Contents

1 ERP Research Summary: T2, Environment and human health

The main purpose of this summary is to help ERP partners gain a quick overview of recent and current research in this topic area, with particular relevance to regulatory duties and policies. It also attempts, briefly, to identify where new research might be targeted in relation to the topic. Each summary will also include climate change as a cross-cutting issue i.e. identify any relevant research in the specific topic area that has a climate change adaptation and/or mitigation aspect.

1.1 Research topic title

Relationships between environmental pressures and human health.

1.2 Topic summary

The ERP is focused on supporting regulators in their duties, and so this summary is mainly focused on short- and medium-term, end user-focused work. Regulators need to understand the ways how, and the extent to which, the environment affects health, and they need evidence to support the derivation of standards – the key question is how effectively we are protecting human health from environmental exposure. This must be answered in order to help regulators to better target their efforts where benefit is greater than cost, using a risk-based, proportionate approach, and to show evidence of the benefit of their interventions.

A key will be identifying the main pressures on health to strengthen our understanding of the linkages from the environmental exposures to the health outcomes, and to facilitate cooperation between environmental regulators and health professionals.

Environment and health research is a broad and complex field of study, defined by the World Health Organisation (WHO) as those aspects of human well-being and disease that are determined by environmental factors[1]. The scope of this report focuses on the physical categories of pollution (manifested in air, water and soil quality) that can harm human health, and also the positive impacts of improved environments. The constraint of space has meant that less detail is given for waste disposal, flooding, nano materials and radioactivity. Endocrine disruption has been omitted (on SEPA's advice) because our current inability to model the combined effects of chemicals limits our ability to regulate this area. Evidence has been collected mostly from the UK and EU.

In the view of the NERC, the natural environment contributes to people's health through the quality of the air we breathe, the food we eat and the water we drink[2]. It offers health enhancing economic and recreational opportunities on the one hand but is threatened by many activities such as transport, industrial processes, agricultural and waste management practices on the other. Environmental pollutants and potentially pathogenic organisms can harm people's health through a series of complex transport and exposure pathways. These are areas of growing public and government interest.

1.3 Key words

Environment; human health; pollution; soil; air; water; climate change; greenspace.

1.4 The relevance of human health to environmental regulation

The Environment Agency's position statement on Environment and Health[3] outlines some key areas (such as air pollution, proximity to landfill sites and exposure to chemicals) that may be associated with deterioration in human health. It points out, however, that further research is needed into the links between exposure to pollution and the effect it has on health, as well as the impacts on health of mixtures of chemicals, microbes or physical changes in the environment, to better inform regulatory decisions. The agency also considers positive health effects, including the use of rivers for recreation.

Health outcomes are also included in SEPA's aims: "By making it clear to customers how they can comply with the law and giving guidance on the best environmental practice, we can ease the burden of regulation while ensuring the best outcomes for the environment, **human health**, the economy and wider society"[4]. The SEPA Research Strategy for 2008-12[5] suggests that tools will need to be developed to monitor the risks to health posed by airborne pollutants, contaminated bathing waters and drinking water; in line with the EA's twofold approach, it also proposes a more salutogenic approach to the benefits to health of improved environments and greenspace.

[1] http://www.era-envhealth.eu/servlet/list?catid=23177

[2] http://www.nerc.ac.uk/research/programmes/humanhealth/background.asp

[3] http://www.environment-agency.gov.uk/research/library/position/41187.aspx

[4] http://www.sepa.org.uk/about_us/what_we_do/regulating.aspx

[5] http://www.sepa.org.uk/science_and_research/idoc.ashx?docid=67dd4cf9-89da-4e17-991a-6618d43c5b9a&version=-1

The Northern Ireland Environment Agency's Strategy Unit[6] includes Environment and Health in the remit of its horizon-scanning activities for issues that may impact on the Agency's work and policy development in the future.

The Drinking Water inspectorate (DWI) believes that good quality scientific research is crucial to the provision of credible and authoritative information on the health aspects of drinking water quality, and it helps ensure that standards and regulations are adequate to protect public health[7].

1.5 Summary of current and completed research

This section identifies summary resources that describe current (section 1.5.1) and recently completed research (1.5.2): these sub-sections are intended to draw the reader's attention to resources that summarise bodies of research, rather than attempting to summarise them here. It then outlines current and recent research projects in the fields of pollution in general (1.5.3), air quality (1.5.4), water (1.5.5), soil (1.5.6), and positive impacts (1.5.7).

