HYGIENIC CONDITIONS IN ANCIENT ROME AND MODERN LONDON

by

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EDWIN CHADWICK, acting on first principles only, outlined a programme for the improvement in the health of the public in the mid-nineteenth century—he claimed that: 'the primary and most important measures, and at the same time the most practical, and within the recognised province of public administration, are drainage, the removal of all refuse from habitations, streets and roads and the improvement of supplies of water'.[1] How was it that these principles, which were well known in the classical world, or even before, had been so completely lost sight of that they needed restating, as if they were a novel concept, by Chadwick?

The Romans fully appreciated the importance of a plentiful and wholesome supply of water, for domestic purposes, to the health of the community. Vitruvius[2] writing in 27 B.C., says that: 'without water neither the animal frame nor any virtue of food can originate, be maintained or provided. Hence great diligence and industry must be used in seeking and choosing springs to serve the health of man.' For 441 years after the foundation of the city, Rome depended on water from the Tiber for drinking and other domestic purposes. In 312 B.C. Appius Claudius Crassus provided the city with water obtained from springs in the Alban hills and brought to consumers by means of an aqueduct. This move was in line with the teaching of Hippocrates that stagnant water should be refused in favour of spring water from the hills or of rain water. By the first century A.D. water was brought to Rome by means of nine aqueducts and was derived from relatively uncontaminated sources in the country. Vitruvius[3] states that the health of sick persons will improve if they are: 'removed from a pestilent to a healthy place and the water supply is from wholesome fountains. . . . Likewise if the water itself in the spring is limpid and transparent, and if wherever it comes or passes, neither moss nor reeds grow nor is the place defiled by any filth, but maintains a clean appearance, the water is indicated by these signs to be light and wholesome.'[4]

In A.D. 97 Frontinus, after a successful career in the army, was appointed Water Commissioner for Rome, a post which he held till his death in 104. He had been a Provinicial Governor in Britain from A.D. 75 to 78, when he had overcome the Silures in Wales and had constructed the Via Julia over their land. In the time of Augustus there had been appointed a curator of water supply with the rank of Consul, together with two assistants of Senatorial rank, to maintain the water supply. The services of 240 skilled slaves were bequeathed to the city by Augustus: these were increased by a further 460 slaves by Claudius, who was also responsible for creating the post of Procurator aquarum. This official worked with the assistance of a Board, but

Frontinus[5] complains of difficulties he experienced which were 'attributable to dishonesty among the employees of the Catchment Board; my investigations show that they have been diverting water from public conduits for private use. There is also a significant number of landowners tapping the conduits that by-pass their property. As a result, the public supply is brought to a standstill by private citizens just to water their gardens. . . . I found irrigated fields, shops, garrets even, and every house of ill repute in Rome, with fixtures to ensure constant running water.'

Estimates of the amount of water reaching Rome vary: Clifford Allbutt, in his Fitzpatrick lectures[6] stated that the water supply of our largest cities was now, per head, (1909–10) one-tenth of the supply of ancient Rome. Other estimates vary between 100 and 40 gallons per head per day in the third century A.D. It has even been suggested that in the reign of Trajan the supply to the city[7] was equivalent to 332 gallons per head per day. The water was conveyed by the aqueducts in concrete channels,[8] with settling basins (piscina) at intervals to allow deposit to settle out and to act as a balance for excessive quantities. The piscina contained sand and acted, presumably, as a primitive form of sand filter. It was also considered an advantage if the water ran over rocks or small stones on its way to the city. Although the early Roman was not aware of ground pollution, both Vitruvius and Frontinus advised that water supply should be sought out from an upland source where ground pollution would be less of a risk. There were also airshafts (lumina) let into the aqueducts at distances of 240 feet. In the city there were large cemented reservoirs (castella) from which the water was brought by lead pipes to houses and to public fountains, which were the source of supply for many of the inhabitants: at the end of the 3rd century A.D. there were 1,302 fountains in Rome.[9] In addition to the public fountains, bathing establishments were a regular feature of Roman towns, military establishments and inns: the wealthier private citizen in the country also had his own baths. The building of these—and some of the baths which survive today are of enormous size—is again evidence of the general concern that the Roman authorities had with the welfare of the people at large. Celsus[10] and other writers maintained that it was more important to preserve health than it was to depend on the medical practice of the day, be it Greek or Roman. A somewhat cynical point of view, but one which retains its validity. Vitruvius[11] says that: 'if the cisterns [of cement] are double or treble so that they can be changed by percolation, they will make the supply more wholesome. For when the sediment has a place to settle in, the water will be more limpid and will keep a flavour unaccompanied by smell. If not, salt water must be added to purify it.' In provincial cities these pipes were often made either of terra cotta or of wood. Vitruvius[12] stated that water is more wholesome when supplied in earthenware pipes than that from lead pipes. For it seems to be made injurious by lead, because white lead is produced by it; and this is said to be harmful to the human body. It is recorded that in many cities the water was also filtered through porous stones to remove gross impurities. There was apparently a dual supply of water, one for drinking and the other for garden and other industrial use. One source, Marcia, was used wholly for drinking: water from this source was least likely to become turbid after rain. According to Baedeker[13] this water had a greater lime content than most of the other sources—'Rome water' he says 'is strongly impregnated with lime.' This is

