

ANNEX 2 – Final Summary of Projects

Workshops, Networks & Working Groups

Food & Environment

NE/E009352/1 Grow your own - health risks and benefits of producing and consuming your own food in urban areas

- Flaws in risk management of own-grown food in urban areas - The risks associated with soil contamination of own-grown food in urban areas are currently assessed using very conservative risk-management methods, leading to unnecessary scares and poor communication of the overall risks to health posed by this.
- The health benefits of increasing intake of fruit and vegetables, and of physical activity connected with growing food has not previously been considered in assessing and managing the risks. Our findings challenge the current approach and calls for a more holistic risk assessment methodology that focuses on actual health outcomes rather than precautionary assumptions.
- The working group has evaluated the current evidence of the risks and benefits of producing and consuming your own food in urban areas. The conclusions are that current risk assessment methods are far too precautionary and fail to take into account the increasingly important health benefits of grow-your-own which encompass multiple benefits some of which are a direct counterpoint to the current public health crisis of obesity and lack of exercise.

NE/E008399/1 Environmental impact on health benefits of organic food production

- Overall, the project has identified that research is needed to provide sound comparative data and assess potential health benefits of any observed differences in composition between organic *versus* conventional foods. Also, it is clear that environmental factors can be highly influential in relation to the composition and safety of foods produced by both systems.
- Public concern over impacts of chemicals in plant and animal production on health and the environment has led to increased demand for organic produce, which is usually promoted and often perceived as containing fewer contaminants, more nutrients, and being positive for the environment. These benefits are difficult to quantify, and potential environmental impacts on such benefits have not been widely studied.
- Factors such as the role of certain nutrients in prevention and promotion of chronic disease, potential health benefits of bioactive compounds in plants, the prevalence of food-borne pesticides and pathogens and how both local and global environmental factors may affect any differences between organic and conventionally produced food.
- Publication of a book that includes 13 full papers from the workshop which was part of the grant.

NE/E009131/1 Quantifying biophilia

- The notion that spending time with 'nature' can reduce stress may seem self evident. Natural recuperative tonics have been prescribed throughout recorded history from Grecian healing groves to Victorian seaside resorts. Today, mental health disorders related to stress, such as depression, are increasing rapidly. Could experiencing nature prevent this? Like so many

intuitive "truths" however this assertion masks a complicated set of unanswered questions.

- There is currently a paucity of evidence linking the evolutionary basis for biophilia, experience of nature and a positive benefit for human health. However we now have novel and innovative tools at our disposal for examining physiological stress responses, alongside a growing knowledge of how the complex mammalian brain may work and respond at a cellular level. These developments enable us to start hypothesising on the mechanisms by which interaction with nature may affect our mental health.
- A protocol is now available online for the relationship between human stress and nature.

Chemical Pollutants

NE/E00864X/1 Soil, health and environment network (SHE-Net)

- Across the three workshops a wide range of disciplines from human toxicology to plant science have been brought together to address the risks to humans resulting from contaminated land. These workshops were attended by an international range of stakeholders including: academics, local and national regulators, environmental consultants and chemical manufacturers. Outcomes included a screening framework for the plant uptake of organic chemicals, how risk communication can be improved and the ongoing need for quantitative risk assessment. A consortium from the three workshops is currently developing a partnership grant to address the issues raised for submission in summer 2009.
- The final workshop of the SHE-Net group was held in Nottingham. Directly addressing risk assessment. Further details can be found at <http://www.reading.ac.uk/soilscience/Research/SHE-Net/ss-SHE-Net-Workshop3.asp>

NE/E009484/1 Multiple Links Towards Integrating Teams for Understanding of Disease and Environment – Multitude

- Members of the teams brought together by this first MULTITUDE workshop have met again in a second workshop, held in Athens in April 2008, to focus particularly on the assessment, perception and communication of environmental risks to human health (<http://conferences.geol.uoa.gr/segh2008/Workshop%20Programme.html>). Participants in Athens also included representatives of several relevant EU-funded projects, including INTARESE, HEIMTSA, NoMiracle and 2-FUN.

Particles & Nanomaterials

NE/E008712/1 A network for the study of the properties and respiratory health effects of natural mineral dust

- A series of meetings was held as the main discussion component of this network. The first was for core members (7 attendees) to discuss the aims of the Network. The second was a plenary workshop held in March 08 for which we had 30 attendees. The one day workshop was very fruitful and, as a group, we defined the outputs which we wanted to achieve including research priorities.
- The network fosters collaborative exchange on a wide range of health-related aspects of natural mineral particles (NMPs). Key areas covered are:

1. Exposure – source, dispersion and atmospheric chemistry of plumes containing NMPs
 2. Toxicity – mineralogy, size spectrum, transformations, surface reactivity and interactions of particles with gas and aqueous phases
 3. Policy – health risk assessment for community and occupational exposures to NMPs; public risk perception; legislative implications
 4. Role of scientists in planning for air pollution episodes involving NMPs
- A review paper and report, which are both now in progress, will synthesise the discussions and guide future research directions, policy relevance and planning.
 - A multi-author review paper is being prepared on Natural Mineral Particles. Most members of the Network are contributing so it is a major task which is still in progress. We hope to submit the paper later in 2010.

