

THE EVOLUTION OF SEWAGE TREATMENT

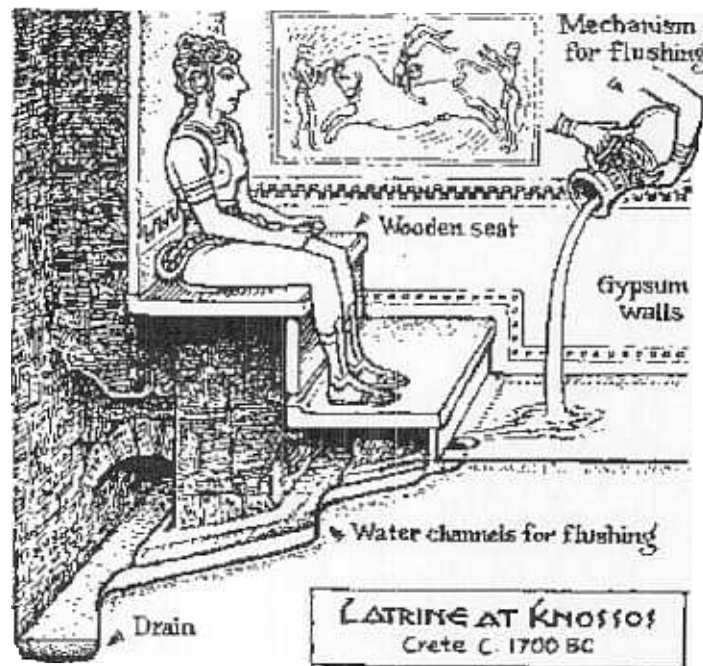
As societies moved from nomadic cultures to building more permanent sites, the concern over waste (solid and wastewater) disposal became an important concern. As we will see it has been an issue that has been dealt with many different ways and knowledge has been lost and regained. When groups were living as hunters and gathers, the natural decomposition dealt with refuse and human wastes naturally. As cities developed other mechanisms were necessary to address waste issues. What we must understand “until recently, wastewater sanitation focused on minimizing health risks, primarily infections diseases. More recently, the scope of wastewater management issues has broadened to include chronic health risks and environmental concerns.

DOMESTIC WASTEWATER TREATMENT IN THE ANCIENT WORLD, 3500 B.C.E TO 500 C. E.

During the Neolithic period (c. 10,000 B.C.E.) movement by nomadic tribes addressed the waste created by human activities. This nomadic movement allowed the earth or the soils treat the waste. In the ancient world cultures or societies developed waste treatment technologies. These varied by the skills the various cultures developed. The City of Ur, by 3500 B.C.E., had an average population of 65,000 people per square mile (a high population density which produced considerable waste). The populace of the city dealt with their waste problem by simply sweeping their wastes into the streets. This caused the street levels to rise and would require, every so often the raising of house doors. These “[p]ractices that were satisfactory in semipermanent small villages were not necessarily suitable in an urban environment”. Nor are these practices acceptable today. We can compare this to cities of the Indus Valley (present day Pakistan) from about 2500 to 1500 B.C.E. Some houses had bathrooms with water flushing toilets. They had well-designed drainage systems. Houses had rubbish chutes, and there were rubbish bins placed around the city for refuse disposal. This was a great leap in waste treatment.

Moving back to the Mediterranean cultures, we see developments in waste treatment technologies. In the Egyptian city of Herakopolis (B.C.E. 2100), the average person treated their wastes much like those in Ur, they threw the wastes into the streets. However, “in the elite and religious quarters, there was a deliberate effort made to remove all wastes, organic and inorganic to locations outside the living and/or communal areas, which usually meant the rivers.” There is also religious teachings that dealt with waste. Mosaic law (B.C.E. 1300) tells “to remove his own refuse and bury it in the earth.” Nehemiah tells of rebuilding Jerusalem where there was a refuse gate where the city wastes were to be dumped. And the Talmud called for the streets of Jerusalem to be washed daily.

The Minoan Culture on the Island of Crete between 1500-1700 B.C.E. had a highly developed waste management system. They had very advanced plumbing and designed places to dispose of organic wastes. Knossos, the capital city, had a central courtyard with baths that were filled and emptied using terra-cotta pipes. This piping system is similar to techniques used today. They had flushing toilets, with wooden seats and an overhead reservoir. "Excavations reveal four large separate drainage systems that emptied into large sewers built of stone." The Minoan royals were the last group to use flushing toilets until the re-development of that technology in 1596.

