**‘CLEVER MICROBES:’**
**BACTERIOLOGY AND SANITARY TECHNOLGY**
**IN MANCHESTER AND CHICAGO DURING THE PROGRESSIVE AGE**

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**ABSTRACT**

A neglected aspect of the history of germ theory is its use in the purification of sewage. In the 1890s, progressive reformers rapidly developed bacteriological methods of wastewater treatment. A comparison of Manchester U.K. and Chicago U.S.A. shows, however, that science and technology were mediated by political culture and institutions. In Manchester, a politics of deference and strong extralocal government gave the authority of scientific expertise a decisive role in policy formation. In Chicago, devolution of power to the ward-bosses meant a quarter century of defiance against the national authority and its effort to get the city to install a modern sanitation system.

In September 1896, the town council of Manchester confronted a crisis of decision-making in uncharted waters of science, technology, and medicine. A national body, the Local Government Board (LGB), and a regional agency, the Mersey and Irwell [Rivers] Joint Committee (MIJC) were pressing the local government to choose a method of sewage treatment. While the LGB was threatening to cut off funding for all public works projects, the MIJC was suing the city for not meeting its standards of wastewater quality. Forced to act, the council felt adrift in a sea of conflicting recommendations from engineers, chemists, biologists, and doctors. “The question was surrounded with great difficulty, and probably there would be opposition on all sides” a member of Rivers Committee, Nathaniel Bradley, reported to the council. “The Committee,” he explained, “in great measure depended upon expert and scientific evidence, and were largely dominated by officials and professional advisers. That must necessarily be so from the very nature of the thing.” Seeking shelter from this political storm, the Committee proposed constructing a 15-mile conduit that would not only dump the sewage in the tidal estuary above Liverpool, but also escape the jurisdiction of the regional bureau of watershed conservation.[1]

In sharp contrast, Chicago was in the process of constructing its "ultimate sink" virtually free from interference from outside agencies of government. Seven years earlier, its municipal reformers had lobbied a bill through the state legislature that created the Chicago Sanitary District (CSD). It was essentially autonomous because it was given its own powers to tax and borrow. Moreover, the special purpose district was granted authority to operate a 28-mile sanitary channel between the Chicago River and the Illinois River Valley. In 1896, its elected administrators were in the midst of building what was, in effect, a gigantic drainpipe that would tap Lake Michigan to wash the city's untreated, albeit diluted sewage down to St. Louis. Although the U. S. Corps of Engineers formally exercised jurisdiction over inland waterways, it had always acted in the past to help Chicago by sponsoring various improvement projects. The state and federal governments had an unbroken record of facilitating the growth of the city, not hamstringing it with regulations.[2]

In both industrial centers, policy makers attempted to combine sanitation and transportation in their plans for engineering the environment. In the case of Manchester, a ship canal to bypass Liverpool had been opened in 1894 as the remedy to perceptions of urban and economic decline. The city had also begun to respond to a long series of disastrous floods by constructing a main drain with an outfall at the top of the canal in order to keep it filled. While satisfying this purpose, an unintended consequence was the transformation of its turning basin into an insufferable cesspool constantly being churned up by ship propellers. Even the parallel installation of a sewage treatment facility, the

Davyhulme plant, next to the canal failed to bring relief or to meet the standards set by the MIJC.[3]

In the case of Chicago, the original goal to improve public health had also been transformed but with full and open volition. Led by the engineer Lyman E. Cooley, local politicians had wrestled control over the CSD from the reformers, turning their plan for a sanitary channel into an Lakes-to-the-Gulf superhighway of commerce. Cooley and fellow city boosters pointed to Manchester's ship canal as a model. Yet, the amount of lake water needed to dilute the city's liquid wastes to safe levels was so large that navigation was made problematic on the canal's downstream currents. To resolve this dilemma, Cooley redesigned the artificial river to be much wider and deeper, leaving little money for other infrastructure projects needed to safeguard the drinking supply from sewage contamination. An unintended consequence would be an epidemic of typhoid fever less than two years after the grandiose scheme opened with tremendous fanfare and great expectations.[4]

In each case, the relatively new and fast evolving science of bacteriology became increasingly central to the policy debate over sanitation strategies. Over the past decade, germ theory has received considerable scholarly attention in the interrelated areas of epidemiology and urban water supplies. However, historians have given much less consideration to its role in revolutionizing the other side of water management, the treatment and disposal of human and industrial wastes. By the mid-1890s, contemporaries involved in the search for the ultimate sink were closely following experiments in the United States and Great Britain to put "clever microbes" to work in finding it. As Daniel Rogers highlights in his brilliant *Atlantic Crossings*, progressive reformers were well versed in the newest trends and inventions to ameliorate the worst environmental conditions of the industrial city. Pressured from above, Manchester's officials made a thorough study of the contact beds of William Dibdin in London, the septic tanks of Exeter, the intermittent filters of Salford, and the Massachusetts Experimental Station's theories of biological sewage treatment. And in 1893, Owens College (now the University of Manchester) established a department of bacteriology. During the same year, Chicago underwent a complete makeover of its public health department in the wake of its worst typhoid fever epidemic, which had threatened to cancel its World's Columbian Exposition. Officials loudly proclaimed the good health of the city, but quietly established a bacteriology laboratory and put a young physician and "microscopist," Dr. Aldoph Gehrmann, in charge.[5]

A comparison of the reception of bacteriology in the two cities shows that institutional structures and political cultures played a pivotal, if not decisive role in shaping the formation of public policy on sanitation technology. As Chris Hamlin reminds us in his pioneering essay on Dibdin, the issues facing decision-makers of the Progressive Era were not simple questions of scientific "progress." On the contrary, they "were much more complicated: they were political and pragmatic, concerned as much with appearance as with substance, and as much with persuading people as with purifying sewage." The contrast between the strong arm of regional and national authorities in the U. K. and the "weakened springs" of federal government in the U. S. could not have been more complete. While Manchester found no safe haven from the pressure from above, Chicago functioned as a virtual city-state, defying with impunity the feeble efforts of Washington to enforce the law for over a quarter of a century. And while the English city operated in a political atmosphere of tight-fisted paternalism and privilege, its American counterpart created a climate of open-ended wheeling and dealing that put the self-serving interests of the ward bosses above all others. True enough, both city council's fostered environmental inequality and social discrimination in the name of low cost government. Yet, this rhetorical trope had little affect in either place on the outcome of the application of bacteriological science to sewage disposal.[6]