confirmed from recent figures which show the Rome water to have a hardness of 32° or 320 mg./L.[14] This being so, it is unlikely that this water would be aggressive to lead, or other metals, and that the consumers would suffer from chronic lead poisoning as has been suggested.

At Carthage,[15] in the reign of Hadrian, an aqueduct, eighty miles long, brought six million gallons per day of water to the city, while a first-century aqueduct, built by Agrippa, a close collaborator of Augustus, supplied water to Nîmes, in France. This is well known by reason of the impressive Pont du Gard which carried the aqueduct over the deep valley of the river Gard.

Some idea of the Roman attention to the suitability of a site for obtaining water for troops can be found in Vegetius *De Re Militari* written in A.D. 375.[16] Here he says that 'an army must not use bad or marshy water: for the drinking of bad water is like poison and causes plagues among those who drink it.' In the same work he says 'if a group stays too long during the summer or autumn in one place, the water becomes corrupt, and because of the corruption drinking is unhealthy, and so malignant disease arises which cannot be changed except by frequent changes of camp.' Both these quotations shew evidence of an acute observation of facts, and would surely conform with the best Chadwickian principles.

Thus it will be seen that the Romans for many centuries were served with an adequate water supply in every sense. This was obtained from uncontaminated sources in rural surroundings. On its passage to the consumer it passed through settling tanks and, often, through some kind of porous filter. The reference to the addition of salt is curious and seems almost to anticipate the use of chlorine as a sterilising agent at the present time. There is nothing much to criticize in the character of this supply, even by the most modern standards.

In Crete,[17] in the second millenium, there is evidence of a piped water supply with sedimentation tanks as well as of main sewers which were connected with the roof drainage to carry off storm water. Shafts into these acted as ventilators, and these were also used for the disposal of household refuse.

Water was supplied to Athens[18] from the hills in the sixth century B.C. and by the fifth century there was an elaborate system in existence whereby water was conveyed in an aqueduct from Mount Olympus, a distance of ten miles, and piped to baths and public fountains. In Greece the aqueducts were often subterranean.

How much the Roman practice of providing a wholesome water supply derived from the then existing practice in Greece is not certain. But it is known that the first hospital in Rome was built as a result of direct contact with Greece. In 293 B.C. there was a serious outbreak of plague in Rome which became so severe and dangerous that the Senate consulted the Sibyline books. From these they received advice to import the cult of Asclepius from Epidaurus: this was done, and a hospital, dedicated to this god, was opened on the Insula Tiberina in 291 B.C.[19]

Turning now to sewage disposal. In Greece[20] there were drainage systems in the cities and many houses had latrines, of a simple type, which were flushed by slop water. There were byelaws which provided for street cleansing and scavenging: how strictly these were enforced however is impossible to tell. In Rome, the Cloaca Maxima, running from the Forum to the Tiber, is said to date from the sixth century