Biogenic Toxins

NE/E00878X/1 Relating Harmful Phytoplankton to Shellfish Poisoning and Human Health

- The workshop found that current UK monitoring practices are sufficient to safeguard human health, but was able to produce various recommendations relating to research directions for the future study of shellfish poisoning and human health that would complement this monitoring. These include:
 1. Establishing environmental conditions governing blooms and toxicity of major shellfish producing phytoplankton species; for use in the generation of risk assessment models.
 2. Obtaining evidence of human intoxication and methods for collection of relevant data.
 3. Studying the UK public perception of shellfish consumption and related health risks.
 4. Developing methodology for an integrated study of shellfish toxicity and related health risks in a targeted community.
- The full report and its conclusions can be found on the SAMS and FRS web sites at www.sams.ac.uk and www.marlab.ac.uk.

Climate Change, Chemical and Microbial Pollution

NE/E008968/1 Impacts of climate change on the risks of biological and chemical environmental contaminants from agriculture to human health

- Expert input and literature has been used on: climate change; health effects resulting from exposure to pathogens and chemicals arising from agriculture; inputs of chemicals and pathogens to agricultural systems; and human exposure pathways for pathogens and chemicals in agricultural systems.
- The current evidence-base for health effects of chemicals and pathogens in the agricultural environment was established. The potential implication of climate change on chemical and pathogen inputs in agricultural systems were determined and the effects of climate change on environmental transport and fate of different contaminant types were explored. These data were combined to assess the implications of climate change in terms of indirect human exposure to pathogens and chemicals in agricultural systems. Recommendations were developed on future research and policy changes to manage any adverse increases in risks.
- Overall, climate change is likely to increase human exposures to agricultural contaminants. The magnitude of the increases will be highly dependent on

the contaminant type. Risks of many pathogens, particulate and particle-associated contaminants could increase significantly. These increases in exposure can however, in the most part, be managed through targeted research and policy changes.

Pathogens

NE/E009026/1 A UK Network for Environmental and Food Virology

- The Network held a Workshop in January 2008 in London (kindly hosted by the Department for the Environment, Food and Rural Affairs), in which the issues regarding food and environmental transmission of viruses were discussed with various stakeholders (other researchers, regulators, funding bodies etc.). A series of presentations was given by Network participants, highlighting the significant knowledge gaps in three areas: environmental transmission, foodborne transmission, and transmission of viral zoonoses through the environment and food.
- The feedback obtained from the Workshop was incorporated within the project's Report "Current Knowledge Gaps Regarding Transmission of Viruses through the Environment and Food in the United Kingdom". This contains a comprehensive description of current and emerging UK issues, followed by detailed recommendations regarding research responses to them.
- Research proposal submitted to BBSRC on transmission of viruses through the environment, with Universities of Surrey, Loughborough and Lancaster.
- ESEI bid with consortium led by Brunel University, on perceptions of risk of disease transmission through environment.
- The final report was presented to Defra.

NE/E008526/1 BAMRA: Bayesian approaches in microbial risk assessment (MRA Working Group)

- Expert opinion is commonly used in Microbial Risk Assessment where formal data are lacking. This is often solicited in an ad-hoc manner. The Sheffield Elicitation Framework (SHELF) has been developed which follows the elicitation model developed at the University of Sheffield over a number of years, and creates a framework within which risk analysts can conduct their own elicitations of expert opinion in as unbiased a manner as possible. This framework has been specifically developed in consultation with professionals from the risk assessment community via the BAMRA group, and thus is of great practical relevance to the MRA field.
- A novel Bayesian sensitivity analysis has been developed for a model describing the risk from Vero-cytotoxic E.coli O157 in milk being sold as pasteurised.

NE/E007899/1 Workshop - Predicting zoonotic outbreaks: building on the plague threshold model

- In Kazakhstan and elsewhere in central Asia, the plague bacterium *Yersinia pestis*, source of human cases of bubonic plague, still circulates in wild populations of gerbils and other small mammals. Intensive surveillance systems established by Soviet scientists in Kazakhstan at the end of World War II appear to have successfully reduced human cases. These programs also resulted in vast amounts of data, referred to as 'The Plague Archives', recording the dynamics of plague in wild animals. Normally percolation theory is used to describe the movement of liquid through porous material.
- The spread of the bubonic plague bacteria in Central Asia by gerbils, works much the same way. Plague bacteria percolate through the landscape transmitted by fleas from one great gerbil family to the next, from burrow

system to burrow system. This is the first time percolation theory has been used to describe accurately the natural dynamics of an infectious disease. This discovery might be helpful to understand how outbreaks of disease occur in other populations. It may, for example, shed new light on the spread of bovine tuberculosis in badgers, and spread of viral diseases in populations of African lions.