Instead, political cultures and institutions gave definition to the authority of science in the decision-making process on sanitation strategies. In Manchester, England, a politics of aristocratic hierarchy and deference privileged the special knowledge of science in the formation of sewage disposal policy. Rivers committeeman Bradley's sense that "the very nature of the thing" put the policy question in the hands of scientific advisors reveals the basic assumptions of this type of political culture. And in a similar manner, the various governmental bodies and parliamentary commissions gave legitimacy to the authority of science by calling prominent representatives from the academic community to give expert testimony on policy questions. In many cases, the officials and the scientists were from the same social class. In the Progressive Era, a classical education in pure science remained an honorable degree for members of the upper class trained at Cambridge and Oxford. A relatively centralized structure of government and society created a political framework that pointed Manchester towards a decision on sanitation technology based on the authority of science.[7]

In Chicago, Illinois, a politics of anarchistic growth and individualism largely marginalized scientists and doctors to the sidelines of policy formation. They were excluded from most inner circles of decision-making on water management and large-scale public works, especially compared to the politicians' reliance on the municipal engineers. As Stanley Schultz has convincingly shown in Constructing Urban Culture, their technical methods and bureaucratic style became an integral part of the political culture of Gilded Age America. On the contrary, those claiming authority based on the sciences of medicine and/or biology were forced to play the role of outside critics, warning the public of impending public health disasters caused by flawed sanitary strategies. Beginning in the early 1880s, members of Chicago's flourishing scientific communities used germ theory to predict epidemics. Over and over again, they explained why the drinking water was being contaminated with sewage containing harmful micro-organisms. And with equal regularity, the politicians largely rejected their recommendations in favor of the engineers who proved more cooperative in advancing the self-serving goals of their party organizations.[8]

Chicago and Manchester invite comparison for three important reasons in spite of very different cultural frameworks and environmental settings. Unlike many cities located downstream from other sources of pollution, these two are richly endowed with pure water for their drinking supplies. Manchester built a system of upland reservoirs and used the three rivers running through it only for wastewater. Chicago sits on the banks of the Great Lakes, which hold one fifth of the world's fresh water. The factories of the two urban centers also produced massive amounts of organic and chemical liquids that added a significant burden to the task of sewage disposal. Although Chicago' nearly one million inhabitants in 1890 was about twice the number living in Manchester, the populations of both were big enough to require large-scale technologies to solve their sanitation problems. In addition, their search for an ultimate sink was complicated by their ambitious goal to turn it into an engine of economic development, a booming shipping lane.

Manchester and the Politics of Deference

The Rivers Committee's report of September 1896 outlined the contours of the politics and science of sewage disposal in the heavily industrialized, Mersey-Irwell watershed. Introduced by its chairman, alderman Joseph Thompson, the normally secretive proceedings of this powerful committee were forced into the public by imminent judicial rulings. The County Police Court was expected to help enforce the MIJC's effluent standards by hitting the municipal government where it hurt, a £50 fine for each day the "Corporation" failed to comply. Reminding the council of his thirty-one years of service, Thompson admitted that he felt trapped and defeated, caught between the proverbial "rock-and-hard place."

On the one side, the MIJC was turning the screws on what it had set almost three years earlier as the city's minimally acceptable "limits of impurity." The exasperated alderman now admitted that the best efforts of the engineers and the scientists in charge of Davyhulme had failed. Technology designed to precipitate most of the solid matter out of the liquid by adding chemicals had neither filtered out nor killed off the organic matter responsible for causing the horrid smells of putrefaction in the ship canal. Instead, the sewage treatment plant generated a mountain of sludge. The city had to buy a 1,000-ton steamer to haul the semi-solid wastes out to sea. Even more problematical, Thompson lamented, the key expert in defining a series of chemical indicators of wastewater quality for the regional agency, Sir Henry E. Roscoe, was also the city's top advisor in charge of the sewage treatment plant. In effect, the chemistry professor held veto power over any plan in this dual role as private consultant and his public positions as a member of the Parliament, the MIJC, and the faculty of Owens College.[9]

On the other side, the LGB was insisting on land filtration as a final step of wastewater disposal regardless of any other novel sanitation strategies that the city might adopt. The most promising of these were based on germ theory. Their enthusiastic advocates claimed that bacteria could be put to work "eating" organic waste not just deodorizing it with chemicals. But in 1896, the LGB remained unconvinced by the biologists' explanations that sewage farms simply represented a primitive, inefficient form of this natural process of purification. The national governing body also had the power to hurt the "Corporation" in the pocketbook by holding its ability to borrow for public works projects hostage to its demands. Alderman Thompson recounted the committee's dismal and equally frustrating experience in trying to meet them.

The only way out, the chairman concluded, was to adopt the committee's new plan for a tidal conduit. It would convey the 26,000,000 gallons of effluent reaching Davyhulme each day to an outfall point of tidal flow at Randle's Sluices, about three miles above Runcorn. The ship canal could be compensated, Thompson proposed, by using fresh water from the city's other controversial water management project, the Lake Thirlmere aqueduct. Besides a bottom-line advantage of the lowest cost option, he argued, the conduit scheme would allow Manchester to escape the jurisdictional reach of the MIJC.[10] For Thompson, this alternative had deviously delightful prospects of turning a bitter political defeat into a final glorious vindication.