B.C.[21] There were numerous connections to it for storm water and for sewage: and slave labour was available for cleansing it.[22] Both public and private latrines drained into the sewers. The construction of this work is a good example of the Roman political acumen which allowed a certain amount of experimental understanding of the problems involved.[23] Even in the early days of the Republic the Romans were sensible of the danger of marsh land, and the presence of the Cloaca Maxima not only drained the central marsh where the Forum now stands but also lowered the level of the ground water. There were also cesspits, which were emptied at regular intervals and their contents removed from the city and used as manure on the fields. Public latrines, for the poor, had existed since the second century B.C. It is interesting to read that the Hall of the Curia in Pompey's theatre was converted into a public latrine as a sign of dishonour after having been the scene of the assassination of Julius Caesar.[24] Some of these latrines were free, for others a small charge was made. Vespasian was interested in raising money by this means.[25] They often communicated with the sewers and were flushed with water on a 'trough closet' system, and there was often provision for washing the hands after use in a basin fed from an adjoining fountain. A fine example of this has been found at Timgad, in Algeria, where the basin occupies one side of the square public latrine: the other three sides provided twenty-four seats on each side.[26] Similar examples are to be found in other Roman cities in North Africa.[27] In addition to the officials appointed in Rome during the Empire, aediles, for the sanitary supervision of the city, had been appointed since the fifth century B.C. These officials were responsible for the care of the drainage, for the cleansing and paving of the streets—these were well paved with side gutters and raised footpaths as can be seen at Pompeii—for the prevention of foul smells, and the general oversight of baths, brothels, taverns and water supplies. It was generally suspected that dust and flies were responsible for spreading diseases. Housing in Imperial and late Republican Rome was satisfactory for the rich and middle class: these latter were, for the most part, housed in blocks of apartments which were three or four storeys high. No bathroom or latrine was provided in them and water was supplied to the ground floor only. Most Roman houses had no heating systems, except in the baths, and in cold weather charcoal braziers were used. The poor lived in huts or wooden sheds, where conditions cannot have been so satisfactory.[28] There was probably a great improvement in the layout of the town after the great fire in A.D. 64, during the reign of Nero.

It will be seen, therefore, that conditions in Imperial Rome at least would have satisfied Chadwick's three sanitary principles. It is difficult to judge, however, what was the effect of these reasonable sanitary conditions on the life of the people. It has been calculated, admittedly only from the study of a small sample, that the average expectation of life of a person of fifteen years of age was twenty years if a male and fifteen years if a female. At seventy years of age, however, the expectation of life was twelve years for a male and ten years for a female. This is a reversal of the sex ratio as we experience it now.[29] All such calculations are highly speculative, and are largely based on data from funerary monuments, but it is interesting to compare this figure with that calculated for a man of twenty-five years between the years 1276 and 1450 when the life expectancy is thought to have improved from twenty-one years to

twenty-seven years:[30] this might give a mean age at death of between forty-five and fifty-two compared with the Roman's death at twenty-seven. It has, as a confirmation of these figures, been noted that over eighty per cent of recorded deaths in the Roman world occurred below the age of thirty.[31] In the absence of any knowledge of which diseases caused death and in what proportion, it is difficult to make any useful comparison with present-day figures. But it has been suggested that the overcrowded insulae, that multiple dwelling-house in which so many of the Roman proletariat lived, were admirably suited for the spread of many transmissible diseases. Augustus tried to impose a seventy-foot limit for the height of insulae. Trajan reduced this to sixty feet giving room for four storeys and a possible low fifth.[32] Nevertheless, the care that the authorities of Imperial Rome bestowed on water supplies and sewage disposal should have helped to prevent, or at least to reduce, outbreaks of typhoid fever and dysentery: cholera was unknown in Europe at that time. Typhus fever may have been prevented by the Roman fondness for bathing and the discouragement thus given to the spread of Pediculus corporis.[33]

Outbreaks of plague were relatively common and had serious effects: 'to the power of Athens' wrote Thucidydes referring to the great plague of 430 B.C. 'nothing was more ruinous'; and equally disastrous to Rome was the Antonine plague and that of Justinian.[34] Nothing was known then of the connection between the brown rat, fleas and plague, and the rapid multiplication of rats was favoured by the retention of decomposing food and other organic refuse in and around houses.[35] 'The Greeks', says Garrison, 'were blind to the fact of contagion, did not in the least understand that disease can be transmitted from person to person, and hence could do nothing for prophylaxis by segregation of actual or suspected cases of infection'. But Galen quotes Hippocrates as saying that 'our natures are the healers of our diseases' and Hippocrates himself held 'no diseases come from the Gods, one more than another, each acknowledging its own natural and manifest cause'.[36] It is recorded by Thucidydes that he tried to drive the plague away from Athens by causing large fires of aromatic wood and ordering strong-smelling flowers to be hung up which indicated a belief that disease may be controlled by human effort by destruction of materies morbi.[37]

