of the power management problem. Framework management divides the problem into smaller groups to control specific functions which are Microgrid Operator (MGO), Charging Station Operator (CSO), and Electric Vehicle Operator (EVO). MGO-strategy is a plan of actions designed to achieve a long-term or overall aim of the power generation from DG of the microgrid to balance the electrical demand. The objective function of the MGO management used MIQP optimisation formulation to control and to schedule the operation of DGs, EVs and electrical demand to avoid possible overloading or network degradation. CSO-policy and EVO-procedure dictate how charging/discharging occur in each area of the microgrid. The objective function of the CSO management used MILP optimisation formulation to control power flow from the battery and supercapacitors of the electric vehicle to the microgrid. The EVO-process implements by linking three sub-process involving the EMS-regulatory for energy management system, PMS-advisory for power management system, and PES-instructive for power electronic interface.

Impact of integration electric vehicles to the microgrid

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Cranfield University

With increasing penetration of renewable energy sources such as photovoltaic (PV) panels and wind turbines, a more structured approach to deal with the uncertainties occurring in the new power system is desirable. In particular, voltage stability becomes essential in smaller distribution networks with distributed micro sources balancing the demand of a cluster of dynamic loads. Distributing the micro sources optimally and efficiently could play a significant role to enhance voltage stability in the system especially in heavily loaded conditions and alleviate the distribution network from the rapidly increase in the electrical demand. The size and placement of distributed generators in a microgrid should be optimised in order to achieve the maximum benefits of the operation. Therefore, the location of distributed generators should be formulated according to the weakest bus on the system for each iteration of voltage stability analysis. In this paper, the impact of distributed generators, which are mainly located at the distribution level, on the voltage stability of smart grid is studied by using the Matpower program to perform systematic power flow analysis. Voltage stability and the weakest bus are determined by using the eigenvalue and participation factor analysis methods respectively. The analysis is demonstrated in a realistic case study of 7 feeders and 49-busbar microgrid connected to the transmission line of a typical power system. The results show that the optimal allocation of the distributed generators on the microgrid has significant impacts on voltage stability enhancement for the microgrid as well as the transmission line.

A new modular power management framework for operating bidirectional vehicle to grid system within microgrid

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The uptake of the electric vehicles (EVs) market is set to create a considerable amount of loads for the electrical power distribution networks in the near future. In general, the EVs will be connected at various locations of electricity network at the different times of the day for the recharge of their batteries. The charging demands of the EVs may tend to coincide with the peak demands of the power distribution network, thus adding extra burdens to the generation capability. On the other hand, the incorporation of microgrids to the existing distribution networks not only enables the penetrations of renewable energy resources but also allows the EVs to be connected as energy storage or even generation units. This paper presents an analytical approach to integrate EVs into the microgrid in order to enhance its voltage stability. Analytical characterization equations linking the microgrid and the EVs are first developed. Then, based on a practical distribution network and realistic load conditions, case studies are undertaken to show the positive impacts of EV integration. Matpower program is used to formulate and perform the power flow analysis. Eigenvalue, eigenvector and participation factor analysis are used to monitor voltage stability and identify the weakest bus on the system. The results show quantitatively the extent to which the addition of electric vehicles can enhance voltage level and voltage stability of the system under study.

Battery energy storage based on D-STATCOM device in distribution grid systems

Shatha Al-kubragyi, Prof. Patrick C.K. Luk, Dr. John Economou, Mohammed Al-Saadi

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Energy storage technology and Flexible AC-Transmission System (FACT) devices have emerged to facilitate the increasing amount of distributed energy generations in modern distribution grids. D-STATCOM is an advanced FACT device that is used in distribution systems. Basically, D-STATCOM acts as a reactive power compensator and voltage controller at the point of common coupling. However, it is limited in its application to improve active power in the system. Therefore, energy storage system devices have been adopted to meet the power system requirements for active power. In this study, a new configuration of D-STATCOM with battery energy storage system is proposed. As a result, the D-STATCOM improves the voltage stability by supporting the grid with active and reactive power. Moreover, simulation results show a significant improvement of the bus voltage under various load conditions.

D-STATCOM Based on Energy Storage for Fault Ride through in Distribution Grids

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Distribution power systems have advanced to work smartly using distribution generators. The interaction of distribution generators with the traditional distribution grid has resulting in bidirectional power flow in the grid. However, distribution generators may affect the power stability and power quality adversely. The battery storage system is widely used in power system applications to solve the power quality problems in distribution power grids, as it provides high energy density compared to other storage types. There are many studies in the literature explaining different strategies to integrate the battery storage system with D-STATCOM. However, the control and the analyses methods of energy unit placement with D-STATCOM during fault condition need further investigation. In this study, the battery storage based D-STATCOM was proposed to provide average power requirement as well as reactive power requirements. The model of the system and control design have validated through simulation results by MATLAB/SIMULINK. The results demonstrated a significant improvement in the performance of the D-STATCOM based Battery Energy Storage System (BESS), which provides the grid with required amount of active power and hence improved power quality in the distribution power grids.