The politics of the report and the storm of public debate that it engendered over the following year exposed the ways in which different groups of progressives understood the new science of bacteriology and the role it could play in reducing shocking urban morality rates, especially among infants. At the time the chairman made his surprise announcement, the tidal conduit plan, the council was undergoing a historic shift from its first generation of ruling Liberals. Since the 1880s, when voting was finally extended to most working class men, the civic sphere of political discourse was becoming more open and contested.[11]

A broadening of the suffrage from Manchester's especially acute case of elite rule also had profound impacts on the political culture within the town council. Two of most influential activist of the era, Sidney and Beatrice Webb, recorded their impressions of Manchester during a five-week stay in the midst of these tumultuous years of civic debate on the links between public health, biological science, and the urban environment. The Webbs believed that the tasks of city government had outgrown its organizational structure. Lending support to the thesis offered here, they observed that "the different parts of the machine are out of joint; it rumbles on in some sort of fashion, because it is pushed along by outside pressure.…"[12]

The Webbs' skepticism perfectly captures the spirit of the age in challenging those in positions of authority. During the Progressive Era, reformers pitted expert against expert in a lively exchange of ideas over the best ways to improve city life. At the September 1896 meeting of the town council, for instance, objections were immediately raised after Thompson introduced the committee report. A venerable leader with a political and social stature to match to the chairman's, Sir John Harwood, demanded time for a thorough vetting of its recommendations. Harwood was the chair of Water Committee, hero of the successful Thirlmere aqueduct project, and member of the

MIJC, along with Thompson. He demanded more time to study the committee's report. Mayor Lloyd too expressed surprise that Thompson was reverting back to the days when the committees routinely expected the council to rubberstamp their proposals.[13]

The week intermission gave both sides time to prepare their speeches for a wider public than the council membership. Alderman Thompson delivered a well rehearsed lecture on the current status of the science and technology of urban sanitation. Taking the audience step-by-step through the various methods of sewage disposal let him establish his technical expertise and legal command of the policy question. After laying land filtration to rest, the committee chairman accurately called the biological work of Dibdin promising but still in the experimental stage. "The whole process as to…call in the use and assistance of bacteria to do the work which land could do better… [could be proclaimed to have] succeeded very fairly, but it must be remembered that those experiments [have] only been on a small scale." He cited cost as the reason this approach was ruled out, leaving only the tidal conduit option.[14]

Although the City Surveyor T. De Courey Meade fell in line behind the committee chairman, his report confirmed that the bacteriological basis of sewage purification was reaching a milestone of technical understanding. In August 1895, Roscoe had converted some of his mechanical, sand filtration beds into biological ones, more or less duplicating Dibdin's work in London. Meade clearly understood that the "slime deposit on the sand constitute[s] the real filtering material in the waterworks filter." He even conceded that Dibden's studies showed that wastewater effluent could be purified to meet any standard of purity. Translating his scientific theory into a practical technology, the engineer posited, would result in "the oxidation of organic matters, both those in suspension and those in solution, through the agency of living organisms. It is the preliminary establishment and subsequent cultivation of these organisms which is to be aimed at in the scientific process of purification by [artificial] filtration."[15] Yet, at the same time, Thompson did not have to distort Meade's encouraging report to portray this new approach as largely unproven and incalculable in terms of ultimate cost.

Reflecting the relative novelty of the application of germ theory to wastewater treatment, the opposition to the tidal conduit plan made no use of it or any other technology as an alternative policy approach to the problem. Instead, it seemed content to lambaste the river committee for incompetence. Rallying the small property owners, the tidal conduit plan's local political opponents joined with lobbyists from downstream interests to force a ratepayers' referendum on the national authorization act. For the first time on an important policy issue, qualified voters in December 1896 rejected a proposal endorsed by their representatives in the town council. Outside pressure could only feel more intense on them after this unprecedented political defeat at the hands of their own constituents.[16]

Linking bacteriology and sanitation technology was not only a new idea in 1896; it was also one attracting a tremendous amount of attention among urban progressives. In many respects, Professor Roscoe saved the day for the town council by persuading the MICJ to give the city one year to come up with a complete plan of wastewater treatment and disposal that could meet the agency's minimum "limits of impurity." During this interval, Dibdin's theories appeared to sweep the field in the scientific community, leaving only practical questions of engineering and management.

Germ theory played an important role in shaping what became a surprisingly well-informed and wide ranging debate on sewage disposal. Compared to a year earlier, the sides staked out on the council floor spilled over into the daily press, fostering a lively discourse of expert against expert, and one insider version against another. Most fascinating was the way in which the Davyhulme experiments became a popular metaphor for scientific and technological progress while the tidal conduit became an icon of a "policy of despair," in the words of an opposition councilman. The chief spokesman of the ratepayers, Dr. R. M. Parkhurst, also alluded to it as "a scheme at once of panic and of despair."[17]

Within this politically charged atmosphere, bacteriological science was cast as a shining beacon of knowledge that could lead the city from the dark pessimism of the council chambers to the bright light of the city healthy of tomorrow. Letters by academics on both sides of the issue underscore the point that the authority of science and technology remained privileged, albeit contested terrain in the 1897 policy debate in Manchester. In this wide-ranging discourse, chemists rather than biologists still held center stage as the voice of science on effluent standards of quality, but their main focus of attention was increasingly dominated by the biological filter beds in London, Manchester, Salford, and other similar field experiments in England and America. The ones lined up against the river committee made good use of germ theory to offer the public an attractive and ingenious alternative to the culvert scheme.[18]

The science of bacteriology promised not only to solve a major problem of the industrial city but to advance a progressive ideal of the conservation of natural resources at the same time. In the end, Dr. Parkhurst's mobilization of the protest vote proved decisive. Opponents of the council's plan raised legitimate questions about the effects of the diversion of so much water from the ship canal in addition to the arguments against defeatism and for faith in science and technology. In contrast, the council's position rested on too thin a base of legalistic and bureaucratic politics. Such a rational was not strong enough to carry the weight of public opinion needed to prevail at the polls. On 31 October 1897, Mancunians voted 49,069 to 20,528 in opposition to the council's culvert plan. No one could question the finality of this overwhelming rejection of its policy choice. In a dramatic jester of defeat, if not despair, chairman Thompson and his fellow members resigned their positions on the Rivers Committee.[19]

Under different leadership, Manchester emerged in 1898 as a champion of the new science of bacteriology. In part, a process of elimination left it as the only viable alternative to the old science of sewage farms. However, the fast growing consensus among sanitary experts behind biological solutions to the problem gave the reconstituted Rivers Committee the confidence it needed to make a commitment to a specific course of action. In this rapidly moving subject of research, the various field and laboratory experiments left little doubt that the scientists were headed in the right direction. Although the precise details of an appropriate technology remained to be worked out by trail and error, the path of knowledge opened by Dibden and company now seemed not only the most promising but also the only rational sanitation strategy.