- There are conditions for successful percolation of the plague through gerbils. If there are too few gerbils, the fleas won't be able to move from one burrow to another, and the spread halts. The use of percolation theory can predict the final size of an outbreak of plague, starting with one infected rodent family group. The vast tracts of land inhabited by connecting burrows of great gerbils contrast starkly with the relatively short distances of about 200 metres travelled by fleas responsible for transmission of plague. This difference in scales means that connectivity of the population and, hence, percolation is the key factor.

NE/E00881X/1 Outdoor Airborne Pathogens and Human Health in the UK

- The natural environment plays a significant role in controlling and determining the source, pathway, exposure routes and, ultimately, health risk of airborne pathogens to humans. It is very important to understand the environmental pathways and properties of these pathogens and their link and mechanism in causing diseases in order to protect human health. This working group aims to build a network and research capacity to tackle human health problems associated with airborne pathogens and the outdoor environment.
- We have successfully developed a multidisciplinary network which links different disciplines together and provides a platform to facilitate discussion and collaboration.
- A report is being prepared to summarise the outcomes of the meetings. This report will be submitted for publication in an international journal. There are various proposals developed and being developed directly due to this network.
- In the first meeting, we invited 3 A-level students, supported by the Nuffield Foundation to participate into the meeting. Subsequently these students undertook a project on airborne faecal coliform bacteria survey at UCL.
- Future plans include: a session on outdoor airborne pathogens in the next HPA meeting in September 200; and to continue the network and proposal development by facilitating meetings and research capacity building.
- A website has been developed:- http://www.ucl.ac.uk/cege/Research/environmental_structural_geotechnical/environmental_engineering/airpath/ in order to facilitate the network activities. The meeting programmes, presentations and reports are posted on this website.
- Bioaerosols from community composting - Working with the London Community Recycling Network and Vital Regeneration, the emission levels of bioaerosols from a community composting site will be assessed leading to the development of methods to reduce the emission.

NE/E008992/1 Going underground: human pathogens in the soil-water environment

- This working group was invited to present its initial findings to the Canadian Water Network (CWN) Pathogens-in-Groundwater meeting. The aims of the CWN group match closely with our own, including the attempt to bridge the gap between researchers and managers by identifying critical areas of uncertainty in data and conceptual understanding of environmental pathogens and human health risks.

- Working Group members (various disciplines and institutions) held a 2-day meeting with representatives from Defra, EA, HPA, water utilities, and consultancies (ADAS, CREH, EPHRU). The workshop brought together representatives from a number of key organisations making decisions on management strategies for pathogens in the soil-water environment. Several areas already identified as science priorities were given further focus by identification as key to the information needs of decision-makers. The ideas and recommendations that were generated are published on the project web site as a downloadable public document.
- British Science Festival 2009 (Dr Jonathan Bridge) - Finalist in the 'perspectives' poster competition, presenting a poster based on the concept of human health risks from environmentally-transmitted pathogens.
- Prof Banwart and Dr Bridge presented a poster at and participated in the NERC Environment and Human Health Science Conference 2009 in Birmingham. This provided the opportunity to present the recommendations of the Going Underground project and engage in detailed discussion of the issues surrounding engagement between researchers and stakeholders (both public and industrial).

Exploratory Studies

Chemical Pollutants

NE/E00895X/1 Modelling and measurement of Cd exposure and pathology in human volunteers living in proximity to a smelter source

- Results indicate that a former smelter (Avonmouth) is a major source of metal pollution of soils and house dust samples collected across the adjacent area. This represents a potential exposure risk to humans living close to the smelter site.
- Modelling of plant Cd uptake using a free ion based approach that includes parameters to account for the impacts of competing ions (e.g. H⁺) could be used to provide a good prediction of Cd concentrations in a range of food crop above use of only total metal concentrations.
- The analysis has revealed new aspects of the likely mechanisms of Cd on humans exposed to environmental relevant concentration and a series of potential biomarkers of these health effects of exposed populations have been derived.

NE/E008917/1 A preliminary assessment of levels of bioavailable anthropogenic platinum-group, lanthanide and high field strength metals in human tissue and DNA

- Trace metal analysis in human tissues - A preliminary database has been produced for trace metal abundances in certain human tissues that report the first concentrations of many trace metals ever measured quantitatively in these tissues. A comprehensive reference database will be published in the future.

NE/E009271/1 Model human digestive system for the determination of bio-accessibility of environmental pollutants

- UK Patent Application Filed for: Simplified gut model for bioaccessibility assessments - The patent is currently in a very broad format to cover measurement in a range of media including soils, which it was developed for, and foods.

- International collaboration - Collaboration with 6 international laboratories is ongoing in an intercomparison exercise, and joint research is underway with the National Environment Research Institute in Denmark.