There is some evidence that Rome and the surrounding country was infected by malaria, and at the same time that there were writers who had some vague and undeveloped ideas of what might be the origin of this. Malaria, a Roman fever, was a source of illness, according to Baedeker,[38] but he says that the centre of the city was free from this fever: the danger spots were the Esquiline, Palatine and Caelian hills, the Colosseum and the Baths of Caracalla. This in 1897, was probably due to lack of adequate drainage in the nineteenth century, and may well not have been the case in Imperial days when the hills were covered with palaces and other great buildings, when the Baths and the Colosseum were intact and in general, regular use. The disease is first recorded in Latium about 400 B.C. and by the second century there are references in the literature to 'swollen spleens'. Varo, about A.D. 200 suggested that: 'tiny, even invisible animals are bred in marshes which enter by the mouth and nostrils'[39] while Columnella states that the marsh: 'breeds animals armed with mischievous stings which fly upon us in exceeding thick swarms.'[40]

At an earlier date, fifth century B.C., a coin had been struck at Selinus, in Sicily, in

honour of Empedocles who had stopped an epidemic of fever by draining a marsh.[41] It was known, too, that to let salt water into a marsh could also stop a fever. By the time of Aristotle malaria was well recognized in Greece; he refers to haggard, sluggish, anaemic and bilious people who have large spleens. Dysentery, too, was well known to both Greek and Roman doctors. Celsus mentions ulcers of the intestines, with a discharge of sanguineous mucus from the rectum accompanied by tenesmus, while in a Greek treatise of the Alexandrian period there is mention of the 'meat washing' stools of dysentery.[42]

With this picture of conditions in Imperial Rome, and of other early civilizations before us, one must ask why it was that conditions had so deteriorated that it was necessary for Chadwick to enunciate his three principles as if these had never been formulated in former civilizations. The Christian era which developed as the Imperial age decayed may have brought with it a relaxation of hygienic precautions. Sickness was often regarded as a punishment for sin, while bathing was not encouraged: it was sinful to see the human body naked, one's own included, as this might induce lecherous thoughts. It is well known that bathing was discouraged among the monks of Westminster Abbey: now this was a Benedictine house, and not so liable to strict rules as some. Here, monks were allowed two baths a year: when, however, this was increased to four, authority soon stepped in, and the number was again reduced to two.[43] This attitude is curious, because clothes in the monasteries were washed regularly and frequently, and from what we know of the sanitary arrangements in the later monasteries these would seem to conform to the best Roman practice:[44] this can be seen in the surviving plans of the water supply and sewage disposal at Christchurch, Canterbury and at St. Gallen in Switzerland.

A. D. White[45] wrote that at that time it was held that 'the abasement of man adds to the glory of God: that indignity to the body may procure salvation to the soul: hence, that cleanliness betokens pride and filthiness humility. Living in filth was regarded by great numbers of holy men . . . as evidence of sanctity.' It was not until the eighteenth century that John Wesley was able to preach that 'cleanliness is, indeed, next to godliness.' Augustine wrote that 'all diseases are to be ascribed to Demons', even Allbutt was forced to exclaim that 'the honour of filth in person, clothing and condition was left to medieval times' and Kipling complained rather sadly:

> My privy and well drain into each other
> After the custom of Christendie
> Fever and fluxes are wasting my mother
> Why has the Lord afflicted me?[46]

When one comes to consider the water supply for London, until the middle of the nineteenth century, one finds a rather different story.

