TRACK AND TRACE TESTS START TO FINGERPRINT ENVIRONMENTAL POLLUTION

Can AD increase its role as an environmental bodyguard? The science of wastewater-based epidemiology might have the answer.

As part of a wastewater treatment plant (WWTP), anaerobic digestion is an excellent way to kill numerous types of pathogens, especially where a pasteurisation stage is involved. Yet another largely invisible service the sector delivers that needs to be recognised. Analysis of wastewater streams, particularly before such treatments, reveal a great deal about what can enter the environment, from drugs and chemicals to disease.

Testing the water at Glastonbury Festival in 2019

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This concept of wastewater-based epidemiology (WBE) was proposed by Christian Daughton of the US EPA in 2001. Much of the early research focussed on detecting and understanding usage patterns of chemicals (e.g., illicit drugs), with an increasing focus over the last decade on chemical biomarkers (e.g., pharmaceuticals, and alcohol) to assess community-wide health and lifestyles. WBE also shows promise for monitoring anti-microbial resistance, as well as non-communicable and infectious diseases, e.g. influenza, norovirus, respiratory viruses and polio.

WBE principles and techniques can also be used outside WWTP's for environmental monitoring. There can be adverse environmental effects, particularly in watercourses, when untreated wastes enter the environment through events such as combined sewer overflows, agricultural run-off or even large public events. The authors of the academic paper entitled 'The environmental release and ecosystem risks of illicit drugs during Glastonbury Festival' (https://bit.ly/3D5uHKP) saw their research widely disseminated by newspaper headlines such as 'MDMA and cocaine levels so high in river at Glastonbury Festival it is harming wildlife' (https://bit.ly/3d0Pu7E).

Even where wastewater is treated using technologies such as AD and pasteurisation, there are still significant gaps in our knowledge of treatment efficacy, not least because of the proliferation of chemicals used in personal care products (have a look at those labels), industry, food production, clothing/textiles and even firefighting foams.

A busted flush

Dr Barbara Kasprzyk-Hordern's research group at Bath University examines untreated wastewaters for specific biomarkers which includes metabolites (products of cellular processes), antibiotics, proteins or, as in the case of SARS-CoV-2, genetic material.

Biomarkers must be measurable/quantifiable, and they must be relatively stable in wastewater so that they don't biodegrade or disappear altogether. Researchers require an understanding of other factors to 'normalise' the data, such as the number of people served by the wastewater treatment plant, the type of processing that takes place and the amount of rainwater ingress. Certain biomarkers may require an understanding of how factors such as the health, age, weight, gender, diet or ethnicity might affect the concentration of the biomarker produced or whether the effect of such factors is trivial.

In a recent EB Network lecture (https://bit.ly/31fTQFw) Dr Kasprzyk-Hordern gave fascinating examples of how her research group tracked stable usage of Diazepam, weekend usage of club drugs such as cocaine/MDMA and increased weekend exposure to pyrethroids (herbicides) associated with vegetable consumption. They were even able to differentiate when someone 'flushed' carbamazepine tablets (used to treat epilepsy), since an excess of the compound was found on a single day without any corresponding rise in the associated metabolite – potentially creating a huge localised ecotoxicological effect which would be completely overlooked by regulators.

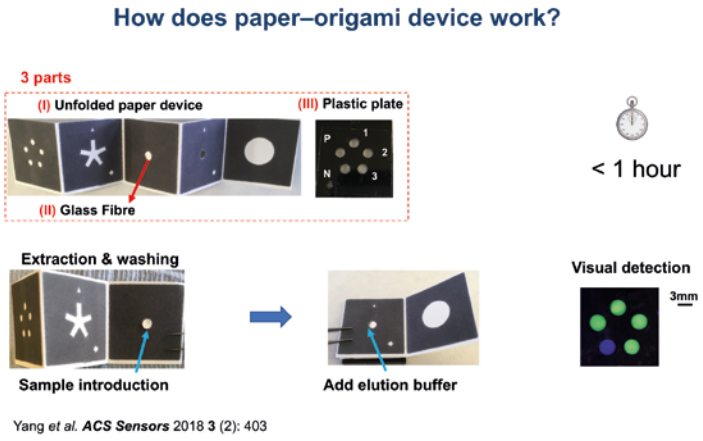
Covid clusters

In a separate EBNet webinar (https://bit.ly/3o2mWAQ), Dr Andrew Singer, a Principal Scientist at the UK Centre for Ecology and Hydrology, explored the current and next generation of monitoring for human and environmental protection, having been involved in the UK's National Covid-19 Wastewater-Based Epidemiology Surveillance Programme (https://bit.ly/3lkSSyF). The pandemic highlighted failures worldwide in the detection and management of the virus, but it also provided an opportunity to accelerate the knowledge and techniques on WBE. The early signs are that by acting as an early warning system, it's possible for WBE to identify geographical areas which require a more focused epidemiological intervention, a cost-effective alternative to the expensive and logistically challenging task of blanket-testing thousands or even millions of people.