Multi-Period Scenario-Based Stochastic Combined Dynamic Economic Emission Dispatch of the Microgrids

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This paper presents a developed robust multi-period two-stage stochastic power dynamic economic and emission dispatch of the MG based on the unit commitment (UC) to minimize the total operating cost. The costs of emission of greenhouse gases, reactive power production, and battery degradation with the active and reactive security constraints are considered in the proposed stochastic optimization approach. The uncertainties that come from the fluctuations of renewable generation are mathematically modelled and incorporated with optimization algorithm to study the impacts of these uncertainties on economic operation of the MG. The proposed stochastic approach is a two-stage optimization, where the first stage is the day-ahead scheduling based on the forecasted data, whereas the second stage is emulated the real-time operation by considering the wind turbines (WTs) and photovoltaic (PV) panels generation variability, where the UC is not changed in the second stage. The proposed optimization approach is applied to the grid-isolated mode. The results reveal that the optimization approach can accommodate the uncertainties. Besides, feasible solution can be obtained for all scenarios.

Impacts of Storage Battery on the Economic Operation of the Microgrids with considering the battery degradation cost

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This paper presents a fully developed unit commitment (UC) combined economic emission optimization approach of microgrids (MGs) to minimize the total operating cost. The models of the reactive power cost, battery operation cost, and emission of greenhouse gases cost with considering a comprehensive set of constraints including steady state security constraints (SSSCs) are considered in the formulation of the optimization problem. Besides, the UC takes into consideration both the active and reactive power when formulating and solving the optimization problem. The impacts of the energy storage on the optimal operation are investigated by applying the proposed optimization approach on the system with and without energy storage. Different scenarios of battery state of charge are considered and the optimization approach is applied to the low voltage multi-feeder grid-connected MG. The results show that the charging and discharging operations of storage battery would typically reduce the total operating cost and maximize the profit, even accounting for battery degradation cost.

Capturing the value of the circular economy through reverse logistics

Serhan Alshammari

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The take-make-dispose economy is very risky for businesses and globe with finite resources. The projections of raw materials consumption is a major challenge for businesses to survive in the future. The scarcity of material drives the legislator and companies in the first place to adopt CE model to sustain themselves. A major enabler for CE model for businesses in term of material usage is reverse logistics where the companies optimize the use of material without compromising the future projection. In order to benefit the most from such a process such as RL to enable CE the companies must understand the requirements of adopting such a process. Here we will present a reverse logistics maturity model that will help the companies to first understand their RL structure and then tap on the potential areas for improvement with RLMM. The RLMM capture the RL components in three level of decision making Strategic-tactical-performance.

Effect of acclimatisation of *Aspergillus flavus* strains on aflatoxins contamination and colonisation of pistachio nuts

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Pistachio nuts can be contaminated by *Aspergillus flavus* under warm and humid conditions. This can result in contaminate with aflatoxin B₁ (AFB₁), classified as a class 1a carcinogen. There have been no studies on the impact that acclimatisation of *A. flavus* to elevated CO₂ may have on colonisation and aflatoxin B₁ contamination. Thus the objectives of this study were to examine whether acclimatisation to 1000 ppm elevated CO₂ of *A. flavus* strains AB3 and AB10 (5 generations) affected AFB₁ production and mycelial growth under interacting Climate Change conditions and compare this with non-acclimatised cultures. The results of this study showed that acclimatisation influenced growth of one strain while there was no significant effect on another strain when colonising pistachio nuts. For AFB₁, the production was significantly stimulated after ten days colonisation after acclimatisation for one strain, while there was no significant increase for the other strain. This suggests that there may be intra-strain differences in effects of acclimatisation and this could influence mycotoxin contamination of such commodities as mixed population of contaminant fungi often occurs. More studies are needed on the acclimatisation of fungal pathogens and their effect on crops under Climate Change scenarios to obtain more accurate data on implications for mycotoxins contamination of economically important commodities.

Can cleaning products provide a safe, hygienic environment for pit latrine users without impacting the surroundings?

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Pit latrines are the most common form of improved sanitation facility in low income countries. In 2013 it was estimated that there were 1.77 billion people world-wide using them as the primary form of sanitation. Pit-based sanitation systems are normally designed to encourage solid liquid separation with the liquid fraction of excreta treated by soil processes as it percolates into the surrounding ground and the solids degrading in the pit and becoming available for nutrient recovery. Commercial cleaning chemicals are frequently used to clean the hard surfaces surrounding the pit latrine as well as being added to the pit itself to combat malodour. There is however concern that the cleaning products may impact the biological processes within the pit latrine which may result in pit latrines filling more quickly and a lack of pathogen inactivation. This would make the use of the faecal matter as a fertiliser more hazardous due to an increase in pathogenic bacteria. There is also concern that disinfection by-products formed through use of cleaning chemicals in pit latrines could potentially contaminate ground water and enter drinking water supply presenting a hazard to human health. However, there is to date limited evidence on this potential impact.

To shed light on these concerns, this study will investigate the impacts of a hypochlorite based, a hydrochloric acid based, a surfactant based and a percarbonate based commercial cleaning chemicals on (i) the biological degradation of faecal matter and (ii) the faecal microbial community dynamics and activity. The fate of the cleaning products and their derivatives will be also investigated to ascertain the potential risk to groundwater and surrounding environments. Results will be integrated into a multimedia model to predict the impact of cleaning products on faecal degradation and inform pit latrine management.