The choice of Sir Bosdin T. Leech as the new chairman of the Rivers Committee was equally important in turning Manchester into an outspoken advocate of biological methods of sewage treatment. Along with fellow Liberal councilor Harwood, he had been most responsible for steering the ship canal proposal through the town council. This considerable achievement earned the yarn merchant a knighthood and a directorship of the transportation company. Now he was asked to use his considerable political skills to convert the city's governmental overseers into apostles of the new science. In sharp contrast to Thompson, Leech asserted that "the Committee were distinctly of opinion that biological filtration presented at once a less costly and more effectual means of filtration than any other…" In the spirit of compromise, he accepted Harwood's suggestion that the city also comply with the LGB's demand for land filtration by purchasing the required 200-300 acres while pushing forward at Davyhulme with maximum speed.[20]

The Leech-Harwood compromise plan contained the elements of a political resolution of the city's conflict with its regulatory overseers. First Leech rallied the needed council majorities to proceed with plans for a small-scale operational test of the bacteriological method of sewage treatment. Then he turned to foster a new partnership with the regional and national agencies. By adopting a specific technology and by embracing germ theory, Leech effectively shifted the burden of scientific proof back to them. The city could now ask whether it had their official sanction to ratchet up the experimental station into a full-scale facility. On 12-13 January 1899, the showdown came at a crucial hearing of the LGB. At issue was Manchester's petition for a loan of £160,000 to construct 26 acres of additional filter beds to expand the 4 acres already devoted to biological methods of sewage purification.

The city's solicitor, M.P. Balfour Browne, came well-armed with the powerful authority of experts to bolster his case for the new science. He strove to demonstrate that Manchester's bacteriological filtration system could more than met the MIJC's minimum standards of effluent quality. A chemist/bacteriologist at Owens College, Gilbert John

Fowler, was emerging as the effective director of the Davyhulme experiments. He supplied the board with technical data. In addition, the city's solicitor brought along several heavyweight reinforcements of the scientific establishment, including professors Percy Frankland and W. H. Perkins. Yet, Browne may have best captured the historic meaning of the hearing in observing that "sewage disposal at one time was simply a matter of engineering… and it is only recently that this matter has passed out of the hands of the chemists and passed into the hands of the biologist, who will tell us...that the method, and the only method, of disposing of sewage is by the bacterial method." The biology-and-land package looked increasingly attractive as a face-saving way out of the inter-agency conflict for all three public institutions. In less than a year, each level of government agreed to the compromise plan, ending the policy standoff over urban sanitation and watershed conservation.[21]

Under pressure from above, the town council became highly motivated to find an ultimate sink for Manchester's rapidly swelling volumes of wastewater. Between 1896 and 1900, this political struggle over science and technology policy spilled over into the larger arena of popular opinion. Urban reformers embraced germ theory as modern and "progressive;" in the case of Manchester, they seemed eager to adopt biological methods of effluent treatment as a step forward towards the future. The very notion that bacteriology offered a new source of authority to challenge the old also may have appealed to some political activists of the Progressive Era. To be sure, Alan Wilson's assessment that the city's sanitation policy was driven by considerations of lowest cost has much to recommend it. He posits, for example, that the referenda of 1897 rejecting the council's culvert plan was simply a protest against higher taxes during a period of depression.[22]

Yet, this victory for the hard-pressed ratepayers was equally a triumph for the new science and the faith people had in its power to solve the environmental and social problems of the industrial city. In the case of Manchester, the authority of experts helped shape policy formation towards a science-based approach to problem solving. The resolution of the Manchester's sanitary strategy at the turn of the century offers an opportune moment to segue into the Chicago story and the opening of its dual purpose, ship canal and sewage ditch.

Chicago and the Politics of Defiance

On 17 January 1900, the much anticipated public works project opened with the third formal proclamation of pure water for Chicago. The two earlier promising but ultimately disappointing milestones of environmental engineering had been the two-mile, water intake tunnel and crib of 1866, and five years later, the deep-cut, drainage channel and canal. Bursting yet again with civic pride, the Chicago Tribune declared the great achievement of the SDC meant, "the city at last is free from the growing menace of a contaminated water supply." Medical experts too responded to the city's sanitary plans in a way consistent over the previous twenty years by taking a more cautious approach. They continued to urged people to heed the daily newspaper bulletins from the bacteriology lab of the health department that warned them when to boil their drinking supplies.[23]

In contrast, the sanitarians of the pre-germ theory period had no solid base of contrary knowledge upon which to raise reservations about the city's environmental planning. Beginning in the early 1880s, however, the science of bacteriology gave chemists and microscopists from the medical colleges new perspectives that cast doubt on the basic design of City Hall's water management system. Their investigations of water quality near the two-mile crib raised serious questions about a strategy based on the belief that Lake Michigan furnished a "fountain inexhaustible" of pure water. Formulated into policy by Chicago's first prominent municipal engineer, Ellis S. Chesbrough, this notion of nature's boundlessness led him to propose that the lake could be tapped as a virtually free source of pure water both for the city's drinking supplies and for diluting its liquid wastes to safe levels. On the contrary, scientific evidence kept accumulating that linked contamination at the intake cribs to discharges from the sewerage system.[24]

But unlike in Britain, the authority of science held a tenuous place in American political culture, especially compared to the nearly sacred space reserved for the engineers in planning large-scale infrastructure projects to improve the quality of urban life. A part of a broader conflict between Chicago's municipal reformers and its ward bosses, attention here will stay focused as much as possible on the influence of germ theory in the struggle for control of water management policy. In spite of growing confidence in the science of bacteriology during the Progressive Era, the city's doctors and academics would remain frustrated, ignored, and isolated on the fringes of decision-making. As they came to see the urban environment as a world teaming with microbes, they kept pointing to the fatal flaw in the city's sanitary strategy. Yet, the engineers were able to retain their privileged positions by proposing ever bigger technological fixes that generated more and more jobs and contracts for the politicians to dole out.

