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CLEANING UP THE THAMES: SUCCESS OR FAILURE?

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Welcome to this first lecture in my 2017-18 environmental series. I am, again, most grateful to the Frank Jackson Foundation for sponsoring the Professor of Environment role, and indeed to Gresham College too, for extending my term of office for a fourth year. Tonight's lecture forms part of two series. Firstly, my own lectures this year will be considering six contested environmental issues, issues where alternative facts, 'post-truth' positions and downright lies have abounded. They include organic farming, national parks, eco-towns, 'green' businesses, and (my own favourite topic) flooding. I will be interrogating some of the claims made by various stakeholders, to see if I can bring listeners a little closer to understanding the interplay of environmental challenges; I will even slip in a little science. Tonight, I will be looking at an issue of local relevance to the audience here in Barnard's Inn Hall, in London: the ever-changing quality of the water in the River Thames, and the management that attempts to ensure that the environment remains healthy. I will be highlighting some of the current controversies, and drawing parallels with what has happened in the past. However, my lecture also forms part of the 'Totally Thames' Festival, a series of events including lectures, exhibitions and walks that celebrate one of Britain's greatest and most historic rivers, flowing through London, which is undoubtedly one of the world's greatest cities. Double value, I hope. I should add that I had thought I might up the online views by titling it 'A Dirty Story', but I refrained.

For the benefit of those unfamiliar with British geography, the River Thames drains a large (for the UK) catchment area in Southern England. The non-tidal part of the river is some 245 kilometres long, ending at Teddington Weir, below which there is another 30 kilometres or so of tidal water that surge up and down through central London. The lower reaches are saline, of course. Geologically, southern England is gradually sinking with respect to sea level, and it is believed that in Roman times that the tides did not reach the area that is now the City area of London, Roman Londinium; yew tree remains have been found, and yews are not tolerant of salt. Moreover, archaeology has established that the river was much wider and shallower than it is today, allowing it to be bridged using simple technology, despite the fact that the channel shifted from time to time.

When we look at the lower reaches of the River Thames today, we see some stunning built landscapes, scenery that reflects not only more than two thousand years of riverside settlement, buildings, monuments and art works, but also a natural corridor that is home to millions of shellfish, fish, birds and mammals, and the plants and microorganisms that underpin the food chain on which they depend. Notably today, oysters, eels, salmon and seals are found, at least from time to time. The Thames still presents a transport route for thousands of ships and smaller craft, and it provides recreational opportunities too. Overlain onto that, the Thames has been, and still is, a ready source of human food. But it also acts as a foul drain for people's wastes, and has done so since the occupants of the earliest villages saw it as a convenient way to dispose of their sewage, and the highly polluting effluents from their industries – butchery, tanning and dyeing, for example. Out to sea, out of mind, at least if the tide is favourable.

Despite the sophistication of environmental and water science, and a European Union-driven regulatory regime that is said to be one the tightest in the world, we still experience massive environmental problems with the Thames. The disgusting nineteenth century pollution will be familiar to many people, as it was depicted not only

in Charles Dickens' bleaker novels, but frequently in Punch magazine cartoons. No doubt some of you will be familiar with the engineering works that followed the so-called 'Great Stink' of 1858, and which provided some much-needed relief from the stench of sewage to the riverside residents.

However, the problem returned in the twentieth century, or perhaps never truly went away, and persists today. Just a few months ago in March this year, 2017, Thames Water, the Australian-owned private company that now manages London's water supply and treats its waterborne wastes, was fined £20.3 Million - the largest ever fine for any company operating in the UK, for inflicting catastrophic damage on the Thames' ecosystems. According to the judgement, their deliberate and repeated releases of virtually untreated sewage directly into the river above London wiped out entire populations of fish, and exposed people to health risks. The final straw was a release of 1.4 Billion litres of raw sewage, the impacts of which can be seen in the photograph, and which brought the legal department of England and Wales' Environment Agency down on them. This was not an exceptional event, either, as they admitted scores of other offences. As the judge remarked, "It should not be cheaper to offend than to take appropriate precautions"; one cannot help thinking that Thames Water believed that the cost of any fine might have been expected to be less than the costs of the remedy, as there seems little other explanation of their behaviour.

