

**The Sanitation Revolution:
The Innovation of Sewers and Indoor Plumbing
in the 19th and 20th Centuries**

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When asked to think of great technological breakthroughs in history, many people mention such flashy inventions as television or computers. But if we narrow the focus to those innovations that have had the greatest impact on human welfare, and for the most people, few innovations can compare with public sewer systems and indoor plumbing. When the *British Medical Journal* polled experts in 1999 about what they considered the greatest medical advance since 1840, the majority picked public sanitation, ranking it above even antibiotics and anesthesia.¹ Without a doubt, the widespread adoption of sanitation systems and indoor plumbing in the early 20th century was the most significant innovation in nearly *doubling* the average lifespan of Europeans and Americans, rapidly decreasing deadly diseases and creating a healthier, more comfortable living environment for the modern world.

The idea of building sewers to carry waste away from houses and cities is thousands of years old. Like many other grand innovations, the concept of indoor plumbing and sewers has been around since ancient times. It can be seen in ancient Roman and Babylonian civilizations, where there were primitive toilets and closed sewers for all to use. After 2,000 years, all of the mechanisms and devices used for controlling sewage had crumbled, and the world had no idea how to properly dispose of human feces. Over the years, many important scientists and inventors such as Leonardo da Vinci and William Byrd looked back on the Roman plumbing fixtures and pipelines and experimented with different forms of flushing water closets and sewage systems, but their ambitious plans never left the drawing board.

Before the invention of large-scale enclosed public sewer systems, large towns and cities

¹ “Sanitation Best Medical Advance,” BBC News.
<http://news.bbc.co.uk/2/hi/6275001.stm>

were heavily polluted.² During the Middle Ages, the common folk dumped their chamber pots of waste right into their backyards and streets. As a result, living in cities and towns meant constant, daily contact with urine and feces. Much of the time, the waste would flow into ground wells and the city water supplies.³ The rich and middle class emptied all of their waste into giant open cesspools, or cesspits, located in their basements. The stench was unimaginable. In 1186, in the palace of the Holy Roman Emperor in Efurt, Germany, the fumes from the palace cesspool caused the floorboards to gradually rot. Once, during a large gathering, the floors collapsed and hundreds of the emperor's guests fell through into the cesspool and drowned in human excrement.⁴

Life was not much better in the New World. English settlers used chamber pots and other crockery items to spread their waste into fields and rivers, or used primitive outhouses that consisted of wood benches hanging over holes in the ground. The waste was stored in underground chambers called cesspits, often located very close to houses. They did not know that as the populations of cities and towns grew, such casual methods of discharging refuse would lead to major pollution problems and various outbreaks of epidemics. "Here in Massachusetts, it is no uncommon thing to find (in rural homes) a well for water supply in close juxtaposition with collections of foul and disgusting matter in vaults of privies, cesspools, pigstyes or barnyards," wrote Harvard-educated civil engineer Edward S. Philbrick in his 1881 book, *American Sanitary Engineering*, commenting on the horrible living conditions of the

² Hector Gavin, M.D., *Sanitary Ramblings, Being Sketches and Illustrations of Bethnal Green*. (London: John Churchill, Princes Street, 1848). <http://victorianlondon.org>.

³ Edward S. Philbrick, *American Sanitary Engineering* (New York: The Sanitary Engineer, 1881), p. 2.

⁴ "Tracking Down the Roots of Our Sanitary Sewers," http://sewerhistory.org/chronos/middle_ages.htm

common people. “A city government erected within ear-shot of our oldest institution for learning still compels every householder to hoard in immediate vicinity of his dwelling, the vilest refuse of his family to ferment and decompose in the soil,” added Philbrick, one of the pioneers of American sanitary engineering.⁵