Without any effective outside pressure from the state or federal governments until the mid-1920s, Chicago's ward bosses promoted their own self-serving interests at the expense of the people and the environment. Left on the sidelines of policy formation, the city's scientific community ironically found itself free to create one of the world's great centers of experimental work on biological methods of sewage disposal. Between 1908 and 1925, they and their allies among the municipal engineers became some of the key pioneers in working out the ways of treating and disposing wastewater still in use today. At the same time, Chicago's policy makers stubbornly refused to install even a single water filtration station or full-scale sewage treatment plant. Instead, they continued to build one gigantic project of hydraulic engineering after the next based on an outmoded notion of nature's boundlessness. Despite overwhelming scientific evidence to the contrary, the politicians in charge of Chicago's water management system continued to act on the assumption that they could always count on the Great Lakes for an unlimited amount of pure water.

As we have seen in the case of Manchester, the 1890s was a period of ferment in bacteriology and epidemiology. Chicago proved no different; it too became an active participant in the trans-Atlantic crossings of urban progressives. While Cooley and the engineers were directing the construction of the ship canal, the scientists and doctors were gaining fresh insight on the relationship between the world of the micro-organism and the environment of the industrial city. Most important here was the growing realization of the pervasiveness of the former in the latter. In other words, germs were everywhere and efforts to contain them would prove difficult if not futile. In 1889, for instance, the state's leading public health official, Dr. John H. Rauch explained that "in

Chicago the sewage undergoes decomposition in the mains…. In rain or floods, sweeping everything out rapidly [into the lake], there is danger of [it] being carried a long distance away and infecting the water supply." Five years later, a popular account of the city's sanitary history exclaimed that "in the operation of these minute beings a new world is brought to light. Their number, even in a defined space, is inconceivable. In a single gramme of butter…there are said to be 2,465,555 micro-organisms." More to the point, the city's bacteriologist, Dr. Gerhmann warned in 1895 that "there is an area of continually contaminated water along the lake front…. To attempt to obtain pure water by locating cribs beyond this line of permanent contamination leads to a false security." His tests found sewage pollution twelve miles out and beyond.[25]

But until the typhoid epidemic of 1902, Chicago's elected officials could also brazenly ignore the critics of its water management policies. When the number of deaths from the disease suddenly jumped to 471 during August and September, Dr. Gerhmann's prescient advice came back to haunt the local defenders of the Chicago Sanitary District. The Tribune, for example, now confessed "the entire water supply is of inferior quality. The only consolation is that if it were not for the drainage canal the water would be inconceivably worse.... It would be rank poison."[26]

Among those investigating the causes of the epidemic was Edwin Oakes Jordan, an assistant professor of bacteriology at the University of Chicago. A recent graduate of the M.I.T/Massachusetts Experimental Station program, he put the epidemic in broad, national perspective by highlighting the city's role as a rail hub, the place where train passengers supplied with Chicago water were dispersed to points across the country. His analysis was remarkable in several respects, not the least of which was its timely publication in the December 1902 issue of the prestigious Journal of the American Medical Association. That the new public health should reach mature form in only ten years is testimony to the revolutionary pace of the paradigm shift in the etiology of disease.[27]

The bacteriologist's report on the causes of the outbreak of typhoid deserves careful consideration because it represents a comprehensive understanding of the environmental implications of the new science for the industrial city. Jordan immediately acknowledged the benefits of the drainage channel, praising it for the reducing the disease since its opening to the lowest rates of death in the history of the city. However, he was equally quick to take its planners to task for their failure to divert all of the city's sewage away from the lake and into the waterway. "Though a lack of foresight and coordinated endeavor on the part of the responsible authorities," he complained, "a large part of the sewage system of Chicago remains at this date unconnected with the Drainage Canal.... It is certainly singular that the present situation should not have been foreseen and guarded against. The excuse for...pour[ing] fresh sewage into the lake for upward of three years after the completion of a great and enormously expensive sanitary undertaking can hardly be adequate." Jordan produced a map, which showed that the wastewater of over a quarter million people was still flushing into the lake. This was undoubtedly the source of the problem "since there seems to be no instance on record where a large city possessing a pure or purified water supply has experienced an epidemic of typhoid fever of the proportions of the one that has just visited Chicago."[28]

To the scientist, the logic of the equation between the protection of the environment and the health of the city now appeared to be self-evident. After making a comparative, statistical analysis of the links between water quality and public health in American and European cities, Jordan turned to discuss all of the alternative theories that placed blame on more localized causes such as rotten food, flying insects, and infected dust. While conceding a scientific possibility of the transmission of disease by these agents, he reasoned that the probability in the present situation was extremely low as opposed to sewage contamination of the water supply during the two months of heavy rains that preceded the outbreak in August. "Since there is an explanation so simple, so in accord with the general experience regarding extensive epidemics of typhoid, and so consonant with the past experience of Chicago itself, it would seem logically unnecessary to seek for another cause."