Apart from such localised pollutant releases, after heavy rain the Thames often experiences chemical and ecological shocks from pulses of poor quality water entering the mainstream through hidden and historic rivers such as the formerly substantial River Fleet and the Tyburn, and overflowing sewers, too. The Thames is unfortunately not unique, and 2016 saw the first national increases in the number of pollution events since 2012. But Thames Water is a highly profitable monopoly, yielding good dividends to its shareholders, hence Londoners paying their water bills, and faced with ever larger charges to cover massive new engineering works (for instance £25 per household per year for the new Thames Tideway Tunnel, a subject to which I will return later), are asking whether the current management arrangements are fit for purpose. Will they deliver what Londoners, or 'customers' as they are normally referred to, actually want for their water supply and their river? Indeed, the Labour Party conference this week has clearly indicated that in their view they are not fit for purpose, and that water companies will quickly be taken back into public ownership under a future Labour administration. Something still seems to be wrong with the Thames, which legislation, vast amounts of public and private expenditure, and a great deal of experience, has been unable to remedy.

This was acutely exemplified in 'Human Race's' 2012 Hampton Court Swim, when hundreds of swimmers in an open water swimming event in the Thames subsequently became ill with gastrointestinal problems. Some were hospitalised. The water had supposedly been checked for pathogens, and confirmed to be safe, but clearly, it was not and contamination had arrived suddenly and in large amounts. Interestingly, age afforded some protection; the over 40s were less likely to have become ill, perhaps one of the few advantages of aging.

The history of human interaction with the Thames is a complex one. I have already touched on the likely state of the Thames' channel in pre-Roman times, but it probably remained fairly healthy particularly as the local population decreased for a time after the fall of the Roman Empire. Little is known about its state over several centuries, but certainly by the thirteenth century, pollution of the river had become significant again. Domestic, industrial and human wastes at this time were generally disposed of in 'kennels', or gutters along the side or centre of the unpaved roads, and piled in uncovered 'middens' behind the houses. Scavenging pigs, ravens and kites made for an unpleasant state of affairs, and in 1354, orders were made that 'kennel' rubbish must be collected weekly and removed to the Essex marshes, on pain of fines. Even so, after rainfall, contaminated water would spread around and seep into the river. Edward III, making a journey down the Thames in 1357 apparently found the stench of the water so offensive that he besought the Mayor and the Sheriffs of London to forbid the throwing of rubbish into the river and its tributaries. However, although some of the immediate issues were resolved, and some tributary blockages removed, the overall position was not addressed by the legislation, which was widely ignored and anyway largely unenforceable.

A 'Bill of Sewers' was initiated under Henry VIII's regime in 1531, to attempt to speed rainfall away into the mainstream Thames, and prevent the spreading of wastes around people's living spaces, but it failed to address the fundamental problems of sewage washing into the estuary and its tributaries. Ben Jonson, writing in 1616

about an imaginary voyage along the River Fleet, formerly a substantial and navigable tributary of the Thames whose name is memorialised in 'Fleet Street' (others have on occasion referred to the printed products of Fleet Street as effluent, of course), made reference to the disgusting odours stirred up from the mud by the oars of small boats, as belching forth 'an ayre as hot as the muster of all your night tubs'. The population by then was about 200,000 people. Other poets also complained; Swift referred to 'Sweepings from Butcher's stalls, Dung, Guts and Blood, Drowned Puppies, stinking Sprats, all drench'd in Mud, Dead Cats and Turnip-Tops come tumbling down the Flood'. The situation was not helped by the fact that public latrines were permitted to be built over the smaller London rivers; their flimsy timber supports were apparently often used as mooring posts by fishermen, sometimes with disastrous consequences of one sort or another.

Some people have regarded the Great Fire of London in 1666 as a 'cleansing' event, and it certainly took some of the organic wastes out of circulation. Former Gresham Professors Sir Christopher Wren and Robert Hooke were instrumental in attempting to develop better systems for the management of London's rivers immediately afterwards, constructing new riverside structures to encourage some civic pride. The lower Fleet, for instance, was turned into a sort of mini Venetian canal, but it failed to capture the public imagination and was soon overwhelmed again by excrement, and was eventually covered over altogether. That was, in fact, not the end of it because in 1846 an accumulation of gas from putrefying wastes in the Fleet blew up, houses were inundated and three workhouses were deluged by a wave of sewage. Liquid history repeating itself, we might say. And the Thames soon deteriorated again too in the face of renewed population growth, setting a pattern of pollution and partial recovery that was to be repeated over and over again through the centuries as different styles of management were attempted, and failed, in the growing metropolis.