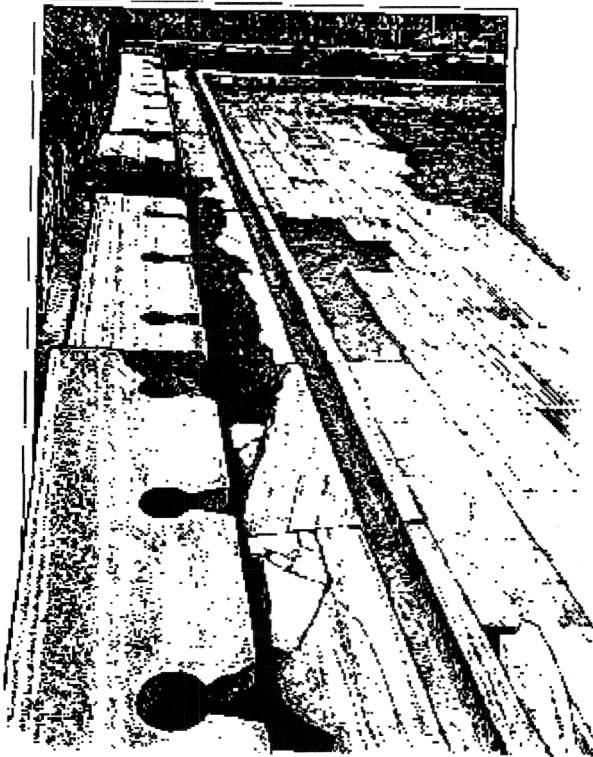


The first dumps were developed by the Greeks (Athens) circa 500 B.C.E. In the development of waste management, Athens, in 320 B.C.E., passed the first known edict banning the disposal of refuse in the streets. In the continued development of waste management, by 300 B.C.E., one of the responsibilities of the Greek city-state was the removal of waste. "The expenses [for waste removal were] covered by levees on landowners. This system was sufficiently viable to last for eight hundred years, until the general breakdown of civic order. In the use of water the early Greeks understood the relationship between water quality and general public health. This concern was passed onto the Romans.

The Romans' waste treatment management practices were the most developed of any civilization prior to the nineteenth century. In fact, the Romans' waste management systems were better than those in the middle ages. The Romans were very advanced technologically. We see the evidence of this in their buildings, roads, and aqueducts that are still

standing and in some cases still in use. The Romans' concern for water is best illustrated in their aqueducts. They developed them to provide water to their cities. The water was used for baths, fountains, public conveniences, and for flushing sewers. The Romans were concerned with locating good water supplies, and they were concerned with obtaining pure water, as stressed by ancient physicians and engineers.

The early Roman Republic was concerned with the extension of the city's water supply, as well as the construction of aqueducts. In fact by 125 B.C.E., the city's water supply had been doubled to meet the rapid expansion. The development of these aqueducts required engineering skills. What we must understand, is the aqueduct systems developed by the Romans were vast. In every part of their Empire they built aqueducts, and the majority of the systems were underground. What we see today is just the tip of the iceberg. As we have seen the Romans put the water to many uses. Particularly in Rome, they used the water to flush their sewers. The Romans employed water-carrying devices to send most of their wastes to nearby the River Tiber via open sewers as early as the 6th century B.C.[E.]. By the 3rd Century, the sewers in Rome were vaulted underground networks called the *Cloaca Mixima*. These building projects continued and by the 4th Century [C.E.], Rome had 11 public baths over 1300 public fountains, and 856 private baths. Not only were there private water-flushed toilets, there were public ones. In [C.E.], 315 Rome had 144 public water-flushed toilets.



Ruins of Roman Public Toilets.

Even with all these advances and waste management, Rome was still an unhealthy city. Disposal of the sewage to the Tiber River and dumping wastes outside the city still caused health concerns. The fall of Rome, in the fifth century C.E., brought an end to plumbing development. In fact with the fall of the [Roman] Empire the lack of central authority and consequently of adequate public funds led to the decline of all public services. Their organization was left to private citizens or to municipal authorities. Only in certain large urban centers did even remnants of Roman systems survive.

DOMESTIC WASTEWATER TREATMENT IN THE MIDDLE AGES, 500 C.E. TO 1500 C.E.

