eri environmental research institute

elements

spring 2018 newsletter

North Highland College University of the Highlands and Islands

University of the Highlands and Islands Oilthigh na Gàidhealtachd agus nan Eilean

From left: Yuan Li, Lydia Niemi and Pavlina Landova

Medicating our environment: human drugs in natural waters

Pharmaceuticals play a fundamental role in modern health care, however, numerous studies have shown that they can also be contaminants that may threaten aquatic organisms and water quality, including potable supplies.

In Scotland, more than 100 million items of medicine (worth £1.3bn) were prescribed in 2016/17 and >3000 active ingredients are currently licensed for use in the UK. Increased longevity and human population growth, together with the drive to promote human health and pharmacological advances have resulted in a proliferation in the quantity and diversity of pharmaceuticals consumed. By 2020, global spending on pharmaceuticals is projected to reach >$1.3 trillion/yr.

Following administration, human pharmaceuticals pass through the body and are introduced into the domestic wastewater system (via urine and faeces) in either metabolised or un-metabolised forms. Likewise, the direct flushing of unused pharmaceuticals down the toilet is commonplace.

However, many studies have shown that wastewater treatment plants (WWTPs) do not always effectively remove or degrade many of these bio-active compounds. WWTP effluents have been identified as the principal pathway for the introduction of these compounds into the aquatic environment. More than 600 pharmaceuticals from classes including antibiotics, antidepressants, beta-blockers, NSAIDs, antifungals and lipid-lowering agents have been detected in rivers, lakes or coastal waters in 70 countries worldwide.

Since pharmaceutical compounds are specifically 'designed' or 'selected' to produce biological effects their potential impact on water quality and non-target

Continued on page 2

Continued from page 1

organisms in the aquatic environment is of growing concern.

For example, 17α-ethinylestradiol, a synthetic hormone commonly used in birth control pills, has been widely shown to cause feminisation of male fish, and this can potentially lead to population collapse (Kidd et al. 2007). Also, the antidepressant fluoxetine has been shown to delay tadpole development in leopard frogs (Foster et al. 2010), whilst (in Sweden) the presence of the anti-anxiety drug (Oxazepam) has been shown to influence the migratory behaviour of salmon smolts (Hellstrom et al. 2017).

As global pharmaceutical use increases, and pressures on water resources grow, understanding the presence and behaviour of these so called 'emerging contaminants' in natural and potable waters has become a priority issue from a scientific and environmental perspective, as well as for human health. Numerous unanswered questions remain - and thus, extensive research opportunities exist.

The ERI is part of a global effort to understand and mitigate against the effects of pharmaceuticals in the environment. Activity spans from developing high sensitivity analytical techniques for target drugs to advancing novel techniques for water remediation.

Current research includes an Erasmus project with the Brno University of Technology to develop 'passive sampling' techniques to assess the distribution of human pharmaceuticals in the aquatic environment (Pavlina Landova). Two PhD scholarships (funded through the Scottish Government's HydroNation programme) will also (a) characterise the degradation pathways for human pharmaceuticals in natural waters (with the James Hutton Institute; Lydia Niemi), and (b) develop and evaluate low cost, natural sorbents for the removal of drugs from wastewater (with the Chinese Academy of Sciences, James Hutton Institute and the University of Dundee; Yuan Li).

ERI is also currently working with local stakeholders such as NHS Highland, Highlands and Islands Enterprise and Scottish Water, and through membership of Healthcare Without Harm, will seek to '*transform health care worldwide so that it reduces its environmental footprint, become a community anchor for sustainability, and be a leader in the global movement for environmental health and justice*'.