1.5.1 Centres, studies and programmes that describe current research

CIRCLE-2[8] (Climate Impact Research and Response Coordination for a Larger Europe) is a European Network of 34 institutions from 23 countries, which is committed to funding research and sharing knowledge on climate adaptation, and the promotion of long-term cooperation among national and regional climate change programmes. Its fourth work package aims to share knowledge from European CCIVA (climate change impacts, vulnerability and adaptation) research projects, and the first outputs are due in June 2011.

The research activities of the European Centre for Environment and Health (ECEHH)[9] at the Universities of Exeter and Plymouth focus on the interconnections between the natural environment and human health. Rather than adopting a conventional approach of investigating threats posed by, for example, air pollutants or specific chemical contaminants, they look at how climate change and changes in biodiversity will affect human health and wellbeing in the coming years. They also address the accumulation of complex mixtures of persistent pollutants, especially in the context of the ageing population demographic. References for their publications to date on water, nano materials, climate change and positive effects are listed in the appropriate sections of this report.

The catalogue of research funded under the EU's seventh framework programme (FP7, 2007-13), gives extensive detail on all planned projects on environment and health [10] and will follow on from FP6 – see next section.

The main conceptual thrust for the MRC-HPA Centre for Environment and Health (CEH)[11] is to integrate individual-level and small-area analyses of environmental exposures and health - using advanced

[6] http://www.doeni.gov.uk/niea/index/about-niea/niea_strategy_unit.htm

[7] http://dwi.defra.gov.uk/research/index.htm

[8] http://www.circle-era.eu/np4/home.html

[9] http://www.pcmd.ac.uk/research_environment.php, http://www.ecehh.org/

[10] http://ec.europa.eu/research/environment/pdf/fp7_catalogue_eh.pdf#view=fit&pagemode=none

[11] http://www.environment-health.ac.uk/Default.aspx

geographical information systems (GIS) and statistical modelling techniques, combined with experimental data, biomarker and mechanistic studies, and analyses of large population cohorts - to tackle environmental health problems of public health and scientific importance. References for their publications to date on air pollution, soil quality and nano materials are listed in the appropriate sections of this report.

1.5.2 Studies and programmes that describe completed research projects

A scoping study in 2009 by SAC Commercial and funded by the Scottish Government, A strategic review of recent past and current research programmes relating to the effects of environmental change on animal, plant and human health[12], offers an overview including the environment and health, and touches on regulation. Its definition of "environmental change" includes climate change.

Environment and Health is a research theme of the European Environment Agency (EEA)[13]. It constitutes 34 publications in English, focusing mainly on air pollution, but also including GMOs and water stress. Its research is conducted under the EU's Framework Programmes – see below for FP5. The EEA shares knowledge by means of Eionet, the European Environment Information and Observation Network[14].

The EU's Fifth Framework Programme[15] (FP5 – 1998-2002) was the first EU research framework programme in which a dedicated environment and health research activity emerged. Findings of relevance to environmental regulation included the adverse respiratory health effects of fine particles, nitrogen oxides and smoking, and the effective use of biomarkers to warn of either potential to develop disease or evidence of exposure to variety of environmental stressors. These results have already fed into the EU policy process on air pollution. Under FP6 (2002-2006) environment and health risk assessment approaches and tools were developed, including methods for the health impact assessment of policy actions, and preliminary work was carried out on the effects of climate change on infectious disease distribution patterns.

The ERANET for Environment and Health (ERA-ENVHEALTH) completed a report in February 2010 entitled 'Overview of environment and health programmes and projects including synthesis and recommendations'[16]. This gave an overview of the European environment and health landscape based on the description of programmes and their related projects owned or managed by the ERA-ENVHEALTH partners and in a wider scope within the Member States. Information was collected from 38 organisations (including the 16 ERA-ENVHEALTH members) in 11 countries, on 49 E&H funding programmes and 461 associated projects. Most of the programmes described in the report aimed to support policy-makers, to protect the environment and human health, to share information between experts, and to inform the public; the most common topics were outdoor air quality, chemical agents, biological agents, exposure assessment and health impact assessment. The authors stress the need for future collaboration in this area.