Such poor sanitary precautions led to the spreading of deadly infectious diseases such as typhoid fever, cholera, malaria, and polio in both Europe and North America. As a result, the life expectancy of the average person gradually declined until it was reduced to less than 45 years of age in the late 19th century. A landmark case study in public health and sanitation history, called the Broad Street Well Epidemic, definitively established the link between sewage-contaminated drinking water and disease. In London, 1854, the deadly disease of cholera swept through the Soho neighborhood in London. Cholera is caused by bacteria that attack the intestines so violently that victims die within hours of excruciating dehydration from diarrhea. A British medical inspector named Dr. John Snow investigated the situation. Snow interviewed the families of the victims of the outbreak and learned that nearly all of the victims drank water from a well on Broad Street. “Within two-hundred-and-fifty yards of the spot where Cambridge Street joins Broad Street, there were upwards of five hundred fatal attacks of cholera in ten days,” wrote Snow, in the investigative report he wrote up at the time.⁶ Later, he discovered that the mother of a girl afflicted with cholera had dumped her daughter’s waste bucket into a leaking cesspool, only three feet from the Broad Street well – a major source of city drinking water. He believed that those drinking from the Broad Street well were inadvertently consuming

⁵ Edward S. Philbrick, *American Sanitary Engineering* (New York: Sanitary Engineer, 1881), pp 2-3. <http://books.google.com/>

⁶ John Snow, M.D., *On the Mode of Communication of Cholera* (London: John Churchill, 1855), p. 38. http://www.ph.ucla.edu/wpi/snow/snowbook_a2.html

microscopic bits of human waste (Dr. Snow didn't know about bacteria yet) that was causing the cholera that would ultimately lead them to their deaths. Dr. Snow removed the pump handle from the Broad Street well, cutting off people's access to its water, and new cholera cases, he believed, began to decline.⁷ Experts today debate whether removing the pump handle actually stopped the epidemic or whether it was already declining when Dr. Snow acted.

Investigating such epidemics as the cholera epidemic in London in 1854, scientists began seeing the connection between infectious disease and human waste. The contagion theory of disease (originally proposed by Agostino Bassi in 1844) was gaining ground in medicine. Edward Jenner, an early pioneer of bacterial anatomy, was one of the first to question the theory that diseases were spread through contaminated air (called "miasma") instead of through contact with bacteria-filled substances.⁸ Gradually by the late 1800s, medical scientists and health inspectors came to believe that there had to be dramatic separation between human waste and drinking water.

In the late 19th century, two technological innovations occurred that dramatically improved the science of sanitation: the development of the modern toilet or water closet, and closed sewer systems, made up of large buried pipes, to carry waste away from cities. The toilet was the easy part. Functioning toilets had been around since the 16th century. A British nobleman named John Harrington built what he called a "privy of perfection" for his godmother, Queen Elizabeth I, in 1596.⁹ The fixture, imperfect but functioning, flushed waste away, but

⁷ E.W. Gilbert, "Pioneer Maps of Health and Disease in England, *Geographical Journal*, 124 (1958), 172-183. Cited by the Public Health Institute, "Broad Street Cholera Detective," online at: http://www.phi.org/public_health_101/case_study.html

⁸ Cf. "Edward Jenner and the History of Vaccination," <http://www.sc.edu/library/spcoll/nathist/jenner.html>.

⁹ Cf. "The 'Flush Toilet, a Tribute to Ingenuity,'" http://masterplumbers.com/pulmbvierws/1999/toilet_tribune2.aso

lacked venting to remove noxious fumes. Nearly two centuries later, around 1775, a watchmaker and innovator named Alexander Cummings constructed an effective flushing water closet based on Harrington's toilet and other mediocre plumbing devices. In 1829, a 26-year-old architect named Isaiah Rogers took the principles of Cummings' invention and developed his own toilet. Rogers' innovation could carry the dirty water away and pump out its contents. But it also added vents through the roof to carry out sewer gas, an essential innovation. Rogers installed his indoor plumbing invention in the Tremont Hotel in Boston, which boasted the first hotel bathrooms in history. "Water was drawn from a metal storage tank set on top of the roof, the recently-invented steam pump raising the water on high," according to an article in the technical journal *Plumbing and Mechanical*. "A simple water carriage system removed the excretal water to the sewerage system. As with other individual buildings of the time, each had its own source of water and removal."¹⁰