The fall of the Roman Empire in the west turned an urban society into a rural one. By 500 [C.E.], the taps were being turned off all over Europe; they would not be turned on again for nearly a thousand years: Sanitation technology entered its dark ages. There was massive depopulation of Rome and most of the western Empire. The deurbanization of the west changed waste treatment. The reduced population density, therefore, rendered traditional methods of waste disposal (tossing it out of the house) more viable. Also, without monitoring the sewers and streets, hygienic conditions fell below the Imperial Roman Standards. This demise in sanitation brought back the outhouse, open trenches, and the chamber pot ... at all levels of society.

This loss of knowledge and hygienic practice brought many problems. During the middle ages, the ages-old practice of separating drinking water and human wastes was largely abandoned, and human wastes could easily migrate from waste pits into wells. Epidemics raged in the cities, but the relationship between excrement and disease was not recognized. In the middle ages people simply threw their waste into the streets. Open gutters in the middle of the streets carried refuse, while rain-water pouring from the roofs was not properly drained. The streets, seldom paved, were often mud-pools from which the excreta of pigs and other animals leaked into wells and private plots. The habits of rural life, which might be harmless on the farm, could and did prove to be fatal in the growing towns of Medieval Europe. Over time in the Medieval era, cities began to grow. The size of the city was determined by the walls; this increased the population density, and with people still practicing their rural habits, the potential for disease developed. In this period the rivers of the two major European cities, London and Paris, were open sewers.

The sanitary conditions in medieval cities lead to rampant disease and death during the middle ages. The waste and excrement provided food for

the rats, thus bringing disease-carrying ticks and fleas into human contact. Diseases directly related to human wastes wiped out many hundreds of thousands of people in the Middle Ages. This included dysentery, typhus (which comes from bad sanitation and is highly contagious), and typhoid fever (from human feces and urine. The conditions in medieval towns and cities as urbanization developed were very poor. The Greek and Roman concern with safe water was lost in this period. The technology to secure safe water was also lost.

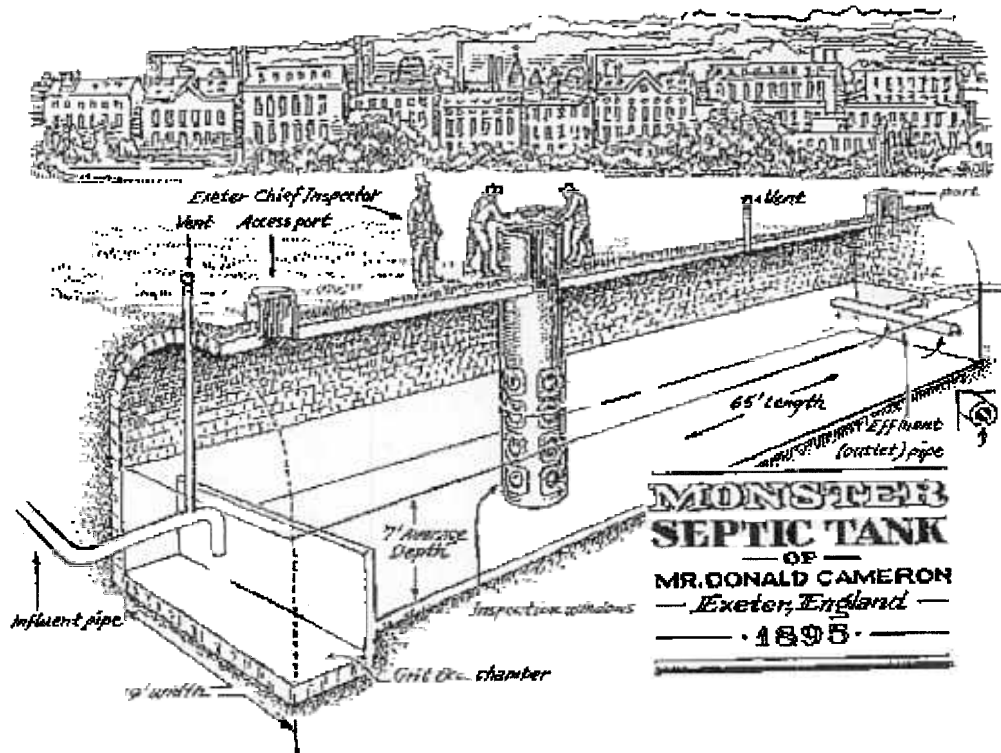
As the middle ages went on, changes did occur. Most of the water changes in water issues were spear-headed by religious orders. Near Milan, the Cistercians introduced the use of city refuse and sewer water as fertilizers on their land about 1150 C.E. Even during the unwashed period, many abbeys in Britain had piped water before 1200 [C.E.]. The Christchurch Monastery at Canterbury, for example, had running water, purifying tanks, and wastewater drainage from toilets, and the monastery was spared from the Black Plague in 1349.

