Dr Aaron Bradshaw talk at 'Social practice theory and global health: Microbes, bodies, environments', June 11th 2025

<u>human-microbial relations and changes in land use and urban space</u>

Urbanisation results in the co-creation of new socio-microbial habitats, communities, and relations. In this presentation I focus on the urban water cycle as a particularly intense site for the coming together of human practices and various microbial ecosystems. There are three key interrelated take home messages from this presentation:

1. Cities and microbes make and remake (co-constitute) one another in specific ways over space and time.
2. Urban microbes are evolving rapidly and in ways that are not good for humans (AMR). This is largely related to human activities.
3. The 'practices' of microbes as they respond to human practices suggest alternative multispecies urban futures.

1. The urban water cycle: General scheme

The urban water cycle is a socio-ecological system that describes the flow of water through cities and its material transformations. Many of the steps concentrate and disperse microorganisms. A range of human-microbial relations ranging from the pathogenic to the productive constitute and are constituted by this cycle. These interactions change over time in ways that are highly relational. In this presentation I am going to focus primarily on these two steps of the urban water cycle: drinking water treatment and wastewater treatment.

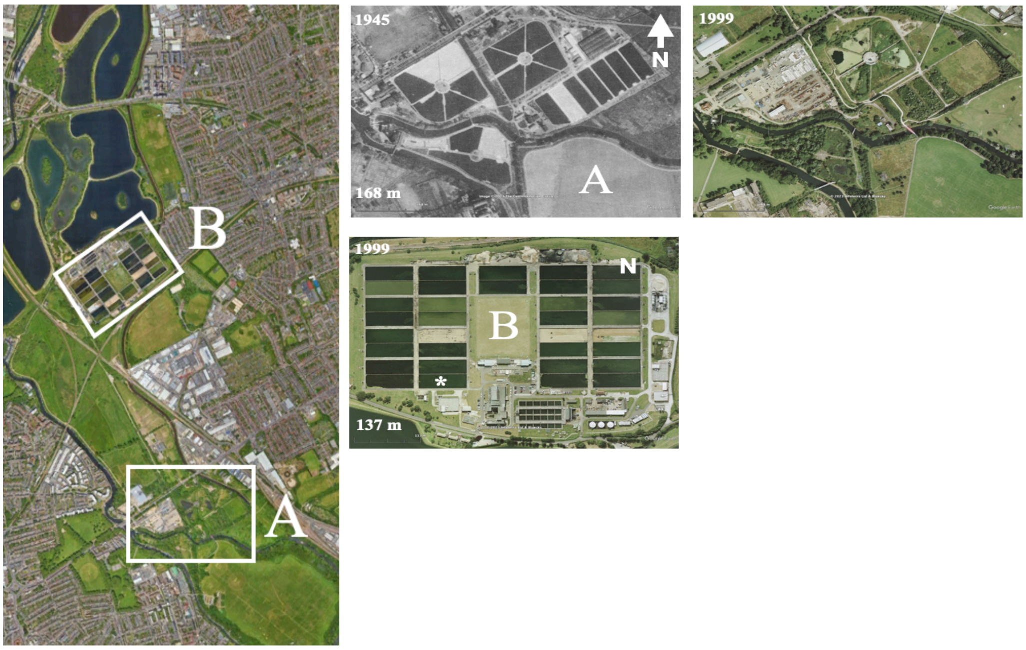
2. Water and microbial dynamics London: Pathogenesis

This is the famous map produced by John Snow showing how the 1846 cholera outbreak in London concentrated around the Broad Street water pump. This map was important in identifying the role of water as a medium for contagion. In 1852 the Metropolitan Water Act was passed, legislating that all drinkable water within five miles of St Paul's Cathedral had to be adequately filtered and stored within covered reservoirs prior to distribution.

3. Water treatment and microbial dynamics in East London: Slow sand filtration

The solution was the introduction of slow sand filters in which raw water is filtered through a bed of sand five to six feet deep before being distributed. The Middlesex Filter Beds in Hackney were first built in the 1850s (**A** in the figure). They were decommissioned in the 1960s and replaced by a new set in Walthamstow forming the Coppermills Water Works (**B** in the figure).

Slow sand filtration was very effective in curbing cholera and other infectious epidemics in nineteenth-century urban centres. Their efficacy is related to a community of microorganisms that colonise the upper layers of the sand. This so-called schmutzdecke ('dirty layer' from German) is a biologically active film composed of bacteria, protozoa, algae, viruses and other microorganisms that predate upon pathogens. This layer acts as a physical barrier, ecological competitor, and metabolic detoxifier. The agency of microbes cultivated by the slow sand filter acts as an extended microbiome that ensures public health from infectious disease outbreaks. Coppermills treats water for about 1/3rd of London's population to the current day.