NE/E008844/1 Born in Bradford: environmental exposure and birth weight

- The main focus of the Born in Bradford (BiB) project was the collection of information for the validation of exposure estimates, together with the initiation of data collection for the exposure modelling and preparing a strategy for linking them to health data.
- Errors in exposure assessment are major source of uncertainty in epidemiological studies, and can reduce the power to detect associations with health, or bias the associations found.
- One particular aspect of this work is a nested validation study of individual level exposure information within a subset of the BiB cohort. Information on each mother's water exposure and travel patterns was recorded in a questionnaire, completed by each mother at recruitment to the cohort, from which her exposure to DBPs and air pollution during pregnancy was calculated.
- Gold-standard methods for exposure assessment (exposure diaries, biomarkers and personal monitoring) have been used in a small subset of mothers in the BiB cohort, in order to assess the validity of the questionnaire. This allowed us to quantify the uncertainty in the exposure estimates we calculated for each mother, and then to adjust the relative risk estimates for measurement error. This improved our relative risk estimates for adverse fetal growth outcomes associated with DBPs and air pollution, for the whole cohort.

NE/E008593/1 Impacts of future environmental change on climate - and air pollution-mediated human health

- Ozone and Mortality in fifteen British conurbations - this quantifies the relationship between ozone, heat and mortality across the largest 15 British conurbations, and examines evidence of interaction between ozone and heat effects on mortality. Results show a strong adverse heat effect and an adverse ozone effect on human health with some suggestion of an interactive health effect i.e. the combined adverse effects of heat and ozone on human health were greater than the individual ozone and heat effects on human health. An important result for the epidemiological community is that the ozone effect is sensitive to modelling of temperature as a confounding variable.
- When maximum temperature is used instead of mean temperature as the confounding variable the ozone effect on mortality is no longer significant for these conurbations. In Greater London, mean temperature was the best confounding variable. Data for the period 1993-2003 was analysed (article in press in *Occup. Environ. Med.* 2010).
- Modelling surface ozone during the 2003 heatwave in the UK - Paper published in *Atmos. Chem. Phys.* and one in revision for *Atmos. Chem. Phys.* The ozone concentrations during the August 2003 heatwave have been simulated using coupled weather and chemistry transport models operating at a high horizontal resolution of 5km by 5km over the UK. On the hottest day of the heatwave (10th August) elevated isoprene emissions (by a factor of 2-5) are likely to have been an important contributor to high ozone concentrations measured on that day.
- Environment and health wrap-up workshop - A wrap-up workshop entitled: "Combining Environmental and Epidemiological modelling: a study of the

Health Impacts of Ozone and Heat on Mortality" was held at Birkbeck college London on Jan 13th 2010. The audience comprised scientists and policymakers in climate, air pollution and health communities. Policymakers came from a number of key UK government organisations (NERC, HPA, Wellcome, EA, DEFRA).

Particles & Nanomaterials

NE/E009336/1 Exploring the link between surface structures and toxicity in mineral particles: case study of induced and intrinsic toxicity in quartz

- The postulate that toxicity may be induced by quartz has been successfully demonstrated and adequately explained using surface area models.
- Experimental simulation also effectively accounted for the observed variation in haemolysis in natural samples except for the enigmatic DQ12 sample that responds by a factor three times more than the models predict. This needs further investigation.
- Surface silanol structures were identified but quantifying differences between samples of varying toxicity requires better methods for characterising grain size and shape metrics.
- This project brought together materials scientists with geoscientists and toxicologists with the aim of sharing techniques and concepts across disciplines to address significant relationships between environment factors and human health.
- The identification of strong correlations between materials characteristics such as lattice strain and biological response demonstrates the value of such interdisciplinary research.

NE/E008232/1 Assessing human exposure, uptake and toxicity of nanoparticles from contaminated environments

- Potential uptake of nanomaterials from water or food has been assessed by using different test models, such as an aquatic invertebrate (water flea), a fish (carp), primary trout hepatocytes and a human intestinal epithelium cell line (Caco-2). Transport of particles through a model of the gastrointestinal barrier (M Cell model) was examined, as well as potential effects on the liver, using the human hepatocyte cell line C3A.
- Silver particles (Ag) and cerium dioxide (CeO₂) were used and all particles were characterised appropriately.
- Ag but not CeO₂ particles, exhibited toxicity in exposures of water flea neonates (96 h acute exposure), primary trout hepatocytes and the human hepatocyte cell line C3A. Nano-Ag was consistently more toxic than the micron-sized silver in all models.
- Uptake of Ag particles into carp in a 21 day sub-chronic study was detected in liver, gills, gall bladder and intestine. Ag was detected in the same organs for both particle sizes, with a trend towards higher uptake of the nano-material.
- *In vitro* exposures resulted in uptake of both Ag and CeO₂ particles of both sizes into C3A hepatocytes, Caco-2 intestinal epithelial cells and M cells (intestinal cells specialised in transport). The results also show the transport of these particles across the gastrointestinal barrier.
- These results are relevant not only in eco-toxicology, but also in human toxicology, since nanoparticles are already in use in products designed for ingestion. There was consistency of relative toxic potential of Ag and CeO₂ particles in systems as diverse as water flea and human cell cultures, and in the size-dependent toxicity of Ag. These findings provide promising steps towards paradigms to determine toxicity of nanomaterials.