Although there is no record of monitoring pollution in the Thames that goes back much beyond the twentieth century, some indications about the water quality can be obtained from the observations made about fish. Fish from the tidal Thames were an important part of all Londoner's diets for many centuries, and catching them provided work for hundreds of local people. The chart shows some of the observations of salmon, trout, grayling, perch, carp, tench, roach, dace, gudgeon, pike, eels, lampreys, plus sole, plaice, skate, halibut, haddock, oysters, mussels and prawns in the salt water zones, at least up until the start of the nineteenth century. Salmon in particular are a valuable and tasty fish, and ones which require both clean water and access to and from the sea, through which they travel long distances before returning to their native spawning grounds. Even up until the middle of the nineteenth century, barbel, chubb and flounders were apparently being caught off London Bridge. The indications are that pollution in the Thames was localised, at least until the eighteenth century, focused on where tributaries entered the mainstream.

However, this state of grace did not last much longer, as a number of damaging environmental changes took place almost simultaneously. The 19th Century saw the industrial revolution, the manufacture of town gas that released phenols and ammonia into local watercourses, the growth of the population of London from 1 million in 1801 to 2.75 Million in 1851, and the widespread adoption of the flushing water closet. This latter was the real killer of the fish. In earlier times, a rudimentary waterborne sewerage system had been used, which may have worked insofar as avoidance of having nightsoil men collecting tubs of human wastes, or excrement being left lying around in streets and yards is concerned. They prevented the situation described by Samuel Pepys on Thursday 28th September 1665, 352 years ago to this very day, who making a scatological observation in his diary about the absence of facilities. "*feeling for a chamber-pott, there was none, I having called the mayde up out of her bed, she had forgot I suppose to put one there; so I was forced in this strange house to rise and shit in the chimney twice…*". Water closets clearly had advantages in allowing a modicum of privacy and security for the most private of personal functions.

But for water quality in the Thames, flushing lavatories rapidly became an environmental catastrophe. Raw sewage entered streams and seeped into the ground everywhere as the city grew. Smaller streams were covered over to render them invisible, if not lacking in pungency. Lacking a comprehensive and functional piped sewer system, London houses were soon literally floating on a sea of toxic excrement in the ground, and the wells and springs that watered the City became even less fit to drink. Basements flooded with contaminated water, and such sewers as existed repeatedly overflowed into the Thames despite some attempts to treat some of their contents by trapping the fluid and allowing solid matter to settle out. Such solids as were recovered, were then taken down the river by barge and dumped in the estuary, a management system which persisted until the late

twentieth century. On high tides, or in dry periods, much of it washed back up the river. By the 1850s, the situation was unbearable – firstly in Bermondsey and Southwark, homes of the poorer sort, but then more widely. When paddle steamers approached, people fled because of the release of noxious sulphur dioxide from 'silt' on the river bed. Faraday, shown in this cartoon, noted in July 1855 when on a barge that the whole area of water between London and Hungerford Bridges 'was opaque, pale brown fluid….feculence rolled up in clouds so dense that they were visible at the surface…smell very bad….the whole river was for a time a real sewer. I do not think I could have gone on to Lambeth or Chelsea….a putrescent pond through London.'

For the last few years there had been a series of disagreements about how to cope with the growing calamity. Commission after Commission was established, each resigning acrimoniously as their drainage schemes were rejected as being too expensive or unfeasible, or with proposed new sewer outfalls too close to the property of those on the Commissions or in a position to influence them. The crunch came in the hot dry summer of 1858, when the 'silt' along the sides of the Thames was a bubbling, reeking ooze as a result of over seventy sewer outlets discharging human wastes direct into the stream, and the smell was so strong that Parliament could not sit at Westminster.

I do not propose to go into the detail of how Joseph Bazelgette became the lead engineer in a scheme to install new interceptor sewers, taking the contents of the surcharged foul sewers into larger pipes along the river margin, draining it further down the estuary prior to discharging the water to the Thames during ebb tides. It was a remarkable example of Victorian engineering. But I do want to emphasise that this scheme was not actually what we would call today the 'best available technology', even of the time. As a result of pressure from the government, the cost of the scheme was reduced by maintaining overflows between the foul and the surface water sewers that took rainwater to the Thames. In heavy rainfall, the foul sewers took in water from the ground and from roofs in too large a quantity to be accommodated, so they were designed to overflow. Bazelgette had wanted complete separation of foul and surface water. The 'pitch' of the proponents was that during rainstorms this sewage would be diluted, and relatively inoffensive, so discharging it direct to the Thames within the city boundary would not matter. And it would cut the required size and cost of any subsequent treatment plants, too. Beyond that, further reductions in cost were obtained by not taking the pipes too far, building these holding stations relatively close to the city at Beckton and Crossness. And so the system was built to take the sewage of 3.5 Million people, with the foul sewers sized to accommodate twice the average flow from these houses before they overtopped into the Thames. It started to operate in 1865, a remarkable turn of speed, and demonstrated the apparent success of vision, radical engineering and public investment, albeit at the lowest cost.