By the 1890s, government leaders realized that the only way to ensure clean drinking water and sanitary conditions was through the creation of massive, city-wide sewer projects that ripped up entire cities. By then, engineers had learned how to channel dirty water through pipes and vent the air properly. They also learned how to filter, screen and eventually treat sewage before it was merely dumped into nearby lakes, rivers or the sea. "Disposal by dilution has retained greater favor in the United States than in England because of the larger bodies of water available for receiving the sewage," wrote two civil engineers in 1916.¹¹ "Dilution is now under fire, however, from some health officers and their engineers, who oppose the discharge of merely screened and settled sewage into rivers or lakes furnishing water for potable purposes."

¹⁰ "The History of Plumbing in America," reprinted from *Plumbing and Mechanical Magazine*, July 1987. Cf. <http://www.theplumber.com/usa.html>

¹¹ Leonard Metcalf and Harrison P. Eddy, *American Sewerage Practice* (New York: McGraw-Hill Company, 1916), p. 30.

Few people could have imagined that indoor plumbing and sewer systems would have such a dramatic impact on both the quality of life and human longevity. “The effects of sanitary improvement have been already manifested to an extent greater than could have been anticipated,” noted American civil engineer George E. Waring, Jr., in his 1867 book, *Draining for Profit and Draining for Health*.¹² When London installed closed sewers and abolished cesspools between 1848 and 1854, for example, the death rate overall went from 23 deaths per 1,000 people to 7 – a 70% decrease in just a decade. Similar dramatic results were seen in Paris and Berlin.¹³ “Half the problems of unsanitary water have been solved in a single generation,” said Nobel laureate and physician Dr. George Whipple in 1911, in the book *Technology and Industrial Efficiency*, speaking of North America. “10 million people in cities now have a clean and safe water supply which has thereby increased their comfort and health.” Experts in the early 1900s estimated that public sanitation systems saved thousands, perhaps millions of lives by preventing the spread of infectious diseases. For example, according to Whipple, the death rate in 1860 from typhoid fever was 50 per 1,000 people. Thanks to clean drinking water, Whipple asserted, the death rate had been cut by more than in half, to about 20 per 1,000 people.¹⁴

While public health researchers agree that sanitation innovations had a huge impact on reducing infectious diseases, some contend that improved nutrition and better housing for the

¹² George E. Waring, Jr., “House Drainage and Town Sewerage in Their Relations to the Public Health,” *Draining for Profit and Draining for Health* (New York: Orange Judd & Co, 1867, p. 222.

¹³ Waring, p. 222.

¹⁴ George C. Whipple, “Present Status of Water Purification in the United States and the Part That the Massachusetts Institute of Technology Has Played,” *Technology and Industrial Efficiency* (New York: McGraw-Hill Book Company, 1911), pp. 399-405. Available online at <http://books.google.com>.

working poor were equally, if not more, important, in promoting better health and greater longevity. “Although the sanitary movement of the nineteenth century and the development of bacteriology substantially lowered death rates from enteric diseases, other serious health problems still existed,” asserts medical historian Warren Winkelstein, Jr. “One was the appalling and ubiquitous rate of infant mortality.”¹⁵ Some experts believe that sanitation innovations are given too much credit for increasing health and quality of life. Carl Schramm, author of *Good Capitalism, Bad Capitalism*, writing in the *Stanford Social Innovation Review*, argues that it was not sanitation innovations alone but also the availability of increased quantities of nutritional food that led people to a healthier, longer life. “The falling costs and increasing quality of food, clothing, and shelter made Americans healthier and more resistant to diseases,” concludes Schramm.¹⁶ However, as important as improved early child care, antibiotics, and better food and housing were in improving living conditions, none of these advances alone could have made much of a difference if epidemic disease had not been suppressed through sanitation innovations.