- Bioavailability of nanoscale metal oxides, TiO₂, CeO₂, and ZnO to fish - Established that there is very limited bioavailability of nanoscale metal oxides, TiO₂, CeO₂, and ZnO to fish when exposed via the water, but that TiO₂ can be taken up from the water into the gills of fish.
- Effect of natural organic matter on bioavailability and uptake of CeO₂ nanoparticles - Long term exposure to cerium dioxide nanoparticles has been carried out to illustrate that natural organic matter affects bioavailability and uptake.
- Effects of metal/metal oxide nanoparticles on fish liver cells - Established that fish liver cell cultures provide a good model for studies investigating the cellular uptake of metal/metal oxide nanoparticles, but they are not sensitive to the reported biological effects of these particles (e.g. oxidative stress).
- Effects of metal/metal oxide nanoparticles on a range of models - Established common effects of metal/metal oxide nanoparticles on a range of species and model systems.
- Grant award - Joint US-UK (NERC) Research Program: Environmental Behaviour, Bioavailability and Effects of Manufactured Nanomaterials (EPA-G2008-STAR-R1) – (total grant £3M). Consortium for Manufactured Nanomaterial Bioavailability & Environmental Exposure (nanoBEE).

NE/E00791/1 A proof of concept study for a structure activity model for the toxicity of nanoparticles

- Activity data has been obtained by testing a panel of nanoparticles in short/term cell toxicology tests that are based on epithelial cell toxicity and pro-inflammatory responses. This model was chosen because the epithelial cell response is well understood as to its role in pathological responses to particles and has been amply demonstrated to discriminate between pathogenic and non-pathogenic particle types and so has a degree of validation.
- Oxidative stress is a type of chemical reactivity that has been put forward as an important mechanism for how particles cause toxic effects on cells so there is emphasis on the oxidative stress capacity of the particles in this study.
- The principal finding of this study is that, on current evidence, there is no characteristic physico-chemical/structural signature that might be useful in pre-screening for potential toxicity of all NPs. Instead, we have identified a number of specific individual characteristics that can cause toxic effects: for example, it appears that a positive zeta potential is a key toxic structural component, as is a high content of some metals (Ni, Zn) or a high aspect ratio.
- Whilst the findings are disappointing from the view of nanotoxicology pre-screening and prediction, they are nevertheless very important in reflecting the current state of predictive nanotoxicology. They highlight the likely heterogeneous nature of the NP hazard and the difficulty that there will be in deriving a single, unified nanoparticle SAR. We believe that we have applied a state of the art approach to the thorny problem of NP structure/toxicity that can be utilised in other studies and using data from other sources. We anticipate at least one high impact paper to arise from the study.

NE/E009166/1 Hazards of nanoparticles to the environment and human health

- Nanotechnology has been described as the next technological revolution, but has also prompted concerns about the potential of nanoparticles to harm humans or the biosphere. It is likely that the same factors responsible for the novel properties of nanoparticles may be the source of their potential hazard. Discrepancies between existing toxicological studies have shown the

importance of good quality, well-characterized nanomaterials for toxicological studies, combined with reliable synthesis protocols.

- It is important to obtain complete characterization, including the recognition of impurities and surface modifications. High quality TiO₂ nanoparticles have been generated for toxicological studies. Phase pure titania nanoparticles of both anatase and rutile crystal structures, monodispersed samples of different sizes (e.g. 10nm, 60nm, 100nm and 200nm) were synthesised and characterised (XRD, DLS, TEM/SEM and BET), and the behaviour of these particles has been investigated in simulated body fluid and cell culture media.
- Characterisation of carbon nanotubes in the context of toxicity studies has revealed a novel finding that impurities in carbon nanotubes, which could have a potential effect on toxicity, may occur at scales invisible to techniques used in their characterisation by manufacturers.
- Successful in winning a European Collaborative Project NanoReTox, under Framework Programme 7. The PI Dr Valsami-Jones is the coordinator.

NE/E008739/1 Determinants of oxidative potential, a health-based metric to assess particulate matter toxicity

- Work has been successfully completed in which the oxidative potential of airborne particles has been measured at a range of sites based at schools within London. The oxidative potential measurements have been related to the size and chemical composition of the particles.
- This pilot study will form the basis for a proposal for a more in-depth study in which the relationship between the measured oxidative potential and health effects upon those breathing the particulate matter will be studied.
- Work on this project has led to an invitation, with funding, to join a project led by RIVM in the Netherlands, which extends the approaches used in this study.

