Some Lessons from the Historical Experience of Industrialised Countries in the Development of Modern Water Systems

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The purpose of this short paper is to sketch how modern water systems were developed in countries in the first wave of industrialisation, such as England, France and the United States of America and to reflect on the implications for the support of water infra-structures in industrialising countries today. This is not to suggest that policies can simply be transferred. Rather, this short paper asks if there are more general lessons that can be learned.

In 1858 the Thames was black with excrement of two million people, ebbing and flowing in the tide. The stench was so great that Members of Parliament were driven from the chamber. *The Times* called it 'The Great Stink' and Parliament was driven to act resulting in Sir Joseph Bazalgette's monumental engineering programme to construct London's sewers. The dangers of such filth were not only aesthetic; the cholera epidemics of 1831-2, 1849 and 1854 had claimed many lives in England and Wales (some 50,000 in 1849 alone and 14,600 in London). Alongside the erupting epidemics of 'King Cholera' that so captured the popular imagination, was the more regular death toll of tuberculosis (50,000) convulsions (25,000), diarrhoea (20,000) scarlatina (12,000) and whooping cough (10,000). Jephson (1972, p. 23) provides us with a contemporary report of the conditions that gave rise to these diseases: 'In Jacob's Island may be seen at any time of day women dipping water, with pails attached by ropes to the backs of houses, from a foul, fetid ditch, its banks coated with a compound of mud and filth, and with offal and carrion – the water to be used for every purpose, culinary ones not excepted'. And yet by the final cholera epidemic in England of 1866 the only part of London seriously affected was the East End, the sole part of London where Bazalgette's sewerage work was incomplete (Hart-Davis, 1999).

One key problem was disposing of waste. The other was the supply of fresh water. In Paris at the beginning of the nineteenth century the supply of water was provided by 2000 water carriers (providing water from the Seine). In 1954 the engineer Belgrand began the first major modern water supply network bringing clean water to Paris. In the provinces, efforts were first put into clearing garbage and cemeteries away from wells and springs. In north America between 1830 and 1880 there was considerable development in fresh water systems in urban areas but it proved harder to fund sewerage. These fresh water systems faced constant pressure owing to rising populations levels, leakage, drought and uncertain levels of consumption. In New York, for example, authorities had to move further north to tap into the Catskill Watershed and large scale municipal waterworks increased the supply of fresh water to the city (while at the same time stimulating sewerage construction to dispose of this water) (see Melosi, 2000).

Where water supplies were relatively plentiful, as in New York, London and Paris, the sewage disposal system used water as opposed to earlier disposal of 'nightsoil' for use as manure in agriculture. (In countries such as Korea, China and Japan, the carting of nightsoil is still widely used with apparently little harm to health and at lower cost than water-based sewerage systems.) Technologically and socially, this required first the adoption of the water closet, in place of the privet. Thomas Crapper's design was particularly important. Secondly, it required the design of a sewerage scheme such as that published by J. W. Leather in 1845 – 'The Means of Providing an Effectual Sewerage for the Town of Leeds' (smooth-sided, small bore pipes on a sufficient gradient to ensure self cleansing in the place of flat-bottomed passages on inadequate gradients). Thirdly, it required government to provide the necessary legal and financial framework. In Britain, these included privately promoted Acts of Parliament such as the 'Leeds Improvement Act, 1842' and the Public Health Acts of 1848 and 1875. The perceived encroachment on the liberty of citizens implied by these acts prompted *The Times* to comment that 'the English People would prefer to take their chance of Cholera, rather than be bullied into health'.

Informing developments in London, Paris and New York was a new understanding of disease and health. A number of strands led to this new paradigm of public health. The first was that there was a relationship between the physical environment and health. At the radical end of this were working class radicals who led a demonstration of 120,000 in London in 1832 to protest against the Government's handing of the Cholera crisis. Henry Hetherington said in February 1832:

> *The Cholera has arrived amongst us, and this, among other blessings, we have to lay at the door of our 'glorious constitution', for it is a disease begotten of that poverty and wretchedness which are occasioned by the wealth and luxury of the few to whom only the constitution belongs.*

The government was prompted to establish a Commission of Enquiry into the circumstances leading to epidemics. Edwin Chadwick's resulting report *The Sanitary Condition of the Labouring Classes* (1842) was a best seller. It struck a reforming, but less radical, note focusing on the empirical relationship between squalor and disease. Chadwick also connected immorality, lawlessness and political radicalism with physical deprivation: 'how much of rebellion, of moral depravity and of crime has its roots in physical disorder and depravity…The fever nests and seats of physical depravity are also seats of moral depravity, disorder and crime with which the police have most to do' (Wohl, 1983, p.7). In clumsy alliance with Chadwick's position could be found prohibitionists, anti-child-labour activists and sanitarians. Others adopted a more Social Darwinist perspective often blaming inadequate mothers, excessive drinking and incompetent budgeting. Alongside this reformist set of arguments, associated in New York with Herman Biggs, was a set of claims based on developments in medical science. Louis Pasteur in France identified the risks posed by impurities in food and water. This, and other developments in medical science, challenged the idea – prevalent until the 1880s - that disease was spread by 'miasmas'. After 1880 bacteriology became the accepted basis for analysing risks from disease. By the 1880s the majority opinion in London, Paris and New York was that a moralised, medically treated, sober, and above all clean labouring class was a bulwark against disease and other social disorders. This is part of the context of the mass provision of clean water and sewerage.