A semi-quantitative survey of fat, oil and grease management in food service establishments

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Fat, oil and grease (FOG) rich wastewater disposed from commercial kitchens into the sewer system can be controlled through the installation of point of use mitigation devices. Failure to install or properly maintain these mitigation devices can result in: increased FOG discharges, deposits formation and sewers failure. This semi-quantitative survey aimed at understanding the current FOG production and management in UK food service establishments (FSEs). Lack of “at source” FOG control and inappropriate maintenance of cooking devices, considered the main issues for FOG pollution, was observed in the majority of the 39 FSEs interviewed. 77% of the interviewees acknowledged the risk associated with FOG material discharged down the drain but didn’t link it to kitchen management. In addition, FOG management is not recognised as part of the Environmental Health Officers (EHOs) monitoring indicating that ‘technical’ FOG prevention and mitigation needs to be accompanied by a better training of FSEs staff and HEOs about FOG pollution and its impact.

Low carbon remediation approach to support sustainable risk based decision making

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More than 200 years of industrialisation has left a legacy of contaminated sites across Europe. According to the European Environment Agency, around three million sites in our continent alone are affected by potentially polluting activities, of which about 500,000 are in need of remediation. As a result, there is considerable pressure to develop innovative and cost-effective solutions to the problems posed by pollution.

This study uses a range of biological assays to assess efficacy of remediation and the ecological health of soils from two former gas works sites undergoing various remediation treatments. The indicators that optimally differentiated the extent of soil remediation were biomass-C, bacteria count, respiration, earthworm toxicity, and mustard seed germination. A six month laboratory scale study was carried out to compare biochar and compost techniques for the remediation of soil contaminated with tar. Replicate biochar and compost were amended with either commercial compost and wood shavings, biochar or no amendment. In addition to fractionated hydrocarbon analysis microbial characterisation and soil eco-toxicological assays were performed.

BACTERIA: Big Data Communication Strategies for Bioaerorols

Martina Della Casa

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Bioaerosols are particles of biological origin suspended in the air that can cause negative health effects on people. These can be released from both natural and anthropogenic sources such as composting facilities. Over time studies have been carried out in the UK to gather data on their concentration and dispersal behaviour in order to better deal with health-related issues. So far, however, these data have not been put together (“big data”) and analysed as a whole using statistical software and GIS maps. Our hypothesis is therefore that the use these approaches to analyse existing data can provide new perspectives that will lead to a measurable reduction in impacts from waste management and other activities responsible for bioaerosol release. In order to analyse those data, R, R Studio, OpenAir and ArcGIS will be used. The results will be then communicated to the public using risk maps and stakeholder mapping techniques.

Ecological and hydromorphological responses to the restoration of lowland chalk streams

Mickaël Dubois

Cranfield University

Chalk streams are unique aquatic ecosystems supporting diverse and productive ecological communities. The low energy, groundwater-dependent systems were biodiversity hotspot, but human activities (channel realignment, weirs, groundwater abstraction) have impacted the flow regime and the habitats. With increasing urbanisation, agricultural intensification and demand for drinking water in chalk catchments, conservation of these important ecosystems is challenging. Water companies are working closely with environmental regulators to reduce the impact of water abstraction on the chalk streams, but require additional evidence on the impacts of flow and habitat restoration to develop long-term plans.

Working with Affinity Water and the Environment Agency, this research project is investigating the impact of groundwater abstraction reduction and physical habitat improvement on fish communities in lowland chalk streams in the south east of England. Therefore several methods are being used to document and quantify changes in hydromorphology and ecology. First, historical fish monitoring data, water quality and river restoration records are being analysed to identify spatial patterns, temporal trends, and possible correlations between fish populations and environmental parameters. Second, field surveys are being conducted at sites of groundwater abstraction reduction and physical habitat restoration. For hydromorphological monitoring, the state of the art technique Structure from Motion photogrammetry (SfM), is being applied to create digital terrain models and orthophotographs, supported by standard geomorphological surveys. The biological surveys involve standard fish sampling technique such as electrofishing, as well as camera trapping and e-DNA surveys. By studying both the hydromorphology and fish community, we can better understand how coarse fish species are linked to their habitat. Finally, this empirical evidence will be used to refine models of fish community dynamics in chalk streams that will support the development of conservation strategies to protect these critical ecosystems for the future.

Spatially heterogeneous tillage and soil resilience

Iain Dummett

Cranfield University

The degradations of soils represents a threat to the sustainability of the global agrifood system. Soil biological communities have long been overlooked and undervalued with respect to their contribution to the generation of ecosystem services in the agricultural context. More recently, an acknowledgement that current agricultural practices in developed nations are not sustainable has highlighted the challenge of identifying practices which are complementary to soil biological communities and their potential for generating ecosystem services in support of crop growth. Sustainable tillage has emerged as one of a number of practices which can contribution to a more sustainable agricultural system in the UK. The research to be presented investigates the effects of strip tillage, a form of sustainable tillage, on soil health with a focus on the resilience of soil biological communities.

Assessing the potential of biochar for soil quality improvement

Jude Ene, Jane Rickson, Ruben Sakrabani

Cranfield University

Biochar is a carbonaceous by-product of organic amendments that has gone through thermal treatment under reduced or low oxygen conditions to produce stable charcoal-like materials. It has been shown to be an effective and sustainable soil amendment to reverse soil degradation and improve soil quality so that a wide range of ecosystem functions can be delivered by soils. These include food production to address global food security issues and the mitigation of climate change through carbon sequestration.