Before the Norman conquest water was taken from the Thames and from the Walbrook.[47] During the reign of Henry II, 'round the city, again, and towards the north arise certain excellent springs at small distances, whose waters are sweet, salubrious, clear and 'whose runnels murmur o'er the shining stones. Among these Holswell, Clerkenwell and St. Clement's Well may be esteemed the principal, as

being the best frequented, both by scholars from the schools, and youths from the city, when in a summer evening they were disposed to take an airing.'[48] It was in the reign of Henry III, in 1230, that lead pipes were first used to carry water and in 1236 he authorized Gilbert Sanford to bring water from Tyburn to London in lead pipes.[49] Later water was brought to the city from other relatively uncontaminated sources at Jack Straw's Castle, Chambery Field and Dalston which were piped to various conduits in the city. In 1544, as the supply was by then insufficient, an Act was passed to enable water to be brought from Hampstead, Marylebone, Hackney and Muswell Hill—all in rural areas—and later, four reservoirs, all interconnected, were constructed on Hampstead Heath, covering an area of twelve acres;[50] eight more reservoirs were later built, all interconnecting, and covering an area, then, of twenty acres: water from these was conveyed in two seven-inch mains to St. Giles. Further conduits were built and in 1568 water was taken from the Thames to a conduit at Dowgate.

In 1582 a Dutchman, Peter Morice, constructed a pumping wheel under the first arch of London Bridge to increase the supply of water, and further conduits for Thames water were built in 1583 and 1610.[51] The Thames, at the point of abstraction, is a tidal river and much sewage and other pollution must have been discharged into the river: the sewage from the palace at Whitehall and from the Tower of London was removed by the scouring action of the tidal river.[52] Water from the New River became available in 1613, and Stow, in 1633, records that:

> what with spring water coming from the several spring heads through the streets of the city to their cisterns, the New River water from Chadwell and Amwell, and the Thames water raised by several engines or water houses, there is not a street in London but one or other of these waters runs through it in pipes conveyed underground, and from these pipes, there is scarce a house whose rent is £15 or £20 a year, but hath the convenience of water brought to it by small leaden pipes laid into the great ones. And for the smaller tenements such as are in courts and alleys there is generally a cook or pump common to the inhabitants so that I may boldly say there is never a city in the world so well served with water.[53]

The quality of the water from the New River was good, and sensible precautions were taken to ensure that it remained so until it reached the consumer. 'Walksmen' were stationed at four-mile intervals, and these had one man working under them whose duty it was to keep the banks in good condition and to thin out weeds. Every five miles there was a grating to trap vegetable and other matter: this was removed by the Walksman as it accumulated. The water passed through chambers with gratings before entering the reservoirs, and these were cleaned out every three months so that: 'the supply is divested of all apparently objectionable impurity before it is allowed to go to the houses of the metropolis for the culinary and other purposes of the inhabitants.' In an attempt to stop bathing in the New River the Company offered to supply water free to public baths if these were erected at the public expense: this offer was not taken up. Bathing continued in the New River, for the Company had not the power to punish individuals who committed this offence, except by an action for trespass upon their land: as the penalty imposed for this offence by the Law was transportation, it recorded that: 'considerations of humanity have hitherto prevented the prosecution of offenders.'[54]

In 1830, the Company, by Act of Parliament, acquired a site of fifty acres at Stoke Newington where a settling reservoir was built: 'so that water by being kept in a state of stillness, will become clear before it flows to the New River Head.' This reservoir held a supply sufficient for several weeks, and was equipped with a 45 h.p. engine. The New River supplied its water by means of wooden pipes, of which 400 miles were laid: twenty miles were renewed each year by reason of wear and tear. The diameter of these pipes varied between 6/7 inches and 10/12 inches. The water companies of the metropolis did not undertake to supply water above the ground floor of any house nor was it at first the practice to keep the mains full by night as well as by day: if a fire occurred at night, a messenger was sent to New River Head or other convenient source, to arrange for a supply of water to be made available to the fireman. By 1827, 70,000 houses were supplied with water.

Among the various water companies which supplied London with water, the Lambeth company, before 1832, obtained its water by means of a pipe, three inches in diameter, which extended for 300 feet into the Thames with a 'dolphin', a device to cover and protect a source of water, at the end. This pipe was extended by 100 feet when a pumping engine was installed and then terminated in a grating which rested on a gravelly bank six feet below the low water mark. Before this extension was provided it was found that the water was turbid and: 'although turbid water be offensive to the sight, experience has satisfactorily proved that it is not dangerous to health, nevertheless perfectly clean and limpid water being preferable for beverage and indispensable for washing and various other domestic purposes' it was felt that all water companies would soon adopt a means for purifying and rendering water thoroughly clean. A similar dolphin was built for the Grand Junction Water Company at Chelsea.[55] The water which was drawn from the Thames at Vauxhall was found frequently to be 'in such a turbid and muddy state as to be quite unfit for various culinary or domestic purposes.' Two reservoirs were then built in Kennington Lane for the South London water company: 'both lined with brick, the bottoms gradually sloping from the circumference to the centre, so that any feculent matter, subsiding from the water, may tend to the lowest point.'