NE/E009395/1 Nanotoxicology of fine particulate material (PM): the role of surfactant and collectins in short-term health effects of PM air pollution

- PM with small aerodynamic diameters, including nanoparticles (NPs), and PM of specific length to diameter ratios or low density can access the lower lung in greater quantities than PM with larger aerodynamic diameters. In the alveolar spaces, these particles initially impact on the surfactant lung lining liquid layer which provides primary host defence against depositing foreign material. Particles may then translocate to the circulatory system and other organs.
- It was hypothesized that the initial impact of PM and NPs on the lung surface would lead to opsonisation by components of lung lining fluid, and would alter the downstream behaviour of invading particles. Polystyrene, silica and carbon NP (approx. 100 nm) behaviour was measured when suspended in nanopure water, saline or PBS, before and after inclusion of key components of the human and mouse lung lining layer. This showed that particles interact with protein and lipids found in the lung lining, *in vitro*. Size distributions and zetapotentials of the particles changed following these interactions. Previously stable particle suspensions could aggregate at sub-physiological concentrations. Subsequent interference of protein form (folding) and concentration in the lung may have significant consequence for protein and lipid performance.
- Particle coating may also affect the rates of collection and removal of solid particles, as it does for biological particles (Kendall et al 2002 and 2007). In combination with A549 epithelial cell exposure studies, evidence has been provided for an adsorption mediated damage mechanism. This may be

important for both atmospheric PM and synthetic NP exposure via the lung, and such data will help in predicting hazard and risk associated with synthetic NP exposures.

NE/E00833X/1 An exploratory study investigating the physiochemical characteristics of ambient air particles responsible for the dysregulation of pulmonary genes

- The genomic and proteomic effects of real urban air particles dosed on human lung tissue is dependent on the size of the particle used.
- A well developed collaboration has been established between the pollution control division of Swansea City Council and our research group. A joint bid (January 2010) has been submitted to the NERC Environment and Health Programme with Swansea City Council and the UK Health Protection Agency.
- The research has shown that in lung tissue dosed with real samples of urban air particulates there is a differential in gene and protein response dependent upon the size fraction used. Notably there was significantly more down-regulation of proteins and genes than up-regulation and this increased at smaller particle sizes.
- This is the first time that the gene and protein responses of size fractionated (in the nanoparticle range) real environmental air samples have been tested on human lung tissue. The relevance being that the differential observed in biological response by size category indicates that causal biomolecular pathways of significance to health should be investigated at a global gene and protein level.
- This should elucidate, when married to full physico-chemical analysis, the size components and physico-chemical constituents of the urban aerosol responsible for driving epidemiologically observed health effects. This in turn will inform policy and regulation with respect polluting sources.

NE/E009565/1 Identification and Verification of Ultrafine Particle Affinity Zones in Urban Neighbourhoods / A Proof of Concept Proposal

- A methodology has been presented and validated through which long-term fixed site air quality measurements are used to characterise and remove temporal signals in sample-based measurements which have good spatial coverage but poor temporal resolution.
- The work has been carried out specifically to provide a spatial dataset of atmospheric ultrafine particle (UFP < 100 nm) data for ongoing epidemiologic cohort analysis but the method is readily transferable to wider epidemiologic investigations and research into the health effects of other pollutant species.

Biogenic toxins

NE/E008534/1 Endotoxin emissions from commercial composting activities

- Endotoxin is aerosolised as a result of composting operations. Inhalation of endotoxin has important health implications and we have set up an in vitro cell-based assay to investigate the inflammatory potential of the endotoxin extracted from the sampling filters in this study. We have utilised human monocyte (MM6) and lung epithelial (D562) cell lines to investigate the inflammatory potential of the endotoxin detected. Endotoxin extracted from the filters was found to stimulate both cell lines to produce significant amounts of pro-inflammatory cytokines.
- Endotoxin extracted from the composting source has a greater inflammatory cytokine inducing effect than commercial *E. coli* endotoxin. This was particularly significant for the lung epithelial cells. This raises the possibility that endotoxin in these bioaerosols is intrinsically more reactive with such

cells or that endotoxin in association with particles has greater inflammatory potential.

- The findings of the research have been communicated to SITA-SUEZ. SITA-SUEZ operate composting facilities and have hosted and co-funded some of this work. The endotoxin project could not be carried out without their approval to access their sites. The information fed back to SITA-SUEZ is used to inform their occupational health assessments and to inform their assessments of site operational activity impacts on public health.

NE/E008933/1 Plant virus infection as a determinant of pollen allergenicity

- Wild plants harbour a variety of viruses and these have the potential to alter the composition of pollen. The potential consequences of virus infection of grasses on pollen-induced allergic disease are not known.
- Extracts were prepared from pollen from uninfected Cocksfoot grass, and from grass naturally infected by the Cocksfoot streak potyvirus (CSV). The prevalence of CSV infection in cocksfoot grasses sampled from the study site varied significantly over an eight-year period, but infection rates of up to 70% were detected.
- Virus infection was associated with small alterations in the quantities of pollen proteins. For individual subjects there were differences in potencies of standardised extracts of pollen from virus-free and virus-infected plants as assessed by skin testing, though a consistent pattern was not established for the group of 15 subjects.
- Infection rates for CSV in cocksfoot grass can be high, though variable. Virus-induced alterations in components of grass pollen have the potential to alter the allergenic potency.

NE/E009328/1 Strategies to manage toxic cyanobacterial blooms in lakes: remote sensing, modelling and cost benefit analysis

- Preliminary analysis of potato crop experiments indicated the presence of microcystins, in potato tubers but this needs to be confirmed
- The reliable detection of cyanobacteria using airborne remote sensing with a robust calibration has been demonstrated across two UK lakes
- General additive models were used to predict cyanobacteria bloom presence and abundance across 134 lakes. The models show potential for predicting the occurrence of toxic algal blooms.
- Models of Loch Leven and Esthwaite Water demonstrated the cyanobacterial abundance increased with total phosphorus and an associated decrease in nitrogen.