Completing the lakefront interceptor sewer project was imperative, but it would be a serious mistake to believe that it represented a final solution to the problem, according to the scientist. On the contrary, Jordan argued, all plans must be based on the assumption that lake would remain a source of everlasting pollution, not purity, into the foreseeable future. "No one familiar with the general sanitary history of water supplies can expect that all chances for water pollution will cease with the completion of the sewage system," he concluded. Jordan painted a picture of the world as a place filled with microbes. Reflecting the fascination of science with statistics, the bacteriologist explained that as many as 172,000 typhoid germs could be found in a just one cubic centimeter of urine. Although a single cruise ship or bather could cause the next crisis, the real threat was rapid industrial and suburban growth, making problematical any water management plan based on the use of the lake without some method of purification.[29]

The scientific revolution in the theory of disease causation led Jordan inexorably towards a dual approach of water filtration and sewage treatment for inland lakes and streams. He concurred with the engineers who were already calling for a major expansion of the CSD to integrate the affluent North Shore suburbs and the Calumet District into the metropolitan system. But he sharply disagreed with their plans for two more heroic canal building projects, especially the one for the industrial district because it would still leave those dependent on water from the 68th Street intake crib in the Hyde Park neighborhood vulnerable to contaminated supplies. Instead of spending an estimated $12 millions on the so-called “Cal-Sag” project, Jordan thought that a water filtration plant at a cost of $2 million would be not only far less expensive but far more effective in protecting the public health. In fact, Jordan calculated that it would cost $8.5 million to install filtration works to safeguard the water supply of the entire city. “It would prove most discouraging,” he predicted, “to discover after the expenditure of seven or eight million dollars for the construction of a drainage canal for the Calumet region that the pollution of the Hyde Park water supply from towns in Indiana south of the Calumet and from other sources was still so great that the amount of typhoid fever in that portion of the community served by this supply remained excessive.”[30]

But Chicago’s ward bosses in control of City Hall and the SDC had no intentions of heeding the authority of science in spite of the glaring failure of the canal for the purpose of either public health or commercial development. Cooley and the engineers had already run up a bill of more than $48 million, twice the projected cost. Yet, the city had neither pure water nor a superhighway of commerce. On the contrary, the elementary incompatibility of the two goals had become immediately evident. The rushing flow of lake water into the artificial river had been so great that it created a hazard for the navigation of its cumbersome barges, repeating the history of the 1871 deep-cut. This time, however, the Army Corps of Engineers intervened, ordering the local agency in May 1901 to reduce the flow by almost 60 percent from 6.5 to 2.7 billion gallons a day. By now, the federal government had also taken an unyielding stand against paying an astronomical amount to deepen the 278 miles of the Illinois River from Joliet to the Mississippi River to accommodate ocean-going ships, to say nothing of the cost of dredging the additional 800 miles to reach the Gulf.[31]

Moreover, the SDC's massive withdrawals lowered the Great Lakes as much as six inches, resulting in the equally unrelenting opposition of Canada to Cooley's megalomaniac dreams. As Corps engineers had predicted as early as 1887 in debating his proposals, such a drop would cause serious problems for navigation through the system of locks and canals that interconnected the lakes. Docking ships in their shallow harbors too would result in economic losses, estimated at a total of $50 million a year. Here then lay the origins of the legal dispute between Washington and Chicago that would languish in the courts until the mid-twenties. An enduring tradition of American federalism has been the appointment of federal prosecutors and jurists with strong local attachments. Without constant diplomatic pressure from the Canadians, even this case of justice long delayed might never have been brought to a resolution. During the interval, the health of the people of Chicago remained at risk from drinking water contaminated with sewage.[32]

Conclusions: Political Cultures of Science and Technology

By the turn of the century, the germ theory of disease causation had triumphed over previous approaches in Manchester and Chicago.[33] In both places as well, the biological basis of sewage purification had become the common understanding. Although the new science was widely accepted, the technology of wastewater treatment and disposal to make best use of this knowledge remained to be worked out. Closely related were political questions because the costs would be significant to advance experimental studies, install large-scale facilities, and operate them year round. For Manchester, a politics of deference meant complying with the rulings of the regional and central agencies while searching for ways to reduce operational expenses. For Chicago, a politics of defiance meant disobeying the orders of the national government while enhancing the self-serving goals of the politicians. Nonetheless, both cities would play key roles in the development of an advanced technology, the activated sludge method, which remains in general use today.

In the case of Chicago, adoption of the new science by sanitary engineers brought them into more and more conflict with policy-makers at City Hall and CSD headquarters. After the great annexation of 1889, the burden of paying for sewer extensions had shifted from common taxes to special assessments on affected property owners. The profits or so-called "surpluses" from the waterworks were no longer diverted into subsidizing sewer construction, giving the ward bosses in control of the finance committee a huge slush fund for patronage jobs and pet projects. As Table One demonstrates, these were very substantial sums.

TABLE ONE
CHICAGO WATERWORKS REVENUES

| Year | Total Revenue | Costs | | | | "Surplus" | |
|---|---|---|---|---|---|---|---|
| | | Salaries | Fuel | Other* | Total Costs | Amount | Profit Ratio |
| 1893 | $2,950,000 | $252,800 | $250,000 | $ 63,200 | $ 566,000 | $2,384,000 | 421.2% |
| 1903 | $3,690,000 | $277,900 | $392,100 | $275,000 | $ 945,300 | $2,744,700 | 290.4% |
| 1913 | $6,500,000 | $403,200 | $437,000 | $780,000 | $1,621,000 | $4,879,000 | 301.0% |

*Includes Repair, Maintenance, and New Construction other than the distribution system.
SOURCES: Chicago, Department of Public Works, Annual Report (1893, 1903, 1913, 1914), passim.

The aldermen knew that these obscene "surpluses" were generated by a flat-rate system of charges for water service as opposed to meter-based billing. They also understood from engineering reports dating back to the 1870s that universal metering was the only practical way to curb the profligate waste of over one half of the water pumped through an underground network of mains that leaked like a sieve. Much of this water found its way by osmosis into the brick sewers. Chronic low pressure and periodic shortages justified an endless round of public works projects.[34]

But without curbing this gross abuse of the fountain inexhaustible, any effort to filter the water supply or to purify the resulting sewage discharges would be extremely expensive. Appointed in 1901, City Engineer John Ericson would spend his entire career, the next quarter century, in frustration and defeat. One panel of outside experts after another would reinforce his recommendation of universal metering but to no avail. In 1915, for example, the Chicago Real Estate Board sponsored a study of Chicago's water management strategies that included several experts from England. At that time, the waterworks was pumping an average of over 600,000,000 gallons a day. Among its findings of fault, the blue ribbon panel reported that "the rate for 1913 of 218 gallons per head per day is excessive even for American cities, whose generous use of water appears to European engineers to be lavish and inexplicable."[35]