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[12] http://www.environmentalresearch.info/search/simple.aspx#d4ea82cf-50cc-461e-a908-fd7f2af40364, ERFF ID 849169

[13] http://www.eea.europa.eu/publications#c9=all&c14=&c12=&c7=en&b_start=0&c5=human

[14] http://eionet.europa.eu/

[15] http://ec.europa.eu/research/environment/pdf/fp7_catalogue_eh.pdf#view=fit&pagemode=none

[16] http://www.era-envhealth.eu/servlet/KBaseShow?sort=-1&cid=23174&m=3&catid=23183

The joint Environment and Human Health Programme[17] was intended to strengthen the UK's capacity for multidisciplinary studies into environment and human health issues, in the context of the overarching question of 'How do we effectively manage the natural environment to improve human health?'. It began in 2007 and the reporting was completed in 2010[18]. It was supported by the NERC, EA, Defra, the MOD, MRC, The Wellcome Trust, ESRC, BBSRC, EPSRC and HPA. Its main areas of interest[19] included: Pollutants, Pathogens, Pathways and People; Transport and dynamics of micro-organisms of human health importance in the natural environment; Emerging infectious diseases; Transport and dynamics of both chemicals and particles of different sizes and compositions in the natural environment that are of human health importance; Technologies providing new capabilities for establishing and predicting the impact of the environment on human health; Social, economic and behavioural factors in the genesis and health impact of environmental hazards. The programme report gives more detailed descriptions of these areas and their respective findings, and project-level detail is held on the ERFF website[20] (ERFF ID 396988).

1.5.3 Individual projects on pollution in general

SEPA's 2006 report on the State of Scotland's Environment[21] identified pressures including localised air pollution, reductions in stratospheric ozone, risks to water quality from diffuse pollution, increases in the amount of waste being produced, potential ecological damage from nutrient enrichment and acidification, loss of biodiversity, and climate change. Data updates are expected to be posted to a new "Scotland's Environment Website"[22] that is intended to provide environmental data in a single location, in support of a new Scottish Monitoring Strategy covering all aspects of environmental monitoring in Scotland.

From the ECEHH:

> Lawton, J.H., Depledge, M.H., et al. (2009). Artificial light in the Environment, Royal Commission on Environmental Pollution, TSO, London. 43pp.
>
> Lawton, J.H., Depledge, M.H., et al. (2010) Adapting institutions to climate change. Royal Commssion on Environmental Pollution , TSO, London (in press).

From the University of Edinburgh[23], on measuring health outcomes and environmental damage:

> Richardson, E.A., Mitchell, R., Shortt, N.K., Pearce, J.R. and Dawson, T. (in press) Developing summary measures of health-related multiple physical environmental deprivation for epidemiological research, Environmental and Planning.

[17] http://www.nerc.ac.uk/research/programmes/humanhealth/

[18] http://www.nerc.ac.uk/research/programmes/humanhealth/documents/ehh-programme-end-report.pdf

[19] http://www.nerc.ac.uk/research/programmes/humanhealth/aims/areas.asp

[20] http://www.environmentalresearch.info/search/

[21] http://www.sepa.org.uk/science_and_research/data_and_reports/state_of_the_environment.aspx

[22] http://www.camerasscotland.org/work/environmental-monitoring

[23] http://www.ed.ac.uk/schools-departments/geosciences/people?indv=1603&cw_xml=publications.html

Pearce, J.R., Richardson, E.A., Mitchell, R. and Shortt, N.K. (in press) Environmental Justice and Health: The implications of the socio-spatial distribution of multiple environmental deprivation for health inequalities in the United Kingdom, Transactions of the Institute of British Geographers.

Moving on to current research, the NERC Science and Innovation Strategy, which sits within the overall strategy for 2007 – 2012, has seven science themes of which one is Environment, Pollution and Human Health[24]. The scope of this theme is: the interactions of humans with the environment (e.g. air, water, soil quality), how man made and natural changes will affect the health and well being of the human population, and how these effects might be prevented or reversed. The key outcomes for this theme are:

1. Reliable predictive capability for the environmental behaviour of pollutants and pathogens;

2. Prediction of effects of changes in other environmental factors that affect human health, such as temperature and drought;

3. Development of abatement technologies using the natural attenuation capacity of the environment;

4. Amelioration of the effects of pollutants and pathogens;

5.Awareness – changes in policy and behaviour;

6.Improved quantification of human health risk due to environmental factors.

The Environmental Exposure and Health Initiative (EEHI) is a current research programme of the NERC[25]. The initiative seeks to support truly integrative and collaborative research programmes that tackle real world questions addressing the interconnections and pathways between environmental pollutants and stressors, exposures, early effects (eg biomarkers) and health outcomes in humans, including variations in susceptibility and the definition of health risks, with the aim to advance the development of evidence based policies. Detail of current projects at the University of Birmingham are described in section 1.5.4 on air quality.

SNIFFER project UKCC01 (2006): Development of a Methodology for Use by Staff Assessing Impacts on Human Health Associated with pollution prevention and control (PPC) Licensing[26], with SEPA and NIEA. The screening tool provides a means of making an initial assessment of the human health impacts that may arise from a PPC installation, in order to determine whether a more detailed assessment is required or whether the impact is judged to be so small that further expenditure of resources on its assessment is not warranted.

