Institution: University of Brighton	
Unit of Assessment: B7 Earth Systems and Environmental Sciences	
Title of case study: Prevention of waterborne disease transmission	ICS [1]

1. Summary of the impact

Researchers at the University of Brighton (UoB) have developed innovative low-cost solutions to pressing global disease problems. In Haiti, rapid deployment of new wastewater technology averted further human crisis when the 2010 earthquake exposed water resources to hospital wastewaters contaminated by the cholera pathogen. In Malawi, the re-design and improved management of rural wells have provided low-income communities with safer drinking water. In Europe, new methods have identified human faecal contamination of rivers and established viral removal rates in a wastewater reuse system, enabling two water companies and two national environmental agencies to meet international standards and protect public health.

2. Underpinning research

Applied environmental microbiology research at the UoB has been a core activity since it established the Environment and Public Health Research Unit (EPHRU) in 1998. The group develops and applies practical tools that either detect or interrupt the transmission routes of human waterborne diseases, with a particular focus on the world's poorest communities. The group's 'multiple barrier approach' to disease control has provided new interventions that prevent human contact with contaminated water.

Early work led by TAYLOR [reference 3.1] demonstrated that wastewater can be disinfected using chemical coagulating agents, and subsequently a pilot treatment plant in Brazil successfully disinfected wastewater from a poor peri-urban community at low cost. This early research was picked up by Médecins Sans Frontières, which commissioned TAYLOR to use his expertise to design wastewater disinfection plants in Haiti (Impact 1).

The research group then focused on the ecological behaviour of waterborne faecal microorganisms, supported by an international collaborative project (EC 1998), demonstrating the impact of antibiotic resistance in European agriculture [3.2]. A broader understanding of the fate and transport of microorganisms of faecal origin at a catchment level later provided new ways to design strategic water-quality monitoring programmes [3.3]. This led UNICEF to invite staff of EPHRU to investigate how drinking water quality in rural Malawi could be improved (Impact 2).

The antibiotic resistance research of EBDON and TAYLOR encouraged them to investigate whether this property of bacteria enabled sources of faecal pollution to be identified. This work was supported by the EU Fifth Framework Programme (FP5) and the EU Interreg IIIA (eg AMACOM and TOFPSW) [3.4]. As a result, EBDON (with TAYLOR) demonstrated that global variations in antibiotic resistance patterns prohibited its universal application [3.4]. EBDON then developed a new and highly effective bacteriophage-based source tracking tool that was able to detect human faeces with high precision. Further, the new method reduced the cost of identifying the impact of municipal wastewaters on rivers and beaches by approximately 90% [3.5]. Later, EBDON demonstrated that his bacteriophage system predicts the presence of waterborne human viruses (*Norovirus* and *Adenovirus*) in wastewaters and receiving waters [3.6]. More recent molecular work investigated the human gut composition of adults from the UK, Japan and North America, which confirmed that EBDON'S source-tracking phages are of exclusively human origin. They therefore represent a highly effective tool to model the behaviour of disease-causing viruses in treatment systems and the natural environment, a feature that has been picked up and used by water companies and environmental agencies (Impact 3).

Key researchers:

James Ebdon: Research Assistant (June 2002–Dec 2003), Research Officer (Jan 2004–July 2006) Research Fellow (Aug 2006–Aug 2007), Senior Lecturer (Sept 2007–Aug 2011), Principal Lecturer (Sept 2011–to date).

Huw Taylor: Senior Lecturer (Oct 1993–July 1998), Principal Lecturer (Aug 1998–Nov 2005) Reader (Nov 2005–July 2011), Professor of Microbial Ecology (Aug 2011–to date).

3. References to the research

The 3 outputs that are marked with a # best indicate the quality of the underpinning research.

[3.1] TAYLOR, H.D., GAMBRILL, M.P., MARA, D.D. and SILVA, S.A. (1994). Upgrading a low-cost physicochemical wastewater treatment plant to solve operational problems. *Water Science and Technology*, 29 (12), pp.247–254. [Quality validation: research output from peer-reviewed UK-government (Overseas Development Agency) funded research].

[3.2] KÜHN, I., IVERSEN, A., FINN, M., GREKO, C., BURMAN, L.G., BLANCH, A.R., VILANOVA, X., MANERO, A., TAYLOR, H., CAPLIN, J., DOMINGUEZ, L., HERRERRO, I.A., MORENO, M.A. and MÖLBY, R. (2005). Occurrence and relatedness of vancomycin-resistant enterococci in animals, humans, and the environment in different European regions. *Applied and Environmental Microbiology*, 71 (9), pp.5383–5390. [Quality validation: peer-reviewed publication in widely recognised international environmental microbiology journal].