“In the Middle Ages, the average human life expectancy did not reach into the teen years, not only because of the extremely high mortality that heavily skewed the data, but also because Europeans, and much of the world during this time, lived in an unhealthy milieu of filth, poor hygiene and nearly non-existent sanitation,” notes medical historian Miguel A. Faria, Jr., M.D., adding that “hygiene and sanitation have resulted in unprecedented longevity.”¹⁷ Due to significant innovations in public sanitation and similar advances in medical hygiene, the Centers

¹⁵ Warren Winkelstein, Jr. “History of Public Health,” *The Encyclopedia of Public Health*, <http://enotes.com/public-health-encyclopedia/history-public-health.html>

¹⁶ Carl Schramm, “All Entrepreneurship is Social,” *Stanford Social Innovation Review*, Spring 2010. http://www.ssireview.org/articles/entry/all_entrepreneurship_is_social/

¹⁷ Miguel A. Faria, Jr., M.D., “Medical History: Hygiene and Sanitation,” <http://haciendapub.com/faria5.html>.

for Disease Control and Prevention estimate that the average life expectancy for Americans has increased by about 30 years since 1900.¹⁸

There is no doubt that many technological and medical advances in the late 19th and early 20th centuries had major impacts on improving human health. However, the proof that public sewers and indoor plumbing played a critical role in promoting human survival can be seen today in recent events. For example, the recent devastating earthquake in Haiti demonstrated what life would be like without modern sewage systems and clean drinking water. The major problem facing rescue workers in Haiti was the destruction of the island nation's sewer system, the contamination of drinking water and the subsequent spread of bacteria and disease.¹⁹ Matters are even worse in India, where more than 638 million people lack basic sanitary necessities such as clean water and good hygiene. "We go to the toilet on the street," a young Indian resident from the city Kolkata told the *Los Angeles Times* in March 2010. "I know other people have to walk in it, but you don't have much choice if you have to go."²⁰ According to a 2010 report by the United Nations Children's Fund and the World Health Organization, 39% of the world population, more than 2.6 billion people, still live without basic sanitation facilities and an estimated 1.5 million children under age five die each year from diseases linked to unsanitary living conditions.²¹

¹⁸ Center for Disease Control and Prevention, "Ten Great Public Health Achievements—United States, 1900–1999," *Morbidity and Mortality Weekly Report* 48 (1999): 241–243. <http://www.cdc.gov/mmwr/preview/mmwrhtml/00056796.htm>

¹⁹ Simon Romero, "Poor Sanitation in Camps Adds Disease Risk," *New York Times*, February 20, 2010, p. A-4. <http://www.nytimes.com/2010/02/20/world/americas/20haiti.html>

²⁰ Mark Magnier, "India Lags Behind in Sanitation Facilities," *Los Angeles Times*, March 22, 2010. <http://articles.latimes.com/2010/mar/22/world/la-fg-india-toilets22-2010mar22>

²¹ WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, *Progress on Sanitation and Drinking-Water: 2010 Update*. : <http://www.unicef.org/media/files/JMP-2010Final.pdf>

The problem of where and how we dispose of human waste remains a controversial issue even in the United States. In March 2010, Orange and Los Angeles Counties filed a lawsuit over the recent decision by Kern County voters no longer to accept truckloads of sewage sludge from these southern counties being spread on their fields. According to a report in the *Orange County Register*, the city of Los Angeles alone dumps over 450,000 tons of “biosolids” in Kern County’s fields and meadows annually.²² “The way folks in Kern County look at it, the city slickers are using their county as a giant toilet – and they don’t like it one bit,” wrote Gordon Dillow in the *Orange County Register*.²³ The problem of getting rid of sewage sludge safely is growing nationwide and will remain an issue well into the future. Scientists are currently researching innovative new ways to recycle biosolids or even utilize them in new green energy production.²⁴

In the end, modern sanitation systems may not be perfect, as the controversy over sludge disposal shows, but this innovation has succeeded in nearly doubling the life expectancy of the average person, creating a better, easier environment to live in, and preventing the spreading of many contagious diseases. It is hard to even comprehend, at times, how far scientists and innovators have come and how much they have accomplished. The protection and purification of drinking water, and the elimination of disease-carrying human waste, have improved the quality of life for billions of people worldwide. Though at times, we may take certain things for granted, it is our duty as Americans to truly appreciate the innovations in sanitation that have dramatically changed the course of our world. Our next goal should be to bring these life-saving