SNIFFER UKCC02 (2007): Assessment of Environmental Legislative and Associated Guidance Requirements for Protection of Human Health[27], with SEPA and NIEA. This project sought to identify the legal duties and responsibilities under the various legislative provisions, and also assess the effectiveness of the available guidance in assisting agency staff and other stakeholders in meeting their responsibilities relating to the protection of human health. The main objectives were to develop an understanding of the requirements of

[24] http://www.nerc.ac.uk/about/strategy/documents/theme-report-health.pdf

[25] http://www.nerc.ac.uk/research/programmes/eehi/events/ao.asp#timetable

[26]http://www.sniffer.org.uk/Resources/UKCC01/Layout_Default/0.aspx?backurl=http%3a%2f%2fwww.sniffer.org.uk%3a80%2fproject-search-results.aspx%3fsearchterm%3dukcc01&selectedtab=completed

[27]http://www.sniffer.org.uk/Resources/UKCC02/Layout_Default/0.aspx?backurl=http%3a%2f%2fwww.sniffer.org.uk%3a80%2fproject-search-results.aspx%3fsearchterm%3dUKCC02&selectedtab=completed

relevant legislation with respect to human health and to identify the roles and responsibilities of the agencies under these legislative frameworks, assess the effectiveness of existing guidance available to agency staff and others to allow them to fulfill their duties with respect to the protection of human health, identify gaps in the guidance and prioritise areas where additional guidance is required, and develop generic guidance that can be applied across a range of legislative regimes to assist agency staff and others where gaps in the available guidance have been identified.

1.5.4 Individual projects on air quality

In terms of current research, the DEFRA-funded project 'Monitoring airborne PM concentrations and numbers in the UK 2009-2012'[28] has been running for a year, and is due for completion in 2013. This is basic research to support policy, incorporating field observation of the environment and long-term monitoring of the release of particulates. It aims to prevent or reduce future damage to the environment, by proposing solutions to reduce pollution at source or limit its spread. This is expected to benefit land, water and air quality.

Good Places, Better Health[29] is a Scottish Government project that aims to create safe and positive environments which nurture better and more equal health and wellbeing. Its prototype phase (due for completion in June 2011) addressed the health outcomes of asthma, obesity, mental health and well being, and accidental injuries, in children up to eight years of age. It may be anticipated that its policy outputs will make recommendations regarding air pollution and its consequences for asthma.

The Division of Environmental Health and Risk Management at the University of Birmingham claims to be the largest University-based air pollution research group in the UK and one of the largest in Europe[30]. Publications focused on the links between health conditions and air pollution are listed on the webpage of the Division's Director, Prof. Roy Harrison[31], and Prof. John Ayres[32]. The Division will be hosting a research symposium on 17th May[33] on novel approaches to linking environmental exposure to health.

From the MRC-HPA CEH[34]:

> R Atkinson, Ross Anderson, Gary Fuller, Ben Armstrong, Roy Harrison. Links between urban ambient particulate matter and health - time series analysis of particle metrics
>
> P Cullinan, KF Chung, T Tetley, P Collins, L Järup, P Ohman-Strickland, J Zhang, MJ Nieuwenhuijsen. Health effects of ambient diesel exhaust: "real-world" studies in London

[28] http://www.environmentalresearch.info/search/simple.aspx#d1b840b2-c43f-4618-a3b0-cc6e75f111fc, ERFF ID 1102771

[29] http://www.scotland.gov.uk/Publications/2008/12/11090318/0

[30] http://www.gees.bham.ac.uk/research/clusters/health/exposure/speakers.shtml

[31] http://www.gees.bham.ac.uk/staff/harrisonrm.shtml

[32] http://medweb4.bham.ac.uk/ssp/Printable.aspx?id=3582

[33] http://www.gees.bham.ac.uk/newsevents.shtml

[34] http://www.environment-health.ac.uk/Publications.aspx

Frank Kelly, Ben Barratt, Ben Armstrong, Richard Atkinson, Sean Beevers, Derek Cook, Dick Derwent Dave Green, Ian Mudway, Paul Wilkinson and Ross Anderson. The London Low Emission Zone Baseline Study

SNIFFER ER12 Scoping study (2010): PM2.5 concentrations, sources health effects and regulatory impacts of new policy framework[35]. In collaboration with the EA and SEPA. Industrial sources and power stations contribute most to national primary anthropogenic emissions (35%), followed by road transport (24%), residential (13%) and shipping (10%). Both short- and long-term exposure to PM2.5 gives rise to a range of health effects, including hospital admissions and mortality from respiratory and cardiovascular diseases. The effects of long-term exposure are more significant than those of short-term exposure, in terms of the overall impact on the nation's health. There is no recognised threshold below which there are no health effects.