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The James Hutton Institute

Scottish Water
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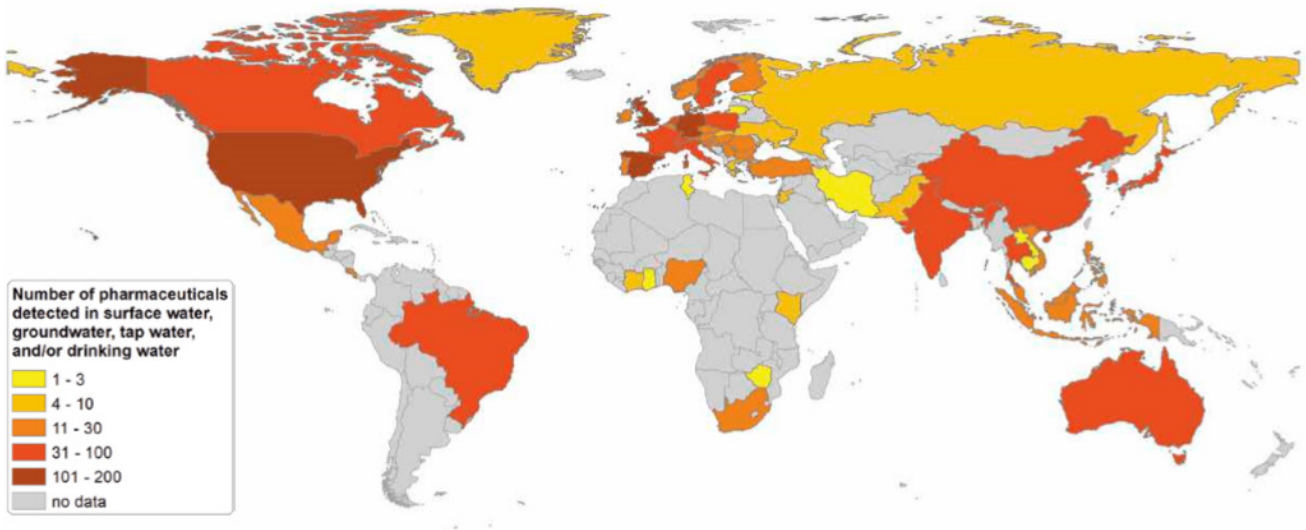
BRNO UNIVERSITY OF TECHNOLOGY

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

NHS Highland

Number of pharmaceuticals detected in surface water, groundwater, tap water, and/or drinking water



Source: Aus der Beek et al., 2016. Pharmaceuticals in the environment-Global occurences and perspectives. Environmental Toxicology and Chemistry; Volume 35 (4) pp 823-835

Remote Sensing of Floating Plastic Litter

Maybe you saw Dr. Lonneke Goddijn-Murphy and Juvenal Dufaur experimenting with plastic objects in the boating pond in Thurso last October and wondered what was going on? Following succesful applications to the Carnegie Trust (Research Incentive Grant) and the NERC Field Spectroscopy Facility for the loan of a field spectrometer, Lonneke and Juvenal measured how daylight interacts with common plastic litter floating in water. The spectrometer took detailed light measurements ranging from the visible to infrared spectrum. The experiment supported Lonneke's development of remote sensing methods for monitoring marine plastic pollution.

Remote sensing is the science of obtaining information about objects or areas from a distance, using sensors mounted on platforms such as ships or satellites. Although marine plastic is a global environmental problem that is of increasing concern, there are still many questions about source, pathways and trends in abundance. Remote sensing of the water surface can help answer these questions but is still in its infancy for marine litter. We are happy to report that although the lighting conditions were challenging, the experiment was successful.

Lonneke was invited to present her latest research at the "Workshop on remote sensing of marine litter" at the European Space Agency (ESA) in Noordwijk, and to discuss ways forward with other experts in this emerging field of environmental science. Everyone agreed that it would be better to not have any plastic in the water at all and that the raised public awareness and legislative measures aimed at reducing plastic waste are encouraging. But, until then, it is important to keep track of marine plastics and their harmful effects by developing long-term, global monitoring methods. Lonneke has also recently represented the work of ERI at a workshop at the Aurora Innovation Centre of the Brittish Antarctic Survey in Cambridge to explore solutions for reducing and mitigating ocean plastic pollution.