²² Pat Brennan, “Will Supreme Court rule on O.C. sewage?” *Orange County Register*, March 18, 2010. Text available online at: http://m.ocregister.com/ocregister/db_13109/contentdetail.htm;jsessionid=384744CBFE175A60120C30A201A378E0?contentguid=qvHfi9JP&detailindex=1&pn=0&ps=3&full=true

²³ Gordon Dillow, “OC Needs to Find a New Place for Waste,” *Orange County Register*, January 4, 2006. <http://www.ocregister.com/news/county-193021-sewage-kern.html>

²⁴ Brandon Rittiman, “UNR Researchers Turn Sludge Into Fuel,” KTVN-TV Reno. <http://www.ktvn.com/Global/story.asp?S=12167534>

sanitation innovations to the suffering people in poor countries worldwide.

Annotated Bibliography

Primary Sources

Books

Gavin, Hector, M.D. *Sanitary Ramblings, Being Sketches and Illustrations of Bethnal Green*. London: John Churchill, Princes Street, 1848. Full text available online at: <http://victorianlondon.org> and also at <http://books.google.com>.

I found this source late in my research and it was precisely what my paper is about. Dr. Hector Gavin provided a detailed, house-by-house survey of every cesspit and privy in a parish of East London known as Bethnal Green. He was revolted by what he found – rotting mounds of putrefying human waste, cesspits overflowing from decades of misuse, rotting floorboards that led to people drowning in seas of excrement. His expose shocked governmental officials into action and led to a great national campaign in England to create public sanitation projects .

Metcalf, Leonard, and Eddy Prescott Harrison. *American Sewerage Practice*. New York: McGraw-Hill Book Company, Inc, 1914-1915. Found online at: <http://books.google.com/>.

This book provided me with many accounts of the specific installation methods of 19th and 20th century indoor plumbing fixtures. I learned that toilets were not the most important factor in channeling away waste. Showers, sinks, and drinking fountains were just as important when it came to separating waste from the public's water supply. This book helped me formulate the main idea of my thesis by giving me a bigger picture of all the separate parts involved with designing good sanitation.

Philbrick, Edward S. *American Sanitary Engineering*. New York: Sanitary Engineer, 1881. Found online at: <http://books.google.com/>.

Not only did this amazing book provide me with a better understanding of the problems that existed without sanitation, but it showed me in great detail how the sewage systems worked and how they were operated. The book was full of different individuals' accounts of living in close contact with their own filth and refuse. This book provided me with a better idea of how disgusting and revolting life can be when sanitary precautions are not made. From this book, I was able to glean many primary quotes on my topic, and much information on the construction of sewage systems.

Snow, John. *On the Mode of Communication of Cholera*. London: John Churchill, 1855.

http://www.ph.ucla.edu/wpi/snow/snowbook_a2.html.

I found this original report online after much searching. It is Dr. Snow's own account of how he tracked down the source of the great cholera epidemic of 1854. His research helped prove the contagion theory of disease and he is considered the virtual father of public health.

Waring Jr., George E. "Chapter XI: House Drainage and Town Sewerage in Their Relations to the Public Health." In *Draining for Profit and Draining for Wealth*, 222-239. New York: Orange Judd & Co., 1867.

This book provided me with very detailed information about the decline in death rates in London that resulted from building sewer lines and banning cesspools. I was able to see the conditions in which people lived every day. After scanning through this book, I had a better idea of the scope of my project and knew what direction I wanted to take.

Waring Jr., George E. *House Drainage and Town Sewerage in Relation to the Public Health*. New York: Orange Judd & Co 1867. <http://books.google.com/>.

In this book, I was provided with much information about the various health problems caused by improper sanitary precautions. I was able to see how damaging exposure to sewage pollution actually is, and how it inflicts life threatening diseases upon people. This book helped me gain primary quotes from the actual people affected by the terrible pollution in their communities.