However, little is published on the effects of biochar applications on soil physical and hydrological properties, namely runoff generation, soil erosion and infiltration. These processes are related to the water regulation functions of soils.

The aim of the study is to evaluate whether biochar (derived from mixed wood feedstock) treatments can improve soil quality and thus the delivery of vital goods and services such as water regulation. To achieve this aim, the study will: 1) characterise the properties of soil / biochar treatments; 2) quantify how runoff, soil erosion and infiltration are affected by biochar application rate and method, biochar particle size, rainfall intensity and duration, and soil type; 3) Investigate biochar effects on biotic communities and activity, and how this influences aggregate stability and hydraulic conductivity; 4) assess the effects of biochar aging on soil quality characteristics. The soil / biochar treatments are currently being characterised in Phase 1 of the study. This will be followed by the hydrological experiment in Phase 2 and the biochar aging experiment in Phase 3.

It is hypothesized that 1) application of biochar to soil reduces runoff and erosion, whilst increasing infiltration; 2) biochar applications increase sorption of organic matter and higher microbial activity to improve aggregate stability and soil structural stability; 3) the physico-chemical properties of biochar determine its effects on aggregate stability, infiltration, runoff and soil loss.

Designing a close loop system for tequila production through materials innovation: An automotive industry case study

Paola Escamilla Greenham, Dr. Adriana Encinas-Oropesa, Dr. Mariale Moreno, Dr. Giorgos Kopanos

Cranfield University

During the tequila production process, agave plant leaves are removed to harvest the stems. Stems are used to extract the base ingredient of the beverage. Approximately 1 million tons of Agave tequilana are produced and processed annually in restricted areas in five Mexican counties, generating large amounts of agricultural waste (Huitron, Perez, Sanchez, Lappe, & Zavaleta, 2008).

The cellulosic waste, or bagasse, is what is left once the agave plant is cooked, chopped, and milled. What do they do with all this organic waste? (The Yucatan Times, 2014). The aim of this project is to design a waste-based circular material flow prediction model for agave bagasse to fully enable Circular Economy (CE) material flows for interior automotive parts.

By promoting the adoption of closing-the-loop production patterns within an economic system, CE aims to increase the efficiency of resource use (Ghisellini et al., 2016).

The approach of this project will consider possible scenarios from an economic, environmental, and social point of view to propose the best solution for the agave bagasse to flow within a CE point of view.

However, novel materials may have qualities that require new waste management infrastructure: first to identify and separate them, and then to reuse, remanufacture or recycle them. Unless they can be dealt with effectively in the waste stream, novel materials will be discarded as residual waste at best or will contaminate existing value recovery systems at worst. Nevertheless, if these factors are considered early enough in the development of a new material, potential problems can be avoided. Ways to capture economic and environmental value for future use can be designed in from the start (Hazell, 2017).

Simulation of irrigation heterogeneity on golf greens using a ballistics model

Carlos Gómez-Armayones, Jerry W. Knox

Cranfield University

In recent years, rising competition for water, coupled with new environmental regulations, are adding further pressure on water allocations to turfgrass for golf. Under this scenario, irrigating efficiently has become one of the main priorities faced by the golf industry. An efficient irrigation relies on irrigation accuracy (how much and how often do I irrigate?) and irrigation heterogeneity (how much uniform is the water distributed?). Uneven water applications in golf are usually related to excessive water and energy consumptions; to an increase of the nitrate leaching and groundwater contamination; and to a reduction of turfgrass quality. To quantify the impact of sprinkler setup and wind speed on irrigation heterogeneity, a model that simulates irrigation on golf greens was developed. The first phase of this research involved field tests, where there was measured the water distribution pattern of a golf rotor sprinkler under windy conditions. Four setups of pressure and nozzle size were used. In a second phase, a model based on ballistics theory was developed to simulate irrigation in golf greens. This model was calibrated and validated using the data collected in field. By last, simulations were carried out on virtual golf greens to understand the impact of wind speed and direction, nozzle size, operating pressure, sprinkler position and green shape on irrigation heterogeneity. Based on the results from irrigation simulations, it was concluded that increments of wind speed greater than 2 m s⁻¹ affected irrigation uniformity negatively, while sprinkler setup and spacing was more closely related to water depth. This model is presented as a useful tool for the golf industry and research community for a better understanding of irrigation design and management. Further research contemplates the coupling of outputs from the irrigation simulations with biophysical and economic models to quantify the impacts of irrigation management on turfgrass development and the environment.