Lonneke is an unfunded collaborator in the ESA funded project Resmali (Remote sensing of marine litter)

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THE CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

Field Spectroscopy Facility
Natural Environment Research Council

Common plastic litter items were measured floating on a natural water surface

From Thurso pond to the European Space Research and Technology Center (ESTEC) in Noordwijk, the Netherlands

What Did The Bugs Ever Do For Us?

During October school holidays, UHI STEM team visited North Highland College to promote science, technology, engineering and maths (STEM) through a series of workshops for school children. Helped by Mairi Stewart (UHI STEM), Dave Braidwood hosted an event about invertebrates, introducing pupils to microscopes and hand lenses as a way of finding out the answer to 'What did the bugs ever do for us?'

Each group first visited the wildflower meadow for a chat about its merits as habitat for bugs / conservation for flower species. Moving to ERI teaching lab (via our microscope room) participants saw the different ways of magnifying specimens – from a hand lens to the scanning electron microscope (SEM). They also learnt about different parts of insects and how these are used for identification. The evolutionary theory of Charles Darwin and Alfred Russel Wallace was mentioned - and the attendees were then let loose!

Using microscopes, pupils studied flies, ants, springtails and beetles, counting wings and legs as they went, and then produced some fantastic drawings. Using their new knowledge of how insects eat, live and defend themselves, they thought of what a future evolving 'super insect' might be composed of – hard wing covering as armour, springing tail for escape, large jaws for attack – and collectively created some phenomenal insects (possibly evolving in our meadow right now)!

Thanks to our 25 attendees who made this such an enjoyable day - we look forward to putting on similar events in the future.

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creating 'super' bugs

Flows Research Flies to Canada

Dr Paul Gaffney, who recently completed his PhD on peatland restoration and water quality, was invited to collaborate with the Peatland Ecology Research Group (PERG) at Université Laval, Quebec. The Grande-Plée-Bleue is a raised bog which is soon to receive 'protected ecological reserve' status from the Quebec government due to its high nature conservation value. However, two large drains have run through the site since the 1950s causing damage to the bog habitat, lowering the water table and encouraging growth of trees. Professor Line Rochefort (PERG) and her team have been working there since 2010, initiating a restoration scheme for the site.

Paul's role in this project is to analyse seven years of hydrology, water chemistry and vegetation data - collected to monitor restoration of the Grande-Plée-Bleue bog. Due to experience gained from the forest-to-bog restoration project on Forsinard Flows NNR, Paul will be able to apply his knowledge of the ecological effects following peatland re-wetting to produce a scientific publication for the group.

So far collaboration has involved two visits to Quebec - the first in October 2017, then February, when Paul presented his own research to representatives from the peat extraction industry at the PERG annual conference.

ERI hope to continue collaboration with PERG, which is also the former group of Dr. Roxane Andersen, leader of the Carbon Water and Climate theme at ERI.

Rewetting on the Grand Plée Bleue bog

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Politicians, Planners and Researchers Meet in South Greenland

REGINA aims to develop planning methods and processes supporting local communities facing the development of large-scale, resource-based industries.

Through the REGINA project, ERI researcher Magnus Davidson joined Northern Periphery and Arctic Programme partners in south Greenland last year to discuss local planning and development. The meeting coincided with the launch of one of three main toolboxes to come out of REGINA.

The SIMP (Social Impact Management Plan) allows an assessment of the social effects in remote communities involved in major change. The SIMP enables continuous monitoring of social change to soften the blow from large scale industries operating in the local area. It highlights the positive effects and the human potential in local communities.

When remote communities are faced with issues surrounding large scale industrial development the focus is often on the economic interests or the environmental consequences, whilst the social and human aspects tend to take second place.

In addition to the SIMP-report, the Demographic Foresight Model (DFM) and upcoming DFM handbook were also unveiled at the event. Magnus has been working with the Nordic Centre for Regional Studies (Nordregio) to model Caithness and Sutherland population demographics resulting from changes in local industry - namely the winding down of decommissioning at the Dounreay nuclear power complex.