Before long however, the complaints about the Metropolitan Board of Works' operation started to come in, initially from residents in Barking who found unpleasant 'silt' accumulating around outfalls, and sued. The Board escaped being fined on a technicality, but the Thames water remained putrid, and by the 1880s there were continuing complaints of nausea, smell, headaches and dead fish over a 25 kilometre reach of the river. Further reports were commissioned, which suggested that the Thames was not actually injurious to health, but was only a nuisance. It was likely to have been a cover up. A few improvements were made to arrangements prior to discharging the sewage into the Thames, by allowing some accelerated settlement of the solids using various chemicals, and there was a little evidence of returning fish. However, by this point scientific evidence about the river itself was starting to accumulate.

The Thames itself was a local source of drinking water for many Victorian Londoners, who in return for paying private water companies for supplies of very dubious quality indeed, were often the recipients of downright lies, or at least 'alternative facts' about its characteristics. The map shows the areas served, on the north and south banks of the river, and the tabulation shows how much water particular households received – sometimes the figures are quite big, but these were large households. The water was filtered through sand columns before being piped to houses and standpipes, and was allegedly safe to drink, although its quality and colour (light green, when seen in volume) did vary with the volume of fresh water in the river. However, in 1896, an analytical investigation from a series of what would be called today 'independent consultants' cast doubt on what was being said by these private companies. The companies had published statistics showing that although the water was described as 'wholesome' and without any suspended solids in it (every record of tests showed 'none' in the suspended solids column of the table), but the presence of silt and solids in it had simply been ignored by the

analysis. The water also contained horrific levels of micro-organisms, bacteria mainly, many of which were injurious to health, and which had not been filtered out. These private companies lied.

In the meantime, the population of London continued to grow. The results of continuing to use the Bazelgette system became more obvious. After the 1890s, a regular river water sampling system was established, albeit not very frequent. I have a series of diagrams that show some of the science of what was happening in the river during the twentieth century.

Dissolved oxygen is one of the most important characteristics of the health of the water, as it is a basic requirement for fish and shellfish life. In the period after 1890 when it had been improving a little, to 1950, it plummeted. To Bazelgette's credit, the interceptor sewer system he had designed was intended only to cope with a population of 3.5 Million, and had partly succeeded in that, but it had subsequently been overwhelmed by the circumstances. The worst situation was around London Bridge, below which the increased dilution from seawater offered some improvement. But the continued growth of the city's population, by the 1950s the Thames in central London was again biologically dead, according to research undertaken by Natural History Museum. Further downstream we can see the same patterns, a sag in oxygen saturation, through the start of the twentieth century. At the Mucking Flats, where sewage sludge was dumped, again there is a clear sag in dissolved oxygen content; barges full of recovered solids had continued to chug downstream to discharge their unpleasant cargoes into the estuary very close to the City, where it would be washed up and downstream with the tides for several cycles before dispersing.

Not only were the discharges from sewage treatment plants and industrial effluents making the water noisome, and certainly undrinkable, but hot water from power station cooling towers and noise from bankside and river-based operations, had created an ecological nightmare. Adding further to this was the increased use of synthetic detergents, use which peaked in the 1960s, and the increasing loads on some of the recently added treatment plants, which became effectively overwhelmed. The diagram shows the rising 'demand' for oxygen created by the decaying sewage in water being discharged from Mogden sewage treatment works, through to the 1970s, for example. Patterns of ammonia in the river water also showed the same spatial and temporal patterns, increasing through the early twentieth century, and peaking just below London Bridge. These circumstances did not prevent the use of the Thames for recreation, because people were perhaps not very aware of the situation. Wildlife certainly was – it had almost disappeared again.