Waring Jr., George E. *Village Sanitary Work*. New York: Scribner's Monthly, 1877. <http://books.google.com/>.

Unsurprisingly, the residents of towns affected by the pollution did not want to wait for their towns to be cleaned up. This book shows what the people of New York did to keep their city clean. I was able to see what the alternatives were for keeping the cities clean and free of sewage waste.

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. *Progress on Sanitation and Drinking-Water: 2010 Update*. <http://www.unicef.org/media/files/JMP-2010Final.pdf>.

This is the official World Health Organization report on the state of sanitation and clear water supplies worldwide. It provides shocking statistics about the dangerously filthy living conditions in poor countries, revealing how much public sanitation work is still unfinished.

Newspaper Articles

Author unknown. "The Sewers and Sewage Farms of Berlin." *Engineering News and American*

Railway Journal. Vol. XXXVI, No. 9. 27 August 1986.

This article described how death rates declined dramatically in Berlin after the city copied the work of engineers in London and Paris and Chicago and built public sewer lines. I used this fantastic source to underscore the decline in death rates after sanitation innovations were implemented.

Brennan, Pat. "Will Supreme Court Rule on O.C. Sewage?" *The Orange County Register*. 18 March 2010.

From this article I learned about the current controversy over Orange and Los Angeles Counties dumping treated sewage, or "sludge," on fields in Kern County. I used this article to learn more about the issues that still need to be resolved regarding today's current sewage disposal methods.

Carlton, Kenneth M. "Typhoid." *Time*. 11 February 1924.

Mainly, I was able to view many charts and death polls in this article. It showed how many people died each year from typhoid fever, which was spread through human waste that infected citizens' food and water supplies.

Crawford, David T. "Build Small Cities Says Ambassador." *New York Times*. 7 December 1912.

This article showed yet another reason for pollution in big cities: overcrowding. Many did not realize that one of the main reasons for the vast amount of waste was the large amount of people crowded together. No one realized that much of the problem could be solved if cities were more spread out. I was able to glean direct quotes from this article and add another element into my project.

Darlington, Alexis. "Will Sue to Stop Pollution." *New York Times*. 18 May 1907.

Before reading this article, I had no idea what the public thought back then about the pollution problems. Now I know. This article showed me just how angry the citizens were about water pollution in their city and what they were willing to do to stop it. I was able to get a more detailed view on the conditions of the 19th and 20th century American cities and towns and how disgusting they were.

Dawson, Charles. "National Affairs: Indians Sick." *Time*. 5 October 1926.

This article described the symptoms of a highly contagious eye-disease that Native American Indians in the Midwest were catching through pollution problems in the water supply. This article provided more background information on the connection between contaminated water and disease.

Denner, Mathew H. "River Pollution Goes On." *New York Times*. 4 August 1910.

In this article, I specifically learned how industrial mills and factories poured their waste into rivers and polluted them. This article shows the ignorance of city officials at the time about the severity of the pollution and what was causing it. This article also described how waste being dumped into rivers, lakes and streams entered the water supply.

Johnson, Samuel F. "Medicine: Rockefeller Report." *Time*. 2 Aug. 1926.

This article shows more terrible afflictions that originate from water pollution. "Last year, the Rockefeller International Health Board aided health enterprises in 97 countries that demanded the destruction of hookworms. Hookworm eradication is proven a simple problem of rural sanitation."

Kendall, Arthur I. "Medicine: Good Germs" *Time*. 15 Oct 1923.

This newspaper article provided me with an interesting counter-argument to my thesis. It presented a skeptical viewpoint about whether sanitation innovations actually prevent disease or interfere with natural human immune responses. This article helped me question and ultimately strengthen my presentation. Though I was surprised by the point the writer was trying to make, his argument helped advance my understanding of my topic to a higher level.

Personal Communications

Luis, Steve. Email communication. 11 May 2010.