Pathogens

NE/E009085/1 A study of helminths as novel vectors and reservoirs of human pathogens in the environment, using in-vivo real-time imaging systems

- New knowledge gained from the project - 1. Pathogenic bacteria within nematode worms are more resistant to environmental changes including pH, UV light and disinfection, than free-living bacteria. 2. Ingestion of nematodes carrying bacterial pathogens can cause systemic infection in vertebrate hosts, suggesting that, given sufficient numbers, nematodes can be vectors of food-borne pathogens. 3. Both free-living and parasitic nematodes have the potential to vector bacterial pathogens. 4. Both human and cattle pathogens can be isolated from parasitic nematodes.
- Fundamental advances in understanding gained from the project - The experiments carried out in the project have enabled an understanding of a

potential mode of pathogen environmental survival and transmission, via both free living and parasitic nematodes.

- New methods and techniques used in the project - A self-bioluminescent reporter strain of Salmonella has been used as a new method for monitoring pathogen survival within nematodes in situ and in real-time.
- Relevance of our findings from the project - This is the first direct evidence that nematodes can vector live pathogenic bacteria and that the vectored bacterial pathogens can cause systemic infection in vertebrate hosts. The findings have far reaching implications for animal husbandry and public health.
- Potential relevance to Government and policy makers - The evidence of pathogen vectoring by nematodes has implications for agricultural land produce decontamination. Recommended decontamination measures will need to take resistance of nematode vectors as well as bacterial pathogens into account.
- Additional knowledge transfer from the project - Dr Sarah Perkins was awarded a Marie Curie Senior Research Fellowship, which she has recently taken up at Cardiff University (moving from Penn State University, USA). She included her research within this project as part of her successful application and has presented the project work to her research group at Cardiff University.

NE/E008038/1 Ljungan Virus - an undetected but dangerous zoonotic agent

- Ljungan Virus (LV) appears to be an important zoonotic pathogen, showing associations with a number of human pathologies, including type 1 diabetes, matching those found in rodents. The presence of LV has been confirmed the UK. Prevalences of around 25% were found in bank voles, field voles, wood mice and house mice, all in rural settings.
- We studied the incidence of type 1 diabetes diagnosed in children aged 0-14 years and diagnosed during the period 1990–2007. All cases were resident in a defined geographical region of Northern England.
- The results have not found any evidence of global space-time clustering for cases of type 1 diabetes diagnosed in North East England. However, this does not preclude the possible involvement of a ubiquitous infection or one that has a heterogeneous latent period. Further research will examine geographical heterogeneity in incidence.

NE/E008844/1 Human health risks from contaminated tap-water. Can we use microbial ecology to assess the integrity of water distribution systems?

- Presentation of results to United Utilities - A seminar on the work was presented to United Utilities, Warrington, who provided assistance with the work. Discussions on the collaboration are continuing.
- Demonstrating organisms associated with drinking water contamination - The work has demonstrated that when disinfection and distribution network integrity are maintained, low diversity community of bacteria occurs. When disinfection is not intact a more diverse community that also includes Archaea and eukaryotes is found.

NE/E009042/1 Seasonal environmental hazards: a multi-disciplinary approach to the analysis of health risks in lower-income countries

- This project involves field testing of a multi-disciplinary approach to the analysis of risks to human health from seasonal environmental hazards in developing countries.

- Each year the Mekong Delta (Vietnam) faces alternate seasonal extremes in the local environment, as the water level in the Mekong Delta changes from flood to dry season.
- Poorer households tend to rely heavily on river water for domestic uses including provision of drinking water, and it is commonly perceived that the seasonal changes alter risk from diarrhoeal diseases and other diseases associated with contamination of water.
- During the year 08/09 the research team completed two further phases of data collection at the study sites in the Mekong Delta. This included an additional set of scenario-based interviews with households via an ESRC-funded supplementary award.
- The team also organized dissemination meetings at local and national level in Vietnam with governmental and non-governmental stakeholders, at which preliminary results and their implications were discussed.
- The research is generating an integrated dataset combining information from environmental monitoring, health data and analysis of health behaviour in order to develop a multi-layered understanding of risk.
- The Environment Health and Development Network, established via a supplement to this grant, hosted its inaugural conference (symposium and e-conference) in June 2009. Participants in the events included UK and overseas researchers, together with stakeholders from UNICEF, funding bodies and non-governmental organizations.
- An agenda for the network was defined and plans taken forward for continuing policy engagement, including funding applications for ongoing work.