Unable to budge the ward bosses on water filtration, young sanitary engineers working for the SDC came up with an alternative solution to delivering drinking water free from dangerous germs. Since the politicians in charge of the agency had no intention of treating sewage other than by dilution, its professional staff was given relatively free rein to conduct small-scale experiments. In Chicago, the 8-10 million gallons a day of liquid wastes laden with organic matter pouring out of Packingtown posed the single greatest challenge. In 1908, Chief Engineer George M. Wiser supervised the use of chlorine as a disinfectant at a research station located near the junction of the stockyard's infamous "Bubbly Creek" and the Chicago River. Wiser and other engineers, including George A. Johnson, concluded that chlorine could also be used to kill germs in water supplies. Johnson soon applied this lesson in Jersey City, N. J., resulting in a well-publicized court case that decided in favor of the novel method.

Soon cities across the country without filtration systems were adding the chemical to their drinking supplies. In 1911, an outbreak of typhoid fever struck consumers of water from the Hyde Park intake crib, just as Professor Jordan had feared. Chicago too adopted chlorination. Although phenols dumped by steel makers into Lake Michigan meant extra heavy doses of the additive were required to protect the public health, the politicians believed they had found the perfect answer to the demand for "pure" water. Chlorination would prevent future epidemic crises from water-borne disease without endangering their "surplus" fund.[36]

In the case of Manchester, the main challenge facing scientists and engineers was reducing the costs of sewage treatment and disposal. After 1901, various technologies were strung together in series to produce a more or less acceptable effluent, but the bill kept mounting for dumping the sludge at sea. As more and more working class homes were finally allowed to install indoor plumbing and hooked up to the main drain, the Davyhulme facility fell behind in adding enough new capacity to handle the ever larger quantities of wastewater to be processed. Open septic tanks were installed because they proved better than contact beds in reducing the amount of sludge, pointing the way towards using bacteria more efficiently to consume it. However, these gains were more than offset by the sheer increase in the volume of wastewater to be purified.[37]

In 1912, Professor Fowler of Owen's College visited Massachusetts' Lawrence Experimental Station and observed studies of aeration of sewage in bottles. Returning home, he was inspired to continue this line of inquiry, enlisting two of the Corporation's engineers, Edward Ardern and W. T. Lockett. Rather than separating the solids from the liquids as the first stage of the treatment process, they found that by allowing the microorganisms to accumulate in the sewage, they would purify it much faster and more completely. Some of this "activated sludge" could then be added to the next patch of raw sewage, producing even better results. Moreover, the much reduced waste by-product had pecuniary value as fertilizer. First publishing in 1914, news of the breakthrough at Manchester spread with remarkable speed throughout the professional community.[38]

In less than a year, Dr. Fowler was providing advice on how to duplicate the new method to sanitarians at the University of Illinois at Campaign/Urbana, Chicago, and Milwaukee, Wisconsin. Information on the results of this work were reported in the trade journals and discussed at the regional, professional organization, the Western Society of Engineers. The CSD's Langdon W. Pearse quickly began tests at the Packingtown station but large-scale trials that advanced the science and technology of activated sludge were only conducted in the other two cities. Over a relatively short period of three years, Manchester, Urbana, and Milwaukee became international leaders. They established the new method as far superior to all previous methods of sewage treatment and disposal.[39]

In contrast, Chicago would lag farther and farther behind, stubbornly holding onto notions of the fountain inexhaustible to underpin its sanitary strategy. In 1922, the SDC would open its first sewage treatment plant in the heavily industrialized area of Calumet. It would use older technologies rather than taking advantage of the new method. Only the forceful intervention of an U. S. Supreme Court three years later finally began to bring Chicago up to modern standards of water management. Almost twenty years more would pass before the city was brought into basic compliance with the court's orders on sewage disposal, besides the installation of a water filtration plant.[40]

Comparative studies of Manchester and Chicago lend strong support for Roger Daniels' assertion that progressivism took place within a trans-Atlantic context. The ascendancy of germ theory provides an especially useful test case because its timing closely parallels the rise of this impulse for urban reform. True enough, European medical practitioners may have been ahead of their American counterparts in adopting a microbiological theory of disease causation. At the same time, however, their academic colleagues appear to have kept abreast of the rapid development of bacteriology, at least in Chicago. Beginning in the early 1880s, scientists from its medical schools applied the lessons of the microscope to answer questions about the safety and quality of the water supply. And with the establishment of the Massachusetts Experimental Station in 1893, important research findings began flowing back to Manchester, informing its debate over sanitation policy. The movement of information and people across the Atlantic in both directions made the search for improved methods of biological treatment and disposal of sewage truly international. There was no gap between the two cities in the state of knowledge about this area of science, technology, and medicine. Emblematic of this process was the close interchanges among experts in the Manchester and the Chicago areas leading to the discovery of the activated sludge method.

A comparative approach also reinforces Chris Hamlin's claim that political culture played a crucial role in shaping public health and sanitation policy during the Progressive Era. This transnational case study illuminates the ways in which decision-making was affected by sharp contrasts in the authority of science and experts, the structure of government and society, and the style of partisan organization and mobilization. In the U.K., the central state had already accumulated a long record of social investigation and direct intervention in the affairs of its cities. Equally important was the intimate bonds of social class among government officials and academic scientists in the formation of a politics of deference. Working together, they took incremental steps towards finding solutions to the interrelated problems of urban sanitation and river conservancy.

In the U. S., the federalist ethos of local self-government worked against the creation of national urban and environmental policies until the crisis of the Great Depression. In Chicago, an extreme version of this devolution of power gave the ward bosses extraordinary leverage in defining public policy. While the engineers in their city building roles also played a part in the configuration of municipal administration, their authority was always subservient to the self-serving goals of the professional politicians. After the turn of the century, they defied not only the national government but also their own sanitation experts. Only highly exceptional circumstances -persistent Canadian diplomacy- eventually prodded Chicago to begin to conform to modern standards of public health and sanitation. Until then, those forced by low incomes into the slums bordering the industrial corridor of the river paid the price of environmental degradation and diminished lives.