Significant health benefits across the UK and European Union (EU) populations have been calculated for a given reduction in exposure to PM2.5. These translate into financial benefits, which more than offset the costs of mitigation programmes currently in place.

Legislation to control exposure to PM2.5 includes both exposure standards to define the level of control required; and measures to limit emissions to meet the standards. This builds on current legislation that addresses PM in general, or PM10 in particular. The report recommends further research into PM2.5 sources and concentrations, so as to allow appropriate control strategies to be developed.

Further reporting on the effects of air pollutants on health can be found at:

Comprehensive report on air pollution and health from the CAFE (Clean Air for Europe) programme[36], with volume 2 on health impact assessment probably the most relevant. Some of the exposure-response functions from CAFE have been updated in recent work by EDPHiS in the HEIMTSA (Health and Environment Integrated Methodology and Toolbox for Scenario Assessment) project[37], but this work is not yet in the public domain.

Recent papers on air pollution and mortality (specifically cardiac) include:

Pope III CA, Burnett RT, Krewski D, Jerrett M, Shi Y, Calle EE, Thun MJ (2009). Cardiovascular Mortality and Exposure to Fine Particulate Matter from Air Pollution and Cigarette Smoke: Shape of the Exposure-Response Relationship. Circulation; 120: 941-948.

And for respiratory symptoms:

Schindler C, Keidel D, Gerbase MW, Zemp E, Bettschart R, Brändli O, Brutsche MH, Burdet L, Karrer W, Knöpfli B, Pons M, Rapp R, Bayer-Oglesby L, Künzli N, Schwartz J, Liu L-JS, Ackermann-Liebrich U, Rochat T and the SAPALIDA Team. (2009). Improvements in PM10 exposure and reduced rates of respiratory symptoms in a cohort of Swiss adults (SAPALDIA). Am J Respir Crit Care Med; 179: 589-587.

[35] http://www.sniffer.org.uk/Resources/ER12/Layout_Default/0.aspx?backurl=http%3a%2f%2fwww.sniffer.org.uk%3a80%2fproject-search-results.aspx%3fsearchterm%3dER12&selectedtab=completed

[36] http://ec.europa.eu/environment/archives/cafe/general/keydocs.htm

[37] www.heimtsa.eu

1.5.5 Individual projects on water quality

The Institute for Environment and Health's (IIEH) research into the health effects of sea bathing water in 2000[38], included a critical review and evaluation of the literature on the health risks associated with recreational sea water contact. The report identifies potential adverse health outcomes including gastrointestinal illness, eye infections, skin complaints, ear, nose and throat infections and respiratory disease. It found that data from dose-response models suggest that adverse health effects may occur at levels lower than the current standards. Bathing water quality is regulated under the revised Bathing Water Directive (2006/7/EC)[39] and is monitored by SEPA and the EA. Key features include increased provision of public information, tighter microbiological standards to be met by 2015 and monitoring to be commenced by 2012.

As an example of public information provision: in Scotland, bathing water quality information is displayed on electronic signs at selected beaches, and in 2005 the Water Environment Division undertook research[40] to investigate their effectiveness in informing beach users about current water quality. The signs were found to be an effective means of communication, although of those who had seen the sign only 20% thought that it had influenced their behaviour. Despite this, 80% thought it had increased their awareness of water quality issues at the beach where they were interviewed.

SNIFFER UKLQ07 (2008): Methods for Estimating Impacts of Rainfall on Bathing Beach Quality. Predicting when poor bathing water will occur is important to provide information to the public and to enhance compliance with the revised Bathing Water Directive (2006/7/EC). Heavy rainfall can lead to poor bathing water quality by increasing run-off from farms and causing overflows in the sewerage network, which occurs throughout the UK, but particularly in areas with higher rainfall such as Scotland, North West England and Northern Ireland. The current method of predicting bathing water quality uses point-source rainfall combined with river flow measurements, but predictions may be improved by considering rainfall over the entire catchment instead of at gauge sites. The project showed that radar data is at least as good as rain-gauges in predicting bathing water failure, thus a radar-based system could operate where no rain-gauges exist and may be preferable for cost and practicality reasons.