Mr. Luis is an environmental consultant with a graduate degree in sanitary engineering from the University of California, San Diego. He read a draft of my paper and encouraged me to consider the broader social, political and economic forces in the 19th century that impacted sanitary conditions. He stressed the huge impact urbanization, industrialization and the advent of the factory system had on creating the overcrowded, unsanitary conditions in the big cities. Mr. Luis also suggested that Dr. John Snow's use of statistics -- collecting exact data and "mapping" the victims of an infectious outbreak - was an even bigger contribution than the pump handle/cholera connection itself.

Personal Investigation

Personal Visit to Rome and Pompeii, April 1-10, 2010

During a spring break visit to Rome, Italy, I observed the sloped streets, drains and gutters that channeled waste away from buildings and toward the mucky Tiber River. In the ruins of the Roman Forum, I drank from a still-functioning ancient water fountain. On a visit south to Pompeii, I saw the lead pipes, marble latrines and tiled baths that the ancient Romans used for indoor plumbing. These images stuck with me as I researched the disgusting sewers and cesspools of Victorian times.

Secondary Sources

Books

Cosgrove, J.J. *History of Sanitation*. Pittsburgh: Standard Sanitary Mfg. Co, 1909. <http://books.google.com/>.

In this book, I read about the actual history of sanitation and its origins. I learned about the Roman and Greek civilizations that adopted primitive forms of plumbing for their cities. This book provided me with the basic facts about plumbing, and sewage systems in general. I debated whether to place this source into the primary section of my bibliography, or the secondary section because though it had secondary content on the Greeks and Romans, it contained very detailed primary information about the sanitary issues in the 1900s.

Lockard, Darrel. *The History of Filtration Part III*, Princeton: Princeton Press, 7 July 1996.

This book provided me with a good summary of the inventors and innovators of indoor plumbing. I learned about where the idea of plumbing and sanitation systems came from, and how they worked back then. I also learned about the evolution of the idea over the years. This book helped reinforce my knowledge of the topic in more ways than one.

Whipple, George C. "Present Status of Water Purification in the United States and the Part That the Massachusetts Institute of Technology Has Played." *Technology and Industrial Efficiency*. New York: McGraw-Hill Book Company, 1911, pp. 399-405. Available online at <http://books.google.com>.

This collection of scholarly scientific articles, prepared for a scientific congress in Boston in 1911, is full of details about the state of public sanitation in the early years of the 20th century. I found it online at Google Books. One article in particular, by George Whipple, was about the problem of heavily polluted water in large cities and what had to be done about it. This was one of the first sources I consulted when I first began my research. It led me to other primary sources.

Newspapers and Magazines

Brennan, Pat. "Will Supreme Court rule on O.C. sewage?" *Orange County Register*. 18 March 2010. http://m.ocregister.com/ocregister/db_13109/

This newspaper article was a last-minute discovery right before I was finishing my paper. It was about a current lawsuit filed by Orange and Los Angeles Counties, in California, to stop Kern County from no longer accepting treated "biosolids" or sludge. It showed me that the problem of getting rid of human waste hasn't been completely solved even today.

Dillow, Gordon. "OC Needs to Find a New Place for Waste." *Orange County Register*. 4 January 2006. <http://www.ocregister.com/news/county-193021-sewage-kern.html>

When I was putting the finishing touches on my paper, I discovered this article about the contemporary problems of disposing of vast quantities of human waste or “sludge.”

Faria, Jr., Miguel A.. “Medical History – Hygiene and Sanitation.” *Medical Sentinel* 2002, 7(4): 122-123. <http://www.haciendapub.com/faria5.html>.

Similar to the *Morbidity and Mortality Weekly Report* 48, I was able to glean information here that dealt with the longevity of the average person after basic sanitation and plumbing systems had been implemented.

Gilbert, E.W. “Pioneer Maps of Health and Disease in England.” *Geographical Journal*, 124 (1958): 172-183. Cited by the Public Health Institute, “Broad Street Cholera Detective,” online at: http://www.phi.org/public_health_101/case_study.html.

This website provided me with a great overview of the cholera epidemic in London and how Dr. John Snow solved the riddle of where the disease had come from and how it was spreading like wildfire in the neighborhood of the Broad Street well.