Magnus also introduced the concept behind the third tool - the Local Benefits Analysis Toolbox. ERI have been developing this together with resulting policy guidelines which aim to help local communities retain economic benefit from large scale resource based industries.

During the meeting the group visited the Kvanefjeld Rare Earth – Uranium project in the northwest corner of the Ilimaussaq complex. Kvanefjeld is the first of several large-scale deposits in Greenland to be delineated. It is recognised as one of the world's largest resources of rare earth elements, as well as containing substantial resources of uranium and zinc.

The Kvanefjeld development has been the main focus of REGINA's work in Greenland. It is expected that the tools created by the researchers and planners will be used to highlight the opportunities, and to tackle the challenges involved in managing the development of this mine.

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Northern Periphery and Arctic Programme 2014–2020
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European Regional Development Fund
REGINA

Mining equipment, south Greenland in the shadow of the proposed Kvanefjeld rare earth element and uranium mine

New faces @ ERI

Dr Szabolcs Pap
Water Technologist

I joined in November 2017 as a Water Technologist in the Environmental Contamination and Ecological Health' theme.

My research is on adsorption technology in water and wastewater treatment with focus on development and characterisation of new adsorption media from biomass and other waste materials; mathematical modelling of adsorption systems and investigation of adsorption mechanisms of organic and inorganic pollutants.

Prior to joining the ERI, I worked at the University of Novi Sad, Faculty of Technical Science as a teaching assistant and PhD researcher. My dissertation deals with the conversation of lignocellulosic waste materials into low-cost activated carbons and their use for heavy metal removal from wastewater. I hope to expand my research at ERI to development of novel remediation techniques for the removal of contaminants from waters and wastes (construction and operation of laboratory-scale and pilot plant systems to evaluate new approaches to water treatment and remediation).

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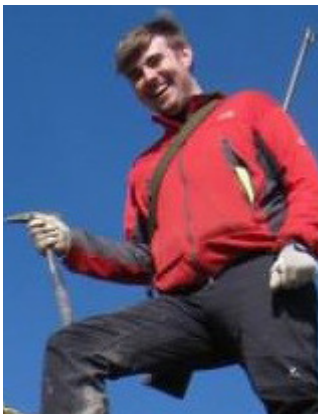
Dr. Chris Marshall
Peatland Scientist



I joined ERI as a Peatland Scientist to cover for Roxane Andersen whilst she is on maternity leave. I am a Postdoctoral Research Fellow at the University of Nottingham, working on the NERC InSAR ToPS project, a collaboration between ERI, Universities of Nottingham and Glasgow, RSPB, SNH, Plantlife and Geomatic Ventures Ltd.

The project aims to use a novel radar technique to measure peatland motion and health using high frequency, low cost Sentinel I satellite constellation measurements. As part of this, I will conduct precise levelling surveys and GPS measurements at sites at Munsary (Plantlife) and Knockfin Heights (RSPB).

My background is as a geologist, examining coal (ancient peat) as a climate record in the Palaeocene Arctic and as an atmospheric dust record during the Permian. More recently I have worked on projects using InSAR remote sensing as a means to monitor tropical peat health in Peninsular Malaysia. I am excited to join ERI and look forward to my time in the Highlands.

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Henk -Pieter Sterk
PhD Student

Since October I have been part of an interdisciplinary team of scientists at the ERI. As a PhD researcher, I will work on a peatland project that aims to relate field-based greenhouse gas measurements with aerial drone-derived imagery and remote sensing (RS) data, in order to create a tool to analyze the whole Flow Country. My studentship is funded by the European Social Fund and the Scottish Funding Council.

During my studies, BSc and MSc Earth Sciences at the University of Amsterdam, I worked on peatlands, although in contrast these were base-rich floating fens, as opposed to the mostly acidic blanket bogs here. After that, I obtained valuable GIS and RS skills. That helped me to conduct research on mapping areas in the Alps that are prone to mass-movements. A new method to digitally map these features was successfully proposed and tested, using various spatial data sources including drone-derived images.