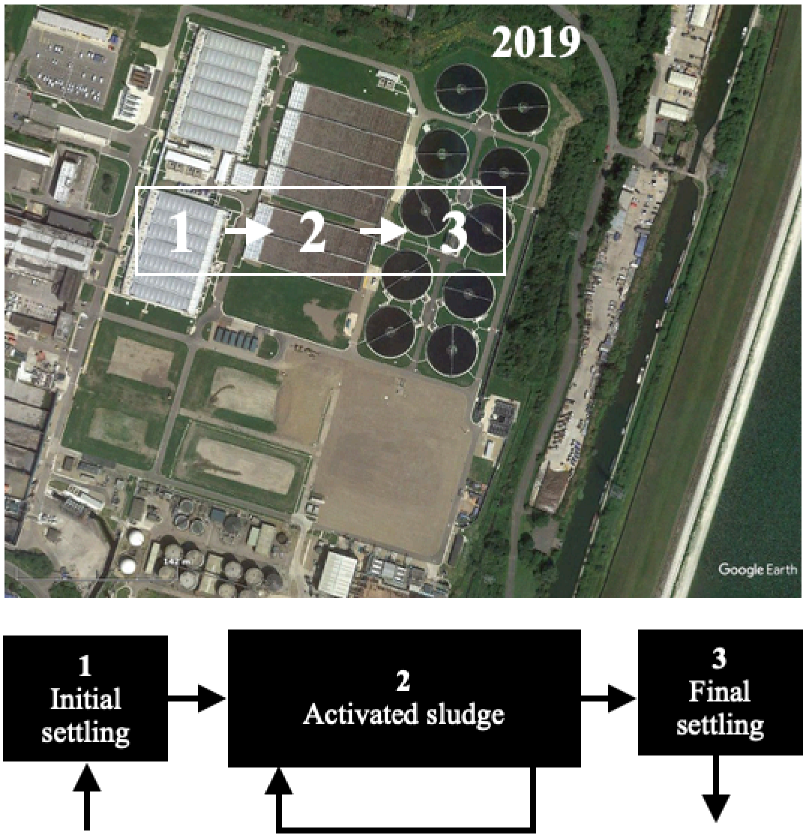


Images from Google Earth

4. Water treatment and microbial dynamics in East London: Activated sludge

Now I will talk about wastewater treatment in East London. Deephams WWTP in Enfield was first constructed in the 1950s. The main goal of sewage treatment is to reduce the 'biological oxygen demand' (BOD) of wastewater effluent. BOD refers to the amount of oxygen required for the microbial-mediated metabolism (i.e., oxidation) of organic compounds and nutrients in a given wastewater sample. High BOD wastewater promotes the exponential proliferation of microorganisms in recipient water bodies and leads to a reduction in oxygen concentrations thereby contributing to 'dead zones.'

In sewage treatment BOD is reduced primarily through aerobic digestion via the activated sludge process. By aerating wastewater, aerobic microorganisms present in the waste stream are cultivated, including those from the waste products of different bodies, residents of urban sewer infrastructure, and those from urban runoff. This occurs in site **'2'** in the figure below. The cultivated organisms then metabolise organic compounds and nutrients, thus reducing the BOD of wastewater. The potential for microbial growth in wastewater is captured and proactively confined within the WWTP. The activated sludge microbial community is complex and it is estimated that there are 10^18 microbes in a WWTP consisting of bacteria, archaea, eukaryotes and viruses.



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5. **WWTPs: Increased rates of microbial evolution**

WWTPs are also highly conducive to microbial evolution in unanticipated and sometimes undesirable directions, for instance AMR. In addition to providing the physical and nutritional conditions for bacterial growth, WWTPs effectively concentrate the selection pressures driving the evolution of AMR which include, in addition to antibiotics, disinfectants, heavy metals, pharmaceuticals, personal care products, and other micropollutants. The evolution of AMR is marked by synergies between micro- and macroscale processes across physical, biological, and social strata. In the WWPTP microbial bodies are transformed as they transform the effluent of human societies.

Another issue, especially in London and the UK at the moment is that water operators are increasingly discharging raw untreated sewage into rivers. This is related to the privatisation of water in the UK and the failure to update infrastructure.

In London, the Dagenham Brook, seen in the photo below, is a key site of dumping. Beyond the immediate acute toxicity from discharging untreated sewage, other issues include the release of accumulative and persistent chemicals, potential transmission of AMR bacteria and genes to downstream ecologies, and longer term changes in ecological structure including the induction of dysbiosis in fish, birds, and small eukaryotes. Microbes link together different scales of ecology and this is catalysed by - and catalyses - the urban water cycle. It is also important to note that the release of treated effluent can cause these issues.


Photo by Author

6. Water treatment and microbial dynamics in East London: Constructed wetlands

In London, as well as around the world, constructed wetlands are increasingly being used to act as additional filters before WWTP effluent rejoins water courses, as well as for other forms of urban runoff. In these systems microorganisms associated with plant roots may remove additional micropollutants that are not removed in the WWTP. One example is Broomfield Park in East London which discharges into the Pymmes Brook (seen in the photo). This brook is the outflow of Deephams WWTP and historically very polluted.