**Endnotes**

[1] Nathaniel Bradley as quoted in Manchester Guardian, 10 September 1896, p. 7 [Hereafter cited as MG.]. Also see ibid., 3-29 September 1896. For the best overview of the subject, see Alan Wilson, "Technology and Municipal Decision-Making: Sanitary Systems in Manchester 1868-1910," (Ph.D. diss, University of Manchester, 1990). The expression, "clever microbes," can be attributed to testimony by Balfour Browne, Local Government Board Inquiry, Application to the Local Government Board for Sanction to Borrow Money for Purposes of Sewerage and Sewage Disposal Before Maj-Gen H. D. Crozier, R.E. and Theodore Thomspon, M.D., Inspectors, Jan 12-13, 1899 (n.p.: n.p., n.d [1899]), p. 9.

[2] See Harold L. Platt, "Chicago, the Great Lakes, and the Origins of Federal Urban Environmental Policy," Journal of the Gilded Age and Progressive Era, 1(April 2002): 122-53; and Joel Tarr, The Search for the Ultimate Sink (Akron: University of Akron Press, 1996), for more general perspectives.

[3] See I. Harford, Manchester and Its Ship Canal Movement (Halifix: Ryburn, 1994); and B. T. Leech, History of the Manchester Ship Canal (2 vols.; Manchester: 1907): 2: 177-79.

[4] See Elmer Corthhell, "The Manchester Ship Canal," Journal of the Western Society of Engineers 4(February 1899): 1-11 [Hereafter cited as JWSE]; and Platt, "Chicago, the Great Lakes."

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Medical History of Chicago 5(January 1937): 22-23. Also see, Nancy Tomes, The Gospel of Germs (Cambridge: Harvard University Press, 1998); and Christopher Hamlin, Public Health and Social Justice in the Age of Chadwick (Cambridge: Cambridge University Press, 1998);

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[9] MG, 3 September 1896; and ibid., 5 October 1897, for the reply of the MIJC to alderman Thompson's position and most complete account of Sir Roscoe's definition of the "limits of impurity." For biographical information on Roscoe, see Charles Coulston Gillispie, ed. Dictionary of Scientific Biography (New York: Scribner's Sons, 1970-76), 2: 536-39.

[10] MG, 10 September 1896.

[11] See the memoirs of Medical Officer of Health James Niven, Observations on the History of Public Health Effort in Manchester (Manchester: John Heywood, 1923); and Derek Fraser, Urban Politics in Victorian England (London: MacMillan, 1979), for the political culture of Manchester.

[12] Sidney Webb and Beatrice Webb, Methods of Social Study (New York: Kelley, 1968 [1932]), p. 195, for the quotation; Harford, Ship Canal, pp. 62-98, 147-66, Appendix B.

[13] MG, 3 September 1896. On the Thirlmere aqueduct, cf. Sir John James Harwood, History and Description of the Thirlmere Water Scheme (Manchester: Henry Blacklock, 1895); and Thirlmere Defense Association, Manchester and Thirlmere Water Scheme (Windemere: Garnett, n.d. [1877?]).

[14] MG., 10 September 1896. For an early examination of the relationship between the science of bacteriology and the technology of sewage disposal, see F. J. Faraday, "On Some Recent Observations in Micro-Biology and their Bearing on the Evolution of Disease and the Sewage Question," Literary and Philosophical Society of Manchester, *Proceedings* 25(1885): 46-55.

[15] City of Manchester, Proceedings of the City Council, 9 September 1896, pp. 1342, 1360, for the quotations; ibid., 1337-89 for the City Surveyor's full report.

[16] MG, 10 September-11 December 1896, passim. Also see the concurrent Sanitary Congress in Leeds, where Dibdin and others were moving from theory to practical engineering. See ibid., 18 September 1897.

[17] R. M. Parkhurst, letter to the editors, ibid., 8, 14, 15 September 1897.

[18] Ibid., 26 October 1897, for the 'The Scientific Aspects of Sewage Purification;" ibid., 14, 15, 16, 20, 27 September, 2, 5, 6, 25 October 1897, for additional commentary with science related aspects.

[19] Ibid., 2, 25 September-31 October 1897, passim; ibid., 1 November 1897, for the vote.

[20] Ibid., 7 April 1898, for Leech's assumption of leadership; and ibid., 26 March 1898, for the proceedings in the courts. For the scientific work at Davyhulme as reported by Fowler, see ibid., 21 March, 5 April 1898.

[21] LGB Inquiry, Application, pp. 6-7, for the quotation; ibid., passim. For biographical information on Fowler, see Chemical Society Journal (December 1953): 4191-92.

[22] Manchester Corporation, Rivers Department, Experts' Report on Treatment of Manchester Sewage. October 30 1899. (Manchester: Blackock, 1899); MG, 15 October 1901; Wilson, "Technology and Municipal Decision-Making," pp. 259-329.

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[28] Jordan, "Typhoid Fever," pp. 1563-65, for the quotations.

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[31] CT, 16-28 July 1871.

[32] International Waterways Commission, "Reports of the International Waterways Commission 1906," in Sessional Paper no. 19a. A. 1907, Canada. Report of the Minister of Public Works (Ottawa: Dawson, 1907). For an account of Canadian diplomacy, see Platt, "Chicago, The Great Lakes," which includes a bibliography of historical and legal citations to the controversy. For the earliest expression of concern about the proposed

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[34] See City of Chicago, Board of Public Works, Annual Report (1874): 13, for the first recommendation for meters as the only way to curb waste.

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[36] For the most complete account, see George A. Johnson, "The Purification of Public Water Supplies," in Water Supply Papers, U.S., Department of the Interior, United States Geological Survey, No. 315 (Washington: GPO, 1913). Also see George M. Wisner, Report on Industrial Wastes from the Stockyards and Packinghouses of Chicago

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[37] Wilson, "Technology and Municipal Decision-Making," pp. 259-329.

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[40] See above, note 32.