BEST POSTER AWARD

SMART GROUND: Enhanced Landfill Mining and Closing the Waste Loop

Zoe Griffiths

Cranfield University

Landfills have been used as final disposal sites for industrial, commercial, hazardous and municipal waste streams for several decades. From previously following a linear economy model of take-make-dispose, “non-sanitary” landfills that pre-date the EU Landfill Directive of 1999 currently store an abundance of valuable materials as waste, including secondary raw materials (SRM), rare earth metals (REE) and plastics. With an estimated 150,000 to 500,000 landfills existing in the EU, this represents a huge untapped resource. Enhanced Landfill Mining (ELFM) offers the opportunity to tap into this resource pool and “close the loop” by transforming waste into materials and recovering energy from waste. Such practices reduce the environmental pressures posed by landfills and enhance the security and supply of raw materials within the EU. However, to date there is no inventory available of SRM present in EU landfills, and best management practices to recover SRM are not always optimized and efficient. In this context, Cranfield University as part of the EU SMART GROUND project (GA No 641988) aims to improve the availability and accessibility of data and information on SRM in the EU territory, while creating collaborations and synergies among the different stakeholders involved in the SRM value chain. Specifically, Cranfield University are identifying key stakeholders, developing a training plan, preparing and delivering training courses across Europe and producing e-learning materials on ELFM and the project outcomes. In turn, this will facilitate and encourage the implementation of ELFM projects across Europe and make the opportunity a reality.

Improving air quality monitoring in developing countries for better public health and higher quality of life (Ghana case study)

Collins Gameli, Hodoli, Prof. Fred Coulon and Dr. Iq Mead

Cranfield University

Ghana being an emerging economic powerhouse in the Sub-Saharan African region, rapid industrialization and urbanization integrated with high demands for energy, food and water imposes pressure on the environment to sustain the increasing population. This requires appropriate policies on environmental resources management to control and mitigate adverse impacts. One of these areas is air quality monitoring but this is primarily difficult to undertake in Ghana because traditional air quality monitoring equipment are expensive to purchase and maintain. There is also lack of governmental support, limited infrastructure and resources as well as expertise with current technical know-how. Other contributory factors include heterogeneity of the Ghanaian environment coupled with poor participation of stakeholders and the media, prevalence of ad hoc awareness raising and capabilities for delivering air quality monitoring strategies which is characteristic of Sub-Saharan Africa.

In order to understand and characterise the sources of selected/scheduled key pollutant species and develop appropriate mitigation strategies and implement environmental guidelines, air quality monitoring must be routine on long-term basis. Relatively low-cost emerging cutting edge sensing technologies are capable of collecting fast, reliable, real-time and onsite data. These simplified remote sensing and environmental technologies have the potential to provide us with data in infrastructure deficient and complex environments such as Ghana at a relatively low-cost as compared to the traditional air quality monitoring equipment. These sensors are robust, operate on low-power and useful in setting up high-density networks for air quality monitoring and suitable for the Ghanaian case study.

Catalytic ketonisation of acetic acid over gallium/zeolite catalysts

Hessam Jahangiri

Cranfield University

Catalytic activity of gallium doped ZSM-5 and Zeolite Beta to unmodified zeolites and bulk Ga₂O₃ in the ketonisation of acetic acid in a continuous flow reactor is investigated. Structural and acidic properties of the catalysts were characterised by XRD, N₂ porosimetry, XPS, pyridine DRIFTS, ammonia titration TPD and propylamine chemisorption TPD experiments.

High- value compounds delivered from insects grown on waste

Natalia Jawiarczyk¹, Whitaker K.², Medina A.¹ and Villa R.¹

¹ Cranfield University

² Entocycle LTD, London

In addition to increasing population, limited land and water, and increasing costs of fertilisers and energy, one of the biggest challenges of food production is wastage. Organic waste management is a complex issue involving social, economic and environmental aspects. About 30% of all produced food is wasted in pre- or post-consumption. Annually 250 billion litres of water and 300 million barrels of oil are used to produce 1.3 billion tons of food worth 750 million \$ that is never eaten (FAO, 2013). These materials can be upcycled to high-value products for animal and human consumption using insects. Insect larvae, in particular, or their components, have the potential to become prime ingredients in food and animal feed.

Essential fatty acids, minerals, vitamins and amino acids occurring in significant amounts in the larvae body, are susceptible to modification based on their feeding material, allowing process tailoring for specific compounds. In addition, co-extraction of high- value products, such as antimicrobial and antifungal agents or chitin, have the potential to significantly increase the cost efficiency of the overall process.

The aims of this study was to develop a close-loop system using mild conditions where *Hermetia illucens* larvae grown on organic waste, were extracted using a sustainable cascade process allowing the contemporary separation of proteins, lipids and chitin.

Hermetia illucens was chosen as most suitable candidate due to its non-pest status and its predisposition to process variety type of waste with high converting efficiency (up to 60%).

Preliminary results showed that larvae composition varies with age, mostly for the protein-lipids ratio and that different lipids can be fractionated at different stages of growth. In addition, the use of different extraction techniques at different growth stages, suggests that the process can be tailored to produce the best larvae type-product ration.

A study of flow behaviour of dense phase at low concentrations in pipes

Aminu Koguna

Cranfield University

Production fluids from the reservoir are transported in pipelines from the well heads to the platform and from the platform to process facilities. At low flow velocity water, sand or liquids like condensate could settle at the bottom of pipelines that could lead to grave implications for flow assurance. During shutdown the settled heavy liquid (e.g. water), could result in corrosion in pipelines, while following restart stages the settled water could form water plugs that could damage equipment, while settled sand could also form a blockage that needs to be purged. Furthermore there is a requirement to know the quantity of water and base sediment in fiscal metering purposes. Observations of low water cut in oil and water flows and low sand concentrations in water and sand, water air and sand flows were conducted in four and two inch diameter pipelines. Conductive film thickness sensors were used to ascertain structural velocities and dense phase fractions. Comparisons are made between two cases in order to gain better understanding of the behaviours and dispersal process of low loading denser phase in multiphase flows.