From the ECEHH[41]:

> Bowen, R.E., Halvarson, H. And Depledge, M.H. (2006). The Oceans and Human Health. Marine Pollution Bulletin, 53, 631-639.
>
> Depledge, M.H. and Bird, W. (2009) The Blue Gym: Health and wellbeing from our coasts. Marine Pollution Bulletin, 58, 947-948.

Papers on the health effects of exposure to polluted water include:

> Exposure to disinfection by-products, fetal growth, and prematurity: a systematic review and meta-analysis. Grellier J, Bennett J, Patelarou E, Smith RB, Toledano MB, Rushton L, Briggs DJ, Nieuwenhuijsen MJ.Epidemiology. 2010 May;21(3):300-13. Review.

[38] http://www.cranfield.ac.uk/health/researchareas/environmenthealth/ieh/ieh%20publications/w2.pdf

[39] http://www.sepa.org.uk/water/bathing_waters.aspx

[40] http://www.scotland.gov.uk/Publications/2005/04/20151710/17111

[41] http://www.ecehh.org/research_publications.php

Total and specific fluid consumption as determinants of bladder cancer risk. Villanueva CM, Cantor KP, King WD, Jaakkola JJ, Cordier S, Lynch CF, Porru S, Kogevinas M. Int J Cancer. 2006 Apr 15;118(8):2040-7.

As an indication of forthcoming research: CAMERAS (Co-ordinated Agenda for Marine, Environment and Rural Affairs Science) has just published two reports on behalf of the Scottish Government[42], Focus on Freshwater Science and Scottish Marine Science Strategy 2010-2015, to identify policy-oriented research priorities. The former[43] addresses human health in terms of clean drinking water (p20) and waste-water management (p21). The latter[44] includes the resilience of the marine ecosystem to contaminants of possible harm to human health (p9).

The EC Water Framework Directive, which came into force on 22 December 2000, established an integrated approach to the protection, improvement and sustainable use of Europe's rivers, lakes, estuaries, coastal waters and groundwater. The UK Technical Advisory Group (UKTAG) maintains a Water Framework Directive (WFD) Research Database[45] to provide up to date information on research supporting the implementation of the WFD in the UK. The database holds information on current, completed and proposed projects directly and indirectly related to the WFD throughout the UK and where available, other EU countries.

1.5.6 Individual projects on soil quality

The State of Scotland's Soil report (2011)[46] follows on from the Scottish Soil Framework (2009)[47], a wide-ranging review of the pressures on, and the opportunities for, our soils. This report responds to the Framework's vision that soils are a finite, non-renewable resource that should be managed for sustainable development. This evaluation suggests that the principal threats to soil functions are loss of soil organic matter, changes in soil biodiversity, and erosion and landslides; soil sealing was also ranked as an important threat. Whilst the report does not explicitly aim to link soil quality to health, soil function needs to be retained to contribute to food production, filtering drinking water, stroing carbon and avoiding landslides (p16).

A recent CAMERAS workshop aimed to establish the current state of knowledge on soil data and carbon monitoring[48]. The discussion papers, available on the CAMERAS website, outline the contributions made. The workshop's focus on establishing what knowledge is held by the partners, and on identifying routes to closer

[42] http://www.camerasscotland.org/news/cameras-announces-publication-focus-freshwater-science-and-scottish-marine-science-strategy-201 (2011)

[43] http://www.camerasscotland.org/sites/default/files/images/docs_store/Focus%20on%20Freshwater%20Science.pdf (2011)

[44] http://www.camerasscotland.org/sites/default/files/images/docs_store/Scottish%20Marine%20Science%20Strategy%202010%20-%202015.pdf (2011)

[45] http://www.wfduk.org/r_and_d/wfddatabase/

[46] Scotland's Soil Report - Dobbie, K.E., Bruneau, P.M.C and Towers, W. (eds) 2011. The State of Scotland's Soil. Natural Scotland, www.sepa.org.uk/land/land_publications.aspx

[47] http://www.scotland.gov.uk/Publications/2009/05/20145602/0

[48] http://www.camerasscotland.org/news/soil-data-and-carbon-monitoring

cooperation, suggests that soil quality projects are still in their infancy – and so that UK-based projects targeted on health outcomes may be some way off yet. Internationally, the US Nutrition Security Institute reported in 2006[49] on the connection between soil depletion and human health, via the nutritional quality of harvested food and sustainable farming systems; the US Department of Agriculture's guidelines for research into soil quality[50] refer to its role in maintaining water and air quality and human health; the Canadian Council of Ministers of the Environment[51] summarises the scientific research which provides the background information and rationale for the derivation of human health and environmental soil quality guidelines for potentially carcinogenic and other polycyclic aromatic hydrocarbons (PAHs).