As John Snow pointed out in his book on cholera[56] the mortality from that disease in the epidemic of 1849 was greatest in the area supplied by the Southwark and Vauxhall and by the Lambeth water companies than in any other district, and that these were the only two companies which supplied Thames water to their consumers untreated: the Chelsea company, which also drew its water from the Thames; 'took great pains to filter the water before its distribution, and in so doing separated, amongst other matters, the greater portion of that which causes cholera.'

The Chelsea water company had its works at the north-east end of Chelsea reach, where it owned several acres of freehold land: the company was started in 1724. In 1829, the engineer to the works, Simpson, constructed filters whose purpose was: 'to deprive the water of all casual impurities, as well as to clarify it completely, previous to its passing from the reservoirs to the cisterns.' The filter had brickwork sides, and the bed covered one acre, with reservoirs beside of one and a half acres. Water was pumped into the reservoirs, where it settled, and was then passed through the filter beds which were formed of gravel and sand. 10,000 tons of water, of 224

imperial gallons per ton, were filtered daily. The filter cost £12,000, with annual expenditure of £1,000. The reservoir in the Green Park, which was situated at the north-east corner, was then adapted to take the filtered water.

In London, in the middle ages, the streets were laid out with either one central or two lateral gutters for rain water, any overflowing from wells and for slops generally.[57] Until 1309 it was ordered that all refuse be taken to the Thames or outside the city, but it was frequently dumped on the banks of the river or in the lanes leading to it. During the thirteenth century the inhabitants who lived along the course of the Walbrook were allowed to let their liquid filth run into the river through drains, but were compelled to catch and retain the solids by means of gratings. At the same time latrines must have been built over the river, for in 1313 and again in 1345 citizens were ordered to remove them. In 1374, however, Thomas alte Ram was made keeper of the Walbrook, and he encouraged the inhabitants to build latrines over it at a cost of 12*d.*, which went to the City funds; he collected these fees during his seven years of office. In 1412, however, all latrines over the Walbrook were abolished, and the stream vaulted over and paved. In 1385 a Sergeant of the Channels was appointed, and there were City rakers, under the control of the Beadles, at least to the extent of one for each ward, who collected the filth from the street in carts and deposited it in dumps by the river, whence it was conveyed downstream by dung boats. The carts were like tumbrils, which tipped backwards and had a back board two-and-a-half feet high. The dung boats were in private hands. Attempts were made to keep the streets clean: towards the end of the thirteenth century a fine of 4*d.* was imposed for throwing filth or rubbish into the streets: in 1372 for throwing slops, urine etc. into the streets, the fine was 2*s.* and in 1414 an informer of this offence was paid 2*s.* 4*d.* A survey in Wardmote, carried out in 1421, shewed that offences were few, although it was said that in Dowgate, not far from the city dump, three lanes were blocked with dung etc. Slaughter houses at Shambles, at Stockmarket and East Cheap were a cause of offence. During all this period there is evidence of action being taken against persons who dumped refuse in the streets or who threw it into the Thames, the Fleet river and the City ditch. Many public dumps were provided and people were supposed to use them. Some private dumps were also available; in 1369 thirteen butchers leased a dump in Holborn at a rent of 12*d.* a week and had two carts in which they took entrails etc. to be buried in pits which were dug there. But the very fact that action was taken, although not frequently, is some evidence that the condition of London streets at that time left much to be desired. It was not until 1845 that cesspools were abolished in London and in 1847 it became obligatory to discharge all sewage into the London sewers; hitherto, they had only received kitchen waste. The first sewer recorded in London was built in 1428[58] but most of the present system was constructed after 1824.[59] The first two of the main sewers of London were not completed until 1861,[60] while in Berlin the need for an adequate sewage system was recognized in 1873 when an important street such as the Leipzigerstrasse was serviced by sewage-tanks which were emptied by women at night to the accompaniment of 'appalling odours'.[61]