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Iain Detrey
PhD Student

I joined the ERI family in October, embarking on my PhD journey with a project entitled 'Assessing the viability of long term peat storage for future peatland restoration in a Shetland onshore E&P development', otherwise known as the 'bog in a box'.

As the title suggests I won't be a regular face around Thurso as I will be based at the North Atlantic Fisheries College/UHI on Shetland for the majority of my project.

My passion for peat first emerged when I studied fresh water ecosystems as part of my biology BSc at Bangor University. I then went on to study it further during my wetland science and conservation MSc, again at Bangor, where I researched the possibility of enhancing the 'Enzymic latch' on peatland carbon storage using a phenolic rich brewing by-product.

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Monitoring Plastic in Seabird Nests

Shag nest with fishing net

Several seabird species are known to incorporate plastic into their nests, particularly those that build substantial surface nests such as gannets and shags.

To date, the majority of evidence concerning nest incorporation is anecdotal, with little understanding of how this issue varies over time and space, or among species. In a recent study assessing the impact of marine plastic on seabirds in the northeastern Atlantic, we only found quantitative, published data for two species -Northern Gannets on Grassholm and Kittiwakes in Denmark. There is, therefore, a need to obtain baseline information on the extent of this issue within this region.

However, visiting all the seabird colonies around the UK is a big task! Fortunately, this year volunteers will be do this as part of the fourth national seabird census 'Seabirds Count'. We have teamed up with JNCC to take advantage of this opportunity and are asking people to also record the proportion of seabird nests that contain plastic, and if possible send us photographs.

If you would like to get involved then please get in touch. This information will help us find out where marine plastic pollution is having the greatest impact on our seabirds, and which species are most vulnerable.

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circular ocean

Seaweed and Drones

The ERI recently undertook a partnership with local company New Wave Foods, Wick, utilising the Scottish Funding Council Innovation Voucher Scheme which encourages new partnerships between a company and a university.

The aim of this feasibility study was to determine percentage cover of seaweed resource at a harvest site by classifying seaweeds to species level in aerial images.

The aerial photographs were obtained by a near infrared-modified camera mounted to the institutions unmanned aerial vehicle (or small drone).

A series of images were stitched together to form a larger mosaic which underwent analysis to identify areas of algae cover. This is useful in vegetation studies whereby healthy plant reflect more infrared light than other materials, like rock and water.

The study found the methods employed are successful in the determination of biomass on the seashore with some species identification being possible from low level flights. Further improvements to the techniques will be investigated including the use of a hyperspectral camera to increase species identification.

Distribution of algae captured using infrared camera

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Interface
The knowledge connection for business

new wave foods

Publications

Commin, A. N., French, A., Marasco, M., **Loxton , J., Gibb, S. & McClatchey**, J. 1 Nov (2017). The Influence of the North Atlantic Oscillation on diverse renewable generation in Scotland. *Applied Energy*. 205, p. 855-867. Doi: 10.1016/j.apenergy.2017.08.126.

Creevy, A. L., **Andersen, R.**, Rowson, J. G. & Payne, R. J. (2018). Testate amoebae as functionally significant bioindicators in forest-to-bog restoration. *Ecological Indicators*. 84, p. 274-282. Doi: 10.1016/j.ecolind.2017.08.062.

Fox, C., Benjamins, S., **Masden, E.** & Miller, R. (2017). Challenges and opportunities in monitoring the impacts of tidal-stream energy devices on marine vertebrates. *Renewable and Sustainable Energy Reviews* . 81, 2, p. 1926-1938. Doi: 10.1016/j.rser.2017.06.004.

French, A. S., Shaw, D., **Gibb, S. W. & Taggart, M. A.** (2017). Geochemical landscapes as drivers of trace and toxic element profiles in wild red deer (Cervus elaphus). *Science of the Total Environment*. 601-602, p. 1606-1618. Doi: 10.1016/j.scitotenv.2017.05.210.