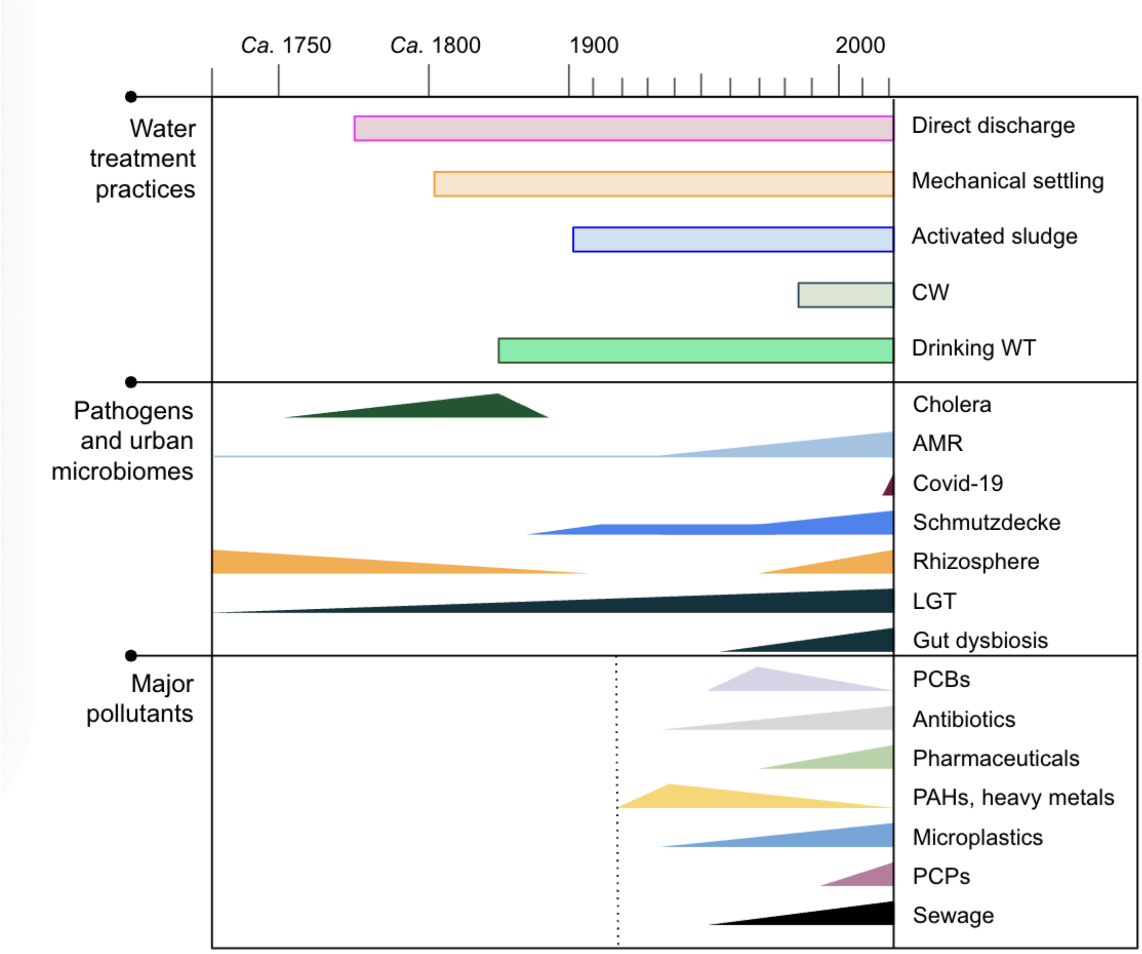


Photo by Author.

However, this is in no sense a simple ‘solution’. Microbial labour is genetically, metabolically, and ecologically entangled with other microbes, nonhumans, and humans. Microbial community formation is stochastic, situated, and path dependent. The urban water cycle captures different forms of microbial agency and makes other forms possible or more likely to emerge. These instantiations cannot be known in advance and often short term ‘successes’ are followed by longer term problems and the temporality of those shifts are not specified. Goals and intentions emerge over time and change as different aspects of microbial agency stand forward. Working with bacteria is always an ongoing socio-material negotiation in localised, situated, and geographically specific biosocial becomings.

7. Temporal pattern of wastewater treatment practices and pollutants in London

This final slide summarises the practices of wastewater treatment, microbiomes, and major pollutants in London over the last two centuries or so. These practices overlap in time and share nodes which nuances ideas of transitions in socio-microbial relations. New interactions do not necessarily overwrite or replace earlier forms of relation and at one point in time a particular relation or practice might predominate whilst others recede into the background only to come back later in mutated forms. Each of these variables interact and affect one another in complex ways. They are all fully bio-physico-social systems.



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