The value of filtered water or of water from a wholesome source was gradually appreciated. 'The practice appears indispensable, in order to obviate the objections of the fastidious; and though it would occasion some addition to the charge for it, the

cost would be a trivial consideration compared with the advantage of a constant supply of pellucid water', wrote Mallett, the chief engineer of Public works, in 1824. But animals with their natural instincts, furnished a puzzling problem for the 'pure water philosophers'; for cattle at streams often wait for drinking till they have made the water turbid by stirring up the sediment with their feet. 'Will it be unreasonable to infer that nature teaches quadrupeds that in such a state it is not only *wholesome* but actually *medicinal?*' asked those who were opposed to the demand. Meantime, it was hoped that filtration would become common, for the chief complaint about water was 'its feculent and turbid condition'. In fact, several Acts of Parliament about this time did contain a clause requiring water to be filtered before going into the supply.[62] In 1817–1818 stories were prevalent that Thames water was dangerous to drink, particularly when contaminated by the poisonous refuse of gas works. The Dolphin, to which reference has already been made, was thought to be a particularly obnoxious object.

A committee, under the chairmanship of Sir Francis Burdett, was set up and a motion introduced into both Houses of Parliament that a Commission be set up to inquire into the water supply of the metropolis. This was agreed and the Commission was appointed in 1827. Dr. Somerville, the physician to the Chelsea Hospital, was among those who gave evidence that 'the water was a horrible mixture, produced by all that is corruptible in the animal and vegetable world, together with the noxious filth of gas and other manufacturers'. He was asked 'Have you ever seen any bad effects of it on your practice?' to which he replied 'No, my patients are supplied with beer, and also very much disposed to correct the bad effects of water drinking by the aid of gin.' James Wills gave evidence that 'the Thames is neither more nor less than the common sewer of London, so far as receiving the content of all the sewers . . . a mass of filth which is in a progressive state of increase and offensiveness . . . may reach a state of putrescence in time.' Medical evidence, however, was contradictory: Dr. Bostock was unable to discover more on the average than three grains of solid contents either dissolved or suspended in 10,000 grains of the Thames. This was confirmed by other doctors who claimed that the worst specimens, from near the Dolphin and at the London docks, did not contain as much as four grains of extraneous matter per 10,000 and that not a particle of this small quantity was 'deleterious to health'. The Commissioners found that there had been a 'general deterioration of the water within the last ten or twelve years.' 'We found this opinion upon the well ascertained fact of the disappearance of fish from those parts of the river, to such an extent as to have led to the almost entire destruction of the fisherman's trade between Putney Bridge and Greenwich, and upon the circumstances that eels imported from Holland can now with much difficulty be kept alive in those parts of the Thames where they were formerly preserved in perfect health'. However, little progress was made. Sir Robert Peel in 1829, rejected Burdett's appeal that Telford should be employed by the Treasury to plan a new water supply for London, for he did not wish to interfere with the Companies who 'were labouring at considerable expense to improve the quality of the water supplied'. However, Burdett employed Telford, at his own expense, to make such a report in which he recommended that water should be supplied by a covered aqueduct from the river Verulam to a reservoir

on Primrose Hill and by a similar aqueduct from the Croydon branch of the river Wandle to a reservoir on Clapham Common. These two works would have cost about £1,100,000. Analysis of the water from the Treasury pump in Whitehall shewed that it contained four times as much suspended matter as did water from the Thames at Hammersmith or the filtered water of the Chelsea Water Company. But dirty water continued to have its apologists: 'the fastidious may call mud and manure filth, yet do not such substances communicate fertility to our fields and gardens, whence we derive the choicest productions both for substance and gratification?'

It was not until the cholera outbreaks of 1849, 1853 and 1854, followed by John Snow's masterly use of deductive logic, that contaminated water was finally proved to be a source of much human disease. From this began the general improvement in water supplies for the metropolis, which culminated in the setting up of the Metropolitan Water Board in 1902. At last London had a public water supply which could compare with that of Imperial Rome, if not in quantity, at least in quality.

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