Disinfection by products after membrane nanofiltration

Shaimaa AbdelMohsen

Cranfield University

There are over 600 known Disinfection by-products (DBPs), THMs (Trihalomethanes) and HAAs (Haloacetic acids) are the most abundant, and are usually used as an indicator for formation of total DBP mixture. The discovery of nitrogenous, brominated and iodinated DBPs, although present at lower concentrations, have shown to be more cytotoxic and genotoxic than their more prevalent counterparts. In 2011, WHO stated, by keeping THMs and HAAs below the guideline values, this will provide adequate control of all DBPs, despite the fact that 45-50% of the total organic halide concentration, representing the halogenated DBP mixture, is unidentified. This partially defined mixture is therefore characterised by its THM and HAA components, and is assumed these can act as a proxy for the composition and toxicity for the whole mixture.

Understanding the relationship between the control pathway and DBP formation is key to giving an insight to their occurrence and exposure. NOM (Natural organic matter) in raw waters act as precursors to the formation of DBPs through the treatment and disinfection process. NOM is a highly complex mixture, its variable and unpredictable nature can make it difficult to predict the DBPs formed. Because of this, the toxicity and exposure to DBPs is also difficult to predict. Little is known about components of the mixture, their interaction and hence their toxicity. Therefore, risk assessment of human exposure becomes difficult to assess.

Analytical methods for the determination of 35 DBPs from 10 categories were used to determine DBPs giving a better understanding of the composition of the DBP mixture. Coagulation, Ion exchange, Advanced oxidation processes and Nanofiltration treatments were also performed on four different water sources. Similarities and correlations between DBPs with aggregated water sources may suggest some universal indicators within water sources and give a better understanding of the DBP as a whole mixture.

Measuring and modelling plant-driven soil carbon dynamics

Chris McCloskey

Cranfield University

Soils are the largest terrestrial carbon reservoir, and the stability of soil carbon stocks has important implications for food production and global carbon budgeting. Soil carbon dynamics are therefore currently an area of intense research. In some circumstances plant roots influence the mineralisation of existing soil carbon via rhizosphere priming effects, and have the potential to significantly increase the rate of soil organic matter decomposition. We do not, however, fully understand the factors controlling rhizosphere priming, and it is not well integrated into soil carbon models. This needs to change if we are to understand the role soils may play as a carbon sink or source under a warming climate and rising carbon dioxide levels.

My PhD project aims to investigate the factors, particularly nitrogen, controlling rhizosphere priming effects in a multi-season experiment under field conditions. I will also assess how rhizosphere priming can be represented in soil carbon models and how this affects their medium- and long-term predictions.

I will do this by monitoring gas fluxes from soil in 24 lysimeters containing two different soil types. I am planting these with a C4 grass species, which fixes carbon at different $\delta^{13}\text{C}$ fractionation from the C3 plants previously grown in the soils. This will enable me to distinguish between carbon dioxide produced by the mineralisation of old soil organic matter and that from the respiration of fresh inputs of organic matter into the soil. Two nitrogen treatments will be used to assess the role of nitrogen in the rhizosphere priming effect. This experiment will take place over two growing seasons, generating a relatively long-term dataset which I will use to test and improve existing soil carbon models.

Interaction between flocs and Powdered Activated Carbon particles during the removal of pesticides

Sara Sanchez-Lopez, Jitka MacAdam, Peter Jarvis, Bruce Jefferson

Cranfield University

Drinking water must meet prescribed values for a range of different chemical and microbial parameters. One of the most challenging types of contaminant to treat are pesticides. In some cases, water companies are not able to regularly meet the prescribed levels of pesticides in drinking water: 0.1 µg/L for individual pesticides and 0.5 µg/L for total pesticides for countries in the European Union (Tang et al. 2016). In the United Kingdom, one of the most problematic pesticides in drinking water has been metaldehyde. Metaldehyde is a pesticide used for control of slugs and snails and over 1400 tonnes of metaldehyde were used between 2008 and 2012 (Nabeerasool et al. 2015). Considering that its half-life in water may reach 17 years and because the pesticide is still widely used by farmers (Tang et al. 2016), the need for technology to remove metaldehyde and similarly difficult to remove pesticides is very high.

A number of existing and new technologies are being developed and tested in order to be able to effectively remove metaldehyde. Adsorption of pesticides using powdered activated carbon (PAC) is one of them because it has a very large surface area for adsorption of pesticides and has strong potential for the removal of low molecular weight organic compounds and taste and odour causing substances (Younker & Walsh 2016). However, when PAC is applied into water, effective methods for removal of the adsorbent particles is needed. This is usually achieved through the addition of chemical coagulants followed by clarification of the resultant flocs. In this study, PAC has been investigated as a possible solution for the removal of persistent pesticides, such as metaldehyde, from drinking water.

The aim of this work was to determine the PAC particle and coagulant interaction to understand how effectively the PAC is trapped in the floc and removed from the water as well as understanding the overall pesticide removal; investigate the relationship between the increase of PAC dose and the amount of coagulant needed to effectively remove it from the water; and understand how the dosing position of PAC relative to the coagulant impacts on the removal of the PAC.