From the MRC-HPA CEH:

> Zheying Zhu, Robert J Edwards and Alan R Boobis. Biomarkers of pesticide exposure and early indicators of adverse effect: development and validation.

SNIFFER ER26 Screening tool: for assessing deposition of ammonia and dust on sensitive receptors from intensive pig and poultry units[52], in collaboration with SEPA, NIEA, EA and Irish EPA. The purpose of this project is to produce an expanded and improved SCAIL-Agriculture screening tool that will cover the UK and the Republic of Ireland, to provide an estimate of the deposition and air concentrations of ammonia and dust (primary particulate matter) from intensive pig- and poultry-rearing sites on/at nearby sensitive receptors. The output from the tool will help environmental regulators to make a decision on whether further, more complex dispersion and deposition modelling are needed.

For health effects of occupational exposure to pesticides there is a comprehensive review from Canada:

> Sanborn M, Cole D, Kerr K, Vakil C, Sanin KH, Bassil K. (2004). Sytematic Review of Pesticide Human Health Effects. The Ontario College of Family Physicians, Canada.

1.5.7 Individual projects on positive impacts on health of environment or greenspace

In addition to the projects described above, that consider the harmful effects on health of pollution, a salutogenic approach is also emerging which considers the potential beneficial effects on health of improved environments.

The Scottish Government's Good Places, Better Health project (see section 1.5.4 above) includes health outcomes of obesity – incorporating both diet and physical activity – and mental health and wellbeing. Although its policy outputs are not due for completion before summer 2011, they will make policy recommendations for access to greenspace or open spaces in general, in relation to both of these health outcomes.

The ECEHH research programme extends beyond the idea of interconnections between the environment and human health, by exploring how we might use the natural environment to promote health and wellbeing:

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[49] http://www.nutritionsecurity.org/PDF/NSI_White%20Paper_Web.pdf

[50] http://soils.usda.gov/sqi/concepts/concepts.html

[51] http://www.ccme.ca/assets/pdf/pah_soqg_ssd_1401.pdf, 2006

[52] http://www.sniffer.org.uk/Resources/ER26/Layout_Default/0.aspx?backurl=http%3a%2f%2fwww.sniffer.org.uk%3a80%2fproject-search-results.aspx%3fsearchterm%3der26&selectedtab=active

White, M, Smith, A, Humphreyes, K, Pahl, S, Snelling, D & Depledge, M (2010) Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. Journal of Environmental Psychology. doi:10.1016/j.jenvp.2010.04.004.

The CAMERAS report, Focus on Freshwater Science[53] addresses the beneficial impacts on human health and wellbeing of healthy freshwater ecosystems (p20).

1.6 Potential areas for future research

In connection with climate change, the SEPA Research Strategy for 2008-12[54] suggested that more understanding is needed in fields including the psychological effects of flooding.

SEPA's 2006 report on the State of Scotland's Environment identifies gaps in knowledge about a number of aspects of the environment including, for instance, land (especially soil) quality, the environmental implications of hazardous chemicals and the relationships between the environment and human health.

The Environment Research Funders' Forum has produced an analysis of issues affecting the environment which might impact on the UK's interests over the next 20 years[55]. It attempts to identify environmental themes that are hedged about with uncertainties, which might develop into full-blown problems that could affect the UK socially, financially or perhaps impact on our health. It identifies broad themes that are developing in an uncertain way, perhaps approaching a tipping point, or about which we know too little, including cities and the environment, food production and sustainability of water supply.

A gap in the knowledge (as reported by a representative of SEPA) is a deeper understanding of the ways in which environmental pressures affect human health, and particularly how the environment – and the pressures placed upon it – are changing, and what the consequences might be for human health in the future. Key pressures might be associated with food production, energy generation, and transport. The current practice by the regulators of monitoring standards to demonstrate that they are protecting the environment, such as people's exposure to substances, assumes that we understand their effect on health: to move from a demonstration of compliance with standards towards a demonstration of health impacts, we will need to model the exposure better. For example, the extent to which the ecosystem can act as a proxy for human health, and the extent to which we can use these as signals for human health exposure - human bio-monitoring has been used in some countries to show the link from environment to health. Further sources might include the Health Protection Agency; lead levels in blood; The UK Department of Health's report on the Health Effects of Climate Change in the UK, 2008[56].

1.7 Other important points to consider

Topics in which SEPA have expressed a strong interest, but which lie outside the scope of this summary, include waste disposal, radioactivity, flooding and nano materials. The concerns are outlined below, and these could form the basis of future research summaries.