Goddijn-Murphy, L., Peters, S., van Sebille, E., **James, N. & Gibb, S.** (2018). Concept for a hyperspectral remote sensing algorithm for floating marine macro plastics. *Marine Pollution Bulletin*. 126, p. 255–262. Doi: 10.1016/j.marpolbul.2017.11.011.

Li, C., Xie, B., Chen, J., Chen, Z., Sun, X. & **Gibb, S. W.** (2017). H_2O_2-microwave treated graphite stabilized stearic acid as a composite phase change material for thermal energy storage. *RSC Adv.* 7, 83, p. 52486-52495. Doi: 10.1039/C7RA11016B.

Naidoo, V., **Taggart, M. A.**, Duncan, N., Wolter, K., Chipangura, J., Green, R. E. & Galligan, T. H. (2018). The use of toxicokinetics and exposure studies to show that carprofen in cattle tissue could lead to secondary toxicity and death in wild vultures. *Chemosphere*. 190, p. 80-89. Doi: 10.1016/j.chemosphere.2017.08.167.

O'Hanlon, N. J., James, N., Masden, E. & Bond, A. (2017). Seabirds and marine plastic debris in the northeastern Atlantic: A synthesis and recommendations for monitoring and research. *Environmental Pollution*. 231, p. 1291-1301. Doi: 10.1016/j.scitotenv.2017.05.210.

O'Hanlon, N. J., Finch, T. & Dudley, S. 1 Nov (2017). Tweeting birds: online mentions predict future citations in ornithology. *Royal Society Open Science*. 171371. Doi: 10.1098/rsos.171371.

Ratcliffe, J., **Andersen, R.**, Anderson, R., Newton, A., Campbell, D., Mauquoy, D. & Payne, R. (2018). Contemporary carbon fluxes do not reflect the long-term carbon balance for an Atlantic blanket bog. *Holocene*. Vol 28, Issue 1 Doi: 10.1177/0959683617715689.

Ratcliffe, J. L., Creevy, A., **Andersen, R.**, Zarov, E., **Gaffney, P.**, **Taggart, M. A.**, Mazei, Y., Tsyganov, A. N., Rowson, J. G., Lapshina, E. D. & Payne, R. J. (2017). Ecological and environmental transition across the forested-to-open bog ecotone in a west Siberian peatland. *Science of the Total Environment*. 607-608, p. 816-828. Doi: 10.1016/j.scitotenv.2017.06.276.

Tamsett, D. (2017). Geometrical Spreading Correction in Sidescan Sonar Seabed Imaging. *Journal of Marine Science and Engineering*. 5, 4, p. 54-68. Doi: 10.3390/jmse5040054.

Thaxter, C. B., Ross-smith, V., Bouten, W., **Masden, E.**, Clark, N. A., Conway, G. J., Barber, L., Clewley, G. & Burton, N. H. K. (2018). Dodging the blades: new insights into three-dimensional space use of offshore wind farms by lesser black-backed gulls Larus fuscus. *Marine Ecology-Progress Series*. 587, p. 247-253. Doi: 10.3354/meps12415.

Turk Sekulić, M., **Pap, S.**, Stojanović, Z., Bošković, N., Radonić, J. & Šolević Knudsen (2018). Efficient removal of priority, hazardous priority and emerging pollutants with Prunus armeniaca functionalized biochar from aqueous wastes: Experimental optimization and modelling. *Science of the Total Environment*. 613-614, p. 736-750. Doi: 10.1016/j.scitotenv.2017.09.082.

Vukelic, D., Boskovic, N., Agarski, B., Radonic, J., Budak, I., **Pap, S.** & Turk Sekulic (2018). Eco-design of a low-cost adsorbent produced from waste cherry kernels M. *Journal of Cleaner Production*. 174, p. 1620-1628. Doi: 10.1016/j.jclepro.2017.11.098.

environmental research from a new perspective

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