Soil Management and the Use of Cover Crops in the UK: A Survey

Tom Storr

Cranfield University

Soil health and cover cropping is the foremost thought of many involved in the arable industry. The need to reduce costs and increase yield to remain profitable is leading many growers to look closely at their soil management practices. For many growers just sustainably managing their soils is not enough - they want to regenerate their soils. Cover crops with reduced tillage are forming part of their approach.

Research on cover crops in the UK is sparse and is only just been published following trials. Recognising that some growers have used cover crops for many years and others are only just beginning to trial cover crops on their farms the survey collected and collated their experiences which total nearly 300 seasons.

The survey was distributed over the winter 2016/17 with responses from all regions of the UK, every soil type and tillage intensity represented. The survey indicates that 95% of farmers are interested in learning about soil health and are using various techniques to measure soil health on farm. In recent years there has been a notable increase in the use of cover crop by farmers - following harvest in 2016 63% of farmers used cover crops. There is evidence that the type of cover crop grown is linked to the soil type of the farm, with tap rooted species utilised on all farms with soils classified as heavy.

The survey acted as a knowledge exchange from industry to academia with the hope that it can inform future trials and advice given to farmers considering the use of cover crops to improve soil health.

Multivariate statistical fault detection and diagnosis for process industry

Ruomu Tan

Cranfield University

Multivariate statistical methods in data analysis have rapidly in this decade. In process industry, these methods are used for analysis and understanding of complex processs of which first principale modelling is difficult; meanwhile a large amount of process data will also facilitate these data-driven techniques. The information extracted from process data can be used for modelling and monitoring of process behaviour. However, many issues that have emerged in monitoring of processes with varying operating conditions and large scale measurement data are still pending. In this work, we investigate Canonical Variate Analysis and its kins as examples of multivariate statistical process condition monitoring algorithms and their application to real industrial-scale case study at the Process System Engineering lab in Cranfield. The advances in multivariate statistical monitoring techniques for complex processes are of great interest from theoretical point of view. In addition, operation safety and efficiency of processes will be enhance by adopting these techniques for decision support and operation assistance.

Pre-feasibility study of utilising geothermal energy on Cranfield University campus

Theodorou Triantafyllos

Cranfield University

The aim of this study is to investigate if the use of geothermal energy for heating would reduce dramatically the Cranfield campus CO₂ emissions. The Cranfield university carbon management plan provides a guideline for a 50% carbon emission reduction by 2020 against the 2005 baseline. The campus heating district nowadays runs with 80°C hot water. However, the coefficient of performance (COP) for a geothermal heating system drops significantly when heating to higher temperatures >50°C and may not be economically viable at such temperatures.

This report explores the application of ground source heat pumps (GSHP):

- to provide the heating of existing buildings, using Martell House as a case study,
- to find an alternative to the current combined heat and power (CHP) system used by the district heating network, especially for the ever-expanding Cranfield campus.

Potential scenarios are analysed qualitatively and quantitatively detailing the possible technical solutions applicable to Cranfield campus.

Cranfield University site been identified as a spot with neither an unusually high thermal gradient nor a confirmed aquifer. Boreholes heat exchangers (BHE) is the best technology available to provide both cooling and heating. Martell House can be chosen as a pilot project for such technology: 17 boreholes of 300m depth and two heat pumps of 181 kW could supply 70°C hot water for the building for a CAPEX of £445,230 and saving 2,534 t of carbon in 20 years. However, a long-term solution is a satellite system running with geothermal and boosted by the return temperature of the main district heating. It could permit to decrease up to 95% the carbon emissions in 2035 from a 2005 baseline, if all buildings were refurbished and linked to the geothermal district. Such a scenario would be effective only if the distribution system is retrofitted and an energy management system is applied.

Ecosystems and temporal scale in the Water-Food-Energy Nexus

Annie Visser

Heriot-Watt University

The potential for the global human footprint to compromise the security of water, food and energy resources cannot be understated. In response, the Water-Food-Energy (WFE) Nexus, a concept to aid the achievement of sustainable development (Hoff, 2011), has emerged. The WFE nexus scaffolds consideration of the interdependencies and trade-offs between these three pillars, operating compatibly with movement towards the circular economy.

Bidoglio and Brander, 2016, suggest a fourth pillar – ecosystem services (ES). These are the, often irreplaceable, services that ecosystems provide to sustain human life. Despite this, ES have been consistently undervalued in the decision-making process (Costanza et al., 1997; Dudgeon et al., 2006). Freshwater ecosystems, particularly, are known to contribute disproportionately to ES (Dudgeon et al., 2006).

Biotic components, dominating the evolution of lotic ecosystems, are used as indicators of river health and thus its ES capacity; macro-invertebrates are able to reveal both long-term temporal and spatial trends/changes. Being mid-food chain, their study has particular implications for higher-order species, such as fish (e.g. Garbe et al., 2016). There are clear (indirect) implications for both water and food.