Dr Singer's comprehensive talk covered a number of projects at universities, prisons, hospitals, schools and care homes, examining the challenges and new insights obtained, as well as potential areas for future research. One of Dr Singer's concluding thoughts was that the Covid-19 pandemic had built the UK's capacity to conduct wastewater surveillance – but he added that opportunities are ripe to develop biological and chemical sensors for these applications.

Rapid testing

Dr Zhugen Yang, who leads the Cranfield advanced sensors lab, is doing just that. His work covers the design of low-cost and rapid sensors for wastewater-based epidemiology with the potential to detect drug use, pathogens, infectious disease and antimicrobial resistance. One example is the creation of a paper-origami device for rapid detection of various pathogens, including bacteria and parasites, that cause infectious diseases (e.g., brucellosis, leptospirosis, and malaria). He is also working on the development of a paper device for tracing SARS-CoV-2 and testing sewage for early warning of the virus. The advantage of these devices is that they are rapid, low-cost, sensitive and portable, making them ideal for use in the field even for non-specialists.



Dr Yang's rapid detection test: each sensor is designed to identify one contaminant.

There are still knowledge gaps in our understanding of the fate of many of these substances before and after treatment in WWTP/AD, so it is certainly an area which requires more research.

FURTHER INFORMATION

For anyone interested in learning more about this area, visit the EB Network's YouTube channel (https://bit.ly/3dg8z65) or contact Dr Zhugen Yang, Cranfield University or Dr Martin Spurr, Newcastle University, who jointly lead the EBNet Working Group on Environmental Sensors and Wastewater Surveillance (https://bit.ly/3pcy1i5).

They are currently running a series of free short webinars on the topic which are readily accessible to specialists and non-specialists alike. Details are available on the Working Group's web page at https://ebnet.ac.uk/about/wg-details/wg-sensors/

ADBA TEAM

Chief Executive, **Charlotte Morton**
T +44 (0)203 960 0784 E charlotte.morton@adbioresources.org

Lead Analyst (Energy & Climate), **Nick Primmer**
T +44 (0)203 960 0773 E nick.primmer@adbioresources.org

Lead Analyst (Environment & Agriculture), **Leanne Williams**
T +44 (0)203 567 0751 E leanne.williams@adbioresources.org

Technical Support Manager, **Josh Henthorne**
T +44 (0)7940 891856 E sosh.henthorne@adbioresources.org

External Affairs Lead, **Giulia Ceccarelli**
T +44 (0)203 176 0503 E giulia.ceccarelli@adbioresources.org

Membership & Business Development Manager, **Maddie Hopper**
T +44 (0)203 176 0779 E maddie.hopper@adbioresources.org

Membership & Business Development Manager, **Zain Keshavjee**
T +44 (0)203 735 8116 E zkeshavjee@worldbiogasassociation.org

Membership & Business Development Manager, **Cristina Martins**
T +44 (0)785 486 7267 E cristina.martins@adbioresources.org

Events Manager, **Cheryl Murdoch**
T +44 (0)203 735 8118 E cheryl.murdoch@adbioresources.org

Marketing Manager – Membership, **Robert Zlokower**
T +44 (0)203 960 0780 E robert.zlokower@adbioresources.org

Marketing Co-ordinator & Business Analyst, **Eduard Vyshnyakov**
T +44 (0)203 735 8114 E eduard.vyshnyakov@adbioresources.org

Financial Controller, **Nicola Steele**
T +44 (0)203 960 0782 E nicola.steele@adbioresources.org

Finance Assistant, **Angela Knight**
T +44 (0)203 960 0782 E angela.knight@adbioresources.org

CEO, Green Gas Trading Limited, **Grant Ashton**
T +44 (0)7951 240728 E grant@greengastrading.co.uk

BMCS Scheme Manager, Green Gas Trading Ltd., **Emily Tradd**
T +44 (0)204 539 1560 E info@greengastrading.co.uk

Editorial Manager – ADBA and AD&Bioresources News, **Jon Hughes**
T +44 (0)203 176 0590 E jon.hughes@adbioresources.org