Epidemiology & Health Risks

NE/E008720/2 Multiple environmental classification of areas for researching spatial health inequalities

- A summary measure has been developed indicating whether or not the surrounding physical environment is healthy. The measure called 'Multiple Environmental Deprivation Index' or MEDix is available for all areas (wards) in the UK. This has never been done before.
- The research shows that the physical environment we live in makes a contribution to the risk of many common causes of death (such as heart disease and some cancers), over and above how wealthy or poor we are.
- Perhaps the main achievement has been to bring an idea from epidemiology (in which these kinds of measures are routinely used to tell us about the socio-economic characteristics of different areas) and apply it to environmental science. Our index also includes aspects of the environment which help keep us well, as well as those things which make us sick.
- Providing a customised version of the end-product to a local authority - As a direct result of our work to publicise the products from this grant, we have been commissioned to produce a local environmental deprivation index for South Lanarkshire council. The methods developed will be applied to a slightly different set of environmental characteristics to try and measure how multiple physical environmental deprivation varies across the local authority.
- Dissemination workshop - In April 2009 a dissemination workshop was held in Edinburgh, to which were invited key scientists and policy makers from across the UK. The methods and findings were presented to the 15 or so attendees with discussion of the pros and cons of our products and approach.

- Teaching - Methods and results from our work have already been incorporated into both postgraduate and undergraduate teaching at Glasgow and Edinburgh Universities.
- Scientific and academic contributions - This year the research focus has been on using our newly created index and classification of environmental deprivation to explore substantive research questions about the relationship between health and environment in the UK, and the extent to which physical environment has a role in determining health inequalities. To this end 3 papers are currently under review with scientific journals which describe the work and use it to show that unequal exposure to adverse physical environment makes a modest but significant contribution to explaining health inequalities in the UK, for particular health outcomes. It is also worth noting that the entire approach to this topic is quite controversial within the scientific community. Not everyone likes or approves of what has been done. However, the key paper, which describes the methodology, has now been accepted for publication.
- New Project supported - Dr Niamh Shortt led a successful application to the ESRC for funding to begin to explain why the new measures of physical environmental deprivation which we created in this grant, are associated with health. In particular, the focus will be on the extent to which physical environmental deprivation seems to have an impact on people's propensity to be physically active or not. The grant is for one year.

NE/E008313/1 Micronutrient deficiency in maternity and child health: scope for agricultural and educational intervention in soil-food-human transfer

- Global food insecurity is associated with micronutrient deficiencies and it has been suggested that 4.5 billion people world wide are affected by deficiencies in iron, vitamin A and iodine. Zinc has also been identified to be of increasing concern. The most vulnerable are young children and women of childbearing age.
- A pilot study has been carried out in Southern Malawi, to attempt to link the geochemical and agricultural basis of micronutrient supply through spatial variability to maternal health and associated cultural and social aspects of nutrition. The aim is to establish the opportunity for concerted action to deliver step change improvements in the nutrition of developing countries.
- Field work undertaken in August 2007 and July/August 2008 involved the collection of blood, soil and crop samples, and questionnaires from 100 pregnant women. A preliminary spatial evaluation is presented. It links soil quality, food production to the nutritional health, behavioural and cultural attitudes of women and children in two regions of southern Malawi (the Shire Valley and Shire Highlands plateau). Differences in agricultural practice and widely varying soil quality (e.g. pH organic matter, C/N and metal content) were observed for both regions and full chemical analysis of soil and food is underway.
- Early assessment of blood data suggests major differences in health and nutritional status between the two regions. Differences in food availability and type and observations of life style are being evaluated through questionnaire analysis.
- This multifaceted environmental, health and social science pilot study, has collected and observed a diverse range of physical materials and linked cultural and social observations. Synthesis and dissemination will provide a unique record of information relating to research processes in subsistence communities and underpinning for bottom up approaches to development interventions for support in subsistence communities.

- Hosting 2 x 6 month commonwealth visiting fellowships Dr Tim Biswick, University of Malawi; Dr Therese Nganje, University of Calabar, Nigeria. Oct 2009-March 2010.

Discipline Hopping

Pathogens

NE/E008054/1 The application of clinical microbiological methods to the study of MRSA in the environment

- Methicillin resistant staphylococci (MRSA) in dairy cattle - after the end of the discipline hop, Dr Glaze and Prof Hawkey have continued to work together, co-supervising work continuing from sampling initiated during the project.
- Unpasteurised milk samples from 50 organic and 50 conventionally farmed dairy herds were screened for methicillin resistant staphylococci to investigate the hypothesis that decreased antibiotic use in organic farming practices will result in a reduction in the occurrence of antibiotic resistance in staphylococci. Methicillin resistant staphylococci were isolated from both farming practices, but more frequently from conventional farms.
- More known pathogens were isolated from conventional farms than organic, and these were resistant to a wider range of antibiotic classes.

Chemical Pollutants

NE/E007732/1 Linking environmental fate and behaviour studies with the toxicology and epidemiology of organic pollutants

- The 'discipline-hop' allowed Dr Thomas to gain insight into toxicological and epidemiological methods and theory, establish potential long-term collaborative links with several toxicology and epidemiology researchers in neurotoxicology, epidemiology, endocrine toxicology and environmental chemistry
- Research on the neurotoxicology of pesticides has provided results that are being submitted for publication.