[53] http://www.camerasscotland.org/sites/default/files/images/docs_store/Focus%20on%20Freshwater%20Science.pdf

[54] http://www.sepa.org.uk/science_and_research/idoc.ashx?docid=67dd4cf9-89da-4e17-991a-6618d43c5b9a&version=-1

[55] http://www.lwec.org.uk/sites/default/files/20071212-report-horizonscanning.pdf

[56] http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_082836.pdf

1.7.1 Waste disposal

The concerns in relation to the environment and health are:

- the treatment of land with waste, affecting food quality and pollution
- generating energy from waste, regarding incineration and exposure to by-products
- landfill.

These might be framed as the sustainable use of resources, or waste minimisation leading to zero waste.

Land that has been contaminated in the past, its consequences for regeneration, eg the south side of Glasgow and preparations/motorway construcyion for the Commonwealth Games.

UNEP report on disease and waster disposal in Kenya[57].

1.7.2 Radioactivity

This is thought to be appropriate to the subject of environment and health, because many of the regulations concerning radioactivity are tied in to human health.

Furthermore, the nuclear accident in Japan has raised questions concerning the extent of our understanding of the consequences of radioactivity on pathways and receptors.

1.7.3 Flooding

The CAMERAS report, Focus on Freshwater Science, identifies a research priority of better understanding the social impacts of flooding and providing appropriate support to communities.

Linking back to the SEPA research strategy that mentions the psychological effect of flooding, regulation is by the Flood Risk Management Act. SEPA's Annual Operating Plan for this year will give a current perspective on the issues and priorities.

http://www.environment-agency.gov.uk/homeandleisure/floods/31618.aspx - background to flood warnings, but not regulation, health or research.

http://www.hpa.org.uk/flooding - Flooding presents a number of risks to health, drowning being the most obvious. Serious injury can be caused by falling into fast flowing water or from hidden dangers under the water, such as missing manhole covers. The stress and strain of being flooded and cleaning up can have a notable impact on mental health and wellbeing.

http://www.earthscan.co.uk/?tabid=419 - Sue Tapsell, Flood Hazard Research Centre, School of Health and Social Sciences, at Middlesex University; Sylvia Tunstall, Flood Hazard Research Centre and link to new book:

> **Flood** Hazard **Research** Centre The Flood Hazard Research Centre (FHRC) is an interdisciplinary centre based at Middlesex University, in the School of Health and Social Sciences. ... www.mdx.ac.uk/**research**/areas/geography/**flood**.../index.aspx

[57] http://www.unep.org/urban_environment/pdfs/dandorawastedump-reportsummary.pdf

http://www.parliament.uk/documents/post/postpn232.pdf - the future impact of climate change on flood risks, and development of precautionary strategies. Basis of a national assessment of the potential UK health.

http://www.scotland.gov.uk/Publications/2007/04/02121350/11 - 2011 ... Brown J D and Damery S L (2002) Managing flood risk in the UK: towards ... Few R , Ahern M, Matthies F and Kovats S (2004) Floods, health.

1.7.4 Nano materials in the environment

Although this is not yet an area for regulators, they seek a better understanding of it. SEPA's Annual Operating Plan seeks to protect and improve the environment, by understanding it: this may imply that we cannot protect people's health from nano materials if we do not understand them, so the purpose of a summary on this would be to point out where published research can be found.

A report from the Food Standards Agency[58] published on 21 April says that consumers are worried about both the safety and the necessity of nanotechnology in food production. However, it also says that the public is more likely to accept the technology if it can be shown to be safe and there are clear benefits to consumers.

From the ECEHH:

> Depledge, M.H. and Owen, R. (2010). Nanomaterials and Human health (in prep).
>
> Depledge, M.H., Pleasants, L. and Lawton, J.H. (2010). Nanomaterials and the Environment, Environmental Toxicology and Chemistry, 29, 1-4.

From the MRC-HPA CEH:

> Andrew Thorley, Sarah Kemp, Julia Gorelik, Yuri Korchev, Terry Tetley. Nanotoxicology.

Further sources:

> Website for Royal Commission on Environmental Pollution (if site is still live following closure of the commission.
>
> Environmental Nanoscience Initiative – event in York a few years ago.
>
> Transatlantic scheme/ initiative, UK lead is Richard Owen at UK Centre for Environment and Health.
>
> Birmingham: http://www.gees.bham.ac.uk/research/clusters/health/nanoscience.shtml

[58] http://www.researchprofessional.com/#main$.Data.1054617$preview1054470aspect$Article$, http://www.food.gov.uk/news/newsarchive/2011/apr/nanoviews