Magnier, Mark. “India Lags Behind in Sanitation Facilities.” *Los Angeles Times*. 22 March 22 2010. <http://articles.latimes.com/2010/mar/22/world/la-fg-india-toilets22-2010mar22>

This article, which I discovered right when I was finishing a draft of my paper for the state finals, illustrated how the problem of sanitation and clean drinking water is still very real today – and afflicts literally billions of people worldwide.

Rittiman, Brandon. “UNR Researchers Turn Sludge Into Fuel,” KTVN-TV Reno. <http://www.ktvn.com/Global/story.asp?S=12167534>

Like the newspaper articles by Dillow and Brennan, this written report on the website of KTVN-TV concerned the current problem of disposing of ever-growing quantities of treated human waste known as “sludge.” This article discussed innovative new ways scientists are tackling the problem – such as using sludge to produce energy.

Schramm, Carl. “All Entrepreneurship is Social.” *Stanford Social Innovation Review* Spring, 2010. http://www.ssireview.org/articles/entry/all_entrepreneurship_is_social/.

This journal article provided me with a discussion of other innovations and advances that happened during the 19th and 20th centuries that have been linked to the increased life expectancy.

Websites

BBC News. “Sanitation Best Medical Advance.” <http://news.bbc.co.uk/2/hi/6275001.stm>.

This article was foundational to picking a topic for my project. It mentioned how indoor plumbing was one of the top medical advances that saved (and still does) millions worldwide. After reading this, I knew I had found a topic for my project.

Centers for Disease Control and Prevention. "Ten Great Public Health Achievements—United States, 1900–1999." *Morbidity and Mortality Weekly Report* 48 (1999): 241–243. Link: <http://www.cdc.gov/mmwr/preview/mmwrhtml/00056796.htm>.

From this source, I was able to extract quality data and statistics about longevity -- how long Americans lived after sanitation innovations were put into use, compared to how long people from other countries lived. I was able to find the overall rate and average life increase thanks to this extremely helpful source.

“Edward Jenner and the History of Vaccination.” University of South Carolina Library Website. 10 March 2010. <http://www.sc.edu/library/spcoll/nathist/jenner.html>.

This article gave me an understanding of the development of the germ theory of disease and how radically this discovery influenced the practice of medicine, as well as promoting public health and sanitation efforts.

Rittiman, Brandon. “UNR Researchers Turn Sludge Into Fuel.” KTVN Channel 2 News 25 March. 2010. <http://www.ktvn.com/Global/story.asp?S=12167534>.

This was an interesting article about how researchers at the University of Nevada are trying to figure out how to make electricity out of sewer sludge.

Winkelstein, Jr., Warren. “History of Public Health.” *The Encyclopedia of Public Health*. <http://enotes.com/public-health-encyclopedia/history-public-health.html>.

Something that I never took into consideration with the number of deaths related to the diseases was that the majority of the victims were newly born babies who lacked immunity to any diseases. This section of the *Encyclopedia of Public Health* helped my project considerably.

“The History of Plumbing in America.” The Plumber.com- Home of great plumbing advice since 1994. 3 March 2010. <http://theplumber.com/usa.html>.

Through this website, I mastered the basics of my topic, and learned how sanitary systems came to be in America and how they were more appreciated. This website showed primitive toilet systems and where they came from, and who created them. All of the basic facts that I needed for my project were on this website.

“Tracking Down the Roots of Our Sanitary Sewers.” <http://swerhistory.org>.

This website provided a complete timeline of plumbing and sewer history from the Ancient Roman baths to the 1990s. This article provided gritty details about how

disgusting and dangerous the open sewers, chamber pots--often stored in the dining room cabinetry – and cesspools under the houses were!

“The ‘Flush Toilet, a Tribute to Ingenuity.’”

http://masterplumbers.com/pulmbvierws/1999/toilet_tribune2.aso.

Even though my project is focused more on the devices that channel waste away from the food and water supply, and from the general public, I still felt that the information about the flush toilet was important because I was able to show the gradual development of sanitation technology over the years, and demonstrate that, despite what most people assume, the toilet is not actually the most important sanitation innovation.