Some Lessons

The lessons for today lie less in specific developments of the nineteenth century, such as the small bore sewer, and more in the general factors which had to be in place to allow the dramatic improvements in access to clean water to take place. These may be organised into four areas:

- Technical and scientific knowledge
- Institution building and alignment
- Political imperatives and leadership
- Innovation, diffusion and path dependency

Technical and scientific knowledge included, first, the engineering knowledge that under-pinned Belgrand, Leather and Bazalgette's work in Paris, Leeds and London respectively. Secondly, by 1880 Pasteur's comment that 'we drink 90% of our illnesses' was becoming accepted; bacteriology would play an important role in the later development of water systems. Prior to that, however, was the 'knowledge' that miasmas caused diseases. Despite what is now seen as the erroneous science behind this, the practical effect of this understanding was to focus attention on filth and bad odours as a cause of disease. Thirdly the construction of social data that allowed Chadwick and others to look at a map, identify the areas of greatest deprivation, and then chart the pattern of disease onto that map providing a powerful empirical basis for directing resources. Fourthly, as engineering developed there also developed a dominant paradigm of 'how things should be done' shared by engineers and policy-makers. This is characteristic of the development of any professionally-led body of knowledge. For water systems, this led to a narrow range of treatment options becoming accepted practice.

Institution building and institutional alignment was characterised in the nineteenth century by experimentation and adaptation. It often failed. In the 1830s, at the start of the cholera epidemics in London, for example, Parliament failed to establish a London-wide response, including the outer parishes. The City of London focused on the commercial and non-residential areas leading to poor provision of water and sewerage in many of the more populace surrounding areas. As late as 1850 some 640,000 persons in London (including its suburbs) were not supplied with water (Jephson, p.21).

The 1848 Public Health Act created the General Board of Health (with Chadwick one of its three members) which lasted for five years. This met much resistance (The Times described the Act as 'a reckless invasion of property and liberty'). The lack of consistent public support for a particular response to the problem, associated with uncertainty over the science helped lead to institutional inertia and conflict. After the demise of the Board of Health, the Privy Council was given some responsibility for public health (1858) and John Simon was appointed medical officer. However, a range of departments had responsibility for housing, burial grounds, baths and wash houses and Metropolitan Water. Prior to the creation of the Metropolitan Water Board there was fierce competition among the private water companies often leaving customers without water, pipes dug up and companies facing bankruptcy. Building a broad coalition behind the nature of the problem and a set of proposed institutional responses took perhaps half a century. Following the Royal Sanitary Commission's recommendation that a single authority take responsibility for public health, the Local Government Board was established in 1871.

If institution-building was often a hit-and-miss affair, co-ordinating existing institutions could also break down. Success depended upon at least two factors. The first was money. It proved more difficult in North America to build sewers than clean water supplies, for example, because it was easier to raise the funding. The second was governmental support. This depended upon securing political support. France, with a more *etatist* tradition, found it easier to deliver grand projects than in London (although, interestingly, municipal politicians like Joseph Chamberlain were more successful in this respect).

In turn, this depended upon political imperatives and leadership. 'King cholera' enjoyed a profile in the popular imagination that was far greater than the number of deaths it caused warranted, when these deaths are compared with the annual deaths caused by Tuberculosis and so forth. However, this combined with the novels of Dickens, the arguments of Chadwick and the threats of a radical working class movement to create an environment where politicians were forced into some sort of action. The 'Great Stink' of 1858 spreading its stench into Parliament was also a factor. Empirical, scientific, moral, religious, and social Darwinist arguments combined to create a bias to action in England. This bias was reached more easily and earlier in France but may have been even harder to achieve in some North American cities.

Innovation in water systems came from a complex process involving recognising that there was a problem, defining that problem, identifying solutions, and constructing the institutions to deliver those solutions. Champions such as Chadwick, Biggs, Simon and Pasteur all influenced the debate but could not impose a solution. Experiments in different parts of the industrialised world, involving water closets, new sewerage and new institutional arrangements, combined with social statistics showing that these appeared to be working. This helped not only innovation, but the diffusion of these innovations both within countries and between industrially developed countries.

Summary of Key Lessons

	Example	**Lesson**
Technical and scientific knowledge	Understanding of the importance of small bore piping and replacing flat-bottomed sewers.	Need to be aware of and apply latest technological thinking
	Miasmas cause disease	Widely-held views need to be challenged
	Mapping of disease and poverty	Empirical evidence can mobilise support
	Engineering community become locked into a dominant paradigm	Need to look beyond the 'experts' for innovative ideas
Institution building and alignment	Conflict among London's water companies	Need to avoid perverse incentives which encourage dysfunctional behaviour
	Importance of civic pride in municipal grand projects	A sense of locality can provide cohesion
	Slow pace of development of sewerage systems in US	Need to ensure that money flows to where change is needed
	Success of *etatist* interventions in	Need to build a political base for a co-

	France	ordinated response
Political imperatives and leadership	Importance of high profile figures such as Chadwick and Biggs	Need for champions and leadership
	Political anxieties over the ‘Great Stink’ and ‘King Cholera’	Disasters also provide an opportunity to bring about change
	Coalition of medical science, engineering, reformism, social Darwinism and prohibitionists gave rise to support for investment in water system	Support unlikely to come from only one source – need to build wide coalitions
Innovation, diffusion and path dependency	Different cities tried different approaches and then learned from each other	Need to foster diversity and learning in water projects
	Empirical evidence of success was a powerful persuader	Collect and use evidence to encourage diffusion of successful approaches
	Engineering becomes institutionalised	Reward innovation

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