Something new was required to address the problem, but what came along was another round of unproven technology, and more legislation. In the half century since 1950, there have undoubtedly been some improvements in water quality. Legislation required industrial premises to stop emitting untreated discharges unless they were licensed, and the quality of their effluents had to be improved, and volumes reduced. However, industry was already closing down in central London, and gas manufacturing ceasing, so that problem was disappearing anyway. Legislation from Europe has removed some of the most obvious contaminants, such as certain pesticides and herbicides that are resistant to breakdown. Other improvements have also been serendipitous; more recently the rapid shift from photographic printing to digital photography, has precipitated a massive reduction in toxic silver compounds in waste water for example, without requiring any legislation.

Sewage treatment plants in the 1960s experimented with new technologies to allow biological processes to act on the wastewater, prior to discharging into the river. Research modelling of flows in the river, freshwater and salt, were undertaken to establish where the worst problems lay, and why. But the lack of investment in facilities, at least to the extent required to address the problems, remained significant through to the 1980s and beyond.
Thirty years ago, a major shift in thinking, that ultimately took the management of water, both clean and dirty, out of the hands of local authorities and public institutions, and back into the hands of private companies. The underlying idea was simple, to prevent the financial investment that seemed to be required to sort out water quality problems, appearing on the public expenditure balance sheet. Again, time does not permit us to explore the details, but there have been improvements to the quality of the water overall, upgrading and rebuilding of sewage treatment works, but some stubborn problems remain. The water still contains tin (particularly Tributlytin, TBT), copper, zinc and phosphorus compounds in damaging quantities, which arrive in the water through partly unknown routes, some from upstream farming, some from shipping and some from local

chemical releases. We are just discovering more about microplastic particles, at nano scale, which flush through the river in vast quantities. And 'accidents', releases of contaminated water from sewage treatment plants, and more generally at times of high flows, persist, as I discussed earlier. At its most basic level, we are still dependent on the system installed by Bazelgette in the mid nineteenth century, for the principles on which the waste system operates. Had a separate sewerage system been installed, as Bazelgette originally suggested, the situation might not have been as bad as it is today. And with the further increases in population, now to about eight million people, the system arguably cannot cope.

The current situation for wildlife is also challenging. The Thames is a home to some interesting species, such as Harbour and Grey Seals who live in the estuary, and a wide range of birds. Wildlife dependent on the Thames' water having been made virtually extinct in the 1850s, and again in the 1950s, some recovery is now taking place, and research by ZSL is exploring this. Eels seem to have returned to the Thames since about 2005, but are still critically endangered not only by poor water quality but by hundreds of barriers to their progress up and down the river; they swim across the Atlantic and back, for breeding. We know surprisingly little about their lifecycle. Despite the optimism of the 1970s, salmon are not yet reliably established in the river – and presumably this situation will not be assisted by catching them for exhibition, either. They are probably not now being poisoned all the time, but the periodic flushes of contaminated water keep the overall ecological health of the water at a low level, and reduce their feeding opportunities. And alarmingly, the presence of hormones derived from contraceptives in the Thames' water also gives cause for concern. This is almost untouched by current treatment technologies. Attempts to reintroduce shellfish colonies into the estuary from populations in Cornwall have resulted in the uprooted creatures growing inappropriate body parts, for instance.

The latest technological attempt to address the problem of poor water quality is the Thames Tideway tunnel, which another interceptor scheme, albeit on a vast scale. Again, there is insufficient time to explore this scheme in more detail, but in simple terms it is an upgraded version of Bazelgette's scheme, that will catch more sewage from sewers before they reach the Thames, but will not stop rainwater getting into the sewers in the first place at the top of the systems. It is a vastly expensive and ambitious scheme, and like earlier ones is a testament to some clever engineering, but sadly, the periodic review of the scheme undertaken by the UK's National Audit Office in March this year concluded that it was not good value. They particularly criticised the time taken to develop measurable standards and to consider different options for meeting the European standards, the limitations of the way the decision to build this scheme had been taken, and noted that some of the evidence used was better than others. They also noted that the eventual costs to 'customers', those living in the Thames catchment area and paying water bills, were uncertain. I cannot say if the scheme will work in the medium term, but in the long term I am doubtful that it will be the final solution. There are some interesting parallels with the past situations, where legislation, science, technology, engineering and public protests have failed to deliver consistent improvements in the water quality. Perhaps what we are seeing here is yet another cycle of up and down in the quality of the water in the Thames, with the next downturn driven by shifts in our climate?