Although subject to limited investigation, lag in ecological response to flow-disturbances (flood/drought) are observed in groundwater-fed rivers (see Boulton, 2003; Wright et al., 2004). This work, through a case-study, statistically modelled response of the macro-invertebrate bioindicator to flow (Visser et al., 2017). The consideration of lag appeared to enhance overall model performance ($R^2 > 0.6$). The results revealed that flows may have a lasting effect on ecological health (2-4 years). This suggests that current modelling efforts, and subsequent planning and management decisions, may underestimate the impact of flow disturbances upon the health of the lotic ecosystem. The need to consider a much broader temporal scale offers potentially essential input to an expanded WFE Nexus which acknowledges the key role of ES.

Conference Program

16th June 2017 - Vincent building (52a) Auditorium
 **#cranWEF17**

For each speaker: 12 min presentation + 3 min Q&A

09:30	Registration
10:00	Keynote speaker : Dr Doug Wilson, Director of Scientific and Evidence Services at Environment Agency (30 min +10 min Q&A)
10:45	Capturing the value of the circular economy through reverse logistics Serhan Alshammari - s.alshammari@cranfield.ac.uk
11:00	Is Geothermal Energy a sustainable solution for future generations? Theo Renaud - theo.renaud@cranfield.ac.uk
11:15	Modelling innovative cooling technologies in Concentrating Solar Power – Hybrid cooling option Faisal Asfand - faisal.asfand@cranfield.ac.uk
11:30	15 min break - posters
11:45	Sampling of bioaerosols from composting sites using traditional and novel sampling techniques Mohanad Jawad - m.jawad@cranfield.ac.uk
12:00	Using chemical and molecular markers for characterising aerosols from contrasting outdoor environments Sonia Garcia Alcega - s.garciaalcega@cranfield.ac.uk
12:15	Ecosystems and temporal scale in the Water-Food-Energy Nexus Annie Visser - av96@hw.ac.uk
12:30	Reconciling competing demands for water – developing regional scale multi-sector collaborative approaches to water resources management David Haro - d.haromonteagudo@cranfield.ac.uk
12:45	Lunch break - posters
14:00	A novel method for quantifying fat, oil and grease (FOG) in commercial kitchen wastewater Caroline Gurd - c.e.gurd@cranfield.ac.uk
14:15	Recycling water, energy and food by anaerobic digestion Ismail Haltas - ismail.haltas@cranfield.ac.uk
14:30	High-value compounds delivered from insects grown on waste Natalia Jawiarczyk - n.jawiarczyk@cranfield.ac.uk
14:45	30 min break - posters
15:15	Quantifying Soil Constraints to rice production Ezekiel Okonkwo - e.okonkwo@cranfield.ac.uk
15:30	Spatially heterogeneous tillage and soil resilience Iain Dummett - i.p.dummett@cranfield.ac.uk
15:45	Restoring Soil Health and Productivity of A Degraded Soil: Impact on Crop Yield Benedict Unagwu - b.o.unagwu@cranfield.ac.uk
16:00	15 min break - posters
16:15	3-Minutes Thesis Competition
17:00	Conference Prizes – Drinks – Live band

Community Action Platform for Energy (CAPE)

CAPE (Community Action Platform for Energy), part of the Milton Keynes Smart program, is an innovative approach to empower local communities and city authorities to deliver step change community energy initiatives. CAPE combines satellite, aerial, energy and socio-economic data to effectively jump-start community-led energy saving projects so communities, local authorities and local supply chains overcome the barriers collaboratively to deliver projects that have a high social impact and energy savings. Empower citizens to use social media to share their experiences to ensure the wisdom of crowds plus the economies of scale that group buy offer. Allow communities control rather than the suppliers.

Contact: Mohit Makhija - mohit.makhija@techmahindra.com

Douglas Bomford Trust

The Douglas Bomford Trust is a charitable organisation that supports a wide range of activities related to the application of engineering approaches in the land-based sector. An important part of the activities of The Trust involves support for relevant PhD projects where the advancement of science and technology as well as the personal development of individuals are important metrics. The Trust also supports travel to participate in conferences and similar activities and awards student prizes at three universities including Cranfield. The Trust operates with a Board of Trustees and has an office on the Cranfield campus operated on a part-time basis by the technical secretary and finance/administrative officer.

Contact: Paul Miller or Elizabeth Stephens - 01234 750 876 - enquires@dbt.org.uk

Institution of Agricultural Engineers

The Institution of Agricultural Engineers (IAgrE) is a professional membership organisation with grades for all those working, or with an interest in, engineering, science and technology within agriculture and the environment. A registered charity working for the public benefit, IAgrE brings together academics, practitioners and industry to share knowledge and promote professionalism in the advancement and application of technology in the landbased sector. We offer professional registration to members with the Engineering Council and the Society for the Environment.

Contact: 01234 750876 - secretary@iagre.org

Royal Society of Chemistry

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Contact: membership@rsc.org

List of Exhibitors

Society for the Environment

Sustainability through environmental professionalism.

Society for the Environment is an umbrella body which licenses professional institutions to register their members as Chartered Environmentalists (CEnv) and Registered Environmental Technicians (REnvTech). Both are required to demonstrate their skills, experience and knowledge of the environment and sustainability through peer assessment.

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The Chartered Institution of Water & Environmental Management

The Chartered Institution of Water & Environmental Management (CIWEM) is the only Royal Chartered professional body dedicated to the water and environment sector.

Contact: General enquiries: +44 (0)20 7831 3110

Membership enquiries: membership@ciwem.org