By the end of the 12th and the beginning of the 13th centuries, changes began to take place. Following the major plagues of the 12th century, waste management became a priority. In 1372 Edward the Third of England proclaimed that “throwing rushes, dung, refuse and other filth and harmful things into the [Thames] shall no longer be allowed”. Following this line, in 1388 an act of Parliament “forbade the throwing of filth and garbage into ditches, rivers, and water” And by the late 14th century London had an organized scavenger system (people would go around and pick up dead animals); yet ultimately, legislation and scavenging tended to be relatively ineffective. This was not, however, because of ignorance but rather because offenders and offended alike were unable to devise adequate alternatives to the available methods of collection and disposal. Moreover, except for those in heavily polluted areas, popular opinion was very much against such measures. During the Renaissance more concern was given to health and water issues. The cesspool was one of the technical developments of the Renaissance. It is a simple pit which allowed solids to settle and the liquid to seep into the ground. Periodically, the cesspools would have to be cleaned out. As the 15th century came to a close, there were other management changes that impacted sanitation. Henry the VI (England) established a Commission of Sewers, which “provided for severe penalties for the pollution of streams and made special provisions for the disposal of tanner and brewers wastes.” Henry the VII outlawed slaughterhouses in cities or towns, because of the danger of disease for the people. There was a new awareness of the role that human and animal wastes played on human health by the end of the 15th century.

DOMESTIC WASTEWATER TREATMENT IN THE MODERN WORLD, C.E. 1500 TO C.E. 1900

In the early modern period there was still little change in the understanding and disposal of human wastes. Wastes were still disposed of in rivers, and water sources were being contaminated. These practices were brought to the New World. As developments grew to cities, the Colonies had to address waste issues. In 1644 eighteen years after taking control of Manhattan Island, “residents were directed to take all wastes out of the fort,” and in 1648 a law was passed prohibiting hogs and goats from running in the streets. The major changes in waste treatment came in the 19th century.

In 1860 Louis Moureas invented the septic tank; however, it would not be given this name until 1895. Septic tanks at this stage were large and were used to treat sewage from communities. “The main purpose of these tanks was to remove gross solids before discharge into the nearest stream or river.” Here we see an understanding of removing the solids, a potential problem for public health. Nevertheless, a problem remained: “effluent was largely untreated and caused pollution of streams and rivers”. The pollution of water was not solved by a septic tank. Even with pre-treatment, the need for disposal technology was becoming evident.



Edward Frankland, in 1868, developed trickling sand filter technology. He devised a system consisting of six-foot high, ten-inch wide cylinders, filling each with different medias like sand and soil. He then ran sewage at

different doses through the different tanks. He calculated the capabilities of the different media in purifying the wastewater. Unfortunately, little data is available to report on at this time. The Experimental Station at Lawrence, Massachusetts, created in 1887, by the Massachusetts State Board of Health worked on disposal issues. At the station in 1893, a sand bed was first used to filter the effluent from a septic tank, reducing the land areas needed for sewage disposal. The land acceptance rates were established to maintain an efficiently-working sand-filter.

What was driving these changes? Disease -- it pushed plumbing and disposal development. The scourge of the 19th century was cholera. The urbanization of cities and the industrial revolution also increasing city populations lead to increased human waste. In the mid-19th century a world-wide epidemic of cholera occurred. Cholera was worse in the poor areas, but even the wealthy were not immune. The relationship of cholera to water was discovered by the English physician John Snow. He traced this disease from its origins in India and the path it took to Europe. Snow traced the contamination to public wells, that were being contaminated by privy vaults in the epidemic of 1854 in London. Thus, the sewer was developed. The British engineers led the way in sewer construction and separation of wastes from drinking water. But this only took the issue of sanitation to the river. The pollution of the rivers, especially the Thames in London, began the call for sewage treatment. The need to solve this health care concern in large cities marked the 19th century as the beginning of municipal socialism.