[3.3] NNANE, D.E., EBDON, J.E., and TAYLOR H.D. (2011). Integrated analysis of water quality parameters for cost effective management of faecal pollution in river catchments. *Water Research*, 45 (6), pp.2235–2246. [Quality validation: peer-reviewed publication in widely recognised international environmental science journal].

[3.4] # EBDON, J.E., and TAYLOR, H.D. (2006). Geographical stability of enterococcal antibiotic resistance profiles in Europe and its implications for the identification of faecal sources. *Environmental Science and Technology*, 40 (17), pp.2327–2332. [Quality validation: peer-reviewed publication in widely recognised international environmental science journal].

[3.5] # EBDON, J.E., MUNIESA, M., and TAYLOR, H.D**.** (2007). The application of a recently isolated strain of *Bacteroides* (GB-124) to identify anthropogenic sources of faecal pollution in a temperate river catchment. *Water Research,* 41 (16), pp.3683–3690. [Quality validation: peer-reviewed publication in widely recognised international environmental science journal].

[3.6] # EBDON, J.E., SELLWOOD, J., SHORE, J., and TAYLOR, H.D. (2012). Phages of *Bacteroides* (GB-124): A novel tool for viral waterborne disease control? *Environmental Science and Technology,* 46 (2), pp.1163–1169. [Quality validation: peer-reviewed publication in widely recognised international environmental science journal].

Key research grants:

EPHRU has been awarded 14 external grants during the past 15 years, with a total income to the UoB of £1.14 m, including:

TAYLOR, RiskManche: Risk Management of Catchments and Coasts for Health and Environment (2012–2015); European Regional Development Fund (Interreg IVA); total funding: €4.5 million; UoB lead partner (UoB allocation: £384,950).

TAYLOR, AquaManche: Aquatic Management of Catchments for Health and Environment (2009–2012); European Regional Development Fund (Interreg IVA); total funding: €2.9m; UoB lead partner (UoB allocation: £282,405).

TAYLOR, Tracking the origin of faecal pollution in surface waters (TOFPSW), European Commission Fifth Framework; (2002–2006), total funding: £600,000 (UoB allocation: £128,750).

TAYLOR, Epidemiology and ecology of enterococci, with special reference to antibiotic resistant strains, in animals, humans and the environment (EC 1998) (1998–2002); European Commission Fifth Framework; total funding: £950,000 (UoB allocation: £116,280).

4. Details of the impact

The UoB EPHRU team uses its expertise in the behaviour of waterborne microbes to produce technology and policy tools that provide local solutions to the global burden of waterborne disease. Three examples are described here:

1) Initiated the first low-cost, on-site emergency disinfection process for cholera treatment centre wastewaters, which prevented the onward waterborne transmission of disease from emergency medical facilities in Port-au-Prince, Haiti.

The UoB team was the trusted source of expertise commissioned by Médecins Sans Frontières to support, at short notice, the development of novel emergency wastewater

disinfection technology at its cholera treatment centres in Haiti following the 2010 earthquake and the subsequent catastrophic outbreak of cholera (source 5.1). Instructed by TAYLOR, the NGO constructed and operated successfully three treatment plants that disinfected over 600,000 litres of highly contaminated wastewater, containing up to 10 million *Vibrio cholerae* pathogens per 100 ml. The design and operation of these *in-situ* treatment plants prevented the hazardous practice of trucking highly contagious materials to uncontrolled disposal sites. This innovation is the first known response to a UN Panel of Experts' recommendation that UN facilities should disinfect their wastewaters in emergencies. The disinfected effluent complied consistently with WHO health standards for unrestricted irrigation, and the intervention therefore protected impoverished communities located downstream of the plants from the risk of cholera infection during the epidemic. The standard operating practices employed in Haiti have been made openly available to all NGOs working in disaster settings on the 'Solutions for Water' web platform of the World Water Forum (5.2).

2. Prompted the launch of a National Water Safety Strategy for Malawi in November 2012 and led the UK-based NGOs Pump Aid and WaterAid to improve the quality of drinking water supplied to rural Malawians.

In Malawi, 1,000 children under five years of age die from water-related illnesses every month, but by improving drinking water and sanitation, water-related diseases can be reduced by nearly 90%. The UoB team's recent work in Malawi, commissioned by UNICEF, demonstrated how well-designed sanitary surveys can play a pivotal role in securing the safety of water supplies in Malawi and other low-income countries. TAYLOR was invited to report the team's findings to Malawian civil servants and international NGOs at a workshop in Lilongwe in August 2012. In response to this, the Malawian government immediately launched the country's first *Water Safety Task Force*. In December 2012, the UK-based NGO Pump Aid made significant changes to its provision of water-supply technology in Malawi as a direct result of the team's report. The research led the NGO to improve standards, implement more rigorous quality management, and to employ additional staff to raise community awareness of the issues raised by the UoB research (5.3). This has already resulted in the improved design and siting of 300 new shallow wells in Malawi during 2013 (with 1,500 to be commissioned by the end of 2015, serving a population of 180,000 people). The research in Malawi also led the NGO WaterAid to review its approach to water-quality testing in the country using the model developed by TAYLOR (5.4). In April 2013, the Water Institute at UNC (USA), in collaboration with the Ministry of Health in Malawi, held a consultative workshop on the development of a national action plan for safe drinking water in Malawi. Evidence from the UNICEF report was used in the recommendation for a strengthening of monitoring and evaluation in this area (5.5). Arising from this work, TAYLOR was invited to join the core group of the 'International Low-cost Water Quality Monitoring Panel of Experts', which will report back to the WHO in 2014.

3. Development of low-cost methods that identify and quantify viruses of human origin in surface waters and engineered treatment systems, enabling European environmental protection agencies and water companies to protect public health and therefore meet the requirements of EU environmental legislation.

New methods developed at UoB to identify human faecal contamination of river basins and treatment systems have been used by national monitoring laboratories to pinpoint sources of pollution in river catchments (eg CEFAS in the UK, the Cypriot State General Laboratory, LAIST (Portugal) and the Swiss Department of Health). Thames Water Services has used the group's findings to control potential health hazards associated with the Old Ford wastewater reuse system at the Olympic Park in East London (5.6) and as a result the company has been able to satisfy an International Panel of Experts that it is adequately protecting human health. Southeast Water and the Environment Agency are using the group's novel hazard maps to support local implementation of the EU Water Framework Directive in southeast England and this work was cited by an independent witness to the UK Defra *Water White Paper*, 17 February 2012 (5.7). Application of our

Microbial Source Tracking method has enabled the Cypriot Ministry for Water Resources to identify previously unknown discharges of human faeces to an ecologically sensitive Cypriot river basin. The Ministry is now enforcing the compliance of local authority wastewater treatment facilities with the EU Urban Wastewater Treatment Directive in the Limnatis (300 km^2) and Garillis river catchments (100 km^2), which are the source of 15% of the country's drinking water supplies (5.8).

5. Sources to corroborate the impact

5.1 Testimonial from a Water and Sanitation Unit Coordinator at Médecins Sans Frontières that confirms the use of emergency wastewater disinfection technology in Haiti.

5.2 'Novel approaches to the treatment and disinfection of cholera treatment centre wastewaters'. Available at, http://www.solutionsforwater.org/solutions/novel-approaches-to-the-treatment-and-disinfection-of-cholera-treatment-centre-wastewaters-2#item-header-targets [Accessed: 30 July 2013]. Site plans and standard operating practices for the latest wastewater disinfection plant in Haiti based on University of Brighton designs.

5.3 Testimonial from the CEO of Pump Aid confirming that UoB research led to improved standards and management relating to siting, build quality and maintenance of pumps in Malawi.

5.4 Testimonial from Research Manager, WaterAid confirming that the UoB research report regarding Malawi raised its awareness of related issues and has led to a review of its approach.

5.5 UNC report on the 18 April, 2013 Stakeholders' Consultative Workshop on the Development of a National Action Plan. UoB research on Malawi is used as evidence on page 9. Report available on request.

5.6 Testimonial from Senior Research Scientist, Thames Water, confirming that the research has assisted the development of novel protocols for the monitoring and control of potential health hazards associated with the Old Ford Wastewater Recycling Plant, at the Olympic Park in East London.

5.7 The UK Defra *Water White Paper*. 17 February 2012. Available at: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvfru/writev/water/wwp31.htm [Accessed: 20 November 2013]. UoB work on wastewater treatment plants in the Sussex Ouse was cited by an independent witness.

5.8 Testimonial available from Cypriot Water Resources' Water Resources Manager confirming that the application of UoB's source tracking method to the identification of discharges of human faeces in an ecologically sensitive river catchment, led to compliance of local authority wastewater treatment facilities with the EU Urban Wastewater Treatment Directive.